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CURRENT BREEDING AND GENETIC HEALTH STATUS OF THE
NORWEGIAN FJORD HORSE

DIPLOMA WORK

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Summary

Julianne Rochmann: Current breeding and genetic health status of the Norwegian Fjord Horse.

The Norwegian Fjord Horse is known as one of the world's oldest horse breeds. It has maintained its characteristics through years of pure breeding, much aided in an early stage by the shielded geographic location of its place of origin; western Norway.

The aim of this thesis was to gain an in depth view of the current situation of the breed as it faces a dwindling number of new foals foaled year by year. I wanted to investigate how the breeding of the Norwegian Fjord Horse is managed and organised and how this would relate to the genetic health of the population as a whole.

I found that there is a well-organized breeding standard available, but that it seems to put too much weight on the exterior appearance of the Fjord Horse, this should be altered to emphasise the usability and health of the individuals.

The characteristic colouring and markings of Fjord Horses has been a substantial component in breeding and developing the breed, but has also caused trouble in earlier breeding attempts as lack of knowledge of the genetic background of coat colours led to many white, walleyed foals born.

The inbreeding has been a growing concern within the breed, currently it is still within acceptable limits, but this is likely to deteriorate if the number of Fjord Horse foals registered does not increase above the critical 200 per year limit. Genetic diversity is at risk of being lost if the trend is not turned around soon.

1. Introduction

1.1 Origin of the breed

The Norwegian Fjord Horse is known as one of the world's oldest and most pure breeds. The breeding has long been centred in the West of Norway, termed Vestlandet, which is why it has also been known by the name Vestlandshest (FHI, 2003). The exact origin of the breed is still under some discussion. It was previously believed that it was descended from the Przewalski wild horse from central Asia, as the dun colour together with the primitive markings are similar on the two breeds. However it has been shown that the number of chromosomes differs, the Przewalski has a total of 66 chromosomes, while the Fjord Horse has only 64 (Bowling & Ruvinsky, 2000). A study made in 2003 showed a genetic relationship between the Mongolian native horse and the Norwegian horse breeds (Bjørnstad et. al 2003), supporting the belief that part of the ancestry of the Fjord Horse arrived in Norway from the far east.

Archaeological excavations have proved the horse to be domesticated in the Bronze Age, circa 1200 BC and Scandinavian Viking burial sites shows that man has bred horses for some 2000 years, the Fjord Horse appears to be a descendant of these earliest horses in Norway (FHI, 2003).

The size and type of Fjord Horse seems to have varied depending on which area of Vestlandet they came from. In Nordfjord and Sunnmøre they were known as larger and more strongly built horses, they had a more profuse mane, tail and feathering than Fjord Horses in Sunnhordaland. The Fjord Horses from Sunnhordaland were smaller, of a lighter build and more refined, this has led to the belief that there might have been different types of Fjord Horse with slightly different origins.

The breed as we know it today is predominantly of the type originating in Sunnmøre and Fjordane. There is one sire in particular which stands out in the history of the breed; Njål 166, foaled 1891 in Stryn. He was the county stallion in Sogn og Fjordane from 1896 until his death in 1910. Njål 166 can be found in the lineage of every living Fjord Horse in the world to date.

As a breed which is easy to feed, versatile, strong, tough but docile and with an excellent ability to work long hours, days on end and under harsh conditions, the Fjord Horse was

most suitable for work on the many small farm in Vestlandet in times before the industrial revolution.

Though mechanisation has made the Fjord Horse redundant as a workforce, affection for the breed remains strong, especially amongst the farmers of Vestlandet, who have appreciated and maintained the fine attributes of the breed up to present time. Because of its charm, kind nature and versatility the Fjord Horse remains a cherished breed today, and is considered by many Norwegians as a national symbol.

1.2 Breeding history

The work with Fjord Horse breeding is built on strong traditions. The lines can be traced back hundreds of years and there is a history of great pride connected to the process of breeding the Norwegian Fjord Horse. The breeding has evolved a great deal over the years as can be seen in the following timeline.

1840-1850 – Formal start of organized breeding.

1843 – Government funded stud was founded at Hjerkinn in the Dovre Mountains with a plan to improve Norwegian breeding.

1850 – The stud failed due to poor management and too little knowledge about the genetic background of breeding. As Uls dun was a popular colour in these times, individuals with this coat was favoured. This particular colour is linked to the C^{cr} gene, were homozygote animals are born white and walleyed. Knowing nothing about this genetic link, this early breeding phase resulted in approximately half of all foals born on the stud where white walleyed individuals.

The government decided to purchase stallions, which could be used by the breeders. Government appointed agronomist, Lindqvist, decided to use Dole Gudbrandsdal Horse stallions as he could not find any Fjord Horse stallions he deemed “suitable for improving the breed”.

1864 – The first show was held in Førde on Vestlandet. Annual shows were held with alternating location between the counties of Møre og Romsdal, Sogn og Fjordane and Hordaland.

1875 – Interest had grown and it was decided to hold two annual shows and also include the county of Rogaland in the southwest.

1895 – The location was no longer alternating, but four annual shows were held, with one in each of the four counties.

1875 – The government began buying quality Fjord Horse stallions.

1870-1880 – The counties, dissatisfied with the government's decision to approve crossbreeding with the Dole Gudbrandsdal Horse, began buying their own stallions. These travelled from district to district to cover mares, like the government owned stallions did.

1907 – The dispute with use of crossbreeding ended in a meeting held in Innvik, Nordfjord. It was decided that only pure breeding would be allowed, from this day the Fjord Horse has been maintained as a pure breed.

1910 – The first Studbook for the Fjord Horse was published. It held 308 stallions foaled between *1857 and 1904*. The studbook keeping has evolved through the times from in its beginning to contain only the evaluated stallions and mares as an “elite Studbook” until today's version where Norsk Hestesenter on behalf of Norges Fjordhestlag register all eligible Fjord Horses. The “Elite Studbook” still exists, but now as an addition to the standard, for stallions and mares prized and merited.

1922 – The first Breeding Consultant for the Fjord Horse was appointed by the government.

1937 – The system of government owned stallions were disbanded and its funds transferred to supporting local breed societies.

1941 – A law was passed which restricted the use of stallions. Previously all stallions could be used but from 1941 only licensed individuals could be used. A notable exception was that an owner could use his own stallion without license on his own mares, this exception stayed in place until *2000* when it was disbanded.

1949 – Norges Fjordhestlag, Norwegian Fjord Horse Society or NFL for short, was founded, making a unified national society for all the various county and district associations.

1967 – All horse breeding was managed by one government appointed Breeding Consultant.

1986 – Norsk Hestesenter, The Norwegian Horse Centre, was founded by the Ministry of Agriculture to take responsibility for all horse breeding, registering, studbook keeping, evaluations and shows.

1992 – The Rio Convention on Biodiversity was held and Norway lay claim to hold the geographical origin of the Fjord Horse. The claim was accepted and Norway was given the responsibility of looking after the breed and its character.

1993 – The role of government appointed Breeding Consultant was disbanded and the work of managing breeding was given to the leader of the breeding section at Norsk Hestesenter.

1994 – The European Union introduced a “Regulation for the approval of purebred equines” which replaced the national law on breeding stallions from 1941

1996 – The European Unions Convention on Domestic Animals declared Norway as the country of origin of the breed.

1997 – With both the Rio convention and the EU giving Norway the responsibility for maintaining the breed, a need to create an international organisation arose. NFL took the initiative and Fjord Horse International, FHI, was formed.

2008 – It was decided that in order to be listed in the Studbook registry there must be a minimum of five known generations in the pedigree of all purebred Fjord Horses.

2015 – From this year it is no longer forbidden to use unlicensed stallions to cover mares. As long as the breeder owns both stallion and mare it will be permitted. However, the resulting foal will be registered differently than foals from a licensed sire, and will not be eligible for evaluation to be merited.

1.3. Breeding standard

The breeding standard is set by Fjord Horse International, and there are four groups of characteristics which are deemed important. These four groups are evaluated when showing a horse and are weighted accordingly:

- Conformation 50%
- Function 30%
- Temperament 10%
- Soundness 10%

1.3.1. Conformation

1.3.1.1. Height

The desired height at the withers is between 135 cm and 150 cm. There is no fixed upper or lower limit, so horses above or below this height might still be licensed.

1.3.1.2. Colour and markings

Brown dun, red dun, grey, uls dun and yellow dun are the five accepted colours, with special importance put on the appearance of primitive markings. Further explanation can be found in chapter 3.4.2.

1.3.1.3. Hair coat

The forelock of mature horses should cover from one half to two thirds of the head. The mane should be cut so as to be upright in a convexly curved shape following the natural top line of the neck.

1.3.1.4. Head

Should be proportional, small and well defined in a way that is representative of the breed type and character. The forehead should be wide and flat, the profile can be flat but a slight concavity is to be desired. The length from eye to muzzle should be short.

The *eyes* should be large and dark with a bright yet calm expression.

The *nostrils* should be wide and in such a proportion as to give a “square” appearance.

Jaws should be well defined, especially on stallions, but lower jaw must not be so heavy as to give a coarse appearance of the head. There should be space enough between the jaws to allow free movement of the head.

Ears should be parallel and there should be an outward curvature from tip to middle. Long ears as well as constant movement is not typical for the breed, and relatively short and wide set ears are to be desired.

1.3.1.5. Conformation and musculature

A harmonious appearance of the body parts is of importance. A range of variations may be accepted as long as the horse shows good depth through the heart girth, good width through the barrel and a proportional amount of muscling that well reflects age and gender.

1.3.1.6. Neck

Should be high set with a convex top line. Stallions in particular should have a strong neck. A smooth transition from the head to the neck as well as good length at the poll is to be desired. Since the Fjord horse has a history of being used for heavy work a short strong neck with straight shoulders has long been favoured. As the breed usage has evolved towards riding, driving and packhorse purposes a longer and more supple neck is to be desired. However, it must be emphasized that a long and thin neck is an undesirable trait.

1.3.1.7. Shoulders and withers

The shoulders should have a gently sloping angle that allows forward extension of the fore limbs. A straight shoulder is no longer desirable. The withers should not be prominent but rather blend smoothly into the outline of the back. They should be defined in a manner as to be a good anchorage for shoulder- and back muscles. The forehand should be of equal length with back and hindquarters.

1.3.1.8. Body and top line

The ribs should be well sprung without appearing rounded. Back and loin area should be well muscled and smooth. Transition between loin and croup should be flexible and blend smoothly together. As the loins are the bridging point between the mid-section and hindquarters they must be carefully assessed, its length should be short but strong and should be proportionate to the back and croup.

1.3.1.9. Hindquarters

The croup should be long, broad, well muscled and sloping. It is important to note that the croup must not appear too flat or too sloping. The tail should be neither set too high nor too low and must be carried freely and naturally. The thighs should appear sufficiently long and

be well muscled when viewed from the side as well as from behind. The thighs should be set at a width proportional to the quarters.

1.3.1.10. Legs

The legs must be in correct alignment and with adequate bone structure. A short and firm cannon bone is to be desired, and the cannon bones must appear clean and dry, they should not be tied below the knee. In addition joints and tendons of the legs must be clearly defined and dry. The *forearm* should be broad and well muscled.

The *thigh and gaskin muscling* of the hind legs should be long and well developed when seen from the side as well as from behind. The gaskin muscling must not appear too long, as this would be considered a disadvantage for a draught horse.

The *carpal joint*, knee, should be large and well defined.

The *hock joint* should be large, well developed as well as dry. The hocks must not be too straight nor too bowed, and should appear prominent when viewed from the side. Small or ill-defined hocks are not typical for the breed and should be considered a disadvantage.

The *fetlock joint* must be strong and well defined.

The *pasterns* should appear strong, be of sufficient length and have a slope, which yields support and elasticity.

The *hooves* should be of good horn quality, be well balanced and with proportional size and roundness. A slightly steeper inside than outside can be accepted.

1.3.1.11. Movements

The movements are of utmost importance for the horse and they should reflect the conformation with proper elasticity and impulsion in order to perform an effortless walk, trot and canter. It is important that all three gaits can be performed with free range of movement, which are energetic, well balanced and with even rhythm. In canter the horse must appear balanced and with supple and elastic forward motion. In trot it shall appear energetic but without excessive action which is not considered typical for the breed.

1.3.1.12. Gender characteristics

The Fjord horse should have characteristics easily separating the genders, with the mare appearing feminine and the stallion masculine. This can be distinguished with a finer structure of the mares' head. The stallion can have a more triangular appearance by having a broader forehead, bigger and more defined eyes and more heavyset jaws. It is to be desired that the musculature of the neck be better developed in stallions than in mares.

1.3.2. Performance

This part of the breeding standard is related to the performance and natural usefulness of Fjord Horse. The key feature is versatility, which is a defining feature of the breed. The following qualities are considered when judging an individual:

- Versatility
- Driving ability
- Riding ability
- Movement
- Temperament

1.3.3. Temperament

The temperament is judged by; the team of judges for conformation, the judge for performance and a veterinarian. It is based on the horses behaviour during the show. 3rd time shown stallions are judged only by the judge team and the veterinarian, and mares are not checked by a veterinarian and are therefore judged by conformation and performance judges alone. The average score from the three instances is calculated and a grade is based on a weighted average of these three grades (Selle, 2010).

1.3.4. Soundness

The soundness of a Fjord Horse is judged based on the horses own soundness and exterior features affecting soundness. Stallions are checked by a veterinarian at all showings, where especially testicles, mouth with emphasis on bite correctness and the legs of the horse are investigated. The veterinarian will also check for disqualifying features which include:

- Uni- or bilateral cryptorchidism, or different size and texture of the testis

- Scrotal hernia on horses 10 years or younger.
- Serious conditions of the mouth, for example parrot mouth or undershot jaw. Any condition causing the upper and lower teeth to not meet, unless this can be proven to have been caused by injury.

2. MATERIALS AND METHODS

2.1. The goal of this thesis was to take an in depth look at the Norwegian Fjord Horse breed. I wanted to discover the methods used for breeding the horse in order to preserve it as the healthy and proud national symbol it is known as in Norway. With today's knowledge and concern about the genetics behind breeding I wanted to find out if such a small population could manage to survive and remain sustainable in the future.

2.2. Material and data were collected and analysed from as many sources as possible, with a main focus on information from Fjord Horse International, The Norwegian Fjord Horse Society and the Norwegian Fjord Horse Registry. In addition several research papers, scientific articles and books were used to find out about the breed and its genetic properties in recent times as well as in the past.

As Norway has been formally issued the responsibility for the breed it became reasonable to have the Norwegian Fjord horse population as a main focus, while data from other Fjord Horse populations has been analysed when appropriate.

3. RESULTS

3.1. Goal of breeding

In order to organise and give structure to the breeding, the Norwegian Fjord Horse society has formed a goal for the breeding, to be implemented in the breeding plan.

The breeding should be kept pure and oriented towards maintaining the character of the Fjord Horse while making room to accept the diversity and the versatility distinctive to the breed, and produce healthy, functional individuals.

Efforts should be made to further maintain the five original colours and also the primitive markings. The markings may vary according to the shade of the horses' overall body colour. Should markings or colours not typical of the breed occur, these must be discriminated against; efforts should be made to avoid their occurrence.

The Fjord Horse should be a strongly built, robust, well-proportioned and athletic horse with great charm and charisma. One must be aware of and accept different types in terms of use. It is desirable to keep breeding a dependable, cooperative and work willing horse, which is also well balanced and calm in disposition. In addition, the goal must include natural and balanced movements with good forward motion.

Emphasis should be kept on the Fjord Horse being a versatile horse. It should be easy to handle and be well suited for family use.

The breeding work must have strong focus on breeding a Fjord Horse, which will be attractive for the future users, and this must be included when judging a horse for exterior, movements and function.

3.2. Actual breeding

In total there is approximately 120 000 horses in Norway today, and each year around 5000 matings are registered (Norsk Hestesenter, 2015). Out of this total the Fjord Horse breed contributes only a small fraction.

Foals born (last notation 11.11.2014)	
Year	Norwegian Fjord Horse
2008	216
2009	228
2010	198
2011	156
2012	127
2013	123
2014	111

Figure 1. (Norsk Hestesenter, 2015)

As it is portrayed in figure 1 we can see a steady decline in the amount of registered purebred Fjord Horses born each year.

Data from the last decades shows the change in activity of the breeding of the Fjord Horse, both in the activity of use of stallions and covered mares and also in how many foals were foaled as a result of it (FHI, 2015).

	Belgium	France	Germany	Hungary	Norway	Sweden
2014	13	39	145	6	33	-
2013	17	35	154	5	32	43
2012	14	44	158	5	37	51
2011	11	46	159	5	33	57
2010	13	48	154	4	35	56
2009	18	54	148	4	41	56
2008	19	60	146		44	56
2007	19	66	126		41	52
2006	20	64	117		44	54
2005	20	64	122		41	46
2004	21	62	129		43	53
2003	31	66	118		45	53
2002	26	71	135		40	52
2001	28	80	120		50	46
2000	26	79	122		53	50
1999	30	89	127		47	51

Table 1 – Number of active licensed stallions in 6 countries from 1999 to 2014 (FHI, 2015)

	Belgium	France	Germany	Hungary	Norway	Sweden
2014	65	142	394	12	140	-
2013	61	133	342	6	200	86
2012	64	169	345	16	225	111
2011	66	212	365		215	100
2010	81	258	368	10	296	160
2009	87	272	406	15	342	120
2008	128	317	464	-	399	103
2007	124	303	434	-	381	117
2006	147	296	507	-	429	-
2005	185	301	525	-	405	-
2004	167	372	495	-	459	-
2003	180	388	483	-	404	-
2002	210	416	518	-	428	-
2001	216	388	522	-	475	-
2000	240	402	503	-	475	-
1999	255	483	538	-	533	-

Table 2 – Number of covered mares in 6 countries from 1999 to 2014(FHI, 2015)

	Belgium	France	Germany	Hungary	Norway	Sweden
2014	49	82	229	11	118	-
2013	57	107	273	6	121	74
2012	78	121	273	16	126	95
2011	69	171	254	9	152	104
2010	87	182	304	15	195	73
2009	88	200	301	-	224	113
2008	98	191	323	-	214	116
2007	86	207	334	-	231	112
2006	114	210	370	-	220	139
2005	100	248	318	-	269	154
2004	95	250	291	-	226	141
2003	116	269	305	-	279	113
2002	120	242	297	-	284	145
2001	135	246	276	-	298	115
2000	147	258	329	-	343	112
1999	211	329	428	-	-	162

Table 3 – Number of foals foaled and registered in 6 countries from 1999 to 2014 (FHI, 2015)

Note that some data in table 1 – 3 are missing due to lack of reported numbers to Fjord Horse International from the National breeding associations and from Hungary due to the fact that their membership in FHI began later than 1999.

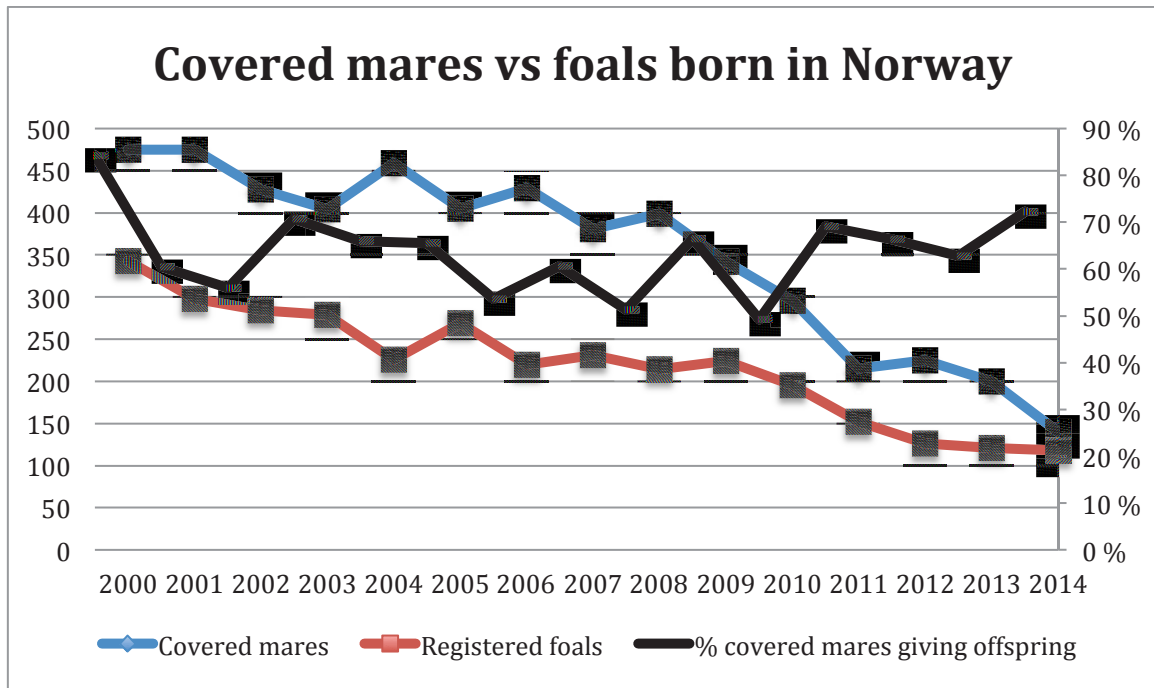


Figure 2 – The development through the last 15 years in covered mares and foals born and registered in Norway.

As we can see in figure 2 the number of mares covered and the foals foaled as a result of these matings has declined steadily over the past 15 years. The rate of foals foaled and registered per mating has not changed significantly during these years, as can be seen from the figure, the variations has been from 49% at the lowest in 2004 up to 84% at the highest in 2014. The reason for the variations from year to year can be explained in part by the long-standing tradition of “hesteslipp” in Norway (Norsk Hestesenter, 2016). “Slipp” entails letting one stallion out on an enclosed area, typically on the mountains of Western Norway, together with a certain number of mares. The horses will remain on this area during the summer months, and be collected in autumn. Since the horses go unsupervised the matings cannot be controlled in an effective way and some mares may simply not be covered at all. Another influencing factor is that the owner of the mare is responsible for

registering the foal produced by the mating, as the owner is not obligated to do so some may refrain from registering.

If we look at the numbers in table 1 – 3 we can see that the tendency of the population of Fjord Horses internationally is decreasing, there has been a steady decline in active stallions and mares as well as in the number of foals foaled and registered each year since the year 2000. It is not a unique feature in Norway but also occurring in the other countries, which are members of Fjord Horse International. One country has managed to reverse the trend on the point of active stallions, in Germany there were 122 registered active stallions in year 2000 and 145 registered in 2014, they have seen a increase in active stallions during the last 15 year. The number of mares covered in Germany has declined over the past 15 years, this means that each stallion is covering fewer mares now than previously. In terms of genetic diversity this can be seen as a benefit as there is less chance of inbreeding.

3.3. Inbreeding within the Norwegian Fjord Horse breed

3.3.1 Inbreeding coefficient

The inbreeding coefficient, F , is defined as the probability of two genes at any locus in an individual are identical by decent. It is influenced by the length and completeness of pedigree, meaning that the longer and more complete the pedigree is the more reliable the inbreeding coefficient will be. This entails that inbreeding coefficients can be estimated quite reliably for the Fjord Horse breed, as the tradition of studbook keeping has been in place for over 100 years.

The inbreeding coefficient has changed over the years and for the Norwegian population of Fjord Horses it can be summarized as follows (Norsk Hestesenter 2015):

- 1910: 0,010
- 1930: 0,047
- 1957: 0,077
- 2009: 0,070

The change in inbreeding during the last generation, ΔF , was calculated at 0,46% in 2009, international guidelines recommend a ΔF of maximum 0,5-1% per generation (Norsk Hestesenter, 2015), which means that the change in inbreeding in 2009 was acceptable. The effective population size, N_e , defined as the number of breeding animals, which would

lead to an increase in inbreeding if they contributed equally to the next generation (Nagy, 2015), this number should not go below 100, and in 2009 the N_e for Fjord Horse population in Norway was 107, this makes the population on a borderline of what can be considered a healthy breeding stock and genetically acceptable.

A study performed at Norwegian University of Life Sciences on small horse populations (Olsen & Klemetsdal, 2010), concluded that with practicing phenotypic selection of 3 year old sires for one year and reselection of these at 4 years for 4 years the Fjord Horse breed could be maintained genetically sound at 200 foals registered per year, and this would ensure a effective population size per generation of minimum 100 individuals. The second most important factor in maintaining the effective population size was discovered to be keeping a large fraction of the offspring from 3 year old sires as this gave room for the use of more stallions. The study showed that the increase in inbreeding becomes problematic if the number of foals foaled goes below 200 registered individuals per year.

In 2009 the number of active stallions, covered mares and foals born were 41, 342 and 224 respectively, five years later in 2014 they have decreased to 33, 140 and 118. This entails that the number of foals registered per year has dropped below the level of maintaining a genetically sound population and the danger of random loss of genetic diversity is imminent.

Another study was performed to evaluate the genetic variability within the Fjord Horse population of North America (Bhatnager et. al, 2011). The effective population size was 207,8 and the total number of founders was 641. Pedigree completeness was close to 100 percent for the past 6 generations. The average inbreeding coefficient was 0,032 for the entire pedigree and 0,016 for pedigrees traced back five generations. The study found that the inbreeding coefficient average by year of birth was increasing until 1983, in the years after it decreased and had stabilized through 2009. Bhatnager et. al (2011) found the effective number of founders, f_e , to be 96, the effective number of ancestors, f_a , to be 30,0 and founder genomes, f_g , to be 12,7. Effective founders, f_e , is defined as the number of equally contributing founders that would be expected to produce the same genetic diversity as in the population being investigated. Effective ancestors, f_a , is the minimum number of ancestors able to produce the complete genetic diversity of a population, it will always be equal or less than f_e . Effective founder genomes, f_g , is defined as the number founders which would be expected to produce the same genetic diversity as in the population being investigated if the founders were equally represented and no loss of alleles occurred (Nagy,

2015).

Based on this information the study concluded that the low $f_e(96)$ and $f_a(30,0)$ together with the high ratio between them, 3,21, suggestive of a disproportion in the use of some individuals, indicated a loss of genetic diversity during the development of the Fjord Horse breed in North America. The significant difference between $f_a(30)$ and $f_g(12,7)$ further indicated random loss of genetic diversity. The study highlights the limited number of sire-lines as a major contributing factor to the increase in inbreeding coefficients and loss of genetic diversity.

3.4. Characteristics of coat colour in the Fjord Horse

3.4.1. General genetic background

The coat colour of horses is determined in a complex manner, there are 11 gene loci which are known to influence coat colour, A, B, C, D, E, G, O, Rn, To, W and Z. In the Fjord Horse 4 of these are especially important;

A – agouti: A and a alleles.

E – extension/Black Factor: E(black) and e(red) alleles.

D – dun dilution; D and d alleles.

C – basic colour gene; in particular the C^{cr} allele known as a dilution factor.

Based on the A and E genes the coat will have a basic colour of black, red or bay. The extension gene, E, will decide if the colour pigment production is black, 'E', or red, 'e'. 'E' is dominant, which means that if one copy of this allele is present the horse will have a black based colour (Zöldág, 2008).

However, the Agouti gene is capable of altering the Extension gene expression, creating the third base colour; bay.

As Agouti, 'A', is also a dominant gene, the expression of one allele will alter from black to bay phenotype. It is important to note that the A gene has no influence on red pigment, so if the base colour is red, 'ee' the Agouti genotype will not be expressed in the phenotype of the horse (Animal Genetics, 2014a).

Base Coat Colour	Black/Red factor	Agouti
Solid black	EE or Ee	aa
Red	ee	AA, Aa or aa
Bay	EE or Ee	AA or Aa

Table 4. Demonstration of the base coat colour determination in relation to E & A genes.

The dun dilution gene is responsible for diluting the basic black, red or bay colours to grey(mouse dun), red dun(chestnut dun) or bay dun(brown dun) respectively. It is a dominant trait, meaning that both DD and Dd genotype combinations will result in colour dilution. An interesting feature of the Norwegian Fjord Horse is that all individuals belong to one of five recognised variations of dun colouring, meaning that if the dilution gene is not present in dominant form, DD, the individual is not recognised as a member of the breed. The terminology of the colour variations is also different from the English terms normally used to describe dun colours, this seems to be a result of the Norwegian language terms which were set in 1922 together with the decision made in 1980 by the annual General Meeting of Norges Fjordhestslag (Norsk Hestesenter, 2015) to acknowledge only five colours as genuine and typical for the breed.

The Dun dilution gene is linked with the “primitive marking” of horses, which means it will lighten parts of the coat while leaving other areas in the original base coat. This gives the horse a distinctive and easily recognisable appearance including:

- *Dorsal stripe*: undiluted base colour along the spine of the horse.
- *Horizontal stripe*: striping on the back of the forelegs.
- *Shoulder blade stripe*: striping across the withers of the horse.

The dorsal stripe is usually clearly visible on all dun horses, while the horizontal and shoulder stripes may be more faint and hard to detect. Other areas which commonly remain undiluted are the mane, tail, face and legs (Animal Genetics, 2015b).

The 4th gene of special importance is the C^{cr} gene allele. This is the factor responsible for the uls and yellow dun colour varieties. It can also occur in the genotype of grey horses, but as the dilution is not as obvious in the phenotype it would still be termed as a grey (blue dun). If double gene alleles are present, C^{cr}C^{cr}, it will give white and walleyed horses.

These horses are misleadingly named albino or pseudoalbino in everyday speech, they are however not true albinos, as their irises remain a light blue colour. The correct term would be cremello or perlino and is not accepted in the Fjord Horse breed. Breeding individuals with the C^{cr} gene is discouraged.

3.4.2. Colour variations of the Norwegian Fjord Horse

As mentioned previously there are 5 basic colours recognized in the Fjord Horse breed, these are the basic primitive colours **brown dun**, **red dun** and **grey**(blue dun). In addition **uls dun** and **yellow dun** are recognized as genuine colours for the breed. Below the different colour variations are described and are also illustrated with images (Norsk Fjordhestlag, 2015)

3.4.2.1. Brown dun



Picture 1. Brown dun coloured Fjord Horse

Also known as “Brunblakk” in Norwegian. It is the most common colour seen in the modern Fjord Horse. The colour of the horses’ body is a pale yellow-brownish and can come in varying shades, from a light creamy yellow to a nearly brown colour. The darker stripe in the mane, tail and forelock known as “mid-section” in English or “Midtstol” in Norwegian is black or a dark brown colour, while the hair on both sides of the mid-section in mane, forelock and tail is white. This feature will also vary with whether the horse is a lighter or darker shade of brown dun, from white to a darker almost brown tone. The dorsal stripe, known as the “eel-stipe” will also carry a dark brown to black colour, same as the mid-section.

Possible genetic combinations:

- AA/EE/CC/DD
- AA/Ee/CC/DD
- Aa/Ee/CC/DD
- Aa/Ee/CC/DD

3.4.2.2. Red Dun



Picture 2. Red dun coloured Fjord Horse

Known as “Rødblakk” in Norwegian. The body has a pale red-yellowish colour and can be found in lighter or darker shades. Some shades can be difficult to difference from the brown dun colour. The mid-section and eel-stripe are red or a brownish red colour, it is always darker than the main part of the body but is never black in colour. The rest of the mane and tail is very light or yellowish, but in the very light shades of red dun these sections may be completely white. Red duns are usually born with light hooves, but these may darken with age.

Possible genetic combinations:

- AA/ee/CC/DD
- Aa/ee/CC/DD
- aa/ee/CC/DD

3.4.2.3. Grey / blue dun



Picture 3. Grey coloured Fjord Horse

Termed “Grå” in Norwegian. The body of a grey Fjord horse can vary from a light silver to a dark slate grey colour. The mid-section and eel-stripe should be black or a darker grey than the main colour, while the remainder of mane and tail can vary from almost white in the lighter to a dark grey in the darkest individuals. Forelock and muzzle are usually darker than what is seen in the brown and red duns.

Possible genetic combinations:

- aa/EE/CC/DD
- aa/Ee/CC/DD
- aa/EE/CC^{cr}/DD
- aa/Ee/CC^{cr}/DD

3.4.2.4. Uls dun



Picture 4. Uls dun coloured Fjord Horse

Termed “Ulsblakk” in Norwegian. It is actually a brown dun with a dilution factor responsible for diluting the production of hair colour. The main colour is almost white or yellowish white. The mid-section and eel-stripe is black, while the remainder of hair in mane and tail is of a lighter shade than that of the body. This makes the uls dun very characteristic in its appearance and can explain its previous popularity among breeders (FHI, 2003)

Possible genetic combinations:

- AA/EE/CC^{cr}/DD
- AA/Ee/CC^{cr}/DD
- Aa/EE/CC^{cr}/DD
- Aa/Ee/CC^{cr}/DD

3.4.2.5. Yellow dun



Picture 5. Yellow dun coloured Fjord Horse

Termed “gulblakk” in Norwegian. Like the Uls dun, this colour is caused by the colour dilution factor C^{cr} , only in this case on a red dun horse. The body will have a yellowish white colour, and the darker areas in the mid-section and eel-stripe will be a darker shade of yellow than the rest of the horse. The remaining portion of the mane, forelock and tail may be completely white or a very light shade of yellow. The eel-stripe may even be in a shade so similar to the main part of the horse as not to be distinct at all. The yellow dun is the most rare colour variation of the breed today.

Possible genetic combinations:

- $AA/ee/CC^{cr}/DD$
- $Aa/ee/CC^{cr}/DD$
- $aa/ee/CC^{cr}/DD$



Picture 6. Overview of colours, from left: red dun, yellow dun, grey, brown dun and uls dun.

3.4.3. Other markings

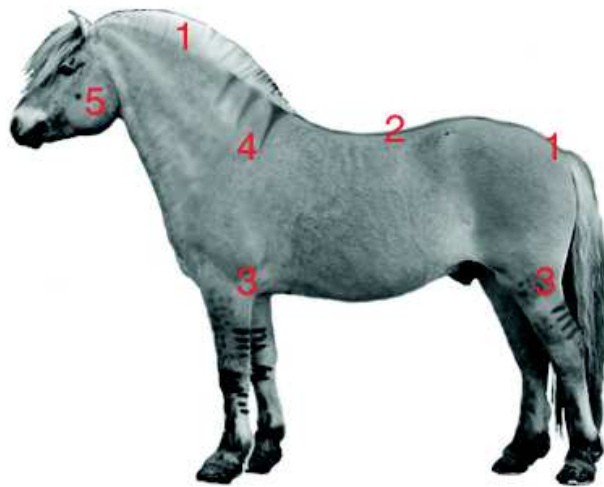
As the Fjord Horse has a distinctive coat colour, other markings are undesirable. White or flesh-coloured markings are seldom seen and are generally not accepted with a few exceptions (FHI, 2003). A white star on the forehead is known to occur from time to time. It is inherited recessively; therefore both parents must carry the gene for it to become visible in a foal. Though it has been recorded in the Fjord Horse as far back as the known records exist, it is only accepted on mares and unacceptable for a stallion.

Flesh coloured markings on the penis of a stallion are accepted.

The sole of the Fjord Horse should be dark, but light coloured soles are accepted for red and yellow duns.

3.4.4. Primitive -zebroid- markings

The primitive markings are a defining feature of the Fjord Horse breed, as seen in the picture below, there are several distinctive features which appear due to these primitive markings. Please note that the picture has been modified to accentuate the markings and are usually not as clearly visible on live individuals. The colour is highly dependant on the main body colour and on lighter shades of dun colour they might be difficult to make out, as for example the light yellow dun Fjord Horses.



Picture 7. Illustration of primitive markings (FHI, 2003)

1. Mid-section: dark marking of mane forelock and tail.
2. Dorsal stripe: along back, following spine of the horse.
3. Zebra stripes: darker horizontal stripes on legs, also scattered spots might be seen on proximal regions on fore- and hind limbs.
4. Shoulder cross: dark stripes across withers, known as “grep” – only rarely seen.
5. Mark of Njål: a single darker mark might be seen on the cheek of some individuals. This mark is named after the prolific stallion Njål 166, foaled in 1891 and counted as the father of the modern Fjord Horse.

3.4.5. Colour influence on breeding, popularity of colour variants

Based on the genetic combinations possible for each of the five dun colours there will be a set number of possibilities for colour combinations in a foal following mating of Fjord Horses, the possible outcomes can be seen in table 5 below.

	Brown dun	Red dun	Grey	Uls dun	Yellow dun
Brown dun	Brown dun Red dun Grey	Brown dun Red dun Grey	Brown dun Red dun Grey Uls dun Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun
Red dun	Brown dun Red dun Grey	Red dun	Brown dun Red dun Grey Uls dun Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun	Red dun Yellow dun
Grey	Brown dun Red dun Grey Uls dun Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun	<i>Red dun</i> <i>Grey</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>
Uls dun	Brown dun Red dun Grey Uls dun Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>
Yellow dun	Brown dun Red dun Grey Uls dun Yellow dun	Red dun Yellow dun	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Brown dun</i> <i>Red dun</i> <i>Grey</i> <i>Uls dun</i> <i>Yellow dun</i> <i>Perlino</i> <i>/cremello</i>	<i>Red dun</i> <i>Yellow dun</i> <i>Cremello</i>

Table 5. Possible colours in offspring resulting from mating different colours of Fjord Horses.

Matings with grey, uls dun and/or yellow dun carry the risk of getting an offspring which carrying a double set of the C^{cr} gene which would make it the unacceptable perlino or cremello colour, this can be avoided by mating with a dam or sire of brown dun or red dun colour. If we look at the division of colours in evaluations or shows from 2000 to 2002, table 6, it is evident that the brown dun is hugely more common than the others (FHI, 2003). This might be in part a result of breeders safeguarding themselves against offspring of undesired colour, or there might be a favouring among judges of individuals of this colour.

	Norway			Denmark			Netherlands		
Year	2000	2001	2002	2000	2001	2002	2000	2001	2002
Brown dun	350	261	202	163	174	149	575	561	545
Red dun	17	12	8	6	13	8	5	6	5
Grey	11	19	12	2	2	2	5	7	5
Uls dun	12	14	9	2	1	1	5	6	10
Yellow dun	1	1	2	0	0	0	0	0	1

Table 6. Division of colours of Fjord Horses in evaluations/shows from 2000-2002

3.5. Change in demand from past to present

What has been wanted from a Fjord Horse has varied over the years and therefore also what characteristics to give priority in breeding. In the 19th century the need was shifting from that of a drive and packhorse, which was light and hardy to a heavier draught horse type, which could aid better in farm labour. In light of this need crossbreeding occurred with the heavier Dole Gudbrandsdal Horse. After the reinstatement of purebreeding in 1907 the emphasis was still on breeding strong and heavily built horses all the way up to the 1960s when machinery made the traditional farm horse superfluous. The breeding aspect changed to create a lighter horse with a more athletic build (Norsk Hestesenter, 2015). As the demand has shifted towards a horse well suited for riding and driving the breeding has focused on a light and athletic horse, but while retaining the aim to breed animals with a functional conformation which has been emphasised since the beginning of breeding Fjord Horses. At present the need is that of a supple horse with a good temperament, which is easy to ride and drive. It should be sure footed and be equally confident in the show ring as on the mountainside. The Fjord horse of today is a good riding school animal and is also used in competitions (Norsk Hestesenter, 2015).

With the change in demand shaping the Fjord Horse towards a versatile horse with many different uses breeders now face challenges with creating a market for the Fjord Horse, at present time there is no niche to create interest in todays horse users. Numbers in the diagrams below show the progression in horses kept in Norway over the past 25 years.

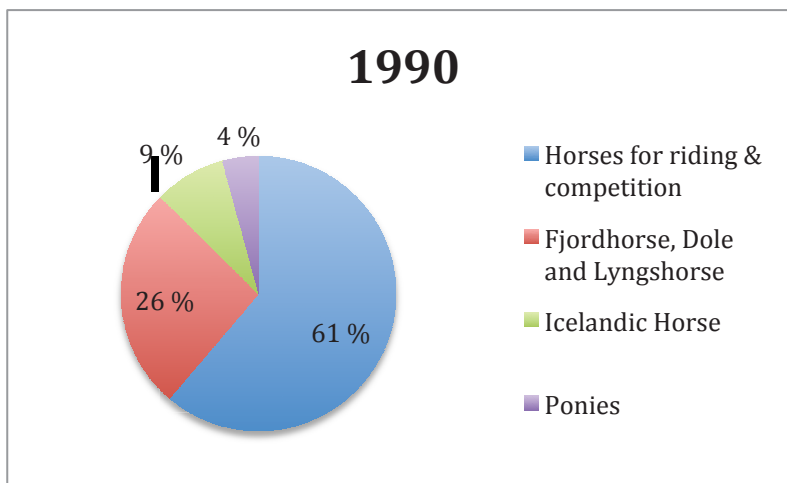


Diagram 1. Distribution of horses in Norway 1990 (Norsk Hestesenter, 2015)

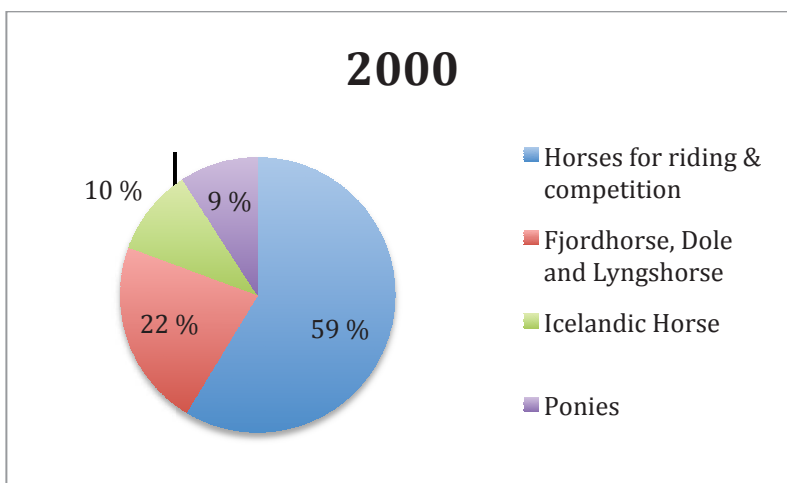


Diagram 2. Distribution of horses in Norway 2000 (Norsk Hestesenter, 2015)

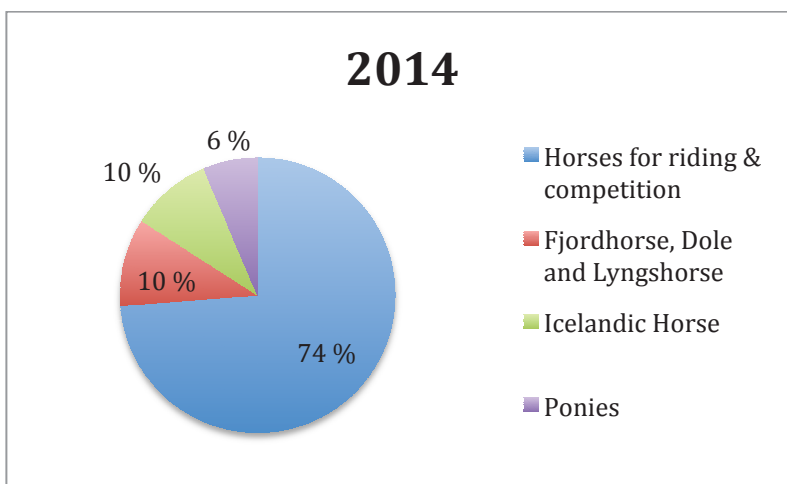


Diagram 3. Distribution of horses in Norway in 2014 (Norsk Hestesenter, 2015)

As can be seen from diagram 1-3 the percentage of Fjord Horses together with the other two unique Norwegian breeds, Dole Gudbrandsdal Horse and Lyngshorse, have been steadily declining over the past decades.

A study was performed in 2012 to see what intentions and interests horse owners in Norway had for their own horses.

Horse owner	Percentage
Hobby/leisure/recreation	72
Trotting/galloping – competitive	32
Breeding	27
Other type of competition	23
Health, therapy or rehabilitation aid	8
Farming or forestry	8
Riding school	5
Tourism	5
Other	3

Table 7. Field of use for horse owners (Vik & Farstad, 2012)

The study gave room for horse owners to list more than one use, therefore the percentage amounts to more than 100. The study showed that the majority, 72% of horse owners keep horses for hobby/leisure/recreation purposes. 32% are engaged in competitive racing with an additional 23% engage in other forms of competition. 27% of owners take part in breeding. 8% use their horses for farming or forestry and an equal percentage for health, therapy riding or rehabilitation. Only 5% use their horses for tourism purposes and another 5% keep them as riding school horses.

3.6. Selection and pre-selection of breeding animals

3.6.1. Selection of stallions

Because stallions have a much higher potential offspring amount in their lifetime than mares they generally have a higher influence on the breed population. This reflects in the breeding plan of Fjord Horses by focusing the majority of selection on stallions. A stallion must be officially evaluated at a public show, which has to be officially announced. The evaluation has to be performed by a designated evaluation group consisting of minimum

one veterinarian and 2 or more judges depending on class. Though evaluations should be performed in shows, the evaluation group has the authority to evaluate, exclude or revoke previous approvals on stallions outside official shows as well (Selle, 2010).

The model of selection contains several potential points of selection of stallions as is portrayed in figure 3. The stallions' achievements in each point is evaluated and weighted according to the current breeding plan for the breed, with a scale of 1-10. The lowest acceptable score at any point is 5, a score below this minimum disqualifies the individual in question from breeding. This effectively makes it a 5-10 scale, where half of the scale in practice is unused.

The first official step is at 3 years of age with the first obligatory individual evaluation. This includes conformation, performance and veterinary control. Successfully evaluated stallions will get a breeding approval for one year and to keep the approval beyond this time they need to perform an extended performance test. This test needs to be carried out at a station in the spring of the stallions 4th year or the year after the first evaluation.

The extended performance test spans over five weeks and entails riding and driving in different circumstances. Stallions will be evaluated by loose jumping, loose show, dressage riding, dressage driving(light), work driving(heavy), gaits & forward movement, behaviour in traffic, behaviour at the stables and overall impression. In addition each stallion shall be examined by a veterinarian at the beginning as well as the end of the test period. The aim behind this extensive testing is to be able to test stallions of an age under equal circumstances and to ensure a thorough and reliable evaluation of health, performance qualities and temperament (Norsk Hestesenter, 2015).

The next obligatory point of selection is the 2nd time individual evaluation of stallions 4 years of age. They will be merited as 1st, 2nd or 3rd prized or, they will be excluded from breeding. No further individual evaluations are required after this, but it is allowed to do so if the breeder wishes to improve the stallions merit, the evaluation will be performed as previously and the new result will stand, regardless if it has improved, remained unchanged or worsened.

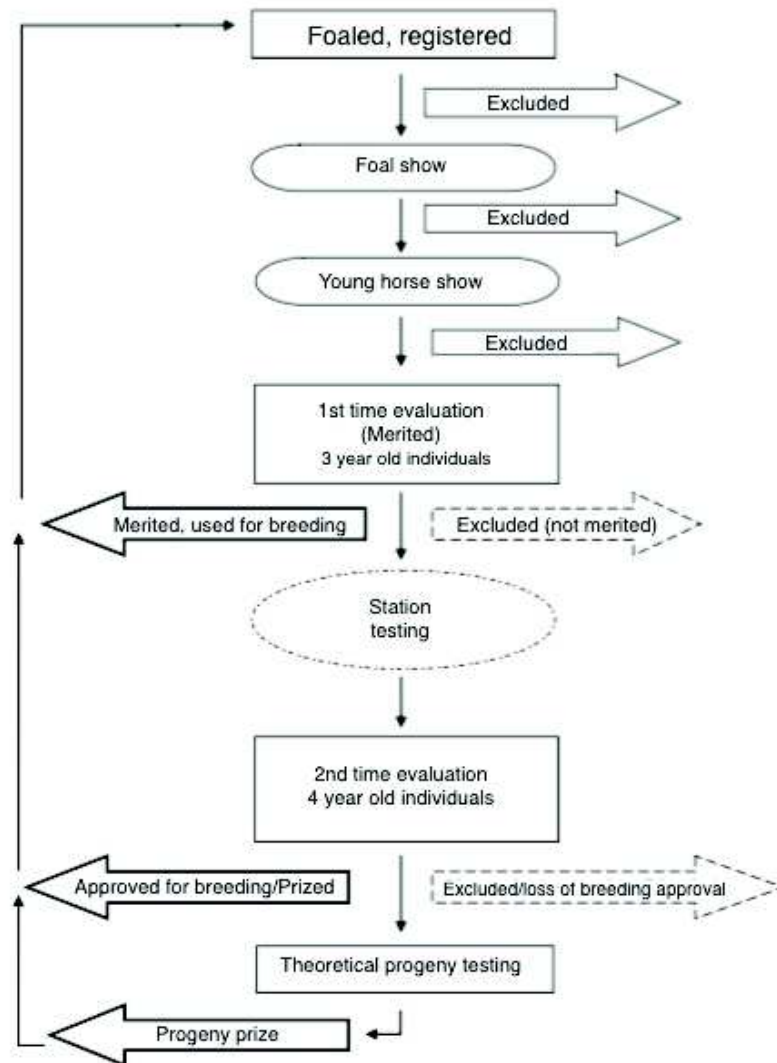


Figure 3. Selection model for stallions. (Selle, 2010)

3.6.1.1. Use of unlicensed stallions

Though previously allowed, a Fjord Horse owner may not use an unlicensed stallion to cover own mares, regardless if he holds ownership of the stallion in question or not.

3.6.2. Selections of mares

The selection of mares is not set as rigidly as for stallions, due to the fact that they carry less influence on the breed population. To qualify for breeding a mare only requires to be registered in the Studbook and have a minimum of five known generations in the pedigree. Nonetheless mares can be shown and evaluated on the same terms as stallions to be

prized/merited, and having own classes for mares in the official shows is an important breeding encouraging initiative (Selle, 2010). In addition it yields valuable information to be used for the progeny testing of stallions and it can give the breeder an indication as to whether the mare is suitable for further breeding or not.

3.7. Percentage of Fjord Horses shown.

As mentioned previously a Fjord Horse should be shown and evaluated by judges to be eligible for breeding. However, it is not a given that all horse owners will have their horses evaluated. Table 8 shows how many Fjord horses are foaled each year and how many of these appear in shows at 3 years.

	Foaled females	Fraction of females shown at 3 years	Foaled males	Fraction of females shown at 3 years
1998	210	0,119	103	0,233
1999	184	0,114	166	0,114
2000	180	0,194	166	0,151
2001	161	0,205	138	0,159
2002	150	0,193	139	0,216
2003	157	0,204	124	0,194
2004	119	0,261	113	0,186
2005	143	0,203	127	0,252
2006	125	0,192	95	0,242
Mean	158,8	0,187	130,1	0,194

Table 8. Fraction of horses foaled each year appearing in shows at 3 years of age (Selle, 2010)

Table 8 shows that on average 18,7% of mares and 19,4% of stallions born each year are eventually shown for evaluation at 3 years of age. The fraction of mares or stallions shown varies over the years, with more mares being shown in 4 of the years listed and more stallions shown 4 of the years, the mean show rate is slightly lower for mares than stallions in total. This entails that less than 20% of registered foals foaled are available for selection by the age of 3. As mares can be breed independent of evaluation, the low percentage of mares shown is not a great concern in terms of breeding and genetic diversity. In stallions it poses more of an issue, as evaluation is obligatory for use in breeding, a low percentage can

lead to an undesirably low number of sires in the population, which can harm the genetic diversity and increase the probability of inbreeding.

3.8. Artificially aided breeding

3.8.1. Use of embryo transplant

A Fjord Horse conceived through embryo transplant cannot be registered in Norway (Norsk Hestesenter, 2015).

3.8.2. Use of sperm, artificial insemination

The Norwegian Fjord Horse Society has established an own insemination station for Fjord Horses at Nordfjordeid. They keep two stallions at the station available for sperm collection during the breeding season.

Sperm from a dead or live licensed stallion may be used, but only during the covering season of the given year or the year of the sires demise. This rule may be omitted, but the stallion judges' panel must give a dispensation.

Stallions licensed for breeding in Norway or stallions with a different country of origin may be used in artificial insemination on Norwegian Fjord Horse mares. However, if bred in another country, the Judges panel for Fjords must accept the use of the imported sperm in question.

By comparison, natural mating with a stallion bred in another country does not require specific authorisation as long as the stallion has been licensed using a evaluation system comparable with the Norwegian system. It therefore seems unjustifiably complicated to require individual application for approval if the horse owner wishes to use AI. The authenticity of the sperm can easily be checked by DNA typing the offspring, as this is already a requirement when registering any Fjord Horse today (Norsh Hestesenter, 2015).

3.8.3. Progeny research

3.8.3.1 Progeny group

Previously, progeny research was performed with a selected progeny group for stallions. This method is out-dated and has proved inefficient, therefore new tools are being considered for implementation into the breeding plan for the Fjord Horse breed.

3.8.3.2 BLUP

Currently a trial system of calculating breeding values by means of the BLUP system, best linear unbiased prediction system, is used. The properties for the Fjord Horse individuals already evaluated in the showing system will form the basis of data for the new system. Using breeding values from a BLUP system used alone will lead to increased inbreeding coefficient in small breed populations (Nielsen et. al, 2011), it is therefore necessary to complement the system with another component; OCS.

3.8.3.3. OCS

Implementing OCS, optimal contribution selection, will stimulate the use of young sires in the breeding and will aid in phasing out older sires, in particular those who have had large contributions genetically by repeated use. In practice this will mean implementing mare quotas for stallions, which should be calculated annually. The BLUP values and mare quotas were first calculated in 2013 and currently an extensive trial period is being performed with an aim to implement the system in the breeding plan in the near future (Norsk Hestesenter, 2015).

Another advantage of implementing OCS is that stallions with a low average genetic relatedness to the other selection candidates will be selected. This will lead to a tendency towards selection of stallions eligible, but not yet approved/merited for breeding. Owners of stallions might not be aware of the genetic potential of their stallions, and the system can be used to actively recruit candidates for stallion evaluations and shows.

3.8.3.4 MAI

Another breeding strategy used by many mare owners is MAI, maximum avoidance of inbreeding. This is a strategy used to select the stallion, which is the least related to the

mare in order to avoid inbreeding. In theory this is a good method, but some problems occur when implementing MAI in a small population like the Fjord Horse breed. As mare owners will choose a stallion with the best possible evaluation scores to cover their mare, many breeders will end up using the same stallion without being aware of this selection favouring a specific stallion for many independent breeders. As a result a generation of half siblings will develop which increases the danger of inbreeding and loss of genetic material.

4. DISCUSSIONS AND CONCLUSION

4.1. Emphasis on sustainable breeding

4.1.1. Breeding goal

After Fjord Horse International was established in 1997 it has become easier to spread knowledge and information amongst Fjord Horse owners and breeders across the nations. It is possible for breeders to know at any given time what is desired of a Fjord Horse individual in terms of appearance and performance.

The goal of the breeding itself has not changed dramatically over the past decades, some minor adjustments have been made, but a thorough update has yet to occur. For a small breed population as the Fjord Horse it might be dangerous to dwell in the past in terms of breeding. The interest in horse keeping, both for leisure and competition are increasing, as is the total number of horses kept. This increase in interest could be beneficial for the breed, but with the added competition from other more specialized horse breeds, the result is a waning interest in the Fjord Horse.

A revision of the breeding goal is sorely needed in order to make the Fjord Horse desirable for the modern horse user. The current goal puts a majority of the focus on the appearance and exterior features of the Fjord Horse and I believe it would benefit from shifting the focus towards the usability of the breed and emphasising these characteristics.

4.1.2. Breeder enlightenment, selection of horses

For a breeder it is important to arrange matings which gives her or him an offspring with good characteristics for future evaluations and shows, as the way for the breeder to have economic gain from the breeding is by producing individuals desirable for potential buyers. The tools available for breeders today are limited in terms of systems, strategies and available information about how to select to ensure the best gain and further development of the Fjord Horse breed.

The breeders have a free choice among the approved stallions available, however, even if the list of potential sires is easily available through Norwegian Horse Society's database, it can be problematic to make a good choice. Especially considering that the number of available stallions is only 45 individuals (Norsk Fjordhestlag, 2015), and, the breeders are not educated or given the knowledge needed to help them choose appropriately. This

system does not aid much in directing the breeding towards a healthier and more genetically diverse population. In my opinion there is a need for management of the breeding on a national level, someone need to take initiative to organise the breeding to aid the individual breeders. As Norway has taken on the responsibility of maintaining the Fjord Horse breed, its government needs to own up to the task at hand.

4.1.3. Breeding recruitment

As the interest in horse keeping increases, efforts to increase the interest in the Fjord Horse breed with it must be made. As the status is today too few foals are registered each year and the danger of inbreeding is imminent. Genetic diversity is essential for a healthy and sustainable population in the future, and the only hope of achieving this is by limiting inbreeding and increase the effective populations size. The most obvious means of increasing the number of foals born is by increasing the number of breeders. The more active breeders, the more covered mares and thereby the more foals foaled as a result.

We should also strive to encourage currently active breeders to ensure continued production of Fjord Horses. There are currently offered financial aid to:

- Breeders using 3 year old stallions: 10000NOK offered per breeding team.
- Breeders using 3 or 4 year old *merited* mares. Breeder must be a member of Norwegian Fjord Horse Society and sum offered is decided based on available funding in year of application.

This is a step in the right direction, but as the last years Annual Report of Norwegian Fjord Horse Society showed that only *one* Breeding team was granted financial aid that year, the breeders might not be sufficiently informed about this offer or, the criteria for being granted funding might be set too high.

4.2. Encourage shows, mares and sires alike.

One of the most important ways to promote and gain publicity about the Fjord Horse breed is by arranging horse shows. This is a great way to create an arena where owners and breeders can meet, exchange experiences and get their horses evaluated by a professional team of judges. In this way breeders will get an idea of whether or not they are producing good individuals or not. At present an average of 18,7% of mares and 19,4% of stallions

born each year are shown for first time evaluation at 3 years of age. In my opinion this percentage is too low and I believe the breeding would benefit from increasing it.

4.3. International Fjord Horse Breed

As it stands today, several countries worldwide, mainly in Europe and North America have their own Fjord Horse populations, the size of the populations vary and an exact number of individuals has been difficult to determine as there is no official databases or registers in place at present. Estimates put the worldwide number of Fjord Horses at 75000 individuals, 5000 of these belong to the Norwegian population (Norsk Hestesenter, 2015).

4.3.1. International Database for all Fjords

The decision to create an international organisation, Fjord Horse International, gives a lot of opportunities, but presently it is not being used to the full extent of its potential. More effort needs to be put into structuring the organisation and its members, and an international database for all Fjord Horses should be made. With such a database in place the countries could get easier access to new genetic material for their population of Fjord Horses. It would be easier to perform genetic evaluations of the breed on national as well as international levels and the breeding could be aided in terms of selecting individuals best suited to aid genetic diversity and avoid inbreeding.

4.4. Regulations of breeding across countries, advantages of easing them

An other aspect to keep in mind is the ease of which breeding can be managed, travelling and transporting with horses over long distances is accompanied with a great deal of logistical challenges as well as concerns for the wellbeing of the mare or stallion in question. Today it is possible to inseminate mares using sperm from a Norwegian or imported from a foreign stallion, which has been accepted by the Judges panel for Fjords. I think this should be made easier for the breeders, they should be more free to choose stallions of foreign origin without having to apply for each individual to be approved by the panel, this could be managed instead by having an International database where the proper qualifications of the given stallion could be checked and compared to the standard of Norwegian stallions.

Today foals born by embryo transfer are not eligible for registration in Norway. With today's advances in technology the authenticity and origin of the resulting foal can safely be validated by means of DNA testing, I therefore believe this regulation should be altered to allow embryonic transfers. This could ensure further genetic gain from other Fjord Horse populations.

5. CONCLUSION

The Fjord Horse as we know it today is at a critical point in the history of its breeding. The continued decline in foals registered each year put the breed at risk of losing precious genetic diversity and increases the probability of detrimental effects of inbreeding, which arises from breeding within such a small population. The foal shortage can cause problems on several levels, short and long term alike. Aside from the short-term economic consequences for individual breeders there is the danger of lost genetic diversity. With a reduced number of horses available for breeding the breed progression can deteriorate and the inbreeding coefficient increase to an unhealthy level.

The knowledge required to recover the breed to a sustainable level is there, what is needed is the initiative and resources to put the knowledge into an organized plan for the future. The Fjord Horse is currently not beyond saving, but someone must take action to guide the breeding forwards.

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