Fjord Foal Sex Ratios are Related to Parent Sex and Age at Breeding

By Cherrie Nolden

1dr Fjords, PhD Dissertator in Animal Sciences at University of Wisconsin-Madison

Fjord breeders often hope for a certain sex foal from each breeding pair. One would expect foal sex ratios at conception to be 1:1, with equal chances for the X or Y sperm to fertilize an egg. This theoretical ratio isn't observed at birth (Hamilton, 1967). Of the many theories proposed to explain the variations in the sex ratio, differences in parental age is a plausible approach (Caughley, 1971; Manning et al., 1997; Nicolich et al., 2000; Orvos et al., 2001; Stone et al, 2013). Horses of the Brazilian breed, Mangalaga Marchador (MM), demonstrated significant variations in foal sex ratio based on the age differences of the parents (Santos et al., 2015). Breeders of Fjord horses may have an interest in producing more fillies or more colts out of certain horses for preservation of genetic diversity, to expand their herd, for marketing purposes, or for other reasons, and if the Fjord population demonstrates variations in foal sex ratios like those of the MM horses, this knowledge would be a valuable tool to breeders. Given that, I was interested in the proportion of each sex produced by Fjord parents of different ages in the NFHR pedigree database. If the sire was the older parent, or the dam was the older parent, did this make a difference in the sex of the foal? Is the sex ratio of the foals different between parents of different ages?

To investigate this, I downloaded 7,971 records from the NFHR Pedigree Database on 1/27/2020, which included Fjords from 1874 to 2020. Of these, there were 6,671 records that contained the birth dates for both sire and dam. 1300 records were incomplete and not used. One record showed a mare foaling the year after she was born, so that mare's birthdate was changed for this analysis based on the foaling and transfer record dates. For calculating sex ratios, I only included years for which there were at least 6 foals registered. This reduced the analysis to 6,596 registered Fjords produced during the 38 years from 1981 to 2019.

In order to account for the known NFHR database bias of Fjord males, primarily geldings, not being registered at the same rate as mares, I corrected the foal count with annually calculated and applied correction factors prior to analysis of sex ratios by parent age. The correction was done by dividing the number of males registered by the number of females registered each year, and counting each female as that ratio value, while counting each male as one individual.

Foal sex ratios are perfectly even, with 50% fillies and 50% colts produced, when the ratio is 1.00. If the ratio of fillies to colts (F:C Ratio) is 1.29, that number can be interpreted as 29 more fillies were produced than colts out of 100 foals produced, or 1.29 fillies were produced to every colt. A filly to colt ratio of 0.85 is interpreted as 15 fewer fillies were produced than colts in 100 foals produced.

If this is confusing, I've presented the data in another way also The Filly Proportion is the likelihood of producing a filly over a colt from a certain breeding. A F:C Ratio of 1.29 indicates that 29% more fillies were produced, and a F:C Ratio of 0.85 says that the filly proportion is -15%, or 15% fewer fillies than colts were produced by the breedings recorded in this dataset. I've chosen to present the data both ways to help make the results more understandable.

Parental age used for these analyses was age at conception of the foal produced. This was calculated by taking 335 days off the recorded birth date of each foal, then subtracting the date the parent was born

from the foal conception date. This gestation length is the average for my personal Fjord mare herd and consistent with average horse gestations.

Results:

Table 1 shows Fjord dam and sire ages at foal conception and the resultant foal sex ratios. Very young parents and older parents tended to produce more fillies, while the middle ages were more evenly split between colts and fillies. Caution needs to be taken when interpreting ratios with small sample sizes (*N*), since the results are far less reliable than when large numbers of foals are represented in the analysis.

Table 1. Sex ratios of Fjord foals by parent age at conception of the foals.

Parent Age	Dam			Sire		
(Years)	*N*	F:C Ratio1	Filly Proportion	*N*	F:C Ratio1	Filly Proportion
1	31	1.852	85.2%	81	1.387	38.7%
2	200	0.853	-14.7%	463	0.808	-19.2%
3	594	1.128	12.8%	556	1.023	2.3%
4	672	0.900	-10.0%	589	0.988	-1.2%
5	653	0.922	-7.8%	589	1.002	0.2%
6	605	1.133	13.3%	470	0.960	-4.0%
7	575	0.917	-8.3%	484	0.995	-0.5%
8	545	1.119	11.9%	406	0.900	-10.0%
9	466	1.042	4.2%	362	1.195	19.5%
10	386	0.869	-13.1%	351	0.963	-3.7%
11	353	1.160	16.0%	345	0.992	-0.8%
12	308	1.036	3.6%	298	1.015	1.5%
13	273	1.066	6.6%	243	1.119	11.9%
14	206	0.951	-4.9%	226	1.203	20.3%
15	172	0.946	-5.4%	195	1.178	17.8%
16	149	0.997	-0.3%	153	1.091	9.1%
17	131	0.788	-21.2%	146	0.943	-5.7%
18	99	0.985	-1.5%	143	1.008	0.8%
19	65	0.881	-11.9%	97	1.000	0.0%
20	44	0.724	-27.6%	101	0.893	-10.7%
21	30	1.102	10.2%	80	0.809	-19.1%
22	19	0.807	-19.3%	62	1.115	11.5%
23	14	1.061	6.1%	53	0.711	-28.9%
24	4	NA	NA	35	1.033	3.3%
25	2	NA	NA	22	1.489	48.9%
26	NA	NA	NA	19	0.955	-4.5%
27	NA	NA	NA	15	NA	NA
28	NA	NA	NA	4	NA	NA
29	NA	NA	NA	6	NA	NA
30	NA	NA	NA	2	NA	NA

[1] F:C Ratio is the number of fillies divided by the number of colts produced, with filly count corrected for annual discrepancies in sex ratio registered.

[2] Filly Proportion is the percent increase in fillies over colts. A negative number indicates fewer fillies than colts by that percent.

Data were derived from the Norwegian Fjord Horse Registry database from 1981 to 2019.

Data are presented as the sex ratios of the offspring. Registration bias was corrected for annual number of females/number of males.

NA indicates that there were no data.

I was also interested in whether foals born to older sires or older dams were biased toward more colts or more fillies. Table 2 shows Fjord pairings of differing ages of dam and sire, and where either sire or dam was the older individual in the pair. From this NFHR dataset, generally, when the sire was older than the dam, more fillies were produced. Filly proportion was lowest when the dam was 10-20 years older than the sire, and when the sire was 15-20 years older than the dam.

Table 2. Count of Fjord foals and ratios based on corrected foal count by dam and sire relative age difference at foal conception

Older Sex	Years Older	*N*	F:C Ratio1	Filly Proportion2
Dam	0 to 5	2136	0.980	-2.0%
	5 to 10	835	1.030	3.0%
	10 to 15	247	0.797	-20.3%
	15 to 20	49	0.750	-25.0%
	20 to 25	3	2.249	124.9%
Equal	0	18	1.026	2.6%
Sire	0 to 5	1874	1.024	2.4%
	5 to 10	832	1.048	4.8%
	10 to 15	409	1.076	7.6%
	15 to 20	163	0.842	-15.8%
	20 to 25	29	0.916	-8.4%
	25 to 30	1	0.884	-11.6%

[1] F:C Ratio is the number of fillies divided by the number of colts produced, with filly count corrected for annual discrepancies in sex ratio registered.

[2] Filly Proportion is the percent increase in fillies over colts. A negative number indicates fewer fillies than colts by that percent.

Data were derived from the Norwegian Fjord Horse Registry database from 1981 to 2019.

Data are presented as the sex ratios of the offspring (registration bias corrected number of females/number of males).

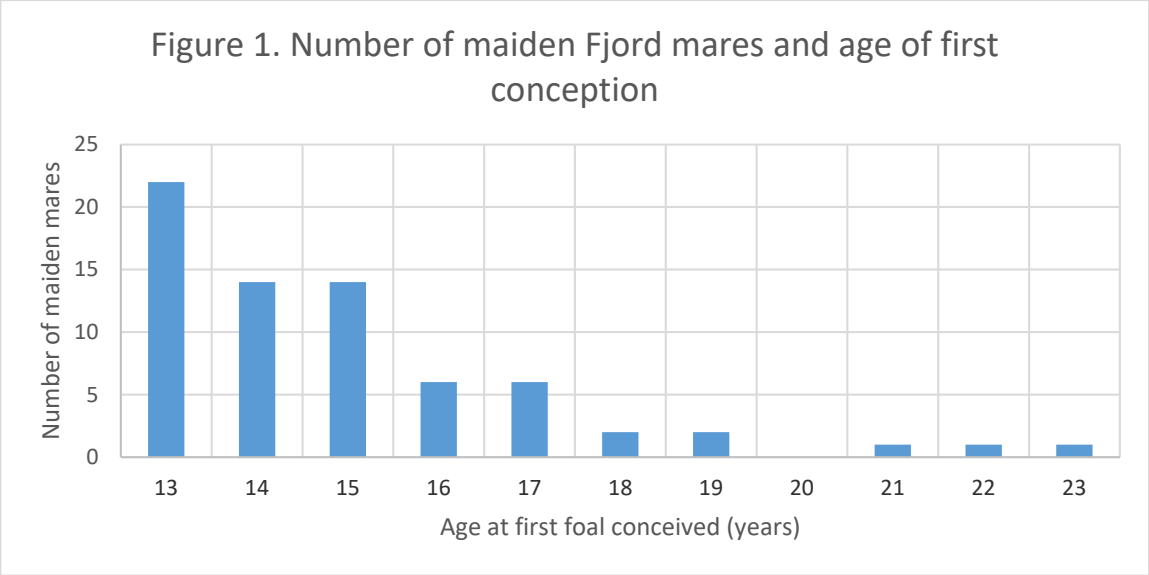
The results of this analysis of the NFHR database are consistent with the results from the Santos et al. (2015) publication on the sex ratios of the Mangalaga Marchador horses in Brazil. Based on these data, if

a breeder wanted to use parental age as a strategy for producing more fillies, a younger dam than sire would be more likely to produce fillies. An older dam than sire will generally produce more colts.

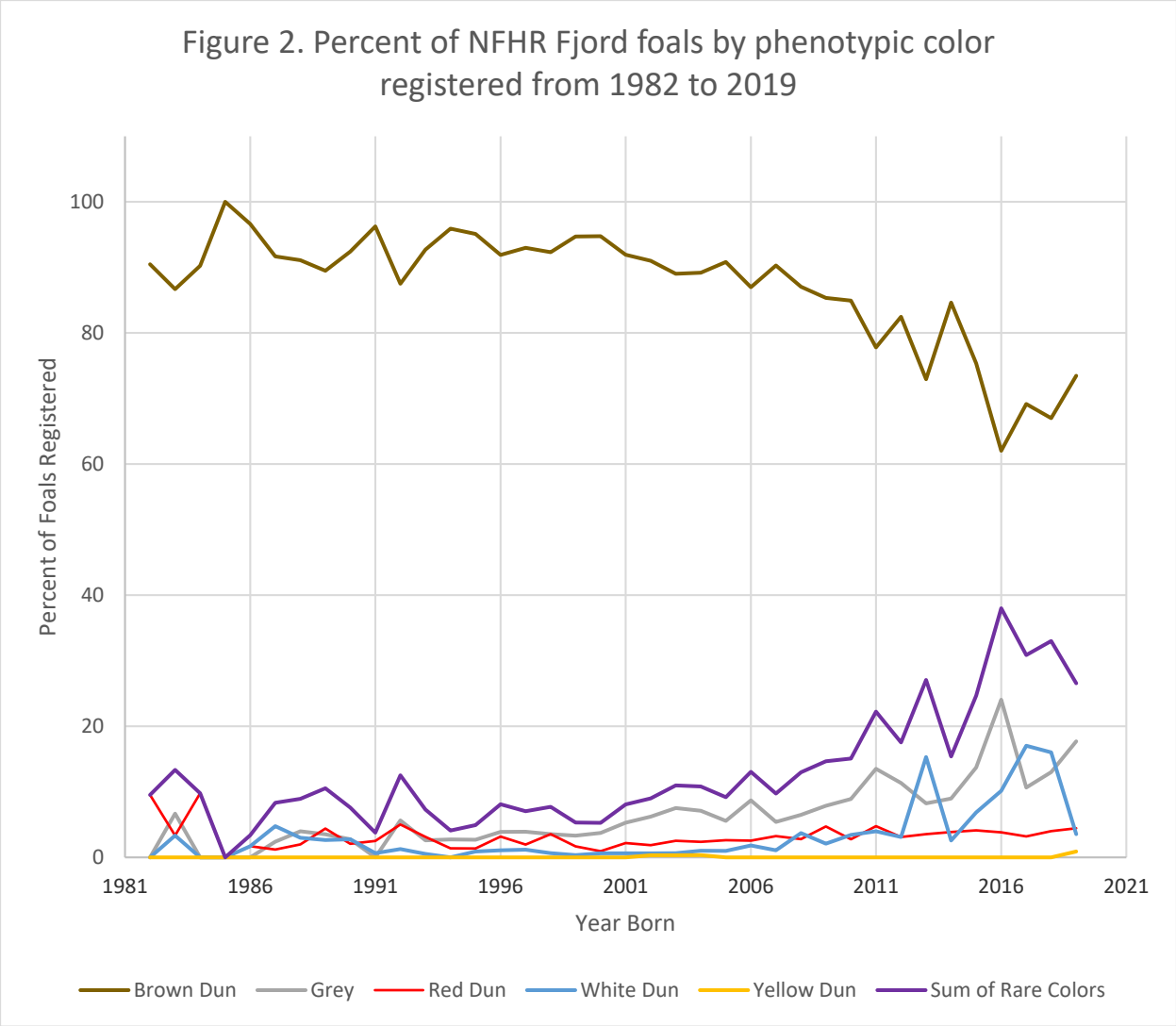
There are many other factors that also impact the offspring sex ratio, and some of them with significantly more impact than parent age, but this dataset did not allow for analysis of those effects. I experimented with one of those other factors during the 2019 breeding season, so we will see if the change I made affects the sex ratio produced by my Fjord herd in 2020. I typically have an even sex ratio of foals produced annually. I didn't make a control group in 2019 since I only bred 16 mares and splitting the group in half for an even set of control and treatment mares would reduce the *N* to 8, which is often too small of a sample for reliable interpretation of treatment effects.

Other interesting facts from this analysis were:

- Thirty one Fjord mares birthed their first registered foal at age 2, and 200 Fjord mares birthed their first foal at age 3. Fjord mares being bred at ages 3-8 were the most common in the NFHR database.
- Fjord stallions were used for breeding at younger ages than mares, with 81 colts breeding their first mares as yearlings and 463 two year old colts producing registered offspring.
- The oldest reproductively successful Fjord mares in the database were 25 at the time of breeding, and there were 113 mares that conceived foals from 20-25 years of age.
- There were Fjord stallions still breeding at age 31.
- The mare who produced the most foals conceived her first foal as a 3 year old and delivered her 18th foal at 24 years old.
- The sire who produced the most offspring in the NFHR database started at 10 years old and his 102nd foal was born when he was 32 years old.
- There have been 69 maiden mares in the Fjord breed conceiving foals beyond the 13 year age that many equine reproduction specialists say is the cutoff. Figure 1 shows the number of maidens and their age at first conception in the NFHR database. The individual mares conceiving their first registered foals at ages of 21, 22 and 23 could indicate unique maiden reproductive soundness in the Fjord breed. It is possible that these mares had produced foals prior to these, but those foals weren't registered. Having foals at younger ages primes mares for successful reproduction later in life, so if these mares hadn't previously produced foals, these ages at first conception are truly remarkable.



- Another interesting thing I saw in the database was not related to foal sex ratios. Breeders have increasingly been using rare-colored Fjords for breeding instead of the brown dun in recent years as understanding of color inheritance has become more prevalent. Proportions of foals born of the rare colors has thus increased, making the rare colors less rare. Relative to 1980's levels, the percent of all rare colors has increased by 24.3%, with greys up 13.8%, white duns up 8.7%, red duns up 1.6%, and yellow duns up 0.22%. Where brown duns used to be nearly all of the Fjords born each year, they were down to 67.9% of the foals registered in 2019. Given the large shift in breeding stock from brown duns to rare colors, I expect that this trend will continue, with rare colored Fjords becoming far less rare in coming years.



This summary does not include the statistics that will be included when the analysis is submitted to a journal for publication and when included in my PhD dissertation. Questions regarding the results of this analysis may be directed to me at canolden@wisc.edu, wonderfjords@yahoo.com, or on my Facebook profile Won Der Fjords. The results will also be posted on the NFHR Facebook group. The NFHR Board of Directors gave me permission to analyze the sex ratios of the NFHR database in this manner with the condition that individual horses not be identified, so I have intentionally not given out specific names of any horses or owners/breeders. The database is publicly available and the information presented here could be similarly compiled by anyone with internet access.

References:

Caughley, G. 1971. Offspring sex ratio and age of parents. Journal of Reproductive Fertility. 25:145–147.

Hamilton, W.D. 1967. Extraordinary sex ratios. Science. 156:477–488.

Manning, J.T., Anderton, R.H., Shutt, M. 1997. Parental age gap skews child sex ratio. Nature. 389:344.

Nicolich, M.J., Huebner, W.W., Schnatter, A.R. 2000. Influence of parental and biological factors on the male birth fraction in the United States: an analysis of birth certificate data from 1964 through 1988. Fertil Steril. 73:487–492.

Orvos, H., Kozinsky, Z., Bartfai, G. 2001. Natural variation in the human sex ratio. Human Reproduction. 16:803.

Santos, M.M., L.L. Maia, D.M. Nobre, J.F.O. Neto, T.R. Garcia, M.C.G.R. Lage, M.I. Vaz de Melo, W.S.Viana, M.S.Palhares, J.M.S. Filho, R.L. Santos, G.R. Valle. 2015. Sex ratio of equine offspring is affected by the ages of the mare and stallion. Theriogenology. 84:1238-1245.

Stone, B.A., Alex, A., Werlin, L.B., Marrs, R.P. 2013. Age thresholds for changes in semen parameters in men. Fertil. Steril. 100:952–958.