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Inbreeding Trends in Norwegian Cattle Breeds at Risk

Inbreeding rates and effective population sizes 1991-2020

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The Norwegian Genetic Resource Centre estimated the inbreeding rate and thereby the effective population size for all of Norway's cattle breeds at risk, using the method by Gutierrez *et al* 2008. When the conservation efforts began in 1990, these breeds were very small in number. However, the current population status shows that the breeds have been wisely managed.

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Preface

The Norwegian cattle breeds at risk are: Døla Cattle, Western Red Polled Cattle, Western Fjord Cattle, Sided Trønder and Nordland Cattle (STN), Eastern Red Polled Cattle and Telemark Cattle. Since the late 1980s, the breeding populations of these breeds have been small or very small, and there has been a substantial risk of a rapidly increasing inbreeding rate and subsequent inbreeding depression.

Thus, for more than 30 years the breeding programs have placed considerable emphasis on avoiding close breeding and using as many breeding animals, especially sires, as possible to avoid inbreeding. However, only recently we became aware of a method that enables us to assess the inbreeding trends in these populations, which in turn allows us to evaluate the outcome of the breeding programs. This report explains the applied method and presents the results.

We have considerable respect for the owners of Norway's cattle breeds at risk, and have given them breeding advice for many years. Thus, we are proud to conclude that the breeding programs seem to have been a great success.

Ås, 03.09.21

Nina Sæther, Academic Director of the Norwegian Genetic Resource Centre

Contents

1	Introduction.....	5
2	Methods.....	6
2.1	Cow Database.....	6
2.2	Large between-breed variation in population trends 1991-2020.....	7
2.3	Inbreeding rate.....	8
2.4	Effective population size.....	9
2.5	What affects inbreeding rate and effective population size?.....	10
2.5.1	Calculating the inbreeding rate (ΔF).....	10
2.5.2	Estimating the effective population size N_e	10
2.5.3	Selecting individuals to calculate ΔF and N_e	11
3	Results and discussion.....	12
3.1	Increased effective population size 1991-2021.....	13
3.2	AI bulls from before 1990.....	14
3.3	The breeds had various starting points in 1990.....	15
3.3.1	Sister population in Sweden (STN).....	15
3.3.2	Outcrossing with NRF helped to save the breed (Eastern Red Polled).....	15
3.3.3	Regular introduction of new AI bulls important (Telemark).....	16
3.3.4	Slow population growth curbs inbreeding rate (Døla & Western Red).....	17
3.3.5	Small population that grew fast (Western Fjord).....	18
4	Conclusions.....	19

1 Introduction

Data collection campaigns were carried out in 1989 and 1991 for the Norwegian cattle breeds at risk. These efforts led to the establishment of a pedigree database for these breeds, the *Kuregister* (“Cow Database”). Ever since, this database has played an important role in monitoring population trends and recording basic pedigree data for the six cattle breeds at risk in Norway; the Døla Cattle, Western Red Polled Cattle, Western Fjord Cattle, Eastern Red Polled Cattle, Telemark Cattle and Sided Trønder and Nordland Cattle (STN). The population status for these breeds has been reported annually, and the trend has been positive: the number of animals has increased for all breeds, albeit at slightly different paces.

The breeding programs’ primary goals have been to avoid a rapid increase of the inbreeding rate and to keep the effective population size as large as possible. Important measures included the avoidance of mating closely related animals, and the use of all heifers and as many bulls as possible in breeding. However, we have so far not had any tools for assessing the effects of such breeding strategies on achieving the breeding objectives. This report presents for the first time an analysis of inbreeding rate and effective population size for these breeds.



Figure 1. Sided Trønder and Nordland Cattle (STN) is the most numerous of Norway’s cattle breeds at risk, both in terms of number of breeding animals and effective population size. This STN herd, owned by R.P. Tørres, is seen grazing in the mountains near Røros in 2019. Photo: Nina Sæther

2 Methods

2.1 Cow Database

In order to analyse pedigree status, one has to have good pedigree data. For the cattle breeds at risk, such data have been available since the Cow Database was established in 1990. At the time, the number of registered breeding dams for the various breeds were (no. of breeding dams in parentheses): Western Fjord Cattle (49), Telemark Cattle (115), Western Red Polled Cattle (52), Døla Cattle (25) and Eastern Red Polled Cattle (11).

Between 1990 and 2009, the digital Cow Database was updated manually; the farmers annually submitted all relevant herd data such as calving, slaughtering, and live animal sales and purchases on paper or by telephone. Starting in 2009, pedigree data on the cattle breeds at risk were electronically transferred from the Norwegian Dairy Cattle Herd Recording System to the Cow Database. As a result, STN data were from then on also included in the Cow Database. Pedigree data on cattle breeds at risk that are registered in the Norwegian Beef Cattle Herd Recording System have been electronically transferred to the Cow Database since 2018. Farmers who are not members of either of the two national herd recording schemes still have to submit their herd data manually, as there currently is no online version of the Cow Database.

A **breeding dam** is defined as a cow or heifer that is at least 87.5 % purebred. Cows must have calved (and registered calving in the Cow Database) within the last two years, and heifers must be two years old, e.g., having been born in 2018 at the time of breeding dam registration in 2020.

Risk-status category, based on reproductive capacity. From FAO, 2013. *In vivo conservation of animal genetic resources. FAO Animal Production and Health Guidelines. No. 14. Rome.*

	Species with high reproductive capacity			Species with low reproductive capacity		
	Critical endangered	Endangered	Vulnerable	Critical endangered	Endangered	Vulnerable
Number of breeding females	< 100	< 1 000	< 2 000	< 300	< 3 000	< 6 000

2.2 Large between-breed variation in population trends 1991-2020

Figure 2 shows the changes in breed populations, as the number of breeding dams (see fact box for definition) at 5-year intervals between 1990 and 2020. The breeds differ considerably in terms of population trends over the past 30 years, and none of the breeds have gone through the same development. The only common denominator is that all breeds have grown in number.

Western Fjord Cattle and Western Red Polled Cattle have had the most divergent population trends, with 49 and 52 breeding dams, respectively, in 1990 and 1018 and 233 breeding dams, respectively, in 2020, see Figure 2. The Western Fjord Cattle population increased rapidly after 1990, and already before 2005 it surpassed 300 breeding dams, which is the threshold for being moved from risk-status “critical endangered” to “endangered”, see fact box for definitions of the various risk-status categories. In spite of a marked population increase between 2015 and 2020, Western Red Polled Cattle still has so few breeding dams that the breed remains in the “critical” category.

Of all breeds, Eastern Red Polled Cattle showed the largest relative population gains in the past decade. The breed’s population has nearly tripled; from 129 breeding dams in 2011 to 473 in 2020. With merely 11 breeding dams in 1990, Eastern Red Polled Cattle had the smallest breeding population when registrations began. Døla Cattle has experienced the steadiest growth of these breeds throughout the past 30 years. In 1990, there were 25 Døla Cattle breeding dams, but the threshold of 300 breeding dams was not reached until 2020, thus changing the breed’s risk status from «critical endangered» to «endangered». Throughout the 1990s, Telemark Cattle was seen as the «big brother» among the breeds recorded in the “Cow Database”, because at the time it was the most numerous recorded breed with its 115 breeding dams (as of 1990). However, population growth has been slow, and has only picked up significantly in the last five years. In 2020, there were 485 registered Telemark Cattle breeding dams, and the breed is now classified as «endangered».

Sided Trønder and Nordland Cattle (STN) was not included in the Cow Database until 2010, when data from the national herd recording scheme began to be automatically transferred. Since then, the breed’s population has shown substantial growth from 1016 to 1806 breeding dams.

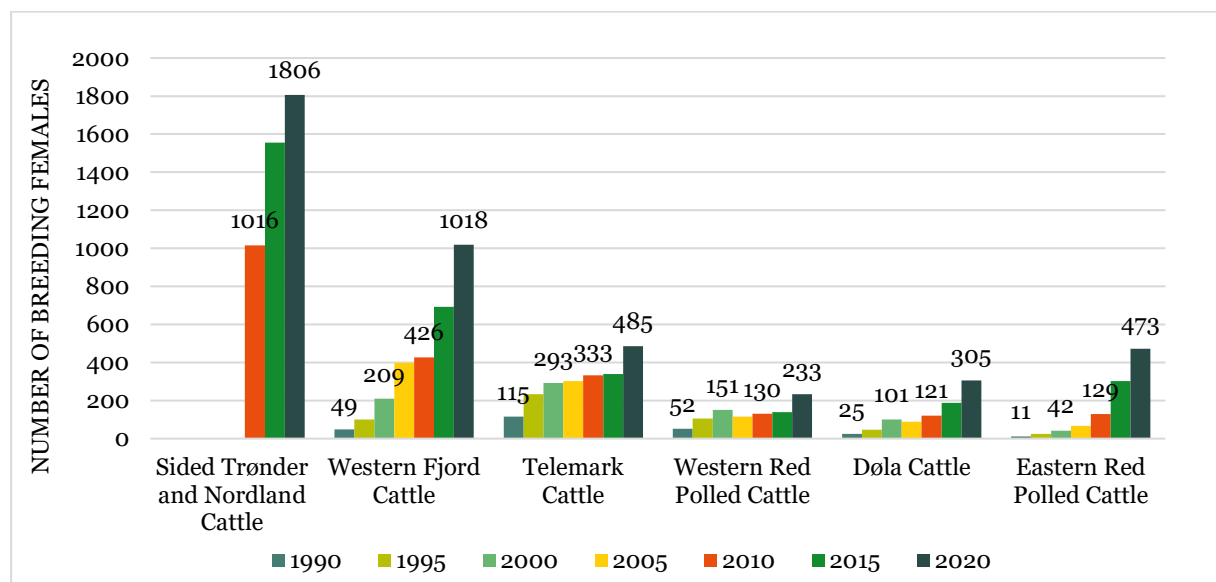


Figure 2. Changes in the number of breeding dams in Sided Trønder and Nordland Cattle, Western Fjord Cattle, Telemark Cattle, Western Red Polled Cattle, Døla Cattle and Eastern Red Polled Cattle, 1990-2020. Source: Cow Database, Norwegian Genetic Resource Centre

2.3 Inbreeding rate

Inbreeding rate: In any closed population, inbreeding and relatedness between individuals will always increase over time. The rate of this increase determines how severely inbreeding will affect the population. At a low rate of inbreeding, it is more likely that selection can counteract the negative effect of inbreeding.

Small populations are more likely to suffer from inbreeding depression, which can result in reduced performance (weight gain, milk yields) and fertility, fewer viable offspring and increased occurrence of genetic, often lethal, diseases and defects. The main way to prevent inbreeding depression is by implementing a breeding strategy that avoids a high rate of inbreeding, thereby helping to maintain genetic variation within the population.

2.4 Effective population size

Effective population size (N_e)

Effective population size is the number of individuals that would give rise to the calculated sampling variance, or rate of inbreeding, if they bred in the manner of the idealized population.

The idealized population is a population that can be described by the following conditions:

- *Migration of genes is excluded*
- *The generations are distinct and do not overlap*
- *The number of breeding individuals are equal in all generations*
- *Mating is random, including self-fertilization in random amount*
- *There is no selection*
- *Mutation is disregarded*

The effective population size is considerably smaller than the real population size. This is due to that the conditions for an idealized population are not fulfilled in a real population size of farm animal. For example:

- *There are unequal numbers of males and females that mate and produce offspring.*
- *The population size varies from one generation to the next.*
- *The variation in number of offspring per parent is not random.*

(Falconer & Mackay 1996)

More simplified one can say that effective population size is a measure for the number of unrelated individuals that contribute genetically to the next generation. It is calculated on the basis of the inbreeding rate of the population. To be genetically sustainable, N_e should be larger than 50, and preferably above 100.



Figure 3. Having a large number of breeding sires in small, endangered populations is essential. This can be achieved by using herd bulls, like this Fjord Cattle bull on a mountain pasture in western Norway. Photo: Nina Sæther.

2.5 What affects inbreeding rate and effective population size?

The relationship between inbreeding rate (ΔF) and effective population size (N_e) is described by $N_e = \frac{1}{2 \Delta F}$, and is affected by breeding strategies in the population. Factors that contribute to increasing the inbreeding rate (and decreasing N_e) are short generation intervals, large variation in the number of offspring per parent, large differences of age at first calving and high generational overlap. This means that using as many breeding sires as possible, making sure that none of the breeding bulls become so-called matador sires with many more offspring than other breeding bulls, and steadily increasing population size are good strategies for limiting the rate of inbreeding and increasing the effective population size.

The descriptions of inbreeding rate and effective population size are mainly based on the FAO's guidelines on *in vivo* conservation of animal genetic resources.¹

2.5.1 Calculating the inbreeding rate (ΔF)

The inbreeding rate is used to determine effective population size, N_e . There are many ways in which to compute inbreeding rate, the most common methods are based on changes of the average inbreeding levels. These methods are sensitive to the lack of pedigree data, which in turn results in not being able to calculate effective population size or overestimating it, so that the population size looks better than it actually is.

Gutierrez et al 2008² developed a robust method for calculating the inbreeding rate in populations with insufficient pedigree data. The method makes up for lacking pedigree data by calculating an individual inbreeding rate that is based on available pedigree data for individual animals.

The equation for computing the individual inbreeding rate is:

$$\Delta F_i = 1 - (1 - F_i)^{\frac{1}{ECG_i}}$$

where F_i is the individual level of inbreeding

ECG_i is Equivalent Complete Generations (Gencoef-1 in the results generated by EVA)

ΔF_i is the individual inbreeding rate.

2.5.2 Estimating the effective population size N_e

When the individual inbreeding rate has been calculated for all individuals in a population, the population's average rate of inbreeding can be computed, expressed as the average rate of inbreeding per generation (ΔF). The result is then inserted into this equation:

$$N_e = \frac{1}{2 \Delta F}$$

The equation gives a measure of the effective population size, N_e . N_e should be larger than 50 to ensure that the population can maintain its genetic variation at a sufficient level.

¹ FAO, 2013. *In vivo* conservation of animal genetic resources. FAO Animal Production and Health Guidelines. No. 14. Rome.

² <https://doi.org/10.1186/1297-9686-40-4-359>

2.5.3 Selecting individuals to calculate ΔF and N_e

Pedigree data is taken from the Cow Database.³ Data from all individuals of the breeds Døla Cattle, STN, Telemark Cattle, Western Fjord Cattle, Western Red Polled Cattle and Eastern Red Polled Cattle that are registered in the Cow Database were retrieved and analysed with the EVA software.⁴ EVA was programmed to base “pedigree completeness” (PEC) on pedigree data from five generations. Only individuals with a generation coefficient of at least 2.0 and a PEC (5 generations) of at least 0.5 were used to calculate N_e .

The individuals with a sufficient amount of pedigree data were divided into three groups according to birth year (1991-2000, 2001-2010, 2011-2020). This was done to show trends over time.



Figure 4. Western Red Polled Cattle, Western Fjord Cattle and STN cows heading home to be milked. Fannrem Farm, 2017. Photo: Nina Sæther.

³ www.kuregisteret.no

⁴ <https://www.nordgen.org/en/our-work/nordgen-farm-animals/eva-program/>

3 Results and discussion

Table 1 presents the calculated effective population size (N_e) and inbreeding rate (ΔF) of the Norwegian cattle breeds at risk, showing percentage (ΔF), average PEC index for the selected individuals, and the number of animals on which the calculations are based.

Døla Cattle had an effective population size of below 50 in the decades of 1991-2000 and 2001-2010, but had an N_e above 50 in the decade of 2011-2020. For STN, N_e was above 100 in all three decades, whereas Telemark Cattle and Eastern Red Polled Cattle had effective population sizes of below 50 in the same three decades. Western Fjord Cattle and Western Red Polled Cattle had N_e values of below 50 in 1991-2000, but above 50 in the two decades of 2001-2010 and 2011-2020.

Table 1. ΔF (inbreeding rate), N_e (effective population size), PEC (average pedigree completeness index for five generations) and number of animals on which the calculations are based, by decade, for the six Norwegian cattle breeds at risk.

Breed	Decade	ΔF	N_e	PEC	No. animals
Døla Cattle	1991 - 2000	1.38 %	36	0.56	65
Døla Cattle	2001 - 2010	1.07 %	47	0.69	581
Døla Cattle	2011 - 2020	0.83 %	61	0.82	1 536
Sided Trønder and Nordland Cattle (STN)	1991 - 2000	0.49 %	102	0.71	154
Sided Trønder and Nordland Cattle (STN)	2001 - 2010	0.39 %	128	0.67	3 554
Sided Trønder and Nordland Cattle (STN)	2011 - 2020	0.41 %	123	0.77	10 392
Telemark Cattle	1991 - 2000	1.62 %	31	0.81	1 295
Telemark Cattle	2001 - 2010	1.50 %	33	0.86	2 091
Telemark Cattle	2011 - 2020	1.41 %	36	0.89	2 799
Western Fjord Cattle	1991 - 2000	1.09 %	46	0.64	674
Western Fjord Cattle	2001 - 2010	0.94 %	53	0.80	3 002
Western Fjord Cattle	2011 - 2020	0.83 %	61	0.91	5 398
Western Red Polled Cattle	1991 - 2000	1.45 %	34	0.61	350
Western Red Polled Cattle	2001 - 2010	0.98 %	51	0.73	914
Western Red Polled Cattle	2011 - 2020	0.90 %	55	0.84	1 287
Eastern Red Polled Cattle	1991 - 2000	1.81 %	28	0.60	44
Eastern Red Polled Cattle	2001 - 2010	1.24 %	40	0.69	524
Eastern Red Polled Cattle	2011 - 2020	1.12 %	44	0.87	2 424

3.1 Increased effective population size 1991-2021

Figure 5 shows the development of effective population size for the six cattle breeds at risk, divided by the decades of 1991-2000, 2001-2010 and 2011-2020. Changes in N_e over time show a positive trend for all breeds except STN. For STN, there is a slight decline in N_e from the decade of 2001-2010 to 2011-2020. However, with an effective population size of well above 100, STN lies clearly over the other breeds at risk. Thus, when considering the clearly increasing trend for all of the five breeds that had N_e values of below 50 in the first decade of 1991-2000, and STN's generally sound status, these results confirm that the current breeding programs for the Norwegian cattle breeds at risk ensure the sustainable management of the breeds' genetic variation.

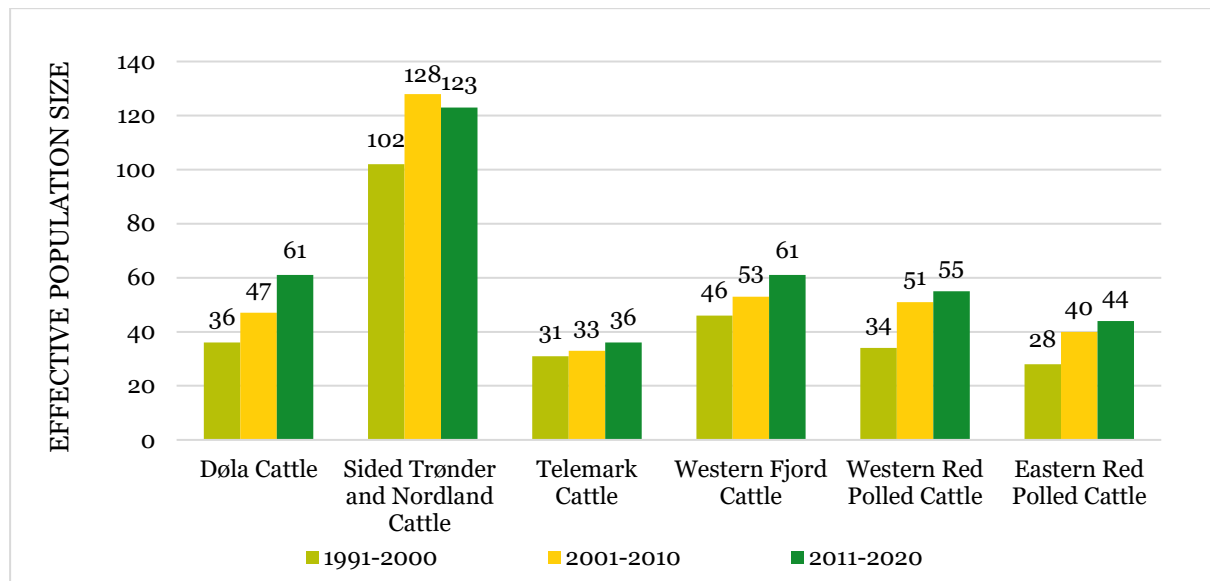


Figure 5. Changes in effective population size for Døla Cattle, Sided Trønder and Nordland Cattle, Telemark Cattle, Western Fjord Cattle, Western Red Polled Cattle and Eastern Red Polled Cattle. Source: Cow Database, Norwegian Genetic Resource Centre.

3.2 AI bulls from before 1990

In the 1950s, the six native cattle breeds that are at risk today all had their own breeding organizations. During the 1960s, the breeding organizations for Døla Cattle, Western Red Polled Cattle, Western Fjord Cattle and Eastern Red Polled Cattle all merged with Geno, the breeding organization for the Norwegian Red Cattle (NRF). Geno thus took possession of the merged breeding organizations' stock of semen. For some time Geno continued to produce semen from these breeds, but eventually Geno only produced semen from NRF as the other breeds became less popular among Norwegian farmers.

The breeding organizations of Telemark Cattle and STN did not merge with Geno, and continued to operate as separate breeder's organizations. As a result, the breeding programs for Telemark Cattle and STN were more active than for the other breeds in the 1980s, and the introduction of new AI bulls was part of these efforts. This explains why there now are significantly more AI bulls from before 1990 for these two breeds than for the other cattle breeds at risk; i.e., 31 STN bulls and 30 Telemark Cattle bulls.

During the last 40 years, Geno has been a significant contributor to the conservation of the six native cattle breeds that during the 1970s had become at risk. Already in the early 1980s, Geno bought bulls for semen production from the native breeds that had merged with Geno during the 1960s.

Today, Geno is the only breeding organization for cattle that produces, purchases and stores bull semen in Norway. Breeding organizations for other cattle breeds in Norway thus buy AI-services from Geno. Geno's supply of semen from both new and older bulls has been of invaluable importance for the conservation and sustainable use of the native cattle breeds at risk.

Table 2. AI bulls admitted before 1990 from the Norwegian cattle breeds at risk. Source: Geno

Breed	No. AI bulls from the 1980s	No. AI bulls from 1960s & 1970s	Total no. of AI bulls born before 1990
Døla Cattle	9	0	9
STN	22	9	31
Telemark Cattle	16	14	30
Western Fjord Cattle	10	3	13
Western Red Polled Cattle	12	4	16
Eastern Red Polled Cattle	10	1	11

3.3 The breeds had various starting points in 1990

3.3.1 Sister population in Sweden (STN)

Although we do not have precise historical data on the number of breeding dams of Sided Trønder and Nordland Cattle (STN), it is reasonable to assume that the population of this breed never was as small as that of the other breeds at risk. We estimate that there were about 300 breeding dams⁵ in the 1970s,



Figure 7. Sided Trønder and Nordland Cattle (STN). Photo: Anna Holene

and presume that this was the period with the smallest population of STN cows. Data from Geno show that there were about 900 first inseminations of STN cows in 1990. In addition, the breed has a sister population in Sweden, the *Fjällko* (Swedish Mountain Cattle), with which there is exchange of genetic material (frozen semen). Due to these circumstances, STN had a completely different starting point than the other breeds, which in turn explains its clearly larger effective population size in the three decades analysed in this study.

3.3.2 Outcrossing with NRF helped to save the breed (Eastern Red Polled)

Eastern Red Polled Cattle was by far the least numerous breed in 1990. At that time, its population consisted of only 11 purebred breeding dams and about 10 AI bulls, which were born in the 1980s and had been accepted for semen collection by Geno. The population increased and was saved from extinction by pure-breeding the eleven remaining dams, and in addition, a number of farmers



Figure 8. Eastern Red Polled Cattle. Photo: Anna Holene

inseminated their NRF cows with Eastern Red Polled semen. The outcrossing with NRF introduced some ‘fresh blood’ into the breed, but also introduced the recessive horned gene. Nonetheless, it is quite an accomplishment to save such a small population while at the same time keeping the inbreeding rate relatively under control, as shown by the results in this report. However, overcrossing with NRF presented the breed with a challenge, seeing that some years ago, several purebred Eastern Red Polled Cattle were born horned. The horned gene was passed down from both sire and dam. To remove the gene from the population, all of the

⁵ <https://www.nationen.no/landbruk/god-ku-skal-bli-enda-bedre/>

breed's AI bull candidates are nowadays gene-tested, and only those who do not bear the horned gene are permitted to be used for semen collection.

During the past ten years, the breed's popularity has increased, and its population has tripled since 2010. Such rapid population growth is only possible when all breeding animals have many offspring. Consequently, many of the new individuals are closely related, e.g., half-sibs. Such close relatedness between the young animals of a population increases the inbreeding rate and reduces the effective population size. Even so, the results presented in Figure 5 show that Eastern Red Polled Cattle has experienced a growth in effective population size in each of the decades studied, with N_e values of 28, 40 and 44 for 1991-2000, 2001-2010 and 2011-2020, respectively.

Although all N_e values for Eastern Red Polled Cattle for the three decades lie below the recommended level for effective population size, the results are nevertheless quite impressive when considering the small size of the population and the rather rapid increase in numbers. This indicates that the breeding strategy was sound in terms of the use of breeding sires, especially in the last decade. It cannot be emphasized enough that farmers keeping this breed still have to be extremely careful to avoid mating closely related animals. Farmers must also make sure to use a sufficient number of breeding sires, both AI bulls and herd bulls, and to retire old bulls from breeding duties.

3.3.3 Regular introduction of new AI bulls important (Telemark)

For years, Telemark Cattle was the most numerous of the five least populous Norwegian cattle breeds. However, during a period in the early 2000s, few new bulls were introduced for semen collection. Between 1998 and 2013, only 13 new bulls were accepted for semen collection. The new AI bulls were offspring of AI bulls and herd bulls were only rarely used. This contributed to the close relatedness among AI bulls and a faster-than-desirable increase of the population's inbreeding level. In 2013, a



breeding group was established as part of a project managed by the Telemark Cattle Breeder's Organization. The group focussed on such issues as increasing both the number of AI bulls and the use of herd bulls. Slowing down the rapid increase of the inbreeding rate in a population requires a long-term effort, but it can be expected that the breeder's organization's focus on keeping the inbreeding rate at a minimum will give positive results in the form of a continued growth of the effective population size.

Figure 9. Telemark Cattle. Photo: Anna Holene

3.3.4 Slow population growth curbs inbreeding rate (Døla & Western Red)

Døla Cattle and Western Red Polled Cattle have in common that their populations are very small and the number of breeding dams is only increasing slowly, see Figure 2. Both breeds have managed to keep the inbreeding rate at an acceptable level. As a result, the effective population size (N_e) has shown a positive development, with both breeds having reached N_e values of above 50 in the last decade. The breeding strategy for these two breeds can thus be considered sustainable, in terms of maintaining their genetic variation. During the past five years, the number of breeding dams has increased substantially. Although this increase did not occur as fast as in Eastern Red Polled Cattle, farmers keeping these breeds must nonetheless also make sure to use a sufficient number of breeding sires to keep the inbreeding rate within the recommended limits.



Figure 10. Western Red Polled Cattle. Photo: Anna Holene



Figure 11. Døla Cattle. Photo: Anna Holene

3.3.5 Small population that grew fast (Western Fjord)



Figure 12. Western Fjord Cattle. Photo: Anna Holene

In 1990, there were only 49 Western Fjord Cattle breeding dams. Since then, the number of breeding dams has grown considerably and steadily, see Figure 2. Between 2010 and 2020, the breeding dam population has more than doubled, from 426 to 1018, respectively. One would expect that such a rapid population growth would be accompanied by a greater increase of the inbreeding rate than desired. However, the results show that the farmers keeping the breed made the right decisions on their breeding strategy.

They managed to maintain the breed's

genetic variation by keeping the inbreeding rate low, which was achieved by a relatively even distribution of offspring per parent. In other words, the population increase was not the result of a few breeding animals having many offspring, especially with regard to sires. Farmers who keep Western Fjord Cattle have a tradition of using many herd bulls in their breeding. Furthermore, the Western Fjord Cattle Breeder's Society has been exceptional when it comes to recruiting AI bulls from offspring of herd bulls, instead of from the offspring of AI bulls. This approach has limited the increase in level of relatedness among the breed's AI bulls. It was thus possible to maintain a sufficiently large effective population size while at the same time the breed population increased considerably and rapidly.

4 Conclusions

The Norwegian Genetic Resource Centre estimated the inbreeding rate and thereby the effective population size for all of Norway's cattle breeds at risk, using the method by Gutierrez et al 2008. When the conservation efforts began in 1990, these breeds were very small in number. However, the current population status shows that the breeds have been wisely managed.

There are multiple reasons for this positive outcome, but important factors certainly have been the effective follow-up and management of the Cow Database, the provision of breeding guidelines based on data from the Cow Database, sound breeding advice from the breed societies to their members, good breeding decisions by the individual livestock keepers and Geno's supply of semen from both new and older bulls of these breeds.

Farmers make their own decisions on how to breed their animals. Thus, it is important that they have the necessary know-how, are given good advice and have access to tools that can help them make the right decisions. Based on the results in this report, it seems as if all of these requirements have been met, thereby providing the needed support to breeders of cattle breeds at risk.

Despite the positive trend regarding the breeds' effective population size, it is not the time to rest on one's laurels. The results show the importance of involving all stakeholders and making well-informed decisions to maintain genetic variation, primarily by using a sufficient number of breeding sires.

To gain a better understanding of these results, the use of breeding sires needs to be further analysed. For example, studying the number of breeding sires and the number of offspring per sire could help to explain how it was possible to keep the inbreeding rates of these breeds within the recommended level. Another topic for further investigation is relatedness between sires.



Figure 13. The success of the breeding programs for the Norwegian cattle breeds at risk should not be taken for granted. We have to continue to work hard, and not rest on our laurels – like this Telemark Cattle heifer seems to be doing on a mountain pasture in the summer of 2017. Photo: Nina Sæther



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The basis of bioeconomics is the utilisation and management of fresh photosynthesis, rather than a fossile economy based on preserved photosynthesis (oil). NIBIO is to become the leading national centre for development of knowledge in bioeconomics. The goal of the Institute is to contribute to food security, sustainable resource management, innovation and value creation through research and knowledge production within food, forestry and other biobased industries. The Institute will deliver research, managerial support and knowledge for use in national preparedness, as well as for businesses and the society at large.

NIBIO is owned by the Ministry of Agriculture and Food as an administrative agency with special authorization and its own board. The main office is located at Ås. The Institute has several regional divisions and a branch office in Oslo.

The Norwegian Genetic Resource Centre was established by the Ministry of Agriculture and Food as a part of Norwegian Institute of Bioeconomy Research (NIBIO).

The Norwegian Genetic Resource Centre coordinates expertise and activities regarding the conservation and utilisation of national genetic resources. The centre has been commissioned to contribute to the effective management of genetic resources in farm animals, crops and forest trees. It also acts as an advisory body to the Norwegian Ministry of Food and Agriculture.