Strategies for the conservation of the indigenous Kerry Cattle of Ireland

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Summary

The Kerry is the most numerous of the three surviving indigenous breeds of cattle in Ireland. With a total population currently under a thousand animals it is listed as endangered in the World Watch list. Conservation efforts currently focus on both *in situ* and *ex situ* conservation. This approach is possible because of the existence of a few enthusiastic pedigree breeders, a breed society and a herdbook with registrations dating back to the 19th century. The Kerry cattle population is small with overlapping generations. The main objective in its conservation is to minimise inbreeding and conserve genetic variation. The Irish Cattle Breeding Federation (ICBF) was recently mandated to support and co-ordinate the conservation efforts which are centred around minimum coancestry selection, a mating advisory service, semen and embryo cryoconservation. To this end, a mean relationship system was developed for the routine computation of inbreeding and provision of a mating advisory system. Four bulls are identified annually for semen collection and storage. A second scheme aims to identify 15 cows for embryo cryoconservation over a three-year period. Future conservation efforts will benefit from the collation of Kerry cattle breeding and production information in a central database. This and a study of the dynamics of the Kerry cattle population are future priorities for ICBF in an effort to prevent the extinction of the Kerry cattle.

Resumen

La raza Kerry es la más numerosa de las tres razas indígenas de bovino que actualmente viven en Irlanda. Con una población total actualmente por debajo de los mil animales, se encuentra en la lista de razas en peligro publicada por la World Watch List. Los esfuerzos actuales de conservación se centran tanto en lo métodos *in-situ* como *ex-situ*. Este enfoque es posible gracias a la colaboración y entusiasmo de un pequeño grupo de mejoradores, una sociedad de raza y al libro de registro de razas que contiene datos desde el siglo XIX. La raza Kerry posee una pequeña población con superposiciones de generación. El mayor objetivo en su conservación se centra en minimizar la endogamia y conservar la variación genética. La *"Irish Cattle Breeding Federation"* (ICBF) ha sido solicitada hace poco para coordinar y dirigir los esfuerzos de conservación que se centran alrededor de la selección del mínimo de consanguinidad ancestral, un servicio de consultoría para los apareamientos, la crioconservación de semen y embriones. Con este objetivo, se ha desarrollado un sistema de puesta en relación para la computación de rutina de la endogamia y la extensión del servicio de consultoría para los apareamientos. Se identificaron cuatro toros cada año para la recogida y conservación del

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semen. Un segundo esquema fue establecido para identificar 15 vacas para la crioconservación de embriones en un período de tres años. Los futuros esfuerzos de conservación se beneficiaran de esta recopilación de bovinos Kerry y de la información recogida en una base de datos centralizada. Todo esto junto con un estudio de las dinámicas de población de la raza Kerry forman parte de las prioridades futuras de ICBF en un esfuerzo de prevenir la extinción de la raza.

Keywords: *Cattle, Conservation, Database, Embryo, Ireland, Semen, Strategy, Kerry, Kinship.*

Introduction

The Kerry is one of the oldest European breeds of cattle and one of the few surviving breeds indigenous to Ireland. Others with some purebred calves registered in 2003 include the Irish Maol (or Irish Moiled) and the Dexter breeds. The Kerry breed was the most prevalent breed of cattle in Ireland until the 17th century when importation and crossing with other breeds resulted in the marginalisation and subsequent concentration of the remaining pure bred animals in the relatively poor south western region of Ireland (Medlycott, 2000). Today, the Kerry cattle can again be seen all over the country even though 65% of the breeders are concentrated in Kerry, Cork, Waterford and Dublin counties (KCSI, 2000).

The Kerry can be described as a small dairy breed of cattle of about the same size as the Jersey cattle (Figures 2 and 4). It is mostly black, horned and weighing between 350-450 kg at maturity. Average production based on a small number of milk-recorded cows in 2001 was 2832kg of milk at 3.68% fat and 3.23% protein. Average lactation length was 230 days while calving interval averaged 360 days (ICBF, 2002). Similar production figures obtained in 1985 were 2 844 kg milk, 3.53% fat and 3.24% protein (O'hUigin and Cunningham, 1990). It is known to carry the partially recessive dwarfism gene which in the homozygous state results in a non-viable 'bulldog' calf while in the heterozygous state, results in the semi-dwarf Dexter (Cunningham, 1963). Detailed description of the animal, its history and breed development can be found in previous publications (e.g. Wilson, 1909; Curran, 1990; O'hUigin and Cunningham, 1990). A major attribute of the breed is its ability to survive and produce reasonable amounts of high solid content milk in relatively harsh weather and grazing conditions. Preventing this breed from going extinct is consistent with the FAO global vision for the conservation of animal genetic resources.

Conservation Efforts

Survival of the Kerry cattle to date can be attributed to the tenacity of a handful of Kerry breeders assisted largely by the Royal Dublin Society (RDS) and the Department of Agriculture and Food (DAF). The RDS was responsible for the establishment and maintenance of the herdbook from the early years. The first volume of the Kerry herdbook was issued in 1890 containing entries for 118 Kerry bulls, 942 Kerry cows and 237 Dexters (Mescal, 2000). The herdbook was closed in 1904 from which time only progeny of registered animals were accepted for registration. Sixty four volumes of the Kerry herdbook have been published to date with only the last three volumes (62 to 64) computerised.

The Kerry Cattle Society of Ireland (KCSI) was founded in 1917 and has worked with the RDS and breeders since then to promote the breed and maintain the herdbook. In 1925, Government legislation created the 'Kerry cattle area' in which by law, only Kerry bulls were allowed to be used. In the late 1970s and throughout the 1980s, the Government introduced a premium payment scheme aimed at encouraging herds keeping purebred Kerry cattle. Public parks took in and maintained large numbers of purebred

cattle. This period also saw the first attempt to conserve the breed by aiming to reduce the rate of increase in inbreeding.

In 1996, a ministerial advisory committee on Genetic Resources of Food and Agriculture was set up. Funds allocated to this committee allowed the first major review and development of a conservation strategy for the Kerry cattle in Ireland. The task of conserving the breed was passed on to the Irish Cattle Breeding Federation (ICBF) shortly after its establishment in 1998.

The ICBF genetic conservation centre was set up in late 1999 and has been involved in two main projects focussed on cryo-preservation of semen and embryos. ICBF has recognised that future efforts at conserving the Kerry breed will be enhanced if the full Kerry herdbook can be computerised and migrated to the cattle breeding central database where all other cattle breeding information is stored. This will facilitate better monitoring and allow more sophisticated analytical methods to be used in identifying candidates for selection that will minimise the rate of change in inbreeding and maintain genetic variation in the Kerry cattle population.

Population Structure

The absence of a central data processing and handling facility for the Kerry cattle has made an understanding of the population structure and dynamics difficult. Information garnished from various sources may at times be inconclusive. A survey commissioned by the Kerry breed society in 1998 put the number of breeders in Ireland (North and South) at 136 with another 28 breeders in Great Britain. Kerry herds are also known to exist in the United States of America (at least two known in 1998) and Canada. A total of 935 females and 25 males where projected to be alive in Ireland and the UK in 1998 by this survey (Kerry Cattle Society, personal communication). A DAF survey put the number of breeding females in the Republic of Ireland in 2001 at 360 based on the number of purebred calves registered and a conservative projection on the number of Kerry cows mated to other breeds.

Table 1 shows a break down of Kerry herdbook registrations since 1998 by sex and country. Majority of the animals registered are from breeders in the republic of Ireland. Generally, not all births are notified to the herdbook perhaps because some of the births

Table 1. Breakdown of Kerry cattle birth and registrations by sex and country.

	1998		1999		200		2001		2002	
Countries	M	F	M	F	M	F	M	F	M	F
Rep of Ireland	38	127	42	93	22	123	23	85	42	134
UK	3	21	4	4	4	21	2	7	5	15
USA	3	5	2	1	1	2	1	3	5	11
Canada	1	13	1	5	12	5	2	5	6	4
Total Reg	45	166	49	104	39	161	28	100	58	164
Total Registered[1]	211		153		200		128		222	
Total notified[2]	276		271		267		257		265	
Total Calving[3]	488		452		518		509		531	

[1]Total number of registered calves.
[2]Total number of notified births.
[3]Total number of calving with Kerry pure bred as dam.
M=Males; F=Females.

are crosses or due to early calf mortality. There is also a possibility that some pure bred Kerry animals are not notified to the herdbook. Table 1 further indicates that not all notified calves are eventually registered. Registration costs the breeder some money and is currently not compulsory.

An analysis of the DAF 'compulsory' calf registration data confirmed the discrepancy between calves born and registered in the herdbook and the possible reasons. For example whereas about 531 calves registered in 2002 had Purebred Kerry dams, only 279 also had Kerry bulls as sires indicating that 47% of the Kerry cows were mated to bulls of other breeds in 2002. Table 2 shows the number of calves registered with at least one Kerry parent between 1998 and 2002. This analysis confirmed DAF's number of purebred calves but showed that a higher proportion of Kerry cows are mated to other breeds to produce crosses than previously thought. Most of the crossbred calves tend to be lost from the population as is indicated by the relatively small number of Kerry crosses that become dams over the years (Table 2).

About 507 cows (including maiden heifers) were reportedly available for breeding in spring 2003. Majority (63%) of these females were born between 2000 and 2002, 25% were born between 1995 and 1999 while the remaining 12% were born between 1985 and 1994. About 16% of the available bulls (alive or semen) were born before 1985, 15% were born between 1985 and 199425% between 1995 and 1999 while the remaining 31% were born between 2000 and 2002.The oldest bull with semen available was born in 1957.

Current Conservation Strategies

The ethos in conservation of Kerry cattle has been the provision of support to Kerry cattle breeders for the continuous 'farming' of Kerry cattle aimed at bolstering *in vivo* conservation at minimum cost. For any endangered species or breed with a small population size, avoidance of inbreeding is very important because of the negative effects of inbreeding depression, increased incidence of lethal genes and loss of genetic variation. A computer based system for the routine computation of mean kinship was first developed in 1998 to support the use of mean kinships as a basis of selecting bulls for semen collection and storage (Cunningham and Splan, 1998). The objective was to maintain the living population with minimum genetic drift and inbreeding by making semen from older generation available for use in later generation. The earlier computer system was difficult to operate and maintain because of the requirement for multiple computing platforms. The Mean Relationship System (MRELS) was developed by the ICBF based on the earlier principles of mean kinship (Cunningham and Splan, 1998).

Table 2. Number of calves registered with Kerry parents by year of birth.

Breed of		Birth year of calf				
Sire	Dam	1998	1999	2000	2001	2002
Kerry	Kerry	309	284	317	291	279
Other Breed	Kerry	179	168	201	218	252
Kerry	Other Breed	46	40	47	41	44
Other breed	KEX*	24	18	19	24	29
KEX	Other Breed	1	10	2	0	1
Purebred Kerry Dams		488	452	518	509	531

KEX= A Kerry cross with some other breed.

Routine Computation of Inbreeding

The Mean Relationship System

Selection of animals based on mean kinship requires a practical and efficient system for routine estimation of kinship. The relationship between any two individuals can be derived from the inbreeding of their offspring. However, when the information is required to choose mates before the offspring is born, the best option is to pair every male animal with every female in the breeding population to produce a phantom progeny. This strategy is feasible because the calculation of the inbreeding coefficient does not require information from the individuals but from the pedigree of the individual starting with its parents.

MRELS is a computer based system for the computation of inbreeding and relationship between potential mates in the breeding population. It is programmed in Fortran® and operates in a Unix environment driven with a single script. Additional packages such as SAS® and Excel® may be required if further analysis and graphics are to be produced from the output of MRELS. The steps in MRELS are presented graphically in Figure 1. The system can be described briefly in the following steps:

1) Update pedigree file with all newly registered animals.
2) Identify male and female animals available for breeding in the population. This can be done either based on a set criteria from the updated pedigree file or by obtaining a list of available animals from the breed society (or breeders).
3) Generate a phantom progeny for all possible pairs of bulls and cows in the breeding population.
4) Add these phantom calves to the updated pedigree file to create a hypothetical pedigree file.
5) Calculate inbreeding coefficients for all animals in the pedigree including the phantom calves.
6) Calculate the additive genetic relationship between mates (Bulls and cows) based on the inbreeding coefficient of their phantom calf.
7) For every bull in the breeding population, calculate the mean relationship by summing over all its mates or all animals including self as may be desired.

The current system relies on the Kerry Cattle Society to supply a list of available male and female animals for steps 1 and 2. In future, it may be possible to derive the breeding population and updated pedigree files directly from the database.

It is important that the pedigree of all animals in the breeding population is known and used to update the pedigree file before the calculation of the inbreeding coefficients. Animals in the breeding population with no pedigree are returned for cross check and excluded if the pedigree cannot be obtained. Missing pedigree entries may result in false low inbreeding coefficients and hence low mean relationships. Choice of individuals is made with this in mind. Output from the package includes a file with the bulls ranked on mean kinship, a list of the top five bulls suitable for use on each cow based on the relationship and the inbreeding of the expected offspring among others. This system can be used to provide a mating advisory service for individual herds and breeders.

Semen Collection and Storage Scheme

The use of frozen semen to minimise inbreeding has been advocated as a suitable strategy in the conservation of genetic variation in a small population (Smith, 1977; Sonesson et al., 2002). The availability and use of old less related males slows down the turn over of generations and reduce annual rate of increase in inbreeding. While earlier proponent suggested the use of semen from only least related bulls in the founder generation (Smith, 1977), Sonesson et al

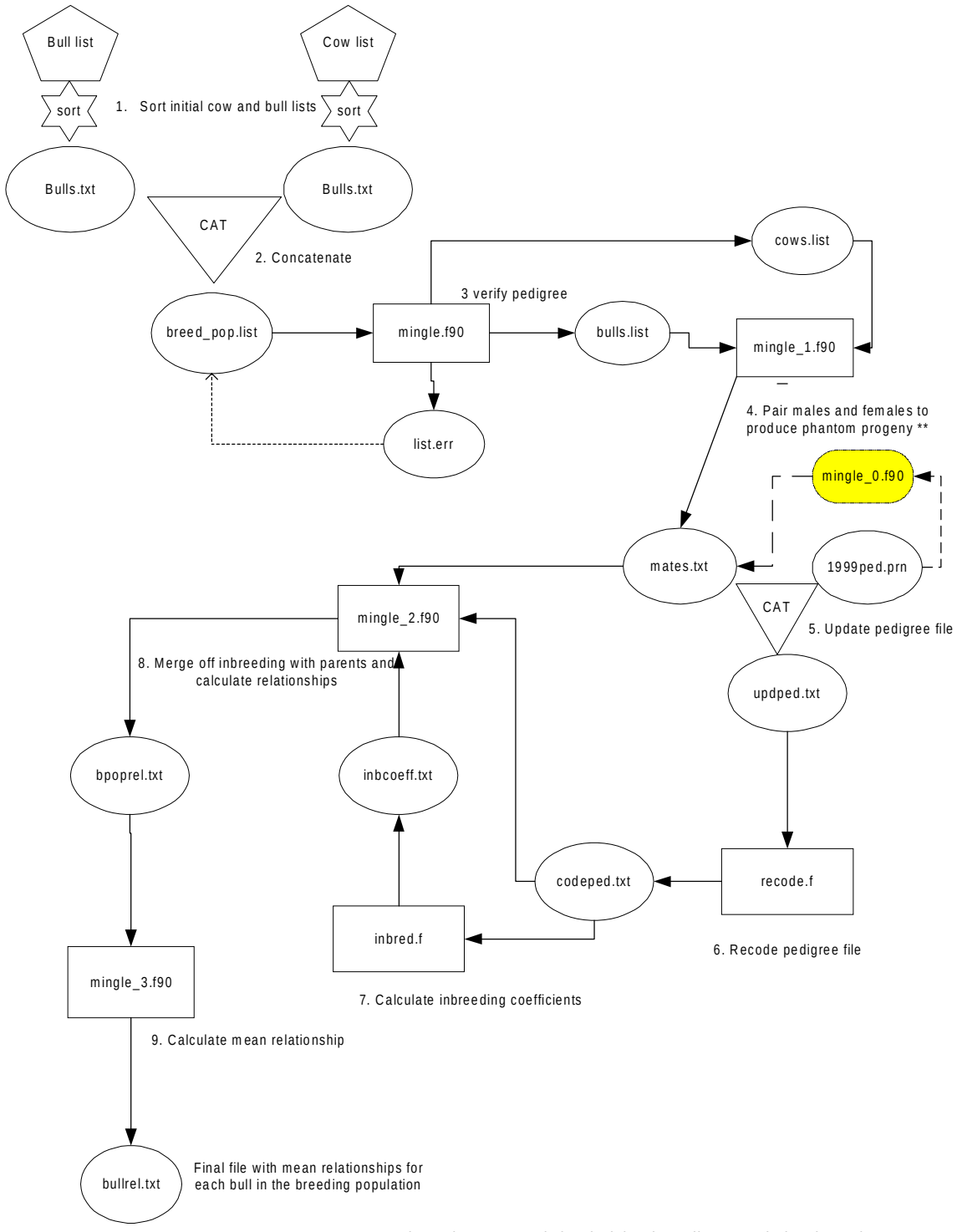

Figure 1. Schematic representation of the mean relationship computer system.

(2002) argue that loss of the genes from the founder dams can only be avoided if males from the first generation are also used. For populations with overlapping generations, various schemes have been proposed for the selection of candidates for semen conservation. Generally, a representative sample of the population genome is required to maximise genetic variation which can be achieved by optimisation in a minimum coancestry selection scheme (Sonesson and Meuwissen, 2001). Mean coancestry or mean kinship is a good measure of genetic variation because it is directly related to expected heterozygosity and it accounts for both founder effects and the effects of genetic drift in a small population. It describes genetic variation both at the gene or allele level as well as at the population level because it is directly related to population size and variances (Caballero and Toro, 2000) as well as genetic distance between individuals within a population (Eding and Meuwissen, 2001).

Based on these principles, four new Kerry bulls are identified each year based on mean kinship and acquired for semen collection. Since its inception, 18 Kerry bulls have been put on AI with semen still available for 12, reserved for three and no more available for another three An offshoot of the Mean Relationship system is a mating advisory service offered to Kerry cattle breeders by the ICBF. Under this scheme, the relationship between each bull and each available cow is computed. The five most suitable bulls for each cow based on mean kinship are identified and the information is made available to the breeders. The objective is to minimise inbreeding in the next generation.

Figure 2. A front view of a Kerry cattle.

Test run

Preliminary analysis of the Kerry cattle pedigree (registrations up to 1998) with MRELS, showed that 12 664 or 74% of the total animals recorded in the herd book were inbred with an average inbreeding coefficient of 0.089 or 8.9%. The population average inbreeding was 6.6%. The corresponding figures with the inclusion of the phantom progeny were 9.8% and 7.6%. This corresponds to an increase in the population mean inbreeding by 0.9% with random mating of bulls and cows in the current breeding population. It is pertinent to note that such random mating will not be achieved hence the actual change in inbreeding could be higher. Figure 3 shows the trend in birth registration and inbreeding from 1900 to 1998. Generally, inbreeding was increasing at the rate of 0.13% per annum between 1900 and 1998.

In the last 20 years, registration has increased from 52 in 1980 to 125 in 1998. There was a noticeable drop in inbreeding in mid/late 1980s probably due to measures introduced in the early 1980s (O'hUigin and Cunningham, 1990). Inbreeding dropped

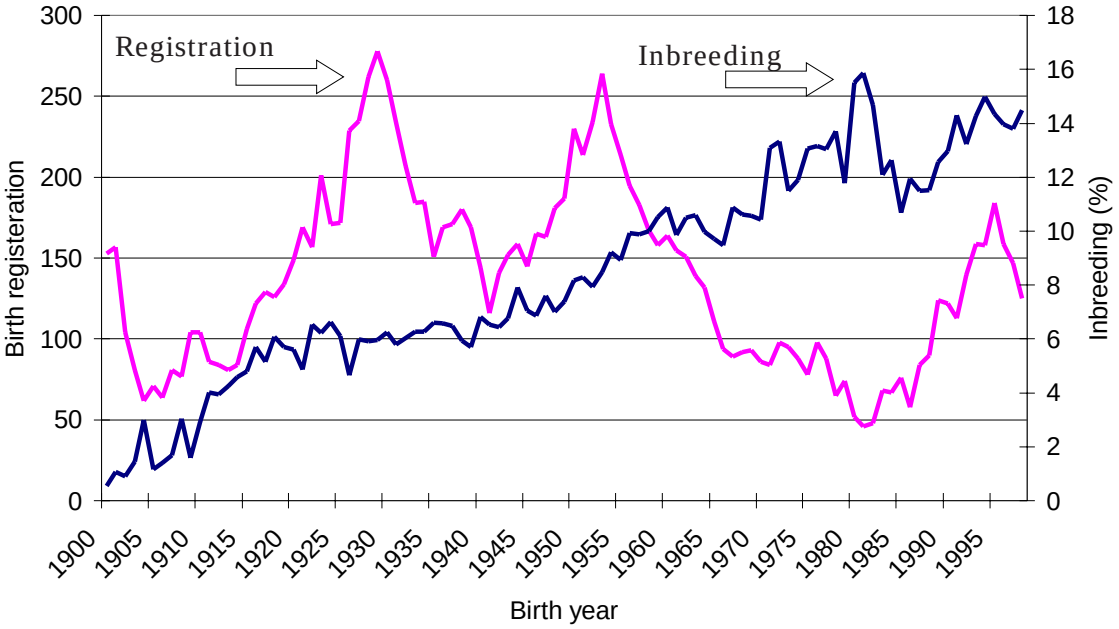

Figure 3. Trend in birth registration and inbreeding over the years from 1990-1998.

from 16% in 1980 to 14% in 1998. It is important to note however that inbreeding has been increasing at the rate of 0.28% per year since 1985.

Embryo Conservation Scheme

Cryoconservation of embryos has been proposed as an additional strategy for genetic conservation of Kerry cattle. This decision was based on the vulnerability of the Kerry cattle population to extinction of the live population in the event of a natural disaster or disease outbreak and the fact that embryos can be used to re-establish the population under such circumstances. Cryoconservation can also be used to slow down the rate of inbreeding by prolonging generation interval when used along with *in vivo* conservation (FAO 2000).

Selection of cows for embryo collection requires careful consideration. In addition to reducing the rate of inbreeding, a second objective is the maintenance of the widest possible variation in the gene bank by storing representative samples of all available genotypes. While minimum relationships alone can ensure that the first objective are attained, DNA profiling and determination of genetic distances are other options for attaining the second (Eding and Meuwissen, 2001). In the absence of DNA profiling various methods have been proposed for identifying candidate donors (FAO, 2000). These are aimed at selecting representative samples of the founder population as well as animals least related to each other in the population of breeding animals.

The embryo conservation project for the Kerry cattle aims to regenerate an effective population size of 50 animals from conserved embryos in the event of extinction of the live population. To achieve this simply, one requires 25 unrelated males and 25 unrelated females which when paired, will each produce one male and one female offspring. This will give rise to 25 pairs of unrelated full sibs.

An analysis was carried out to determine the number of male and female animals required to produce sufficient embryos to obtain an effective population size of 50. Consideration was given to all mitigating factors such as embryo loss, quality,

Figure 4. A typical Kerry cattle in an exhibition.

pregnancy rate, disproportionate sexes and calf mortality. The results showed that ideally, there was a 90% chance of producing sufficient embryos from mating 25 unrelated males in the current population to 25 unrelated females. Each pair was expected to produce 4 good quality embryos of which at least 2 (one male and one female calf will be born.

In reality various factors makes the achievement of the ideal situation impossible. The level of inbreeding is already so high that finding 25 unrelated males is impossible. Also most of the available cows are owned by active farmers/breeders which means that some may not be available for the scheme. The current objective is to identify store embryos from 15 donor cows over a 3-year period.

Identification of cows

The MRELS system was used to compute mean kinships (i.e. relations between cows in the breeding population including relationship with self). A total of 507 cows and 29 bulls were reported to be available to choose from. All 536 animals (Males and females) were paired with each other including self to obtain 287 296 phantom offspring. These were added to the existing pedigree of 17 936 animals (updated with registrations up to 2002). The inbreeding coefficient (F) was computed for all animals in the updated pedigree. Relationship between parents was computed as two times the inbreeding coefficient of their offspring. The relationship for very pair of animals in the breeding population was thus derived from the inbreeding of their phantom offspring.

The mean relationship of each cow to all available cows was computed by averaging over all (507) cows including herself. Cows with low mean relationships due to missing pedigree entries were identified by tracing three generations of the pedigree for all cows in the breeding population. Because all available males already have semen stored for AI, the main emphasis was on the selection of donor cows. To achieve this, all cows in the breeding population were split into sire families and ranked in ascending order of mean kinship. The first 24 cows with 3 generations of pedigree known from 15 different sire families were selected. In the second stage of selection, the available bulls were ranked within cows based on their individual relationship to each of the selected cows. A different mate for each cow was selected based on the least related available bull with 3 generations of pedigree known. Mating was restricted to one cow per bull so

as to minimise relationship between the embryo population as well as have a wide genome base.

Results and Discussion

The average inbreeding for all cows in the breeding population was 11.5±6.9 ranging between zero and 55%. The top 25% most inbred cows had inbreeding coefficients of at least 13.8%. Inbreeding of the 29 bulls averaged 10.4%±4.4% ranging between 0 (bulls with incomplete pedigree) and 21%.

The mean kinship of cows in the breeding population ranged from 20 to 29% for animals with at least 3 generations of pedigree. Some cows with only two generations of pedigree had mean kinship under 20%. About 11% of the cows had inbreeding coefficient of zero because of a missing parent or missing pedigree of one parent. Only 1 bull had inbreeding of zero for the same reason. However majority of the animals with inbreeding coefficients under 10% had one or more parents missing in the first 3 generation of its pedigree.

The year of registration range from 1988 to 2002. An attempt to select a different bull as potential mate for each cow was not possible because of the restrictions and few number of bulls (including stored semen). Nevertheless the 5 donors to be selected each year will be mated to different sires. The choice will depend on availability and health status of the identified animals. This process is currently ongoing

The ICBF Database and Future Conservation Efforts

FAO guidelines for the management of small populations at risk (FAO, 2000) has proposed studying the dynamics of the breed in order to decide on a conservation strategy. For Kerry cattle, the existence of a well kept herdbook, and the relatively large number of enthusiastic breeders allowed the decision for *in vivo* conservation to be taken from the onset. It is becoming increasingly apparent however that registration in the herdbook alone does not give a clear picture of the dynamics of Kerry cattle in Ireland hence a study of the dynamics of the Kerry cattle is still required. Such a study can easily be undertaken if all Kerry cattle breeding information is available in a central database.

Over the past three years, ICBF has established a centralised cattle breeding database and embarked on the process of migrating cattle breeding data from the numerous separate systems in Ireland. Migrating the Kerry data to this database has been given priority. It will facilitate in the future, the application of more sophisticated methods in the selection of Kerry bulls and cows aimed at minimising inbreeding and perhaps development of the breed through selection and breeding for niche products which will ensure the continued *in situ* conservation of this endangered breed.

Conclusion

Our experience to date suggests that success with any in vivo conservation strategy requires the full cooperation of the breeders. Government incentives and the service offered by ICBF will continue to provide a useful support to the conservation effort. Migration of the Kerry herdbook to the cattle breeding database will allow better management and planning of future conservation efforts. More detailed studies of the dynamics of Kerry cattle is required so as to harness the genetic variation from all Kerry bulls and cows within and outside Ireland.

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