

Genomic and genealogical coancestries within and between the Norwegian and the Swedish Fjord horses

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Saija Tenhunen 1),3), Hanne Fjerdingby Olsen 1), Nils Ivar Dolvik 2), Dag Inge Våge 1), Gunnar Klemetsdal 1) Photos: Saija Tenhunen & Anniina Kallioniemi

- 1) Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences
- 2) Department of Veterinary Sciences, Norwegian University of Life Sciences
- 3) VikingGenetics

Norwegian Fjord Horse



Mongolian wild horse (Przewalski)





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- One of the oldest horse breeds
- Distinct phenotype

Norwegian Fjord Horse



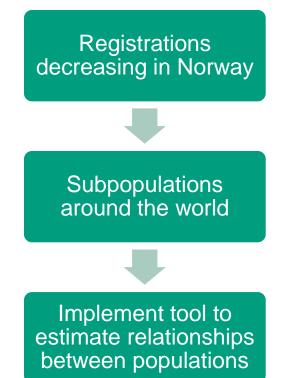
Mongolian wild horse (Przewalski)



Genomic and genealogical coancestries within and between the Norwegian and the Swedish Fjord horses



- One of the oldest horse breeds
- Distinct phenotype



Material



Samples	 In total 413 samples 311 Norwegian 102 Swedish
Pedigree data	 Norway 26,446 horses CGE 13.7 Sweden 14,595 horses CGE 12.4
Molecular data	 Axiom Equine Genotyping Array chip 670,796 SNPs After data quality control 485,918 SNPs

Methods – Coancestry



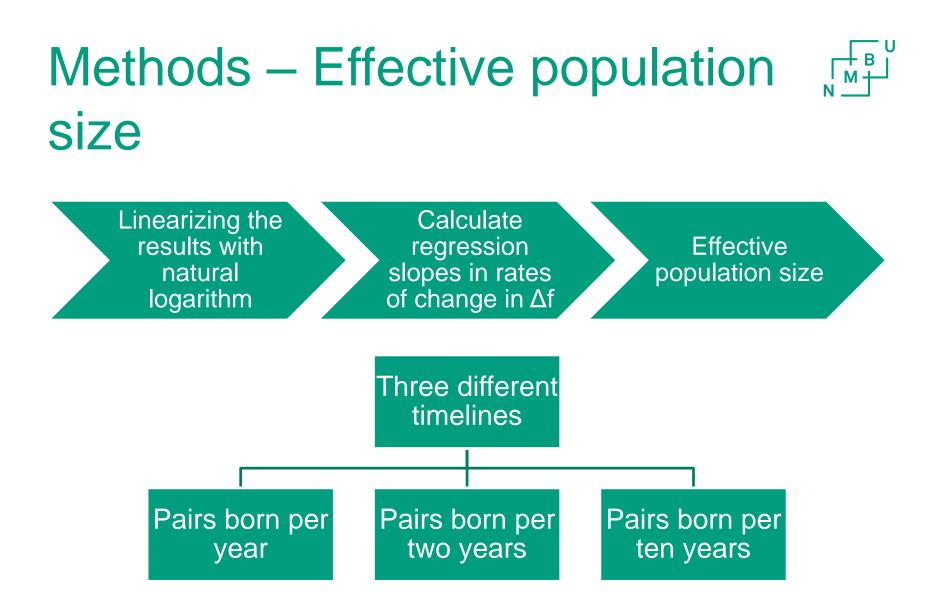
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Three coancestry methods

Pedigree (fped)

Molecular homozygosity (fhom)

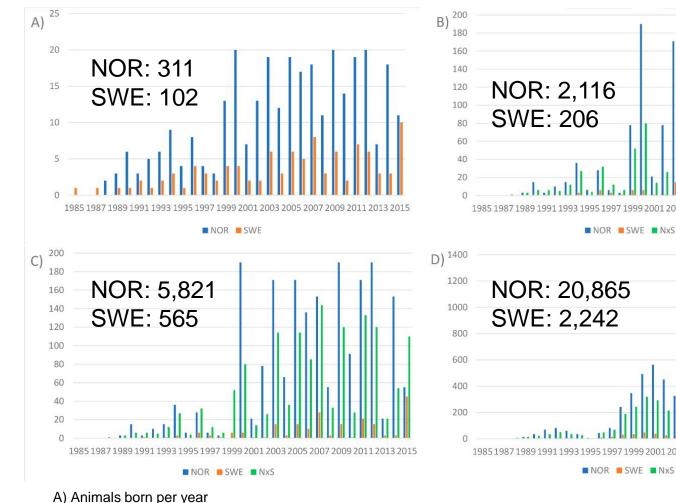
Shared genomic segments (fseg)



Ne was also calculated from individual pedigree inbreeding

Timelines and animal distribution from 1985 to 2015

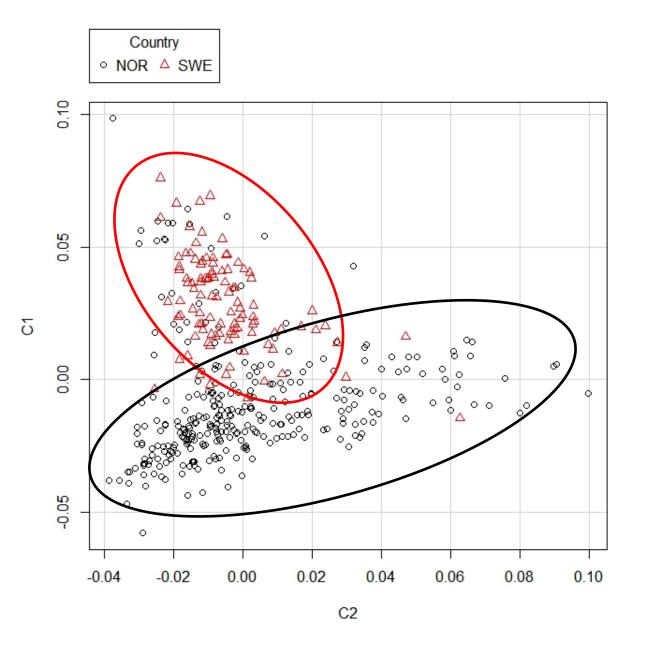




B) - D) Animals pairs born per year

Genomic and genealogical coancestries within and between the Norwegian and the Swedish Fjord horses

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	Regression of		Intercept			Reg. Coefficient			R ²		
Regressi			Nor	Swe	NxS	Nor	Swe	NxS	Nor	Swe	NxS
$\mathbf{f}_{\mathrm{hom}}$	on	f_{ped}	-1.417	-1.419	-	1.410	1.531	-	0.703	0.866	-
fseg100kb	on	fped	-0.068	-0.062	-	0.983	0.952	-	0.636	0.819	~
fseg500kb	on	fped	-0.063	-0.057	-	0.973	0.950	-	0.630	0.817	-
fseg1.5Mb	on	fped	-0.038	-0.031	-	0.897	0.886	-	0.560	0.784	-
fseg2Mb	on	fped	-0.032	-0.024	-	0.863	0.858	-	0.533	0.774	-
fseg100kb	on	$\mathbf{f}_{\mathrm{hom}}$	0.838	0.792	0.784	0.644	0.603	0.601	0.770	0.891	0.562
fseg500kb	on	$\mathbf{f}_{\mathrm{hom}}$	0.834	0.797	0.777	0.637	0.603	0.593	0.764	0.890	0.551
fseg1.5Mb	on	$\mathbf{f}_{\mathrm{hom}}$	0.794	0.762	0.735	0.591	0.560	0.546	0.687	0.848	0.459
\mathbf{f}_{seg2Mb}	on	$\mathbf{f}_{\mathrm{hom}}$	0.768	0.740	0.704	0.568	0.540	0.520	0.652	0.829	0.422

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		Intercept			Reg. Coefficient			R ²			
Regressi	Regression of		Nor	Swe	NxS	Nor	Swe	NxS	Nor	Swe	NxS
$\mathbf{f}_{\mathrm{hom}}$	on	\mathbf{f}_{ped}	-1.417	-1.419	-	1.410	1.531	-	0.703	0.866	-
fseg100kb	on	fped	-0.068	-0.062	2	0.983	0.952	-	0.636	0.819	~
fseg500kb	on	fped	-0.063	-0.057	-	0.973	0.950	-	0.630	0.817	-
fseg1.5Mb	on	fped	-0.038	-0.031	-	0.897	0.886	-	0.560	0.784	-
f _{seg2Mb}	on	fped	-0.032	-0.024	-	0.863	0.858	-	0.533	0.774	-
fseg100kb	on	$\mathbf{f}_{\mathrm{hom}}$	0.838	0.792	0.784	0.644	0.603	0.601	0.770	0.891	0.562
fseg500kb	on	$\mathbf{f}_{\mathrm{hom}}$	0.834	0.797	0.777	0.637	0.603	0.593	0.764	0.890	0.551
fseg1.5Mb	on	$\mathbf{f}_{\mathrm{hom}}$	0.794	0.762	0.735	0.591	0.560	0.546	0.687	0.848	0.459
\mathbf{f}_{seg2Mb}	on	$\mathbf{f}_{\mathrm{hom}}$	0.768	0.740	0.704	0.568	0.540	0.520	0.652	0.829	0.422



		Intercept			Reg. Coefficient			R ²			
Regressi	Regression of		Nor	Swe	NxS	Nor	Swe	NxS	Nor	Swe	NxS
$\mathbf{f}_{\mathrm{hom}}$	on	f_{ped}	-1.417	-1.419	-	1.410	1.531	-	0.703	0.866	-
fseg100kb	on	fped	-0.068	-0.062	-	0.983	0.952	-	0.636	0.819	~
fseg500kb	on	fped	-0.063	-0.057	-	0.973	0.950	-	0.630	0.817	-
fseg1.5Mb	on	fped	-0.038	-0.031	-	0.897	0.886	-	0.560	0.784	-
fseg2Mb	on	fped	-0.032	-0.024	-	0.863	0.858	-	0.533	0.774	-
fseg100kb	on	\mathbf{f}_{hom}	0.838	0.792	0.784	0.644	0.603	0.601	0.770	0.891	0.562
fseg500kb	on	$\mathbf{f}_{\mathrm{hom}}$	0.834	0.797	0.777	0.637	0.603	0.593	0.764	0.890	0.551
fseg1.5Mb	on	$\mathbf{f}_{\mathrm{hom}}$	0.794	0.762	0.735	0.591	0.560	0.546	0.687	0.848	0.459
\mathbf{f}_{seg2Mb}	on	$\mathbf{f}_{\mathrm{hom}}$	0.768	0.740	0.704	0.568	0.540	0.520	0.652	0.829	0.422



	Mean	ı.		Range	Range					Variance			
	Nor	Swe	NxS	Nor		Swe		NxS		Nor	Swe	NxS	
fped	0.082	0.065	-	0.030	0.344	0.017	0.311		-	0.00063	0.00104		
fhom	0.785	0.782	0.778	0.761	0.885	0.763	0.873	0.760	0.868	0.00009	0.00015	0.00003	
fseg100kb	0.141	0.119	0.115	0.060	0.439	0.055	0.379	0.047	0.396	0.00085	0.00120	0.00036	
fseg500kb	0.136	0.114	0.110	0.055	0.427	0.049	0.375	0.038	0.390	0.00085	0.00120	0.00036	
fseg1.5Mb	0.108	0.087	0.083	0.016	0.401	0.016	0.337	0.011	0.366	0.00088	0.00119	0.00039	
f _{seg2Mb}	0.100	0.079	0.076	0.012	0.389	0.008	0.327	0.005	0.354	0.00088	0.00115	0.00039	

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	Regressio	n Coefficien	it (b)		Standard Error (SE)				
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	-0.0007719	-0.0001603	•	•	0.0000053	0.0000031		-	
N	26446	14677			-	•			
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb} f _{hom}	-0.00105 -0.00049	-0.00082 -0.00089	-0.00035 -0.00009	-0.00065 -0.00026	0.00017 0.00024	0.00051 0.00080	0.00010 0.00012	0.00012 0.00016	
N	2116	206	1397	3719	2116	206	1397	3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb} f _{hom}	-0.00090 -0.00040 5821	-0.00017 -0.00023 565	-0.00034 -0.00006 3839	-0.00061 -0.00024 10225	0.00010 0.00013 5821	0.00029 0.00043 565	0.00006 0.00007 3839	0.00007 0.00009 10225	
N	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
10 years	- 3975	. 1963.25			1 1 1 1 1 2			21222.0	
fscg100kb fhom	-0.00087 -0.00043	-0.00004 0.00007	-0.00039 -0.00016	-0.00056 -0.00023	0.00005 0.00007	0.00017 0.00024	0.00003 0.00004	0.00004 0.00005	
N	20865	2242	13867	36974	20865	2242	13867	36974	
-	Effective	population s	size (Ne)		Confidence Interval (CI)				
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	71	269	•	-	70-72	259-279	-		
N	26446	14677	- C	•	26446	14677	-		
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb}	52	52	137	75	40-76	24— co	89-302	55-116	
fhom	113	48	525	184	57-3759	18 w	$144-\infty$	84— co	
N	2116	206	1397	3719	2116	206	1397	3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb	61	260	141	79	51-77	58— co	105-214	65-101	
fhom	139	189	792	202	84-401	40 ∞	233- co	117-73	
N	5821	565	3839	10225	5821	565	3839	10225	
10 years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb	63	1136	125	87	57-72	119— co	107-152	77-100	
fhom	129	00	293	209	98-187	106— co	194-602	149-34	

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	Regressio	n Coefficier	nt (b)		Standard Error (SE)				
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	-0.0007719	-0.0001603		•	0.0000053	0.0000031			
N	26446	14677				-	-	•	
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fseg100kb	-0.00105	-0.00082	-0.00035	-0.00065	0.00017	0.00051	0.00010	0.00012	
fhom	-0.00049	-0.00089	-0.00009	-0.00026	0.00024	0.00080	0.00012	0.00016	
N	2116	206	1397	3719	2116	206	1397	3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fseg100kb	-0.00090	-0.00017	-0.00034	-0.00061	0.00010	0.00029	0.00006	0.00007	
fhom	-0.00040	-0.00023	-0.00006	-0.00024	0.00013	0.00043	0.00007	0.00009	
N	5821	565	3839	10225	5821	565	3839	10225	
10 years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb	-0.00087	-0.00004	-0.00039	-0.00056	0.00005	0.00017	0.00003	0.00004	
fhom	-0.00043	0.00007	-0.00016	-0.00023	0.00007	0.00024	0.00004	0.00005	
N	20865	2242	13867	36974	20865	2242	13867	36974	
	Effective	population :	size (Ne)		Confidence Interval (CI)				
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	71	269	•	-	70-72	259-279	×	-	
N	26446	14677	•	•	26446	14677	-		
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fseg100kb	52	52	137	75	40-76	24— co	89-302	55-116	
fhom	113	48	525	184	57-3759	18 w	144— co	84— ω	
N	2116	206	1397	3719	2116	206	1397	3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb	61	260	141	79	51-77	58— co	105-214	65-101	
fhom	139	189	792	202	84-401	40 co	233 co	117-731	
N	5821	565	3839	10225	5821	565	3839	10225	
10 years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb	63	1136	125	87	57-72	119— co	107-152	77-100	
fhom	129	00	293	209	98-187	106— co	194-602	149-347	
N	20865	2242	13867	36974	20865	2242	13867	36974	

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	Regressio	n Coefficier	nt (b)		Standard Error (SE)				
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	-0.0007719	-0.0001603	•	•	0.0000053	0.0000031		•	
N	26446	14677	-		-	-	-		
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb} f _{hom}	-0.00105 -0.00049	-0.00082 -0.00089	-0.00035 -0.00009	-0.00065 -0.00026	0.00017 0.00024	0.00051 0.00080	0.00010 0.00012	0.00012 0.00016	
N	2116	206	1397	3719	2116	206	1397	3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb} f _{hom} N	-0.00090 -0.00040 5821	-0.00017 -0.00023 565	-0.00034 -0.00006 3839	-0.00061 -0.00024 10225	0.00010 0.00013 5821	0.00029 0.00043 565	0.00006 0.00007 3839	0.00007 0.00009 10225	
50 to v	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
10 years fscg100kb fhom N	-0.00087 -0.00043 20865	-0.00004 0.00007 2242	-0.00039 -0.00016 13867	-0.00056 -0.00023 36974	0.00005 0.00007 20865	0.00017 0.00024 2242	0.00003 0.00004 13867	0.00004 0.00005 36974	
	Effective	population :	size (Ne)	Confiden	ce Interva	I(CI)			
	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
Fped	71	269	•	-	70-72	259-279	-		
N	26446	14677	•	-	26446	14677	-		
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
f _{seg100kb} f _{hom} N	52 113 2116	52 48 206	137 525 1397	75 184 3719	40—76 57—3759 2116	24— ω 18— ω 206	89—302 144— ω 1397	55—116 84— ω 3719	
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb fhom N	61 139 5821	260 189 565	141 792 3839	79 202 10225	51—77 84—401 5821	58— ω 40— ω 565	105—214 233— co 3839	65—101 117—73 10225	
10 years	Nor	Swe	NxS	All	Nor	Swe	NxS	All	
fscg100kb fhom N	63 129	1136 co	125 293	87 209	57—72 98—187	119— α 106— α	107—152 194—602	77—100 149—34	
N.T.	20865	2242	13867	36974	20865	2242	13867	36974	

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	Regression Coefficient (b)				Standard Error (SE)			
	Nor	Swe	NxS	All	Nor	Swe	NxS	All
Fped	-0.0007719	-0.0001603	•	•	0.0000053	0.0000031		
N	26446	14677	-		-		-	-
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All
f _{seg100kb} f _{hom}	-0.00105 -0.00049	-0.00082 -0.00089	-0.00035 -0.00009	-0.00065 -0.00026	0.00017 0.00024	0.00051 0.00080	0.00010 0.00012	0.00012 0.00016
N	2116	206	1397	3719	2116	206	1397	3719
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All
fseg100kb fhom	-0.00090 -0.00040 5821	-0.00017 -0.00023 565	-0.00034 -0.00006 3839	-0.00061 -0.00024 10225	0.00010 0.00013 5821	0.00029 0.00043 565	0.00006 0.00007 3839	0.00007 0.00009 10225
N	Nor	Swe	NxS	All	Nor	Swe	NxS	All
10 years	- 3075				1 1 1 1 1 2			21225.0
fseg100kb fhom	-0.00087 -0.00043	-0.00004 0.00007	-0.00039 -0.00016	-0.00056 -0.00023	0.00005 0.00007	0.00017 0.00024	0.00003 0.00004	0.00004 0.00005
N	20865	2242	13867	36974	20865	2242	13867	36974
	Effective population size (Ne)				Confidence Interval (CI)			
	Nor	Swe	NxS	All	Nor	Swe	NxS	All
Fped	71	269	•	-	70-72	259-279		
N	26446	14677	-	-	26446	14677	-	-
Pairs per year	Nor	Swe	NxS	All	Nor	Swe	NxS	All
f _{seg100kb}	52	52	137	75	40-76	24— co	89-302	55-116
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N	2116	206	1397	3719	2116	206	1397	3719
Two years	Nor	Swe	NxS	All	Nor	Swe	NxS	All
fscg100kb	61	260	141	79	51-77	58— co	105-214	65-101
fhom	139	189	792	202	84-401	40 ∞	233- co	117-73
N	5821	565	3839	10225	5821	565	3839	10225
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fscg100kb	63	1136	125	87	57-72	119— co	107-152	77-100
fhom	129	00	293	209	98-187	106— co	194-602	149-34
N	20865	2242	13867	36974	20865	2242	13867	36974



Conclusion

- One breed genetically but there is some differences between subpopulations
- Recommendation to use fseg to calculate relationships between Fjord horse populations
- Greates possibility to build international breeding cooperation
- Practical issues:
 - -Rather expensive genotyping
 - -Calculating shared segments is still slow
 - New methods to speed up the process?







Email: saten@vikinggenetics.com