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ANIMAL GENETIC RESOURCES INFORMATION

BULLETIN D'INFORMATION SUR LE RESSOURCES GÉNÉTIQUES ANIMALES

BOLETIN DE INFORMACION SOBRE RECURSOS GENETICOS ANIMALES

Food and Agriculture Organization of the United Nations
Organisation des Nations Unies pour l'alimentation et l'agriculture
Organización de las Naciones Unidas para la Agricultura y la Alimentatción

UNEP

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Initiative pour la Diversité des Animaux Domestiques
Iniciativa para la Diversidad de los Animales Domésticos

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Editorial

Research, Environment and Development. Interactions on Animal Production

Scientific advances and new methods of technology for food production, preservation and processing, transport and marketing force us to a fast change. Only time will show whether the present pace of rapid change will, on balance, have an overall positive or negative effect on the future state of the rural world. This change should be managed to prevent devastating effects not only on traditional animal production but also on the environment as a whole and allow for a planned evolutionary process so that humans and animals can adapt to the new socio-economic conditions they both must face.

Animal agriculture already contributes, to a greater or lesser extent, to the degradation and erosion of natural resources. If not well-managed, livestock production may specifically contribute to land degradation, the decline and pollution of water resources, the emission of greenhouse gases over and above the erosion of biodiversity. On the other hand, with good management, livestock production can make a positive contribution to the natural resources base by enhancing soil quality, increasing plant and animal biodiversity and substituting for scarce, non-renewable resources such as fossil fuels. Wherever possible these economically and environmentally attractive scenarios should be promoted, and policies and technologies which do so identified. However, as the expected increase in demand for food of animal origin must be met, it is likely that negative effects of livestock production, resulting from not well thought out intensification and higher productivity, will continue to emerge. The challenge is to identify policies and technologies which mitigate any negative impact on the environment but which, at the same time, satisfy the considerable demand for livestock products and the social needs of the consumers and the producers. Additionally, an important factor is that present day popular interest is concentrating on the applicability of animal research results and the ethics that surround it. The hesitation and emotions existing at all levels and spheres of the population, with regard to such developments as transgenesis and its possible relevant applications, reflect the pace of scientific changes and are provoked by the growing interest and the puzzlement of the man in the street in genetically modified organisms and the possible medium- and long-term implications of modern biotechnology programmes.

Without necessarily promoting less progressive, conservation approaches and uneconomical environmental policies, it should be stressed that, regarding the livestock sector, today we run the risk of over-hastily accepting and applying new alternatives that might neglect the fundamental factors of adaptability and time which could lead to serious consequences especially in less benign environments.

The Editors

Editorial

Recherche, Développement et Environnement. Interactions avec la Production Animale

Les progrès scientifiques et les nouvelles méthodes technologiques utilisés pour la production, la conservation et la transformation des produits alimentaires, ainsi que pour leur transport et leur commercialisation, nous obligent à effectuer des changements rapides. Seul le temps pourra dire si cette situation de changements rapides aura un effet positif ou négatif sur le futur du monde rural. En outre, ce changement devrait être contrôlé pour pouvoir prévenir les effets néfastes , non seulement sur la production animale traditionnelle, mais aussi sur l'ensemble de l'environnement, et devrait, également, donné lieu à un processus d'évolution planifier qui permette aussi bien aux hommes qu'aux animaux de s'adapter et faire face aux nouvelles conditions socioéconomiques.

La production animale contribue, de toute façon et en différentes mesures, à la dégradation et à l'érosion des ressources naturelles. Si une bonne gestion n'est pas appliquée, la production animale peut contribuer de façon spécifique à la dégradation du territoire, au déclin et à la pollution des ressources hydriques, ainsi qu'à l'émission des gaz qui provoquent un effet de serre et à l'érosion de la biodiversité qui s'en suit. Avec une bonne gestion, la production animale peut par contre devenir un apport positif pour les ressources naturelles de base, ceci à travers l'amélioration de la qualité des sols, l'augmentation de la biodiviersité végétale et animale et la substitution des ressources rares et non renouvelables, telles que les carburants fossils. Là où cela est possible, il serait nécessaire de mettre au point et promouvoir les mesures technologiques et politiques appropiées afin d'adopter ces propositions intéressantes. Cependant, si nous considérons la possibilité d'une augmentation de la demande d'aliments d'origine animale, on peut supposer que les effets négatifs en provenance de ce secteur, et qui sont dus au manque de connaissances sur l'intensification et une majeure productivité, continueront à exister. Le défi posé consiste à indentifier les politiques et les technologies qui puissent réduire tout impact négatif sur l'environnement mais qui, en même temps, puissent satisfaire la demande considérable de produits d'origine animale et les besoins sociaux des consommateurs et des producteurs. D'autre part, un autre facteur important est l'intérêt populaire actuel qui est centré sur la possibilité d'application des résultats de la recherche et toute la question d'éthique qui en dérive. Les doutes et le sentiment qui existent à tous les niveaux et dans les différentes sphères de la société en ce qui concerne ce genre d'études sur la transgenèse et ses possibles applications, reflètent la situation provoquée par les changements scientifiques et sont dus à l'intérêt croissant et à la perplexité générale vis-à-vis des organismes génétiquement modifiés et les conséquences à moyen et long terme des programmes modernes sur la biotechnologie.

Sans vouloir promouvoir des approches de conservation moins progressifs et prôner des politiques environnementales négatives, on devrait souligner que, en ce qui concerne le secteur de la production animale, aujourd'hui on risque d'accepter et d'appliquer hâtivement de nouvelles alternatives qui ne prennent pas en considération des facteurs fondamentaux d'adaptabilité et de temps, ce qui entrainerait de sérieuses conséquences, surtout pour les environnements les moins bénins.

Les Editeurs

Editorial

Investigación, Desarrollo y Ambiente. Interacciones con la Producción Animal

Los avances científicos y los nuevos métodos tecnológicos utilizados para la producción, conservación y transformación de los alimentos, así como para su transporte y comercialización, nos obligan a efectuar cambios muy rápidos. Sólo el tiempo podrá demostrar si el actual ritmo de cambio tendrá un efecto positivo o negativo sobre el futuro del mundo rural. Estos cambios deberían además estar controlados para prevenir los efectos perjudiciales no sólo sobre la producción animal tradicional, sino también sobre el medio ambiente en su conjunto, y deberían, a su vez, dar lugar a un proceso de evolución planificado que permitiera tanto a los hombres como a los animales adaptarse a las nuevas condiciones socioeconómicas a las que se enfrentan.

La producción animal contribuye ya, en mayor o menor medida, a la degradación y erosión de los recursos naturales. Si no se lleva a cabo una buena gestión, puede contribuir a la degradación del suelo, a la disminución y la contaminación de los recursos hídricos, a la emisión de gases que provocan el efecto invernadero y además a la erosión de la biodiversidad. Por otra parte, con una buena gestión, la producción animal puede contribuir positivamente al mantenimiento de los recursos naturales, mejorando la calidad de los suelos, incrementando la biodiversidad vegetal y animal y sustituyendo los recursos escasos y no renovables, como los carburantes fósiles. Siempre que sea posible, estas contribuciones positivas desde el punto de vista económico y medioambiental deberían promoverse, poniendo a punto las medidas tecnológicas y políticas necesarias. Sin embargo, teniendo en cuenta que se espera un incremento de la demanda de alimentos de origen animal, se supone que los efectos negativos provenientes de la producción animal seguirán surgiendo, debido a la mal planificada intensificación y al aumento de productividad. El desafío está en identificar las políticas y tecnologías que puedan mitigar cualquier impacto negativo sobre el medio ambiente pero que, al mismo tiempo, puedan satisfacer la demanda considerable de productos de origen animal y las necesidades sociales de los consumidores y de los productores. Por otra parte, otro factor importante es que en la actualidad hay un mayor interés de la sociedad en las posibles aplicaciones de los resultados de la investigación y las cuestiones éticas que de ello se deriva. Las dudas y la preocupación existentes en todos los niveles y sectores de la población con respecto a novedades como la transgénesis y sus posibles aplicaciones, reflejan la situación provocada por los cambios científicos y se deben al interés creciente y a la perplejidad por parte de la gente corriente en todo lo referente a los organismos genéticamente modificados y las posibles consecuencias a medio y largo plazo de los modernos programas de biotecnología.

Sin querer con esto promover enfoques de conservación menos progresistas y políticas medioambientales ineficientes desde un punto de vista económico, hay que resaltar que, en lo referente a la producción animal, hoy en día se corre el riesgo de aceptar y aplicar apresuradamente nuevas alternativas que no tengan en consideración factores fundamentales de adaptabilidad y tiempo, lo que provocaría graves consecuencias, especialmente en los ambientes menos favorables.

Los Editores

Genetics of disease resistance in *Bos taurus* cattle

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Summary

This review summarises evidence for genetic variation of *Bos taurus* cattle to diseases encountered under temperate conditions, including internal and external parasitism, susceptibility to mycotoxic diseases (tall fescue toxicosis, facial eczema, ryegrass staggers), mastitis, ketosis, pasture bloat, leukosis, tuberculosis, foot and mouth, brucellosis and BSE. Averaging mean heritability estimates reviewed from 8 diseases (weighted equally) gave a value of 0.21, indicating that measurable genetic variation for disease traits in *Bos taurus* cattle is somewhat less than that for production traits, such as milk yield or body weight. Many estimates, however, have high standard errors, and there could be an upward bias resulting from non-reporting of zero or non-significant estimates.

Few single-trait selection experiments have been conducted to study the genetics of disease resistance traits in cattle. For the disease traits where selection is being applied extensively, index selection for improved disease resistance and increased production is more common than single-trait selection. Results from a long-term (25 year) divergent selection experiment with resistance/susceptibility to pasture bloat in cattle in New Zealand are reviewed. Four single-year experiments comparing progeny of 'high' *versus* 'low' sires for resistance to disease are also reviewed, one in Australia studying faecal nematode egg counts, one in the USA involving the mycotoxic disease, tall fescue toxicosis, a third in New Zealand involving the mycotoxic disease, facial eczema, and a fourth in the USA involving *Brucella abortus.*

Resumen

Esta revisión resume la variedad genética evidente en *Bos taurus* a las enfermedad encontradas en condiciones templadas, incluido el parasitismo interno y externo, la susceptibilidad a las enfermedades micotóxicas (festuca cañosa, excema facial, tetania del raygras), la mastitis, la cetosis, el timpanismo pratense, la leucosis, la tuberculosis, la brucelosis y la BSE. La media de heredabilidad estimada sobre 8 enfermedades nos da un valor de 0,21, lo que indica que la variación genética medible en cuanto a enfermedades en el caso de *Bos taurus* es algo inferior con respecto a la producción, tal como el rendimiento en leche o rendimiento corporal. Varias estimaciones poseen sin embargo una elevada desviación estándar, y puede haber una ulterior desviación debida a la omisión del zero o de las estimaciones no significativas.

Algunos experimentos sobre selección de rasgos simples han conducido llevado a estudiar la genética de los rasgos de resistencia a enfermedades en bovinos. Para los caracteres sobre enfermedades, a los que se aplica una selección extensiva, el índice de selección para mejorar la resistencia a la enfermedad y aumentar la producción es más común que en el caso de la selección de un rasgo simple. Se analizan aquí los resultados obtenidos a largo plazo (25 años) y que muestran una divergencia entre el experimento de selección y la resistencia/susceptibilidad al timpanismo pratense en los bovinos de Nueva Zelanda. Quatro experimentos de un año comparan la descendencia de “arriba” hacia “abajo” de los machos en cuanto a la resistencia a enfermedades; uno en Australia realiza un conteo de las larvas de los nematodos fecales; uno en Estados Unidos sobre la enfermedad micotóxica, un tercero en Nueva Zelanda referido a enfermedad micotóxica y excema facial; y el cuarto en Estados Unidos sobre *Brucella abortus*.

Key words: *Cattle,* Bos taurus, *disease, resistance, genetics*

Introduction

Animals have always been subjected to assault by infectious and parasitic organisms and presumably the natural selection pressure in the wild is severe. In recent centuries, domestic animals have been subjected to artificial selection, particularly for visible traits and then for easily measurable traits such as live weight or height. For disease traits in cattle, however, studies of animal variation are less common than for live weight or height, so less is known about the potential to change animal susceptibility. In times when the use of antibiotics and drug therapy was common, cheap and acceptable, there seemed little incentive to select for disease resistance. The position has now changed because of increasing concerns over drug resistance by parasites, bacteria and viruses, increasing demands for residue-free animal products, and at the same time increasing concerns for animal welfare. Selection for disease resistance has been applied successfully in poultry, and opportunities are also being applied increasingly in pigs and sheep in some countries. This article reviews information on genetic variation in the susceptibility of cattle to disease, with the major emphasis on *Bos taurus* cattle, thereby restricting the review predominantly to temperate conditions.

Parasites

Internal parasites

Most genetic studies on the host resistance of farm animals to helminth parasites have been carried out in sheep, although the question of host resistance is also of interest in cattle and goats. There are numerous reviews of responses achieved to divergent selection for (sheep) host resistance to internal parasites (e.g. Woolaston & Eady, 1995; Morris *et al.* 1995b). These have concluded that selection has been successful in experimental flocks (e.g. Morris *et al.*, 1997b), with single-sample heritabilities for faecal egg count ranging from 0.2 to 0.3 (occasionally 0.4 or above), and the reviews have also described selection opportunities being applied in industry ram-breeding flocks. By following similar research techniques to those in sheep as described above, what has been found in cattle?

Barlow and Piper (1985) estimated heritabilities for single-sample faecal egg count in Australian Hereford and Hereford-cross cattle, with values of 0.04±0.17 and 0.29±0.19 for the two most common genera in the trial *(Cooperia* and *Haemonchus,* respectively), and with a value of 0.04±0.18 for all genera combined. An estimate of 0.29±0.18 was obtained for faecal egg count in Angus cattle in the USA (Leighton *et al.*, 1989).

By implication, responses similar to (or smaller than) those achieved in sheep could be achieved from selection applied to young cattle, although standard errors for heritability estimates are large in both cattle experiments cited here. Esdale *et al.* (1986) have described a single-year experiment with F_2 *et sequ.* Africander x Hereford cattle, where the progeny of 3 high and 3 low faecal-egg-count sires were compared, giving a realised heritability of 0.52 for the mean of 4 egg counts, a significant progeny group difference in faecal egg count (P<0.005) and a single-sample repeatability of 0.20±0.05.

Data for (log) faecal egg count from Friesian-cross and Brahman-cross calves under temperate conditions in New Zealand (Morris *et al*., 1992) have provided a further repeatability estimate of 0.21±0.08. From Barlow and Piper (1985), repeatabilities of egg counts for the two genera and for the total egg counts were 0.30 to 0.31. These indicate that, for individual assessments of an animal's phenotype for selection, it is useful to take more than one egg count record.

External parasites

Cattle ticks

Perhaps most work on host resistance to external parasites in Bos taurus cattle has been done by CSIRO at Rockhampton, with Hereford-Shorthorn and other crosses in investigations of resistance to the cattle tick *(Boophilus microplus*). A review of heritability estimates for host resistance to ticks in *B. taurus* and *indicus* breeds (Davis, 1993) led to an average of 0.34±0.06, or a value of about 0.30 for *B. taurus* alone.

Tick resistance was one of the traits monitored in the CSIRO Hereford-Shorthorn cattle selected for production (weight gain) under disease-challenge conditions. Extreme levels of resistance to ticks were found in one particular heifer, and subsequently in some of her relatives. As a result, matings were set up using likely carrier sires, and a two-allele major gene effect was identified (Frisch, 1994; Kerr *et al*., 1994). The heterozygote mean was in between those of the two homozygotes, but the degree of dominance depended on the extent of tick challenge under which the animals were evaluated.

Bush ticks

Infestation levels of cattle to the bush tick, *Haemaphysalis longicornis,* have been compared in Herefords and their crosses in Grafton, New South Wales (Dicker and Barlow, 1979). The *Bos taurus* animals harboured twice as many ticks as *Bos indicus* crosses (Brahman x Hereford), but significant differences amongst Hereford, Friesian x Hereford crosses and Simmental x Hereford crosses were not detected. Heritabilities were not estimated.

Mycotoxic Diseases

Tall fescue toxicosis

Tall fescue *(Festuca arundinacea)* is the most important cool-season forage grass in much of south-eastern and central regions of the USA (Stuedemann and Hoveland, 1988), being grown on about 14 million ha of land. Tall fescue toxicosis in cattle is caused by ergot alkaloids, predominantly ergovaline, from the fungal endophyte *(Acremonium coenophialum),* found in some tall fescues, and this leads to reduced intake in cattle, reduced weight gain, reduced milk production, reduced tolerance of heat stress and various metabolic, behavioural and physiological effects (Stuedemann and Hoveland, 1988). Breed differences in the depression of weight gains have been recorded (Morrison *et al.,* 1988), providing initial evidence of genetic differences in the host. Hohenboken and Blodgett (1997) have successfully selected for and against tall fescue toxicosis susceptibility in mice by selecting for and against a depression in growth whilst on an endophyte-infected fescue seed diet. In a subsequent study, Wagner and Hohenboken (1998) established that a toxin-containing diet had a larger detrimental impact on long-term reproduction of mated pairs of the susceptible than of the resistant line. The divergent selection lines of mice were shown to differ also in the activities of two liver detoxication enzymes.

These and other indirect measures of monitoring genetic susceptibility to fescue toxicosis or selecting against it could be tried in cattle. However, differences among aged Angus cows in lifetime production while grazing endophyte-infected fescue pastures could not be related to variation among them in physiological indicators of fescue toxicosis (Hohenboken *et al.,* 1991). Also, progeny of a presumed resistant bull and of a control bull did not differ in physiological responses to fescue toxicosis (Gould and Hohenboken, 1993), although they did differ in rectal temperature whether on a diet of toxin-containing fescue or not. Apparent resistance to the condition may therefore be mediated by inherent differences in "basal" body temperature and liability to heat stress. Lipsey *et al.* (1992) progeny tested one susceptible and one tolerant bull for rectal-temperature response to heat stress at WC whilst on a diet containing ergovaline. Progeny of the susceptible bull were more temperature-sensitive to addition of dietary ergovaline ($P<0.05$) than were those of the resistant bull. A simplified test might provide an opportunity for industry to begin to breed for resistance, if it was desirable within the prevailing cost structure.

Facial eczema

Facial eczema is caused by a toxin, sporidesmin, found in spores from the saprophytic fungus, *Pithomyces chartarum.* The fungus grows on the dead litter at the base of grasses in pastures during late summer/autumn in lower-lying areas of the North Island of New Zealand. The disease also occurs in Australia, Argentina, Uruguay, South Africa, USA and France, but the common and severe outbreaks seem to be in New Zealand for climatic and other reasons. Sporidesmin is a potent toxin that injures many body tissues, particularly the liver. The extent of liver injury in susceptible ruminants can be determined from analysis of serum gamma glutamyltransferase activity about 3 weeks after a toxic challenge. A long-term experiment selecting for high or low susceptibility to facial eczema (using the gamma glutamyltransferase indicator) in Romney sheep in New Zealand was established in 1975 and is still continuing (Morris *et al*., 1995a).

From cattle studies set up in 1989 following a field challenge in Jersey cows (Morris *et al*., 1990), the heritability of gamma glutamyltransferase activity was estimated to be 0.31±0.10. Studies in which calves were dosed with sporidesmin have subsequently been carried out with male progeny groups of Friesian and Jersey sires (Morris *et al*., 1998a), giving heritabilities of 0.29±0.15 and 0.77±0.13 respectively. Activities of this and other enzymes following sporidesmin challenge are closely correlated genetically (Morris *et al.*, 1998a), and they also have high between-animal repeatabilities under challenge conditions. A single-year progeny-test study with 5 highly susceptible and 5 resistant Jersey sires was also carried out, showing successful direct selection (Morris *et al.*, 1991b), so that selection for facial eczema resistance under commercial conditions would be practical if desired.

Studies are now underway in sheep to find the gene(s) responsible for facial eczema resistance, and to find a genetic marker close to (or on) the gene (Phua *et al.,* 1998). It is likely that these results would have direct relevance to cattle testing and selection. The availability of a genetic test would save the need for direct challenge with the toxin.

Ryegrass staggers

Ryegrass staggers (RGS) is a neurotoxic disease in ruminants caused by the mycotoxin, lolitrem B, found in endophyte-infected swards of perennial ryegrass *(Lolium perenne L).* RGS can cause severe distress to animals and also management problems for farmers. Under summer/autumn grazing conditions, RGS can cause muscular incoordination in animals, and is most obvious in cattle or sheep when they are under the stress of being moved, mustered or driven by working dogs. Its effects are reversible, when the toxin and the stress are removed.

A selection experiment for resistance or susceptibility to RGS is underway in sheep in New Zealand (Morris *et al.,* 1998b). With a single-record heritability of 0.068±0.028 and a between-animal repeatability of 0.24±0.05, an average divergence of 26 percentage points in RGS incidence has been achieved between the two lines after the first 5 years of selection (21 *vs* 47%).

A similar testing procedure using natural challenge could be applied in experimental cattle, given that RGS in cattle has also been recorded as having a significant between-animal repeatability, and that susceptibility to the disease runs in families (Morris, CA, unpublished data, 1998).

Mastitis

The inheritance of susceptibility of dairy cattle to mastitis has been studied for many years. Four early heritability estimates (1950-1972) reviewed by Spooner *et al.* (1975) had an average value of 0.25 (range 0.10 to 0.38), whilst recent estimates from regional or national databases are generally much smaller, e.g. 0.06 to 0.11 for records from 200 000 first lactations in Norway (Simianer *et al.,* 1991). There could be many reasons for the difference: improved statistical methodology, sire by environment interactions, natural and artificial selection having removed the most susceptible families of cows over the last 40 years, improved dairy-shed hygiene having altered the challenge, or the effects of altered milking machine technology and larger herd sizes. An extensive review by Miller (1982) gave separate heritability estimates for bacteriological measures of mastitis (average 0.10, n=3 studies), clinical treatment data (average 0.12, n=12) and somatic cell count (average 0.20, n=9). More recent heritability estimates for somatic cell count are still low, e.g. 0.09 to 0.11 in Canada and 0.10 in the USA (Powell *et al.,* 1997). Large-scale programmes have now been set up on a national basis (e.g. in Norway and Sweden) to rank bulls and select them on indices which include the milk traits and reduced mastitis, ketosis or 'any disease'.

Ketosis

Scandinavian dairy cattle selection programmes include records of (and selection against) ketosis, as mentioned above. The heritability estimates reported in Norway ranged from 0.08 to 0.11 (Simianer *et al.,* 1991). Consequently, large daughter group sizes are required for accurate sire proofs, and this is part of the current Scandinavian progeny test design.

Bloat

"Foamy" or "pasture" bloat occurs in ruminants, especially cattle, when they are unable to disperse the gases of fermentation as quickly as these gases are produced. It is common in spring and autumn in New Zealand dairy cows. The conditions necessary for bloat to occur in susceptible animals are not known precisely. It is a metabolic problem which is more commonly encountered, but is not restricted to, animals grazing high white clover levels in white clover/ryegrass swards. Animal selection studies have been underway at Ruakura since 1972/73 (Morris *et al.,* 1991a), as described below. "Feedlot" bloat is a different syndrome, which was studied by Lindahl *et al.* (1957) who noted animal-to-animal variation in susceptibility, but no genetic factors were investigated.

Herds of Friesian-Jersey cross animals, selected at Ruakura for high or low susceptibility to pasture bloat, were established in 1972/73, and selection has continued since then. Outside sires were used for four years, and then the two herds were closed. Young stock have been scored for 2 to 3 weeks each year for susceptibility to bloat whilst grazing bloat-potent pasture. As reported by Morris *et al.* (1997a), after 23 years of divergent selection, herds differed by 1.2 phenotypic standard deviations for single-record (half-day) scores, the single-record heritability equalled 0. 19±0.04 and the repeatability equalled 0.44±0.02. Minimal response has been achieved since about 1984 in the low susceptibility herd, although the high susceptibility herd has continued to become more susceptible. The data are consistent with the presence of a major gene for bloat, recessive for susceptibility, which accounts for at least 78% of the genetic variance. A search for a linked genetic marker is underway, to provide a simple DNA test using blood, milk or semen, obviating the need to score animals on potent pasture. A candidate gene has also been found, coding for a parotid salivary protein (bSP30). This protein has higher concentrations in the low susceptible herd than in the high susceptible herd (Rajan *et al.*, 1996). Thus, a secreted salivary protein and the genetic mechanism for its control are both under study here.

Leukosis

The aetiological agent of enzootic bovine leukosis is the bovine leukaemia virus (BLV), and B-cells are the principal target of BLV infection (Kenyon and Piper, 1977). Lewin and Bernoco (1986) investigated the role of the major histocompatibility complex in BLV infection in an infected Shorthorn herd, and found that specific bovine lymphocyte antigen types were associated with resistance or susceptibility to BLV. Resistance/susceptibility was shown to segregate in 33 offspring sired by a bull which was heterozygous at the appropriate locus. The authors concluded that "the bovine lymphocyte antigen system can be used to select for resistance to B-cell proliferation and the development of lymphocytosis in BLV-infected herds".

Analyses of data from Black and White cattle in Russia by Kulikova and Petukhov (1994) have provided a heritability estimate of 0.3 for incidence of leukosis.

Tuberculosis

The same Russian workers reported a heritability of 0.06 to 0.08 for resistance to tuberculosis in Black and White cattle, in a population showing a "morbidity" (? incidence) of 20.8%. Sire-offspring and daughter-dam relationships were analysed to obtain these estimates (Petukhov *et al.*, 1998). In a previous publication (Kulikova and Petukhov, 1994), the authors reported a positive genetic correlation between susceptibilities to tuberculosis and leukosis.

Foot and Mouth Disease

Templeton *et al.* (1988) quoted French data (Prat, 1952-53) showing that resistance to foot and mouth disease runs in families. All but one cow on a dairy farm contracted foot and mouth in 1938. Fourteen years later, after the herd had been re-established, another outbreak was experienced and there were then six resistant cows (three remaining healthy and three with only mild symptoms); all were descended from the original resistant cow.

Brucellosis

Templeton *et al.* (1990) described a study on natural resistance to brucellosis in cattle, in which they bred 11 resistant and 10 susceptible cows to a resistant bull, with the two groups of offspring being challenged with a discriminating dose of virulent *Brucella abortus.* Progeny were challenged as heifers in midgestation (16 to 24 months of age) or as bulls from 12 to 16 months of age. The percentage of animals resistant to brucellosis was three times higher (54%) in the offspring of resistant than susceptible dams. Also, the in *vitro* replication of *B. abortus* was controlled more effectively in macrophages from resistant-line animals than in those from susceptible-line animals, both before and after the animals were exposed to the disease challenge.

In more recent work (Adams *et al., 1996),* the potential of the resistant herd was assessed and a positive genetic correlation between resistance to *Brucella abortus* and to *Mycobacterium bovis* was reported.

BSE

Intensive work on many aspects of bovine spongiform encephalopathy (BSE) in recent years has included a search for evidence of host variation in susceptibility. Different forms of the host-encoded prion protein have already been found in cattle (Goldmann *et al.*, *1991)* which suggest that there are indeed host differences in susceptibility, as for scrapie in sheep.

Foot defects

An extensive review of the genetics of foot defects in cattle was published by Greenough (1991). There were various causes of foot defects, ranging from foot rot, lameness-producing lesions of the hind limb, claw disorders and laminitis, and he reported low heritabilities for most traits or their components. Overall in dairy cattle, a subjective score is usually given to ‘feet and legs’, which again is lowly heritable. Thus, selection could be applied to improve foot structure, if required.

In the future the consumer might decide to discriminate on animal welfare or food-safety grounds, because another supplier’s product (or production system) is more desirable. In this context, ‘desirable’ could mean produced by cows under less stress (e.g. fewer lame or sick animals) or products from cows with fewer or no history of veterinary or prophylactic intervention (i.e. residue-free products).

Elements or metabolites in blood

Although genetic variation in trace element or metabolite concentrations in the blood does not demonstrate genetic variation in disease incidence *per se,* it could be a useful indicator of animals near a lower or upper threshold. For example, we have estimated a heritability of 0.15±0.06 for Mg concentration in lactating Jersey cows which were the daughters of 65 sires (Morris *et al.,* 1990). It is not known if the genetic outliers for low Mg could be more prone to the clinical condition of grass staggers (hypomagnesaemia). In the same study, heritability estimates for Na and K concentrations were very close to zero. In a British study, Rowlands (1974) obtained heritability estimates (231 Hereford-Friesian calves, 12 sires) of 0.93±0.36, 0.74±0.32, 0.40±0.23, 0.28±0.19, 0.26±0.18 and 0.09±0.12, for concentrations of haemoglobin, glucose, K, albumin, inorganic $P0_4$ and Na respectively.

Discussion

It is becoming clear that there is natural genetic variation in *Bos taurus* breeds for resistance to most of the diseases to which they are commonly or occasionally exposed. Over recent decades, however, we have been hiding this genetic variation (or not requiring expression of this genetic variation) because of the widespread use of drenches, vaccines, sprays etc., and because of the elimination of some diseases altogether (e.g. foot and mouth in some countries).

In this review, heritability estimates were obtained from the literature for 8 of the diseases considered. Averaging 8 mean heritability estimates (i.e. using one mean value for each disease) gave an overall mean of 0.21. Many of the separate heritability estimates had high standard errors, so the estimates for most traits are not very precise. However, it is encouraging to note that all the single-year selection studies described above, and the multi-generation study (on bloat), were successful in breeding divergent lines of cattle.

Some heritability estimates may not have been published because they were low or not significant, in which case there may be an upward bias to the overall value calculated here. However, if a disease trait has a heritability of 0.21 or greater, selection to change the mean incidence level is feasible although progress may not be as fast as for milk yield or live weight (other things being equal). For some traits (e.g. mastitis), where current heritability estimates are much lower, large progeny group sizes are now being generated in order to provide the accuracy required for continued sire selection. In other cases, e.g. ryegrass staggers or bloat, repeated records and restricted-maximum-likelihood analyses may be used to improve the accuracy of breeding value estimation above that possible with single-record phenotypic selection.

For the future in *Bos taurus* breeds, it seems that there will be some opportunities for following up candidate genes, ultimately to identify a major gene controlling host resistance to a disease. Use of a genetic marker on the gene, or very closely linked to it, will probably be the method of choice to select bulls and possibly cows for breeding. This may need to be repeated for a series of diseases, although the selection studies in mice by Biozzi *et al. (1982)* suggest that there should be opportunities for cross-resistance where antibodies play a dominant role.

A review (Morris, *1998)* of selection responses for disease resistance achieved in 15 New Zealand and Australian single-trait experiments with sheep and cattle (mainly the former) showed that realised heritabilities averaged 0.28. It is to be hoped that research funding for selection studies on disease resistance will continue, so that we may learn more about how to breed for resistance. This would improve animal welfare and herd productivity, and would increase the availability of residue-free animal products.

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Indigenous cattle of Zanzibar: the need for conservation

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Summary

The indigenous cattle of Zanzibar commonly referred to as Zanzibar Zebu belong to the Small East African Zebu but with some influences of Boran and Somali cattle. The breed is under pressure from cross-breeding and from economic reforms that may lead to genetic erosion. This paper is an attempt to describe the characteristics and environment of these cattle as well as highlighting the implications of the prevailing conditions for conservation.

Resumen

El bovino indígena del Zanzibar normalmente se refiere al zebú de Zanzibar, descendiente del pequeño zebú del Este africano pero con algunas influencias del bovino del Boran y Somalia. La raza se encuentra bajo presión por los cruzamientos efectuados y por las distintas reformas económicas que han llevado a una erosión genética. Este artículo presenta una descripción de las características y del ambiente de estos bovinos, e intenta subrayar las implicaciones de las principales condiciones de conservación.

***Key words**: Characteristics,* In situ/ex situ *conservation, Origin, Unguja, Pemba, Zebu.*

Introduction

Zanzibar comprises two main islands, Unguja (also called Zanzibar) and Pemba, with several islets adjacent thereto, off the coast of East Africa. Although administratively Zanzibar runs an autonomous government, it is part of the United Republic of Tanzania (URT). We can also speak of Tanzania as consisting of the mainland and the isles (Unguja and Pemba). Unguja island, covering a total land area of 1 464 km^2, is separated from the mainland of Tanzania by a channel which is at its narrowest 36 km across. It lies between latitudes 5°40' and 6°30' south; and longitude 39° east. Its sister island of Pemba has a total land area of about 864 km^2, and lies about 40 km NNE of Unguja, between latitudes 4°50' and 6°30' south and between longitudes 39° and 39°50' east.

Zanzibar is endowed with strains of cattle that have sustained the lives of thousands of people for centuries. The majority of these cattle are found in Pemba as the presence of tsetse is a limiting factor in Unguja (see table 1). The loss of genetic diversity in Zanzibar is imminent due to the artificial manoeuvres by man in an attempt to secure livelihood and extract more from its livestock. The existence of artificial insemination in cattle and extensive introduction of exotic breeds make this species most vulnerable to genetic erosion. The objective of this paper is therefore to describe the general characteristics of cattle in Zanzibar and highlight the need for their conservation.

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Origin

The cattle of Zanzibar have been described by Tidbury (1954), Griffin (1986), Mason (1988), and Felius (1995) as belonging to the Small East African Zebu, which is an indigenous type common in East Africa. Their origin has been a subject of many speculations. Payne (1970) and Epstein and Mason (1984) provided a general account of movements of thoracic-humped zebu cattle into the eastern horn of Africa by about A.D. 669. In addition, Payne (1970) suggested the direct sea route from India as the probable way by which these cattle entered Zanzibar in the earlier times. From these sources, zoological records (Moreau and Pakenham, 1941; Swynnerton and Hayman, 1951) plus records of the earlier explorers (Rigby, 1861; Burton, 1872), updated information on trade and people's movements (Sheriff, 1987), and recent records (Khan, 1921; Muir, 1941). It was found necessary to divide the influxes of cattle into the islands of Unguja and Pemba in three major historical epochs (Ali, 1997). Far back in history, cattle were introduced by migrating people from southern Arabia and India, either through the mainland of East Africa or directly via the sea route. In the middle centuries (1500-1700), slave and maritime trade were responsible for bringing in cattle from the mainland of East Africa. Lastly, in the colonial era of the 19th century and the period that followed, cattle were imported for either experimental purposes, commercial production, or slaughter, and more so to Unguja than to Pemba. Although the origin of zebu cattle in Zanzibar can be traced to sources in India and southern Arabia, analysis based on past history, physical characteristics, and population data would tend to suggest greater similarities to small East African Zebus from the mainland of East Africa, with some noticeable features of Boran and Somali cattle.

Table 1. Total number of cattle in Zanzibar.

Year	Unguja	Pemba	Total
1913	4 614	6 534	11 148
1938	6 908	30 061	36 969
1947	6 640	27 668	34 308
1951	9 662	32 969	42 631
1960	16 233	31 525	47 758
1966	19 599	30 179	49 778
1978	28 225	31 915	60 140
1985	28 365	48 000	76 365
1993*	45 750	65 943	111 693

*=1992/93 Zanzibar livestock census (preliminary report)
Source: Department of livestock.

Physical and Production Characteristics

The outcome of the different means by which cattle entered Zanzibar and the subsequent exposures to climatic and management features existing in the islands of Unguja and Pemba is the occurrence of a cattle population with some unique features. The Zanzibar Zebu, as cattle of these islands are called, show variability in colour patterns (Figure 1 and 3). The commonest colours are of the reddish type (light red, dun, roan, and brindle), black, and grey. Local Zebu cattle were described by Tidbury (1954) as being small, neat animals, whose height at hook bones is usually between 104 and 125 cm, with usually small and flat horns and with a pronounced hump. Adult bulls were reported to weigh on average about 320 kg and cows about 250 kg. Work carried out recently by the present author in Pemba from which also the cattle studied by Tidbury originated found lower values for both height at withers and estimated body weights (see table 2). Body weights in this study were estimated using the following regression equation: Body weight (kg)=-293+3.68 Heart girth (cm), developed after measurements were initially made on a sample of 37 zebu cattle at the Mtakata Dairy Farm where the weighing bridge could be obtained. An interesting observation of the recent work is the lower values of body measurements for bulls compared to cows. This could be explained by earlier off-take of bulls under field conditions and hence in such cases measurements would be made with younger animals (see age range in table 1).

It is generally believed that cattle in Unguja and Pemba are used for milk, beef and traction. But the work done recently by the author indicated cattle in Pemba serving more as living savings accounts to insure against unforeseen events. Pemba cattle are smaller than those found in Unguja, but are said to be relatively better milkers (Payne, 1970). Mean lactation yield for cows in Pemba (excluding milk taken by the calves) was estimated by Griffin (1986) to be 205 litres for a mean lactation length of 205 days. Mean weaning age for calves was estimated to be 13 months and calving percentage for cows of only 35% due to long periods of anoestrus. There is also some seasonality in occurrence of oestrus with peak observations in the months of October, November, December and January due to the relatively better condition of cattle than in other months. On average Zanzibar Zebu calve for the first time at 3.5 years of age and the average calving interval is about 20 months. Figure 2 shows a Zanzibar Zebu heifer. Figure 4 represents a grazing Zanzibar zebu cow.

Climate and Soils

In general the climate to which the cattle in Zanzibar are exposed is shaped very much by the trade winds of the tropical Monsoon system. The rainfall pattern is bimodal in nature, with a long rainy season *(Masika)* from mid March to the end of May, and short rains *(Vuli)* in the months of October to December. Comparing the two islands, Pemba, on average, receives more rainfall (1 900 mm) than Unguja (1 600 mm). The distribution of rainfall is such that there is more rainfall in the western sides than in the east. Temperatures in Zanzibar are high during the short dry season of January to February, with

Figure 1. Zanzibar Zebu. Various colour patterns.

maximum mean of 32°C, and low during the cool season lasting from May to September. The mean annual maximum and minimum temperatures are 29.3°C and 21.1°C, respectively. The relative humidity is high, with a monthly average ranging from 87% in April *(Masika)* to 76% in November *(Vuli)*, and a minimum at 60% during the dry season.

According to earlier local classification based on physical characteristics, soils of Pemba can be categorized into upland soil types differentiated by geomorphology, and lowland soils whose parent material forms the basis for classification (CATAD, 1988). In general, soils of the western side of both Unguja and Pemba are deeper than those of the eastern side. This feature, together with the rainfall pattern described before, is associated with many differences of agricultural significance and actually forms the basis for the agroecological zonification of the two islands into the deep soil zone on the western side and coral rag zone to the eastern side.

Management

The management of cattle for most farmers in Zanzibar is rather traditional, involving limited use of shelters and veterinary inputs (Griffin, 1986; CATAD, 1988; Ali, 1997). Most farmers have no formal education and have acquired knowledge of livestock keeping through field experiences. Tethering is the dominant grazing system of feeding animals. This may be a response to limitations associated with raising livestock in crop producing areas where conflicts with crop farmers is a sensitive issue. Grazing is done on permanent crops, in fallow lands, and in the interseasonal crop lands in sophisticated systems of cattle movements. Fodder shortage is perceived by farmers as the most common problem of livestock keeping (Griffin, 1986; Ali, 1997). Field experiences point out the cyclical loss and recovery of condition among animals with seasons in Zanzibar. Diseases and insect disturbances are only secondary problems making the use of veterinary inputs a rare thought in the minds of most livestock keepers. East Coast Fever is the primary health concern, particularly for young animals. Worms and other malaise become a health threat during the dry season when fodder is scarce and animal conditions are weak. Griffin (1986) observed morbidity and mortality rates of 53% and 7%, respectively, for cattle in Pemba. This implies that even though animals do suffer from various health problems, the majority recover and only few die.

Numbers

Data for total number of cattle in Zanzibar for the period from year 1913 to 1993 is presented in table 2 and table 3. It is evident from table 2, that the cattle population in the two islands has increased ten-fold from 1913 to 1993. Pemba has however comparatively more cattle than Unguja. This can be traced from 1913 onwards where the official records are available. Whereas for Unguja there was a slow growth at the beginning, for Pemba the period between 1950 and late 70's appears to have been very critical for the growth of the cattle population.

The Zanzibar Zebu is included in the World Watch List of domestic animal diversity as a breed at risk (FAO, 1995). It is unclear why such categorization is made to the Zanzibar Zebu if the name refers to all cattle in these islands, whose population is in the tune of many tens of thousands. The argument presented in this paper for the need to conserve Zanzibar Zebu is not based on its risk status as judged by the number of breeding individuals, but rather to genetic erosion due to widespread use of cross-breeding and to consequences emanating from the current economic reforms.

Implications for Conservation

Although livestock genetic resources in Zanzibar appear to be largely of similar origin to those found elsewhere in East Africa, the geographical and environmental features in the islands of Unguja and Pemba have

Table 2. Characteristics of Zanzibar Zebu.

Traits	Bulls (n = 33; age range 2-6 years) Average±SE	Cows (n = 147; age range 2-18 years) Average±SE
Withers height (cm)	99.9±1.1	102.8±0.5
Heart girth (cm)	123.9±1.9	128.4±0.9
Body weight (kg)	162.9±7.1	179.4±3.4

Table 3. Total number of cattle in Zanzibar by class.

Class	Unguja	Pemba	Total
Bulls	5 699	10 513	16 212
Cows	20 391	26 143	46 534
Heifers	9 039	12 073	21 112
Male calves	5 203	8 686	13 889
Female calves	5 418	8 518	13 936
Total	45 750	65 943	111 693

Source: MALNR (1993). Zanzibar livestock census 1992/93 (preliminary report).

Figure 2. A Zanzibar Zebu heifer.

shaped livestock populations, particularly cattle, into unique types. The existence of tsetse flies in Unguja island is a factor that has disturbed cattle populations over many generations. Therefore, Pemba has historically served as refuge sanctuary for cattle in Zanzibar. The cattle of Pemba have, however, been exposed to the challenges of East Coast Fever (ECF) over many generations, and natural selection has probably favoured animals which are to some extent resistant to this disease. ECF is claimed to have wiped out a large number of cattle in the region from time to time. Both Unguja and Pemba are islands and are geographically isolated from the mainland of East Africa. For Pemba, the isolation has been strengthened by the fact that the channel separating it from the mainland is wider (56 km) and deeper than that of Unguja. This isolation has made the cattle population of Pemba one of the most closed in the region. Inbreeding has probably prevailed for generations and loss of genes is probable.

Besides inbreeding, the threat due to extensive introduction of exotic breeds by means of artificial insemination demands close attention. Currently, artificial insemination is commonly carried out in cattle in the deep soil zone where demand for milk is high. Artificial insemination permits very rapid replacement of existing populations (Cunningham, 1992). Therefore, if cross-breeding is allowed to continue unchecked, chances of loosing the indigenous cattle are very high. Another threat to the

Figure 3. Zanzibar Zebu. Various colour patterns.

Figure 4. A Zanzibar Zebu cow grazing using a tether.

cattle of Zanzibar is the growth of tourism and the hotel industry. It is possible that the demand for beef to supply the chain of hotels in these areas might tempt farmers to sell their cattle at numbers far beyond the reproductive rate of the population. Sales are even called for because the original grazing areas are now the important sites for hotel businesses. The eastern coast that includes most of the coral rag lands in Zanzibar were important cattle refuges for the country. The prices of beef in Zanzibar town on the Unguja island is very high compared to that of other parts in the country. This is currently causing a drain of cattle in large numbers from rural areas of Unguja and from Pemba into Zanzibar town for slaughter purposes.

Therefore, it can be concluded that the conservation of cattle in Zanzibar is of paramount importance. In this endeavour both *in situ* and *ex situ* methods should be adopted. However, before any steps for conservation are considered, it is important to document genetic differences between cattle of Zanzibar and those found elsewhere in Tanzania. This work should be preceded by characterization work involving base-line surveys and monitoring of population status in the two islands. Efficient and effective conservation work may mean in the first place the need to review the legal and policy aspects associated with animal genetic resources. In this regard the commitment of the government is of utmost importance.

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The use of DNA markers in deciding conservation priorities in sheep and other livestock

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Summary

The genetic diversity of most livestock species is reducing and it is not possible to preserve all livestock breeds. In order to preserve as much of the genetic diversity as possible we must first have a robust method of measuring the genetic differences between breeds. The analysis of microsatellite allele frequency is now the method of choice. Using sheep as an example, this paper describes the methods used for both microsatellite amplification and the analysis of the data once it has been collected.

Resumen

La diversidad genética de muchas especies ganaderas ha quedado muy reducida y no es posible preservar todas las razas. Para poder preservar el mayor número posible de razas, debemos, en primer lugar, poseer un método riguroso de medida de las diferencias genéticas existentes entre razas. El análisis de la frecuencia alélica de microsatélites es hoy en día un método importante. Tomando como ejemplo los ovinos, este artículo describe los métodos utilizados para la amplificacion de microsatélites y el análisis de datos una vez recogidos.

Key words*: Microsatellites, genome mapping, linkage, DNA, Genetic distance.*

Introduction

The aim of this article is to introduce the new methods that have become available recently to examine the genetic diversity within species. The new methods are based on the discovery in 1989 of microsatellites, a new type of DNA polymorphism (Weber and May 1989). Microsatellites, which are also known as STR's (simple tandem repeats) or SSR's (simple sequence repeats), are a new type of DNA marker that are not only informative but relatively easy to type and score. Microsatellites not only increase the ease of typing but also decrease the number of genotypes needed. This has made them the markers of choice in genetic linkage studies, including making maps and searching for genes affecting productive traits, auditing pedigree records, as well as what we will consider in this paper, estimating genetic diversity.

Genotyping Methods

At the heart of any microsatellite is a simple sequence, either a mono-, di-, tri- or tetra-nucleotide, that is repeated between 10 and 50 times. Virtually all of the microsatellites that have been found for sheep and other ruminants have the sequence (AC/GT) as the repeat unit. The reason for this is not that the other types do not exist but that this type is the most abundant within the ruminant genomes and hence it is much easier to find and characterize. The variation between

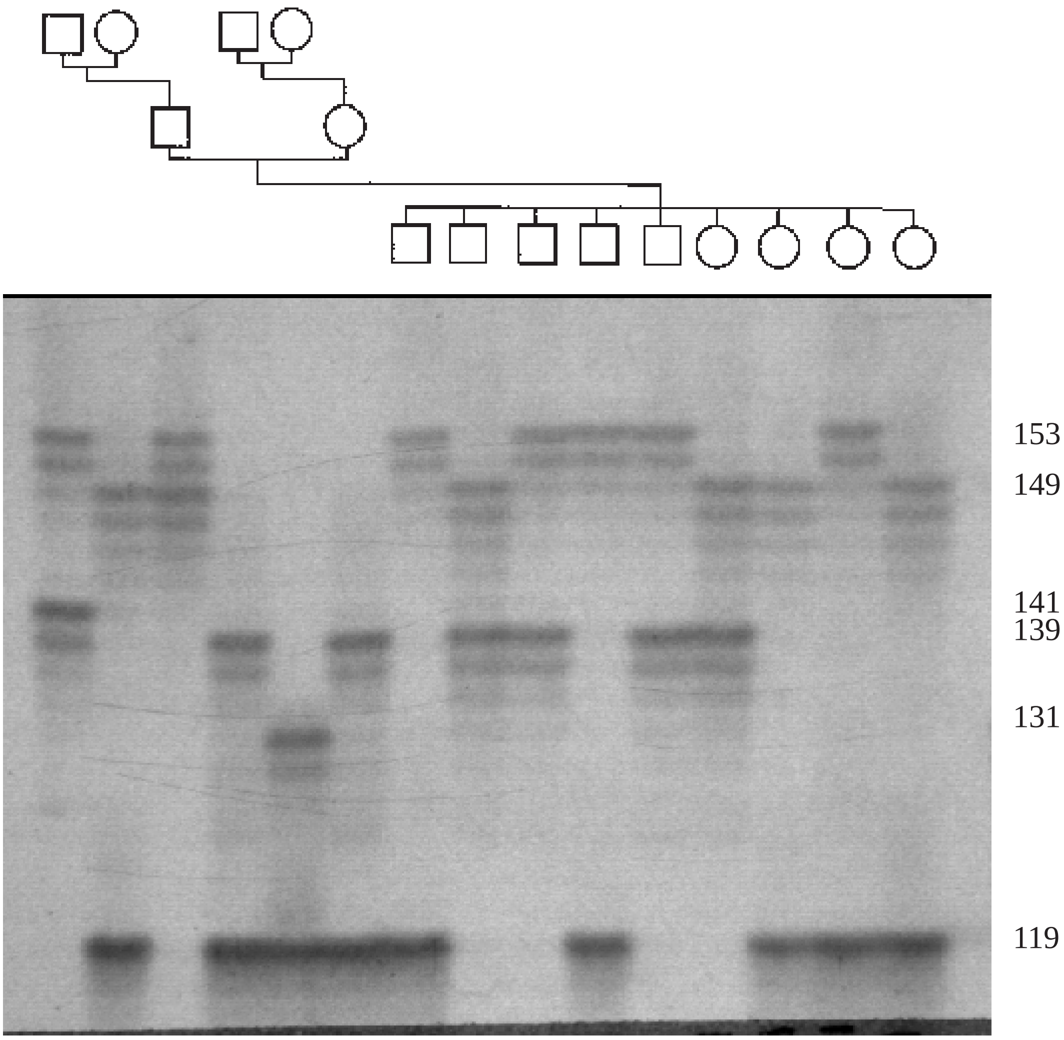

Figure 1. Analysis of a three generation pedigree of sheep with OarFCB226. A total of six different alleles can be identified in this family. The size of the different alleles which range from 119 to 155 basepairs is shown at the right side of the autoradiogram. The structure of the 3 generation pedigree is shown at the top of the figure.

alleles of the microsatellites is due to variation in the number of simple sequence repeats. The way microsatellites are typed is to design primers to the unique DNA sequences on either side of the repeat and, using PCR, amplify the region containing the repeat. The size of the PCR amplicon is then measured, usually by electrophoresis on a DNA sequencing gel, which resolves differences in DNA size.

A typical result from a microsatellite amplification is seen in figure 1. In this case the method of analysis uses radioactivity. One of the primers used to amplify the microsatellite has been labelled at its 5′ end with ^{33}P using T4 polynucleotide kinase. The products of the PCR reactions using the labelled primer are then run on a DNA sequencing gel which resolves length differences of only 1 base pair between PCR products. There are other ways of analysing the PCR products than by the use of radioactive markers. Increasingly one of the microsatellite markers is synthesized with a flourescent dye attached to the 5′ end and an

Table 1. List of microsatellite markers used by the AgResearch Molecular Biology Unit for examining genetic differences between sheep breeds.

Name	Primer sequences (5′→3′)	Accession no.	Reference
BM6506	GCACGTGGTAAAGAGATGGC	G18455	Bishop *et al.* 1993
	AGCAACTTGAGCATGGCAC		
BM757	TGGAAACAATGTAAACCTGGG	G18473	Bishop *et al.* 1993
	TTGAGCCACCAAGGAACC		
BM1824	GAGCAAGGTGTTTTTCCAATC	G18394	Bishop *et al.* 1993
	CATTCTCCAACTGCTTCCTTG		
BM4621	CAAATTGACTTATCCTTGGCTG	G18529	Bishop *et al.* 1993
	TGTAACATATGGGCTGCATC		
BM6444	CTCTGGGTACAACACTGAGTCC	G18444	Bishop *et al.* 1993
	TAGAGAGTTTCCCTGTCCATCC		
McM357	ATCTCTTTGCTCACCAATTAAGCA	L34279	Hulme *et al.* 1994
	CCTGAGAAAACATTGAGTGTGCG		
OarFCB20	AAATGTGTTTAAGATTCCATACAGTG	L20004	Buchanan *et al.*1993
	GGAAAACCCCCATATATACCTATAC		
OarFCB11	GGCCTGAACTCACAGTTGATATATCTATCAC	L01531	Buchanan and Crawford 1993
	GCAAGCAGGTTCTTTACCACTAGCACC		
OarFCB128	CAGCTGAGCAACTAAGACATACATGCG	L01532	Buchanan *et al.* 1993
	ATTAAAGCATCTTCTCTTTATTTCCTCGC		
MAF23	GTGGAGGAATCTTGACTTGTGATAG	M38719	Swarbrick *et al.* 1990
	GGCTATAGTCCATGGAGTCGCAG		
McM218	GATCCTAGCATCAGTCTCCAGATG	L39828	Hulme *et al.* 1995
	CACTAAAAGCTTATGAAAGTTCCAGC		
OarHH64	CGTTCCCTCACTATGGAAAGTTATATATGC	L12558	Henry *et al.* 1993
	CACTCTATTGTAAGAATTTGAATGAGAGC		
MCM214	AAGCGACTCAGGAGCAGCAG	L38982	Hulme *et al.* 1995
	AATGCTTGCATTTATCAAAAGCC		
ETH225	GATCACCTTGCCACTATTTCCT	Z14043	Steffen *et al.* 1993
	ACATGACAGCCAGCTGCTACT		
MAF209	TCATGCACTTAAGTATGTAGGATGCTG	M80358	Buchanan *et al.* 1992
	GATCACAAAAAGTTGGATACAACCGTGG		
OarFCB48	GAGTTAGTACAAGGATGACAAGAGGCAC	M82875	Buchanan *et al.* 1993
OarCP34	GCTGAACAATGTGATATGTTCAGG	U15699	Ede *et al.* 1995
	GGGACAATACTGTCTTAGATGCTGC		
OarCP49	CAGACACGGCTTAGCAACTAAACGC	U15702	Ede *et al.* 1995
	GTGGGGATGAATAATCCTTCATAAGG		
OarFCB304	CCCTAGGAGCTTTCAATAAAGAATCGG	L01535	Buchanan *et al.* 1993
	CGCTGCTGTCAACTGGGTCAGGG		
OarCP20	GATCCCCTGGAGGAGGAAACGG	U15695	Ede *et al.* 1995
	GGCATTTCATGGCTTTAGCAGG		

automated DNA sequencing system (eg ABI 377) used to analyse the fragments. There are also some methods available which use ethidium bromide staining to detect and analyse the PCR fragments in non-denaturing polyacrylamide gels. An excellent Web site which describes in great detail the various methods used to isolate and conduct microsatellite analysis can be found at: http://www.inapg.inra.fr/dsa/microsat/microsat.htm.

For most livestock species there are now many microsatellite markers to choose from, far more than is necessary to compare allele frequencies between breeds. We, therefore, have the luxury of choosing those markers that are highly variable and also are very reliable and robust to use. The markers that we have chosen to use for the analysis of different sheep breeds are listed in table 1.

The mutation rate of microsatellites is very high by comparison with mutations that occur in other regions of the genome. Estimates in sheep are that a mutation, which is either the deletion or insertion of repeat units, occurs at a rate of $1.3 \pm 0.5 \times 10^{-4}$ mutations per gamete per generation (Crawford and Cuthbertson 1996). This rate is approximately 10 fold higher than the mutation rate for DNA sequence in the D-loop region of the mitochondrial genome and between 100 and 1 000 fold higher than the mutation rate of intronic genomic DNA. It is this high mutation rate which makes microsatellites ideal for examining genetic variation within a species.

For most studies of breed diversity it is recommended to type at least 20 animals at as many loci as practically possible with a minimum of 20 loci (Nei and Takezaki 1996) Assuming we are examining 20 loci, a mutation rate of 1×10^{-4} mutations/gamete/locus means that a new allele is likely to arise at any one of the 20 loci with every 250 animals born. Given the random nature of these mutations it is not hard to imagine that it would not take long for two populations that have been kept apart to begin to show different allele frequency differences. It is these allele frequency differences which are used to determine how long ago the populations studied have been apart.

Another important consideration when dealing with very rare breeds is that small population sizes will reduce one's ability to accurately estimate genetic differences as such things as founder effects will distort allele frequencies. Various statistical methods are available for analysing gene frequency data when the effective population size is small eg. (Wilson, 1980) but these lie beyond the scope of this article.

Statistical Methods

One intention of statistical methodology is to understand characteristics of the natural variation of populations, and to estimate these from subsamples of the population. The extent to which two (or more) comparable populations differ can then be assessed relative to the amount of variation within the populations.

A microsatellite from a sheep of a given breed provides a pair of alleles which are independent of each other and can be described in terms of the number of basepairs of DNA. These define categories, and so the distribution of counts within a population is multinomial. This assumes that individuals are independent of each other, and so must be unrelated, as well as randomly assigned. A standard way to compare the allelic composition of several populations, then, is to use a chi-squared contingency table, which can be analysed using a Poisson generalized linear model with log link function (McCullagh and Nelder, 1986). Terms are fitted for r alleles and c populations, and a test is given by the residual deviance, which has a $\chi^2_{(r-1)(c-1)}$ distribution. Often categories for rare alleles are combined, or merged with the common allele of the next smallest basepair number.

A widely-used measure of the difference in genetic composition of two populations is given by Nei's (bias corrected) genetic distance (Nei, 1978), denoted by D. If t is the time since the two populations diverged from a common ancestor population and μ is the mutation rate per generation, then the expected value of D is approximately $2\mu t$. So if the mutation rate is known, the time at which populations diverged can be estimated, or vice versa. This assumes that the ancestor population was in Hardy-Weinberg equilibrium, which can be tested using a likelihood ratio test (Weir, 1990). Standard errors can be calculated by resampling. Often calculated parameters can be compared with historically known dates (Buchanan *et al.*, 1994).

There are a number of more recent measures of genetic differentiation which relate specifically to microsatellites [see, for example, Goldstein *et al.* (1995), Slatkin (1995)]. A comparison of the various measures, focusing on the their use in phylogenetic tree construction, (Takesaki and Nei 1997) found the D_A (Nei *et al.* 1983) and D_G (Cavalli-Sforza and Edwards 1967) are the most efficient in obtaining correct tree topology. The measures D_S (Shriver *et al.* 1995) and $(\delta m)^2$ (Goldstein *et al.* 1995a) were found to be the best at estimating the branch length of trees.

Further insights into population differences can be gained from resampling methods. For example, to determine the extent to which a set of alleles identifies the population of origin, the genotypes across all microsatellites of 1 000 individuals were simulated, assuming they belonged to a given population *a priori*, and each most likely population of origin *a posteriori* was calculated by Bayes' Theorem (Buchanan *et al.*, 1994). This approach has shown strong population identification based on 8 or more microsatellites.

Conclusion

Most of the endangered livestock breeds are found in regions far from the molecular genetics laboratories required for microsatellite analysis. This could be seen as a major problem for the widespread adoption of this technology. Fortunately only a small amount of animal tissue is required as a source of DNA to enable the analysis to be performed. DNA can be extracted from tissues which are easily collected, transported and stored, such as hair and wool follicles or small samples of ear tissue. In this way it should be possible to document the genetic diversity of rare breeds of livestock regardless of where they are found. Until we have information about the genetic relatedness of breeds no rational decisions can be made regarding which breeds should be preserved for future generations.

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The development and maintenance of animal recording systems in Greece: a case study

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Summary

Animal performance recording and breeding in Greece aim at improving milk production of pure-bred cattle under intensive systems and of sheep and goats under semi-intensive or extensive production systems. Although milk recording was established in Greece by the Ministry of Agriculture in 1952, it is only since 1978 that it has been carried out more systematically on larger populations and in the frame of a more specific genetic improvement programme for each animal species and breed. For the application of this programme, close co-operation has been set up among the competent services of the Ministry of Agriculture, the Agricultural Universities of the country and the relevant farmers' organisations which are in the process of being established. Milk is recorded on 61 867 dairy cows (29% of the total dairy population) in 1 425 herds (average herd size 43 cows), 31 611 dairy sheep (0.36% of the total sheep population) in 429 flocks (average flock size 72 ewes) and 3 296 goats (0.06% of the total goats population) in 36 flocks (average flock size 92). The procedures of performance recording and the future planning, aiming at increasing the number of animals and the recorded traits as well as the supporting of the farmers in managing their herds/flocks, are presented.

Résumé

En Grèce le contrôle laitier et l'élevage visent à l'amélioration de la production du lait de bovins de race pure sous des systèmes de production intensifs et des ovins et caprins sous des systèmes de production semi-intensifs ou extensifs. Quoique le contrôle laitier a été fondé en Grèce par le Ministère de l'Agriculture en 1952, seulement depuis 1978 celui-ci a été porté plus systématiquement sur des populations plus larges et dans le cadre d'un programme d'amélioration génétique pour chaque espèce et race animale plus spécifique. Pour l'application de ce programme, une co-opération étroite a été initié parmi les services compétents du Ministère de l'Agriculture, les Universités d'Agronomie du pays et les organisations des éleveurs pertinentes qui sont en cours d'être établies. Il existe 61 867 vaches laitières en contrôle (29% de la population laitière totale) dans 1 425 troupeaux (taille moyenne du troupeau 43,4 vaches), 31 611 brebis laitières (0,36% de la population ovine totale) dans 429 troupeaux (taille moyenne du troupeau 71,7 brebis) et 3 296 chèvres (taille moyenne du troupeau 92,5 chèvres). On présente le processus du contrôle de performance et les plans futurs ayant pour but d'augmenter le nombre des animaux et les caractéristiques

contrôlées, ainsi que d'offrir aux éleveurs le soutien nécessaire pour la gestion de leurs troupeaux.

Key words: *Recording schemes, Data processing, Computerisation*.

Brief Characterisation of the Animal Recording System

Species and breeds involved. Number of herds/flocks and animals recorded

The bovine population in Greece has changed rapidly during the last 35 years. The number of cattle has decreased from 1 131 000 animals in 1965 to 608 000 in 1993. In 1996 the number of dairy cows is estimated at 216 000 head, 94% of them being Holstein-Friesian. Only 29% of these dairy cows are recorded (Table 1; Georgoudis, 1988; Baltas, 1995).

The present total sheep population is 10 069 million animals in 153 000 flocks. About 80% of this population consists of crossbred sheep and are found in every part of the country. Most of these animals are the result of a long-term and uncontrolled crossbreeding. The major segment of the sheep population belongs to the Zackel type, which is found all over the country and is characterised by the long tail and the coarse wool. A second segment of breeds belong to the Ruda type, with finer and more uniform wool and is found mainly in Macedonia, Thrace and on some Aegean islands. A third category consists of the so-called semi-fat-tailed type, found on East Aegean islands. Although all of the above breeds can be broadly classified as dual-purpose sheep (milk and meat), the second and third categories include breeds combining high prolificacy and milk yield (Table 1; Boyazoglu, 1991a; Zervas *et al*., 1991).

The present goat population in Greece numbers 5 821 000 animals, of which 90% belong to various indigenous types. These local breeds represent about 4.5 million head in 200 000 flocks. The local goat is to be found over the entire country and derives its name from the particular region. Great interest is being attracted to the Skopelos goat (Table 1; Hatziminaoglou *et al*., 1985; Baltas, 1995).

Overall input level of the production environment

Dairy cattle are kept in environments which range from the upper medium to high level of inputs. Nevertheless, in Greece the general purposes, procedures and conditions for recording are the same for all species and breeds (Georgoudis, 1988; Baltas, 1995).

Sheep population is characterised by specific breed structure and husbandry methods. A large number of sheep-producing units are composed of a small number of animals per flock. In fact, 60% of all flocks include ≤50 ewes, which shows that they are of complementary importance to other agricultural production activities. The major animal production activity is milking, followed by meat from young lambs slaughtered after early weaning at 40 to 60 days. Complementary feeding during the last part of pregnancy and the suckling period (with the exception of some semi-intensive or housekept flocks on the plains) and the application of a transhumance are characteristic of most of the major extensive flocks (Boyazoglu, 1991a and b; Zervas *et al*. 1991; Baltas, 1995; Ligda *et al*., 1997).

Goat production has always been practised, to a large extent, within a particular socio-economic and spatial context. It generally concerns infertile, mostly degraded areas, which only the forest could have eventually made economically viable. Very extensive husbandry systems are applied to the local breeds, which play a major role in the rural economy of the difficult mountainous and semi-mountainous regions of the country. Extensive grazing conditions are, thus, put to value, which would not otherwise be of use (Hatziminaoglou *et al*., 1985).

Table 1. Dairy, sheep and goats' milk recording in Greece: Populations, number of recorded animals and herds/flocks.

Species and breeds	Total population	Recorded animals (percent recorded)	Total herds/flocks	Recorded herds (% recorded)
Dairy cow breeds *(data from 1996)*	216 000	61 867 (28.6%)	n.a.	1 425
Holstein Friesian	203 000	61 508 (30.3%)	n.a.	1 411
Brown Swiss	13 000	225 (1.7%)	n.a.	9
Simmental	n.a.	134	n.a.	n.a.
Sheep breeds* *(data from 1994)*	561 800	31 611 (5.6%)	8 645	429 (5.0%)
Mountains of Epirus (Boutsiko)	28 700	2 450 (8,5%)	300	24 (8.0%)
Sfakion	75 000	1 650 (2.2%)	1 050	20 (1.9%)
Karagouniko	208 000	14 800 (7.1%)	3 210	210 (6.5%)
Serres	38 000	2 200 (5.8%)	670	32 (4.8%)
Frisarta	27 800	5 011 (18.0%)	835	73 (8.7%)
Chios (purebred)	7 300	1 000 (13.7%)	350	10 (2.9%)
Lesvos	177 000	4 500 (2.5%)	2 230	60 (2.7%)
Goat breed**	8 000	3 296	n.a.	36
Skopelos *(data from 1994)*	8 000	3 296 (41.2%)	n.a.	n.a.

* only for the breeds mentioned in the table. For the total sheep population see table 2.
** local goat populations are not controlled.

Animal categories involved in the recording process

In each controlled herd/flock, all females (cows/ewes/goats) and subsequently all their female progenies (calves/lambs/kids) which are maintained as replacements, are involved in the recording process. Performance recording on the Agricultural Research Stations involves all the animals in the flock (sheep, goats only), which are considered as breeding nucleus for the genetic improvement of the relevant breed.

Figure 1. A flock of milk-recorded Skopelos goat breed (Animal Genetic Improvement Centre of Karditsa).

Purpose(s) of the scheme

In general, cattle, sheep and goat performance recording aims at genetic improvement through mass selection milk production and estimating the necessary genetic parameters for milk yield, needed for the operation of the genetic improvement scheme. Two types of recording schemes are recognised. On-farm and on-station performance recording.

On-farm performance recording for dairy cattle, sheep and goats was conceived to provide, firstly, data for the genetic improvement of the animals and secondly, to supply management and technical information for the farmers.

For cattle, no progeny testing or family selection has been applied until now. The lactation data collected by the recorders are processed by computers and the information on the 305-day and total lactation is sent to the farmers who use it for selection. The AI bulls, which are all imported and progeny tested in other countries (USA, France, Germany, etc.), are chosen by the farmers according to their breeding value calculated abroad. Models for the calculation of the breeding value of the recorded cows and their progenies, by BLUP-Animal Model methodology are routinely prepared, but not yet fully utilised in the everyday practice (Georgoudis, 1988; Georgoudis *et al*., 1992).

Performance recording in the Agricultural Research Stations aims at collecting data for studying the various native sheep and goat breeds of the country and is carried on without the involvement of the livestock keepers. These institutions are supervised by the National Foundation for Agricultural Research.

Regarding sheep and goats which are recorded on field, the farmers also receive the calculation of the total lactation for each animal, based on individual recordings. With these data the farmers can select only the best females, because there is no information on the males. There are two exceptions to this situation. Since 1986, an attempt has been made to implement a progeny testing scheme for the rams of the Karagouniko breed in Thessaly. Actually, this programme has not been applied continuously because of the lack of personnel (milk recorders) and the existence of serious problems regarding the organisation of the AI. The other exception is the performance recording of the Agricultural Research Station in Chalkidiki, where a programme has been recently started to utilise the Chios sheep of the Station as a nucleus for the breed, by applying an index selection and disseminating genetically superior male and female animals to commercial flocks (Gabrilidis, 1993; Baltas, 1995; Georgoudis *et al*., 1995; Ligda *et al*., 1997).

Animal identification

Identification is made by plastic eartags. This unique official number actually consists of two sets of digits, namely the herd number and the number of the animal made up of the year of birth and an in-herd running animal number. Identification for milk recording and A.I. applied for genetic improvement in cattle, are identical. Furthermore, the Greek Veterinary Service is using for all species a second plastic eartag aiming at the identification of the animals for health purposes.

Traits measured

The traits considered and the collected information are:

1. Individual identification of all animals.
2. Mating and lambing/kidding dates and consecutive number.
3. Type of birth, sex of the lambs or kids and litter size.
4. Monthly controls of milk yield (a.m. and p.m.) after the suckling period.
5. Fat, protein and lactose content of milk.
6. Live weight records of lambs at regular intervals (birth, before and after weaning).
7. Live weight records of ewes at mating and at lambing.

Actually, some of these traits (traits 5, 6 and 7) are not regularly recorded on the field (Georgoudis, 1988; Gabrilidis *et al*., 1993; Baltas, 1995; Ligda *et al*., 1997).

The method of milk recording is the official A1, once a month two milkings per day. The controller records for each ewe in his first visit after lambing/kidding, the identification number, the age in years, the data and the consecutive number of the lambing/kidding, the number and the sex of the lambs/kids born alive (after the first 24 hours). The visits are repeated once a month and the milk yield is measured in the first visit after the suckling period. Measurement takes place by a volumetric tube with markings of 1/100 lt. This is done until the end of the lactation period of each ewe/goat, that is when daily milk drops under 0.05 lt (~ 50 g). The collected data with a sample for measuring the milk contents is delivered immediately after the visit to the responsible body, the Animal Genetic Improvement Centre (Georgoudis, 1988; Baltas, 1995).

Other information collected

Information regarding feeding or health traits is not collected. Pedigree information derives, when properly registered, from the individual identification and lambing data. No efforts have been made until now to collect and analyse information related to herd/flock management.

Types of analysis of samples and processing of data

Analysis of samples and processing of data are not undertaken on the farms. Milk samples are analysed at the Animal Genetic Improvement Centres (Drama, Thessaloniki, Karditsa, Ioannina, Athens) with two MILKOSCAN apparatuses in each Centre (type 104 without printing and 133 with printing device), capable of measuring fat, protein, lactose and solids with and without fat, at the rate of 700 samples per hour. After milk content is determined, the results are matched with milk recording data and finally sent for processing to the central computer. The trend is moving towards storing and processing the collected data at local PC's (in one Animal Genetic Improvement Centre it has already been done) (Baltas, 1995).

Computerisation and storing of the data

The processing of the data is accomplished centrally. At the beginning of the implementation of animal recording a small-scale computing centre was established in co-operation between the Ministry of Agriculture and the Department of Animal Husbandry - Laboratory of Animal Genetics and Breeding of the Aristotle University of Thessaloniki, at the University Farm.

This computing centre provides facilities for processing milk and reproduction control data collected in northern and central Greece, where the major part of the dairy cattle population is kept. In the meantime, part of the processing work is accomplished by personal computers in the Animal Genetic Improvement Centre using home made software (Georgoudis and Alifakiotis, 1985; Georgoudis, 1988).

The method applied for the calculation of marketable milk production of the ewes and goats controlled is the Fleischmann, modified to accomplish a 42, instead of 24 day suckling period.

Processing for the cattle recording data takes place every month and the results are sent back to the farmers. At the present time, processing for sheep and goats is accomplished once, at the end of the production period and the advice to the farmers is based on the results of the total lactation of each ewe/goat and the average production, as well as the standard deviation of the flock in relation to the average and standard deviation of the whole region for which the Animal Genetic Improvement Centre is responsible (Georgoudis, 1988).

Government and farmers' involvement

The Greek Ministry of Agriculture is responsible for the proper implementation of the on-farm performance recording. A basic adverse factor for the promotion and improvement of the animal recording and the livestock structure in general, has been the absence of organised initiative on the part of the livestock breeders. As a consequence, there are no genealogical books belonging to farmers' organisations.

The difficulties of the implementation of the recording system are not counterbalanced by an individual and collective interest in the results provided. Furthermore, a degree of breeders' resistance to recording is noticed because of the tedious work involved in milk sampling and weighing. Also, the discussions for passing at least a part of the recording cost on to the farmers do not help its further development. To overcome these constraints, the current trend is to simplify the recording and to accelerate data turnaround (Baltas, 1995).

Who pays for the recording

The responsibility for the on-farm performance recording has been exclusively undertaken by the Ministry of Agriculture and the financial support comes from the Greek government. Performance recording on the Agricultural Research Stations is supervised by the National Foundation for Agricultural Research, which indirectly receives financial support from the Ministry of Agriculture.

Furthermore, during the previous periods (since 1993), the Ministry of Agriculture granted the farmers considerable premiums to join the recording and genetic improvement scheme (Baltas, 1995).

Type and nature of technical support

The recording and genetic improvement scheme is scientifically and technically supported by the Ministry of Agriculture and the Agricultural Universities.

The Directorate for Inputs to Animal Production which is responsible for the Animal Genetic Improvement in the Greek Ministry of Agriculture, operates five regional Animal Genetic Improvement Centres (Drama, Thessaloniki, Karditsa, Ioannina, Athens). These Centres monitor the milk recording and genetic improvement scheme, process and evaluate the collected data in collaboration with the Animal Production Department of the University of Thessaloniki, inform the producers on the relevant results and provide them with technical advice on selection, breeding and feeding. Further technical advice to farmers is also given by the Regional Agricultural Development offices of the Ministry of Agriculture (Georgoudis, 1988; Baltas, 1995).

Principal people involved in the development and maintenance of the scheme

The Ministry of Agriculture, Directorate for Inputs to Animal Production with five regional Animal Genetic Improvement Centres. The Agricultural Universities (Thessaloniki and Athens) have been involved in the development and continue to support the scheme with computer facilities, software for processing the collected data and scientific methodology for the genetic evaluation of the recorded populations (Georgoudis, 1988; Baltas, 1995;).

Figure 2. A flock of milk recorded Karagouniko sheep breed (Animal Genetic Improvement Centre of Karditsa).

Figure 3. Ewe of Chios breed with its lambs (Agricultural Research Station of Halkidiki).

Main Reason for Introducing and Maintaining the Scheme

The official animal performance and especially milk recording has been applied in Greece for about 50 years and it can be divided in four periods.

The first period, which could be characterised as an introductory one, covers the years between 1952 and 1962, when milk recording was planned by the regional services of the Ministry of Agriculture and intended to identify only the variability of milk yield of sheep raised in farms, without being an integral part in the framework of a genetic improvement programme of the known breeds. Generally, this period could be characterised as an introductory one, without a well-founded organisation and with a lot of omissions in milk recording and data processing. An exception to this was the recording applied in a considerable number of the Chios breed sheep on the homonymous island. Related activities have also taken place in livestock research Institutes, though these Institutes did not and still do not participate in the official recording and genetic improvement scheme.

The second period covers the years from 1963 to 1977 and is characterised by the issuing by the Ministry of Agriculture of the relevant decisions and regulations for the organisation and operation of the herd book and milk recording of the common cattle, sheep and goat dairy breeds. Milk recorders were employed by the regional services of the Ministry of Agriculture in order to carry out milk and fat content recording, body conformation measurements, collection of feed intake information and processing of the data. Generally, the performance recording scheme was well and systematically organised, but the number of recorded animals was limited and the collected data were not being evaluated and used properly, mainly due to the lack of scientific and technical personnel.

The third period covers the years from 1978 to 1992 and is characterised by the establishment in the Ministry of Agriculture of the Directorate of Animal Genetic Improvement (later renamed Directorate for Inputs to Animal Production) and of five regional Animal Genetic Improvement Centres (Drama, Thessaloniki, Karditsa, Ioannina, Athens), which monitored the milk recording and genetic improvement scheme, processed and evaluated the collected data. In 1978 and 1982 the regulation of animal milk recording of 1963 was amended, as well as the relevant decision concerning the organisation and operation of herd book (Giossis, 1988).

The genetic improvement scheme, which has been introduced since 1978 and also applied during the period that followed, was based on the use of imported frozen semen from progeny tested bulls. This semen is used by the AI to service only cows participating in the milk recording scheme. Bulls, born by the best of these recorded cows, are bought by the AI service in order to cover the frozen semen needs for the rest of the dairy cow population. In 1987 the Department of Animal Production of the Faculty of Agriculture of the Aristotle University of Thessaloniki started to evaluate the imported progeny-tested sires with a BLUP model. In 1992 the evaluations extended to cover also the recorded cow population with an Individual Animal Model based solely on milk yield and performed twice yearly (Georgoudis and Alifakiotis, 1985; Georgoudis, 1988; Georgoudis *et al*., 1992).

The fourth period, which is a continuation of the previous period, started in 1993 and has not yet concluded. In this period, the Ministry of Agriculture is also still in charge of the organisation and operation of milk recording and herd book keeping, but the intention is to totally involve the co-operative organisations, under the supervision of the Ministry (Baltas, 1995).

Most Significant Activities and Design Peculiarities That Have Enabled the Scheme

Initiation

The genetic improvement scheme, which has been introduced since 1978 and with minor modification being carried out until today, is characterised by the establishment in the Ministry of Agriculture of the Directorate of Animal Genetic Improvement and of five regional Animal Genetic Improvement Centres. These Centres monitor the milk recording, process and evaluate the collected data in collaboration with the Animal Production Department of the University of Thessaloniki and informed the producers on the relevant results. The Ministry of Agriculture is still in charge of the organisation and operation of milk recording and herd book keeping, but there is the intention to totally involve the co-operative organisations, under the supervision of the Ministry (Baltas, 1995; Georgoudis, 1988).

Maintenance

During the recent period milk recording was carried out more systematically, on a larger scale and in the framework of a more specific genetic improvement programme for each animal species and breed. A number of milk recorders has been employed, but they were not enough to cover the needs of the milk recording programme. Furthermore, a close co-operation has been established between the competent services of the Ministry of Agriculture and the Animal Production Department of the University of Thessaloniki. The use of computers has been started and as a result, the whole programme has improved, as far as the collection, evaluation and use of all the relevant data by the farmers and the responsible scientists are concerned. In addition to the milk yield, data on milk composition and those related to artificial insemination and parturition are being collected (Baltas, 1995).

Figure 4. A typical dairy cattle unit under milk recording (Animal Genetic Improvement Centre of Diavata).

Problems and Short Comings

The controllers' working conditions are very hard, especially when they are working with small ruminant producers, because the installations are very little improved or primitive. The identification of the animals has proved to be very difficult in flocks with a very large number of animals.

The Animal Recording and Genetic Improvement Centres are staffed with a small number of scientists and supporting personnel, resulting in a small proportion compared to the number of controlled animals. Taking into account that the production units are spread out over long distances, it is understandable that monitoring the controllers' work is difficult and the farmers are very often not consulted.

Accuracy of the collected data is crucial for animal recording schemes and great efforts have been made in order to secure this. For this to be accomplished, it is very important to hire controllers through an appropriate procedure. In Greece, the animal recording scheme does not dispose of vehicles, so the controllers are obliged to use their own cars, taking a reimbursement per kilometre covered. The applied recording scheme implies that the controller visits twice (in the evening and the morning of the next day) each farm, having as a consequence very high travel costs and dead hours between these visits.

The actual computer processing is mostly the easiest part today as computers are generally sufficiently powerful. Efficient organisation of input to the computer, building up sophisticated databases and designing useful output to the farmers are, however, difficult problems.

Very few sheep and goat keepers do realise the economic benefits resulting from the genetic improvement of their flocks. Nevertheless, they are applying to participate in the existing animal recording schemes, aiming at getting financial subsistence coming from national or EU resources.

Under these circumstances, a large part of livestock keepers have no interest in the monthly recording results nor do they welcome the controllers in their units. It is reported that some of them force the controller to fill out the official sheets arbitrarily or complete the milking before the controller's visit because, in this way, they avoid, in their opinion, the stressing of the animals as a result of the control process.

These reactions of livestock keepers result in the controllers' disappointment, which leads them to laziness and indifference. The personnel involved in animal recording have attempted to improve this situation with personal contracts, written instructions, seminars and even threatening them with exclusion from the scheme. The general opinion is that year-by-year all the above practices have yielded positive results, e.g. the better general education of the new-comers in the recording scheme and the increase of the production yield of the recorded populations (Baltas, 1995).

Future Directions and Changes to the Design and Operation of the Scheme

According to a recent resolution of the Ministry of Agriculture, the foundation of independent co-operatives or non-profit organisations has been proposed, in an attempt to spread out the animal performance recording and apply specific genetic improvement projects more systematically. Furthermore, attempts will be made for the farmers to financially contribute to the milk recording programme, while during the previous periods the Ministry of Agriculture granted them considerable premiums to join the recording and genetic improvement scheme.

The farmers' organisations will be responsible for the identification of the new-born calves/lambs/kids, the application of milk recording and analysis of the milk samples for fat and protein content, the

Figure 5. A herd of local Brachyceros cattle breed in the region of East Macedonia.

collection of reproduction data and the keeping of a database for production and pedigree. For these activities, the establishment of separate organisations for cattle, sheep and goats are underway. Especially, sheep and goat breeding will be carried out in collaboration with several research institutions, which may have a breeding nucleus. Progeny testing, estimation of genetic merit and evaluation of secondary traits, will be carried out by the regional Animal Genetic Improvement Centres, in collaboration with the Agricultural Universities of the country (Baltas, 1995).

Decentralising of the production records by region (input and output) would give more flexibility to the recording programme and would allow the farmers to have the relevant records sooner.

Other planned applications are the introduction of simplified recording methods appropriate for low to medium input production systems and the introduction of computers in managing the dairy herds and flocks. Furthermore, the development of communications with the use of modems between the computing centre and the on-farm personal computers of the co-operative members will allow them to interact directly with the databases.

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Caballo Chilote

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Summary

The present paper includes an historical briefing, a morphological description of blood polymorphism, and current use of the Chilote pony horse breed. Its characteristics differentiate it from other horse breeds present in Chile.

Historical records, phenotypic and genetic characteristics show that the ancestors of this breed were brought to Chiloé by the Spanish conquerors.

The actual population of the Chilote pony in Chiloé islands, as estimated by the present study, is not more than 300 horses. In order to maintain this genetic material it appears relevant to start with a conservation project for this horse in Chile.

Resumen

El presente trabajo muestra antecedentes históricos, descripción morfológica, polimorfismos bioquímicos y uso actual del caballo Chilote, raza tipo pony. Sus características definidas lo diferencian de otras razas existentes en Chile.

Antecedentes históricos, características fenotípicas y genotípicas indican que los ancestros de esta raza fueron Caballos de la Península Ibérica traídos a Chiloé por los conquistadores españoles.

Actualmente no quedan más de 300 ejemplares en la Isla de Chiloé, por lo tanto para conservar este recurso genético aparece relevante iniciar un proyecto de conservación de la raza en Chile.

***Key words**: Chiloé, Origin, Blood polimorphism, Physical characteristics, Conservation, Pony.*

Introducción

Ubicación geográfica

Los Caballos Chilotes forman un grupo de animales pequeños con una alzada alrededor de 120 centímetros, que se encuentran en la Isla Grande y Archipiélago de Chiloé, en el Sur de Chile (figura 1).

El clima en la Isla corresponde al templado, marítimo lluvioso. Las precipitaciones oscilan entre los 1 200 a 3 000 mm anuales. La temperatura media anual es de 10,7ºC, con máximas en los meses veraniegos de 30ºC y mínimas entre Otoño e Invierno de 5ºC, con heladas poco frecuentes en la costa, sin nieve.

Antecedentes históricos

Los primeros caballos que llegaron a Chile, fueron los que vinieron en la expedición de Diego de Almagro en 1535, pero su número fue reducido al mínimo por las inclemencias del tiempo y en la lucha con los indios. Los que sirvieron de base de crianza a la Colonia

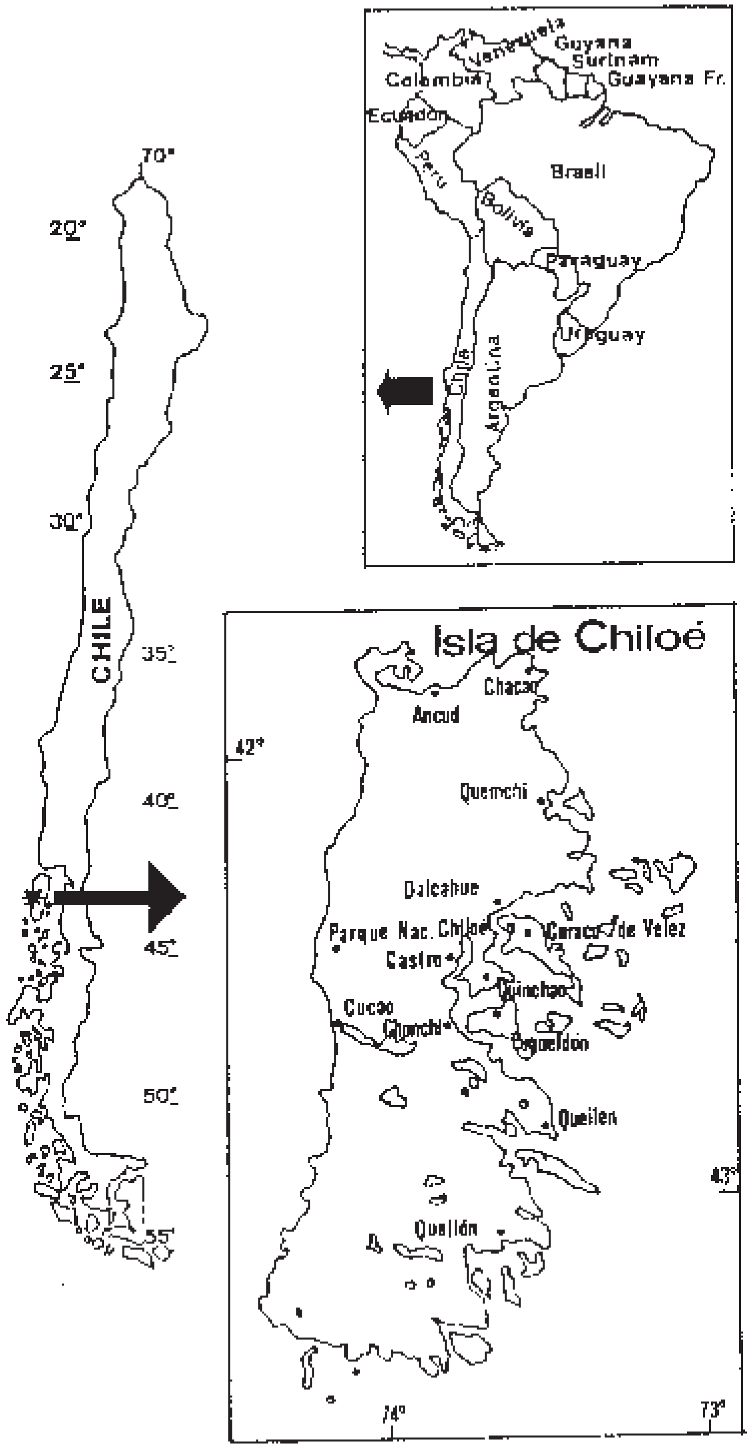

Figura 1. Ubicación de la Isla Grande de Chiloé en el Continente Sudamericano.

de Chile, fueron reclutados en Charcas (Perú) y traídos por el Conquistador don Pedro de Valdivia el año 1540 (Solanet, 1946).

Antecedentes históricos, características morfológicas y un análisis genético confirman que el Caballo Chilote tiene como ancestros caballos de la Península Ibérica. Las condiciones geográficas, climáticas y el aislamiento, formaron un tipo de caballo bien adaptado a su medio. El Caballo Chilote, en su forma actual, existe solamente en Chile y se considera como único Pony de origen Español, que se ha desarrollado en Sudamérica (Cothran y col., 1993).

Descripción Morfológica

Durante un estudio realizado en el año 1996, en la Isla de Chiloé se registraron un total de 83 Caballos Chilotes, lo cual se estima que correspondería al 30% de la población total (Voeltz, J.S. 1996).

La clasificación tipológica reveló que los Caballos Chilotes pertenecen al grupo Elipométrico según peso corporal, que su perfil generalmente es convexo o rectilíneo y que se trata de ponies con buena relación de las extremidades con respecto a la profundidad del cuerpo.

Existe una gran variedad de coloraciones del pelaje con clara tendencia hacia los colores obscuros. El Caballo Chilote es de aspecto elegante, tiene una cabeza con líneas finas, el cuello ligeramente arqueado, magro y musculoso. La cruz perfectamente definida se prolonga suavemente hasta confundirse con el dorso.

La linea superior es fuerte con lomo y dorso corto. De grupa caída con inserción de cola baja. Los miembros son finos, bien proporcionados y en general son de posición e implantación correctas. Los cascos de los Caballos Chilotes son chicos, extremadamente duros, firmes y bien formados, aun sin manejo de despalme.

Los movimientos son armónicos, el paso es relativamente largo, el trote regular, el galope es corto y rápido, acompañado con una pisada muy segura aun en terrenos adversos. Esta seguridad en el andar es una de las características más importantes del Caballo Chilote. Además destaca por ser un animal atento y observador con un excelente carácter y una docilidad única (figura 2).

Polimorfismos Bioquímicos Sanguíneos

Se analizó un total de 58 Caballos Chilotes, tipificándose 10 polimorfismos bioquímicos, los cuales son: Transferrina (Tf), Alfa 1 Glicoproteína (A1B), Esterasas (Es), Albúmina

Tabla 1. Variables hipométricas promedios de Caballos Chilotes, obtenidos durante un estudio realizado en la Universidad Austral de Chile, 1996. (Voeltz, J.S. 1996).

Variables hipométricas promedios en cm	Caballo Chilote		
	Machos	Hembras	Media
Alzada	121	118	120
Perímetro Torácico	138	136	137
Perímetro Metacarpiano	16	15	15
Longitud Escápulo - Isquial	129	126	127

Figura 2. Estos caballos por su docilidad, son usados por niños en Chiloé.

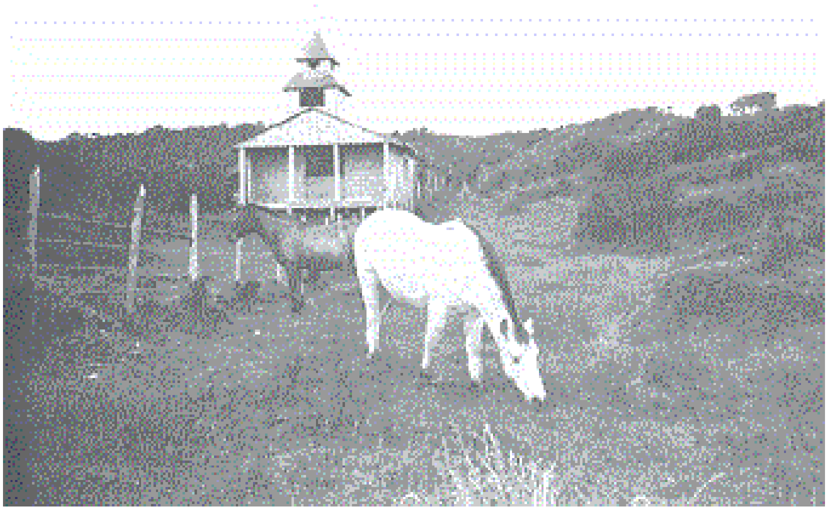

Figura 3. El Caballo Chilote, en un paisaje típico de la Isla de Chiloé.

(A1), Proteína transportadora de vitamina D (Gc), Fosfogluconato deshidrogenasa (PGD), Fosfoglucomutasa (PGM), Glucosa fosfato isomerasa (PGI), Hemoglobina (Hb) e Inhibidor de Proteasa (PI) (Cothran y col, 1993).

A partir de las frecuencias alélicas calculadas, se determinaron diversos parámetros génicos tales como Heterocigocis esperada, Valor de Densidad Genética, Variabilidad Genética y Coeficiente de Similitud Genética llegándose a la conclusión que indican clara y fehacientemente que los Caballos Chilotes tienen como ancestros comunes, razas de la Península Ibérica, no determinándose con presición qué raza o razas contribuyeron al desarrollo del Caballo Chilote actual.

Tabla 2. Frecuencias alélicas en los polimorfismos bioquímicos estudiados en Caballos Chilotes, 1993. (Cothran y col, 1993).

Locus	Alelo	Frecuencia Alélica
Tf	D	0.052
	E	0.017
	F2	0.181
	F3	0.086
	H1	0.060
	H2	0.293
	0	0.181
	R	0.129
A1B	K	0.640
	S	0.360
Es	F	0.017
	G	0.276
	Y	0.431
	L	0.138
	S	0.009
	R	0.129
A1	A	0.466
	B	0.534
Gc	F	1.000
PDG	D	0.088
	F	0.904
	S	0.009
PGM	F	0.069
	S	0.931
PGM	F	0.069
	S	0.931
GPI	Y	0.974
	S	0.026
Hb	B1	0.629
	B2	0.371
Pi	G	0.028
	L	0.495
	L2	0.055
	P	0.028
	R	0.009
	S	0.349
	T	0.009
	U	0.009
	S3	0.018

El caballo en la Isla de Chiloé

Como en todas partes del mundo, el caballo va perdiendo importancia como fuerza de trabajo por el desarrollo tecnológico. En Chiloé, por la situación económica de los pequeños agricultores y por las características del terreno, más la falta de buenos caminos, el caballo todavía juega un rol en la vida diaria. El caballo chico, bien adaptado al medio, con su casco extremadamente duro y su andar seguro, es el animal más adecuado para este ambiente (figura 3 y 4).

Actualmente en los pueblos aislados de la Isla, el caballo pasa a ser el medio de transporte más adecuado dado el tipo de caminos y las condiciones en que quedan éstos en la época invernal y dada la escasez de recursos tanto para el mantenimiento del buen estado de los caminos, como para la adquisición de un vehículo. El excelente carácter del Caballo chilote lo hace apto para niños, cualidad que es bien apreciada por los habitantes de la Isla de Chiloé, cuyos hijos lo utilizan como medio de transporte cotidiano.

En proporción menor se ocupa el Caballo Chilote en faenas agrícolas y para actividades recreativas, como Carreras a la Chilena. En el sector de Cucao constituyen una fuente adicional de ingresos con el arriendo a turistas, pero puesto que para arriendo el

Figura 4. Son caballos de poca alzada, con buenas proporciones corporales.

visitante prefiere animales de mayor alzada, la gente en Chiloé está vendiendo sus Caballos Chilotes y los está cambiando por caballos más altos.

Métodos de Conservación de la Raza

La Universidad Austral de Chile, a través del Instituto de Zootecnia y Centro de Inseminación Artificial en conjunto con la Secretaría Regional Ministerial de AgriculturaXª Región, INIA-Remehue y Carabineros de Chile, está elaborando un programa para la preservación del Caballo Chilote. Para ello se va a comenzar con un registro genealógico como base del reconocimiento oficial de la raza. Una vez aceptada, se dirigirá la crianza del Caballo Chilote en la Isla de Chiloé, para aumentar el número de animales y llegar a una población estable. Recientemente se creó un Centro de Montas en la Isla de Chiloé para facilitar la crianza de estos caballos. Además de incentivar la reproducción de los equinos en la Isla de Chiloé, se va a promover el Caballo Chilote para el deporte ecuestre infantil a nivel nacional, se iniciará un plan piloto de Hipoterapia en la Universidad Austral de Chile, a través del Instituto de Zootecnia. Con una buena estrategia de marketing, esto puede llegar a ser la base de la preservación de la raza, ya que este caballo con su excelente carácter se presta para estos fines.

Actualmente existen algunos rebaños de Caballos Chilotes, donde se está preocupando de una crianza selectiva de animales típicos.

Además de mantener material genético en forma de animales vivos seleccionados, se está estudiando la posibilidad de conservar embriones y semen congelado.

El origen del Caballo Chilote en la Península Ibérica le puede dar cierta importancia en Europa como reserva genética, ya que los Caballos Chilotes se mantuvieron relativamente aislados y no se mezclaron con caballos de otros orígenes.

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Review of global rabbit genetic resources: special emphasis on breeding programs and practices in the lesser developed countries

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Summary

Presently, there is little organization or co-operation among countries with rabbit breeding programs with the common aim of maintaining genetic diversity, with the exception of Europe and the Mediterranean region. Particularly in the lesser developed countries (LDC's), there is limited evidence that maintaining genetic diversity in rabbit populations is even a national priority. Based on consultancies and project experiences in over fifteen LDC's, and limited reports from the literature, evaluations of breeding programs at national rabbit breeding centers have generally been less than encouraging with regard to the management of genetic resources: utilization and conservation. The purpose of this position paper is to review rabbit genetic resources management practices and trends in rabbit breeding program development which pertain to genetic resources utilization and conservation issues, and with special emphasis on the LDC's. Several measures are discussed that could enhance breeding program integrity, greater benefit limited-resource farmers, and also foster international and regional participation in rabbit genetic resources conservation programs.

Resumen

Actualmente, salvo en Europa y en la región mediterránea, existe sólo una pequeña cooperación entre países en cuestión de programas sobre razas de conejos con el objetivo común de mantener la biodiversidad genética. En particular, en los países menos desarrollados (PMD) el mantenimiento de la diversidad genética de las poblaciones de conejos no forma parte de las prioridades nacionales. Basándonos en consulencias y proyectos realizados en más de quince PMD, así como en algunos informes presentes en la literatura, podemos decir que las evaluaciones de los programas de mejora de razas de conejos en los centros nacionales han sido, en general, poco alentadoras en lo referente a la gestión de los recursos genéticos: utilización y conservación. El objetivo de este artículo es revisar las prácticas de gestión de los recursos genéticos en conejos y las tendencias en los programas de desarrollo de mejora relacionados con la utilización de los recursos genéticos y posibilidades de conservación, todo ello con especial referencia a los PMD. Se discuten varias medidas que podrían aumentar la integridad de los programas de mejora, beneficiar ampliamente los recursos limitados de los agricultores y también favorecer la participación internacional y regional en los programas de conservación de recursos genéticos de conejos.

Key words: *Rabbits, Characterization, Utilization, Conservation, Genetic improvement*

Introduction

The first published report on the global need for rabbit genetic conservation programs and the organization of rabbit data banks was by Lukefahr (1988a). It is no coincidence that such program efforts, to date, have been most

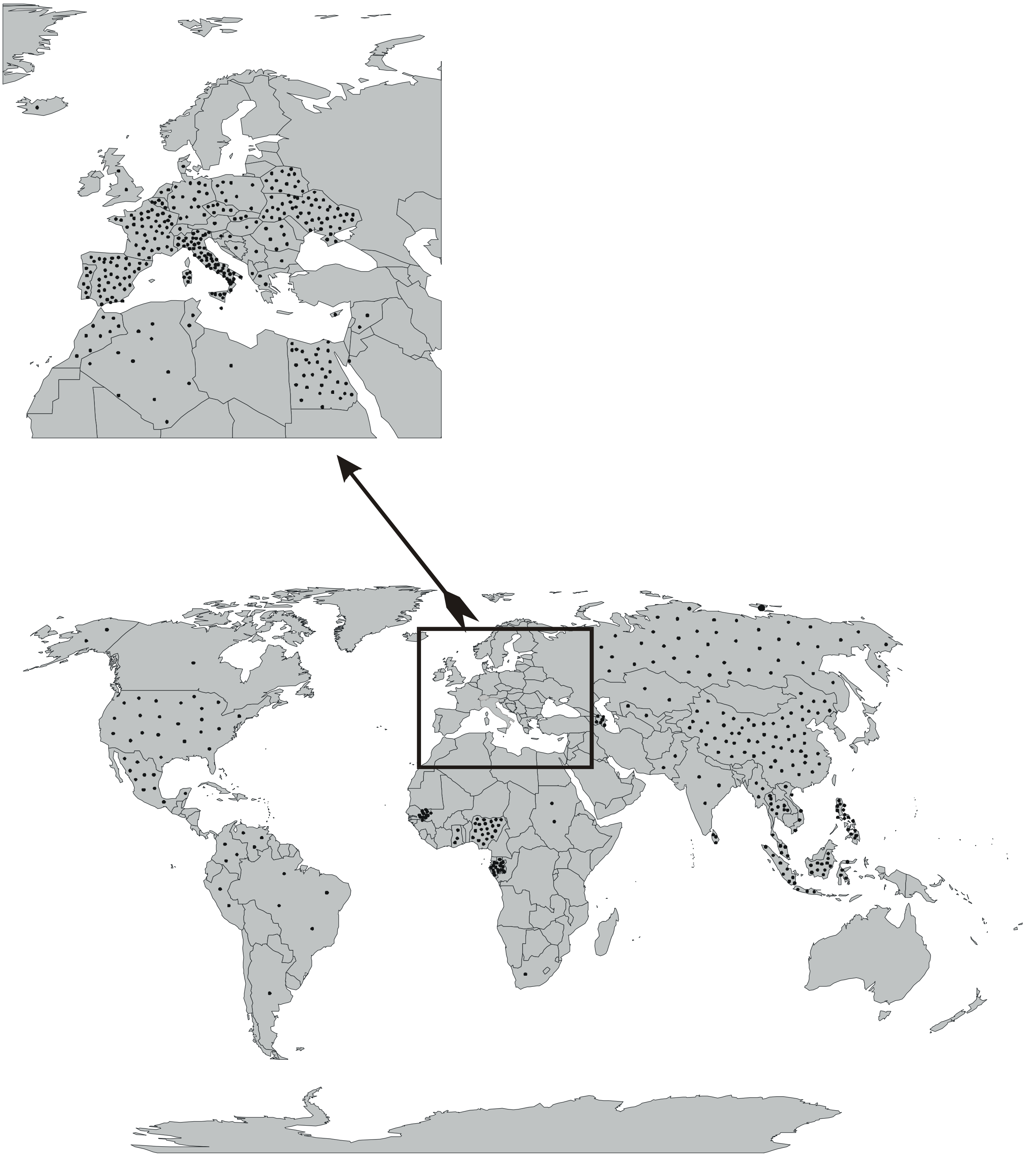

Figure 1. Female rabbit population in the World.
1 dot = 100 000 heads

active in Europe and in the Mediterranean region (Bolet *et al.,* 1996; Khalil, 1997) where the rabbit (*Oryctolagus cuniculus*) evolved and was first domesticated as a food source. According to Colin and Lebas (1995), 52% of the world's total number of breeding rabbit females (does) exist in Europe. Estimates of the world's rabbit population is 64 million does (Colin and Lebas, 1996) and 709 million total rabbits (Lukefahr, 1985). The global distribution of rabbits, based on country estimates by Colin and Lebas (1996), are presented in figure 1.

In the lesser developed countries (LDC's), the potential is greatest for inexpensively produced rabbit meat to offset national meat shortages (Owen, 1981). In recent years, small-scale rabbit projects have been gaining more international attention as a feasible measure for poverty alleviation and increasing of self-reliance in food production, two important elements in the World Food Summit Plan of Action (FAO, 1996). However, the world's distribution and level of productivity of rabbits is generally lowest in the LDC's (Lukefahr and Cheeke, 1991a) (figure 1). For instance, less than 5% of the world's supply of breeding does is estimated to be in Central and South America, only 14% in Africa, and 22% in Eastern Europe (Colin and Lebas, 1996). The same report figured that one-quarter of all breeding does exist in Asia; however, two-thirds of all rabbits in China (36% of rabbits in Asia) are reported to be of Angora breeds which are raised mainly for wool (Colin, 1995). It is evident from these figures that rabbit breeding projects in the LDC's should be expanded but also closely supported through international efforts that enhance active partnership roles such as in animal genetic resources management programs. Such international or regional efforts might be helpful in ensuring the maintenance of the genetic diversity in the rabbit for the development of sustainable production systems.

The purpose of this paper is to address several rabbit genetic resources management issues and constraints and to review trends in rabbit breeding program development with special emphasis on the LDC's. Recommendations will be made on realistic measures that might promote better management of rabbit genetic resources and that would also foster active regional and international partnerships in that respect.

Identification of Indigenous Breeds

Arnold (1994) reported that the rabbit was first domesticated in Europe as recent as the 18th century. Other reports indicate that domestication may have occurred as early as the 5th or 6th centuries (Sandford, 1992). One exception is the report by Chen (1984) which claims that the rabbit was first domesticated in China during the Han dynasty (206 BC to 200 AD). However, it is unclear if this involved a unique indigenous species or an introduction of European wild rabbits.

Indigenous breeds may only be found in Europe and the Mediterranean region in proximity to the rabbit's center of origin, which according to Callou *et al.* (1996) is Spain and the south of France. In this geographical context, indigenous breeds may possess the most developed adaptative qualities due to evolutionary forces. In Tunisia, local rabbits have small body size, small litters, large ears, etc.; the population has conformed to cope under adverse environmental conditions, although there is much variability within this population (Finzi *et al.,* 1988). In Egypt, Ibrahim (1988) noted that Baladi (Arabic for "local") and Giza local breeds had less dense fur than Bouscat Giant White and Flemish Giant breeds from European, and Shafie *et al.* (1970) observed that the Baladi White had lower pulse and respiratory rates and lower body temperature than the Baladi Black strain. Also, Gad *et al.* (1995) reported that NZW showed greater seasonal fluctuations in blood parameters and body weight gains than did Baladi rabbits. In Russia, the Soviet Chinchilla breed has been selected for dense fur (Miroshnichenko, 1984). Alternatively, in a socio-economic context, indigenous breeds may exist world-wide, for example, the

Criollio and Creole in Latin America and the Caribbean, the Japanese Large-eared rabbits in Asia, and "local strains" in Africa, India, Indonesia, etc.

Rabbits were probably first introduced to most LDC's less than 100 to 150 years ago. The most popular meat breeds: the Californian (CAL) and the New Zealand White (NZW), both of U.S. origin, were developed in the present century. The introduction of these two meat breeds, in particular, resulted in the displacement of indigenous or local breeds (Fauve de Bourgogne in France (Lebas *et al.,* 1997), the Carmagnola Grey in Italy (Pagano Toscano *et al.,* 1992), and the Spanish Giant in Spain (Martin-Burriel *et al.,* 1996) in many countries with a strong tradition of rabbit meat production. Later, this same trend occurred in Czechoslovakia, Hungary, Poland, and in other Eastern European countries. Such introductions continue to pose a threat to the existence of local breeds or strains.

One could divide indigenous breeds into standard and non-standard groups. Loosely defined here, a standard breed is continually selected according to a common breed description and/or performance criteria developed by a breeder's association. Generally, standard breeds are predominantly found in large commercial and/or fancy herds (*e.g.,* CAL, Dutch, Fauve de Bourgogne, NZW, and Rex), whereas non-standard breeds (*e.g.,* Baladi and Creole breeds) are more typically found in villages on small farms where they are reared under low-cost conditions (*e.g.,* fed fresh forages, seasonal breeding, and raised in hutches or underground). The rationale for this distinction is that selection criteria may well vary between these two groups. For example, a standard commercial breed may be selected largely for productivity (*e.g.,* large litters, rapid growth, and lean cutability). In contrast, a non-standard breed, may be selected largely for functionality (*e.g.,* steady reproduction [number of litters that a doe produces in a year], health history and/or rusticity). Such a major distinction should be accounted for in data bank descriptions. Of relevance, an observed trend in many countries is the displacement of indigenous breeds or local strains as a consequence of exotic or standard breed introduction. Local populations need to be characterized and inventoried so that conservation or even preservation programs can be considered before such valuable germ plasm is lost.

Aside from Europe and the Mediterranean region, considering the brevity since domestication, to what extent do breeds and/or "local strains" (generally undefined and indiscriminantly bred stock whose relatively recent but precise origin is unknown), as presently found throughout the world, represent unique genotypes for fitness and production characters? Has there been sufficient time for natural and artificial selection to produce real diversity between country populations (between and within breeds) so as to justify conservation programs in all countries or regions? Of relevance, Martin-Burriel *et al.* (1996) observed marked genetic distances between and within several French and Spanish rabbit breeds, but similar degrees of heterozygosity, based on electrophoretic variation for eighteen blood proteins (figure 2). In the next century, molecular genetic techniques (the reader is referred to the excellent papers by Zaragoza *et al.,* 1987 and Mulsant and Rochambeau, 1996) should be especially useful in solving some of these important issues to justify the extent of global rabbit conservation program activity.

Inclusion of Fancy Breeds

In the U.S., 45 rabbit breeds are recognized, but most are solely raised for show exhibition, and therefore might be questionable for inclusion in rabbit genetic resource programs. In the U.S., there is undoubtedly better organization among clubs engaged in fancy or show rabbit breeding than there is among groups of commercial rabbit breeders, perhaps due, in part, to marginal profitability in the meat rabbit industry. Hypothetically, under the prevailing socio-economic forces, it would probably be more challenging to conserve commercial breeds that provide food and fiber than it would be to conserve fancy

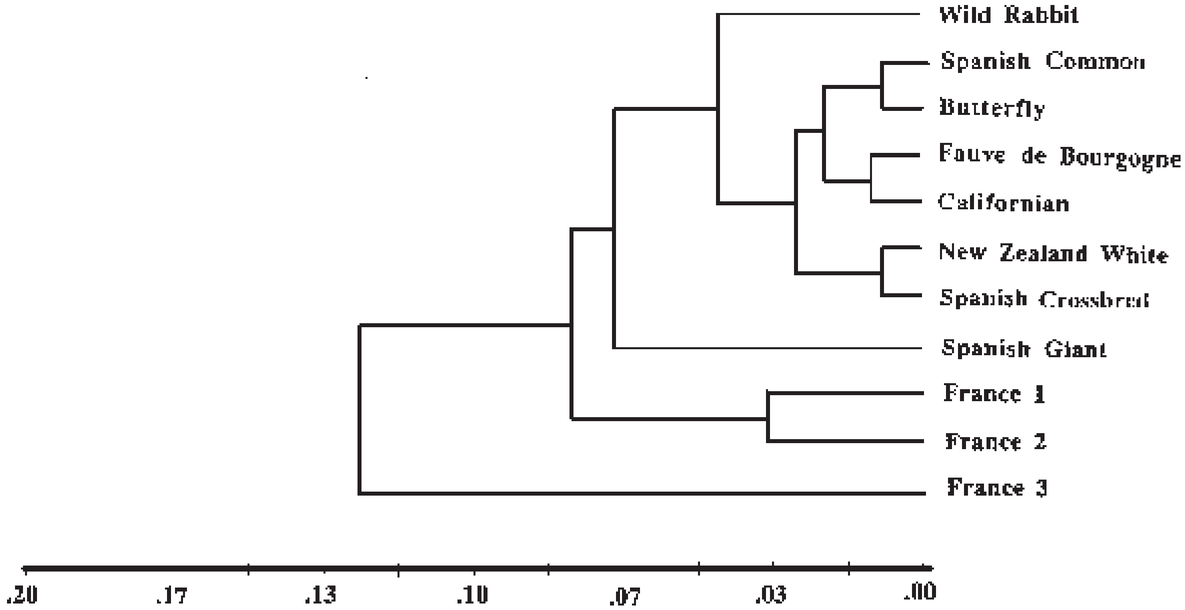

Figure 2. Genetic distance dendogram for rabbit populations [Adapted from Martin-Burriel et al. *(1996) and used with permission from F. Lebas, Editor, World Rabbit Science].*

Figure 3. Togo. Local rabbits displaying astounding phenotypic variability indicative of high heterozygosity levels in a small rabbitry near Lome.

breeds. The same dilemma may well exist in some other developed countries. Probably the only useful information available on U.S. fancy breeds is the annual number of rabbits by breed which are registered; however, such figures are probably well below the actual (albeit unknown) population size.

All breeds - commercial and fancy alike - should at least be included in initial characterization and documentation stages of data bank processing. Some fancy breeds should probably receive higher priority for possible conservation. For example, the Flemish Giant certainly possesses genes for rapid post-weaning gains, whereas the contribution of the Netherland Dwarf breed would be seemingly negligible.

The "Purebred" Stock Myth

There is generally good agreement that many rabbit breeds exported to other countries were later outcrossed to other breeds or strains. In developed countries, for example, a common practice among fancy rabbit breeders is to outcross to other breeds to incorporate more desirable genes for specific traits. This breeding practice raises the question; "Are all purebred breeds really purebred?" Obviously not. Moreover, the term "purebred" is a misnomer. The term, "straightbred", is more appropriate. Generally, straightbred animals breed true for only a limited number of simply inherited traits, such as for coat color and for major genes which affect fur type (*e.g.,* normal, rex, and angora) and body size (*e.g.,* dwarfism). If straightbreds breed true for all traits then there would be no genetic variation and hence no opportunity for genetic progress through selection. Therefore,

Figure 4. Tunisia. Impressive ear size of a local rabbit as a vital functional trait in thermo-regulation (Courtesy of A. Finzi).

attention should not be paid as to whether a breed is truly "purebred", but whether it is a distinct population that is utilized and worthy of conservation.

In the LDC's, where in many cases imported exotic breeds have been intercrossed with other breeds (including local strains), usage of the term "upgraded breeds" or "upgraded purebreds" is common. Should an upgraded NZW populations, for example, be inventoried as straightbred NZW? How should local strains, such as the Criollio or Kenyan White, be classified (*i.e.,* indigenous or non-native, straightbred or crossbred)? The critical decision is certainly not about which terms are most appropriate, rather it is about whether the distinct breed or strain is utilized, whereby it should be characterized, inventoried and conserved. Moreover, particularly in the LDC's, rabbit scientists should not adhere to the "purebred" myth under the popular notion, albeit false pretense, that purebreds are superior to local strains.

The Inbreeding Myth

In addition to claims of straightbred stock shortages in the LDC's, there also appears to be a common concern of deteriorative effects of inbreeding on production traits. In certain cases, especially where pedigree records have been maintained, the concern may be a genuine one because the integrity of a population could be at risk if inbreeding is not controlled. In other cases, the claim was unfounded and simply used to justify the request for a new shipment of exotic straightbreds. It has also been observed that such requests have many times involved small numbers of less than 30 breeding animals (usually because of high shipping costs or limited facilities) which would soon promote inbreeding. This pattern could yield a perpetual cycle of repeated requests for new stock. In the LDC's, a commonly observed practice among experienced farmers in rural villages is to exchange breeding bucks regularly to avoid close inbreeding.

Shortage of Straightbred Stocks

In the LDC's, a common problem claimed is the shortage of straightbred stocks. The real problem, however, is usually the lack of breeding infrastructure (*i.e.,* breed associations, breeding objectives, multiplication of improved stocks, and recording systems). However, upon close observation and inquiry at numerous national or regional breeding stations, it became evident that previously imported breeds were invariably later outcrossed to other exotic breeds or, if available, to the more plentiful local strain(s). Again, some station managers have referred to the outcross as an upgraded breed. Surprisingly, in a number of country visits, one practice is to take the offspring of outcrossed litters where there is segregation in simply-inherited genes for body coat color and group them accordingly, for example, into cage rows designated for CAL, NZW, Blue Vienna, and Chinchilla. Or, new breed names are assigned to the resultant outcross color variants (*e.g.,* "Country X" White).

Such practices would make the task seem insurmountable to ascertain real genetic diversity between breed populations among countries or regions. Molecular genetic analyses might possibly later reveal that such transitional genetic stocks are quite heterogeneous as opposed to genuine straightbred populations. If true, this could possibly be an advantageous situation because, especially in adverse environments, a high degree of heterozygosity or heterosis might be important for fitness-related characters (*e.g.,* fertility and survival) as a means of eventual local adaptation (Falconer and Mackay, 1996).

Role of Exotic Breeds

A major issue is the suitability of imported breeds ("exotics") typically from temperate regions for ultimate use by farmers in adverse tropical or arid regions. Personal observation suggests that exotics usually have fared quite

*Table 1. Exotic and crossbred mature stock inventory in 1975 at the National Rabbit Project in Ghana.**

			Born in Ghana			
	Surviving exotics		Exotic		Crossbred	
Exotic breed	bucks	does	bucks	does	bucks	does
Alaska	7	0	0	1	9	9
Blue Vienna	20	4	6	12	22	24
Californian	3	1	0	0	0	0
Champagne d'Argent	6	2	0	2	1	1
Chinchilla	3	1	0	0	0	0
Checkered Giant	2	1	0	0	0	0
Creme d'Argent	9	1	6	7	0	1
Flemish Giant	3	1	1	0	10	18
French Lop	2	1	0	0	2	1
Thuringer	15	4	1	11	3	3
Total	70	16	14	33	47	57

*A total of 120 animals were shipped between 1973 and 1974.
Source: Technoserve, 1975.

poorly under adverse environmental conditions at the farmer's level on small farms (Lukefahr and Cheeke, 1991b). However, in less adverse environments, such as in the Sichuan province of China, satisfactory performance of CAL and NZW rabbits in peasant villages has been reported (Pu *et al.*, 1990). More research is needed to compare breeds under local farmer conditions.

In the LDC's, there appears to be little incentive to develop new composite breeds that are better adapted under adverse environments. The author is familiar only with the reports from Brazil (Moura *et al.*, 1994) and China (Junlian and Fengyi, 1988; Zhen, 1992) on the development of new rabbit breeds which involved several generations of selection and some evidence that genetic progress was realized. It could be argued that in many LDC's there is less interest in rabbit breeding and that there is also a general shortage of animal geneticists.

Further, what evidence exists that artificial selection within present breeds or local strains has been applied and shown to be effective in contributing to greater genetic diversity among populations throughout the LDC's? An exception may pertain to Angora rabbit breeding where artificial insemination is practised in Chile (Kappel, 1985) and in China (Yan, 1988). Another notable exception is the history of rabbit breeding in Russia (Sandford, 1992). However, if diversity is detected, the precise cause (*e.g.*, effects of selection, outcrossing or inbreeding), as well as the original genetic profile of imported exotic breeds and/or local strains involved, may not be known.

Role of Locally Adapted and/or Heterogeneous Populations

The following example is characteristic of many such experiences involving poor adaptation of exotic breeds in adverse environments in the LDC's but satisfactory performance of crossbreds in villages.

Figure 5. Dominican Republic. Appropriate use of adapted and hardy Criollo rabbits in a village development project managed by women.

Between 1972 and 1984, the National Rabbit Project (NRP) in Ghana received fifteen exotic breeds from Switzerland and the U.S. (Lukefahr *et al.*, 1992). Under local conditions of climate, fresh forage feeding with limited supplementation, and basic management, the exotics were eventually lost due to poor adaptation and/or low reproduction success (N. Mamattah, personal communication). Producing exotic x local (F_1) crosses as opposed to exotic straightbreds was generally more successful (table 1). The F_1 crosses were thrifty, had rapid growth rate, and had good fertility. In particular, when F_1 stock was later distributed to farmers for meat production in villages, breeding performance was satisfactory. Although crossbreeding was the solution in this case example, it is generally recommended that only breeds of merit (open to definition) be chosen for use in such a crossbreeding program.

In addition, a study conducted at the NRP (involving 687 rabbits and following several generations of *inter se* matings) reported a high heritability of 0.42 for 90-day body weight, which suggested the heterogeneous nature of this composite population (Lukefahr *et al.*, 1992). In agreement, Moura *et al.* (1997) estimated heritability of 0.48 for average daily gains between 56 to 84 days of age in 1 446 rabbits from a four-breed composite population in Hawaii.

It is the opinion of the author that the maintenance of heterogeneous and/or locally adapted populations may have real merit in some situations, despite the popular notion that such stocks are genetically inferior. In particular, locally adapted populations as opposed to exotic or upgraded straightbreeds may be more amenable for inclusion in genetic resources data banks and for effective conservation than attempts to reintroduce, identify or conserve exotic straightbreds or to develop new breeds at breeding stations. Local rabbits are prolific, tractable, and popular among limited-resource farmers. Another common observation is that local rabbits appear to be anatomically and

Table 2. Characteristics of anatomical and physiological soundness of local rabbits in tropical and arid regions.

Anatomical soundness

- Small to moderate mature size/large body surface area (possibly minimizes nutrition stress when the diet quality is poor/stress to high ambient temperature and/or relative humidity).
- Large ears in proportion to body size (effective means of coping with heat stress).
- Sound leg and feet structure (essential when reared on rustic hutch floors).
- Fur qualities (less dense, thin texture or diameter, and short fur to alleviate heat stress).
- Meat qualities (light to moderate rather than excessive muscling is less likely to lead to nutritional stress in fryers and in breeding stock).
- Number of functional teats (no less than 6 to 8).
- Well developed testicles and scrotum.
- Light versus dark body coat color may be advantageous.
- Absence of genetic defects (splayed legs, malocclusion, *etc.*).

Physiological soundness

- Adaptability to climate - Basal metabolic function (*e.g.,* normal pulse and respiratory rates and body temperature). Normal fertility (gametogenesis) even in hot weather.
- Adaptability to sub-optimal diets (high forage intake/appetite and good digestion efficiency).
- Adaptability to hutch confinement (resistance to stress associated with boredom and/or inactivity).
- Docile temperament or behavior.
- Resistance to disease and parasites (under proper basic feeding and sanitary conditions, local rabbits are noted for their hardiness and good health).
- Litter size/Kit survival (survival is enhanced in small to moderate size litters).
- Body condition (vital to maintain while doe regularly produces litters [maximum of 4 litters/annum in adverse environments]).
- Moderate milk production (risks of mastitis is presumably reduced if stock is not selected for high milking ability).
- Slow to moderate growth rate (reduced risk of Enteritis/ Enterotoxemia is usually observed in fryers fed on high fiber/low energy diets on small farms).

physiologically sound in many regards as these qualities pertain to growth to mature body size, level of reproduction, and general adaptation (table 2). Qualities such as ear length, fur density, fertility during hot months, forage intake capacity, etc., may have real merit as potential selection critera as opposed to traditional selection measures of production (*e.g.,* litter size and growth rate). Research in this area is obviously needed.

Also, in such a population (local or heterogeneous) it would be possible to sample rabbits from villages for restocking in the catastrophic event that the nucleus stock at the breeding station was lost. Logistically, and where appropriate, this approach could enhance the security of long-term conservation efforts.

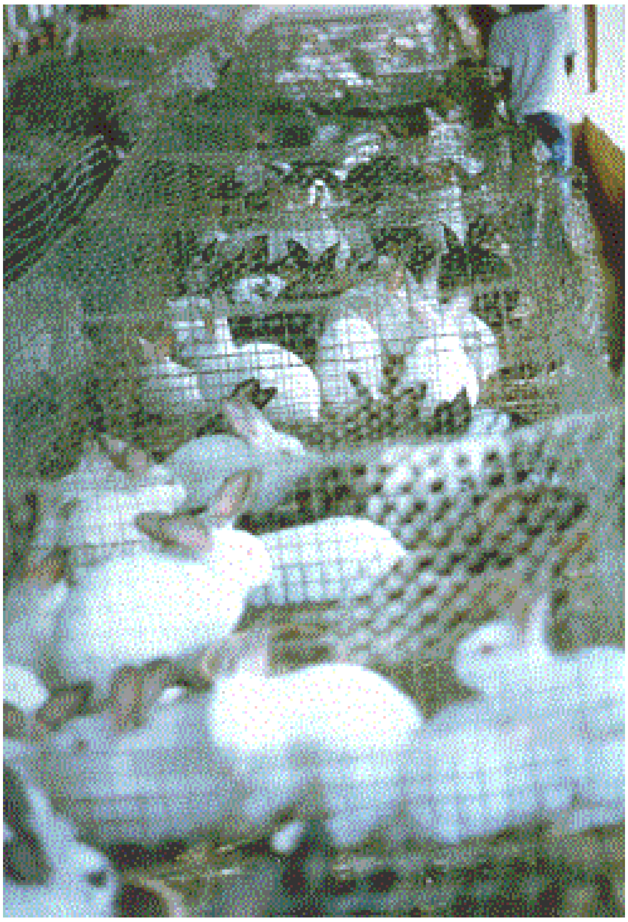

Figure 6. Dominican Republic. Predominate use of exotic breeds in a commercial rabbitry near Santo Domingo.

Facility and Resource Constraints

A major constraint in the LDC's is limited facilities, or lack of breeding infrastructure, to properly maintain closed and sufficiently large straightbred populations. In many countries there are, in fact, serious resource constraints at breeding stations which would preclude direct involvements in conservation programs. One approach would be to designate only one country in a region with the best facilities, resources, and genetic expertise to maintain valuable breeds or strains (*e.g.*, Creole, Criollio, Japanese Large-eared, Kenyan White, and Soviet Chinchilla) as found in other contiguous countries. To reiterate, the option may exist to utilize local strains through a network of farmer leaders in a major rabbit raising region of the country, whereby this activity could lead to conservation.

In lieu of breeding stations, one option is to carry out conservation programs through the efforts of rabbit farmer leaders who represent villages in a given region. Generally, the care, feeding, and management of rabbits by experienced breeders on small farms is usually better than conditions at major breeding stations where worker incentives, feed shortages, budget constraints, *etc.*, can often be a problem. Also, exchanges of breeding stock takes place more readily amongst farmers (between and within villages or communities) than between breeding stations and farmers. Of relevance, the involvement of women project leaders is especially encouraged as there have been many such successful rabbit projects (Lukefahr, 1988b; Finzi and Amici, 1991). However, while this field-based conservation approach has its advantages, good project organization and co-ordination would be essential, and such a program would require the official approval by participating governments.

Genetic Research Priorities for Limited-Resource Rabbit Farmers

It is most unfortunate that there is a paucity of research studies that have determined the most appropriate genetic stocks for usage by limited-resource farmers. Studies from the LDC's, invariably, took place at government breeding stations or at large commercial farms where conditions are considerably different from those found in villages at the level of small-scale farmers. Further, standard breeds are typically found at the former whereas non-standard breeds (local strains) and/or crossbreds are often found in villages.

Table 3. Comparative studies involving exotic and local breeds and crosses conducted in tropical and arid regions.

Country breed*	No. of rabbits	LSB	SR	AWW	ADG	MW	Reference
				Trait**			
Benin	161						Kpodekon *et al.* and Lebas *et al.* (1996)
NZW		-	-	.37	19.4	1.49	
L		-	-	.41	23.4	1.79	
Egypt	261						Rashwan et al. (1997)
Baladi Red (BR)		5.6	.43	.34	14.1	1.13	
Baladi Black (BB)		6.1	.49	.54	16.4	1.45	
NZW		4.4	.77	.51	14.5	1.31	
NZW X BR		4.9	.65	.34	18.9	1.39	
NZW X BB		6.1	.65	.43	19.2	1.50	
Guadelupe							Matheron and Dolet (1986)
Creole		6.6	.68	-	-	-	
NZW		7.4	.69	-	-	-	
India	168						Sundaram and Bhattacharyya (1991)
SC		7.0	.71	.42	19.3	2.00	
L		4.6	.87	.44	12.9	1.50	
SC X L		5.2	.94	.35	16.8	1.73	
Malaysia	435						Sangare and Ariff (1995)
CAL		6.7	.46	.46	-	-	
Rex		5.6	.42	.42	-	-	
L		5.2	.52	.40	-	-	
CAL X L		6.2	.59	.48	-	-	
Rex X L		6.3	.55	.41	-	-	
Sudan	***						El Amin (1978)
Baladi		4.7	.85	.31	-	1.31	
CAL		7.1	.75	.68	-	3.79	
NZW		7.5	.74	.60	-	3.31	

* Breeds: NZW = New Zealand White; L = local breed; SC = Soviet Chinchilla; CAL = Californian.

** Traits: LSB = litter size born; SR = survival rate; AWW = average weaning weight, kg; ADG = postweaning average daily gain, g/d; MW = market weight, kg. Across studies, the AWW was recorded between 28 and 31 days (age was not specified in the Sudanese study). The MW was recorded at 84 days, 87 days, 112 days, and at maturity in the studies from Egypt, Benin, India, and Sudan, respectively. The SR measure involved preweaning survival in the reports from Guadelupe, India and Sudan, and postweaning survival in the report from Egypt.

*** Number of rabbits involved in the study was not reported.

Figure 7. Indonesia. Opportunity for on-farm research to compare breeds. Exotic and local rabbits together in a small rabbitry. (Courtesy of P.R. Cheeke).

Few reports are available involving comparisons between exotic and local breeds and their crosses, none of which took place on small farms (table 3). In contrast, there are many more reports (too numerous to include in this report) which compared only exotic breeds at breeding stations in the LDC's for potential use in commercial operations. Only one report from Egypt is presented in the table, although there have been numerous such studies reported from this country. One novel experiment by Kpodekon *et al.* (1996) and Lebas *et al*. (1996) involved the comparison of NZW to a local strain in Benin, whereby the latter genotype had significantly heavier weaning and 87-day final weights and achieved more rapid pre- and post-weaning gains. Interestingly, the study involved a French shipment of NZW neonates which were fostered to litters reared by local does in Benin. The study was conducted at a breeding station under semi-commercial conditions.

To date, results from such breed evaluation studies are inconclusive, except that breeds which bear smaller litters tend to have higher survival rates. Although the NZW was developed in the hot environment of southern California, and while in some studies (Matheron and Dolet, 1986; Kpodekon *et al.,* 1996) this breed has appeared to perform relatively well, it was not selected for adaptation to subsistence conditions on small farms. Moreover, it is difficult, perhaps even inappropriate, to make broad (across country) comparisons between local and exotic breed populations because even country populations of the same breed could be unique and also environmental and/or local conditions could vary greatly. Studies which show local breeds to be less productive than exotic (commercial) breeds does not necessarily mean that there is room for genetic improvement. Local breeds have adapted to be less productive under adverse

Figure 8. Ghana. Local doe with Flemish Giant-sired litter at the National Rabbit Project, Kwabenya. Note growth potential and large ears of kits.

Figure 9. Ghana. Poor genetic adaptation of imported New Zeland White rabbit at a remote project village site.

environmental conditions as found on small farms. The rearing of a large and rapid growing litter on a poor quality diet could be devastating to a local doe and her litter! Adoption of the use of commercial breeds may not be appropriate for reasons of economy of scale (*i.e.,* inexpensive diet of poor quality, low nutrient requirements, rustic housing, and no hired skilled labor). While commercial breeds certainly possess genes for production, they may lack essential genes for trait functionality (table 2).

A research priority is to test the relative performance of rabbit breeds and strains, exotic and local, under small farm conditions. Traits pertaining to functionality as well as productivity should be closely monitored. Better feeding and management may be essential to support exotic breeds, which in some cases may not be justified.

Of relevance, the author has assisted private voluntary organizations in arranging overseas shipments whereby exotic breeds were directly placed on selected farms in several villages where local stock were also present. This approach was preferred over sending exotics to breeding stations where conditions in some cases were known to be deplorable, and where there was little exchange between researchers and farmers. Farmers kept production sheets to collect information on breeds and crosses, although the sample size has been usually too small to draw major conclusions about the suitability of breeds or crosses. The challenge is to design or carry out projects that involve adequate numbers of small-scale farmers who keep basic production records on breeds or strains of rabbits whereby valid comparisons could be made. Such a useful study which evaluated CAL, NZW, and crossbred stock was conducted on 110 farms in Poland as reported by Brzozowski *et al.* (1998).

Figure 10. Lithuania. Traditional colony-rearing, winter hay feeding, and maintenance (non-reproduction) of tractable, mature local rabbits protected inside a farm building (Courtesy of S. Janavicius).

Conclusions and Recommendations

This paper has addressed a number of issues that relate to the identity and management of global rabbit genetic resources. The salient points of this paper are as follows:

- Indigenous rabbit breeds with major adaptation merits may only be found in Europe and the Mediterranean region from a geographic as opposed to a socio-economic context.

- Data bank descriptions should reflect the distinction between productivity of standard breeds versus functionality of non-standard breeds or strains.
- Breeds or local strains that possess truly unique genotypes of merit for fitness and production characters should receive priority as candidates for conservation.
- A country's repertoire of commercial and fancy breeds should at least be characterized and inventoried in the documentation stage of data bank processing.
- Shortages of exotic breeds in LDC's, or lack of breeding infrastructure, have often led to inbreeding or outcrossing to other breeds or strains which may complicate the task of identifying genuine breeds or unique genotypes and of detecting the precise cause of genetic diversity.
- Shipments of exotics oftentimes involve small numbers of breeding animals which can promote inbreeding.
- Facility and resource constraints and lack of breeding infrastructure at breeding stations may preclude direct involvements in rabbit breed evaluation or conservation programs.
- One country in a region with the best facilities and resources could possibly maintain valuable breeds or strains as opposed to duplicative efforts in contiguous countries.
- In the LDC's there appears to have been little incentive to develop new and more adaptable breeds, and there is limited evidence that genetic selection efforts have been effective.
- A high degree of heterozygosity might possibly enhance local adaptation for fitness-related characters under adverse environmental conditions, such as in tropical and arid regions.
- Qualities such as ear length, fur density, fertility during hot months, etc. (functional traits), may have merit as potential selection critera, especially in regions with adverse environments.
- Heterogeneous (locally adapted) populations utilized by farmers may be more acceptable for inclusion in genetic resources data banks and for conservation than attempts to reintroduce, identify or conserve exotic straightbreds or to develop new breeds at breeding stations.
- The suitability of exotic breeds performing under adverse environmental conditions at the limited-resource farmer level is questionable based on project cases, although literature reports are not available.
- A research priority, and an obvious challenge, is to test the relative performance of rabbit breeds and strains on small farms under limited-resource conditions.
- In conclusion, rabbits have a unique niche to inexpensively produce food and fiber for rural families, especially in the LDC's. Hence, it is imperative that global rabbit genetic resources management programs continue to focus especially on breeds or local strains that are typically utilized under small-scale and limited-resource conditions. Utilization by farmers is just as or is more important than conservation. Oftentimes, utilization is the only practical means of conservation. In some cases, conservation programs might even be appropriately and effectively conducted in the field under small-farm conditions.

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Indigenous domestic turkeys of Oaxaca and Quintana Roo, Mexico

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Summary

The presence and role of indigenous turkeys in Oaxaca and Quintana Roo, Mexico, were investigated by means of on-site assessment and an orally administered questionnaire. Questions included breed characteristics, uses, management conditions, advantages and limitations of the breed. An indigenous breed of turkey in Oaxaca and Quintana Roo was described. A strong interest in the raising and commerce of turkeys in Oaxaca was noted, however in Quintana Roo substantial reductions in numbers of turkeys have occurred over the last two decades. Mortalities of turkey poults ranging from 50-100% due to a disease with symptoms compatible with *Histomonas meleagridis* infection were reported. This appears to be the most significant limiting factor to raising turkeys in a back-yard type of system in Oaxaca and Quintana Roo. Raising turkeys separately from chickens is probably the most effective strategy for decreasing indigenous turkey poult mortality of this type.

***Key words** : Genetic resources,* Histomonas meleagridis*, Historic origins, Characteristics,* Meleagris gallopavo

Résumé

La présence et le rôle du dindon de race indigène en Oaxaca et Quintana Roo au Mexique ont été étudiés à travers une évaluation sur place et un questionnaire oral. Ce dernier comprenait les thèmes suivants: caractéristiques de la race, utilisation, élevage, avantages et désavantages de la race. La présence d'une race indigène de dindon en Oaxaca et Quintana Roo fut confirmée et décrite. Un fort intérêt vers l'élevage commercial du dindon de race indigène fut noté en Oaxaca. Par contre, d'importantes pertes de dindons se sont produites en Quintana Roo au cours des deux dernières décénies. Le facteur le plus limitant pour l'élevage du dindon dans un système de cours a été le taux de mortalité parmi les dindonneaux de 50 à 100% du à une maladie qui présentait des signes compatibles avec une infection d' *Histomonas meleagridis.*La réduction effective du taux de mortalité parmi les dindonneaux de race indigène pourrait diminuer en séparant l'élevage des dindons de celui des poules.

Introduction

The domestic forms of the turkey in Central and South America are derived from the South Mexican Turkey (*Meleagris gallopavo gallopavo*) (Crawford, 1992). The wild turkey (*Meleagris gallopavo*) is represented by six subspecies, of which three are historically recorded from Mexico: the nominate subspecies, the South Mexican Turkey (*M.g. gallopavo*), the Rio Grande Turkey *(M.g. intermedia*), and the Gould's Turkey *(M.g. mexicana*). The former range ofthe South Mexican Turkey included the area between Puerto Vallarta (state of Jalisco) and Acapulco (state of Guerrero), on the Pacific coast, east to

Tuxpan (state of Veracruz) and Veracruz (state of Veracruz) on the Gulf of Mexico. Schorger (1964) stated that the range of the South Mexican Turkey was greatly reduced, and restricted to only the southern part of Michoacan. At the present time, three of the larger zoological gardens in Mexico - Mexico City (Parque Zoologico de Chapultepec), Guadalajara (Parque Zoologico de Guadalajara), and Tuxtla Gutierrez (Zoologico Miguel Alvarez del Toro) - had no wild turkey breeding groups, or any specimens on display (Mallia, personal observations, 1997). Domestication of the South Mexican Turkey probably occurred near Oaxaca, possibly as early as the Neolithic Age in Europe (FAO, 1995). There is a great sense of urgency to preserve the genetic variability of the indigenous strains of domestic turkeys in Mexico, and information should be collected and assessed, to prevent their extinction, as was the fate of the domesticated turkey of the Puebla Indians in southwestern U.S.A. (FAO, 1995).

Documented Observations by the Spanish on First Encountering the Domestic Turkey Present in Mexico

There are numerous early accounts of the first encounters of the Spanish with domestic turkeys in Mexico; this testifies to the turkey's well-established presence as a domestic bird and food source for the indigenous people at the time of the Spanish landing in Mexico. The Spaniards were presented with turkeys, together with other foods, on several occasions. Cordoba and his expedition arrived in Campeche in the state of Campeche, Yucatan peninsula, in 1517, and were presented with several dewlapped fowl of the size of a peafowl by the local inhabitants; there were numerous turkeys present in a nearby farm (de Las Casas, 1951, in Schorger, 1964). Members of the Grijalva expedition in 1518 were given turkeys by the Indians of Cozumel island, of the Yucatan Peninsula, and also by the inhabitants in the area corresponding to the present-day city of Veracruz in the state of Veracruz on the Gulf of Mexico (Diaz del Castillo, 1933, in Schorger, 1964). The Cortes expedition of 1519 observed that the domesticated turkey was widely present in most villages and towns in Mexico, throughout the Yucatan Peninsula, along the Gulf coast to Veracruz, and inland to the central highland where present-day Mexico City stands (de Tapia, 1866 in Schorger, 1964; Diaz del Castillo, 1933, in Schorger, 1964). Turkeys were the most readily available and economical meat-source in Mexico (Prescott, 1894, in Schorger, 1964), with numerous turkeys being sold in the local Indian markets (Lorenzana, 1770, in Schorger, 1964; Diaz del Castillo, 1933, in Schorger, 1964). Male turkeys were large, some with as much meat as two peafowls from Spain (Motolinia, 1914, in Schorger, 1964). The female is smaller than the male, and hen turkey meat was said to be particularly good to the palate (Sahagun, 1938, in Schorger, 1964). The domestic turkeys were flightless, and were present in several colour forms, including black, brown, red, and white (Sahagun, 1938, in Schorger, 1964).

Materials and Methods

Time and spatial aspects of the study

Oaxaca state was selected for this study because the domestication of the turkey may have first occurred in this region. The Zapotec people that inhabit the valleys around the city of Oaxaca have retained much of their culture, arts, and traditions, hence the higher probability of encountering domestic turkeys in this state. The Valle de Tlacolula runs east of the city of Oaxaca, and the towns and markets of Tlacolula, Santa Ana del Valle, Teotitlan del Valle, and Mitla were visited for this study. The Maya of the Yucatan Peninsula also preserve much of their culture and tradition, and in Quintana Roo this is particularly evident in the south and inland parts of the state; the area of choice was considered relatively uninfluenced by large-scale tourism in the northern part of the state, yet relatively easily accessible. The area included for the study were the towns, villages, hamlets and isolated ranches along Highway 307, clustered around Felipe Carrillo Puerto, Nohbec, Xul-ha, and on the Costera Bacalar, between Bacalar Pueblo and Cenote Azul. The information for the study was gathered in January 1996 and June 1997.

Questionnaire

Participants in this study included local inhabitants rearing, selling, or purchasing turkeys in Oaxaca and Quintana Roo in January 1996 and June 1997. They were located by visiting the towns on their market day, thus procuring vendors and purchasers on site. Turkey-growers and other purchasers were also identified in the towns and villages either by the presence of turkeys in enclosures adjacent to homes, or by word of mouth. A questionnaire in Spanish was orally administered to 18 turkey breeders in Oaxaca, and 16 in Quintana Roo. Information on population data, description of the breed, its uses, management conditions and performance were collected. A version of the questionnaire in English is reported in table 1. Photographs were taken showing facial characteristics (Figure 1), body conformation and plumage (Figure 2), and the systems under which the birds were raised (Figures 3 and 4).

Results

General information

The narrow-breasted turkeys kept in Oaxaca and Quintana Roo were classified as indigenous: the stock was purchased or bartered locally, usually at the village level, or at local markets where birds from nearby villages and towns marketed. These turkeys are known as *pavo*, which is the standard name for turkey in Spanish. Some people refer to the indigenous turkey as *pavo creollo* to distinguish it from imported, synthetic, broad-breasted strains of turkeys.

Population data

The population size was not estimated because the non-random nature of the sample did not lend itself to calculating a valid population estimate. The size of the individual turkey clusters ranged from one to eighteen. Most backyard clusters contained between five to twelve turkeys. The ratio of males to females was usually 1:3-5; most of the breeders confirmed that this was an ideal ratio of males to females within a harem. One or several harems were often kept together within the same enclosure. The distribution of the indigenous Mexican turkey by location and sex of bird is summarized in table 2. Anecdotal information suggests that the number of females kept in the Valle de Tlacoloula, Oaxaca, appears to be fairly stable; however, a decline has been reported by participants in southwestern Quintana Roo since the late 1970s'. The risk status of the indigenous turkey in Oaxaca may, however, still be described as endangered, as the number of birds available appears to be fairly low, despite the purported stability in numbers of breeding birds. In the area of southwestern Quintana Roo covered in this study, the risk status for indigenous turkeys can probably be described as endangered.

Description of the breed

All turkeys observed in both states were markedly tame and of a calm disposition; they could easily be approached, and were all flightless. The turkeys mixed easily with each other, and also with other species such as muscovies, Pekin ducks and domestic fowl. Various colour phases were present (Figures 1 and 4): black, red (buff), and white were present as pure colours, with all feathers on the same turkey being the same shade. Minor variations of tonality were observed for the buff specimens, where the tail feathers, and wing primaries and secondaries were markedly paler. Pure black, white, and buff specimens did not have a metallic sheen of the plumage. White and buff specimens were not observed in Quintana Roo. Birds

Table 1. Domestic turkey questionnaire for breeders of the indigenous Mexican turkey; Oaxaca and Quintana Roo.

Q1. How many birds, males, females, young, do you have, and where are the turkeys kept ?
Q2. How many females are ideally kept for each male ?
Q3. Do they forage, do you feed them, or both ?
Q4. From where do you obtain new stock ?
Q5. Do you keep chickens or ducks with the turkeys ?
Q6. If Q5.is in the affirmative: do you perceive any problems ?
Q7. At what age do the males and females mature ?
Q8. What weight do the males and females have at maturity ?
Q9. What colour are the eggs, does the hen incubate the eggs, how many does she lay annually?
Q10. What is the morbidity and mortality of the young, and if so, mainly at what age ?
Q11. How do you notice that the turkey is ill, and how many of the ill recover ?
Q12 What is the main purpose behind rearing turkeys ? Any other uses ?
Q13. Why do you breed chickens ?
Q14. Is there a good market for turkeys ?
Q15. If Q14 is in the affirmative: what stops you from raising more turkeys ?
Q16. Is there a particular feather colour preference for turkeys ?
Q17. Have you heard of the large, fleshy white turkeys raised in the U.S.A. ?
Q18. Have you ever cross-bred the non-indigenous heavy birds with the local ones ?
Q19. Do you ever use a veterinarian, or veterinary products for the turkeys when ill ?
Q20. Would you welcome further studies on the health and production of your own turkeys ?

described as brown most closely resembled the wild-type turkeys, and had numerous pale barring and mottling of the feathers, especially of the tail, primaries, secondaries and wing coverts; a metallic sheen of the plumage usually accompanies this colour phase. The black and brown colour phases were predominant in Oaxaca, and the only ones present in Quintana Roo. There were also black birds, but with a buff spot at the extremity of the feathers, giving the turkeys a slightly mottled appearance; this specimen type was particularly frequent in Quintana Roo. Black specimens with occasional, irregularly placed white or buff feathers were present in Oaxaca; unlike the pure black birds, a metallic sheen of the plumage was present. Another colour phase observed in Oaxaca had a white base colour, and with black or chocolate markings symmetrically distributed through the body; individual feathers had repeated barring and shadings across the length of the feather, but particularly towards the apex. In Quintana Roo, approximately 50% of the turkeys were black, and 50% were brown or mottled black. In Oaxaca, about 40% were black, 35-40% brown, and 20-25% were white, buff, or of mixed colours. Despite the wide range of colour phases, body size and confirmation was fairly homogeneous across both states (Figures 2-4).

A well-developed snood, dewlap and caruncles are strong markers for domesticity; all features were markedly evident in all turkeys, including brown phase specimens with wild-type plumage (Figure 1). The white and buff birds had only a limited amount of blue skin, present around and below the eyes; the rest of the head and neck, and overlying

Figure 1. Facial characteristics of indigenous domestic turkeys (Oaxaca).

caruncles were bright red. The black and brown phases had a more variable distribution of blue skin; Quintana Roo birds had relatively little blue skin, distributed as for the white or red phases. Oaxacan black, brown and mixed-colour phases often had extensive areas of vivid blue skin extending across the face and neck and nape, covered with vivid red caruncles. The snood, dewlap and caruncles were red for all turkeys, although well-delimited areas with a dark pigmentation were present on the snood of some of the black phase turkeys. Beaks, shanks and feet were pink-tan for white and buff birds, and predominantly dark grey or black in black and brown turkeys. The egg colour was reported to be pale buff for all colour phases.

Uses, management conditions and performance

The indigenous turkey was reported to be kept primarily for meat in Oaxaca and Quintana Roo. Many of the growers, especially in Oaxaca, also had a strong sense of pride in the tradition of raising the multi-hued bird, and kept several specimens in enclosed plots of land in front or adjacent to their homes (Figure 3). The convenience of the back-yard type of management system is an advantageous factor that was frequently commented upon by participants of this study. When reared in enclosed compounds having numerous trees and shrubs, the birds were encouraged to forage among leaf litter, with little or no feed supplementation (Figure 4). Turkeys kept in smaller, unpaved

Table 2. Distribution of the indigenous Mexican turkey by location and sex of bird.

Location	Number of clusters (by location) Count	Males	Females
Mitla	5	9	32
Santa Ana del Valle	4	8	20
Teotitlan del Valle	4	7	28
Oaxaca (Total)	18	41	114
Tlacolula	5	9 (17[1])	34
Costera Bacalar	5	9	36
Felipe Carillo Puerto	4	4	21
Nohbec	4	4	16
Xul-ha	3	3	9
Quintana Roo (Total)	16	20	82
Combined Areas (Total)	34	61	196

[1]Includes males for sale at the market

compounds and yards were supplemented with commercial poultry mash feed and food scraps (Figure 3).

For turkey buyers in both Oaxaca and Quintana Roo, the purchase of turkeys was either for breeding purposes, or for special occasion meal preparations; the meat of slower-growing, non broad-breasted turkeys, especially that of the hen turkey, is considered to be a gastronomical delicacy in these two states, due to its particular flavour and tenderness. Many of the locals who were not familiar with the synthetic, broad-breasted strains of turkeys were impressed by descriptions of the quantity of meat present in these hybrids. However, people who had tasted meat from broad-breasted turkeys were unanimous in stating that its organoleptic properties were markedly inferior to that of the indigenous birds, specifically in that it was too dry and lacked flavour. Birds are not used for breeding until they are at least a year old; the participants in this study suggested that at this age females weigh around 12-16 pounds, and males 15-20 pounds. However, mature males were said to reach 25-28 pounds. The long time necessary for maturation, coupled with high mortality rates, were said to be the reason for the high prices of adult indigenous turkeys.

Occasionally, turkeys were kept in small pens with domestic fowl, and fed exclusively on commercial poultry mash feed and food scraps; these turkeys were few in number, and often under-sized. On enquiry, it was determined that these specimens were usually the surviving runts of clutches of turkey poults. Indeed, turkeys raised with domestic fowl, especially in restricted areas, experienced high mortality rates; poults of 5-12 twelve weeks of age experienced mortalities of 50-100%. Older turkeys were also affected, but mortalities were considerably lower. Sick turkeys were quiet, depressed with lowered heads and ruffled feathers, and droppings were pale and loose. The unpredictable, and often poor survival rate of turkey poults is one of the major limiting factors reported by the local people for the success in rearing indigenous turkeys in the traditional manner. This has resulted in larger numbers of domestic fowl being reared instead of the turkey.

Discussion, Conclusions and Recommendations

The turkeys examined in this study appear to be a distinct population, the result of a long history of domestication in Mexico. The localities where turkeys were more numerous coincided with geographical areas inhabited by ethnic groups with strong cultural identities, as evidenced by the richness of their costumes, weaving, and handicrafts. This is particularly true for the Zapotec in the Valle de Tlacolula, east of the city of Oaxaca where the study in Oaxaca was conducted. Fewer turkeys were observed in the other state included in the study, southwestern Quintana Roo. It is possible that the influence of the highly-developed Cancun - Tulum corridor further north, with its newly - found wealth based on tourism, is having a modifying effect on the adjacent parts of the state. Most Mayans in this region do not wear

Figure 2. Body conformation and plumage of indigenous domestic turkeys (Oaxaca).

Figure 3. Turkeys raised under back-yard conditions (Oaxaca) with ducks and chickens.

the traditional costume, nor are local handicrafts particularly evident. It seems more likely that the indigenous turkey will persist in Oaxaca; the fine qualities of turkey meat, and specifically that of the indigenous turkey, are well noted, as is the convenience of the back-yard management system with which they are raised. Recognition of their value augers well for their survival.

More detailed studies on the morphometric characteristics and production data on a larger sample of turkeys are necessary. Future studies should probably focus on Oaxaca, where substantial populations with a wide genetic pool seem to still be present; a wider area within the state should be also covered.

A major concern for people raising indigenous turkeys with the back-yard type of system is the poor survival rate of turkey poults. The symptoms and mortality rates suggested by the participants would indicate that *Histomonas meleagridis* infection (blackhead) is responsible for the pronounced losses. Chickens habitually harbour the caecal worm *Heterakis gallinarum,* and the worm often carries *H. meleagridis*. Earth worms can also carry *H. gallinarum* and *H. meleagridis*, and probably represent an important strategy for the long-term survival of the caecal worm and protozoan in the soil (Levine, 1985). The epidemiology of blackhead indicates that turkeys should never be reared on the same site as chickens, yet the mixing of turkeys and fowl is standard practice in Oaxaca and Quintan Roo. Further studies are necessary to confirm the presence of *H. meleagridis* infection in indigenous turkeys. Education through extension work may help by promoting strategies that limit the spread of blackhead.

Ex-situ conservation may be achieved through the collection of representative specimens of indigenous turkeys for placement in zoological gardens and agriculture institutions; this may be the only realistic option for turkeys in Quintana Roo, where populations appear to have dropped drastically over the last two decades. *In-situ* conservation may be promoted by emphasizing the purported excellent organoleptic traits of meat from indigenous turkeys, and the convenience of their back-yard type system of management. This will probably meet with a substantial degree of success in Oaxaca, where the local inhabitants appear to be more predisposed to recognizing the value of the turkey, as its role is still firmly entwined with current local traditions. Implementing disease-control strategies will also go a long way in making the indigenous Mexican turkey an economically viable option for the production of economical, high quality animal protein in rural Mexico and elsewhere.

Acknowledgments

I would like to thank David Waltner-Toews and Dominique Charron for their helpful suggestions.

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Crawford, 1992. A global review of the genetic resources of poultry. In: Management of global animal genetic resources. FAO Animal Production and Health Paper, No. 104, Rome, Italy, 205-214.

Figure 4. Turkeys raised under back-yard conditions (Quintana Roo) with chickens.

FAO, 1995. World Watch List for Domestic Animal Diversity, 2nd Edn. Rome, pp. 769.

Levine, 1985. Veterinary Protozoology, 1st Edn. Iowa State University Press, Ames, Iowa, pp. 414.

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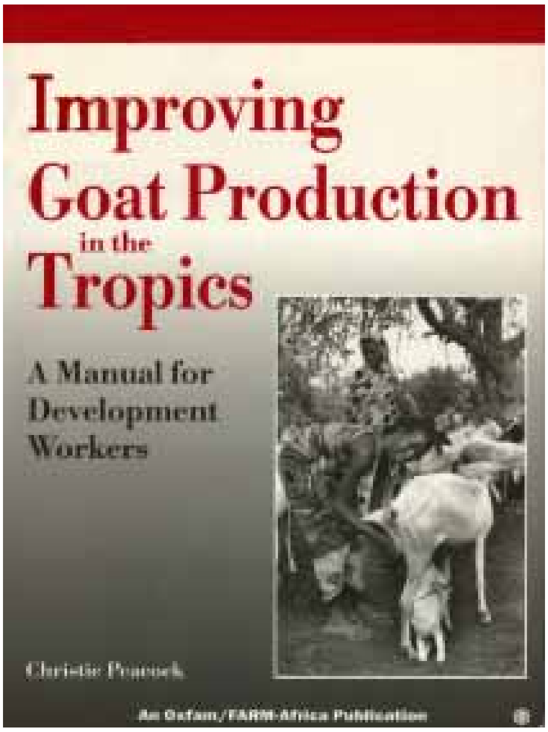
Improving goat production in the tropics
A manual for development workers

FARM-Africa and Oxfam (UK and Ireland)
274 Banbury Road, Oxford OX2 7DZ, UK, 1996
ISBN 0-85598-268

The book is written mainly for developmental workers and extension agents. The language of the book is easy with many illustrations , tables, flow charts and decision aids. The book deals with different goat production systems in the different tropics, e.g. pastoral, agro-pastoral, mixed farming in arid, semi-arid, sub-humid, humid and highland production environments. The step-by-step problem diagnostic procedures and situation objective analysis explained in the book are a very desired feature. Material is presented in 11 chapters: Introduction, Common Problems of Goats in the Tropics, Assessing Goat-production Problems, Basic Nutrition, Improved Nutrition, Goat Health, Breeds and Breeds improvement, Management of Large Goat Farms, Processing and Marketing Goat Products and Goat Improvement Programmes. It also have four pages of glossary and an alphabetical subject index. The book draws much on the experience of its author in Ethiopia through agricultural developmental aid organisations.



A rare breeds album of American livestock

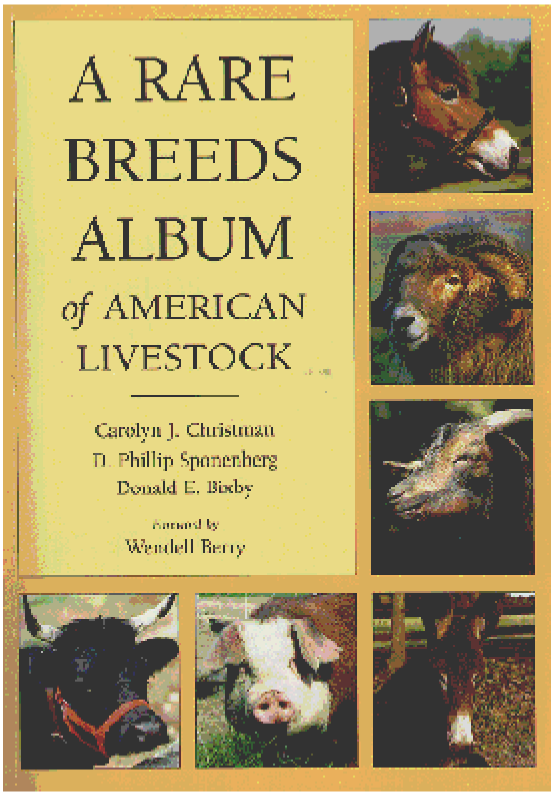
Eds: C.J. Christman, D.P. Sponenberg & D.E. Bixby, Published by the American Livestock Breeds Conservancy American Livestock Breeds Conservancy
PO Box 477, Pittsboro, NC 27312 USA
Tel. +1-919-5425704; Fax +1-919 5450022
ISBN 1-887316-02-7

This long-awaited book is the first full-color guide to 70 endangered breeds of cattle, horses, asses, sheep, goats, and pigs in America. It describes each breed's history, characteristics, uses, and status. The book was written to show what is at stake -- the farm animal breeds whose loss would deplete agricultural resources and impoverish the human experience.

Many breeds are so rare that they have disappeared from books and periodicals, and this is a major obstacle to their survival. A Rare Breeds Album addresses the problem by presenting the wide variety of livestock breeds in need of conservation, from the little-known San Clemente goat to the well-recognized Ayrshire cow. The book includes breeds which are native to America, such as the Navajo-Churro sheep and Hereford pig, and those which have been recently imported, such as the Poitou ass. Some rare breeds, such as the Rocky Mountain horse, are becoming popular, while others, such as the Canadienne cow, barely survive.

A Rare Breeds Album of American Livestock is a full-color guide to 70 rare breeds of asses, cattle goats, horses, pigs, and sheep. The book describes each breed's history, characteristics, and uses. It is a compelling portrait of the farm animals at risk. The book is soft cover with 126 pages, 85 color illustrations, a list of breed association addresses, and an index. A Rare Breeds Album will be a unique resource for animal breeders, educators, farmers, historians, veterinarians, and others who want to learn more about animal diversity or find the right livestock breed for a specific job. Its clear, non-technical style makes the book accessible to students, while the information provided will satisfy the curiosity of scientists.

Through A Rare Breeds Album of American Livestock the authors made a remarkable job in bringing a dear part of the American livestock development heritage to the front of biodiversity and environment issues that are quite relevant to present development efforts.



Introduction to quantitative genetics

Eds: Falconer & Mackay
Forth edition 1996, reprinted in 1997
Addison Wesley Longman Ltd., Edinburgh Gate, Harlow, Essex, CM20 2JE, England
ISBN 0582-24302-5

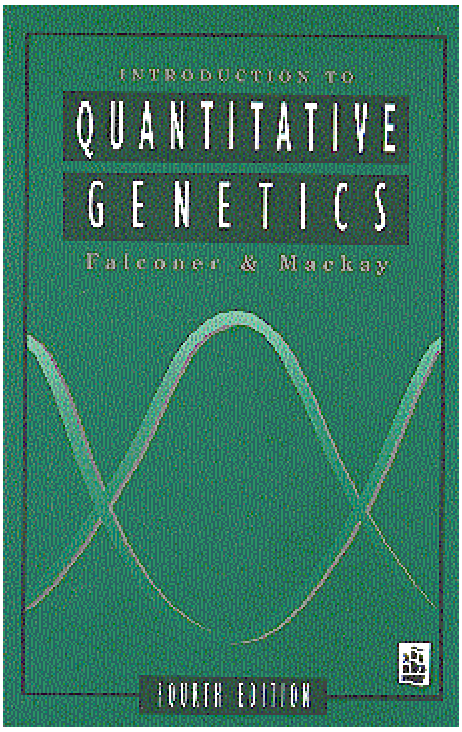
This book was written with the intention of providing an introductory textbook, with the emphasis on general principles rather than on practical applications. The mathematics does not go beyond simple algebra; neither calculus nor matrix methods are used. Some knowledge of statistics, however, is assumed, particularly of the analysis of variance and of correlation and regression.

The second edition kept the same structure but was somewhat enlarged by the inclusion of developments in the intervening twenty years , and by more attention being given to plants. In consequence the book came to contain a good deal more material than is needed by those for whom the subject is part of a course on general genetics. The section headings, however, should facilitate the selection of what is relevant.

The revisions made in this new edition are less extensive. The desire not to increase the length of the book has meant that many of the recent developments are noted by little more than references to the sources. The demonstration that mutation is not negligible for quantitative genetics has, however, necessitated more substantial revision of Chapter 12 and to a lesser extent Chapters 15 and 20.

The book includes problems at the end of each chapter and their answers at the end of the book

Quantitative genetics is now merging with molecular genetics and this very active area of the subject needs more consideration than it was given in the previous edition. Accordingly, a new chapter has been added, on quantitative trait loci (QTL's) - the location and characterisation of the genes causing quantitative variation. Chapter 20, on natural selection, has been largely rewritten, with fuller treatment of mutation and the maintenance of genetic variation; we hope these additions will make the book more useful to students of evolutionary quantitative genetics. In the earlier chapters, the treatment of polymorphism and of neutral mutation has been expanded, and some sections in the chapters on inbreeding have been shortened.



Genetics and analysis of quantitative traits

Eds: M. Lynch & B. Walsh
Sinauer Associates, Inc., 23 Plumtree Road, Sunderland, MA 01375 U.S.A.
Fax: +1-413-5491118; E-mail: publish@ sinauer.com
ISBN 0-87893-481-2

This book offers a fresh look at the genetic analysis of quantitative traits, incorporating all elements of mathematics and statistics needed for the understanding of its aspects. The book does a very good job in integrating aspects of quantitative genetics across species, plants and animals and across disciplines, breeding, evolution, etc.

This publication comes in 980 pages including 27 chapters, five appendices, extensive literature listing and comprehensive author, organism and trait indexes

This book has been prepared in a way that will encourage its use as a textbook in quantitative genetics. But the book also provides a coverage of the literature so that it should be useful as a basic reference. Throughout, the authors have attempted to develop central theoretical concepts from first principles. To aid the less statistically sophisticated reader, several chapters and appendices that review essentially all of the statistical tools employed in the book have been included. Wherever possible, theoretical and analytical concepts were illustrated with empirical examples from diverse settings.

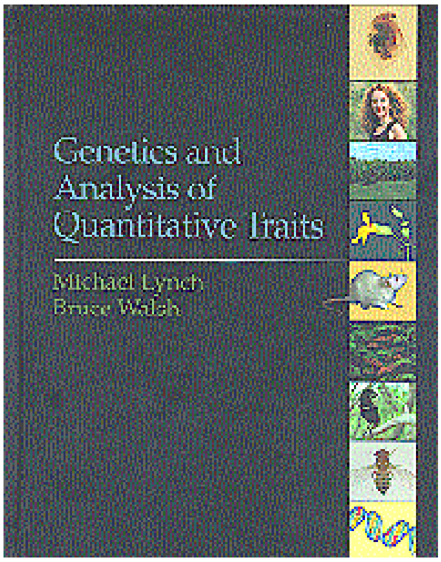
The book is divided into four parts, each containing different chapters.

The first part contains basic notions about quantitative genetics regarding distributions, covariance, regression, correlation, components of environmental variation, inbreeding depression etc.

The second parts analyses the quantitative traits loci principles, starting from polygenic mutations, detecting major genes, mapping and characterising QTL (inbred line crosses and outbred populations).

The third part deals with estimation procedures comprising, among the other, parent-offspring regression, sib analysis, cross-classified designs, genotype x environment interactions, estimation of breeding values, etc.

Finally, the appendices list the expectations of compound variables, path analysis, maximum likelihood estimation.



South African livestock breeding

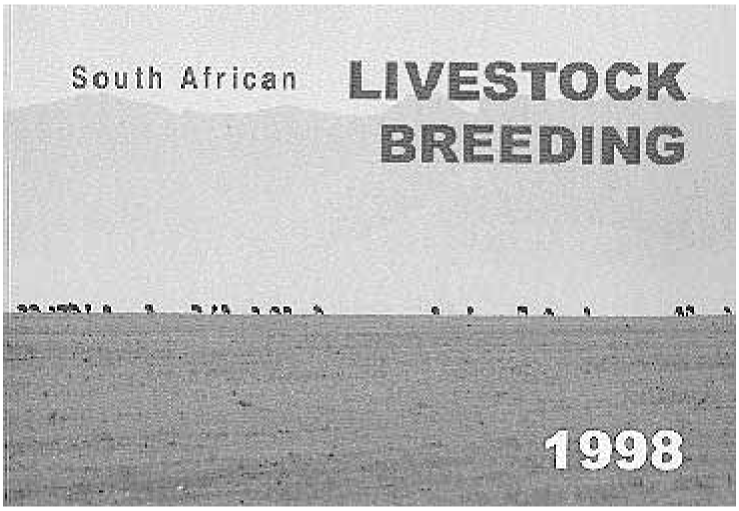
Eds: J.P. Camper, C. Hunlun & G.J. van Zyl
South African Stud Book and Livestock Improvement Association
P.O. Box 270, Bloemfontein 9300
Republic of South Africa, tel.: +27-51-4489347
ISBN 0-620-22048-1

The aim of the editors of this book was to be as impartial as were humanly possible. No attempt to encourage the use or marketing of one particular breed at the expense of another, or comparative figures was allowed.

The book starts with a short description of the South African Stud Book and the infrastructures made available by the SA Livestock Improvement Association, its services and functions. After that, statistics of members and animals are reported.

The testing schemes for cattle, pigs, small stock are then described together with the genetic evaluation criteria used for the evaluation of the animals.

A general description of the available biotechnology applications used in South Africa (diagnostic services, artificial insemination, embryo transfer) are then outlined.



After this initial part, the publication follows with the description of the beef, dairy, goat, horse, pigs and sheep breeds. All the information for each breed is schematically reported with clear coloured photos, distribution, performance, population and physical characteristics

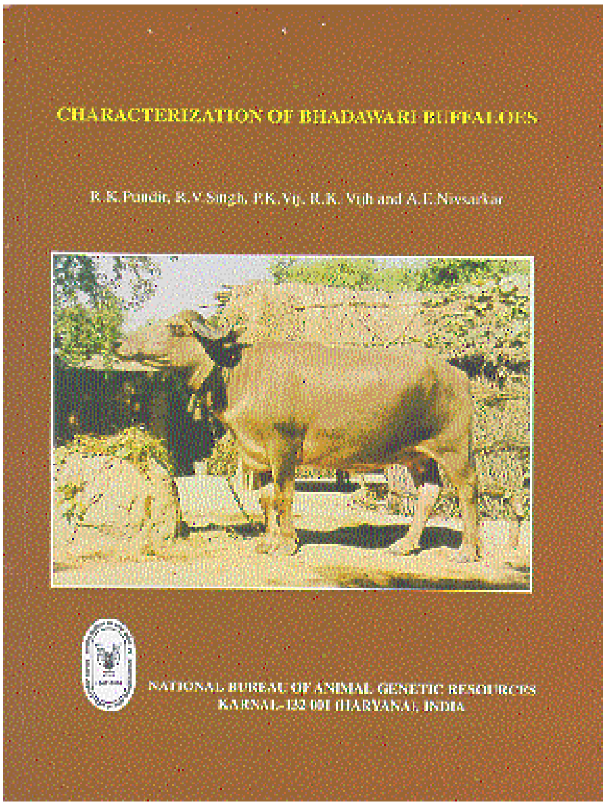
In this 1998 edition, apart from explaining the livestock improvement infrastructure in South Africa, the book gives information concerning the origin and improvement of the breeds and the founding of breeders' societies. It has also attempted to give more information on the achievements made during the more recent past. This biennial publication will be a source of valuable information for interested people for many years to come.

Characterisation of Bhadawari Buffaloes

Eds: P.K. Pundir, R.V. Singh, P.K. Vij, R.K. Vijh & A.E. Nivsarkar
National Bureau of Animal Genetic Resources
P.B. No. 129, Karnal 132 001, (Haryana), India
Research Bulletin No. 7, 1977

The Indian Bhadawari buffaloes are well reputed for their milk high fat percentage in India. The breeding tract and natural habitat of this breed is Bah tahsil of Agra, Chakarnagar and Barhpura blocks of Etawah, Amba and Porsa tahsil of Morena and Mahagaon tahsil of Bhind district. Surveys showed steep decline in the population of the breed (from 200 000 in 1977 to 29 000 in 1991) and the trend suggests that the breed may get extinct if suitable measures for conservation are not taken immediately.

Keeping in view the urgent need of conservation and improvement of this important germplasm, this publication attempted to identify, evaluate, compile all the available information and develop norms of this breed for its characterisation and potentialities. Past and present breeding plans, genetic improvement programmes were discussed and breeding and conservation strategies were proposed. The publication covers environment and natural habitat, population, physical characteristics, management practices in the breeding tract, performance, genetic parameters and cytogenetic architecture of the breed.



ICAR technical series No. 1

Ed.: K.R. Trivedi

Proc. of International Workshop on Animal recording for Smallholders in Developing Countries held in Anand, India, 20-23 October 1997, jointly organised by ICAR, FAO and NDDB

ICAR, Via A. Torlonia 15/A, 00161 Rome, Italy

Tel.: +-39-6-44238013; Fax: +39-6-44241466; E-mail zoorec@rmnet.it

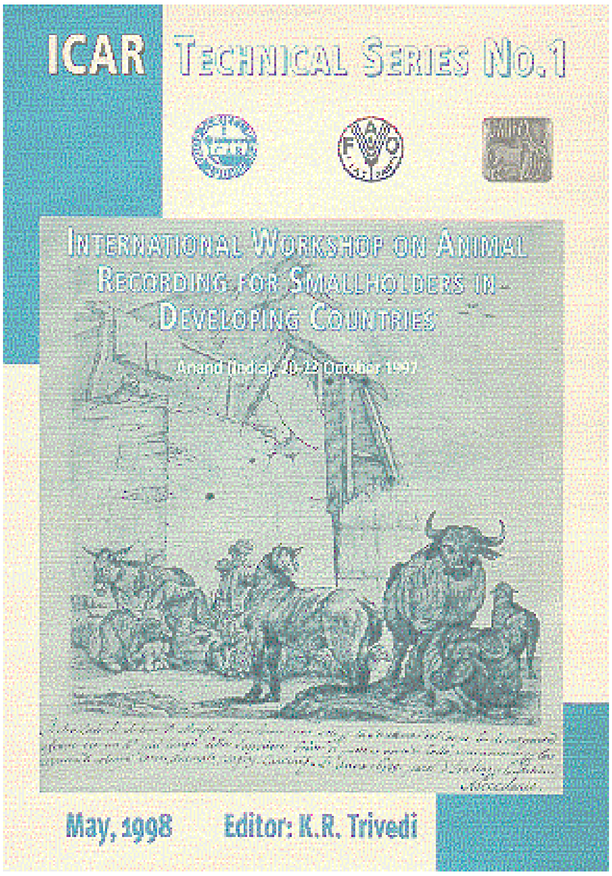
Animal recording in medium input-animal production systems, is a challenging task as it has to take into consideration a wide range of basic factors, such as what records to use to achieve what objectives, the socio-economic context.

ICAR (International Committee for Animal Recording) and FAO (Food and Agriculture Organisation of UN), along with India's National Dairy Development Board (NDDB), collaborated to organise this Workshop held at Anand, India. The Workshop, attended by experts from 25 countries and organisations, was an appropriate and timely platform for discussing issues related to animal recording with special reference to medium-input production systems.

These Proceedings include national experiences in the form of country reports, seminal papers dealing with basic aspects of recording and recommendations addressed to different international and national bodies.

Divided into five parts, the book starts with the "Recommendations and Summaries" developed during the Workshop, followed by twenty-two "Country Reports", three "General Papers", five "Seminal Papers" and terminates with two "Annexes".

The Proceedings of the workshop will be a most useful document for policy makers and people engaged in the implementation of animal recording programmes in developing countries.



Performance recording of animals - State of the art, 1998

Proc. of the 31st biennial session of ICAR, Rotorua, New Zeland
January 18-23 1998, organised by ICAR, LIC and EAAP
EAAP publication No. 91
Wageningen Pers, P.O. Box 42, 6700 AA Wageningen, The Netherlands
ISBN 90-74134-54-8 ISSN 0071-2477

This publication contains the proceedings of the 31st Biennial Session of the International Committee for Animal Recording (ICAR) held 18-23 January 1998, Rotorua, New Zealand. During the session progress reports were presented by the Sub-committees, Task Forces and Working Groups of ICAR.

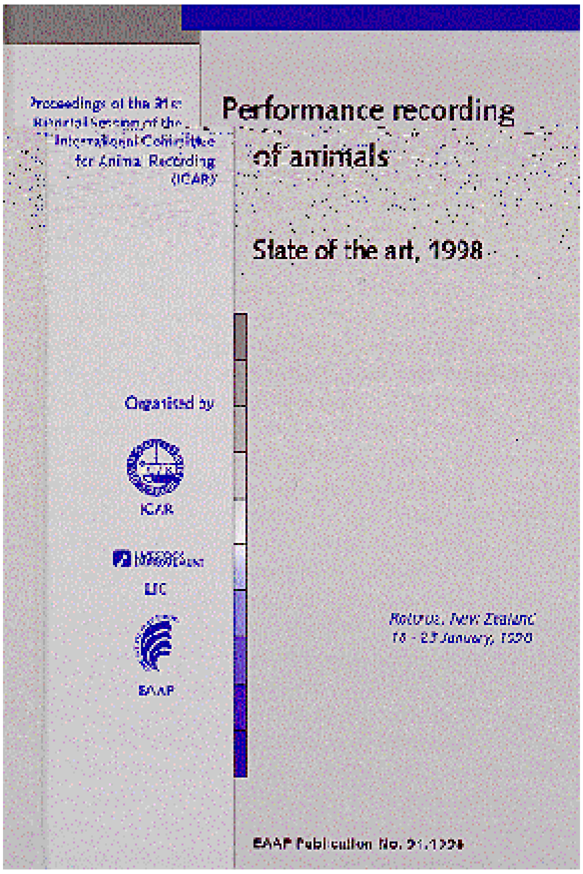
A feature of the 1998 ICAR session was the reports of the Accuracy Working Group and the INTERBULL Audit Working Group.

These two groups have been addressing the very important issues of the accuracy of the animal records and animal evaluations respectively. Both groups' reports, which have yet to be fully considered by ICAR and INTERBULL, are contained in these proceedings.

Four sessions were held containing a range of contributed short papers. Grouped loosely under the headings of Computing, Milk Traits, Cattle Breeding and General, these papers provide a detailed insight into developments which are affecting the direction of animal recording in member countries.

The reports of Task Forces, Sub-committees and Working Groups offer good review of the important work being undertaken by ICAR.

Interspersed with these reports are a number of submitted short papers on topics of particular relevance to the group.
In all, over 50 technical papers and reports were presented during the sessions.



The domestic rabbit

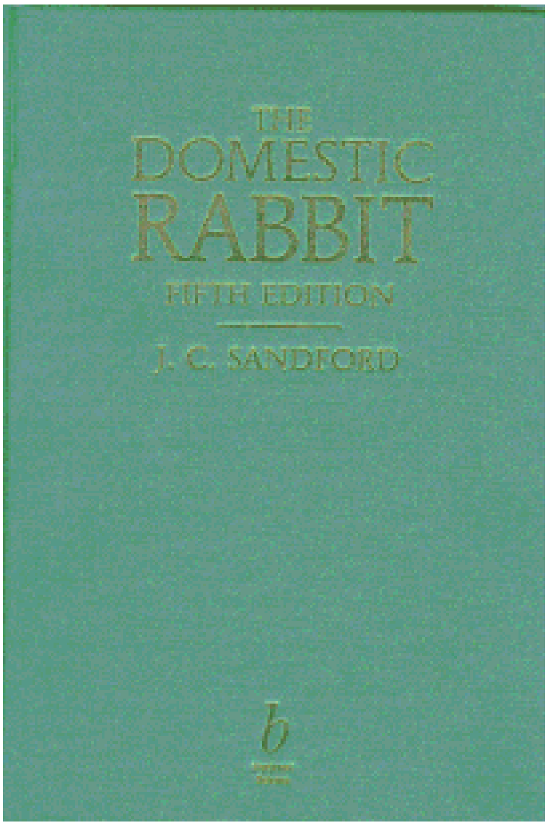
Ed.: J. C. Sandford
Blackwell Science Ltd. Osney Mead OX2 0EL, England
Fifth edition
ISBN 0-632-03894-2

Since the first edition of this book was published almost forty years ago there have been many changes in rabbit husbandry worldwide. In order to reflect the so many changes, this fifth edition of the book includes extensive revisions and is now substantially larger, with three new chapters and 47 colour photographs.

In the last few decades, great developments have occurred within the commercial rabbit industry which currently produces over a million tonnes of rabbit meat per year throughout the world. Modern technology has been introduced and many units involved in the production of rabbit meat have greatly increased in size.

A small section of this book was devoted to rabbit production in third world countries where food is so badly needed

The fifth edition contains details of sixteen new breeds and for the first time includes colour photographs of 47 breeds that are covered in the book . Unfortunately, no close ups are provided, despite much effort, for the rare breeds of Beige or Isabella, Blanc de Hotot, Blanc de Termonde, Deilenaar, Pointed Beveren and Squirrel.

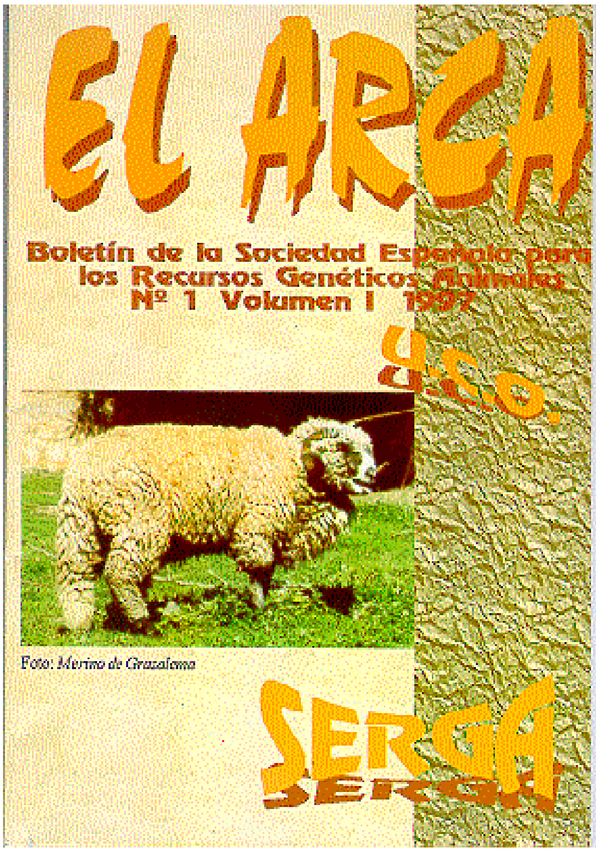


El Arca

Boletín de la Sociedad Española para los Recursos Genéticos Animales (SERGA)
No. 1 Vol. 1 1997
Servicio de Publicaciones de la Universidad de Córdoba
Dpto. Genética y Unidad de Etnología, Facultad de Veterinaria
Avd. Medina Azahara 9, 14.005 Córdoba
Tel: +34-957-218742/218708, Fax: +34-957-218666, E-mail: SERGA@uco.es

El Arca no se ha concebido sólo como una publicación meramente de difusión, sino que también pretende aportar información de carácter científico que se nutrirá especialmente de las contribuciones de aquellos investigadores relacionados con la conservación de nuestro patrimonio genético animal quienes la imprimirán un nivel científico adecuado. Para cuidar especialmente estos aspectos disponemos de un comité científico compuesto por especialistas de los diferentes ámbitos de la gestión de los RGA.

El Arca es un boletín de periodicidad semestral y de difusión gratuita, sin fines de lucro y que se financia con aportes del Servicio de Publicaciones de la Universidad de Córdoba. Por ello cualquier información que en él aparezca, aunque pueda tener un contenido publicitario, no tiene otra intención que colaborar a enriquecer tanto el conocimiento y como la preservación de nuestros RGA y no revertirá en beneficio económico alguno para la Revista.



AMD African Mammals Databank - A Databank for the Conservation and Management of the African Mammals

Institute of Applied Ecology, Via A. Luciani 32, 00197 Rome, Italy
Tel/Fax: +39-6-4403315; E-mail: md@mclink.it

Report to the Directorate-General for Development (DGVIII/A/1) of the European Commission. Project No. B7-6200/94-15/VIII/ENV, Brussels 1998. Vol 1 and 2, pp. 1174

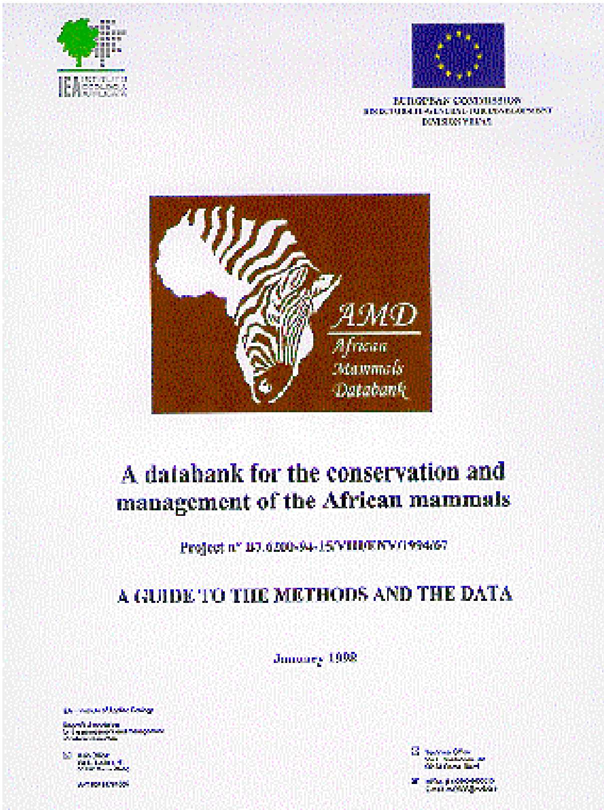
The report deals with a project on the data bank that is now being designed to manage all data on endangered species, including evaluation of population sizes in the various fragments of the species' ranges; it includes both alpha-numeric information and a full range of georeferenced data on species distribution.

The project uses tools such as GIS (Geographical Information System) to store and analyse data for the identification and evaluation of conservation action for the medium and large mammals in Africa.

The project was designed to collect, store, organise and analyse data for distribution to the community of institutions and individuals worldwide concerned with the design and implementation of conservation projects in Africa: as such, its ultimate goal is to provide background data and a service to the conservation community.

A total of 281 species, belonging to 12 orders and 28 families were included in the data bank.

This project intends to contribute to the conservation of the African mammals by providing a first study of their global distribution patterns and by nurturing the new chapter of conservation biology on broad scale analyses. The databank also intends to make available to the conservation and scientific community the raw and semi-processed data that is needed to develop further analyses on distribution trends and patterns.



Recent advances in small ruminant research

Eds: J.E. Lindberg, H.L. Gonda & I. Ledin
Proceedings of the Seminar of the FAO-CIHEAM network of Co-operative Research on Sheep and Goats Subnetwork on Nutrition, jointly organised with the Institute Agronomique et Véterinaire Hassan II, Rabat (Morocco), 24-26 October 1996
Séminaires Méditerranées, Vol. 34
CIHEAM , Ctra. Montanana 177, 50059 Zaragoza, Spain
ISSN 1016-121-X; ISBN 2-85352-172-9

The FAO-CIHEAM Network of Co-operative Research on Sheep and Goats, founded in 1979, aims at spreading knowledge on specific subjects related to small ruminants, particularly those which may offer useful applications for farmers. This network has supported important progress as regards methods applied to small ruminants, practical applications, laboratory research results and improvement of the quality of sheep and goat products (cheese, carcass, etc.). It also has an important mission of spreading technical and scientific information as well as helping technology transfer.

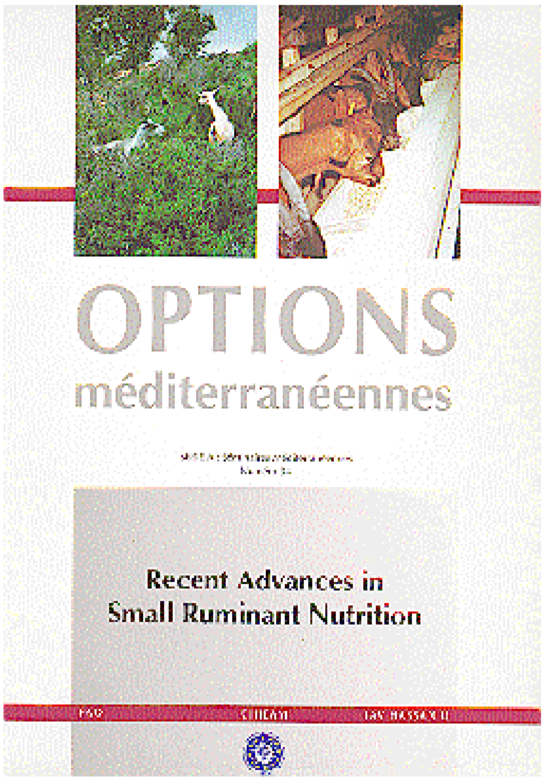
The Sub-network on Nutrition meets every two years to review the subjects included in its programme during the previous meeting. After the meetings of Reading, Grangeneuve, Nancy, Bella, Ostersund and Thessaloniki, the last one was held in Rabat from 24 to 26 October 1996.

The first two sessions of the Seminar discussed strategy of small ruminants to use the vegetation from tree and shrub Mediterranean rangelands and by-products. The particularities of small ruminants in their use of rangeland biomass and some by-products, as well as their usage constraints, were clearly identified.

Session 3 was devoted to food intake, digestion and metabolism of small ruminants, confirming the characteristics of goat feeding behaviour, specifying supplementation strategies according to the types of basal ration and, showing certain genotype-related metabolic particularities.

In session 4 the adaptation capacity of small ruminants to harsh conditions was tackled especially the adaptation to water or protein deficiency.

In sessions 5 and 6, the nutritional effects on fertility pregnancy and lactation of ewes and goats, and also on lamb and kid growth were revisited.



Editorial Policies and Procedures

The mission of the Animal Genetic Resources Information Bulletin (AGRI) is the promotion of information on the better use of animal genetic resources of interest to food and agriculture production, under the Global Strategy for the Management of Farm Animal Genetic Resources. All aspects of the characterization, conservation and utilization of these resources are included, in accordance with the Convention on Biological Diversity. AGRI will highlight information on the genetic, phenotypic and economic surveying and comparative description, use, development and maintenance of animal genetic resources; and on the development of operational strategies and procedures which enable their more cost-effective management. In doing this AGRI will give special attention to contributions dealing with breeds and procedures capable of contributing to the sustainable intensification of the world's medium to low input production environments (agro-ecosystems), which account for the substantial majority of the land area involved in livestock production; the total production of food and agriculture from livestock; and of our remaining farm animal genetic resources.

Views expressed in the paper published in AGRI represent the opinions of the author(s) and do not necessarily reflect those of the institutions which the authors are affiliated, FAO or the Editors.

The suitability of manuscripts for publication in AGRI is judged by the Editors and reviewers.

Electronic publication

AGRI is available in full electronically on the Internet, in addition to being published in hard copy, at:
<< http://www.fao.org/dad-is>>

Types of Articles

The following types of articles are published in AGRI.

Research articles

Findings of work on characterization, conservation and utilization of farm animal genetic resources (AnGR) in well described production environments, will be considered for publication in AGRI. Quality photographs of these genetic resources viewed in the primary production environment to which they are adapted, accompanying the manuscripts are encouraged.

Review articles

Unsolicited articles reviewing agro-ecosystems, country-level, regional or global developments on one or more aspects of the management of animal genetic resources, including state-of-the-art review articles on specific fields in AnGR, will be considered for publication in AGRI.

Position papers

Solicited papers on topical issues will also be published as deemed required.

Other published material

This includes book reviews, news and notes covering relevant meetings, training courses and major national, regional and international events and conclusions and recommendations associated with the outcomes of these major events. Readers are encouraged to send such items to the editors.

Guidelines for Authors

Manuscript submission

Manuscripts prepared in English, French or Spanish with an English summary and another summary in either French or Spanish, should be submitted to AGRI Editor, AGAP, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy. Alternatively a manuscript may be sent as a WinWord Electronic Mail attachment to < agri@fao.org >. Photographs, coloured or black and white, and figures must be always sent by mail.

Manuscripts should be typed double-spaced and with lines numbered in the left margin. All pages, including those of references, tables etc., must be consecutively numbered. The corresponding author is notified of the receipt of a manuscript.

For manuscripts that are accepted after revision, authors are encouraged to submit a last version (3½" disc format) in Word 6.0 for Windows of their revised manuscript along with the printed copy.

Preparation of the manuscript

The first page of the manuscript must include the running head (abbreviated title), title, names of authors, institutions, full addresses including postal codes and telephone number and other communication details (fax, e-mail, etc.) of the corresponding author. The running head not exceeding 45 characters plus spaces, should appear at the top of page 1 of the manuscript entirely in capital letters. The title of the manuscript is typed in upper and lower case letters. The title should be as brief as possible not exceeding 150 characters (including spaces) with species names when applicable. Authors, institutions and addresses are in upper and lower case italics. There is one blank line between the title and the authors. Addresses are typed as footnotes to the authors after leaving one blank line. Footnotes are designated numerically. Two lines are left below the footnotes.

Headings

Headings of sections, for example Summary, Introduction, etc., are left-justified. Leave two blank lines between addresses footnotes and Summary and between the heading Summary and its text. Summary should not exceed 200 words . It should be an objective summary briefly describing the procedures and findings and not simply stating that the study was carried on such and such and results are presented, etc. Leave one line between the summary text and Keywords which is written in italics as well as the keywords themselves. All headings of sections (14 regular) and sub-sections (12 regular) are typed bold and preceded and succeeded by one blank line and their text begins with no indention. The heading of a sub-subsection is written in italics, and ends with a dot after which the text follows on the same line. Keywords come immediately after the summaries. They should be no more than six, with no "and" or "&".

Tables and figures

Tables and figures must be enclosed with the paper and attached at the end of the text according their citation in the document. Photos will not be returned

Tables

Tables, including footnotes, should be preceded and succeeded by 2 blank lines. Table number and caption are written, above the table, in italics (12) followed by a dot, then one blank line. For each column or line title or sub-title, only the 1st letter of the 1st word is capitalized. Tables should be numbered consecutively in Arabic numerals. Tables and captions should be left justified as is the text. Use horizontal or vertical lines only when necessary. Do not use tabs or space-bar to create a table but only the appropriate commands.

Figures

Figures including titles and legends should be preceded and succeeded by two blank lines. Figure number and title are written, below the figure, in italics (12) and end with a dot. The term figures includes photos, line drawings, maps, diagrams etc.

All the submitted diagrams, must be

accompanied with the original matrix of the data used to create them. It is strongly advised to submit diagrams in Word 6.0 or Excel 5.0. Figures should be numbered consecutively in Arabic numerals.

References

Every reference cited in the text should be included in the reference list and every reference in the reference list should have been mentioned in the text at least once. References should be ordered firstly alphabetically by the first author's surname and secondly by year.

Example for reference in a periodical is:

Köhler-Rollefson, I., 1992; The camel breeds of India in social and historical perspective. Animal Genetic Resources Information 10, 53-64.

When there are more than one author:

Matos, C.A.P., D.L. Thomas, D. Gianola, R.J. Tempelman & L.D. Young, 1997; Genetic analysis of discrete reproductive traits in sheep using linear and nonnlinear models: 1. Estimation of genetic parameters 75, 76-87.

For a book or an ad hoc publication, e.g., reports, theses, etc.:

Cockril, W.R., (Ed), 1994; The Husbandry and Health of the Domestic Buffalo. FAO, Rome, Italy, pp 993.

For an article in the proceedings of a meeting:

Hammond, K., 1996; FAO's programme for the management of farm animal genetic resources. In C. Devendra (Ed.) Proceedings of IGA/FAO Round Table on the Global Management of Small Ruminant Genetic Resources, Beijing, May 1996, FAO, Bangkok, Thailand, 4-13.

Where information included in the article has been obtained or derived from a World Wide Web site, then quote in the text, e.g. "derived from FAO. 1996" and in the References quote the URL standard form:

FAO, 1996; Domestic Animal Diversity Information System <http://www.fao.org/dad-is/>, FAO, Rome

Normes et règles éditoriales

L'objectif du Bulletin d'Information sur les Ressources Génétiques Animales (AGRI) est la vulgarisation de l'information disponible sur la meilleure gestion des ressources génétiques animales d'intérêt pour la production alimentaire et agricole, d'après les recommendations de la Stratégie Mondiale pour la Gestion des Ressources Génétiques des Animaux Domestiques. Tous les aspects relatifs à la caractérisation, la conservation et l'utilisation de ces ressources seront pris en considération, suivant les normes de la Convention pour la Biodiversité.

AGRI désire diffuser de l'information sur la génétique, les enquêtes phénotypiques et économiques et les desciptions comparatives, l'utilisation et la conservation des ressources génétiques animales, ainsi que toute information sur le développement de stratégies opérationnelles et de normes qui puissent permettre une meilleure gestion de la relation coût/efficacité. C'est pour cela que AGRI prendra spécialement en considération toutes les contributions référées aux races et aux normes capables de permettre une intensification durable des milieux (agroécosystèmes) à revenus moyens et bas dans le monde; qui comprennent la majeur partie des terres consacrées à l'élevage, à la production totale des aliments et l'agriculture provenants de l'élevage; et tout ce qui reste comme ressources génétiques des animaux domestiques.

Les opinions exprimées dans les articles publiés dans AGRI appartiennent seulement aux auteurs et donc ne représentent pas nécessairement l'opinion des instituts pour lesquels ils travaillent, la FAO ou les éditeurs.

L'opportunité ou non de publier un article dans AGRI sera jugée par les éditeurs et les réviseurs.

Publication électronique

En plus de sa version imprimée, la version totale de AGRI se trouve disponible sur Internet, sur le site:
<<http://www.fao.org/dad-is/>>

Types d'articles

Les articles suivants pourront être publiés sur AGRI:

Articles de recherche

Seront prises en considération pour leur publication sur AGRI les études sur la caractérisation, la conservation et l'utilisation des ressources génétiques des animaux domestiques (AnGR) accompagnées d'une bonne description du milieu. On encourage les auteurs à envoyer des photographies de bonne qualité qui montrent les races en question dans leur milieu naturel de production.

Révisions

Occasionnellement, des articles contenant une révision des agroécosystèmes, au niveau national, régional ou mondial, avec un ou plusieurs aspects se rapportant à la gestion des ressources génétiques animales, y comprises les mises à jour des différentes zones de AnGR, seront pris en considération.

Articles spécifiques

Ponctuellement, des articles sur des thèmes spécifiques pourront être demandés pour la publication d'éditions spéciales.

Autre matériel pour publication

Ceci comprend la révision de livres, nouvelles et notes de réunions importantes, cours de formation et principaux évènements nationaux, régionaux et internationaux; ainsi que les conclusions et recommendations par rapport aux objectifs des ces principaux évènements. Les auteurs sont priés d'envoyer ce genre de matériel aux éditeurs.

Guide pour les auteurs

Présentation du manuscript

Les articles se présenteront en anglais, français ou espagnol, avec un résumé en anglais et sa traduction en français ou en espagnol; et seront envoyés à l'éditeur de AGRI, AGAP, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italie. L'autre possibilité est d'envoyer l'article par courrier électronique avec le document adjoint en version WinWord à <agri@fao.org>. Les photographies, en couleur ou en blanc et noir, seront toujours envoyées par courrier normal.

Les manuscripts se présenteront à double interligne et avec le numéro correspondant à chaque ligne sur la marge gauche. Toutes les pages seront numérotées, y comprises celles avec les références bibliographiques, les tableaux, etc. L'auteur recevra une lettre lui donnant bonne réception de son document.

Lorsqu'un article, après sa révision, sera accepté, on demandera à l'auteur d'envoyer la version finale révisée sur disquette (format 31/2") en Word 6.0 x Windows, ainsi qu'une copie sur papier.

Préparation du manuscript

Sur la première page du manuscript on indiquera le titre de l'article en abrégé, le titre et noms des auteurs, des institutions, les adresses complètes (y compris code postal et numéro de téléphone); ainsi que tout autre moyen de contact tel que fax, e-mail, etc. avec l'auteur principal. Le titre abrégé ne devra pas dépasser les 45 caractères, plus les espaces nécessaires, et s'écrira sur la partie supérieure de la page 1 du manuscript en majuscules. Le titre en entier du manuscript sera écrit en majuscules et minuscules; il devra être aussi bref que possible, sans dépasser les 150 caractères (y compris les espaces nécessaires), et avec l'indication des noms des espèces. Les noms des auteurs, des institutions et les adresses seront en italique et en lettres majuscules et minuscules. On laissera un espace en blanc entre le titre et les noms des auteurs. Les adresses seront indiquées comme des notes à pied de page pour chacun des auteurs après avoir laissé un espace en blanc après les noms. Chaque note de pied de page sera numérotée. On laissera deux espaces en blanc après les adresses.

Titres

Les titres de chaque chapitre, par example Résumé, Introduction, etc. seront alignés à gauche. Laisser deux espaces en blanc entre les notes de pied de page avec les adresses et le Résumé, et entre le titre Résumé et le texte qui suit. Le résumé ne devra pas dépasser les 200 mots. Il s'agira d'un résumé objectif qui fasse une brève description des processus utilisés et des résultats obtenus, et non pas une simple présentation du travail réalisé avec une description générale des résultats. Laisser un espace en blanc entre la fin du texte du résumé et les mots-clés, qui seront écrits en italique ainsi que le titre Mots-clés. Les mots-clés seront au maximum six et il ne devra pas y avoir de "et" ou "&". Tous les titres principaux de chapitre (14 regular) et sous-chapitre (12 regular) seront en gras avec un espace en blanc avant et après. Le texte commencera sans retrait. Un titre à l'intérieur d'un sous-chapitre s'écrira en italique, suivi d'un point, avec le texte à continuation.

Tableaux et figures

Les tableaux et les figures iront à la fin du texte en suivant l'ordre d'apparition dans le texte. Les photographies ne seront pas dévolues aux auteurs.

Tableaux

Les tableaux, y compris les notes de pied de page, devront avoir un espace en blanc avant et après. Le numéro du tableau et le titre s'écriront sur la partie supérieure en italique (12) avec un point à la fin et un espace en blanc en dessous. Sur chaque colonne, titre d'en-tête ou sous-titre, seulement la première lettre du premier mot sera en majuscule. Les tableaux et leur titre seront alignés à gauche, ainsi que le texte. Les lignes verticales et horizontales seront utilisées seulement si nécessaires. Ne pas utiliser les tabs ou la barre de séparation pour créer un tableau.

Figures

Les figures, y compris les titres et les légendes, seront précédés et suivis de deux espaces en blanc. Le numéro de la figure et le titre s'écriront sur la partie supérieure en italique (12) avec un point à la fin. Sous la rubrique figure on trouvera les photographies, les graphiques, les cartes, les diagrammes, etc. Dans le cas des diagrammes, la matrice originale avec les données utilisées pour son élaboration devra être envoyée. On recommande l'utilisation de Word 6.0 ou Excel 5.0 pour la présentation des diagrammes.

Références

Toute référence présente dans le texte devra apparaître sur la liste des références, et chaque référence de la liste aura été citée au moins une fois dans le texte. Les références iront en ordre alphabétique du nom de l'auteur, suivi de l'année. Example dans le cas d'une référence sur une revue:

Köhler-Rollefson, I.,1992; The camel breeds of India in social and historical perspective. Animal Genetic Resources Information 10, 53-64.

Lorsqu'il s'agit de plus d'un auteur:

Matos, C.A.P., D.L. Thomas, D. Gianola, R.J. Tempelman & L.D. Young, 1997; Genetic analysis of discrete reproductive traits in sheep using linear and nonlinear models: 1. Estimation of genetic parameters 75, 76-87.

Dans le cas d'un livre ou d'une publication ad hoc, par example un rapport, une thèse, etc.:

Cockril, W.R., (Ed), 1994; The Husbandry and Health of the Domestic Buffalo. FAO, Rome, Italy, pp 993.

S'il s'agit d'un acte d'une réunion:

Hammond, K., 1996; FAO's programme for the management of farm animal genetic resources. In C. Devendra (Ed.) Proceedings of IGA/FAO Round Table on the Global Management of Small Ruminant Genetic Resources, Beijing, May 1996, FAO, Bangkok, Thailand, 4-13.

Lorsque l'information contenue dans l'article ait été obtenue ou dérive d'un site World Wide Web, il faudra mettre le texte entre guillemets; par example "tiré de la FAO. 1996" et indiquer dans les Références la forme standard URL:

FAO, 1996; Domestic Animal Diversity Information System <http://www.fao.org/dad-is/>, FAO, Rome

Reglas y normas editoriales

El objetivo del Boletín de Información sobre Recursos Genéticos Animales (AGRI) es la divulgación de la información sobre una mejor gestión de los recursos genéticos animales de interés para la producción alimentaria y agrícola, siguiendo la Estrategia Mundial para la Gestión de los Recursos Genéticos de los Animales Domésticos. Todos los aspectos referidos a la caracterización, la conservación y el uso de estos recursos serán tomados en consideración, de acuerdo con la Convención sobre la Biodiversidad.

AGRI publicará información sobre genética, encuestas fenotípicas y económicas y descripciones comparativas, uso, desarrollo y conservación de los recursos genéticos animales, así como sobre el desarrollo de estrategias operacionales y normas que permitan una gestión más eficaz de la relación costo/eficacia. Por ello, AGRI prestará especial atención a las contribuciones referidas a razas y normas capaces de contribuir a la intensificación sostenible de los medios (agroecosistemas) con ingresos medio y bajos en el mundo, que comprenden casi la mayor parte de las tierras dedicadas a la producción ganadera; la producción total de alimentos y agricultura provenientes de la ganadería; y el resto de los recursos genéticos de animales domésticos.

Los puntos de vista expresados en los artículos publicados en AGRI son solamente las opiniones de los autores y, por tanto, no reflejan necesariamente la opinión de las instituciones para las cuales trabajan dichos autores, de la FAO o de los editores.

La oportunidad o no de publicar un artículo en AGRI será juzgada por los editores y revisores.

Publicación electrónica

Además de su publicación impresa, la versión íntegra de AGRI se encuentra disponible electrónicamente sobre Internet, en el sito: <<http://www.fao.org/dad-is/>>

Tipos de artículos

Serán publicados en AGRI los siguientes tipos de artículos:

Artículos sobre investigación

Se tomarán en consideración para su publicación en AGRI los estudios sobre la caracterización, conservación y uso de los recursos genéticos de los animales domésticos (AnGR) con una buena descripción del entorno. Se agradecerá el envío de fotografías de calidad que presenten a las razas en cuestión en su ambiente natural de producción.

Artículos de revisión

Se podrán tener en consideración ocasionalmente aquellos artículos que presenten una revisión de los agroecosistemas, a nivel nacional, regional o mundial, con el desarrollo de uno o más aspectos referidos a la gestión de los recursos genéticos animales, incluidas las revisiones sobre el estado actual de las distintas áreas de AnGR.

Artículos específicos

Se solicitarán puntualmente artículos sobre temas específicos para ediciones especiales.

Otro material para publicación

Incluye la revisión de libros, noticias y notas referidas a reuniones importantes, cursos de formación y principales eventos nacionales, regionales e internacionales, así como conclusiones y recomendaciones relacionadas con los objetivos de estos principales eventos. Se invita a los lectores a enviar este tipo de material a los editores.

Guía para los autores

Presentación del manuscrito

Los artículos se presentarán en inglés, francés o español, junto con un resumen en inglés y su traducción en francés o español, y se enviarán al editor de AGRI, AGAP, FAO, Viale delle Terme di Caracalla, 00100 Roma, Italia. Otra posibilidad es enviar el artículo por correo electrónico adjuntando el documento en versión WinWord a <agri@fao.org>. Las fotografías, a color o en blanco y negro, se enviarán siempre por correo normal.

Los manuscritos se presentarán con doble espacio y con el número correspondiente a cada línea en el margen izquierdo. Todas las páginas serán numeradas, incluidas las de las referencias bibliográficas, cuadros, etc. El autor recibirá una notificación sobre la recepción de su documento.

En el caso de aceptación de un artículo después de su revisión, se solicitará al autor una versión final de su artículo revisado en disquete (formato 31/2″) en Word 6.0 x Windows, así como una copia impresa del mismo.

Preparación del manuscrito

En la primera página del manuscrito se indicará el título abreviado del artículo, títulos y nombres de los autores, instituciones, direcciones completas (incluido código postal y número de teléfono); así como otros medios de contacto tales como fax, e-mail, etc., del autor principal. El título abreviado no deberá sobrepasar los 45 caracteres más los espacios correspondientes, y aparecerá en la parte superior de la página 1 del manuscrito en mayúsculas. El título entero del manuscrito viene escrito en mayúsculas y minúsculas. Dicho título debe ser lo más breve posible y no sobrepasar los 150 caracteres (incluidos los espacios necesarios), con los nombres de las especies, si necesario. Los nombres de los autores, instituciones y direcciones se escribirán en cursiva y en letras mayúsculas y minúsculas. Se dejará una línea en blanco entre el título y los nombres de los autores. Las direcciones se escribirán como notas de pie de página de cada autor después de dejar una línea en blanco entre los nombres y éstas. Cada nota de pie de página con la dirección vendrá indicada numéricamente. Se dejarán dos líneas en blanco después de las direcciones.

Títulos

Los títulos de cada sección, por ejemplo Resumen, Introducción, etc., vienen alineados a la izquierda. Dejar dos líneas en blanco entre las notas de pie de página con las direcciones y el Resumen y entre el título Resumen y el texto que sigue. El resumen no deberá exceder de 200 palabras. Deberá ser un resumen objetivo que describa brevemente los procesos y logros obtenidos, y no una presentación de cómo se ha llevado a cabo el estudio y una descripción genérica de los resultados. Dejar una línea en blanco entre el final del texto del resumen y las palabras clave, que se escribirán en cursiva así como el titulo Palabras clave. No deberán ser más de seis y no deberán contener "y" o "&". Todos los títulos principales de capítulo (14 regular) y subcapítulo (12 regular) serán en negrita e irán precedidos y seguidos de una línea en blanco. El texto correspondiente empezará sin sangrado. Un título dentro de un subcapítulo se escribirá en cursiva e ira seguido de un punto con a continuación el texto correspondiente.

Cuadros y figuras

Los cuadros y las figuras se incluirán al final del texto siguiendo el orden de cita dentro del mismo. Las fotografías no serán devueltas a sus autores.

Cuadros

Los cuadros, incluidas las notas de pie de página, deberán ir precedidos y seguidos por dos líneas en blanco. El numero del cuadro y su título se escribirán en la parte superior en cursiva (12) con un punto al final y seguido de una línea en blanco. En cada columna o título de encabezamiento o subtítulo, sólo la primera letra de la primera palabra irá en mayúscula. Los cuadros irán numerados de forma consecutiva con números árabes. Los cuadros y sus títulos se alinearán a la izquierda, así como el texto. Se utilizarán líneas horizontales o verticales sólo cuando sea necesario. No utilizar tabuladores o la barra espaciadora para crear un cuadro.

Figuras

Las figuras, incluidos los títulos y leyendas, irán precedidas y seguidas de dos líneas en blanco. El número de la figura y el título se escribirán en la parte superior en cursiva (12) con un punto al final. La palabra figura incluye las fotografías, los gráficos, los mapas, los diagramas, etc. En el caso del diagrama se enviará la matriz original con los datos utilizados para crearlo. Se recomienda encarecidamente la utilización de Word 6.0 o Excel 5.0 para la presentación de los diagramas.

Referencias

Toda referencia presente en el texto deberá aparecer en la lista de referencias y, de la misma manera, cada referencia de la lista deberá haber sido citada por lo menos una vez en el texto. Las referencias deben ir en orden alfabético del apellido del autor, seguido por el año.

Ejemplo en el caso de una referencia de una revista:

Köhler-Rollefson, I.,1992; The camel breeds of India in social and historical perspective. Animal Genetic Resources Information 10, 53-64.

Cuando se trata de más de un autor:

Matos, C.A.P., D.L. Thomas, D. Gianola, R.J. Tempelman & L.D. Young, 1997; Genetic analysis of discrete reproductive traits in sheep using linear and nonnlinear models: 1. Estimation of genetic parameters 75, 76-87.

En el caso de un libro o de una publicación ad hoc, por ejemplo informes, tesis, etc.:

Cockril, W.R., (Ed), 1994; The Husbandry and Health of the Domestic Buffalo. FAO, Rome, Italy, pp 993.

Cuando se trate de un artículo dentro de las actas de una reunión:

Hammond, K., 1996; FAO's programme for the management of farm animal genetic resources. In C. Devendra (Ed.) Proceedings of IGA/FAO Round Table on the Global Management of Small Ruminant Genetic Resources, Beijing, May 1996, FAO, Bangkok, Thailand, 4-13.

Cuando la información contenida en el artículo haya sido obtenida o derive de un sito World Wide Web, poner el texto entre comillas; por ejemplo "sacado de la FAO. 1996" e indicar en las Referencias la forma estándar URL:

FAO, 1996; Domestic Animal Diversity Information System <http://www.fao.org/dad-is/>, FAO, Rome