European approaches to conservation of farm animal genetic resources

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Summary

Based on several sources of information an overview has been given on the development, present situation and problems of conservation of animal genetic resources in Europe.

Presently, 1 029 breeds of cattle, sheep, goats, pigs, horses and asses are registered by the EAAP-Animal Genetic Data Bank, Hanover. 42.8 % of the breeds are classified as being 'at risk'. More than 360 conservation programmes are underway, which, however, in many cases seem to be operated independently of the status of endangerment and of similar breeds in other countries.

The primary objectives of conservation in Europe, i.e. 'conservation for potential use, later' and 'conservation for cultural reasons', are different from the objective 'conservation for sustainable use, now', which is primarily expressed for developing countries. Different objectives call for different answers to questions, such as: are breeds appropriate units of genetic diversity, how should endangerment be defined, what should be conserved and is incrossing and selection compatible with conservation?

In view of the large number of breeds 'at risk' and of similar breeds existing in different countries as well as the high costs of conservation it is concluded that characterisation of breeds for genetic uniqueness is presently the most urgent task in conservation. This requires effective co-operation across national borders in Europe.

Résumé

Sur la base de différentes sources d'information on présente une révision sur le développement, la situation actuelle et les problèmes de la conservation des ressources génétiques animales en Europe.

Actuellement 1 029 races de bovins, ovins, caprins, porcins et équins sont enregistrés dans la Base de Données sur les Ressources Génétiques Animales de la FEZ à Hannover. Parmi ces races, 42,8% sont classées dans la catégorie "à risque". En ce moment plus de 360 programmes de conservation sont en oeuvre, cependant, dans plusieurs des cas, ils semblent opérer indépendemment du niveau de danger de disparition et de la présence des mêmes races dans d'autres pays.

Les objectifs principaux de la conservation en Europe, tels que "la conservation pour l'utilisation potentielle future" et "la conservation pour des raisons culturelles", sont bien différents des objectifs de "conservation pour l'utilisation durable actuellement" présentés comme prioritaires par les pays en voie de développement. Les différents objectifs mènent à différentes réponses aux questions telles que: Est-ce que les races sont des unités appropriées pour la diversité génétique? Comment pourrait-on définir le niveau de danger? Que devrait-on conserver et est-ce que le croisement et la sélection sont compatible avec la conservation?

Etant donné le nombre de races "à risque" et la présence de ces mêmes races dans d'autres pays, ainsi que le coût élevé de la conservation, on conclu que la caractérisation des races dans le seul but génétique est actuellement le thème plus urgent de la conservation. Ceci nécessite d'une coopération effective entre tous les pays européens.

Key words: *Genetic diversity, Farm animals, Endangerment, Conservation programmes, Objectives, Europe*

Introduction

Europe is a heterogeneous region of the world with 46 or so countries, several supra-national institutions and many Non-Governmental Organisations (NGOs). As a result approaches to conservation of farm animal genetic resources (FAGR) differ not only in the observed objectives and species but also in length of involvement and, possibly, in the effectiveness of actions in this field.

According to FAO's World Watch List for domestic animal diversity (1995), about 34 per cent of the so far listed breeds of the major farm animal species; cattle, goats, horses, pigs and sheep are bred in Europe and about 69 per cent of the active conservation programmes of breeds at risk of the mentioned species are underway in this region. Obviously, Europe can play an important part in the maintenance of the world's farm animal genetic resources.

The activities in Europe started some time before the UNCED Rio Conference in 1992 formulated the Convention on Biological Diversity. One significant milestone in the process of growing awareness of conservation was the informal and later formal foundation of the Rare Breeds Survival Trust (RBST) in 1968 and 1973, respectively, and the foundation of the Rare Breeds Farm Park, 1969, at Warwickshire in the United Kingdom. Subsequent milestones were:

1969 Discussion of 'Needs and methods of gene conservation in animal breeding' in the Genetics Commission of the European Association for Animal Production (EAAP), in Helsinki (Maijala, 1970).

1970 Use of markers to estimate genetic distances among breeds (Kidd and Pirchner,1971).

1979 Animal breeding scientists propose a definition of the status of endangerment of breeds and criteria for conservation of endangered breeds (Deutsche Gesellschaft für Züchtungskunde,1979).

1979 Foundation of the Nordic Working Party on Animal Gene Banks for the Scandinavian countries (Maijala *et al*.,1992).

1980 Set-up of the Working Group on Animal Genetic Resources (EAAP-WGAGR) by the Commission on Animal Genetics of the European Association for Animal Production.

1983 Survey by the EAAP-WGAGR on breeds and country populations in Europe (Maijala et al.,1984).

1987 Set-up of the EAAP Animal Genetic Data Bank (EAAP-AGDB) at the Institute of Animal Breeding and Genetics, Hanover (Simon, 1990).

1992 Commission of European Communities 'Workshop and Training Course on data collection, conservation and use of animal genetic resources' in Hanover.

1993 EAAP-publication No. 66 'Genetic diversity of European livestock breeds', with status of endangerment and formation of groups of similar breeds.

1994 Nomination of National Focal Points in FAO Member-Countries of Europe as national co-ordinators for conservation of FAGR.

1996 INTERNET presentation of information of European breeds by the EAAP-Animal Genetic Data Bank, Hanover, and INTERNET-presentation of information of the FAO Domestic Animal Information System DAD-IS, Rome.

Conservation of farm animal genetic resources is a continuous process, which in Europe is taking place on several levels and with different kinds of actions. Earlier reports on the situation in Europe were given by Maijala et al.(1984), as a report of the EAAP-Working Group on Animal Genetic Resources, Simon and Buchenauer (1993), as a report of the EAAP Animal Genetic Data Bank, and by Ollivier et al. (1994), with concluding remarks on the situation in different regions of Europe and on urgent tasks. Since then the nomination of National Co-ordinators for conservation in European countries and the forthcoming of the EC-Regulations 2078/92 and 1467/94 have given additional strength to the idea of conservation of FAGR in this region.

For the preparation of this paper, information of the following sources could be used: From the EAAP-AGDB, Hanover, information on breeds of the major farm animal species; cattle, sheep, goats, pigs, horses and asses, as registered until February 1997; in addition information from the National Organisations of EAAP, the National Focal Points for Animal Genetic Resources of European countries, the European Commission in Brussels, from many NGOs and from individual experts who are active in this field.

The intention of this paper is to collect present information of various sources and form one integrated picture of approaches to conservation of farm animal genetic resources in Europe and to come to conclusions on priorities of actions in this field.

Quantity of Farm Animal Genetic Resources, Number of Breeds

Following the practice of the EAAP-WGAGR, the quantity of farm animal genetic resources is measured in terms of breeds. This term is used for a group of similar interbreeding animals within a country, which, according to the people who work with them, should be regarded as a breed. The term 'breed' includes groups of animals, which by other people may be called strain, variety or line. A synonymous term could be 'country population' as explained by Maijala et al. (1984).

The number of breeds of the major farm animal species; cattle, sheep, goats, pigs, horses and asses which have been recorded by the EAAP-AGDB until 1997 is presented in table 1.

In 36 countries a total of 1 029 breeds is recorded. Only breeds are listed for which a reasonable amount of information could be obtained. The number of breeds of the individual species; cattle, sheep, goats, pigs, horses and asses is 311, 338, 101, 134, 139 and 6, respectively. These numbers are quite impressive; however, due to the recording systems within countries they may include several breeds with the same or similar genetic background. This can be a problem if decisions have to be made, such as which one out of several endangered breeds should be conserved and which not. It will be of interest to know how many of these breeds are considered to be endangered.

Status of Endangerment of Breeds

The question which criteria should be used to define the status of endangerment of a breed is not settled. Several systems have been proposed (Deutsche Gesellschaft für Züchtungskunde DGfZ, 1979; Maijala *et al.*,1984; European Commission 1992,1994; Bodo, 1995; FAO,1995; Simon,1995; and others). The procedure applied here is basically the same as that proposed by Simon and Buchenauer (1993). It considers four conditions which represent danger for the continuance of the present genetic makeup of a breed:

- Low number of breeding herds and decreasing population size, each as an indicator of imminent danger of the loss of the breed in the near future,
- 'immigration' or use of animals of other breed(s) for reproduction, as a factor in the genetic change of the breed,

Table 1. Number of breeds in six farm animal species in European countries (EAAP-Animal Genetic Data Bank, 2/1997).

Country	Species						Total
	Cattle	Sheep	Goats	Pigs	Horses	Asses	
Albania	5	8	8	4	4	0	29
Austria	8	2	0	0	2	0	12
Belgium	10	6	3	3	4	0	26
Bulgaria	2	0	0	0	0	0	2
Croatia	5	4	1	1	4	0	15
Cyprus	2	2	2	3	0	0	9
Czech Republic	1	1	0	1	1	0	4
Denmark	5	4	1	2	2	0	14
Estonia	3	0	0	1	1	0	5
Finland	4	2	1	2	11	0	20
France	44	55	6	17	31	0	153
Germany	27	26	5	16	11	0	85
Greece	3	12	2	0	2	0	19
Georgia	3	0	0	1	0	0	4
Hungary	1	3	0	1	6	0	11
Iceland	2	2	1	0	1	0	6
Ireland	12	5	1	2	5	0	25
Italy	31	54	29	9	20	5	148
Latvia	1	0	0	1	0	0	2
Lithuania	2	0	0	1	0	0	3
Luxembourg	4	1	0	1	3	0	9
Netherlands	4	11	2	3	3	0	23
Norway	3	6	1	2	4	0	16
Poland	4	8	0	8	2	0	22
Portugal	8	9	3	1	3	0	24
Romania	5	5	1	7	0	0	18
Slovakia	2	3	0	1	0	0	6
Slovenia	3	2	0	3	1	0	9
Spain	34	37	18	3	1	1	94
Sweden	2	3	1	0	2	0	8
Switzerland	8	9	9	3	3	0	32
Ukraine	6	0	0	3	0	0	9
United Kingdom	36	56	4	14	10	0	120
Other*	21	2	2	20	2	0	47
Total	311	338	101	134	139	6	1029

*former CSFR, USSR, Yugoslavia

Table 2. Assumed maximum values of inbreeding in 50 years of conservation, F-50% (), and resulting range of effective population size Ne per class of endangerment.

Species	Class of endangerment 1) Not endang. (≤10%)	2) Potentially endang. (11-20%)	3) Minimally endang. (21-30%)	4) Endang. (31-40%)	5) Critically endang. (>40%)
Pigs	≥ 157	156- 74	73- 47	46- 33	< 33
Sheep+goats	≥ 95	94- 45	44- 28	27- 20	< 20
Cattle	≥ 67	66- 32	31- 20	19- 14	< 14
Horses/asses	≥ 52	51- 25	24- 16	15- 11	< 11

- low 'effective population' Ne size as a condition which affects the increase of inbreeding as well as random drift of the population's gene frequencies.

A three-step procedure is applied.

Firstly, definition of species' specific minimum values of effective population size Ne for five classes of endangerment, depending on the maximum values of acceptable inbreeding, F-50, after 50 years of conservation. For the five classes of endangerment the following maximum values of F-50 were assumed:

1) not endangered ≤10%,
2) potentially endangered 10-20%,
3) minimally endangered 21-30%,
4) endangered 31-40%,
5) 5 critically endangered >40%.

The corresponding maximum increase of inbreeding per generation ΔF is deduced from F-50 by solving formula (1)

$$Fg = 1 - (1- \Delta F)^g \quad \text{(Falconer, 1989)} \quad (1)$$

for $\Delta F = 1 – (1- Fg)^{1/g}$ (2) , where Fg= F-50.

The generation interval y (in years) with the resulting number of generations g in 50 years are assumed for the six species as follows (y/g): pigs 1.5/33, sheep and goats 2.5/20, cattle 3.5/14, horses and asses 4.5/11.

The required minimum effective population size per species and class of endangerment is deduced from ΔF per generation by formula (3)

$$Ne = 1/(2\Delta F) \quad \text{(Falconer, 1989)} \quad (3)$$

The resulting values of effective population size Ne per species and class of endangerment are listed in table 2.

Secondly, for the individual breed computation of the effective population size Ne' by means of the formula (4)

$$Ne' = 4mf/(m + f) \quad \text{(Falconer, 1989)} \quad (4)$$

with m and f the number of male and female breeding animals, respectively, which are used for the reproduction of the breed. We defined f as the number of females which are registered in a herdbook (since these allow pedigree-information in planning of matings for reproduction to be observed), and which are used in the order of 100 per cent for purebreeding. In case these requirements are not met f is estimated as ¼ of the number of unregistered females U (or of the total population size T), times the percentage of purebreeding p:

$$f = pU/4 \quad \text{or} \quad f = pT/4.$$

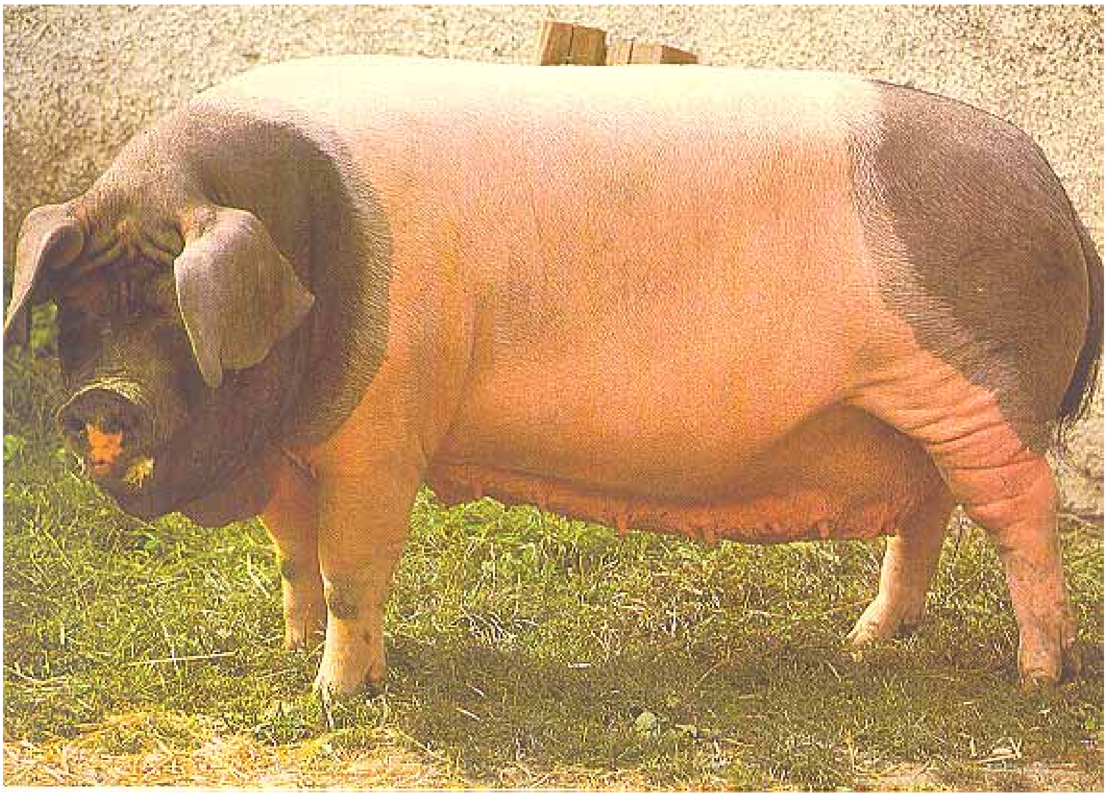

Figure 1. Sow of breed German Saddel Back. For seven similar breeds conservation programmes are under way in six European countries. (Photo: Anonymous)

Table 3. Number of breeds classified for endangerment.

Species	Total	Class of endangerment					
		Not endang.	Poten-tially endang.	Mini-mally endang.	Endang.	Criti-cally endang.	"At risk"
		(1)	(2)	(3)	(4)	(5)	(2-5)
Cattle	305	165	87	24	9	20	140
Sheep	322	210	58	21	7	26	112
Goats	88	64	8	7	4	5	24
Pigs	126	61	23	10	3	29	65
Horses	135	59	51	12	5	8	76
Asses	6	3	1	0	0	2	3
Total	982*	562	228	74	28	90	420

*47 additional breeds - due to missing information - could not be classified.

For a known number of registered female breeding animals that are used for purebreeding only with a percentage of p f is reduced accordingly by multiplication with p.

If m, the number of male breeding animals used for reproduction of the breed is not known m is estimated from f as m = f/30, i.e. by assuming a mating ratio of m:f = 1:30.

If m is less than 40 and the number of males MC is known of which cryoconserved semen is available, the number of males m is increased by addition of the value of MC/3, i.e. it is assumed that 1/3 of the number of males with cryoconserved semen can be regarded as additional males which are available for reproduction of the breed.

By comparing Ne′ of the breed with the minimum values of Ne for the relevant species in table 2 the breed is allocated to one of the five classes of endangerment.

Thirdly, downgrading the breed into one class of higher endangerment for each one of the following additional conditions:

- The number of breeding herds is less than 10 and the number of female breeding animals is below 500,
- the number of female breeding animals is decreasing and already below 1000,
- the percentage of matings for reproduction of the breed with animals of other breed(s) is equal or higher than 20 percent.

Compared with the system of Simon and Buchenauer (1993) the starting points for acceptable F-50 values of the classes 1 to 4 were raised and the maximum value of incrossing was increased from 10 to 20 percent. This resulted in fewer downgradings and a higher percentage of breeds classified as being not endangered.

Following this system 420 or 42.8 % of a total of 982 breeds with sufficient information were allocated to classes 2 to 5 and as such were classified as breeds ‘at risk’ (table 3).

The species with the highest percentage of breeds classified as being ‘at risk’ was horses (56.3%), followed by pigs (51.6), asses (50.0%) and cattle (45.9%). Sheep and goat breeds appear to be least endangered with 34.8% and 27.3% ‘at risk’, respectively. It is interesting to note that in all species the number of breeds classified as being ‘critically endangered’ is remarkably higher than the number of breeds classified as being ‘endangered’.

Conservation Activities

Apart from breeding companies for poultry and pigs, nothing is known about activities of commercial breed - societies on conservation of rare breeds. However, in Germany some breed - societies are committed to the herdbook operation for a rare breed of their region. Actual conservation is mainly performed by farmers, hobby-farmers, research institutions and state-farms.

Live-animal conservation programmes

Live-animal conservation in reproducing herds is the most frequently adopted conservation method. It is an attractive method, allowing adaptation of the breed to changing production and environmental conditions and an immediate use of animals for evaluation, research and commercial breeding. Information on the number of live-animal conservation programmes was obtained from three sources: The EAAP-Animal Genetic Data Bank (EA), the newly nominated National Focal Points in Europe (NFP) and from the European Commission (D. Dessylas, Brussels, 1997, personal communication) (EU).

The information from the EU is related to endangered breeds that are supported according to EEC Regulation 2078/92. So far this support has been restricted to local breeds in danger of extinction of the cattle, sheep, goat and *equidae* species in the 15 EU-Member States.

A total of 365 programmes is registered by EA for the major farm animal species, 285 of these or nearly 78 per cent are underway in EU-Member States (table 4). The total sum reported by NFP is in the same order (334); however, within countries and within species the numbers of the reported conservation programmes can be quite different (e.g. in France, Italy and Portugal). The NFP also

Table 4. Live animal conservation programmes in countries of Europe, as registered by EAAP Animal Genetic Data Bank EA, National Focal Points NF and European Union EU, respectively; NR = No response to request

Country	Cattle			Sheep			Goats			Horses			Pigs		Total per country		
	EA	NF	EU	EA	NF	EU	EA	NF	EU	EA	NF	EU	EA	NF	EA	NF	EU
a) 15 EU-member countries																	
Austria	6	NR	10	1	NR	4		NR	4	2	NR	6		NR	9	NR	26
Belgium	2	3	2		8						2	2			2	13	8
Denmark		4		1	1		1	1		1	3		2	2	5	11	0
Finland	3	3	3	1	2	1			1	1	1	1			5	6	6
France	40	18	14	43	22	9	1	5	2	2		15	5	6	91	51	40
Germany	14	11	9	12	14	12	2	3	3	7	12	12	6	4	41	44	36
Greece		2			8			2		1	2				1	14	0
Ireland		3	3	1	2	7			1			1		2	1	7	5
Italy	25	10	16	1	7	19		11	7	7	3	18	4	4	37	35	60
Luxembourg	2	2								1	1	1			3	3	1
Netherlands	3	5		4	4		2	1		1	2				10	12	0
Portugal	6	2	4	6	1	3	1		2	3					16	3	9
Spain	12	NR	25	4	NR	13	2	NR	4		NR	12	2	NR	20	NR	54
Sweden	2	3	3	2	3	3		2	2		2			1	4	11	8
United Kingdom	12	9		16	23		2	7		4	6		6	2	40	47	0
EU-Countries	127	75	89	92	95	70	11	32	26	30	34	68	25	21	285	257	253
b) 18 Non EU-Member countries	16	21		22	21		12	3		19	24		11	8	80	77	
Total	143	96	89	114	116	70	23	35	26	49	58	68	36	29	365	334	253

Table 5. Ex-situ *keeping of farm animal breeds in zoos and farm parks on 124 locations in Germany. Raw data from Falge (1996); Ne = effective population size.*

Species	Number of Breeds	Number of "Herds"	Animals per "herd"	Average number of Animals per breed (in different herds)	Average number of Males per breed (in different herds)	Ne
Cattle	28	136	4.9	20.3	6.3	20.7
Sheep	30	253	10.3	86.9	15.9	54.1
Goats	24	172	8.6	61.3	15.1	48.2
Pigs	12	131	5.4	59.3	19.5	59.7
Horses	23	120	5.0	26.1	7.0	22.1
Asses	6	80	3.7	48.8	14.8	45.9
Chickens	42	112	7.7	20.6	5.6	18.7
Geese	10	48	3.3	16.0	6.3	19.5
Ducks	12	39	5.3	17.3	7.5	21.8
Total	187	1091	6.0	39.6	10.9	31.1

reported live-animal conservation programmes for additional species, i.e. for asses, dogs, rabbits, chickens, ducks, geese and even for bees, fishes and silkworms. It can be noted that the EU-Member States Denmark, Greece, Netherlands and the United Kingdom have not participated in the EEC-project 2078/92 so far.

Contributions of zoos and farm parks

As already mentioned, conservation of endangered breeds of farm animal species is generally performed on farms. However, such animals are also kept ‘ex situ’ in zoos, farm parks and in so-called Ark-farm projects (Seibold, 1996). Falge (1996) reported animal numbers in 124 institutions of this kind in Germany (table 5):

Animals of 187 breeds of 9 farm animal species are kept in these institutions. The average number of males and of total animals per breed, spread over several locations, is quite low (10.9 and 39.6, respectively). Computation of the effective population size Ne according to formula (4), chapter 3, resulted in values from Ne = 19 for geese and ducks to Ne = 60 for pigs. These values appear rather low if long-term conservation should be achieved.

Thirty-five farm-parks with *ex-situ* conservation of several rare breeds are reported from seven European countries, with 25 farm-parks alone in the United Kingdom (J. Guenterschulze, Warder, 1997, personal communication). In the UK, farm-parks are visited on average approximately by 100 000 people per year (L. Alderson, Warwickshire, 1997, personal communication). The Rare Breeds Survival Trust in the UK and the Gesellschaft zur Erhaltung alter und gefährdeter Haustierrassen, GEH, in Germany developed approval schemes for farm-parks in order to ensure given standards (Chiperzak *et al.*,1995). No information is available on the number of animals and on the farm animal breeds and species which are kept in zoos and farm-parks in the whole region of Europe. The specific value of zoos and farm-parks is that they offer visible

Table 6. Programmes for cryconservation of semen and embryos. T=total, IS=programmes with information on number of sires involved. Data from EAAP-AGDB.

Species	Semen		Embryos	
	T	IS	T	IS
Cattle	194	173	74	49
Sheep	46	39	6	3
Goats	18	15	1	1
Pigs	30	29	0	0
Horses	26	25	4	3
Asses	0	0	0	0
Total	314	281	85	56

evidence of endangered breeds to the public, hence contributing to an increased awareness of the need of conservation.

Cryoconservation of semen and embryos

Cryoconservation of gametes and embryos is a quick and rather inexpensive way to prevent the loss of the genetic potential of a breed (Brem *et al*., 1984). Properly structured stores of frozen semen and embryos can also be used to support live animal conservation programmes with a minimum increase of inbreeding (Simon, 1993). Table 6 summarises the information on cryoconservation as reported by the EAAP-AGDB.

The largest number of projects of semen and embryo storage is reported for breeds of cattle. Here the number of programmes for semen (194) is even higher than the number of live-animal conservation programmes (139, table 4). Possibly, these numbers include projects of cryostored semen for commercial use. Information on the number of males or sires represented in stored semen and embryos is important to judge their usefulness for the re-activation of an extinct breed. As can be seen in table 6 this information is available in most cases, though completion appears necessary.

Activities on a supra-national level in Europe

Several organisations and institutions are active in projects of conservation which involve more than one country in Europe. In chronological order – according to the start of their activities – the following have to be mentioned:

1. EAAP, the European Association for Animal Production, regularly offers a platform for the presentation of papers on topics of conservation of FAGR at its annual meetings (see 'milestone' 1969, chapter 1). Its Commission on Animal Genetics established the EAAP Working Group on Animal Genetic Resources in 1980, whose main objectives are the study, documentation and cataloguing of conservation and development of animal genetic resources in Europe. In 1987 the working group suggested setting up a data bank, which, with the support of the Deutsche Forschungsgemeinschaft DFG, was founded as the EAAP- Animal Genetic Data Bank at the School of Veterinary Medicine, Hanover, in the same year. Since then the volume and quantity of European breed resources could steadily be increased. During the years 1989-1992 the Hanover data bank accepted responsibilities as 'EAAP-FAO-Global Animal Genetic Data Bank'; since then the responsibility of a Global Animal Genetic Data Bank has been transferred to the newly established FAO Domestic Animal Information System DAD-IS in Rome. Since 1997 EAAP has been acting as co-ordinator for the EU-concerted action 'A Permanent Inventory of European farm animal genetic resources'. This project is

Figure 2. Heifers of breed Tyrol Grey. For five similar breeds conservation programmes are under way in five European countries. (Photo: Averdunk).

supported by EC-Regulation 1467/94 and delegates additional responsibilities to EAAP.

2. NAGB, the Nordic Working Party on Animal Gene Banks, was established in 1979 by the five Scandinavian countries Denmark, Finland, Iceland, Norway and Sweden. It has mapped out conservation needs and activities and built a Nordic Information Centre with a data bank. The Nordic Council of Ministers, NCM, is funding the secretary of the working party, the operation of the Nordic Data Bank and specific research (Maijala *et al*.,1984). Breed information of Scandinavian countries is transferred via the Nordic Data Bank to the EAAP-AGDB Hanover.
3. DAGENE, the Danubian Countries Alliance for Conservation of Genes in Animal Species, was founded in 1989 as a group of individual experts, NGOs and governmental institutions of 10 countries of the Danubian region which are interested in conservation of FAGR in this area. Main objectives are the exchange of information and co-operation in similar projects and the organisation of meetings on regional aspects (I. Bodo, Budapest, 1997, personal communication).
4. Commission of the European Communities. The European Union has become an important factor in improving co-ordination and actual support for conservation of FAGR in the 15 Member-States: Council Regulation No. 2078/92 'On agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the country side'. The scheme allows support of farmers who 'rear animals of local breeds in danger of extinction'. An EU-specific system for the classification of endangerment is used, which presently allows the promotion of 253 breeds with up to 100 ECU per livestock unit. - Council Regulation 1467/94 'On the

conservation, characterisation, collection and utilisation of genetic resources in agriculture'. The main objective is to co-ordinate and promote existing work on plant and animal genetic resources in the Member States. Until now 12 plant and 3 animal projects have been supported, the animal side having been severely underrepresented so far. One of the projects deals with the initiation of a 'Permanent Inventory of European farm animal genetic resources and of current work on conservation, characterisation, collection and utilisation of those resources'; it is hoped that this can be developed into an efficient instrument. - AIRE 2066, the concerted action project 'Analysis of genetic diversity to preserve future breeding option'. The main objective is to co-ordinate the work of 27 participating laboratories in 14 countries, in particular to use the same set of DNA-markers for assessing genetic diversity within and between cattle breeds. In addition, a Cattle Diversity Data Base, CaDBase, was set up in Edinburgh with a link to the EAAP-AGDB, Hanover.

5. SAVE, Safeguard for Agricultural Varieties in Europe, was founded in 1995 as an umbrella-organisation for NGOs in Europe. Main objectives are: co-ordination of similar activities in different countries, development of awareness of conservation, exchange of know-how and actual support for specific conservation projects. SAVE became particularly active in countries of Eastern Europe (Gruenenfelder, 1995; W. Kugler, St.Gallen, 1997, personal communication).

Number of Registered Conservation Programmes and Its Relation to the Degree of Endangerment

Table 4 shows that the number of registered live-animal conservation programmes is quite high. The differences in numbers reported by the three sources, EAAP, National Focal Points and European Union, can be explained in part by different countries involved in the respective survey, different ways of assessing endangerment, different requirements for support, (e.g. number of female breeding animals, accepted herdbook) and possibly by different interpretation of what is meant by conservation.

It is of special interest to look at the relation between the percentage of conservation programmes and the class of endangerment of breeds. The figures are presented in table 7, including the coefficient of Spearman's rank correlation r_s. The average of the five species shows no tendency of an increased proportion of conservation programmes in classes of higher endangerment. Spearman's rank correlation r_s=0.12 is low and not significant. None of the five species has the highest proportion of conservation programmes in class five of the breeds with the highest risk status. For sheep, goat and horse breeds the rank correlation even turns out to be negative (-0.44, -0.62 and –0.32, respectively). In class 1, with breeds classified as 'not endangered', conservation programmes are reported for 32% of the breeds. This is remarkable since the system of assessment of endangerment applied here appears to be rather severe, compared with the system used by FAO (1995) (see chapter "Assessment of breeds for endangerment").

It is difficult to explain these results. However, it seems to be meaningful in countries of Europe to examine more closely the objective of conservation, the system of assessing the status of endangerment of breeds and the question whether all breeds which have been classified as being endangered equally deserve to be conserved.

Table 7. Percentage of breeds with live animal conservation programmes by class of endangerment. Rank correlation r_S between class of endangerment and percentage of conservation programmes.

Species	Class of endangerment 1 Not end.	2 Pot. end.	3 Min. end.	4 Endangered	5 Crit. end.	R_S
Cattle	38.8	59.8	41.7	66.7	50.0	0.60 n.s.*
Sheep	30.0	48.3	66.7	28.6	19.2	-0.44 n.s.
Goats	29.7	12.5	14.3	25.0	0	-0.62 n.s
Pigs	13.1	34.8	60.0	33.3	37.9	0.62 n.s.
Horses	42.4	25.5	41.7	40.0	37.5	-0.32 n.s.
Total	32.0	44.9	48.6	42.9	33.3	0.12 n.s.

* p < 0,05

Table 8. Live animal conservation programmes LAC for 'similar' breeds SB, total and in classes of endangerment

Subgroup of similar breeds, formed by EAAP-AGDB	Total number of Countries involv.	SB	LAC	Number of SB and LAC In class 1 (not endang.) SB	LAC	In class 2-5 ('at risk') SB	LAC
Cattle							
1.2 Origin Black Pied	6	8	6	6	4	2	2
3.7 White Lineback	4	5	5	4	4	1	1
5.2 Alpine Brown	4	6	4	3	2	3	2
5.4 Iberian Brown	2	11	9	7	6	4	3
6.2 Grey Mountain	5	7	5	4	3	3	2
Sheep							
5.2 S.Europ.Milk Sheep	6	15	7	11	4	4	3
8.4 Churra Type	2	8	4	7	3	1	1
Pigs							
3.1 Saddle Backs	6	8	7	1	0	7	7
Horses							
5.10 South Europ. Ponies	4	6	5	3	3	3	2
Total		74	52	46	29	28	23

Figure 3. An example of original Black Pied cattle.

Conservation Programmes within Groups of Similar Breeds

For breeds registered in the EAAP-AGDB, an attempt was made to form groups of similar breeds by use of information of breed history, geographic origin, phenotypic appearance, type of use, known genetic background, etc. (Simon and Buchenauer, 1993). For this report an additional analysis was run in order to find out to what extent conservation programmes are underway for similar breeds in different countries. An extract of the results is presented in table 8.

In nine subgroups of similar breeds a total number of 74 breeds is listed; 28 of them were classified as being 'at risk'. The breeds within subgroups are located in 2 to 6 countries, the number of conservation programmes for breeds at risk is n = 23. Obviously the decisions to conserve endangered breeds are made without taking into account the existence of conservation programmes for similar breeds in other countries. The situation appears even worse if we realise that for 46 breeds of the same subgroups, which were classified as being not endangered, 29 additional conservation programmes are reported. This draws attention to the need of clarifying the genetic relationship among breeds and to the need of co-operation across national borders.

Discussion

In the previous chapters it could be shown for Europe that:

- the quantity of farm animal genetic diversity – if expressed in the number of breeds – is still quite large,
- on average some 43 per cent of these breeds have to be regarded as more or less endangered,
- and that an impressive number of conservation programmes (~ 360) is underway.

However, it has become also apparent that in many cases decisions to conserve breeds seem to be not only independent of their status of endangerment but also of the existence of conservation programmes for similar breeds in other countries. This calls for a closer look at the essential elements of present approaches to conservation in Europe.

Breeds as appropriate units of genetic diversity and of conservation

All groups of interbreeding animals which according to the practice in the reporting countries should be regarded as breeds are registered as such by the EAAP-AGDB. This number probably includes several breeds with the same or similar background. The total number of registered breeds of a species therefore has to be regarded as an overestimate of the available genetic diversity.

From genetic theory we know that genetic diversity of populations is a function of the frequencies of genes and of gene combinations. As a consequence, the objective of conservation in principle should be genes and gene combinations. It is interesting to note that the UN-Agenda 21 (1992), in chapter 15 'Conservation of biological diversity', calls 'to conserve and maintain genes, species and ecosystems', not of breeds.

However, our ability to identify genes of farm animal species and their interaction has been very limited, so far. In addition, for several reasons, farm animal species are subdivided into breeds as operating units within which the decisions and actions for breeding are performed. Therefore, for the time being, it is realistic to use breeds as indicators of available genetic diversity of a species. However, if it comes to conservation of genetic diversity, preference should be given to those breeds which can be assumed to be 'containers' of a unique genetic potential, i.e. of genes or gene combinations which are not available in other breeds.

Assessment of breeds for endangerment

By use of the system explained in chapter 3 a higher percentage of breeds was classified as being 'at risk' in Europe (42.8 %) than by the FAO-system of WWL-2 (1995) (32.8 %). The two systems differ essentially in three criteria:

- The way of considering a minimum population size, below which a breed should be regarded as being 'at risk',
- the way of dealing with incrossing or migration, i.e. the use of animals of other breed(s) for reproduction,
- and taking account of the number of breeding herds in which the breed is kept .

For the minimum population size the FAO-system asks for absolute numbers of breeding animals, i.e. that the total number of breeding females and males are greater than 1000 and 20, respectively; same numbers for breeds of all species.

In contrast, the system we used for our analysis asks for a minimum effective population size Ne – a term from population genetics – of the breed in question, where the minimum value of Ne is deduced from the maximum increase of inbreeding, which appears acceptable in a time period of 50 years of conservation (F-50). Taking account of different generation intervals of different species, species-specific values of Ne are obtained (see table 2).

If the minimum numbers of the FAO-system are transformed into the corresponding effective population size the resulting value of Ne = 82 is - compared with the respective values of table 2 - above the value for breeds of horses and asses (52), but below the values for sheep and goats (95) and for pigs (157). In other words breeds of the latter three species will be declared earlier to be more or less endangered by the system used here than by the FAO-system. In addition, in our system only females that are registered in a herdbook – or an estimate of these - are used in estimation Ne of a particular breed. This again increases the probability that the breed will be classified as being 'at risk', compared with considering the total number of female breeding animals or the overall population size.

The factor migration, i.e. incrossing or the use of animals of other breed(s), is not considered in the FAO-system. In our system a breed is transferred into one class of higher endangerment, if more than 20 per cent of the matings for reproduction are performed with animals of other breed(s). Taking account of migration appears meaningful since migration results in a deviation from the Hardy-Weinberg-equilibrium of gene frequencies, which in essence is not compatible with preservation of the present known and unknown genetic potential of a breed.

The number of breeding herds or breeding locations in which the breed is kept: If this number is less than 10 and the number of female breeding animals is below 500 then the breed is downgraded into a class of higher endangerment. A low number of breeding herds can increase the risk of rapid disappearance of the breed due to disease hazards, natural disasters or loss of interest of people.

Considering the three mentioned criteria (time based population size, incrossing and the number of herds) in the risk assessment, results in a higher proportion of breeds at risk than by the FAO-system. However, we feel that it allows a better coverage of breed dynamics, which is relevant to conservation.

Two other systems are of practical importance in Europe: The European Union defines the maximum number of female breeding animals for an endangered breed by EC-regulation 2078/92 (STAR-reports 1992, 1994) with 5 000 for cattle and horses and with 7 500 for sheep and goats, respectively (stable population size assumed). These numbers are 5 to 7 times larger than the limit set by the FAO-system with the result that many more breeds can be declared to be at risk and can apply for support. A justification for these high numbers cannot be seen.

The acceptance procedure of the Rare Breeds Survival Trust (RBST) (Alderson, 1995) on the other hand is quite demanding: Continuous existence of the breed for 75 years and at least 2 of the 3 following requirements:

Table 9. Relative importance of risk factors for downgrading a breed from 'not endangered' into classes of endangerment (in percent)

Risk factor	Species					All
	Cattle	Sheep	Goats	Pigs	Horses	Species
Effective Pop. Size Ne	44.8	62.4	57.6	71.8	46.5	57.9
Incrossing/Migration	29.8	13.1	11.9	6.2	29.9	18.7
Decreasing No of females	13.6	15.2	25.4	12.3	16.5	15.1
Low number of herds	7.5	9.3	5.1	9.7	7.1	8.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Accepted herdbook for six generations, less than 20 per cent contribution by other breeds and thirdly parent breeds used in the formation of the breed are no longer available. In addition: fewer than the following number of breeding females: pigs 500, goats 500, cattle 750, horses 1 000 and sheep 1 500. Last but not least, the factors minimum number of distinct male lines, decreasing population size and low number of breeding units are considered.

This acceptance procedure appears to be a well-founded system with many valuable criteria (although the critical animal numbers seem to be defined independently of the generation intervals of species). However, it will probably be difficult, in general, to supply both the quantity and quality of the required information on those breeds which are approaching endangerment.

Compared with the various systems of risk assessment mentioned above we feel that the system we used for the breeds of the EAAP-AGDB is an acceptable compromise between considering population genetic theory, short term risk factors and obtainable information. Table 9 presents information on the relative importance of the four factors used in our system for the downgrading of a breed from the status of 'not endangered' into classes of endangerment. Summarising all species, 57.9 per cent of the downgradings are due to a low effective population size, 18.7 % are caused by incrossing and 15.1 % by a decreasing number of female breeding animals. A low number of herds affects endangerment only in the order of 8.3 %. However, this may be caused in part by missing information of the number of herds. For breeds of cattle and horses the use of breeding animals of other breeds for reproduction is obviously not uncommon, because 29.8% and 29.9% of the downgradings, respectively, are due to these factors. In pigs incrossing (6.2%) is of least significance to endangerment, whereas the effective population size Ne is of relatively highest importance (71.8%).

Of course, the results of the applied classification system depend on the observed criteria and on the way of combining these into a system of risk assessment. For example it may be questioned whether the assumed values of maximum coefficients of inbreeding, length of generation intervals of species, maximum percentage of incrossing, etc., are the best possible ones and whether formula (4) for estimation of the effective population size is adequate for small populations with decreasing numbers of breeding animals and with generally increased variance of family size. Nevertheless, for a rational approach to conservation it appears necessary to take a position on these criteria.

Different objectives of conservation call for different approaches

One of the main differences among the various systems of risk assessment can be seen in the fact, whether migration, i.e. use of breeding animals of other breeds, is considered as a risk factor or not. The question whether this is meaningful depends on the primary objective of conservation (Simon,1999). From the many statements on conservation objectives of FAGR, e.g. by Bowman (1974), DGfZ (1979), Maijala *et al*. (1984), Simon (1984), UNEP (1992), Blair (1995), Hammond (1995), Cunningham (1996), British Society of Animal Science (1997), three main objectives have become apparent:

1. Subunits of species, such as populations, breeds, lines or strains, which under predominantly favourable production conditions are no longer competitive, may possess – unknown so far – a genetic potential which may become useful for future breeding options. The resulting argument, which we may call 'Conservation for potential use, later'(Simon,1999), is mainly expressed in developed countries of Europe and North America.
2. In regions with predominantly unfavourable production conditions, indigenous populations or breeds – in spite of their usually limited production

potential – generally form the basis of food security for an increasing human population because of their generally good adaptation to harsh production conditions. The argument, which we may call 'Conservation for sustainable use, now', is expressed mainly in and for developing countries of the world.
3. Rare breeds can be regarded as part of our living heritage and as such deserve to be preserved for historical, ethical or local reasons. This argument, which we may call 'Conservation for cultural reasons', seems to be expressed mainly in developed countries of Europe and North America.

Since objective number 1, 'conservation for potential use, later', aims to preserve an unknown genetic potential for requirements that are as yet unknown in far distant unknown future, it is essential to avoid all influences that can change the genetic makeup of the population, or – in terms of population genetics – that can change the Hardy-Weinberg-equilibrium of the population (Simon, 1995; 1999).

This requires avoidance of migration or the use of animals of other populations for reproduction, avoidance of artificial selection of mates in pursuit of defined breeding goals 'for improvement' and it requires the minimisation of random drift of gene frequencies and inbreeding by providing a sufficient effective population size Ne (Falconer, 1989). Therefore, it appears necessary to observe migration or incrossing already in the risk assessment, if conservation for potential later use is the primary objective of conservation, which at least in Europe is of high relevance (Simon, 1995).

Objective number 2, 'conservation for sustainable use, now', asks for a completely other strategy of conservation. Here, immediate use of endangered breeds is required in order to serve the immediate needs of the human population for food security. Genetic changes of breeds for improvements both by artificial selection within the breeds and by planned incrossing of animals of other, highly-productive breeds is an essential tool of sustainable use and conservation (see, for example, Rege and Bester, 1998; Mariante and Fernandez-Baca,1998). For this reason the situation of incrossing need not be considered in risk assessment, if 'conservation for sustainable use, now' is the main objective.

Finally, if objective number 3, 'conservation for cultural reasons' is the main objective of conservation, the situation of incrossing or use of animals of other breeds can be dealt with in either way. Purists may demand strict purebreeding and may reject any minor 'contamination' by 'foreign blood'. Others may tolerate the introduction of animals of similar breeds as long as the outside appearance of the breed is not severely changed. In other words, the consideration of incrossing is not a major issue in risk assessment, if conservation is pursued mainly for cultural reasons. A similar position may be taken on the question of selection of mates for 'genetic improvement' or for adaptation during conservation.

Summing up this section, we can see that the primary objectives of conservation in Europe are different from the ones in developing countries, say in Africa, South America or in Asia. It also follows that different procedures of risk assessment and of practical conservation should be applied (Simon, 1999).

The problem of choice of endangered breeds for conservation

An adequate approach to dealing with this problem is again affected by the primary objective of conservation. Within the context of conservation for cultural reasons, preference for specific breeds is usually expressed by the people or institutions which actually work with the breed. In this situation it is probably not adequate to impose criteria from outside as long as support from outside is not requested. Nevertheless, for example the NGO Rare Breeds Survival Trust requires in its acceptance procedure 'a distinct characteristic not found elsewhere', if other requirements are not met completely (Alderson,1995).

For the primary objective 'conservation for sustainable use, now' candidate breeds for the combined goal conservation and improvement should be the most promising adapted local breeds, preferably evaluated on the basis of reliable data of their adaptive value and on their combining ability with highly productive exotic breeds, as explained by Rege and Bester (1998).

For the primary objective 'conservation for potential use, later' priority should be given to those endangered breeds which – unknown so far - could possess a genetic potential which could become valuable in the future and which cannot be expected in other breeds. The main criterion for selection of a breed, therefore, should be the degree of genetic uniqueness or the degree of genetic distance in comparison to other breeds, i.e. both to the more popular breeds and to other endangered breeds, as explained for example by DGfZ (1979), Camussi *et al*.(1985), Weitzman (1993), Barker (1994) and Ollivier,1996).

Bearing in mind the relatively high number of breeds 'at risk' in Europe (Table 3), the availability of similar breeds in different countries and the generally high costs of conservation (Brem *et al*., 1984; Smith, 1984; Lömker and Simon, 1994), clarification of genetic uniqueness of breeds appears to be one of the most urgent tasks in conservation of FAGR in Europe. This can only be achieved in a satisfying way on a supra-national level, for which effective co-operation among all acting institutions across national borders is required.

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Inbreeding and loss of founder alleles in four variations of a conservation programme using circular mating, for Danish Shorthorn Cattle

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Summary

The beef cattle breed Danish Shorthorn is used as a model for simulation of four variations of the circular mating scheme running for 50 years. Schemes 1 and 2 used a fixed exchange of bulls between female groups while schemes 3 and 4 used a random exchange of bulls between female groups. The number of bulls used in schemes 1 and 4 was 16 while the number of bulls used in schemes 2 and 3 was 8. Inbreeding levels were computed and gene dropping was applied to estimate the risk of founder allele loss. In the population of year 50 the inbreeding levels for the four mating schemes are not statistically different. The male founder alleles contribute strongly to the population of year 50. The female founder alleles are in greater risk of being lost than the male founder alleles.

Résumé

La race bovine à viande Danish Shorthorn est utilisée comme modèle pour la simulation de quattre variations du schéma circulaire d'accouplement au long de 50 ans. Les schémas 1 et 2 utilisent un échange fixe de taureaux dans des groupes de femmelles. Le nombre de taureaux utilisés dans les schémas 1 et 4 a été de 16, tandis que le nombre de taureaux utilisés dans les schémas 2 et 3 était de 8. On a établi les niveaux de consanguinité et appliqué le comptage des gènes pour estimer le risque de perte d'allèles de base. Dans la population de la 50ème année les niveaux de consanguinité pour les quattre schémas d'accouplement ne sont pas statistiquement différents. Les allèles mâles de base contribuent fortement à la population de la 50ème année. Les allèles femmelles de base se trouvent en plus grand péril de perte que ceux des mâles.

Key words*: Gene dropping, Diversity, Beef cattle.*

Introduction

Several methods for the conservation of animal genetic diversity have been developed. Cryogenic storage is a conservation method free from human interference which might bring about genetic change (Bodó, 1990). Though storage of frozen semen and embryos has been known and used for years, the most important and practical method of conserving genetic diversity now and in near future is to manage genetic variability in some small living populations (Smith, 1984; Wang *et al.*, 1994). For most livestock breeds the conservation of a living population involves private breeders. Therefore it is necessary to have the support of the breeders if a conservation programme is to be a success (Rognoni & Finzi, 1984). This calls for breeding plans that are fairly easy for the breeders to implement in the population, e.g. breeding plans that fit the demographic structure of the population.

Many studies have been carried out on the topic of conserving small populations with a minimum of inbreeding (Kimura & Crow, 1963; Smith, 1984; Chevalet & Rochambeau, 1985; Bodó, 1990; Wang *et al.*, 1994). The majority of the authors suggested dividing the population into breeding groups of females and a rotation of males among the groups in a circular mating scheme. Chevalet & Rochambeau (1985) compared three turnover rates of the males in a circular mating scheme implemented in a small dairy cattle breed by simulations. In the first and second systems the males were used for two years in each group of females; totally the males were used for 16 years. In the first system the bulls were replaced by a son. In the second system the programme was initiated by selection of eight bulls and one male offspring of each bull as a replacement male. When a bull was culled the replacement male became the new bull and one of the culled bulls sons was selected as a new replacement male. Thus, the second system prolonged the generation interval of the males as compared to the first. In the third system the males were only used for two years and only in one group of females. Chevalet & Rochambeau (1985) found that prolonging the generation interval of the males delayed the inbreeding, but the rapid turnover (system three) gave the lowest inbreeding level.

Not only is the inbreeding of concern in conservation genetics, attention has also been given to the founder representation in the population under study and to preventing loss of founder alleles in the future (Chevalet & Rochambeau, 1985; MacCluer *et al.*, 1986; Lacy, 1989; Boichard *et al.*, 1997). With less breeding males than females, as is the case in cattle populations, there is a tendency of loss of female founder alleles, but a rapid turnover of the males enables the population to keep alleles from the female founders (Chevalet & Rochambeau, 1985).

In the circular mating schemes outlined by other authors (Kimura & Crow, 1963; Chevalet & Rochambeau, 1985) a fixed scheme is used for the exchange of males between the groups of females. In practice breeders might find it difficult to follow such a strict plan for the use of the males.

In this paper the objectives are:

1. to test the hypothesis that a random exchange of males between the groups of females increases the inbreeding level compared to an exchange of males that follows a fixed scheme;
2. to test the hypothesis that increasing the number of males will result in a decrease in female founder alleles.

Materials and Methods

Data of the beef cattle breed Danish Shorthorn (figure 3), provided by The National Committee of Danish Cattle Husbandry, is used as a model for simulations of four variations of the circular mating scheme. The first generation in the simulation of the mating schemes is founded by the Danish Shorthorn population of 1997 which consisted of 96 females and 8 males (Trinderup *et al.*, 1998). This year is referred to as year zero in the simulations.

Initially the females are divided into eight breeding groups, each of 12, referring to the original herds found in the data material. The number of females is fixed through the time period simulated to exclude the effect of fluctuations in population size.

Based on the age distribution of the females found in the data the replacement rates over age classes were computed (table 1). These replacement rates were used as culling probabilities for the cows in the simulations. As can be seen in table 1, the maximum age of females was set to 12 years in the simulations. The females were at least two years before they were mated for the first time. Once a cow was mated it was assumed that she gave birth to one calf of random sex each year until she was culled. To prevent loss of female founder alleles and to reduce variation in female family size the first choice of a replacement heifer was a daughter of the culled cow. A cow's offspring were kept in the population until she was replaced in order to maximize the possibility of having a daughter for replacement. Otherwise a heifer from the same breeding group or herd was randomly selected.

The difference between the four mating schemes was the way the breeding bulls were used in the population as illustrated in figure 1 and outlined in the following.

Scheme 1

Each of the eight bulls were assigned to one of the eight herds in year 0. Each bull was mated to all the females of his herd in year 0 and one son was randomly selected. Each of the eight selected young bulls were sent from the *j*'th herd to the *j+1*'th herd, except for the 8'th herd where the young bull was sent to the first herd. After year 0 the 'old' bulls were mated to the cows and the 'young' bulls were mated to the heifers. The following year, after a new rotation of young bulls, the 'old' bulls were culled and replaced by the 'young' bulls, who now were mated to the cows, and the new 'young' bulls were mated to the heifers. Thus, each breeding bull was used in two years. The rotation of bulls follows a fixed system which ensures that the male descendant of a certain bull returns to the herd with the female descendants after eight rotations. This scheme doubles the number of males from the original eight to sixteen.

Scheme 2

This scheme was similar to scheme one, except that here was only one bull per herd. This bull was mated to both heifers and cows. The bulls were only used for one year before they were replaced by one of their sons and the number of bulls was kept at the original eight.

Scheme 3

As scheme 2, but here the bulls were randomly assigned to a herd. This means that a bull was allowed to breed in the herd that he was born in.

Scheme 4

As scheme 1, except that the 'young' bulls were randomly selected among all the bull calves born and all living, non-breeding bulls up to 10 years of age. As in scheme 1 the breeding bulls were culled after two years. The selected bulls were not assigned to any herd, but could be mated to all cows and heifers in the population just like bulls from artificial insemination centres (A.I.-bulls).

PASCAL programmes were written to simulate the circular mating schemes. Each simulation of a mating scheme had a time span of 50 years or approximately 12 generations and were repeated 200 times.

The inbreeding coefficient for each animal was computed as proposed by Quaas (1976). The base animals for the inbreeding coefficient computation were the animals with unknown parents found in the data of Danish Shorthorn (Trinderup *et al.*, 1998). The founders of the circular mating schemes, the Danish Shorthorn population of 1997, were therefore not unrelated animals as defined by other authors (e.g. Lacy, 1989), but the animals entering the circular mating schemes (Foose, 1986; Falconer & Mackay, 1996). The founders of the circular mating schemes were the reference generation of a gene dropping (MacCluer *et al.*, 1986) which was conducted in order to estimate the founder representation after 50 years of breeding.

Results

Figure 2 shows the change in mean inbreeding coefficient over time in the four circular mating schemes. The inbreeding coefficients were highest in the schemes with random exchange of bulls in the first seven years of the simulations. But for animals born after year eight the inbreeding coefficients were almost the same in all four mating schemes.

Table 2 shows the inbreeding levels and trends with the standard deviation for the animals in the population of year 50. To reduce the confounding of the year of birth and the number of ancestral generations the

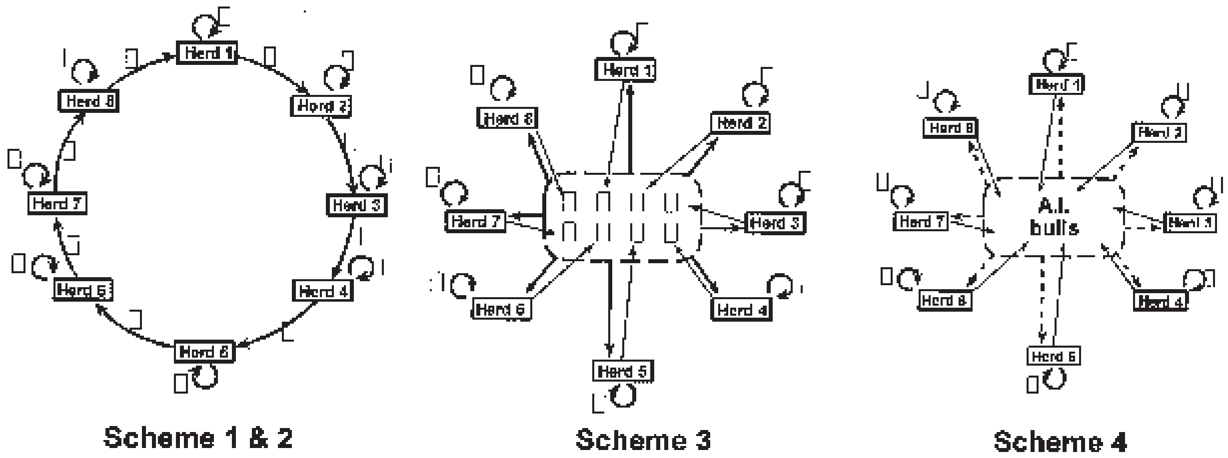

Figure 1. Illustration of the differences between the four mating schemes.

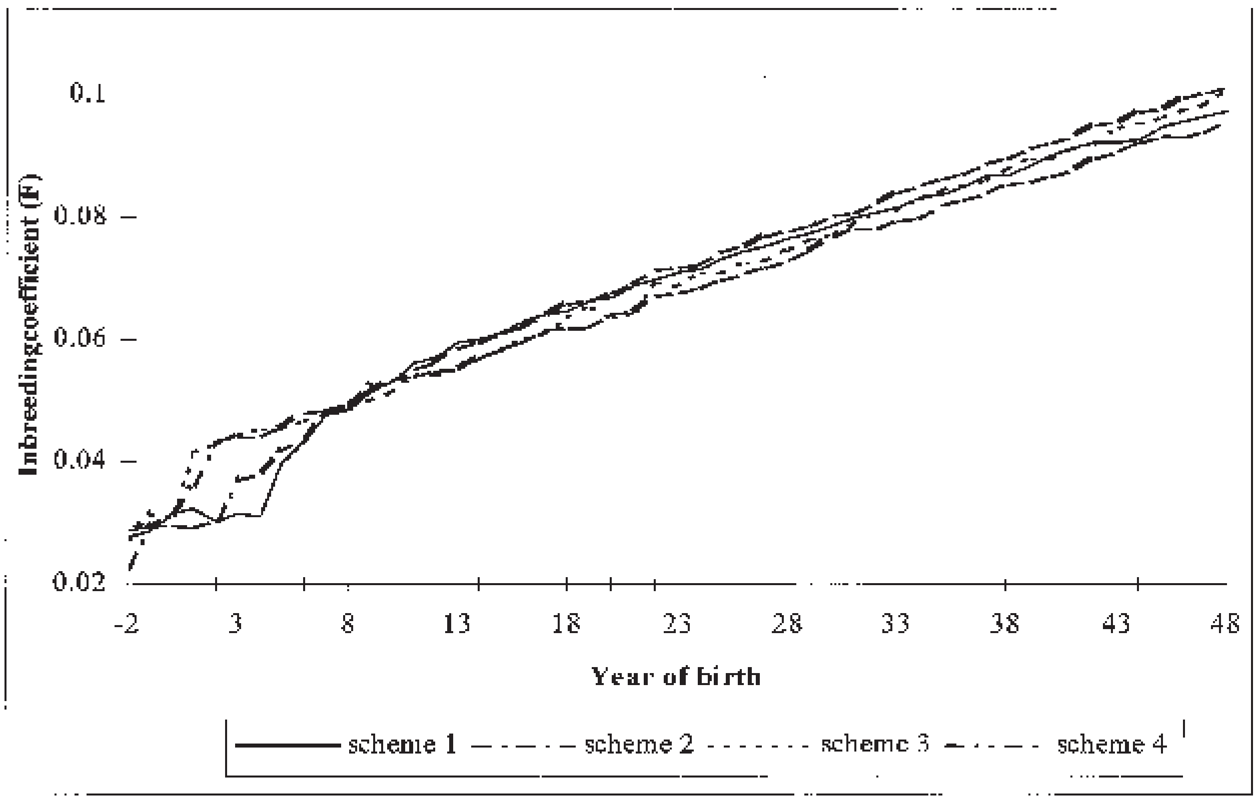

Figure 2. Average inbreeding levels per year of birth.

inbreeding trends should be tabulated for animals with more than seven ancestral generations (Te Braake *et al*., 1994). Thus, the inbreeding trends were tabulated from the two last generations in the simulations. The schemes with random exchange of bulls had the largest inbreeding trend and thus the smallest effective population size. Though scheme 4 (16 bulls) had the second highest inbreeding trend, this scheme resulted in the lowest mean inbreeding trend in the population of year 50. Scheme 1 (16 bulls) had the lowest inbreeding trend and the second lowest mean inbreeding levels at the end of the simulations. However, the standard deviations indicate that there is no statistical difference between the four mating schemes in rate of inbreeding and mean inbreeding level in the population of year 50.

Table 3 shows the result of the gene dropping. The criteria used here were the average contribution of alleles from each male and female founder, the total male and female founder allele contribution and the minimum and maximum percentage of the 200 replicates in which the alleles of a male or female founder was lost. The mating schemes using 16 bulls (i.e. schemes 1 and 2) resulted in the largest individual and total contribution of male founder alleles and the smallest minimum values of percent replicates with male founder allele loss. In all four mating schemes the maximum and minimum percent replicates with male founder allele loss were lower than the percent replicates with female allele loss. The percentages of replicates where the alleles of a female founder were lost were very much the same for all four mating schemes, due to the fact that the replacement strategy was identical in all four mating schemes.

Discussion

It was expected that if there were any differences in inbreeding trends among the four mating schemes they would be small, because the same replacement strategy for the females were used in all the mating schemes, the difference in population size was very small and there were only small variations in the generation length for the males. In the simulations there was no significant difference in inbreeding trend or in inbreeding level after 50 years. In the first few years there seems to be a difference between the schemes using random exchange of males and the schemes using a fixed plan for exchange of males. This confirms the hypothesis that random use of males results in an instantly higher inbreeding level, but the difference is not permanent. When the first rotation of males is completed, the inbreeding increases in the schemes with fixed exchange of males to the level of the schemes with random exchange of males after which the rate of inbreeding is fairly similar in all four mating schemes.

Concerning the inbreeding level and trend it can be concluded that it is not important that the breeders follow a strict plan for the exchange of males as long as they follow the guidelines used in these simulations: minimising the variation of family size within sires and dams and avoid fluctuations of population size. The size of inbreeding trend found in these simulations of about 0.5% is acceptable in any breeding plan, because with such a low increase in inbreeding it is possible to select the animals showing the least inbreeding depression (Adalsteinsson *et al*., 1994).

The distribution of male and female alleles in the founder population (year 0) is 7.7% male founder (8 bulls among 104 animals) alleles versus 92.3% female founder alleles (96 cows among 104 animals). The total contribution to the population of year 50 found in schemes 2 and 3, using eight bulls, was 20% male founder alleles and 80% female founder alleles (table 3), as found by Chevalet & Rochambeau (1985) in a simulation study running over 40 years. The change in the contribution of male and female founder alleles over years is due to the more intense use of bulls. Hence the male founder alleles are over-contributing to the population of year 50, whereas the schemes fail to some extent to keep the female founder alleles segregating.

Table 1. Replacement probabilities for female age classes.

Age, years	3	4	5	6	7	8	9	10	11	12
Probability	0.178	0.159	0.209	0.137	0.267	0.189	0.267	0.318	0.333	1.0

Table 2. Mean inbreeding and inbreeding trend with standard deviation in the population of year 50.

Mating scheme	Inbreeding trend [a)] %	S.D.	N_e [b)]	Mean inbreeding [c)] %	S.D.
1	0.47	0.22	106	9.48	0.29
2	0.52	0.19	97	9.82	0.37
3	0.62	0.37	81	9.71	0.53
4	0.55	0.32	91	9.28	0.46

a) Computed from the last two generations and averaged over the 200 replicates.
b) Calculated by the equation: $N_e = 1/(2*\Delta F)$.
c) Mean inbreeding coefficient of the last generation averaged over the 200 replicates.

Table 3. Founder contribution to the population of year 50 and risk of allele loss.

Mating scheme	Individual contribution of the two sexes, % males	females	Total contribution of the two sexes, % males	females	Replicates with founder allele loss, % males min.	max.	females min.	max.
1	3.07	0.79	24.52	75.48	4.5	12.0	30.5	48.0
2	2.44	0.84	19.54	80.46	10.5	16.5	30.0	48.0
3	2.54	0.83	20.31	79.69	11.5	20.0	33.0	48.0
4	3.04	0.79	24.34	75.66	4.0	22.0	32.0	47.5

Our simulations indicate that in a conservation programme using a circular mating scheme it can be up to the individual breeders to manage the exchange of bulls among the groups of females. The over contribution of founder sire alleles found in this investigation indicates that the initiating sires of a conservation programme should be selected carefully. A method to ensure that the founder sires of a conservation programme are of the type of interest is the gene dropping method as shown by Trinderup *et al*. (1998). The observed small differences between the four mating schemes indicate that other factors, such as economy, should be considered in the choice of conservation programme.

Figure 3. Danish Shorthorn cattle.

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Advances in the Brazilian animal genetic resources conservation programme

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Summary

Brazil has various species of domestic animals which developed from breeds brought by the Portuguese settlers soon after the discovery. Over the last five centuries, these breeds have been submitted to natural selection in particular environments and therefore today, they present characteristics adapted to the specific environmental conditions. From the beginning of this century, some exotic breeds, selected in temperate regions, have begun to be imported. Although more productive, these breeds lack adaptation traits, such as resistance to disease and parasites found in breeds considered to be "native", but even so, little by little, they have substituted the native breeds to such an extent that the latter are, today, in danger of extinction. To avoid the loss of this important genetic material, Brazil created an Animal Genetics Resource Conservation Programme, coordinated by the National Research Centre for Genetic Resources and Biotechnology (Cenargen) of the Brazilian Agricultural Research Corporation (EMPRAPA). The conservation has been carried out by various Research Centres of EMPRAPA, Universities, State Research Corporations, as well as by private farmers, with a single coordinator at national level, Cenargen. The conservation is being carried out through Conservation Nuclei, situated in the habitats where the animals have been subjected to natural selection (*in situ*), and by the storage of semen and embryos (*ex situ*). The recently created Animal Genetics Laboratory of Cenargen allowed genetic characterisation studies on cattle and horse breeds to begin, and, in the near future, work with asses, buffalo and sheep will be conducted.. From the results of this research it will be possible to compare the native breeds and estimate genetic distances between them. The harmonisation of chosen micro-satellites with those which have been used in other Latin America and Iberian Peninsula countries will be extremely useful for comparative studies and will allow future exchange of germplasm between countries.

Resumen

Los colonizadores portugueses, cuando vinieron al Brasil, trajeron consigo, animales domésticos. Estos se multiplicaron, y han sido sometidos a un amplio proceso de selección natural, adquiriendo características adaptativas y/o de producción para las diversas situaciones ecológicas del país y se han transformado en lo que conocemos como razas "locales" o "criollas". Cerca de tres siglos después del descubrimiento, muchos criadores comenzaron a importar animales de razas nuevas, buscando mayor productividad. El establecimiento de políticas que promovieron la dilución de germoplasma autóctono a través de programas extensivos de cruzamiento con esas razas importadas resultó en rápida substitución de las razas locales. Aunque éstas presenten productividad más baja que las exóticas, están extremamente bien adaptadas a las condiciones ambientales, a los que estuvieron sometidos bajo selección natural. En este trabajo discutimos la situación actual de la

conservación de las razas todavía existentes en Brasil. La investigación sobre evaluación, conservación y utilización de reservas genéticas de razas con características únicas, debe proveer la fundación para la utilización efectiva del germoplasma a nivel global. Complementariamente al uso tradicional de recursos genéticos animales, están los avances significativos en genética animal alcanzados en las dos últimas décadas, usando técnicas de biología molecular, tales como el mapeamento y la identificación de genes. Toda esta preocupación con la diversidad de los animales domésticos ha llamado la atención de los investigadores a la rápida desaparición de las razas locales, y, consecuentemente con la dilución del germoplasma autóctono a través del uso extensivo de programas de hibridación. La conservación de recursos genéticos animales en Brasil viene realizada en diversos Centros de Investigación de EMPRAPA (Empresa Brasileira de Pesquisa Agropecuária), Universidades, Empresas de Investigación de distintos Estados, bien como por productores privados, involucrando todo el país, bajo la coordinación del Cenargen (Centro Nacional de Investigación de Recursos Genéticos y Biotecnologia). La conservación se realiza por medio de núcleos de conservación, mantenidos en el habitat donde los animales están adaptados (*in situ*) y por el almacenamiento de semen y embriones (*ex situ*), incluyendo 7 especies animales: bovinos, bubalinos, cerdos, ovejas, cabras, caballos y asnos. Una importante tarea del Programa es aumentar la conscientización sobre la importancia de la conservación de recursos genéticos animales.

Introduction

Brazil has various species of domestic animals (Figure 1 to 4), which developed from breeds brought by the Portuguese settlers soon after the discovery. For almost five centuries, these breeds have been submitted to natural selection in determined environments so that, today, they present characteristics adapted to the specific environmental conditions.

From the beginning of this century, some exotic breeds, selected in temperate regions, have begun to be imported. Although more productive, these breeds lack adaptation traits, such as resistance to disease and parasites found in breeds considered to be "native", but even so, little by little, they have substituted the native breeds, to such an extent that the latter are, today, in danger of extinction. To avoid the loss of this important genetic material, Brazil created an Animal Genetic Resources Conservation Programme, coordinated by the National Research Centre for Genetic Resources and Biotechnology (Cenargen) of the Brazilian Agricultural Research Corporation (EMPRAPA).

The conservation has been carried out by various Research Centres of EMPRAPA, Universities, State Research Companies, as well as by private farmers, with a single coordinator at national level, Cenargen. This programme includes the following stages:

1. identification of populations in an advanced stage of genetic dilution;
2. phenotypic and genetic characterisation of germplasm; and
3. evaluation of productive potential. The conservation is being carried out by Conservation Nuclei, situated in the habitats where the animals have been subjected to natural selection (*in situ*), and by the storage of semen and embryos (*ex situ*). An important challenge for this programme is to increase awareness among the different segments of society for the importance of the conservation of animal genetic resources.

Objectives of The Brazilian Conservation Programme

The objectives of the Brazilian Animal Genetic Resource Conservation Programme are:

1. Identifying and characterising phenotypically conservation nuclei, establishing centres of originand assessing genetic diversity and variability for the groups of animals in danger of extinction;

Figure 1. Lavradeiro horse (Northern region).

2. Monitoring existing animal conservation nuclei;
3. Starting new conservation nuclei of breeds, which are identified as being in danger of extinction;
4. Conserving *ex situ* genetic material by cryopreservation of semen and embryos;
5. Genetically characterising the breeds involved in the Programme; and
6. Increasing the awareness of the diverse segments of society about the importance of the conservation of animal genetic resources.

Brazilian Animal Genetic Resources

Native breeds

The first cattle arrived in the American continent with the settlers in 1493, when some animals were left on the *Hispaniola* Island, which today is the Dominican Republic and Haiti. Cattle arrived in Brazil for the first time in 1532, introduced by the Portuguese. New introductions were made from the Archipelago of Cape Verde, where the Portuguese had been since 1460.

With its continental dimensions, Brazil has a huge variety of ecosystems where the different species of domestic animals brought by the first settlers began to establish themselves. Through centuries of natural selection, these animals attained special adaptation features specific to the ecological niche where they developed. Little by little, these animals dispersed over the whole Brazilian territory, and adapted to the very diverse environmental conditions with special characteristics such as in the Mato Grosso Pantanal, the North Eastern Agreste, the southern Brazilian Plateau and the Pampas of Rio Grande do Sul.

Due to the increasing demand for food of animal origin, farmers from many developing countries followed a course which, inevitably, led to the dilution of the “local” germplasm by the use of intensive crossbreeding with animals of exotic breeds. Many of these programmes failed, since the introduced animals had lower productive indices than the “local” breeds. This meant that a considerable number of farmers, in establishing their production systems, started to give a deserved importance to the “local” breeds, because of their adaptation to the environment which is usually hostile especially in the tropical region.

Zebu breeds

At the end of the last century, the introduction of animals, which until then had been considered extremely exotic – the zebu, began. Today these breeds are responsible for almost the total meat production in the country, as purebred or crossbred animals, from the latitude of São Paulo State northwards.

The zebu was first introduced into Brazil at the end of the 19th century. These animals, which originated in India, were originally crossed with the local breeds. Little by little the local breeds were absorbed. As a result, Brazil has today the largest zebu population in the world, while in their country of origin, where they are considered sacred, they are raised freely and protected by the community until they die a natural death.

Before the first importation of zebu cattle to the Southeast region of Brazil, the Southern region, of temperate climate, had already imported British cattle breeds which were highly productive. The latter did not have the same adaptation problems as animals of the same breeds in the tropical regions of the country. As in central Brazil, the British breeds introduced in the south of the country were used in crossbreeding schemes, leading again to a drastic reduction in the effective population size of the local breeds.

The expansion of the zebu breeds in Brazil is an undisputed reality. Today about 80% of the Brazilian cattle population is made up of zebu cattle or their crosses with Creole and European cattle. Although, up to this time, the conservation Programme is only involved with the native breeds, as they are threatened with extinction, there is already a demand from the zebu breeders that these breeds also be included. This is due to the almost total domination of the Nellore breed in Central Brazil. Of the six principal zebu breeds that exist in Brazil, approximately 85% of the total number of animals registered are Nellore.

Another aspect, which should be highlighted, is the fact that the use of new technologies and more efficient methods in genetic improvement programmes have led to profound changes in the procedures used by the breeders in the selection and reproductive management of their herds. Since 1984, when the first Bull Summary was published (Mariante *et al*., 1984), the breeders began to have more precise information about the genetic merit of each individual selection candidate. This, together with techniques which allowed the increase in reproductive capacity of the genotypes of interest (artificial insemination, embryo transfer and in vitro fertilization), have made the decision taking process more objective, especially when referring to the choice of animals for reproduction and mating schemes.

From the beginning of the publication of the Bull Summaries a large number of breeders started to put greater emphasis on the productive traits (taken from the Classification Table of the Summary), leaving behind the qualitative traits, such as breed characteristics and type. Bulls which up to then may have been left aside because of one or another external trait, which did not please the more conservative breeders, sired offspring with exceptional weight gains, proving that they imprinted production traits which were more important at slaughter. These bulls then became highly demanded by the Artificial Insemination Centres and their semen was sold at very high prices.

This situation resulted in the use of a small number of bulls, especially those classified as Elite, which, certainly led to the reduction in genetic variability. Ironically, this bull classification due to merit, together with more modern practices in animal reproduction

Figure 2. Pantaneiro horse (Northern region).

already mentioned, are partially responsible for the reduction in genetic variation (Mariante, 1990).

These preocupations of breeders led to the demand for the creation of a Germplasm Bank where semen and oocytes of zebu breeds would be stored, and would be monitored by EMPRAPA-Cenargen, although it would be situated at the headquarters of the Brazilian Association of Zebu Breeders in Uberaba, Minas Gerais State. The choice of animals which would be selected to donate semen and oocytes could be based on the Family Catalogue, which to date has been published for the Nellore breed (Magnabosco *et al*., 1997). The catalogues for the other zebu breeds should be published in the near future.

Information is presented about the zebu breeds originally introduced and selected in Brazil (Gir, Guzerat, Nellore and Sindi), and those formed there (Indubrasil and Tabapuã). Some animals of the Kangaian breed were also imported, but today their effective population size is greatly reduced.

Gir

The first animals of the Gir breed were probably imported around 1906. The greater portion of the importation, which resulted in creation of nuclei which exist today, dates from 1920.

Guzerat

The main importations of the Guzerat breed were to the Curvelo region, Minas Gerais State. Later, farmers in the Uberaba district, of the same state, became interested in raising this breed. The breed continued to expand to the north of São Paulo State and from there to other regions of the country. In the region known as the Minas Triangle, Minas Gerais State, it was used in crossing programmes with the Gir and Nellore breeds, creating the Indubrasil breed.

Nellore

The Nellore breed belongs to the second Indian group (cattle with white or grey hair and short horns), by the classification of Joshi and Phillips, referred to by SANTIAGO (1987). The Brazilian Nellore population is originated from importations made in 1930 and notably those in 1960 and 1962. At the present time the Brazilian Nellore is tending to the type of the Indian Ongole. Of all the zebu cattle found in Brazil the Nellore stands out because of its production qualities and it is becoming more prized by the breeders. Although for some time it had been left aside because of its short ears, similar to those of European cattle, today it is in first place in terms of Genealogical Registration, as well as its overwhelming use as bulls in herds of other breeds. The animals are highly fertile, resistant to parasites and to tropical disorders, precocious and have extraordinary maternal ability. In Brazil, the Nellore is essentially a meat producer, which has been subjected to highly intensive selection to obtain males for slaughter.

Sindi

The Sindi breed is very similar to the Gir from the west of India,to Sahiwal, from Punjab and the red cattle of Afghanistan. Due to the movement of nomad tribes in its home track, it had been crossed with Gir in some regions. The Sindi, which arrived in Brazil in about 1906 and 1930, had the Baixada Fluminense region, in the state of Rio de Janeiro, as their destination as well as the Novo Horizonte and Jardinópolis townships, in the São Paulo State. In general, these animals were small, good looking and useful in areas where there was a lack of forage, where it would be more difficult to maintain larger animals.

Table 1. Species and breeds included in research projects in the Brazilian Programme of Animal Genetic Resources Conservation - 1999.

Species	Breed	Region of the country
Cattle	Mocho Nacional (National Polled)	Southeast
	Pantaneiro	Centrewest (Pantanal)
	Curraleiro or Pé-duro	North east
	Criollo Lageano	South
Buffaloes	Baio	North
	Carabao	North
Asses	Jumento Nordestino (North-eastern Ass) or Jegue	Northeast
	Jumento Brasileiro (Brazilian Ass)	Southeast
Horses	Pantaneiro	Centrewest (Pantanal)
	Lavradeiro	North
Goats	Canindé, Gurguéia, Moxotó, Marota, Repartida	Northeast
Sheep	Criollo Lanado	Northeast
Diverse species	Animal Gene Bank (AGB)	Centrewest

Table 2. Number of semen doses and embryos stored in the Animal Germplasm Bank (AGB) of Cenargen, in 1999.

Species/Breed	No. of semen doses	No. of embryos
Cattle		
Criollo Lageano	6 159	9
Mocho Nacional	6 533	54
Caracu	3 950	47
Curraleiro	5 300	17
Criollo Argentino	288	-
Pantaneiro	4 277	20
Junqueira	2 143	4
Patuá	250	-
Goats		
Moxotó	546	-
Canindé	109	-
Sheep		
Criolo Lanado	500	56
Horses		
Pantaneiro	-	1
Asses		
J. Nordestino	150	-
Total	30 205	208

Indubrasil

The Indubrasil, according to Santiago (1984), was the first zebu breed formed by Brazilian breeders, based on cattle imported from India. Initially, its pioneers in the Minas Triangle gave it the name of Induberaba, but only in 1936 was it officially recognised as the Indubrasil, a name that it keeps today. Its origin, although basically founded from the Gir, Nellore and Guzerat breeds, is obscure as to the exact genetic contribution of each of the breeds or zebu types used.

Tabapuã

According to Santiago (1984), the first polled zebu, object of selection in Brazil, was the Tabapuã, named after the township where it was formed in São Paulo State. Phenotypically, these cattle resemble the American Zebu (Brahman), which means that several Brahman cows, when dehorned, are confused with Tabapuã animals. Despite this, its racial composition is mainly Nellore with some Guzerat and Gir.

Formation of Conservation Nuclei

The Conservation Nuclei, organised in the form of research projects, can be found all over the country. The elaboration of research projects, usually based in research centres near the habitats where the animals were naturally selected over the last few centuries, was the solution adopted to try and rescue the small effective populations of the breeds in danger of extinction.

The articulation of Cenargen with these Conservation Nuclei (Germplasm Banks) is made by Germplasm Curator (based in Cenargen), in collaboration with the Curators of the Germplasm Banks (normally the research project leaders). In the present collaborative programme, there are 3 Germplasm Curators for animals at Cenargen: one for large species (cattle, buffaloes, horses and asses), one for small species (sheep, goats and pigs) and one for wildlife.

The Animal Germplasm Curators are researchers of Cenargen, attributed with giving advice to the Technical Head in relation to germplasm considered relevant to national agriculture and animal production. They work at national and international level, with subjects related to the enrichment of knowledge and conservation of product germplasm, being supported by technical areas for these activities. Among other functions, the animal Germplasm Curator has to promote, start and follow activities related to conservation, multiplication and/or regeneration of germplasm of products under their responsibility. The Curators of the Germplasm Banks have the responsibility to

Table 3. Recent Scientific Events which included Conservation of Animal Genetic Resources in their programmes.

	Date	Event
Tampico, Mexico	November, 1998	4th Ibero American Congress for Criollo Breeds
Kathmandu, Nepal	August 1998	4th World Conference on Conservation – RBI
Colina, SP, Brazil	July 1998	National Equine Forum
Soeul, Korea	July 1998	8th World Congress of Animal Production
Valdivia, Chile	May 1998	X Chilean Veterinary Medicine Congress
Armidale, Australia	January 1998	5th World Congress on Genetics Applied An. Production
Niterói, RJ, Brazil	December 1997	Workshop of the Rio de Janeiro Research Corporation
Amsterdam, Holland	November, 1997	CEDLA Workshop
Brasilia, DF, Brazil	July 1997	Workshop on Conservation of Animal Genetic Recourses
B.Horizonte, MG, Brazil	May 1997	Brazilian Animal Production Congress – Zootec'97
Ottawa, Canada	February 1997	Symposium organised by Ag-Canada
Guadeloupe, F.W.I.	December 1996	Caribbean Meeting, INRA
Bogota, Colombia	November 1996	3rd Ibero American Congress for Creole Breeds
C.Grande, MS, Brazil	October 1996	XV Pan American Veterinary Congress (PANVET)
R. Preto, SP, Brazil	May 1996	33rd Brazilian Animal Breeding Society Congress
Brasília, DF, Brazil	November 1995	Workshop for curators of Conservation Nuclei
Orlando, USA	July 1995	87th Annual Meeting American Society of An. Science
San José, Costa Rica	July 1995	Towards an Inter American System for An. Genet. Res.
Circello, Italy	June 1995	Expert Consultation of FAO
Guelph, Canada	August 1994	4th World Congress on Genetics Applied An. Production
Kingston, Canada	August 1994	3rd World Conference on Conservation – RBI
Buenos Aires, Argentina	July 1994	Argentinean Association of Animal Production Congress
Rio de Janeiro, RJ, Brazil	July 1993	Annual Meeting of the Brazilian Na. Production Society
Santiago, Chile	July 1993	Conservation Symposium (ALPA Meeting)
Zafra, Spain	September 1992	1st Ibero American Congress for Creole Breeds
Córdoba, Spain	September 1992	World Meeting on Domestic Animal Breeds
Turrialba, Costa Rica	July 1992	Conservation & Development of An. Genet. Res. in L.A.
Rio de Janeiro, RJ, Brazil	June 1992	Science Forum (Earth Summit)
Nanjing, China	January 1992	FAO International Course on Regional Gene Banks

maintain the Conservation Nuclei as well as to multiply, regenerate and distribute the germplasm.

At the present time the Programme of Conservation of Animal Genetic Resources has 13 ongoing research projects (Table 1).

As already mentioned, the Conservation Nuclei are being kept where the animals were naturally selected over centuries. In a huge country such as Brazil, with several different climates, there is no reason to conserve animals in environments different from those to which they are adapted. Trips for the identification of new nuclei, in order to maintain endangered breeds considered to be native, means that new populations are continually being identified. Some are very similar to breeds officially included in the *in situ* conservation programme and others have totally distinct characters. In general, these populations, which have been identified in the last few years, have extremely reduced effective population sizes. The strategy used has been to include them initially in the cryopreservation programme, so as to assure the storage of genetic material in the BGA in Cenargen. At the same time, their blood is collected to be used for genetic characterisation.

The results of genetic characterisation could reduce existing doubts about breed groupings. As an example, we can cite the case of the Criollo Lageano, Franqueiro and Junqueira cattle. All have huge horns and some breeders insist that they are the same breed, while others treat them as separate breeds. With genetic characterisation, strategies could be developed based on facts and not on suppositions.

Cryopreservation

To avoid the disappearance of local breeds, FAO began contacts in 1987 to install regional Animal Gene Banks (RAGBs) for developing

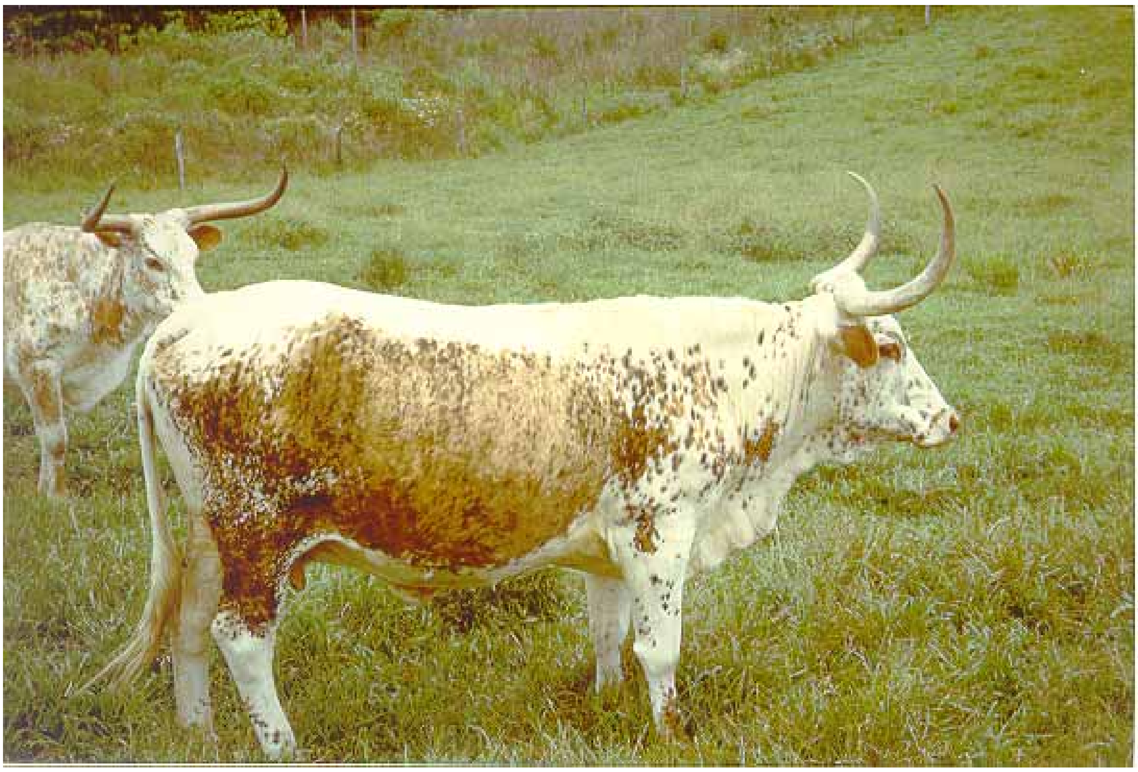

Figure 3. Criollo Lageano cow (Southern region).

Table 4. Number of animals of various breeds threatened with extinction on Cenargen's Experimental Farm in 1999.

Species/Breed	Number of males	Number of females
Cattle		
Caracu	1	1
Criollo Lageano	1	5
Curraleiro	7	10
Junqueira	2	3
Mocho Nacional	1	1
Pantaneiro	6	18
Patuá	1	2
Puganu	1	1
Goats		
Azul	1	4
Canindé	2	`3
Marota	3	6
Moxotó	3	8
Nambi	2	2
Repartida	1	4
Horses		
Campeiro	2	6
Pantaneiro	4	5
Asses		
Casco de Mula	1	1
Inhata	1	2
Monteiro	1	2
Moura	1	1
Nilo	1	2
Piau	1	1
Rabo de Peixe	1	2
Total	51	104

countries. At that time Cenargen/EMPRAPA had been chosen to host the Bank that would be responsible for the storage of semen and embryos of the breeds of domestic animals in danger of extinction in South America. A copy of the material would be stored in the Instituto Nacional de Tecnologia Agropecuaria, Argentina, for security reasons. Because of health legislation differences, regulating the entry and exit of genetic material between countries, none of these RAGBs was established. There is a need to reach a common denominator, so that the future exchange of germplasm is facilitated, as the RAGBs have no commercial purpose, just storage for future use. RAGBs were also proposed for Asia and Africa. Seeing that, at that time, this goal would be difficult to achieve, FAO decided to stimulate these countries to create their own Animal Germplam Banks or to strengthen those that already existed. At the same time it gave priority to the Domestic Animal Diversity – Information System - DAD-IS (FAO, 1998a). The erosion of domestic animal diversity is very clear as is evident from the number of breeds threatened with extinction world-wide (Hammond, 1993). With the help of many countries and organisations, particularly the European Association for Animal Production (EAAP), in 1991 FAO started a world-wide programme, with the collection of population data for seven main species of domestic animals. To date, two editions of the *World Watch List for Domestic Animal Diversity* have been published (FAO, 1993 and FAO, 1995).

In Brazil, the conservation of animal genetic resources was not jeopardised, since when FAO proposed the creation of the RAGBs, Brazil had already created its own Animal Germplasm Bank (AGB). The Brazilian AGB is kept at Cenargen, which is responsible for the storage of semen and embryos of various breeds of domestic animals threatened with extinction in Brazil. It has existed since 1983 and it is because of its existence that Cenargen was chosen to host the South American RAGB, as mentioned above. Table 2, shows the present state of the Brazilian AGB.

Conservation Nuclei must exist for semen, embryos and oocytes of the species/breeds in danger of extinction to be collected. For some breeds included in the Brazilian programme, there are less donor bulls than the number recommended by Smith (1984), which are 25 donors per breed with 100 doses/bull. Unfortunately, when the *ex situ* conservation began, some of the breeds did not have this number of males. Therefore, although more than the recommended 100 doses/bull has been collected, the number of bulls was reduced. In other cases, as the Argentine

Creole, as it is not a Brazilian Breed and its use in Brazil is not common (although some bulls were used on the Criollo Lageano of the Fazenda Canoas, Santa Catarina State) it was decided to stop the collection, and the semen already collected was kept by the AGB.

As the Conservation Nuclei are increased in size and number, or new herds are identified, the intention is to collect genetic material from the greatest possible number of animals, thereby increasing the genetic representation in the AGB.

Another National research programme of EMPRAPA, is that of Biotechnology Applied to Agriculture and Animal Production. This contemplates a project which intends to develop animal reproduction techniques that may be used in Conservation work. Among the techniques being studied are embryo bisection, *in vitro* fertilisation, cloning and the formation of transgenic animals.

Genetic Characterisation

For a long time the characterisation of different breeds of domestic animals in Brazil was based, almost exclusively, on phenotypic data (morphology and production), which sometimes is insufficient to distinguish between pure breeds and those heavily influenced by environmental factors (Panepucci, 1986). With reference to genetic characterisation, the few papers published on Brazilian native breeds include only cytogenetic studies, blood groups and protein polymorphisms.

In the bovine species, structural differences of the Y chromosome observed in different karyotypes of animals of European origin (*Bos taurus*) show that this chromosome is submetacentric, while Afro-Asian breeds (*B. indicus*) are acrocentric. While studying the Curraleiro breed, Brito (1995) verified the occurrence of polymorphism of this chromosome at a cytogenetic level. About 68% of the animals had an acrocentric Y chromosome, which indicates that, at some time during the formation of this breed, zebu type animals were introduced. This dimorphism of the Y chromosome had been observed by Tambasco (1985) in four native bovine breeds (Caracu, Mocho Nacional, Curraleiro and Criollo Lageano), which indicates that both bovine subspecies were involved in the formation of native breeds. Although the Criollo Lageano has a lower acrocentric Y chromosome frequency, this could be due to the geographical location of this breed (found in the South of the country where the zebu influence is much smaller). Crossing the two species may have been favourable for these breeds, because it associated certain qualities of the taurines, such as precocity and productivity, with hardiness and disease resistance of the zebus.

Another study with native cattle breeds was carried out by Dr. Mário Poli (personal communication), of INTA, Argentina, consultant to Cenargen, in 1985. Poli cites that from phylogenetic trees, based on data obtained from the study of thirty blood factors and genetic frequencies, only three systems were determined (F, J and L), since the lack of genealogical registers made it impossible to estimate the frequency of more complete phenogroups.

In the Caracu breed, Bicalho (1985) carried out a population study of different breeding nuclei based on blood groups and protein polymorphisms. It was concluded that this breed originated from the Portuguese breeds Alentejana and Mertolenga, although there are no registers of the latter breed entering Brazil. The author concluded that the Caracu has low genetic variability and was subdivided into four genetically distinct subpopulations. From the analyses, it was suggested that animals should be exchanged between nuclei to prevent greater loss of genetic variability.

The genetic characterisation of several cattle breeds was the subject of a doctorate thesis using protein polymorphisms. The study included three native Brazilian breeds (Caracu, Pantaneiro and Mantiqueira), one native Argentinean (Argentine Creole) and two zebu breeds (Nellore and Gir). The genetic distances between pairs of populations were calculated using NEI method (1972 and 1978), from gene frequencies of eight protein systems, using the DISPAN programme. The highest values were obtained between pairs where one of the breeds was of *Bos taurus* origin and the other of *Bos indicus.* The average distance between the native Brazilian and the Nellore and Gir breeds was 0.1083 and 0.0964, respectively (LARA, 1998). The small values obtained for genetic distances between the Caracu, Mantiqueira and Pantaneiro with the Argentine Creole, suggest a great similarity between them and support the hypothesis that these breeds were founded by Iberian cattle, probably sharing the same ancestry.

The small number of projects in this area, up to the present time, helped establish the Animal Genetics Laboratory of Cenargen as a priority. The laboratory started to function in February 1998 and will work primarily with DNA polymorphisms for the genetic characterisation of the populations of animals of the conservation programme. At the same time, a DNA Bank is being set up, which already has samples from several species of animals (60 heads of cattle, 18 horses, 113 asses, 154 goats and 89 buffaloes). The intention is that, in the short term, cells and tissues of several species, including wild animals, should be stored.

For the first stage, the intention is to verify the degree of diversity within the breeds/native populations, to gain a global idea of genetic distances using similarity indices. Following an FAO recommendation, 50 animals of each breed will be used. Since the sampling process is vital for the success of the proposed plan, an investigation will be made into the Conservation Nuclei and/or Breed Societies, when they exist, of the geographical distribution of each breed, so that the samples are representative of the whole population known to exist. The DNA may be collected from blood or semen.

For comparative studies, two methods for the evaluation of DNA polymorphisms will be used. Since there is not sufficient data in the literature to evaluate, from molecular information, what constitutes a distinct breed, it is necessary to compare different markers (Grattapaglia, personal communication).

A priori, the RAPD will be used as it is relatively cheap and fast, as well as relevant to the study (Egito, 1995). Micro-satellites will also be used, as they are well developed in cattle studies. This technique differentiates the heterozygotes which are co-dominant thus generating more information to discriminate the variability within populations, helping in the choice of individuals for conservation. In the Animal Genetic Laboratory, work has already begun on cattle and horses and will soon include asses, buffaloes, goats and sheep species.

The primers for the micro-satellites on cattle were selected from thirty identified by the International Society of Animal Genetics (ISAG), after a meeting in 1996. These primers are the same recommended by MoDAD-FAO (FAO, 1998b) and are being used for genetic characterisation of the Iberian breeds in a project being carried out by the University of Porto, Portugal, and financed by the European Community. This fact will make the comparison of the breeds studied in both projects easier and facilitate the exchange of germplasm between the countries.

Public Awareness of the Importance of Conservation of Animal Genetic Resources

Another objective of the programme is to make the various sectors of society aware of the importance of conservation of animal genetic resources. Presenting the programme on various opportunities has helped significantly. The creation of a *Farm Park,* as has occurred in several European countries will be another strategy to bring this theme to the public attention.

Presentation of the Brazilian Animal Genetic Resources Conservation Programme

The presentation of the Brazilian Programme has stimulated the creation of Conservation Nuclei in Brazil, as well as of other National

Animal Germplasm Banks in other Latin American countries. The creation of these other banks may allow, in the medium term, the collection of all the material in one place - the RAGB (with a duplicate in a second country) as proposed by FAO in 1987. In this way, the Programme has been presented in different events in Brazil and abroad. In Brazil the intention is to bring the philosophy of the work with animal conservation to society, as well as the actual state of development of the programme (often stimulating the creation of new Conservation Nuclei); abroad the intention is to

1) show the state of animal genetics resources conservation in Brazil, stimulating the creation of new National Banks and
2) present the actual conservation situation on the continent as a whole. It is hoped that the awareness level of society on the importance of conservation of animal genetic resources is being raised at both the national and international level.

Since the conservation of animal genetic resources is a relatively new topic, it has only recently been included in the programmes of congresses and symposia. Until recently, the researchers who dared to breach this topic were labelled as philosophers. It was said that the so-called "native" breeds should be conserved in Zoological Gardens. Fortunately, this point of view is changing rapidly, and the most important congresses in the animal area are including sessions or symposia on this topic. At last, traits such as adaptation, hardiness and disease and parasite resistance, which many of these local breeds have, are being recognised and valued. Table 3 presents some of the places and sessions where the Brazilian Animal Genetic

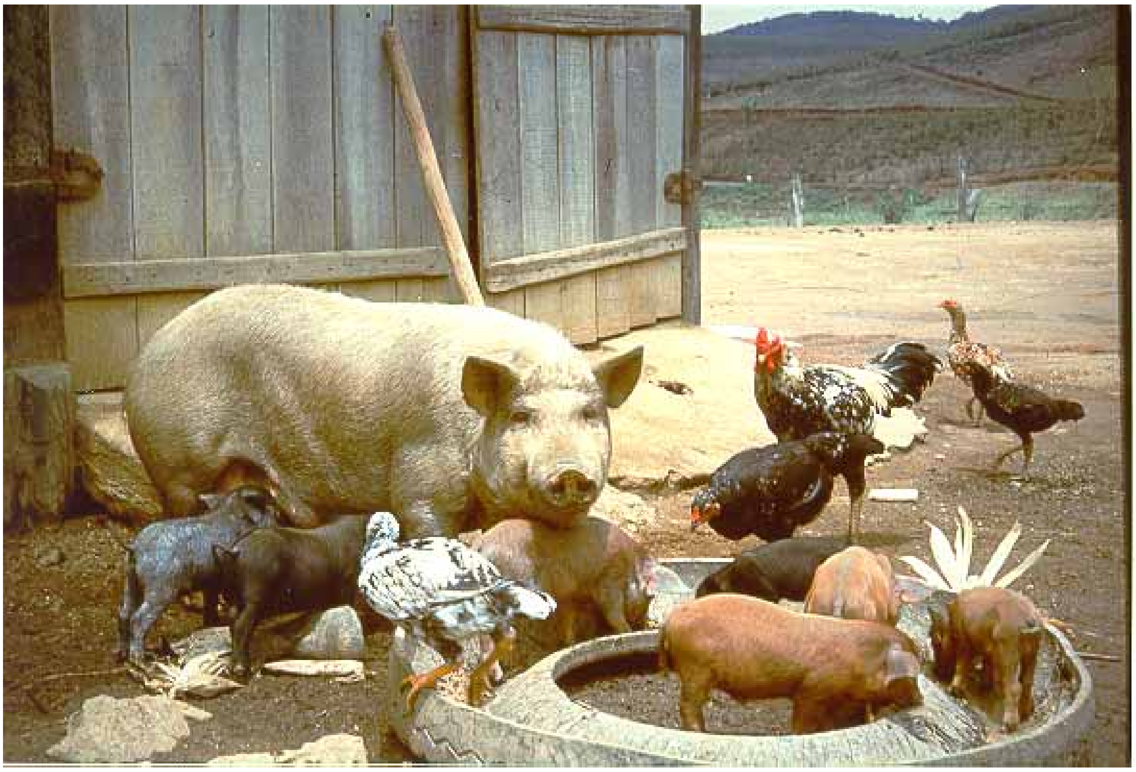

Figure 4. Tatu pig (South-Eastern region).

Resources Conservation Programme has been presented over the last seven years, so that the increasing status of conservation can be evaluated.

Brazilian farm park

In 1993, the Animal Germplasm Bank (AGB) of Cenargen was recognised by the Brazilian Ministry of Agriculture, who donated an area of 900 ha for the installation of a *Farm Park*, which will be called Farm Park for the Animal Diversity in Brazil. The main objective of this park will be to bring together, in Brasilia, living examples of domestic animal breeds of different species (cattle, buffaloes, horses, asses, sheep, goats, pigs and poultry) which are in danger of extinction. This Farm Park will be open to the public and is already being built on Cenargen's Experimental Farm. Up to the present time, a large part of the animals that will be shown on the Farm Park have already been brought to Brasilia, and are being used for semen and embryo collection stored in the AGB. Table 4 shows the number of animals of the various species/breeds that can be found in Brasilia and which will be part of the Farm Park.

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Indexes

AGRI 1 to AGRI 25

Contents AGRI 1-25[1]

[1]Title. author(s): pages

Pages refer to those on the electronic version (CD Rom and Internet), which might not coincide with the hard copy.

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AGRI 18/1996

AGRI 19/1996

AGRI 20/1996

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AGRI 24/1998

- El ganado criollo Romosinuano (Romo). G. Martínez Correal: 1-11
- Genetic resistance to endoparasites in sheep and goats. A review of genetic resistance to gastrointestinal nematode parasites in sheep and goats in the tropics and evidence for resistance in some sheep and goat breeds in sub-humid coastal Kenya. R.L. Baker: 13-30
- The Ponies of the Giara highland. M. Dattilo: 31-39
- The Black Maltese: a Mediterranean, light breed of poultry. J.G. Mallia: 41-48
- Amélioration des performances pondérales du Pigeon au Maroc par croisement de deux races locales avec une race d'origine européenne. B. Benazzouz, A. Soulaymani & A. Mokhtari: 49-61
- Caractéristiques morphobiométriques de la poule du Sénégal. A. Missohou, R.S. Sow & C. Ngwe-Assoumou : 63-69

AGRI 25/1999

- The state of African cattle genetic resources. I. Classification framework and identification of threatened and extinct breeds. J.E.O. Rege: 1-26
- Characteristics of Munjal sheep. B.P. Kushwaha, Riyazuddin, R. N. Singh & S. Parthasarathy: 27-31
- Conservation of livestock breed diversity. J.S.F. Barker: 33-43
- The development of a system of linear measurements to provide an assessment of type and function of beef cattle. G.L.H. Alderson: 45-55
- A programme for the inventory, characterisation, evaluation, conservation and utilisation of European rabbit (*Oryctolagus cuniculus*) genetic resources. G. Bolet, M. Monnerot, C. Arnal, J. Arnold, D. Bell, G. Bergoglio, U. Besenfelder, S. Bosze, S. Boucher, J.M Brun, N. Chanteloup, M.C. Ducourouble, M. Durand-Tardif, P.J. Esteves, N. Ferrand, G. Hewitt, T. Joly, P.F. Koehl, M. Laube, S. Lechevestrier, M. Lopez, G. Masoero, R. Piccinin, G. Queney, G. Saleil, A. Surridge, W. van der Loo, J. Vanhommerig, J.S. Vicente, G. Virag & J.M. Zimmermann: 57-71
- The Peel-Neck chicken of Belize and Guatemala, Central America. J.G. Mallia: 73-78
- European approaches to conservation of farm animal genetic resources. D.L. Simon: 79-99
- Inbreeding and loss of founder alleles in four variations of a conservation programme using circular mating, for Danish Shorthorn Cattle. M. Trinderup, J.N. Jørgensen & M. Hansen: 101-108
- Advances in the Brazilian animal genetic resources conservation programme. A. da S. Mariante, M. do S. M. Albuquerque, A. A. do Egit & C. McManus: 109-123

Authors' Index [1, 2]

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Breed/type Index[1, 2]

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Selected secondary citations[1, 2]

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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.

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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.

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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.

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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 "&".

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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 nonnlinear 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 3 1/2″) 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