Service PopReport at Institute of Farm Animal Genetics

FRIEDRICH-LOEFFLER-INSTITUT
FLI
Bundesforschungsinstitut für Tiergesundheit

PopReport
A Pedigree Analysis Report

Population: UNKNOWN
Inputfile: POPREP.TXT
Initiated by: quaglia@anabic.it
Submitted at: 2019-01-10 16:39:02
Started at: 2019-01-10 16:40:01
Finished at: 2019-01-10 17:32:59

Courtesy: Department of Animal Breeding and Genetics
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http://popreport.fli.de

Some Notes About Your PopReport Job:

- INFO: This job ran on machine rie-ex-web160 with 12 CPUs and MemTotal: 32950688 kB
- INFO: Your entered dateformat was 'YYYYMMDD', your dateseparator 'undef'.
  138790 input lines processed.
  138790 animals accepted.
- INFO: (concerning Inbreeding Report)
  This table shows the shortening of the number of male and female animals per year for the AGR computations. The original (orig) number of records is shortened (cut) to keep the product of $male * female$ within acceptable limits. See details later in the Inbreeding Report.

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
1974	743	743	6102	5384
1975	808	808	7398	4950
1976	882	882	9320	4535
1977	946	946	10781	4228
1978	893	893	11243	4479
1979	883	883	12116	4530
1980	840	840	13368	4762
1981	797	797	14331	5019
1982	809	809	15711	4944
1983	790	790	16306	5063
1984	801	801	17739	4994
1985	794	794	18863	5038
1986	802	802	20536	4988
1987	827	827	21889	4837
1988	840	840	23656	4762
1989	855	855	24740	4678
1990	876	876	25380	4566
1991	849	849	25280	4711
1992	831	831	25303	4813
1993	825	825	25198	4848
1994	809	809	24884	4944
1995	805	805	23876	4969
1996	767	767	22824	5215
1997	737	737	22212	5427
1998	746	746	22037	5362
1999	764	764	21626	5236
2000	771	771	21094	5188
2001	781	781	20757	5122
2002	798	798	20988	5013

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2003	868	868	21671	4608
2004	935	935	22543	4278
2005	1012	1012	23577	3953
2006	1090	1090	24817	3670
2007	1150	1150	25537	3478
2008	1216	1216	25821	3289
2009	1261	1261	25564	3172
2010	1307	1307	25381	3060
2011	1322	1322	25064	3026
2012	1335	1335	24139	2996
2013	1330	1330	23222	3008
2014	1328	1328	22143	3012
2015	1268	1268	20410	3155
2016	1151	1151	17610	3475
2017	948	948	14318	4219

Pedigree Analysis Report for Population: UNKNOWN

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Contents

List of Tables

List of Figures

1 Pedigree completeness per year

An estimate of an individual's inbreeding coefficient depends on the extent to which its ancestry is known to some defined generation in the past. The more complete the knowledge of an individual's ancestry, the more reliable is its estimate of inbreeding coefficient relative to some defined base population. MacCluer *et al.* (1983) proposed an index to measure pedigree completeness. This index summarizes the proportion of known ancestors in each ascending generation. It quantifies the chance of detecting inbreeding in the pedigree (Sϕrenson *et al.*, 2005). The following formula was used to compute pedigree completeness (MacCluer *et al.*, 1983):

$$I_d = \frac{4 I_{d_{pat}} I_{d_{mat}}}{I_{d_{pat}} + I_{d_{mat}}}$$

and

$$I_{d_k} = \frac{1}{d} \sum_{i=1}^{d} a_i \qquad k = pat, mat$$

where k represents the paternal (pat) or maternal line (mat) of an individual, a_i is the proportion of known ancestors in generation i. The d is the number of generations considered in the calculation of the pedigree completeness. For example, if $d = 5$ then five ancestral generations will be taken into account in the computations. The values for pedigree completeness range from 0 to 1. If all ancestors of an individual to some specified generation (d) are known, then $I_d = 1$ or if one of the parent (*i.e.* sire or dam) is unknown, $I_d = 0$. The pedigree completeness values averaged per year are presented on the Table.

Table 1: The average pedigree completeness (%) for 1 to 6 generations deep by year

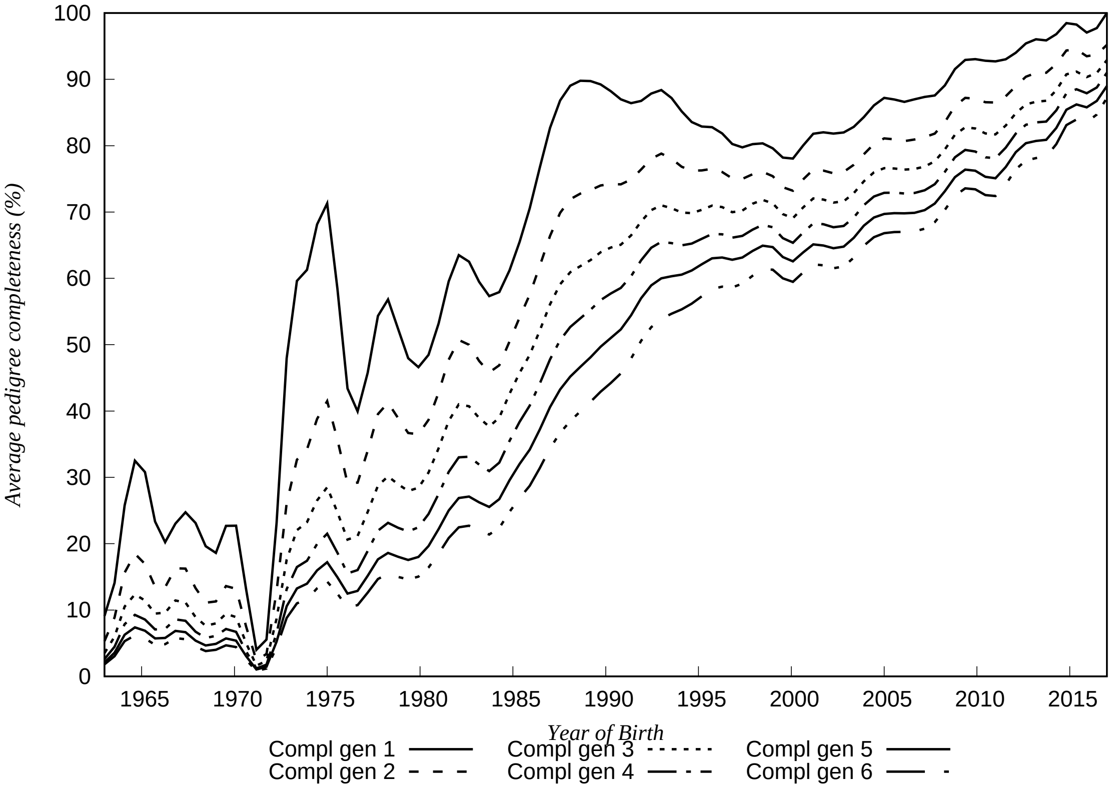
Year	No of Animals	Compl. gen 1	Compl. gen 2	Compl. gen 3	Compl. gen 4	Compl. gen 5	Compl. (%) gen 6(%)
1927	4	0.0	0.0	0.0	0.0	0.0	0.0
1929	6	33.3	16.7	11.1	8.3	6.7	5.6
1931	6	50.0	33.3	22.2	16.7	13.3	11.1
1933	2	100.0	66.7	47.2	35.4	28.3	23.6
1958	1	0.0	0.0	0.0	0.0	0.0	0.0
1959	2	0.0	0.0	0.0	0.0	0.0	0.0
1960	9	0.0	0.0	0.0	0.0	0.0	0.0
1961	4	25.0	12.5	8.3	6.2	5.0	4.2
1962	13	30.8	16.7	11.1	8.3	6.7	5.6
1963	22	9.1	5.3	3.5	2.6	2.1	1.8
1964	25	24.0	14.7	9.9	7.4	5.9	5.0
1965	34	32.4	17.9	12.0	9.0	7.2	6.0
1966	58	20.7	12.8	9.1	6.8	5.5	4.6
1967	75	24.0	16.8	11.7	8.8	7.0	5.9
1968	124	22.6	12.8	8.6	6.5	5.2	4.3
1969	193	18.6	11.3	8.0	6.1	4.9	4.0
1970	264	23.5	13.7	9.3	7.0	5.6	4.6
1971	1767	6.2	3.6	2.4	1.8	1.5	1.2
1972	1283	12.2	7.0	4.8	3.6	2.9	2.4
1973	1517	54.0	29.4	19.8	14.8	11.9	9.9
1974	1697	61.9	34.7	23.6	17.7	14.2	11.8
1975	1485	71.3	41.5	28.5	21.5	17.2	14.3
1976	2189	45.2	29.8	21.0	15.8	12.7	10.6
1977	1789	43.1	32.1	23.4	17.8	14.3	11.9
1978	2176	56.8	41.1	29.9	22.9	18.4	15.3
1979	2146	50.6	38.0	28.5	22.1	17.8	14.8
1980	2726	46.7	36.7	28.7	22.7	18.2	15.2

Continue...

Year	No of Animals	Compl. 1 gen	Compl. 2 gen	Compl. 3 gen	Compl. 4 gen	Compl. 5 gen	Compl. (%) 6 gen (%)
1981	2617	53.2	42.8	34.4	27.5	22.2	18.5
1982	2877	63.2	50.5	40.8	32.8	26.7	22.3
1983	2765	60.5	48.4	39.6	32.4	26.6	22.3
1984	3233	57.2	45.9	37.9	31.2	25.8	21.6
1985	3293	62.6	51.8	43.8	36.6	30.5	25.6
1986	3827	71.5	58.2	49.0	41.3	34.6	29.1
1987	4104	82.7	66.4	56.1	47.8	40.6	34.4
1988	4397	88.8	71.7	60.7	52.4	44.9	38.2
1989	3976	89.8	73.1	62.4	54.8	47.6	40.9
1990	3426	88.8	74.2	64.4	57.3	50.4	43.6
1991	3106	86.7	74.3	65.4	59.0	52.9	46.3
1992	3298	86.9	76.7	68.9	63.1	57.4	51.0
1993	3716	88.4	78.8	71.0	65.5	60.0	53.9
1994	3774	85.5	77.0	70.0	65.0	60.5	55.2
1995	3385	83.0	76.2	70.1	65.7	61.8	56.9
1996	2886	82.5	76.4	71.0	66.8	63.2	58.7
1997	2784	79.9	74.9	69.9	66.1	62.8	58.7
1998	2940	80.3	75.8	71.4	67.5	64.3	60.6
1999	2905	79.6	75.4	71.3	67.7	64.7	61.3
2000	3191	77.9	73.1	69.0	65.3	62.5	59.4
2001	3447	81.4	76.1	71.8	68.0	64.9	61.9
2002	3633	81.9	76.0	71.6	67.9	64.7	61.7
2003	3639	82.2	76.3	71.9	68.2	65.1	62.1
2004	3723	84.6	79.0	74.9	71.3	68.2	65.2
2005	4051	87.2	81.1	76.6	72.9	69.7	66.8
2006	4223	86.6	80.7	76.4	72.8	69.8	67.0
2007	3971	87.3	81.2	76.7	73.1	70.1	67.3
2008	3797	88.1	82.5	78.4	75.0	72.1	69.3
2009	3421	92.2	86.6	82.2	78.8	75.8	73.0
2010	3502	93.0	87.0	82.5	79.0	76.1	73.3
2011	3421	92.7	86.5	81.7	78.1	75.1	72.4
2012	3139	93.8	88.7	84.6	81.5	78.7	76.1
2013	3301	96.0	90.9	86.6	83.5	80.7	78.1
2014	2890	96.1	91.4	87.3	84.2	81.5	79.0
2015	2004	98.7	94.7	91.2	88.4	86.0	83.7
2016	504	97.0	93.4	90.3	87.9	85.8	83.6
2017	7	100.0	95.2	92.9	91.0	89.0	87.2

The average pedigee completeness for animals born within the last 10 years: 1 generations deep = 93.5%. 2 generations deep = 88.1%. 3 generations deep = 83.9%. 4 generations deep = 80.6%. 5 generations deep = 77.8%. 6 generations deep = 75.1%.

Figure 1: Average pedigree completeness for 1 to 6 generations



The figure above presents the average percentage of pedigree completeness for a pedigree depth of 1 to 6 generations by year of birth, between 1963 and 2017 for the UNKNOWN breed.

2 Inbreeding

2.1 Distribution of animals by year and inbreeding level

This section presents a distribution of animals by inbreeding levels and year of birth. Eleven inbreeding classes of size 5% were defined. The last inbreeding class included all animals with inbreeding coefficient >50%. The number of animals by inbreeding class and year are given in the table.

Table 2: Distribution of animals by year and inbreeding levels

(Classes 1=0-5%, 2=6-10%, 3=11-15%, 4=16-20%, 5=21-25%, 6=26-30%, 7=31-35%, 8=36-40%, 9=41-45%, 10=46-50% and 11=>50%)

	Classes										
Year	1	2	3	4	5	6	7	8	9	10	11
1927	4	-	-	-	-	-	-	-	-	-	-
1929	6	-	-	-	-	-	-	-	-	-	-
1931	6	-	-	-	-	-	-	-	-	-	-
1933	2	-	-	-	-	-	-	-	-	-	-
1958	1	-	-	-	-	-	-	-	-	-	-
1959	2	-	-	-	-	-	-	-	-	-	-
1960	9	-	-	-	-	-	-	-	-	-	-
1961	4	-	-	-	-	-	-	-	-	-	-
1962	13	-	-	-	-	-	-	-	-	-	-
1963	22	-	-	-	-	-	-	-	-	-	-
1964	25	-	-	-	-	-	-	-	-	-	-
1965	34	-	-	-	-	-	-	-	-	-	-
1966	58	-	-	-	-	-	-	-	-	-	-
1967	74	-	1	-	-	-	-	-	-	-	-
1968	124	-	-	-	-	-	-	-	-	-	-
1969	190	1	1	-	1	-	-	-	-	-	-
1970	264	-	-	-	-	-	-	-	-	-	-
1971	1767	-	-	-	-	-	-	-	-	-	-
1972	1280	1	-	-	2	-	-	-	-	-	-
1973	1512	2	3	-	-	-	-	-	-	-	-
1974	1684	2	6	-	3	2	-	-	-	-	-
1975	1457	3	12	-	13	-	-	-	-	-	-
1976	2152	4	21	-	12	-	-	-	-	-	-
1977	1751	11	21	-	6	-	-	-	-	-	-
1978	2120	21	24	4	5	2	-	-	-	-	-
1979	2080	17	14	12	20	1	2	-	-	-	-
1980	2632	30	28	20	14	-	1	-	1	-	-
1981	2506	40	35	9	20	3	1	-	2	1	-
1982	2773	37	29	10	19	6	2	1	-	-	-
1983	2656	34	31	11	22	9	2	-	-	-	-
1984	3138	29	31	3	24	7	1	-	-	-	-
1985	3139	58	36	13	41	4	2	-	-	-	-
1986	3615	84	46	20	52	5	4	1	-	-	-
1987	3847	100	47	13	71	12	13	-	1	-	-
1988	4147	99	40	13	60	25	9	3	1	-	-
1989	3776	85	30	18	47	19	1	-	-	-	-
1990	3215	89	34	20	42	22	-	4	-	-	-

Continue...

	Classes										
Year	1	2	3	4	5	6	7	8	9	10	11
1991	2929	78	27	11	24	32	3	2	-	-	-
1992	3049	113	56	17	24	31	7	1	-	-	-
1993	3406	169	48	29	30	30	4	-	-	-	-
1994	3504	142	48	17	29	31	2	1	-	-	-
1995	3108	126	67	17	18	43	3	2	1	-	-
1996	2646	145	34	8	14	34	5	-	-	-	-
1997	2505	170	42	14	7	43	3	-	-	-	-
1998	2653	161	71	16	3	35	1	-	-	-	-
1999	2585	211	50	17	2	36	-	2	2	-	-
2000	2939	148	34	18	4	45	1	1	1	-	-
2001	3153	175	43	9	1	61	1	2	2	-	-
2002	3330	179	42	12	3	59	5	3	-	-	-
2003	3345	189	44	19	4	37	1	-	-	-	-
2004	3377	205	41	18	14	65	2	1	-	-	-
2005	3630	251	67	17	13	68	3	2	-	-	-
2006	3761	267	77	28	8	79	2	1	-	-	-
2007	3514	263	88	26	11	64	3	2	-	-	-
2008	3336	281	73	23	14	69	1	-	-	-	-
2009	2913	318	73	20	10	85	-	2	-	-	-
2010	3092	280	50	16	2	59	2	1	-	-	-
2011	2966	289	65	23	5	70	1	2	-	-	-
2012	2693	310	59	19	3	53	2	-	-	-	-
2013	2844	325	54	17	1	56	2	-	1	1	-
2014	2490	289	38	24	1	47	1	-	-	-	-
2015	1692	205	40	20	1	42	-	4	-	-	-
2016	404	73	9	3	1	12	1	1	-	-	-
2017	6	1	-	-	-	-	-	-	-	-	-

2.2 Number of *all* and *inbred* animals, sires and dams by year

This section presents the number of all and inbred animals, sires and dams by year. The following information is given in the table for all animals, sires and dams:

Tot No. : the number of animals / sires / dams in a given year.

Inbred No. : the number of inbred animals / sires / dams in a given year.

Avg *F* : the average inbreeding coefficient.

Table 3: Numbers and average inbreeding of animals and parents by year

	Animals			Sires			Dams		
Year	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F
1927	4	-	-	-	-	-	-	-	-
1929	6	-	-	2	-	-	2	-	-
1931	6	-	-	3	-	-	3	-	-
1933	2	-	-	2	-	-	2	-	-
1958	1	-	-	-	-	-	-	-	-
1959	2	-	-	-	-	-	-	-	-
1960	9	-	-	1	-	-	-	-	-
1961	4	-	-	1	-	-	1	-	-
1962	13	-	-	5	-	-	4	-	-
1963	22	-	-	2	-	-	2	-	-
1964	25	-	-	7	-	-	6	-	-
1965	34	-	-	10	-	-	12	-	-
1966	58	-	-	12	-	-	12	-	-
1967	75	1	0.0017	16	-	-	18	-	-
1968	124	-	-	28	-	-	32	-	-
1969	193	4	0.0024	31	-	-	38	1	0.0033
1970	264	-	-	52	-	-	64	-	-
1971	1767	-	-	73	2	0.0021	110	1	0.0023
1972	1283	3	0.0004	91	1	0.0014	159	-	-
1973	1517	5	0.0003	212	1	0.0006	816	-	-
1974	1697	14	0.0013	265	2	0.0014	1046	3	0.0004
1975	1485	29	0.0034	262	2	0.0010	1041	2	0.0002
1976	2189	39	0.0027	216	3	0.0023	974	5	0.0007
1977	1789	47	0.0029	207	5	0.0042	762	5	0.0008
1978	2176	66	0.0033	268	11	0.0073	1219	13	0.0013
1979	2146	78	0.0052	237	15	0.0088	1079	21	0.0029
1980	2726	137	0.0052	235	19	0.0095	1268	29	0.0028
1981	2617	184	0.0068	232	21	0.0101	1375	41	0.0032
1982	2877	195	0.0059	253	38	0.0164	1792	58	0.0038
1983	2765	209	0.0068	247	45	0.0181	1659	70	0.0044
1984	3233	244	0.0054	253	55	0.0217	1831	61	0.0035
1985	3293	339	0.0080	230	58	0.0242	2083	98	0.0044
1986	3827	435	0.0093	246	70	0.0256	2739	128	0.0044
1987	4104	659	0.0115	303	92	0.0235	3388	186	0.0040
1988	4397	878	0.0112	317	107	0.0252	3891	228	0.0047
1989	3976	850	0.0099	319	123	0.0294	3577	265	0.0057
1990	3426	874	0.0123	276	125	0.0326	3056	301	0.0077
1991	3106	971	0.0128	261	135	0.0377	2740	343	0.0077
1992	3298	1371	0.0157	293	171	0.0388	2915	470	0.0105

Continue...

	Animal			Sires			Dams		
Year	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F
1993	3716	1730	0.0164	287	170	0.0356	3312	540	0.0087
1994	3774	1943	0.0164	285	189	0.0331	3317	661	0.0101
1995	3385	1864	0.0186	266	197	0.0342	2916	729	0.0117
1996	2886	1701	0.0186	288	223	0.0324	2481	738	0.0130
1997	2784	1698	0.0210	281	235	0.0344	2279	797	0.0135
1998	2940	1875	0.0206	300	260	0.0317	2421	959	0.0144
1999	2905	1896	0.0216	294	269	0.0314	2488	1103	0.0156
2000	3191	1978	0.0195	306	282	0.0287	2669	1219	0.0148
2001	3447	2238	0.0213	343	323	0.0294	3029	1473	0.0158
2002	3633	2320	0.0207	356	341	0.0298	3239	1572	0.0163
2003	3639	2348	0.0196	379	364	0.0284	3274	1655	0.0172
2004	3723	2546	0.0234	399	389	0.0290	3421	1867	0.0177
2005	4051	2791	0.0246	446	435	0.0280	3773	2064	0.0177
2006	4223	2936	0.0256	479	471	0.0291	3975	2214	0.0171
2007	3971	2749	0.0260	518	513	0.0288	3748	2120	0.0190
2008	3797	2720	0.0267	526	518	0.0273	3612	2145	0.0202
2009	3421	2576	0.0305	552	545	0.0311	3294	1996	0.0217
2010	3502	2615	0.0270	590	585	0.0314	3389	2015	0.0211
2011	3421	2519	0.0288	607	604	0.0312	3327	1889	0.0197
2012	3139	2452	0.0300	591	588	0.0325	3058	1930	0.0221
2013	3301	2646	0.0304	625	623	0.0327	3239	2052	0.0230
2014	2890	2355	0.0306	595	593	0.0343	2850	1830	0.0227
2015	2004	1730	0.0359	480	478	0.0332	1991	1409	0.0268
2016	504	435	0.0391	210	208	0.0334	500	374	0.0285
2017	7	6	0.0368	7	7	0.0292	7	6	0.0227

2.3 Descriptive statistics of inbreeding coefficients of *all* animals by year

This section presents the summary statistics of inbreeding coefficients of all animals born in a given year. The columns in the table are:

No. of animals : all animals born in a given year.

Min : the lowest inbreeding coefficient.

Max : the highest inbreeding coefficient.

Avg *F* : the mean inbreeding coefficient.

Std : the standard deviation of inbreeding coefficients.

Table 4: Inbreeding coefficients (F) of ALL animals by year

		F			
Year	No of Animals	Min	Max	Avg	Std
1927	4	0.0000	0.0000	0.0000	0.0000
1929	6	0.0000	0.0000	0.0000	0.0000
1931	6	0.0000	0.0000	0.0000	0.0000
1933	2	0.0000	0.0000	0.0000	0.0000
1958	1	0.0000	0.0000	0.0000	-
1959	2	0.0000	0.0000	0.0000	0.0000
1960	9	0.0000	0.0000	0.0000	0.0000
1961	4	0.0000	0.0000	0.0000	0.0000
1962	13	0.0000	0.0000	0.0000	0.0000
1963	22	0.0000	0.0000	0.0000	0.0000
1964	25	0.0000	0.0000	0.0000	0.0000
1965	34	0.0000	0.0000	0.0000	0.0000
1966	58	0.0000	0.0000	0.0000	0.0000
1967	75	0.0000	0.1250	0.0017	0.0144
1968	124	0.0000	0.0000	0.0000	0.0000
1969	193	0.0000	0.2500	0.0024	0.0206
1970	264	0.0000	0.0000	0.0000	0.0000
1971	1767	0.0000	0.0000	0.0000	0.0000
1972	1283	0.0000	0.2500	0.0004	0.0100
1973	1517	0.0000	0.1250	0.0003	0.0060
1974	1697	0.0000	0.2813	0.0013	0.0162
1975	1485	0.0000	0.2500	0.0034	0.0260
1976	2189	0.0000	0.2500	0.0027	0.0221
1977	1789	0.0000	0.2500	0.0029	0.0204
1978	2176	0.0000	0.2813	0.0033	0.0219
1979	2146	0.0000	0.3125	0.0052	0.0314
1980	2726	0.0000	0.4063	0.0052	0.0288
1981	2617	0.0000	0.4531	0.0068	0.0340
1982	2877	0.0000	0.3750	0.0059	0.0310
1983	2765	0.0000	0.3125	0.0068	0.0335
1984	3233	0.0000	0.3125	0.0054	0.0292
1985	3293	0.0000	0.3125	0.0080	0.0356
1986	3827	0.0000	0.3750	0.0093	0.0386
1987	4104	0.0000	0.4063	0.0115	0.0440
1988	4397	0.0000	0.4063	0.0112	0.0430
1989	3976	0.0000	0.3394	0.0099	0.0376
1990	3426	0.0000	0.3948	0.0123	0.0422
1991	3106	0.0000	0.3750	0.0128	0.0414
1992	3298	0.0000	0.3750	0.0157	0.0430

Continue...

		F			
Year	No of Animals	Min	Max	Avg	Std
1993	3716	0.0000	0.3145	0.0164	0.0416
1994	3774	0.0000	0.3679	0.0164	0.0394
1995	3385	0.0000	0.4102	0.0186	0.0439
1996	2886	0.0000	0.3203	0.0186	0.0407
1997	2784	0.0000	0.3203	0.0210	0.0429
1998	2940	0.0000	0.3213	0.0206	0.0391
1999	2905	0.0000	0.4402	0.0216	0.0413
2000	3191	0.0000	0.4023	0.0195	0.0399
2001	3447	0.0000	0.4023	0.0213	0.0427
2002	3633	0.0000	0.3857	0.0207	0.0421
2003	3639	0.0000	0.3140	0.0196	0.0359
2004	3723	0.0000	0.3746	0.0234	0.0432
2005	4051	0.0000	0.3927	0.0246	0.0436
2006	4223	0.0000	0.3844	0.0256	0.0442
2007	3971	0.0000	0.3806	0.0260	0.0442
2008	3797	0.0000	0.3109	0.0267	0.0438
2009	3421	0.0000	0.3818	0.0305	0.0483
2010	3502	0.0000	0.3817	0.0270	0.0413
2011	3421	0.0000	0.3822	0.0288	0.0449
2012	3139	0.0000	0.3131	0.0300	0.0420
2013	3301	0.0000	0.4724	0.0304	0.0420
2014	2890	0.0000	0.3148	0.0306	0.0405
2015	2004	0.0000	0.3906	0.0359	0.0463
2016	504	0.0000	0.3860	0.0391	0.0496
2017	7	0.0000	0.0596	0.0368	0.0192

2.4 Descriptive statistics of inbreeding coefficient of *inbred* animals by year

This section presents the summary statistics of inbreeding coefficients of *inbred* animals by year of birth. The columns in the table are:

No. of animals : all *inbred* animals born in a given year.

Min : the lowest inbreeding coefficient among inbred animals.

Max : the highest inbreeding coefficient.

Avg F : the mean inbreeding coefficient.

Std : the standard deviation of inbreeding coefficients.

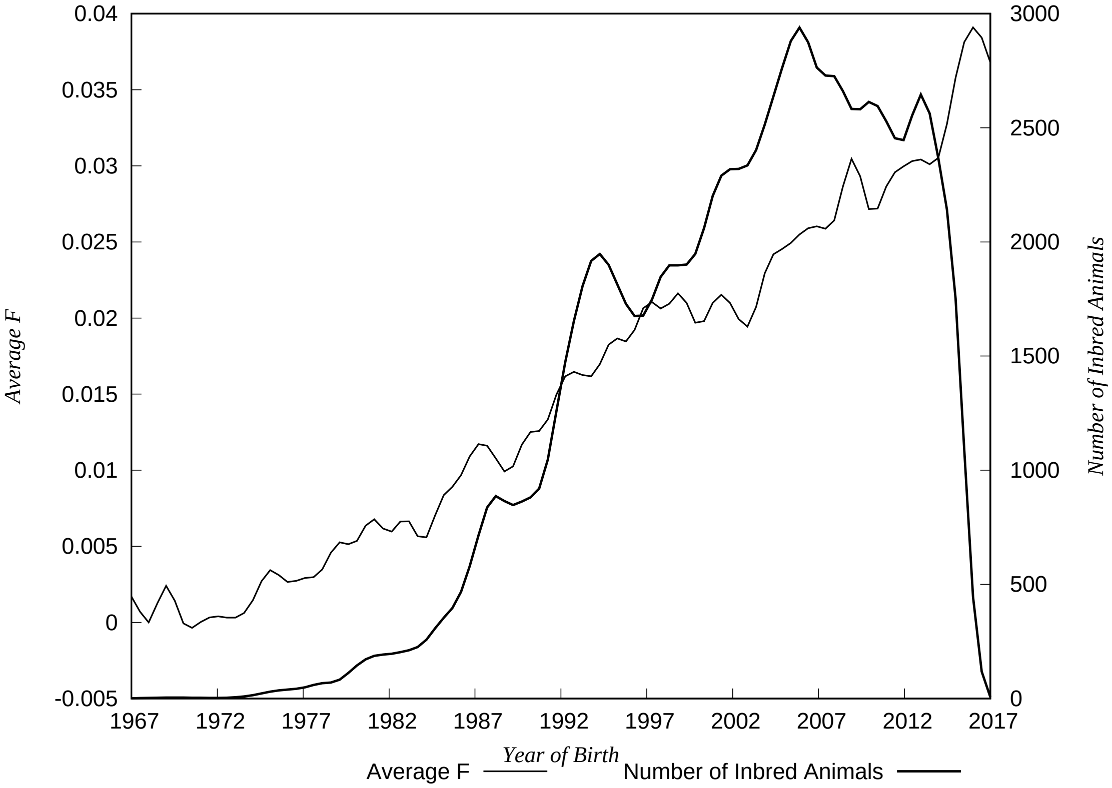
Table 5: Inbreeding coefficients (F) of INBRED animals by year

		F			
Year	No of Animals	Min	Max	Avg	Std
1967	1	0.1250	0.1250	0.1250	-
1969	4	0.0313	0.2500	0.1172	0.0967
1972	3	0.0625	0.2500	0.1875	0.1083
1973	5	0.0625	0.1250	0.1000	0.0342
1974	14	0.0313	0.2813	0.1585	0.0862
1975	29	0.0313	0.2500	0.1721	0.0748
1976	39	0.0078	0.2500	0.1508	0.0712
1977	47	0.0313	0.2500	0.1090	0.0660
1978	66	0.0039	0.2813	0.1083	0.0672
1979	78	0.0078	0.3125	0.1425	0.0874
1980	137	0.0039	0.4063	0.1041	0.0793
1981	184	0.0039	0.4531	0.0963	0.0888
1982	195	0.0020	0.3750	0.0871	0.0844
1983	209	0.0010	0.3125	0.0898	0.0863
1984	244	0.0001	0.3125	0.0719	0.0807
1985	339	0.0015	0.3125	0.0778	0.0833
1986	435	0.0010	0.3750	0.0815	0.0852
1987	659	0.0005	0.4063	0.0715	0.0881
1988	878	0.0001	0.4063	0.0559	0.0822
1989	850	0.0001	0.3394	0.0463	0.0701
1990	874	0.0001	0.3948	0.0481	0.0726
1991	971	0.0002	0.3750	0.0409	0.0657
1992	1371	0.0001	0.3750	0.0378	0.0602
1993	1730	0.0001	0.3145	0.0352	0.0553
1994	1943	0.0001	0.3679	0.0319	0.0503
1995	1864	0.0001	0.4102	0.0338	0.0546
1996	1701	0.0001	0.3203	0.0315	0.0491
1997	1698	0.0001	0.3203	0.0344	0.0506
1998	1875	0.0000	0.3213	0.0323	0.0450
1999	1896	0.0001	0.4402	0.0331	0.0472
2000	1978	0.0001	0.4023	0.0315	0.0468
2001	2238	0.0001	0.4023	0.0328	0.0493
2002	2320	0.0001	0.3857	0.0324	0.0490
2003	2348	0.0001	0.3140	0.0304	0.0408
2004	2546	0.0003	0.3746	0.0342	0.0485
2005	2791	0.0000	0.3927	0.0357	0.0487
2006	2936	0.0000	0.3844	0.0368	0.0490
2007	2749	0.0001	0.3806	0.0376	0.0488

Continue...

		F			
Year	No of Animals	Min	Max	Avg	Std
2008	2720	0.0008	0.3109	0.0373	0.0479
2009	2576	0.0002	0.3818	0.0405	0.0519
2010	2615	0.0002	0.3817	0.0361	0.0442
2011	2519	0.0001	0.3822	0.0391	0.0484
2012	2452	0.0010	0.3131	0.0384	0.0440
2013	2646	0.0012	0.4724	0.0379	0.0437
2014	2355	0.0005	0.3148	0.0376	0.0418
2015	1730	0.0006	0.3906	0.0416	0.0474
2016	435	0.0018	0.3860	0.0453	0.0507
2017	6	0.0310	0.0596	0.0430	0.0113

Figure 2: Comparison between the average inbreeding coefficients (F) and the number of inbred animals by year



3 Effective Population Size

3.1 Effective Population Size based on the rate of inbreeding

Effective population size (Ne) is the number of individuals that would give rise to the observed or calculated rate of inbreeding (ΔF), if they bred in the manner of the idealized population (Falconer & Mackay, 1996). The Ne is a a measure of genetic diversity within a population. It is therefore an important parameter in breeding of domestic animals and planning strategies for conservation of endangered animal and plant species (Nomura, 2002). This section presents effective population size calculated using $Ne = 1/2\Delta F$. The rate of inbreeding per generation (ΔF) was calculated using

$$\Delta F = \frac{F_t - F_{t-1}}{1 - F_{t-1}}$$

where F_t and F_{t-1} are the average inbreeding of offspring and their parents, respectively (Falconer & Mackay, 1996). The columns in the table are:

Avg *F* Animals : average inbreeding coefficient for animals born in a given year.

Avg *F* Sires : average inbreeding coefficient for sires of animals born in a given year.

Avg *F* Dams : average inbreeding coefficient for dams of animals born in a given year.

Avg *F* Parents : average inbreeding coefficient for sires and dams of animals born in a given year.

ΔF **:** the rate of inbreeding per generation.

Ne **:** the effective population size.

Note: The effective population size was not computed for $\Delta F = 0$ since it is undefined.

Table 6: Effective population size by year via rate of inbreeding

	Avg F					
Year	Animals	Sires	Dams	Parents	ΔF	Ne
1927	-	-	-	-	-	-
1929	0.0000	0.0000	0.0000	0.0000	0.0000	-
1931	0.0000	0.0000	0.0000	0.0000	0.0000	-
1933	0.0000	0.0000	0.0000	0.0000	0.0000	-
1958	-	-	-	-	-	-
1959	-	-	-	-	-	-
1960	0.0000	0.0000	0.0000	0.0000	-	-
1961	0.0000	0.0000	0.0000	0.0000	0.0000	-
1962	0.0000	0.0000	0.0000	0.0000	0.0000	-
1963	0.0000	0.0000	0.0000	0.0000	0.0000	-
1964	0.0000	0.0000	0.0000	0.0000	0.0000	-
1965	0.0000	0.0000	0.0000	0.0000	0.0000	-
1966	0.0000	0.0000	0.0000	0.0000	0.0000	-
1967	0.0005	0.0000	0.0000	0.0000	0.0005	924
1968	0.0004	0.0000	0.0000	0.0000	0.0004	1404
1969	0.0011	0.0000	0.0010	0.0005	0.0006	852
1970	0.0008	0.0000	0.0007	0.0003	0.0004	1188
1971	0.0002	0.0019	0.0013	0.0016	-0.0014	-367
1972	0.0003	0.0027	0.0009	0.0018	-0.0015	-341
1973	0.0003	0.0014	0.0003	0.0009	-0.0006	-906
1974	0.0005	0.0009	0.0003	0.0006	-0.0001	-5498
1975	0.0011	0.0007	0.0003	0.0005	0.0006	893
1976	0.0014	0.0009	0.0004	0.0006	0.0008	654
1977	0.0016	0.0016	0.0004	0.0010	0.0006	790
1978	0.0022	0.0030	0.0006	0.0018	0.0004	1236

Continue...

	Avg F					
Year	Animals	Sires	Dams	Parents	ΔF	Ne
1979	0.0028	0.0045	0.0009	0.0027	0.0001	3614
1980	0.0036	0.0076	0.0014	0.0045	-0.0009	-551
1981	0.0044	0.0106	0.0018	0.0062	-0.0018	-272
1982	0.0047	0.0128	0.0024	0.0076	-0.0029	-171
1983	0.0053	0.0143	0.0030	0.0086	-0.0033	-151
1984	0.0056	0.0146	0.0032	0.0089	-0.0034	-149
1985	0.0062	0.0156	0.0036	0.0096	-0.0034	-146
1986	0.0069	0.0160	0.0039	0.0099	-0.0031	-164
1987	0.0079	0.0157	0.0040	0.0098	-0.0019	-258
1988	0.0086	0.0162	0.0042	0.0102	-0.0016	-318
1989	0.0091	0.0191	0.0045	0.0118	-0.0027	-186
1990	0.0098	0.0213	0.0050	0.0131	-0.0034	-149
1991	0.0107	0.0237	0.0055	0.0145	-0.0039	-129
1992	0.0117	0.0256	0.0062	0.0158	-0.0042	-118
1993	0.0127	0.0273	0.0068	0.0170	-0.0044	-115
1994	0.0134	0.0289	0.0077	0.0182	-0.0049	-103
1995	0.0145	0.0304	0.0088	0.0195	-0.0050	-100
1996	0.0158	0.0297	0.0098	0.0196	-0.0039	-129
1997	0.0170	0.0294	0.0106	0.0198	-0.0029	-172
1998	0.0180	0.0283	0.0114	0.0197	-0.0018	-285
1999	0.0188	0.0274	0.0121	0.0196	-0.0008	-606
2000	0.0193	0.0271	0.0131	0.0200	-0.0006	-776
2001	0.0202	0.0269	0.0141	0.0203	-0.0002	-2894
2002	0.0205	0.0266	0.0149	0.0206	-0.0001	-6640
2003	0.0206	0.0261	0.0155	0.0206	0.0000	-32653
2004	0.0210	0.0250	0.0161	0.0204	0.0006	795
2005	0.0216	0.0248	0.0166	0.0205	0.0012	426
2006	0.0223	0.0242	0.0167	0.0203	0.0020	251
2007	0.0232	0.0239	0.0173	0.0204	0.0028	179
2008	0.0239	0.0237	0.0179	0.0207	0.0033	153
2009	0.0252	0.0240	0.0186	0.0212	0.0041	123
2010	0.0262	0.0248	0.0191	0.0219	0.0044	114
2011	0.0269	0.0259	0.0194	0.0225	0.0045	112
2012	0.0276	0.0267	0.0200	0.0233	0.0045	111
2013	0.0284	0.0279	0.0209	0.0243	0.0042	120
2014	0.0290	0.0291	0.0215	0.0252	0.0040	126
2015	0.0301	0.0302	0.0221	0.0261	0.0041	122
2016	0.0303	0.0309	0.0224	0.0266	0.0038	131
2017	0.0310	0.0313	0.0227	0.0270	0.0042	120

3.2 Effective population size based on the number of parents

This section presents the effective population size calculated based on the number of parents. The following formula was used to calculate Ne (Falconer & Mackay, 1996):

$$Ne = \frac{4N_m N_f}{N_m + N_f} * .7$$

where N_m and N_f are the number of male and female parents, respectively.

Accounting for mass selection as proposed by Caballero (1994) yields the added factor of .7 assuming that selection is on a trait with a heritability of .4 .

The above formula refers to the number of breeding males and females in a population with discrete generations. Here, we identify a generation of animals as those animals born in the time span of one generation interval (GI window) which ends in the reporting year. The parents of animals born in this GI window are then entered in the above equation to compute the Ne for each reporting year as listed in the table.

Thus, a sliding window will run over the years counting all animals born in that window and their sires and dams. To obtain the number of years involved in that GI window go to the population report and find the total generation interval which is the last figure at the bottom of table 5.

This setup implies that the number of parents in consecutive reporting years will include, in part, to the same animals.

The columns in the table are:

Number of animals : born in GI window ending in the reporting year

Number of sires : of animals born in the GI window

Number of dams : of animals born in the GI window

Number of parents : number of sires plus dams of animals born in the GI window

Ne : effective population size in the reporting year

Table 7: Effective population size by year via number of parents

	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
1927	4	1	1	2	1
1929	10	3	3	6	4
1931	16	6	6	12	8
1933	18	8	8	16	11
1958	1	1	1	2	1
1959	3	1	1	2	1
1960	12	2	1	3	2
1961	16	3	2	5	3
1962	29	8	6	14	10
1963	51	10	8	18	12
1964	76	15	14	29	20
1965	109	23	26	49	34
1966	165	35	38	73	51
1967	231	48	56	104	72
1968	351	68	86	154	106
1969	531	89	118	207	142
1970	773	125	177	302	205
1971	2515	173	278	451	299
1972	3764	222	422	644	407
1973	5223	366	1196	1562	785
1974	6845	482	2080	2562	1096
1975	8206	577	2896	3473	1347

Continue...

	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
1976	10202	648	3639	4287	1540
1977	11727	702	4099	4801	1678
1978	12136	802	4955	5757	1933
1979	12999	852	5636	6488	2072
1980	14208	862	5960	6822	2109
1981	15128	849	6194	7043	2091
1982	16520	815	6765	7580	2037
1983	17096	811	7264	8075	2043
1984	18540	818	8082	8900	2080
1985	19657	775	8699	9474	1992
1986	21338	770	10004	10774	2002
1987	22716	783	11633	12416	2054
1988	24496	811	13514	14325	2142
1989	25595	833	14754	15587	2208
1990	26256	838	15722	16560	2228
1991	26129	841	16325	17166	2239
1992	26134	897	16958	17855	2385
1993	26023	929	17360	18289	2469
1994	25693	927	17265	18192	2463
1995	24681	899	16543	17442	2387
1996	23591	888	15613	16501	2353
1997	22949	864	14976	15840	2287
1998	22783	870	14749	15619	2300
1999	22390	844	14464	15308	2233
2000	21865	840	14050	14890	2219
2001	21538	851	13807	14658	2244
2002	21786	868	13948	14816	2288
2003	22539	900	14339	15239	2371
2004	23478	946	15051	15997	2492
2005	24589	988	15887	16875	2604
2006	25907	1063	16851	17914	2800
2007	26687	1139	17558	18697	2995
2008	27037	1200	17957	19157	3150
2009	26825	1284	18073	19357	3357
2010	26688	1356	18244	19600	3534
2011	26386	1417	18263	19680	3682
2012	25474	1472	17815	19287	3807
2013	24552	1530	17384	18914	3937
2014	23471	1551	16867	18418	3977
2015	21678	1564	15803	17367	3985
2016	18761	1490	14093	15583	3773
2017	15266	1359	11923	13282	3416

4 The Average and Rate of Additive Genetic Relationships by year

The coefficient of inbreeding (F) of an individual is equal to the additive genetic relationship (AGR) between its parents or the coefficient of co-ancestry *i.e.* $F_i = f_{sd}$ where i is the individual and s and d are its sire and dam respectively (Falconer & Mackay , 1996). Under random mating, the rate of inbreeding (ΔF) is equal to the rate of additive genetic relationships (Δf). Thus, the effective size (Ne) can be obtained from either $\frac{1}{2\Delta F}$ or $\frac{1}{2\Delta f}$. Therefore, the discrepancy between the two effective sizes indicates a deviation from a random mating system.

In this report, the additive genetic relationships were computed using the PEDIG Fortran Package of Boichard (2002) and specifically the *par3.f* program (*see* the PEDIG manual for details). Briefly, the average additive genetic relationship among individuals within a group (*e.g.* animals born in a given year) is computed as the average inbreeding of the progeny of all possible matings among the individuals. Two steps were followed to calculate the rate of AGR (Δf) per generation or for animals born in a given year and a generation earlier. Firstly, the generation interval for animals born in a given year was calculated as the average age of their parents they were born. Secondly, the generation interval was subtracted from the year of birth of the current cohort to obtain the year of birth of the cohort born a generation earlier. Thus, the rate of additive genetic relationship is:

$$\Delta f = \frac{f_t - f_{t-1}}{1 - f_{t-1}}$$

where f_t and f_{t-1} are the average additive genetic relationship of the cohort born in generation t (or the current year) and the cohort born a generation earlier.

The number of animals born in the cohort beginning with the reporting year year as well their average AGR and inbreeding and their rate is presented in the Table. Notice that the AGR value reported is the average of all possible matings between males and females in the cohort. Thus, with 1000 males and 2000 females in the cohort this average is based on $1000 * 2000 = 2000000$ additive genetic relationships. The generation interval between this cohort and their parents is also presented. The average and rate of inbreeding and AGR are also presented in the Figures below. The effective population size based on the rate of AGR (computed as a regression of AGR on year) over the entire period is also presented.

Note: Due to computer hardware constraints, datasets with huge numbers of animals will be shortened preventing weeks of computation. The currently implemented algorithm is based on the number of acceptable computations in terms of CPU time:

$2000 male * 2000 female = 4000000 computations$

This should give a sufficiently precise estimate of the average AGR.

Operationally, from cohorts larger than 2000 males and 2000 females 2000 males and 2000 females as picked through a random number generator, thereby cutting the files to be processed down to a size which can computationally be handled.

The affected years will be documented in the coverpages of this report. Please refer to this information.

Table 8: Average Additive Genetic Relationships (AGR)

		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
1927	4	0.00000	-	0.00000	-	-
1929	10	0.02000	-	0.00000	-	2 (2.0)
1931	16	0.02344	-	0.00000	-	-
1933	18	0.02969	-	0.00000	-	-
1944		- -	-	-	-	-
1945		- -	-	-	-	-
1946		- -	-	-	-	-
1947		- -	-	-	-	-
1948		- -	-	-	-	-
1949		- -	-	-	-	-

Continue...

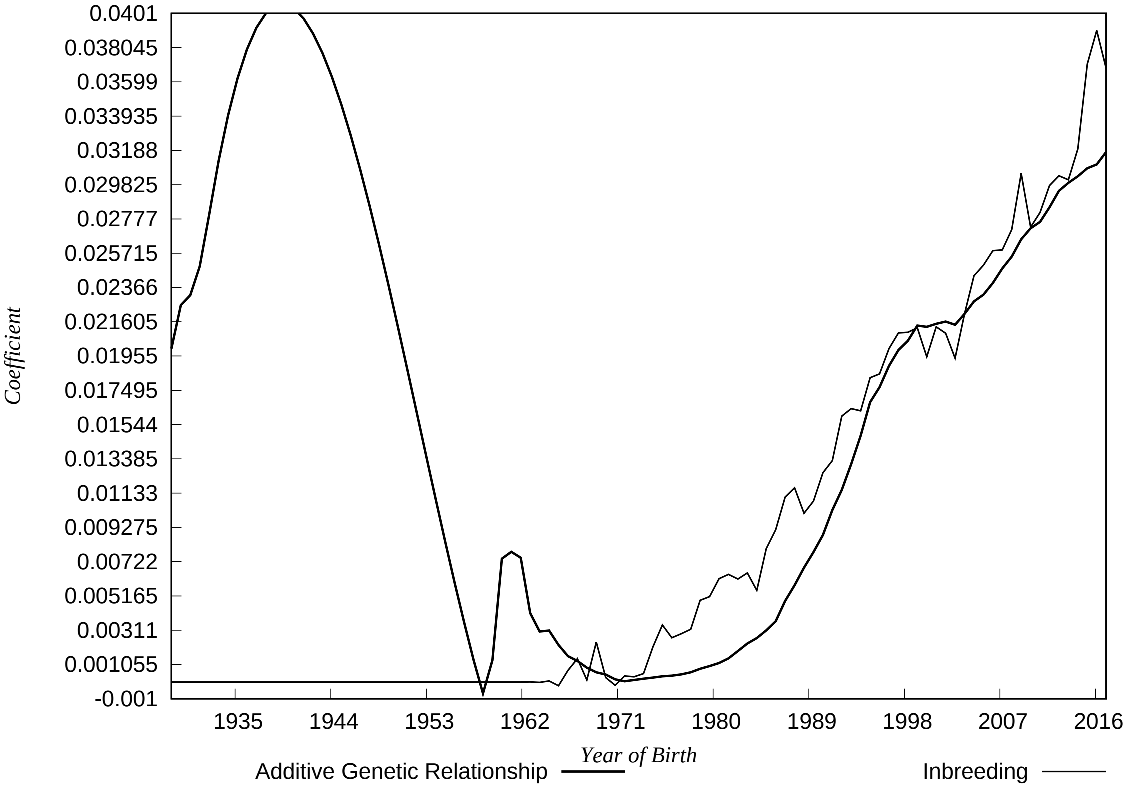
		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
1950		- -	-	-	-	-
1951		- -	-	-	-	-
1952		- -	-	-	-	-
1953		- -	-	-	-	-
1954		- -	-	-	-	-
1955		- -	-	-	-	-
1956		- -	-	-	-	-
1957		- -	-	-	-	-
1958	1	0.00000	-	0.00000	-	-
1959	3	0.00000	-	0.00000	-	-
1960	12	0.00694	-	0.00000	-	-
1961	16	0.00781	-	0.00000	-	-
1962	29	0.00721	-	0.00000	-	5 (5.0)
1963	51	0.00343	-	0.00000	-	-
1964	76	0.00320	-	0.00000	-	2 (2.2)
1965	109	0.00270	0.00270	0.00000	0.00000	6 (6.4)
1966	165	0.00172	0.00172	0.00000	0.00000	2 (2.0)
1967	231	0.00135	-0.00563	0.00170	0.00170	2 (2.2)
1968	351	0.00091	-0.00696	0.00000	0.00000	2 (2.1)
1969	531	0.00058	-0.00668	0.00240	0.00240	3 (3.1)
1970	773	0.00042	-0.00302	0.00000	0.00000	4 (4.4)
1971	2515	0.00010	-0.00311	0.00000	0.00000	4 (4.3)
1972	3764	0.00007	-0.00263	0.00040	0.00040	4 (4.3)
1973	5223	0.00017	-0.00155	0.00030	0.00030	4 (4.2)
1974	6127	0.00024	-0.00111	0.00130	-0.00040	4 (4.4)
1975	5758	0.00033	-0.00058	0.00340	0.00340	5 (4.8)
1976	5417	0.00038	-0.00020	0.00270	0.00030	5 (5.1)
1977	5174	0.00046	0.00004	0.00290	0.00290	5 (5.4)
1978	5372	0.00061	0.00051	0.00330	0.00330	5 (5.2)
1979	5413	0.00084	0.00077	0.00520	0.00480	5 (5.2)
1980	5602	0.00102	0.00085	0.00520	0.00490	5 (5.3)
1981	5816	0.00127	0.00103	0.00680	0.00551	5 (5.2)
1982	5753	0.00167	0.00134	0.00590	0.00251	5 (5.3)
1983	5853	0.00222	0.00184	0.00680	0.00411	6 (5.5)
1984	5795	0.00259	0.00213	0.00540	0.00251	6 (5.5)
1985	5832	0.00310	0.00249	0.00800	0.00472	6 (5.7)
1986	5790	0.00376	0.00292	0.00930	0.00412	6 (6.0)
1987	5664	0.00516	0.00415	0.01150	0.00633	6 (6.0)
1988	5602	0.00613	0.00486	0.01120	0.00443	6 (5.9)
1989	5533	0.00741	0.00574	0.00990	0.00402	6 (6.0)
1990	5442	0.00831	0.00611	0.01230	0.00554	6 (6.2)
1991	5560	0.00998	0.00741	0.01280	0.00744	6 (6.1)
1992	5644	0.01135	0.00828	0.01570	0.00776	6 (5.5)
1993	5673	0.01308	0.00935	0.01640	0.00717	6 (5.5)
1994	5753	0.01502	0.00991	0.01640	0.00496	5 (5.3)
1995	5774	0.01714	0.01108	0.01860	0.00748	6 (5.6)
1996	5982	0.01799	0.01066	0.01860	0.00879	6 (5.6)
1997	6164	0.01966	0.01144	0.02100	0.00881	6 (5.6)

Continue...

		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
1998	6108	0.02011	0.01023	0.02060	0.00790	6 (5.6)
1999	6000	0.02127	0.01004	0.02160	0.00599	6 (5.8)
2000	5959	0.02131	0.00834	0.01950	0.00315	6 (6.0)
2001	5903	0.02148	0.00655	0.02130	0.00498	6 (6.1)
2002	5811	0.02160	0.00454	0.02070	0.00214	6 (6.3)
2003	5476	0.02148	0.00356	0.01960	0.00102	6 (6.3)
2004	5213	0.02244	0.00284	0.02340	0.00245	7 (6.7)
2005	4965	0.02303	0.00299	0.02460	0.00408	7 (6.7)
2006	4760	0.02360	0.00238	0.02560	0.00409	7 (6.9)
2007	4628	0.02462	0.00338	0.02600	0.00663	7 (7.0)
2008	4505	0.02540	0.00401	0.02670	0.00552	7 (7.2)
2009	4433	0.02655	0.00506	0.03050	0.01001	7 (7.1)
2010	4367	0.02726	0.00590	0.02700	0.00755	7 (7.0)
2011	4348	0.02775	0.00543	0.02880	0.00553	7 (7.0)
2012	4331	0.02888	0.00598	0.03000	0.00554	7 (7.1)
2013	4338	0.02977	0.00632	0.03040	0.00493	7 (6.5)
2014	4340	0.03013	0.00565	0.03060	0.00472	7 (7.2)
2015	4423	0.03074	0.00548	0.03590	0.00945	7 (-)
2016	4626	0.03099	0.00456	0.03910	0.00887	7 (-)
2017	5167	0.03179	0.00466	0.03680	0.01007	7 (-)

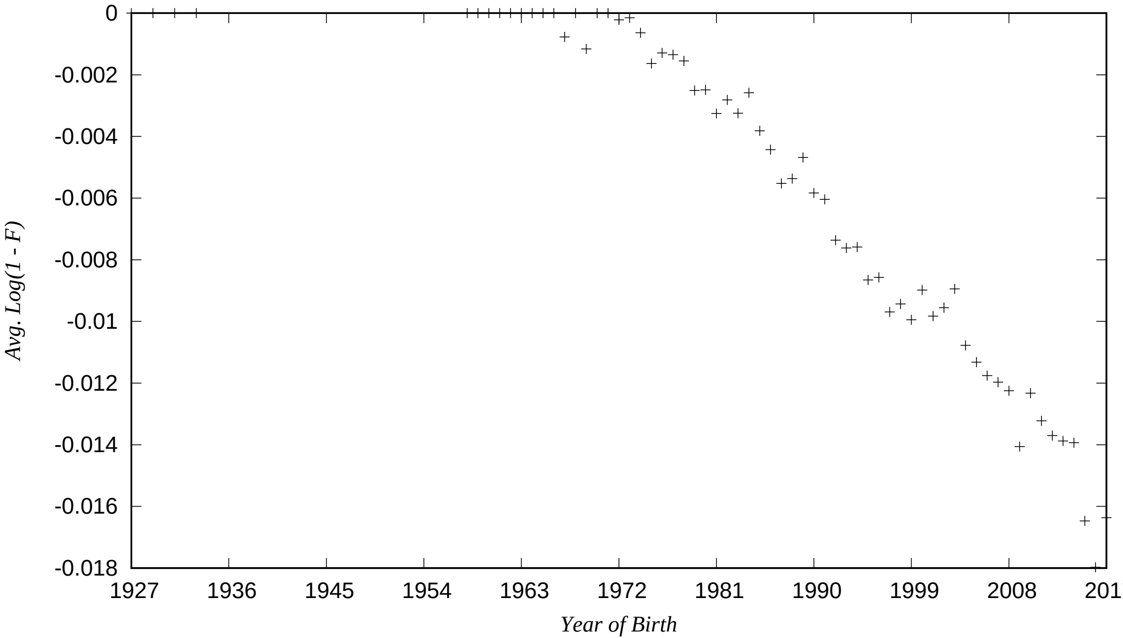
Fixed Time interval used to calculate Delta AGR: 7

Figure 3: Average Additive Genetic Relationships and Inbreeding Coefficients by year of birth



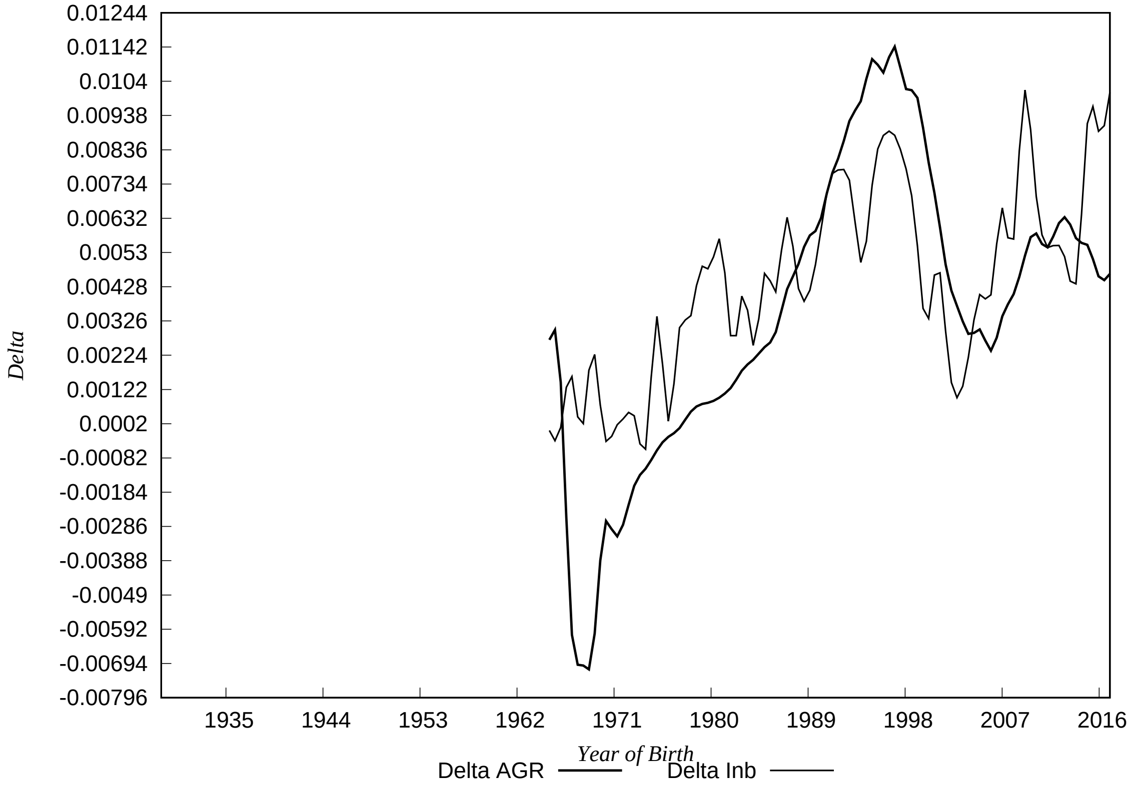
The average rate of change of the additive genetic relationships between 1929 and 2017 for the UNKNOWN breed was 0.00031 per year based on the slope of the regression fitted. This result in a Δf per generation of 0.00220. The rate of change of the average inbreeding coefficients based on the slope of the regression between 1929 and 2017 was 0.00051, which represents a ΔF per generation of 0.00367. The effective population sizes for the UNKNOWN breed, based on Δf and ΔF were 227 and 136, respectively.

Figure 4: Average Log(1-F) by year of birth for animals born between 1927 and 2017.



(The rate of inbreeding per generation for the UNKNOWN breed, based on the Log(1-Inbreeding) is 0.0056 which presents an Ne of 89. Calculations were performed on 138790 animals born between 1927 and 2017.)

Figure 5: The Rate of Inbreeding and Increase in the Additive Genetic Relationships by year of birth



Service PopReport at Institute of Farm Animal Genetics

FRIEDRICH-LOEFFLER-INSTITUT
FLI
Bundesforschungsinstitut für Tiergesundheit

PopReport
A Population Monitoring Report

Population: UNKNOWN
Inputfile: POPREP.TXT
Initiated by: quaglia@anabic.it
Submitted at: 2019-01-10 16:39:02
Started at: 2019-01-10 16:40:01
Finished at: 2019-01-10 17:32:59

Courtesy: Department of Animal Breeding and Genetics
Institute of Farm Animal Genetics (FLI)
Eildert.Groeneveld@gmx.de
Höltystrasse 10
D–31535 Mariensee, Germany
http://popreport.fli.de

Some Notes About Your PopReport Job:

- INFO: This job ran on machine rie-ex-web160 with 12 CPUs and MemTotal: 32950688 kB
- INFO: Your entered dateformat was 'YYYYMMDD', your dateseparator 'undef'.
  138790 input lines processed.
  138790 animals accepted.
- INFO: (concerning Inbreeding Report)
  This table shows the shortening of the number of male and female animals per year for the AGR computations. The original (orig) number of records is shortened (cut) to keep the product of $male * female$ within acceptable limits. See details later in the Inbreeding Report.

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
1974	743	743	6102	5384
1975	808	808	7398	4950
1976	882	882	9320	4535
1977	946	946	10781	4228
1978	893	893	11243	4479
1979	883	883	12116	4530
1980	840	840	13368	4762
1981	797	797	14331	5019
1982	809	809	15711	4944
1983	790	790	16306	5063
1984	801	801	17739	4994
1985	794	794	18863	5038
1986	802	802	20536	4988
1987	827	827	21889	4837
1988	840	840	23656	4762
1989	855	855	24740	4678
1990	876	876	25380	4566
1991	849	849	25280	4711
1992	831	831	25303	4813
1993	825	825	25198	4848
1994	809	809	24884	4944
1995	805	805	23876	4969
1996	767	767	22824	5215
1997	737	737	22212	5427
1998	746	746	22037	5362
1999	764	764	21626	5236
2000	771	771	21094	5188
2001	781	781	20757	5122
2002	798	798	20988	5013

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2003	868	868	21671	4608
2004	935	935	22543	4278
2005	1012	1012	23577	3953
2006	1090	1090	24817	3670
2007	1150	1150	25537	3478
2008	1216	1216	25821	3289
2009	1261	1261	25564	3172
2010	1307	1307	25381	3060
2011	1322	1322	25064	3026
2012	1335	1335	24139	2996
2013	1330	1330	23222	3008
2014	1328	1328	22143	3012
2015	1268	1268	20410	3155
2016	1151	1151	17610	3475
2017	948	948	14318	4219

Monitoring the Population UNKNOWN

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January 10, 2019

Methods in monitoring breeding populations

A number of methods are available to estimate the effective population size on the basis of pedigrees. When it comes to monitoring animal genetic resources not all methods are equally well suited. Further, depending on the conditions in the population under consideration, different methods may have to be chosen. Issues requiring possibly different methods to be chosen are e.g. sub population stratification, pedigree completeness, and sampling. Guidelines on the appropriate choice are given below.

Table 1 presents six methods for census and pedigree based N_e estimates. For details see Groeneveld et al. (2009) and Gutiérrez et al. (2009). Based on the rates computed, the N_e is estimated as $N_e = \frac{1}{2 \times \Delta F^*}$ for the pedigree based methods.

Table 1: Methods for estimating the effective population size N_e

Method	**Source**	**Formula**	**Description**
N_e-Cens	Wright (1923)	$N_e = 4 * \frac{S_n * D_n}{S_n + D_n} * 0.7$	S_n = number of sires per generation, D_n = number of dams per generation
N_e-ΔFp	Falconer & Mackay (1996)	$\Delta F_p = \frac{F_t - F_{t-1}}{1 - F_{t-1}}$	$F_t = \oslash$ inbreeding coefficient of offspring, $F_{t-1} = \oslash$ inbreeding coefficient of direct parents
N_e-ΔFg	Falconer & Mackay (1996)	$\Delta F_g = \frac{F_t - F_{t-1}}{1 - F_{t-1}}$	$F_{t-1} = \oslash$ inbreeding coefficient of the $\oslash$ parents generation
N_e-Coan	Falconer & Mackay (1996)	$\Delta f_g = \frac{f_t - f_{t-1}}{1 - f_{t-1}}$	$f_t = \oslash$ additiv genetic relationship (AGR) of offspring, $f_{t-1} = \oslash$ AGR of parents
N_e-Ln	Pérez-Enciso (1995)	$\Delta F_{ln} = (-1)bL$	b = slope from the logarithmic regression of $ln(1-F)$ on year of birth, L = generation interval
N_e-Ecg	Gutiérrez et al. (2009)	$\Delta F_i = 1 - \sqrt[ecg_i - 1]{1 - F_i}$	ecg = sum of all known ancestors with $\left(\frac{1}{2}\right)^n$, F_i = individual inbreeding coefficient

Choosing the best method

Given the number of methods available, a decision has to be taken on the choice of the most appropriate method for the population under consideration.

Populations are often monitored for effective population size with the objective to start an action once the size falls below some threshold. This may be the start of a management program or the establishment of a gene bank.

In this situation it is important to obtain an estimate from a method which can respond quickly to changes in population size. Different methods use time windows of different length. Thus, the method with the shortest window is best suited for our monitoring purposes.

There is, however, one other aspect which requires attention before considering the time window: we have two different classes of pedigree based methods: the first is based on inbreeding while the second computes the coancestry of an hypothetical contemporary breeding population. With random mating both are expected to produce the same results. If however there is a population stratification, i.e. selection within herds with little exchange of breeding stocks, then the average inbreeding will be high but the coancestry across the whole population will be much smaller. In this case the latter method better reflects the loss of genetic diversity in the complete breeding population.

For this reason the decision tree for picking the best method consists of these two major steps:

1. test for population stratification such as selection within herds
2. among the remaining methods chose the one requiring the shortest data history

The choice among the remaining methods is based on the window length required for the N_e computation. As can be seen from the Figure A the methods require data windows with different lengths and will, thus, respond to rapid changes in population size with different sensitivity. Ordering them according to the window length and putting the least appropriate N_e-Cens last, gives Table 2.

Figure 1: Data history on which the respective N_e estimate is based for each of the six N_e-methods

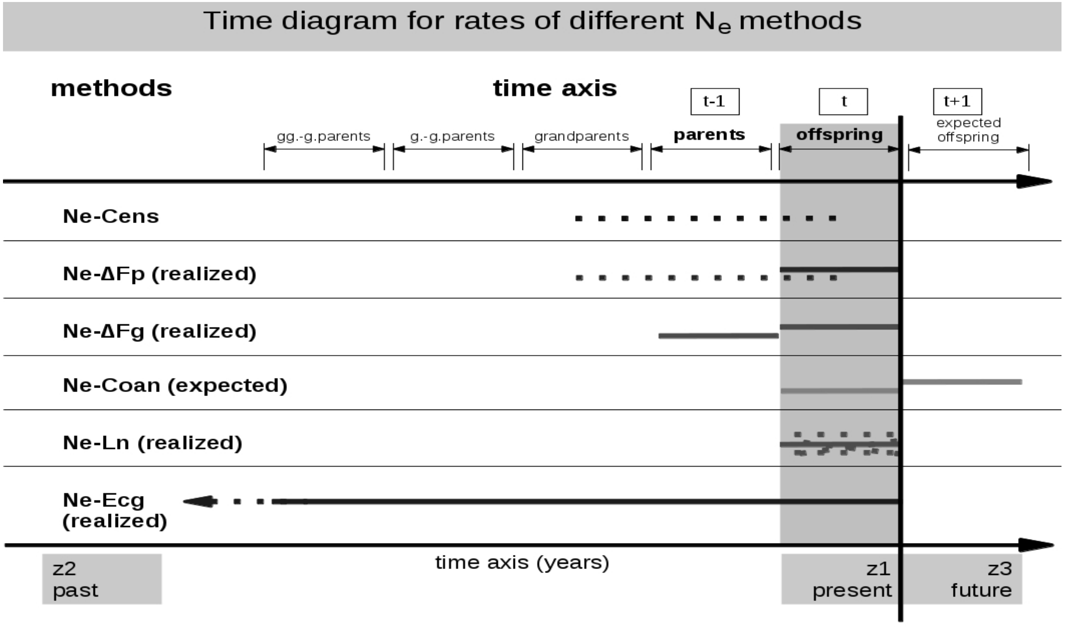

Table 2: Order of methods in cascade

Method	**Based on data from**
N_e-Ln	animals born in generation t
N_e-ΔFp	animals and their parents born in generation t
N_e-ΔFg	animals born in generation t and $t-1$
N_e-Coan	animals born in generation $t+1$ and t
N_e-Ecg	animals with their complete ancestors born in generation t
N_e-Cens	parents of animals born in generation t

Thus, N_e-Ln will be chosen by default. However, if the side conditions are not met, then the second shortest N_e-ΔFp will be considered, again looking at the side condition, and so on.

The required side conditions are the completeness of N_e and a relatively stable development of the N_e from one year to the next. Due to random processes the rate of inbreeding can be negative, resulting in a negative N_e, which is clearly meaningless and leads to the rejection of the method.

Further, if the N_e changes drastically from one year to the next, this is also considered dubious.

Defining the side condition

We are assuming a yearly assessment of the effective population size N_e. Thus, we are using reporting years, where the most recent year is the relevant one to assess the population size. However, populations can have very different generation intervals. As indicated in Figure 6 the minimum time an N_e estimate is based on is one generation interval. Above, we have given the reasoning for chosing a method. However, a few more conditions need to be determined. When looking at the N_e estimates across reporting years, it is clear that they vary possibly considerably from one year to the next due to sampling. This variation will even lead to negative N_e estimates which do not make sense. While presenting these in Table 3 and 4 as actual negative numbers we define a side condition that for one generation interval we must not have an undefined or missing estimate. Table 4 shows the actual estimates for one generation interval, one line for each reporting year. Thus, we define **side condition 1** as: **"neither missing nor negative N_e in any reporting year for the length of one generation interval".** As an example, with a generation interval of 7 years, none of the last 7 years must have a negative N_e.

Negative estimates are actually a special case of the more general side condition 2, which addresses variability of the N_e estimates: if one method has a much smaller variation in N_e estimates, we would be much more comfortable using this than others that are worse in stability. Thus, side condition 2 determines a threshold as far as variability of the estimates go for a method to be discarded. Here, we have chosen the square root of the residual after fitting a linear regression to the yearly N_e estimates. The cut off point for rejecting a method is set to 20 N_e. This means that the **side condition 2 sets the standard error of the estimate to 20 $\mathbf{N_e}$** which is actually quite large.

For populations with very short generation intervals, like one year, we would not have a means of assessing the variability of the estimates, because on the basis of side condition 1 we would have only one data point. Thus, a minimum of 4 years, i.e. datapoints are required.

Five of the six methods are based on the rate of inbreeding while N_e-Coan is based on the additive genetic relationship. A test on population stratification can be made based on the consistent difference in population size between methods N_e-Coan and N_e-ΔFg. These two means are computed on the respective N_e across all years as defined above.

Summing up we have introduced:

side condition 1: neither missing no negative N_e estimates over the last number of years of the generation interval length but a minimum of 4 years

side condition 2: standard error of the estimate of a linear fit over the reporting years included in side condition 1 must not get larger than 20 N_e.

It must be noted that the side conditions are pure heuristics and that different users may want to use different values.

We even consider it advisable to critically evaluate the selection procedure for an N_e each time a statement about the population size is made.

The decision tree in detail

Data for executing the decision tree are given in Table 4. It gives the input data for the decision tree with as many years as constitute one generation interval. The last line gives the standard error of the estimate from a linear regression of N_e on years.

Table 5 provides the data used in the side conditions.

The first line in the body of Table 5 gives the difference between N_e-Coan and N_e-ΔFg which is used to assess population stratification. This is followed by the 6 methods with the completeness and stability column. The last column shows an 'OK', if the side conditions as described above are met. If a user decides that a certain cut off point should be modified, for instance changing the stability value from 20 N_e to 10, this can be done in this table and will likely change the last column. Numbers in red indicate that the current thresholds are not met, while all others are printed in green.

The cascade

The decision tree can be easily followed on the basis of Table 5. Actually, its entries have already been sorted: the most appropriate methods coming first with the census method being last if all others fail due to not meeting the side conditions.

Thus, excuting the decision tree is simple: starting at the top of Table 5 the method which has the first 'yes' in the 'OK' column is the method of choice.

Population stratification

A comparison of N_e from inbreeding (N_e-ΔFg) and coancestry based (N_e-Coan) will give insight into whether something close to random mating is performed: both estimates should be rather similar. If however N_e-Coan is substantially larger, selection within herds can be assumed and this parameter be chosen. The investigator will probably be able to either substantiate or discard this claim. Figure 4 will give a quick overview about the situation: in such a case the slope of the N_e-Coan will be flatter.

Table 5 shows the decision going from top to bottom. The first line is an evaluation of the N_e-ΔFg. The entry in column 'OK' is set only to 'yes' if the N_e for the coancestry method N_e-Coan is numerically larger than for the inbreeding based N_e-ΔFg no matter how big the difference is and if the side conditions completeness and stability are met. This is equally arbitrary than the cut off points chosen for the side conditions 1 and 2. Other values (like a difference of 2) may be equally appropriate.

Deciding on the final method

Table 5 shows the decision going from top to bottom. The first line with a 'yes' in the 'OK' column represents the method of choice following the rational outlined above. As we go from one line to next, we move from the best choice to the next best. Where we encounter a 'no' under the 'OK' column, a side condition has not been met, and, thus, the methods is disguarded. As outlined above, we have the two side conditions 'Completeness' and 'Stability' which are reflected in the two columns with the respective headings in Table 5. The entries to the 'Completeness' column are the pairs 'actually complete' vs 'total number' of years. Thus, '4/8' means that out of the required 8 years 4 estimates were positive.

The 'Stability' column gives the actual σ estimate along with the threshold much like the completeness column. Violations of the constraints are printed in read. A method is only 'OK' if both - and for N_e-Coan in line 1 all three - constraints are met.

Please note, that the most current year has to be complete as far as data goes. If you can provide data for some months only you should remove this year completely. Otherwise the computation of N_e might be incorrect.

It also has to be noted that the procedure chosen is heuristic in particular the threshold for the variability of the N_e. Thus, in the face of additional information on the breed considered a user may find a different choice more appropriate.

In any case, mostly it is important to be sure about the order of the population size and not so much about the value behind the decimal point.

A word of warning

Figure 2 provides counts per reporting year. The user should study them and relate them to the N_e estimates. Drastic changes should be reflected in the estimates. Also, in those cases N_e-Ecg will likely not be a good procedure as it basically takes an average over the complete pedigree length.

Surprisingly, pedigrees are often quite incomplete which directly impacts on the utility of the methods. To assess the quality of the pedigree Figure 3 should be studied. Incomplete pedigrees will likely overestimate the population size. This will also be reflected by Figure 5 which will look more like a cluster of dots than something that looks like a regression line. Also, Figure 6 gives a visual impression how stable estimates are.

To some degree, the effect of incomplete pedigrees will be accounted for by the side conditions. But it is the obligation of the user to decide at which point an estimate still makes sense in the face of bad pedigrees.

References

[Falconer & Mackay, 1996] Falconer, D. S. and Mackay, T. F. C. (1996). *Introduction to Quantitative Genetics*. Longman, Essex, U.K., 4th ed. edition.

[Groeneveld et al., 2009] Groeneveld, E., v.d. Westhuizen, B., Maiwashe, A., Voordewind, F., and Ferraz, J. B. S. (2009). POPREP: A Generic Report for Population Management. *Genetics and Molecular Research*, 8(3):1158–1178.

[Gutiérrez et al., 2009] Gutiérrez, J. P., Cervantes, I., and Goyache, F. (2009). Improving the estimation of realized effective population size in farm animals. *J. Anim. Breed. Genet*, 126:327–332.

[Pérez-Enciso, 1995] Pérez-Enciso, M. (1995). Use of the uncertain relationship matrix to compute effective population size. *J.Anim.Breed.Genet.*, 112:327–332.

[Wright, 1923] Wright, S. (1923). Mendelian analysis of the pure breeds of livestock. *J. Hered.*, (14):339–348.

Breed: UNKNOWN • 138790 pedigree records • generation interval: 7 • January 10, 2019

Figure 2: Number of breeding animals

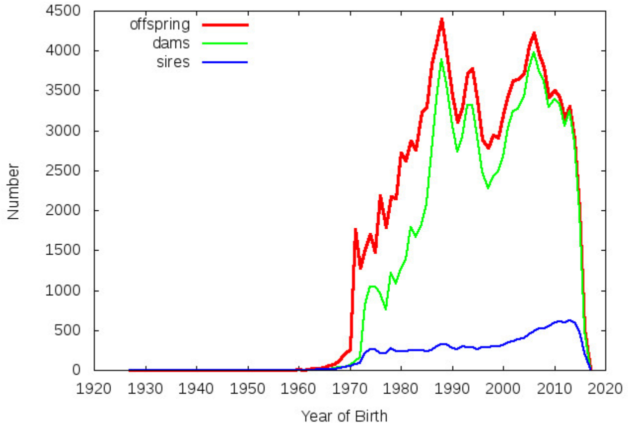

Figure 3: Average pedigree completeness for 1 to 6 generations

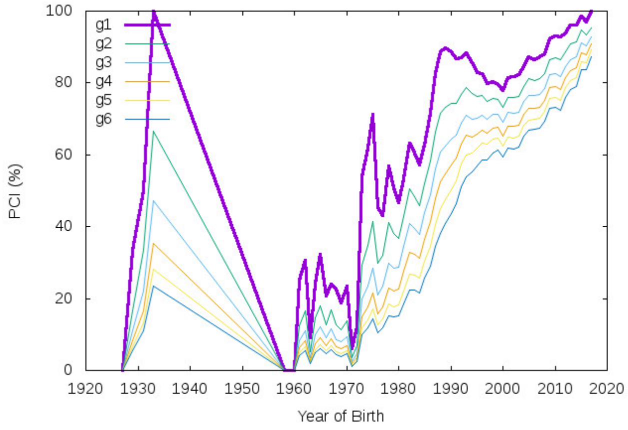

Figure 4: Average Additiv Genetic Relationship (Coan) and Inbreeding (F)

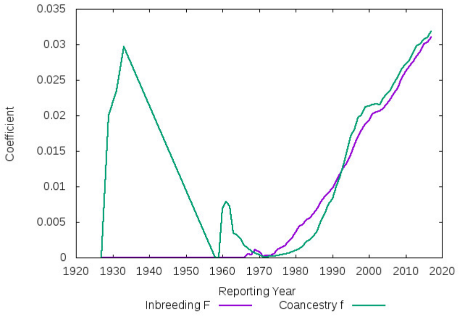

Figure 5: Average ln(1-F) by year of birth

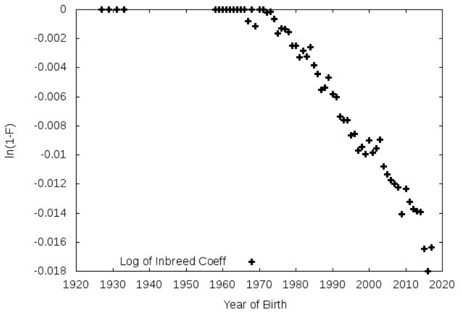

Figure 6: Ne with different calculation methods by reporting year

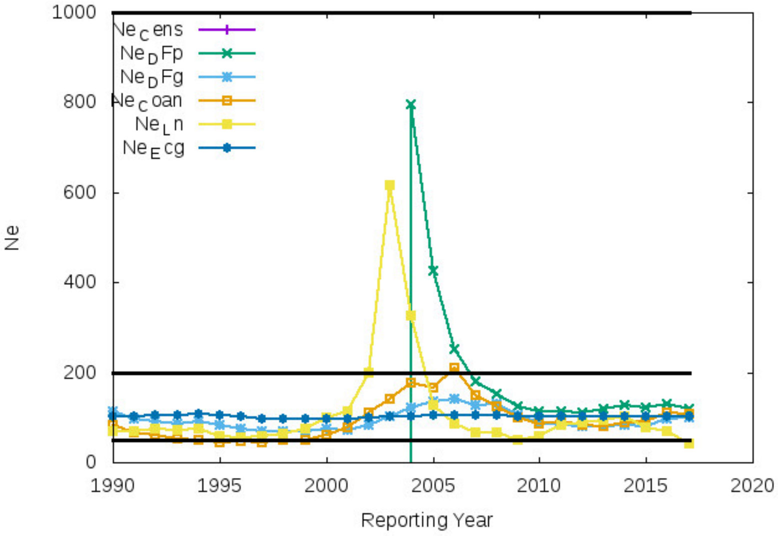

Table 3: Effective Population Size N_e

N_e-Method	2017	2016	2015	2014	2013	2012	data history
N_e-Cens	3416	3773	3985	3977	3937	3807	2010 – 2004
N_e-ΔF_p	120	131	122	126	120	111	2017 – 2004
N_e-ΔF_g	100	96	79	83	80	81	2017 – 2004
N_e-Coan	107	110	91	88	79	84	2024 – 2011
N_e-Ln	41	69	77	102	94	88	2017 – 2011
N_e-Ecg	102	103	101	102	101	101	2017 – 1927

Proposed N_e: N_e-Coan (substructure) = 107
Note: The last year is assumed to have complete data!

Table 4: Decision tree for $\mathrm{N_e}$ calculation

Year	N_e-Cens	N_e-ΔF_p	N_e-ΔF_g	N_e-Coan	N_e-Ln	N_e-Ecg
2017	3416	120	100	107	41	102
2016	3773	131	96	110	69	103
2015	3985	122	79	91	77	101
2014	3977	126	83	88	102	102
2013	3937	120	80	79	94	101
2012	3807	111	81	84	88	101
2011	3682	112	83	92	83	101
σ	211.0	5.5	6.3	8.6	15.7	0.6

Table 5: Decision cascade – side conditions

Method	Completeness [Years]	Stability [σ]	Diff	OK
N_e-Coan[a]	14/14	8.6|6.3/20	7.00	yes
N_e-Ln	7/7	15.7/20	-	yes
N_e-ΔF_p	7/7	5.5/20	-	yes
N_e-ΔF_g	7/7	6.3/20	-	yes
N_e-Coan	7/7	8.6/20	-	yes
N_e-Ecg	7/7	0.6/20	-	yes
N_e-Cens	7/7	211.0/20	-	no

---

[a] Avg N_e-Coan – Avg N_e-ΔF_g: 93.00 - 86.00 = 7.00

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PopReport
A Population Structure Report

Population: UNKNOWN
Inputfile: POPREP.TXT
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  138790 input lines processed.
  138790 animals accepted.
- INFO: (concerning Inbreeding Report)
  This table shows the shortening of the number of male and female animals per year for the AGR computations. The original (orig) number of records is shortened (cut) to keep the product of $male * female$ within acceptable limits. See details later in the Inbreeding Report.

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
1974	743	743	6102	5384
1975	808	808	7398	4950
1976	882	882	9320	4535
1977	946	946	10781	4228
1978	893	893	11243	4479
1979	883	883	12116	4530
1980	840	840	13368	4762
1981	797	797	14331	5019
1982	809	809	15711	4944
1983	790	790	16306	5063
1984	801	801	17739	4994
1985	794	794	18863	5038
1986	802	802	20536	4988
1987	827	827	21889	4837
1988	840	840	23656	4762
1989	855	855	24740	4678
1990	876	876	25380	4566
1991	849	849	25280	4711
1992	831	831	25303	4813
1993	825	825	25198	4848
1994	809	809	24884	4944
1995	805	805	23876	4969
1996	767	767	22824	5215
1997	737	737	22212	5427
1998	746	746	22037	5362
1999	764	764	21626	5236
2000	771	771	21094	5188
2001	781	781	20757	5122
2002	798	798	20988	5013

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2003	868	868	21671	4608
2004	935	935	22543	4278
2005	1012	1012	23577	3953
2006	1090	1090	24817	3670
2007	1150	1150	25537	3478
2008	1216	1216	25821	3289
2009	1261	1261	25564	3172
2010	1307	1307	25381	3060
2011	1322	1322	25064	3026
2012	1335	1335	24139	2996
2013	1330	1330	23222	3008
2014	1328	1328	22143	3012
2015	1268	1268	20410	3155
2016	1151	1151	17610	3475
2017	948	948	14318	4219

Population Structure Report for Population: UNKNOWN

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Contents

List of Tables

List of Figures

1 Number of breeding males and females by year

The number of breeding animals at a given time determines the genetic structure of the population in subsequent generations. Under simplified conditions (*e.g.* ratio of males to females is 1:1, random selection, distribution of family size is Poisson, *etc*), the number of breeding males and females can be used to calculate the effective population size (to be defined later). In the context of this report, an animal only becomes a 'breeding' animal by either having a service record (if available) or show up as a parent in a birth record of an offspring. This may constrast to a situation, where animals get 'selected' with the intent to use them as parents but effectively are never put into service.

The number of breeding males and females used in the population in a given year is presented in this table. The table is broken down by birth year with the last column (Number of animals born) giving the total number of animals born for the current breed for that particular year.

It is the objective of this table to provide an overview about the genetic composition of each birth year's batch of new animals: giving the number of sires and dams that produced the current year's crop of offspring. Thus, for 'services' and 'birth' we find under column 'sires' the number of sires involved in the services and births. The same applies to the column 'dams'. Thus, the ratio of 'number of animals born' and the counts in 'birth' gives the average number of offspring per sire/dam in that year.

The column 'select' goes one step further: firstly, based on the set of animals born in the particular year, it is determined how many of those offspring became parents in later years. Then, for this subset the number of sires and dams are determined and printed under column 'select'. Clearly, this figure has to be less or equal to the corresponding figure under 'births'. Keeping this figure high will help avoid inbreeding.

The description for each column is:

Services: The number of sires/dams that participated in services in a given year.

Births: The number of sires/dams with offspring in a given year.

Select: Those animals born in the given year which became parents later on determine the subset. "Select" gives the number of sires and dams represented in this subset.

The total number of sires and dams is not the sum of the sire and dam columns but rather the total number of sires and dams occuring in all years. This figure will tend to be smaller than the sum from the years, as the same sire or dam may show up in multiple years.

For example: For the UNKNOWN breed in 1966, 12 sires and 12 dams produced the 58 offspring during this year. In the batch of future parents (select) born in this year 1966 12 sires and 12 dams were represented.

Table 1: Number of sires and dams in reproduction by year of birth of offspring

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
1929	-	2	2	-	2	2	6
1931	-	3	3	-	3	3	6
1933	-	2	1	-	2	1	2
1960	-	1	1				9
1961	-	1	1	-	1	1	4
1962	-	5	5	-	4	4	13
1963	-	2	2	-	2	2	22
1964	-	7	7	-	6	6	25
1965	-	10	10	-	12	12	34
1966	-	12	12	-	12	12	58
1967	-	16	16	-	18	18	75
1968	-	28	26	-	32	27	124

Continue...

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
1969	-	31	27	-	38	34	193
1970	-	52	44	-	64	54	264
1971	-	73	67	-	110	96	1767
1972	-	91	80	-	159	128	1283
1973	-	212	146	-	816	366	1517
1974	-	265	181	-	1046	456	1697
1975	-	262	184	-	1041	489	1485
1976	-	216	165	-	974	506	2189
1977	-	207	157	-	762	438	1789
1978	-	268	205	-	1219	635	2176
1979	-	237	187	-	1079	560	2146
1980	-	235	185	-	1268	671	2726
1981	-	232	183	-	1375	713	2617
1982	-	253	202	-	1792	968	2877
1983	-	247	185	-	1659	901	2765
1984	-	253	198	-	1831	982	3233
1985	-	230	185	-	2083	1066	3293
1986	-	246	189	-	2739	1274	3827
1987	-	303	237	-	3388	1553	4104
1988	-	317	244	-	3891	1688	4397
1989	-	319	236	-	3577	1616	3976
1990	-	276	217	-	3056	1548	3426
1991	-	261	213	-	2740	1376	3106
1992	-	293	213	-	2915	1408	3298
1993	-	287	231	-	3312	1570	3716
1994	-	285	228	-	3317	1638	3774
1995	-	266	223	-	2916	1475	3385
1996	-	288	232	-	2481	1302	2886
1997	-	281	228	-	2279	1284	2784
1998	-	300	257	-	2421	1373	2940
1999	-	294	231	-	2488	1428	2905
2000	-	306	266	-	2669	1591	3191
2001	-	343	291	-	3029	1747	3447
2002	-	356	309	-	3239	1839	3633
2003	-	379	295	-	3274	1744	3639
2004	-	399	313	-	3421	1717	3723
2005	-	446	347	-	3773	1828	4051
2006	-	479	347	-	3975	1769	4223
2007	-	518	356	-	3748	1582	3971
2008	-	526	336	-	3612	1395	3797
2009	-	552	316	-	3294	1095	3421
2010	-	590	320	-	3389	998	3502
2011	-	607	264	-	3327	743	3421
2012	-	591	189	-	3058	499	3139
2013	-	625	90	-	3239	193	3301
2014	-	595	24	-	2850	30	2890
2015	-	480	-	-	1991	-	2004
2016	-	210	-	-	500	-	504

Continue...

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
2017	-	7	-	-	7	-	7
Total	-	5073	3690	-	69726	35261	138790

2 Age structure of parents by birth year of offspring

This section gives a quick overview of the age structure of breeding males and females by birth year of offspring as summarized in the Tables. The animals of interest or cohort is *the total number of animals born in a given year*. The second row in the header of tables lists the different age groups (in *years*) for male and female parents. It should be noted that parents greater or equal to 16 years of age were grouped together i.e. age group ≥ 16 years. The values in the body of table are the number of male/female parents in a given age-year subgroup. A dash ("-") in the table indicates that there were no animals of a particular age group in a given year. The last column presents the average age of all male/female parents.

For example: For the UNKNOWN breed in 1968, 2 two year-old males were used in reproduction while 4 three year-old males were used. The average age of males that produced offspring during 1968 was 1.5 year.

Table 2: Age distribution of males in reproduction by year of birth of their offspring

Year	age of males in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1929	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1931	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1933	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1960	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1961	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1962	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	7.2
1963	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1964	5	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1.4
1965	7	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	8.4
1966	11	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.1
1967	13	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3
1968	21	2	4	1	–	–	–	–	–	–	–	–	–	–	–	–	1.5
1969	23	–	3	2	1	–	1	–	–	–	–	–	–	–	–	1	3.0
1970	35	6	3	–	–	2	2	1	1	–	–	–	–	–	–	2	3.5
1971	45	6	5	6	2	–	2	1	2	1	2	–	–	–	–	1	3.0
1972	44	16	7	6	4	4	–	5	1	3	–	–	–	–	–	1	3.2
1973	37	119	21	8	5	5	3	2	6	1	3	–	–	–	–	2	3.0
1974	38	97	70	17	5	7	6	7	1	7	3	4	–	–	–	3	3.7
1975	22	87	62	41	11	5	6	5	5	3	7	1	2	–	1	4	4.2
1976	18	70	39	30	23	5	5	3	3	9	1	3	1	2	–	4	4.6
1977	13	52	65	25	20	8	4	3	2	2	6	2	2	1	1	1	4.1

Continue...

Year	age of males in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1978	36	50	68	51	24	12	4	4	3	4	2	5	2	1	–	2	3.9
1979	14	60	48	38	27	18	8	3	2	4	3	3	4	1	1	3	4.4
1980	22	50	53	31	29	18	7	8	3	1	2	5	–	3	–	3	4.3
1981	13	60	54	38	22	18	8	5	3	2	–	1	3	–	2	3	4.0
1982	15	61	69	34	26	15	14	6	4	2	–	–	1	2	–	4	4.0
1983	14	67	50	46	32	15	12	1	2	1	4	–	–	–	1	2	3.8
1984	14	60	65	41	32	19	9	5	4	1	1	–	1	–	–	1	3.8
1985	22	43	57	41	24	17	11	6	4	1	–	–	–	1	–	3	3.9
1986	11	56	56	46	29	15	13	10	4	4	–	–	–	–	–	2	4.0
1987	19	75	56	52	36	21	12	14	6	5	4	–	–	–	–	3	4.2
1988	22	71	64	42	36	24	21	8	8	5	5	5	1	–	–	5	4.5
1989	14	84	63	50	32	23	17	6	6	8	3	5	4	2	–	2	4.3
1990	10	77	60	41	27	18	17	7	7	3	4	2	1	1	–	1	4.1
1991	12	74	58	43	23	18	14	4	2	7	3	1	1	–	–	1	3.9
1992	11	92	60	44	29	20	12	7	6	5	3	2	2	–	–	–	3.9
1993	10	86	74	46	29	18	8	4	4	2	2	1	1	1	–	1	3.7
1994	12	79	72	50	33	16	10	3	4	1	2	1	1	–	1	–	3.7
1995	7	77	56	47	39	17	10	6	3	1	–	1	–	1	1	–	3.8
1996	10	90	67	48	35	20	11	2	3	–	1	–	–	–	1	–	3.6
1997	6	76	75	51	30	21	12	4	2	2	–	2	–	–	–	–	3.7
1998	7	71	74	59	38	23	10	9	2	1	2	1	3	–	–	–	3.9
1999	15	59	58	66	38	32	10	8	3	2	1	1	–	1	–	–	4.0
2000	7	86	45	45	48	31	19	12	7	5	–	–	–	–	1	–	4.2
2001	6	89	76	36	38	44	21	7	8	6	6	2	1	–	–	3	4.4
2002	7	91	66	63	30	29	25	18	9	9	2	4	–	–	–	3	4.4
2003	13	82	70	65	42	24	28	18	11	4	8	4	5	1	1	3	4.7
2004	13	91	90	55	45	36	15	15	9	12	6	4	3	3	–	2	4.5
2005	10	100	86	71	61	37	31	8	12	10	5	4	5	2	3	1	4.5
2006	13	104	99	76	51	47	25	22	7	11	7	3	6	4	1	3	4.6
2007	11	117	118	85	57	42	29	16	10	5	6	10	3	2	5	2	4.5
2008	8	114	114	83	71	38	30	15	15	6	4	7	6	3	2	10	4.7
2009	12	112	117	88	66	59	23	20	19	8	7	–	2	7	1	11	4.7
2010	9	118	104	101	77	61	45	22	16	9	5	6	1	1	3	12	4.8

Continue...

Year	age of males in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
2011	15	96	102	99	88	66	41	33	21	14	6	4	6	–	–	16	5.1
2012	6	119	95	81	69	71	43	29	26	14	7	8	3	5	–	15	5.3
2013	12	116	125	74	71	61	53	37	24	16	9	6	2	1	4	14	5.2
2014	12	91	107	107	51	63	45	38	28	11	14	6	5	2	–	15	5.3
2015	4	83	91	66	65	32	32	34	23	16	4	8	2	2	2	16	5.5
2016	4	37	49	31	15	17	12	10	8	7	3	–	4	1	1	11	5.7
2017	–	1	1	–	–	2	–	–	–	1	–	–	–	–	1	1	9.3
Total	825	3623	3195	2367	1686	1214	796	511	359	252	163	122	84	51	34	196	7.4

For example: For the UNKNOWN breed in 1971, 2 two year-old females were used in reproduction while 2 three year-old females were used. The avarage age of females that produced offspring during 1971 was 1.6 year.

Table 3: Age distribution of females in reproduction by year of birth of their offspring

Year	age of females in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1929	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1931	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1933	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1961	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1962	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1963	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1964	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1965	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1966	12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1967	17	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	1.2
1968	30	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	1.2
1969	35	1	1	–	–	–	1	–	–	–	–	–	–	–	–	–	1.2
1970	59	1	3	–	1	–	–	–	–	–	–	–	–	–	–	–	1.2
1971	101	2	2	2	–	–	1	–	1	–	–	–	–	–	–	1	1.6
1972	150	–	6	–	1	–	1	–	1	–	–	–	–	–	–	–	1.2
1973	756	24	17	5	6	1	1	–	–	2	1	–	–	–	–	3	1.3
1974	535	142	314	25	8	7	2	6	–	2	1	–	1	1	–	2	2.1
1975	359	134	313	192	11	8	7	4	4	1	2	1	–	1	1	3	2.7
1976	358	138	171	181	97	7	6	6	4	–	2	2	1	–	–	1	2.7
1977	115	120	123	141	154	79	15	3	4	–	3	–	2	1	–	2	3.8
1978	418	139	168	139	112	132	77	10	8	4	4	5	–	–	1	2	3.3
1979	234	188	208	111	98	90	90	44	5	5	3	1	–	1	1	–	3.6
1980	211	174	244	186	126	97	77	73	40	14	9	6	3	4	–	4	4.2
1981	202	189	228	195	153	119	89	75	61	33	15	8	3	–	2	3	4.4
1982	220	260	276	220	260	186	115	106	56	45	28	8	7	1	2	2	4.5
1983	130	221	250	244	184	185	156	91	80	51	32	14	8	1	4	8	5.0
1984	80	214	296	287	222	183	188	143	84	53	35	21	9	8	2	6	5.2
1985	98	276	246	327	258	211	190	169	136	82	34	23	18	5	3	7	5.3
1986	128	378	399	314	364	333	256	188	161	95	60	37	10	7	2	7	5.2

Continue...

Year	age of females in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1987	85	481	494	432	401	414	360	205	196	139	90	47	28	3	5	8	5.4
1988	79	608	551	556	411	420	398	314	197	135	99	57	41	14	5	6	5.4
1989	49	510	548	445	437	380	340	279	263	133	76	49	40	16	4	8	5.5
1990	18	440	474	412	368	304	276	235	191	147	84	55	28	10	7	7	5.5
1991	21	390	399	383	360	301	237	173	146	135	102	34	31	11	7	10	5.5
1992	24	414	434	427	346	329	263	227	149	103	84	58	26	18	4	9	5.5
1993	28	405	460	449	428	390	310	251	194	137	89	67	57	16	15	16	5.7
1994	18	422	434	420	383	401	329	275	190	152	105	89	46	25	11	17	5.9
1995	17	408	374	339	355	334	280	229	215	125	87	64	33	26	17	13	5.9
1996	18	356	359	283	238	263	258	191	152	137	87	53	39	25	12	10	5.9
1997	4	296	327	298	243	248	170	197	165	111	75	58	41	19	19	8	6.0
1998	10	290	326	332	302	203	206	189	156	145	103	64	41	23	20	11	6.1
1999	9	241	312	310	350	254	212	205	179	144	110	69	45	24	10	14	6.2
2000	8	282	315	298	341	314	283	200	162	147	113	92	66	30	9	9	6.3
2001	14	349	346	324	349	352	319	242	212	135	129	100	70	45	21	22	6.3
2002	23	337	401	347	317	331	346	279	216	161	155	131	81	59	21	34	6.5
2003	12	409	362	358	344	316	316	271	271	180	145	103	86	49	25	27	6.4
2004	8	438	427	412	341	316	272	275	272	212	143	108	66	61	28	42	6.4
2005	13	481	473	416	425	323	315	308	256	232	187	124	78	63	41	38	6.4
2006	13	449	465	520	426	406	325	306	233	232	222	158	69	59	34	58	6.5
2007	14	467	463	421	431	389	304	267	229	201	172	148	96	56	28	62	6.4
2008	22	465	450	416	376	384	310	259	202	173	172	122	109	68	39	45	6.4
2009	19	386	414	365	351	351	340	251	202	160	137	120	60	56	42	40	6.4
2010	8	361	393	422	376	346	338	301	215	168	133	128	61	60	29	50	6.5
2011	10	346	367	425	389	338	303	259	215	198	157	89	77	56	39	59	6.5
2012	8	276	337	358	352	347	288	248	182	180	154	109	83	57	26	53	6.7
2013	15	282	330	421	380	338	328	279	204	198	145	117	79	51	26	46	6.6
2014	8	294	294	305	314	306	302	252	187	156	140	112	65	55	21	39	6.7
2015	7	203	181	194	205	203	202	160	183	131	91	89	50	41	28	23	6.9
2016	1	47	59	61	60	47	49	44	36	29	20	19	6	11	6	5	6.5
2017	–	–	2	2	–	–	–	–	–	2	1	–	–	–	–	–	6.4
Total	4863	13734	14837	13721	12455	11286	9851	8089	6515	5025	3836	2759	1760	1137	617	840	6.5

3 Distribution of parity of dams at birth of offspring

The rate of genetic progress in the population depends among other things on the turnover of breeding stock. In general, under artificial breeding, animals that stay in the population longer tend to leave more offspring. Thus, the distribution of parity of dams over time may be informative about the rate of turnover in the population. The distribution of breeding females in different parity groups in a given year is presented in the Table. Dams with parity ≥ 16 are often few in the population and they are conveniently placed together in one group i.e. ≥ 16 group. In this instance, the *cohort is defined as the total number of animals born in a given year.*

For example: For breed UNKNOWN in 1969, 2 females were in their second parity while in 1972, 2 were in their third parity.

Table 4: Distribution of females by parity number

Year	parity number										
	1	2	3	4	5	6	7	8	9	10	11
1929	2	–	–	–	–	–	–	–	–	–	–
1931	3	–	–	–	–	–	–	–	–	–	–
1933	2	–	–	–	–	–	–	–	–	–	–
1961	1	–	–	–	–	–	–	–	–	–	–
1962	4	–	–	–	–	–	–	–	–	–	–
1963	2	–	–	–	–	–	–	–	–	–	–
1964	6	–	–	–	–	–	–	–	–	–	–
1965	12	–	–	–	–	–	–	–	–	–	–
1966	12	–	–	–	–	–	–	–	–	–	–
1967	18	–	–	–	–	–	–	–	–	–	–
1968	31	1	–	–	–	–	–	–	–	–	–
1969	36	2	–	–	–	–	–	–	–	–	–
1970	61	4	–	–	–	–	–	–	–	–	–
1971	106	4	–	–	–	–	–	–	–	–	–
1972	155	2	2	–	–	–	–	–	–	–	–
1973	780	37	–	1	–	–	–	–	–	–	–
1974	897	146	6	–	–	–	–	–	–	–	–
1975	835	175	34	–	1	–	–	–	–	–	–
1976	772	178	28	6	–	–	–	–	–	–	–
1977	505	197	53	10	1	–	–	–	–	–	–
1978	936	211	62	16	6	–	–	–	–	–	–
1979	785	209	69	14	3	–	–	–	–	–	–
1980	903	262	83	21	2	2	–	–	–	–	–
1981	971	289	87	29	6	3	–	–	–	–	–
1982	1308	345	109	33	3	1	–	–	–	–	–
1983	1176	345	91	38	10	2	–	–	–	–	–
1984	1309	365	116	33	15	–	1	–	–	–	–
1985	1432	477	137	30	15	5	–	–	–	–	–
1986	2000	538	142	43	14	7	1	–	–	–	–
1987	2423	682	207	57	20	11	2	–	–	–	–
1988	2762	846	207	66	16	3	1	2	–	–	–
1989	2351	852	275	75	24	5	3	–	1	–	–
1990	1990	725	259	64	17	7	3	1	–	–	–
1991	1715	693	240	70	25	6	–	2	1	–	–
1992	1857	705	242	73	28	10	1	–	–	1	–

Continue...

Year	parity number										
	1	2	3	4	5	6	7	8	9	10	11
1993	2098	788	306	88	27	11	3	–	–	–	1
1994	2016	835	318	112	30	9	2	3	–	–	–
1995	1773	764	254	97	22	8	2	1	2	–	–
1996	1427	668	268	77	37	4	5	–	–	–	–
1997	1348	573	229	85	28	17	2	–	1	–	–
1998	1450	616	234	90	20	15	4	1	–	–	–
1999	1459	652	247	89	29	5	10	2	–	–	–
2000	1623	645	260	94	39	9	1	2	–	–	–
2001	1829	756	296	94	39	14	5	2	–	–	–
2002	1939	799	325	128	32	19	1	–	–	–	–
2003	1898	854	337	125	47	12	4	1	2	–	–
2004	2035	832	347	122	62	18	6	1	2	1	–
2005	2179	978	383	159	52	23	4	2	1	1	–
2006	2289	1029	442	143	57	18	7	1	–	2	–
2007	2113	966	416	166	71	18	8	4	–	–	–
2008	2025	917	401	170	61	32	7	6	–	–	–
2009	1847	877	355	132	61	16	3	3	3	–	–
2010	1920	868	395	134	54	28	6	1	–	–	–
2011	1861	880	364	139	47	24	11	3	2	–	–
2012	1684	829	329	134	55	18	11	3	–	2	–
2013	1785	880	368	137	50	18	9	2	–	–	–
2014	1588	713	350	128	46	21	3	5	3	–	–
2015	1092	534	201	103	36	19	4	2	1	–	–
2016	286	132	45	22	5	4	4	1	–	1	–
2017	4	3	–	–	–	–	–	–	–	–	–
Total	69726	26678	9919	3447	1213	442	134	51	19	8	1

4 Generation interval

Generation interval is one of the key factors affecting the rate of genetic progress and therefore the genetic structure of the population. As a general rule, the shorter the generation interval the rapid is the genetic change in the population holding other factors constant. Generation interval can be defined as the average age of the parents at the *birth of their selected offspring* (Falconer & Mackay, 1996). In the calculation of generation interval, an offspring is considered selected if it has produced at least one progeny. Computation of the generation interval for a given year was carried out as follows:

1. All animals born in a given year were considered (subset 1)
2. Animals in subset 1 that become parents in the later years were identified (subset 2)
3. The parents of animals in subset 2 were identified (subset 3)
4. The generation interval was calculated as the average age of the animals in subset 3 at birth of their offspring in subset 2.

In livestock, transfer of genes from parents to offspring occurs through four selection paths i.e. sires to sons, sires to daughters, dams to sons and dams to daughters. Thus, the generation interval were computed for the four selection paths and is expressed in *years*. Furthermore, generation interval was calculated separately for the males and females. The values in the body of the table are the average generation intervals for a given selection path followed by the number of animals within that path. The overall generation interval for the entire population is also provided in the table.

For example: For the UNKNOWN breed the Generation interval (average age of parents when their selected offspring were born) for the selection path between sire to son (ss) was 2.0 year in 1966. This values was calculated based on the avarage ages of 6 selected sons, born during 1966. During the same year the generation intervals for the sire to daughter (sd), dam to son (ds) and dam to daughter (dd) selection paths were 2.1, 2.0 and 2.0 year, respectively. During 1966, the generation interval for the males was 2.0 year and 2.0 year for the female born during this year. The generation interval in 1966 for all four selection paths together, or for the population in total (pop), was 2.0 year, based on the average age of parents of 12 selected offspring.

Table 5: Generation interval and number of animals by year of birth for different selection paths

(ss=sire to son,Nss=number of selected males for ss,sd=sire to daughter,Nsd=number of females for sd,ms=dams to sons,Nms=number of males for ms,md=dams to daugthers and Nmd=number of females for md,male=avg age of sires,Nmale=number of sires where age is known,female=avg age of dams,Nmale=number of dams where age is known,pop=interval for the population,Npop=number of selected offspring)

Year	Generation interval and number of animal													
	ss	Nss	sd	Nsd	ms	Nms	md	Nmd	male	Nmale	female	Nfemale	pop	Npop
1929	2.0	1	2.0	1	2.0	1	2.0	1	2.0	2	2.0	2	2.0	2
1962	12.2	3	2.0	2	2.0	2	2.0	2	8.1	5	2.0	4	5.0	5
1964	2.9	3	2.0	4	2.0	3	2.0	3	2.4	7	2.0	6	2.2	7
1965	14.1	6	8.9	5	2.0	7	2.0	5	11.7	11	2.0	12	6.4	12
1966	2.0	6	2.1	6	2.0	6	2.0	6	2.0	12	2.0	12	2.0	12
1967	2.4	4	2.1	14	2.8	4	2.0	14	2.2	18	2.2	18	2.2	18
1968	2.2	8	2.2	18	2.0	8	2.1	19	2.2	26	2.1	27	2.1	27
1969	2.5	8	4.7	25	2.1	7	2.0	27	4.2	33	2.0	34	3.1	35
1970	2.8	7	7.4	48	2.2	7	2.1	48	6.8	55	2.1	55	4.4	57
1971	8.4	8	5.9	89	7.3	8	2.1	88	6.1	97	2.5	96	4.3	98
1972	5.5	15	6.7	112	2.0	15	2.1	113	6.6	127	2.1	128	4.3	129
1973	5.3	67	6.0	303	3.5	66	2.3	303	5.9	370	2.5	369	4.2	371

Continue...

Year	Generation interval and number of animal													
	ss	Nss	sd	Nsd	ms	Nms	md	Nmd	male	Nmale	female	Nfemale	pop	Npop
1974	5.6	80	5.8	380	2.8	80	2.9	378	5.8	460	2.9	458	4.4	460
1975	5.0	68	6.3	426	3.2	68	3.5	425	6.1	494	3.4	493	4.8	494
1976	9.4	52	6.4	454	3.9	52	3.4	455	6.7	506	3.5	507	5.1	508
1977	5.2	62	6.6	380	4.7	63	4.3	379	6.4	442	4.4	442	5.4	443
1978	5.5	80	6.3	565	4.6	80	4.2	565	6.2	645	4.2	645	5.2	646
1979	5.1	75	6.3	496	3.8	75	4.3	489	6.1	571	4.2	564	5.2	573
1980	6.2	87	5.6	583	4.9	87	4.9	588	5.7	670	4.9	675	5.3	676
1981	5.5	83	5.3	634	5.2	83	4.9	636	5.3	717	5.0	719	5.2	720
1982	5.1	85	5.6	897	5.5	85	5.0	893	5.5	982	5.0	978	5.3	983
1983	5.8	70	5.4	835	5.7	71	5.5	836	5.5	905	5.5	907	5.5	909
1984	5.0	85	5.3	910	5.9	85	5.6	908	5.3	995	5.6	993	5.5	1000
1985	6.0	81	5.6	970	6.1	82	5.8	992	5.6	1051	5.8	1074	5.7	1075
1986	5.5	82	6.2	1189	6.0	81	5.8	1199	6.2	1271	5.8	1280	6.0	1281
1987	5.9	104	6.1	1445	5.7	105	5.9	1458	6.1	1549	5.9	1563	6.0	1564
1988	5.7	85	6.0	1607	5.9	85	5.9	1611	5.9	1692	5.9	1696	5.9	1700
1989	5.7	93	6.0	1520	5.7	93	6.1	1533	6.0	1613	6.1	1626	6.0	1627
1990	4.9	102	6.4	1441	5.4	105	6.1	1453	6.3	1543	6.1	1558	6.2	1562
1991	5.4	81	6.1	1268	5.4	81	6.1	1301	6.1	1349	6.1	1382	6.1	1383
1992	4.2	83	4.9	1300	5.8	84	6.1	1330	4.8	1383	6.1	1414	5.5	1415
1993	4.2	99	4.6	1451	5.6	99	6.4	1483	4.6	1550	6.3	1582	5.5	1582
1994	4.3	107	4.3	1483	6.2	107	6.4	1538	4.3	1590	6.4	1645	5.3	1646
1995	4.5	103	4.8	1321	5.9	103	6.4	1386	4.8	1424	6.4	1489	5.6	1491
1996	4.1	79	4.7	1172	6.0	79	6.4	1231	4.7	1251	6.3	1310	5.6	1312
1997	4.3	89	4.6	1167	6.3	89	6.5	1201	4.6	1256	6.5	1290	5.6	1293
1998	4.2	98	4.5	1248	6.0	98	6.7	1285	4.5	1346	6.6	1383	5.6	1388
1999	4.7	108	4.8	1225	6.3	108	6.7	1326	4.8	1333	6.6	1434	5.8	1438
2000	4.3	110	5.1	1384	6.2	110	6.8	1489	5.1	1494	6.7	1599	6.0	1604
2001	4.6	123	5.4	1504	6.0	123	6.8	1634	5.4	1627	6.8	1757	6.1	1765
2002	4.9	124	5.4	1571	6.2	124	7.1	1727	5.4	1695	7.0	1851	6.3	1856
2003	5.1	149	5.8	1455	7.0	149	6.9	1601	5.7	1604	6.9	1750	6.3	1753
2004	5.7	152	6.3	1443	7.0	152	7.0	1575	6.3	1595	7.0	1727	6.7	1735
2005	6.2	161	6.6	1567	7.1	161	6.8	1678	6.6	1728	6.8	1839	6.7	1851
2006	6.2	168	6.9	1464	7.0	168	6.9	1611	6.9	1632	7.0	1779	6.9	1782
2007	7.4	154	7.2	1286	6.7	154	6.8	1434	7.2	1440	6.8	1588	7.0	1592
2008	6.7	165	7.7	1146	6.8	165	6.9	1237	7.6	1311	6.9	1402	7.2	1409
2009	6.4	149	7.6	900	6.8	149	6.8	952	7.4	1049	6.8	1101	7.1	1103
2010	6.1	173	7.6	807	6.6	173	6.7	833	7.3	980	6.7	1006	7.0	1006
2011	5.7	137	7.7	606	6.3	137	6.8	608	7.3	743	6.7	745	7.0	751
2012	6.2	124	7.7	370	6.6	124	6.8	378	7.4	494	6.8	502	7.1	503
2013	5.8	65	7.0	126	6.3	65	6.4	129	6.6	191	6.4	194	6.5	194
2014	6.2	17	8.1	13	7.3	17	7.6	13	7.0	30	7.4	30	7.2	30
Total	5.5	-	5.8	-	5.9	-	6.2	-	5.8	-	6.2	-	6.0	-

5 Family size

Family size refers to the number of offspring of an individual that become breeding individuals in the next generation (Falconer & Mackay, 1996). Under *ideal conditions* as specified by Falconer & Mackay (1996), parents have an equal chance of contributing offspring to the next generation. In practice, particularly in production animals, genetic contribution of the parents is not the same. Unequal contribution leads to differences or variation in family size.

The consequence of increased variation in family size is an increase in the rate of inbreeding and the reduction in the effective population size ($Ne = 1/2\Delta F$ *where* Ne is the effective population size and ΔF is the rate of inbreeding per generation).

The variance of family size can be minimized, i.e. regressed to zero as the number of offspring become equal for all parents. The Table presents the summary statistics for family size (i.e. the maximum and average) for the male and female parents. Offspring have been categorized into four groups as follows:

All offspring: all offspring born in the population.

Selected offspring: offspring that have a service record.

Selected sons: male offspring that have a service record.

Selected daughters: female offspring that have a service record.

In addition, the distribution of family size is also presented. The most influential individuals in the populaiton are also identified (Figures 1 to 8). The information is presented separetly for sires and dams considering *all* and *selected offspring.*

Table 6: The maximum and average number of family sizes

	All offspring				Selected offspring				Selected sons				Selected daughters			
	sires		dams		sires		dams		sires		dams		sires		dams	
Year	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg
1927	3	2.5	3	2.0	3	2.5	3	2.0	2	2.0	1	1.0	3	3.0	2	2.0
1929	53	33.7	4	3.3	35	18.3	4	3.0	5	2.3	2	1.7	30	24.0	3	2.0
1931	78	32.0	4	3.0	47	17.7	3	2.0	8	4.5	-	-	39	14.7	3	2.0
1958	1	1.0	-	-	1	1.0	-	-	-	-	-	-	1	1.0	-	-
1959	5	5.0	1	1.0	2	2.0	1	1.0	1	1.0	1	1.0	1	1.0	-	-
1960	3	1.8	5	2.2	3	1.8	3	1.4	2	1.5	1	1.0	2	1.3	2	1.3
1961	83	42.0	1	1.0	52	26.5	1	1.0	8	8.0	-	-	44	22.5	1	1.0
1962	56	29.0	2	1.4	33	17.4	2	1.3	6	5.0	1	1.0	29	15.4	1	1.0
1963	30	14.3	4	1.9	22	9.1	3	1.5	9	3.0	2	1.1	13	7.4	3	1.4
1964	155	21.5	3	1.5	82	12.0	3	1.5	6	2.6	2	1.2	76	13.7	3	1.4
1965	65	18.8	3	1.6	40	11.2	3	1.4	13	4.4	1	1.0	35	9.5	2	1.3
1966	109	21.5	6	1.9	64	13.6	5	1.5	12	5.6	2	1.1	56	11.5	5	1.5
1967	655	37.8	5	1.7	292	19.7	4	1.5	16	3.1	2	1.3	276	21.2	4	1.4
1968	28	5.3	6	1.6	16	3.3	6	1.4	10	2.5	3	1.3	14	2.8	4	1.3
1969	67	8.1	4	1.4	38	4.4	4	1.3	9	2.6	2	1.2	35	3.8	4	1.2
1970	129	8.4	7	1.7	89	5.1	6	1.4	25	4.0	4	1.3	64	4.4	4	1.3
1971	80	7.8	7	1.4	32	4.9	5	1.3	6	1.7	3	1.1	26	4.7	4	1.3
1972	119	8.1	6	1.4	64	5.1	5	1.3	13	2.4	3	1.1	51	4.7	5	1.2
1973	95	10.2	6	1.4	66	7.0	5	1.3	25	2.5	2	1.1	41	6.4	5	1.3
1974	78	8.5	6	1.5	35	5.4	6	1.4	5	1.6	3	1.3	34	5.2	6	1.3
1975	217	14.1	9	1.6	100	8.4	8	1.4	10	2.5	5	1.3	96	7.9	5	1.3
1976	413	19.9	8	1.5	218	12.2	5	1.3	27	3.8	4	1.3	191	11.4	5	1.2
1977	545	17.9	8	1.5	265	10.9	6	1.3	18	3.1	4	1.2	247	10.7	5	1.3
1978	558	32.1	9	1.5	277	20.2	7	1.3	22	3.3	3	1.2	255	19.0	5	1.3
1979	1150	32.8	7	1.5	536	20.4	6	1.4	27	3.8	3	1.2	509	19.3	5	1.3

Continue...

	All offspring				Selected offspring				Selected sons				Selected daughters			
	sires		dams		sires		dams		sires		dams		sires		dams	
Year	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg
1980	823	28.5	11	1.6	422	17.4	10	1.4	33	3.2	6	1.3	389	16.8	6	1.3
1981	1378	34.8	9	1.6	535	19.2	6	1.3	20	3.5	2	1.2	515	19.2	6	1.3
1982	879	34.8	7	1.6	322	17.7	6	1.4	8	1.9	4	1.3	319	17.7	5	1.3
1983	738	43.3	9	1.6	373	25.2	7	1.4	16	4.8	3	1.2	359	23.6	6	1.3
1984	973	23.7	9	1.6	448	13.0	6	1.3	15	2.5	3	1.1	433	12.7	6	1.3
1985	489	25.9	8	1.6	202	16.1	7	1.4	14	2.7	5	1.2	202	15.6	6	1.4
1986	79	12.6	8	1.6	44	8.5	6	1.4	15	2.9	3	1.1	38	7.7	5	1.4
1987	258	16.6	9	1.6	126	11.0	7	1.4	13	2.3	5	1.4	126	10.5	6	1.4
1988	458	21.5	10	1.6	215	13.6	8	1.5	23	3.2	3	1.2	195	13.4	6	1.4
1989	1022	38.9	9	1.7	461	21.8	8	1.4	29	5.2	3	1.1	432	20.7	7	1.4
1990	2671	50.5	11	1.7	1225	28.6	8	1.5	134	7.6	4	1.3	1091	26.4	7	1.4
1991	575	34.6	8	1.7	307	19.3	6	1.5	7	2.2	3	1.2	301	19.7	6	1.4
1992	1080	40.4	9	1.7	554	22.1	8	1.5	54	5.9	4	1.3	500	20.6	7	1.4
1993	1443	41.2	8	1.7	744	22.2	7	1.5	60	5.9	4	1.2	684	20.5	7	1.4
1994	1479	36.3	8	1.8	716	21.0	6	1.5	73	5.8	4	1.2	643	20.2	5	1.4
1995	1613	53.8	8	1.8	834	31.4	7	1.5	92	5.6	4	1.3	742	30.0	5	1.4
1996	68	13.0	10	1.9	45	8.0	9	1.5	11	2.5	6	1.2	35	7.3	6	1.5
1997	1035	51.5	8	1.8	580	28.0	6	1.4	41	6.9	3	1.2	539	26.0	5	1.4
1998	920	26.1	8	1.8	399	14.6	6	1.4	33	3.7	5	1.3	369	13.5	4	1.3
1999	1163	29.4	10	1.8	565	16.3	8	1.4	43	4.0	5	1.3	522	15.2	5	1.3
2000	564	21.1	8	1.8	218	10.6	5	1.3	21	3.7	3	1.2	197	9.6	4	1.3
2001	347	18.5	10	1.8	126	9.5	5	1.4	13	2.4	3	1.2	120	9.2	5	1.3
2002	907	26.6	8	1.7	238	10.1	7	1.3	24	2.9	3	1.2	214	9.5	5	1.2
2003	554	22.8	9	1.7	228	9.0	6	1.3	34	3.9	3	1.2	194	8.4	6	1.2
2004	524	15.1	7	1.6	138	5.1	5	1.2	22	2.3	3	1.1	116	4.5	5	1.2
2005	79	14.9	8	1.6	32	5.3	4	1.2	11	2.7	3	1.2	25	4.6	3	1.1
2006	754	16.7	6	1.5	147	5.3	4	1.2	25	2.8	3	1.1	122	4.4	3	1.1
2007	659	14.5	6	1.4	127	4.2	4	1.1	24	2.7	4	1.1	103	3.6	2	1.0
2008	538	14.1	5	1.4	53	3.5	3	1.1	20	2.3	2	1.1	33	3.0	2	1.1
2009	217	9.3	4	1.3	24	2.6	2	1.0	5	1.7	2	1.0	19	2.4	2	1.1
2010	39	7.2	4	1.2	12	2.0	2	1.1	5	1.8	2	1.1	7	1.6	2	1.1
2011	187	6.3	3	1.1	6	1.9	1	1.0	5	1.8	1	1.0	2	1.2	1	1.0
2012	64	4.0	2	1.1	1	1.0	1	1.0	1	1.0	-	-	-	-	1	1.0
2013	9	2.0	2	1.0	-	-	-	-	-	-	-	-	-	-	-	-
2014	3	1.4	1	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Total	2671	21.3	11	1.6	1225	12.7	10	1.4	134	3.3	6	1.2	1091	12.2	7	1.3

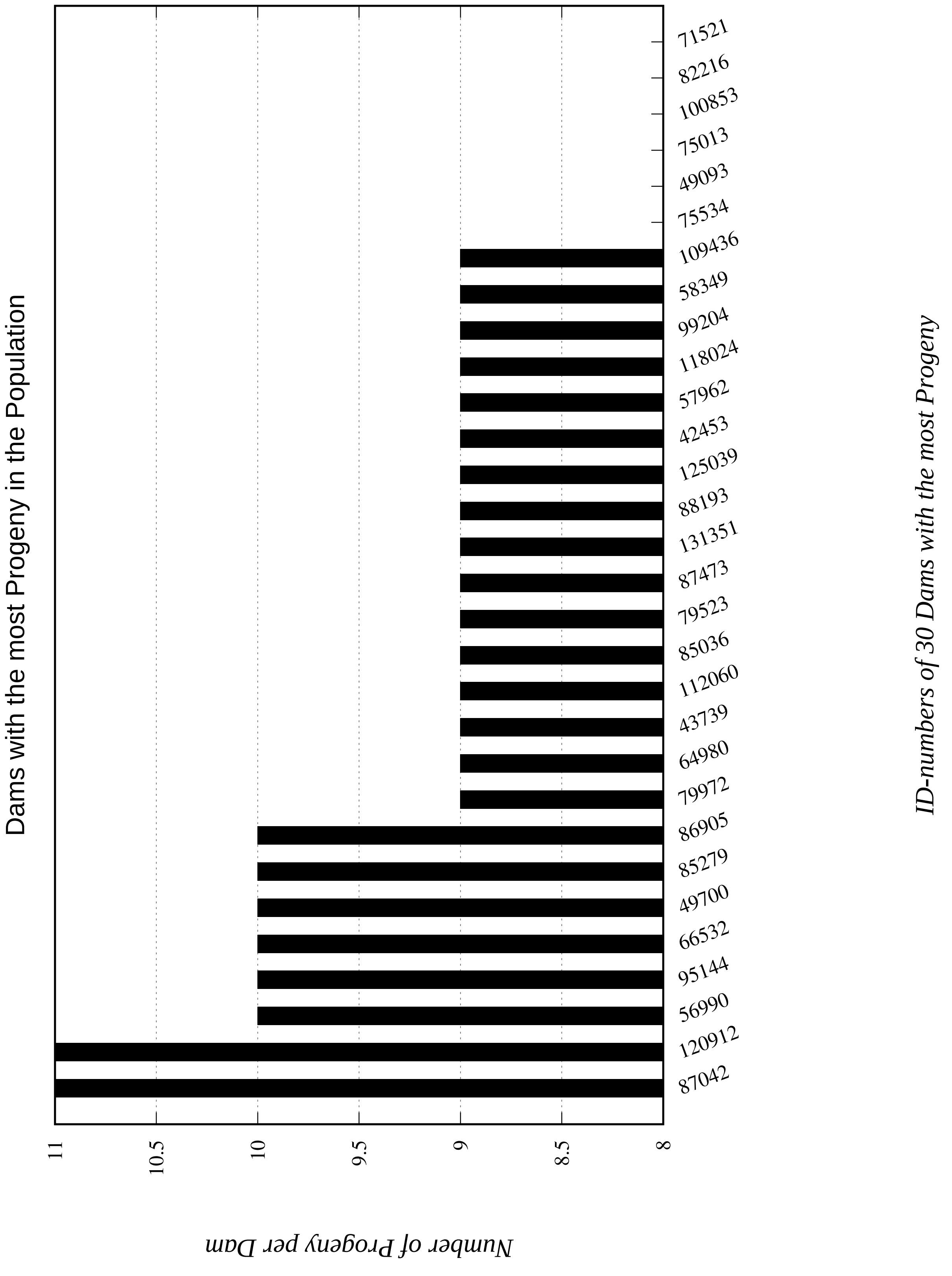


Figure 1: Dams with the most Progeny in the Population

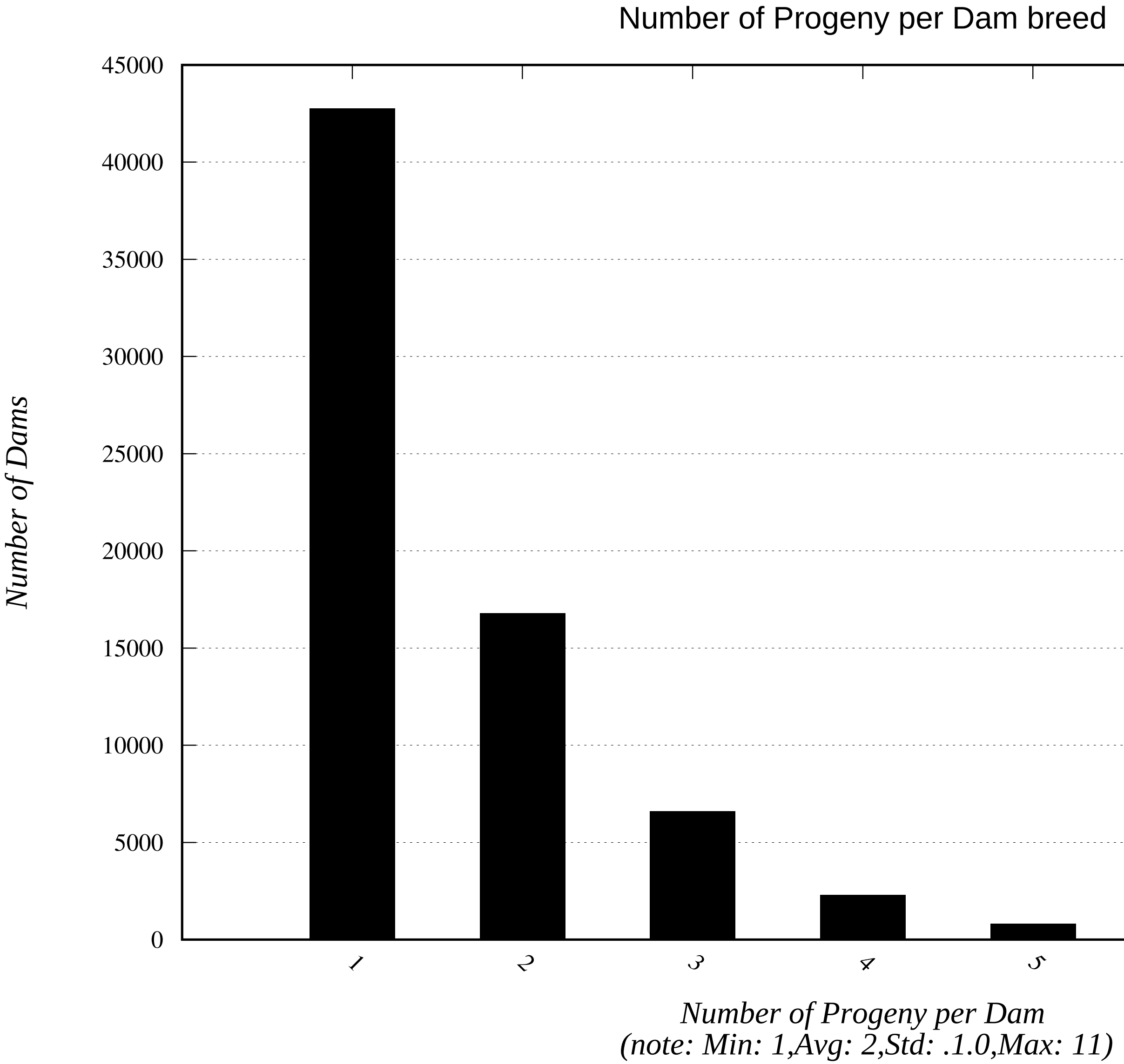
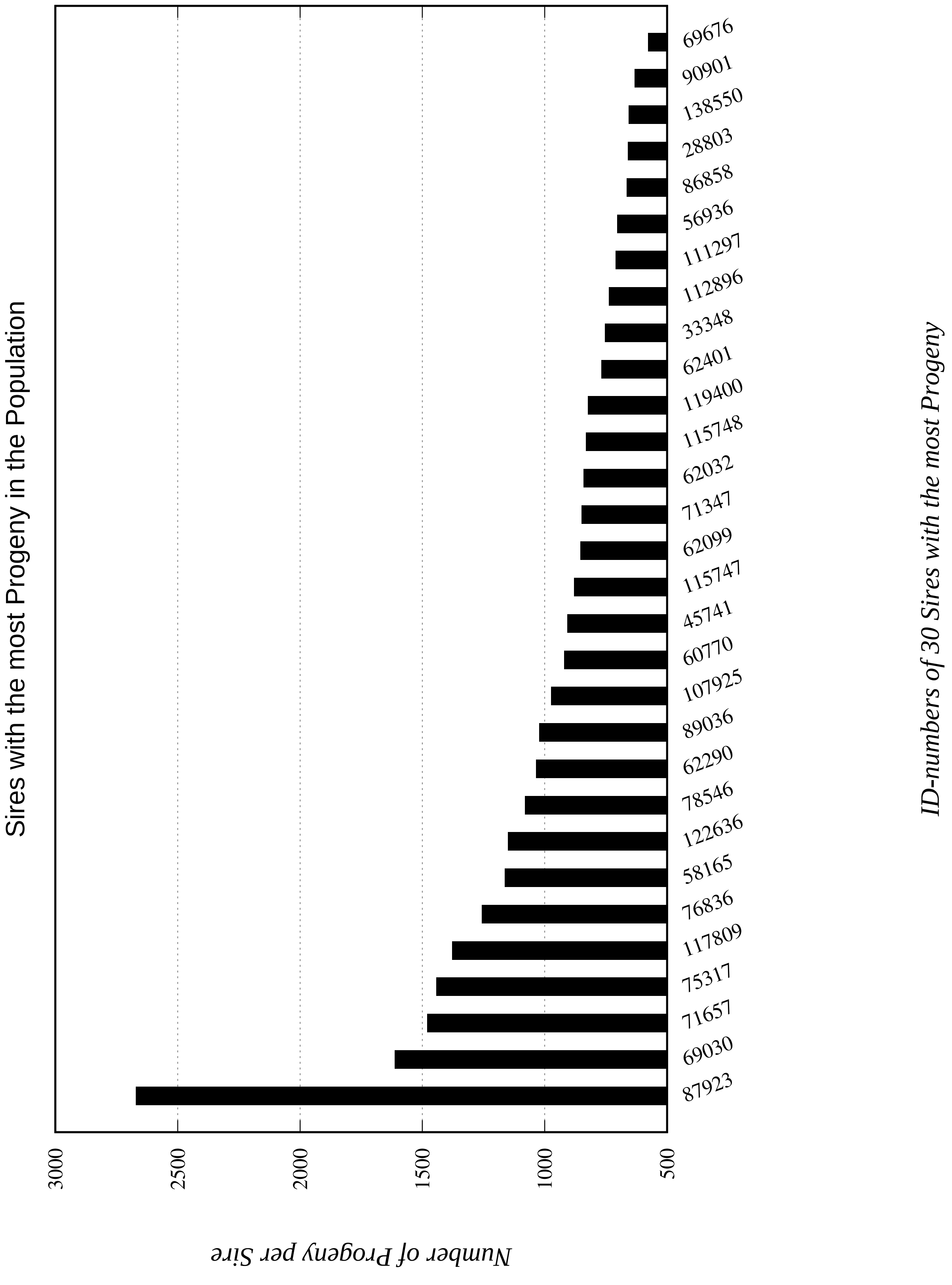


Figure 2: Number of Progeny per Dam

Figure 3: Sires with the most Progeny in the Population



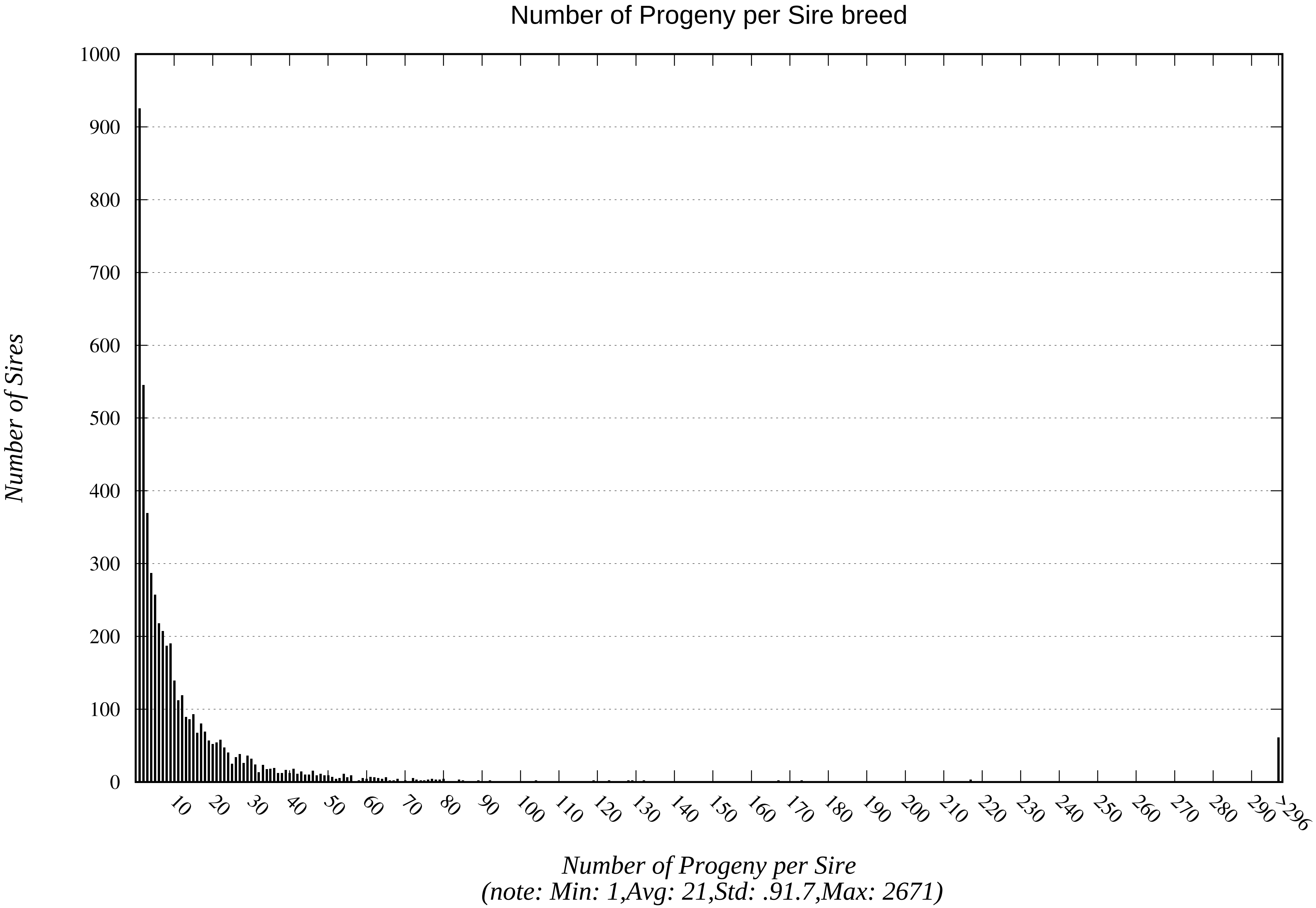


Figure 4: Number of Progeny per Sire

Figure 5: Dams with the most Selected Progeny in the Population

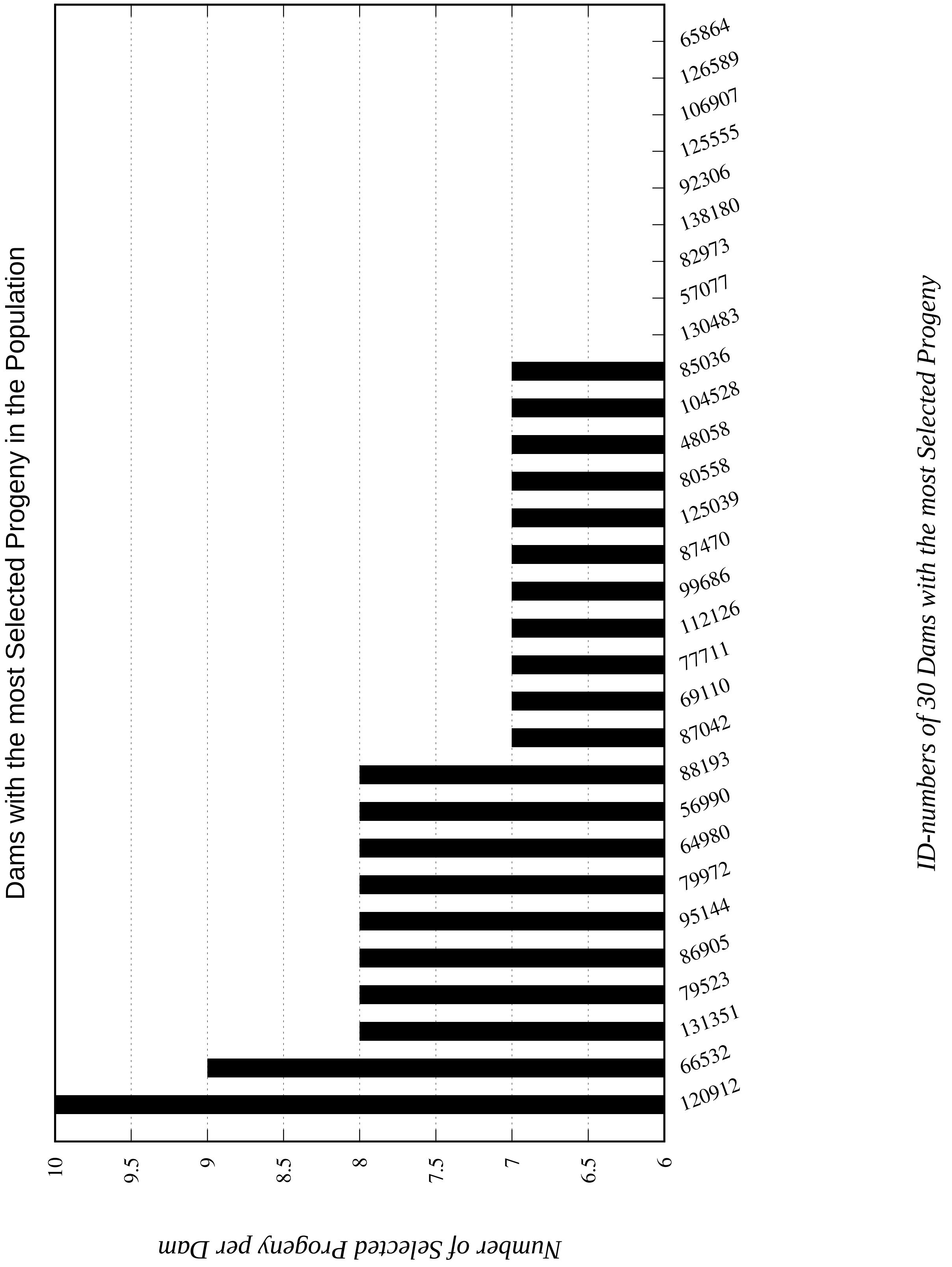
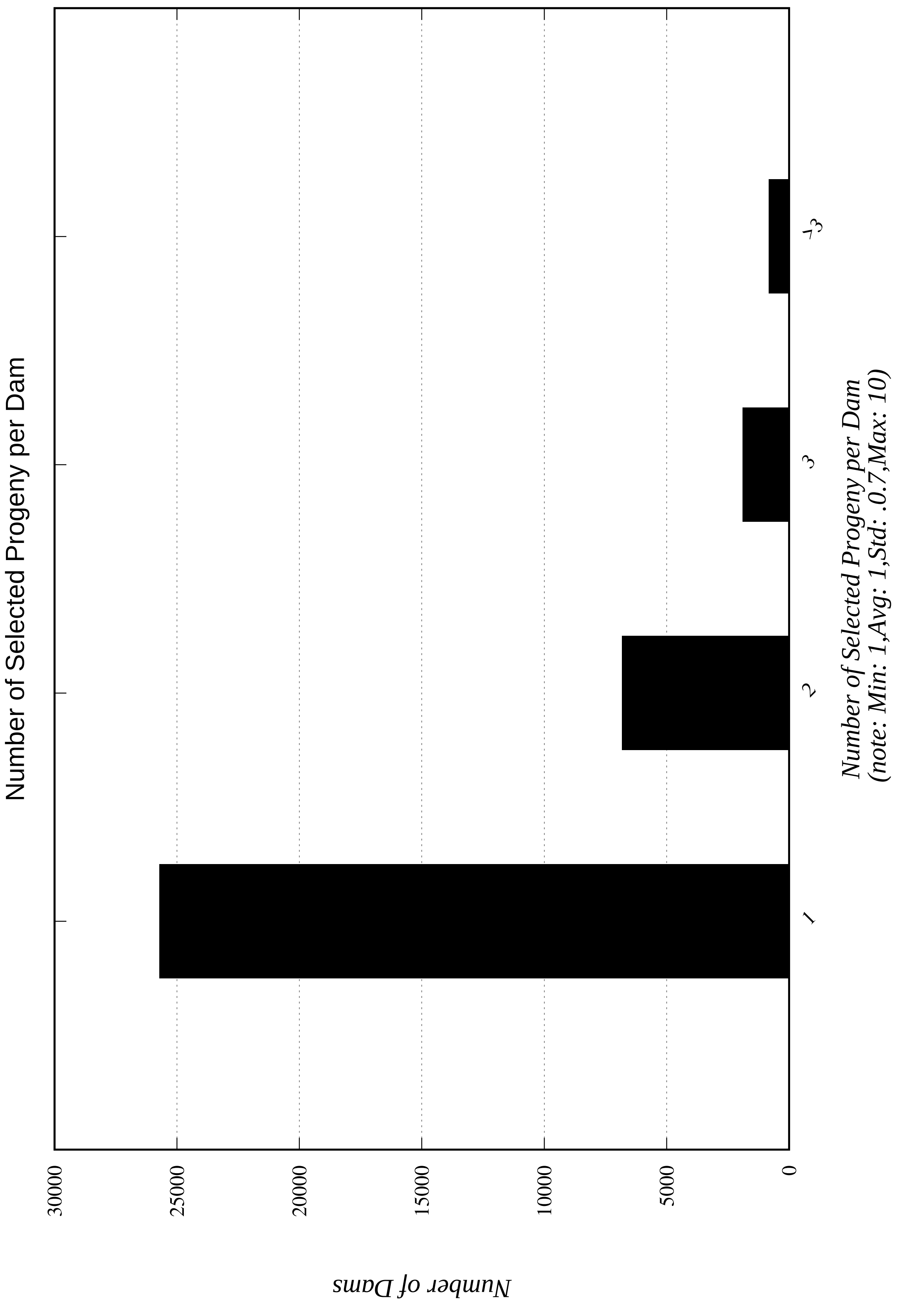


Figure 6: Number of Selected Progeny per Dam



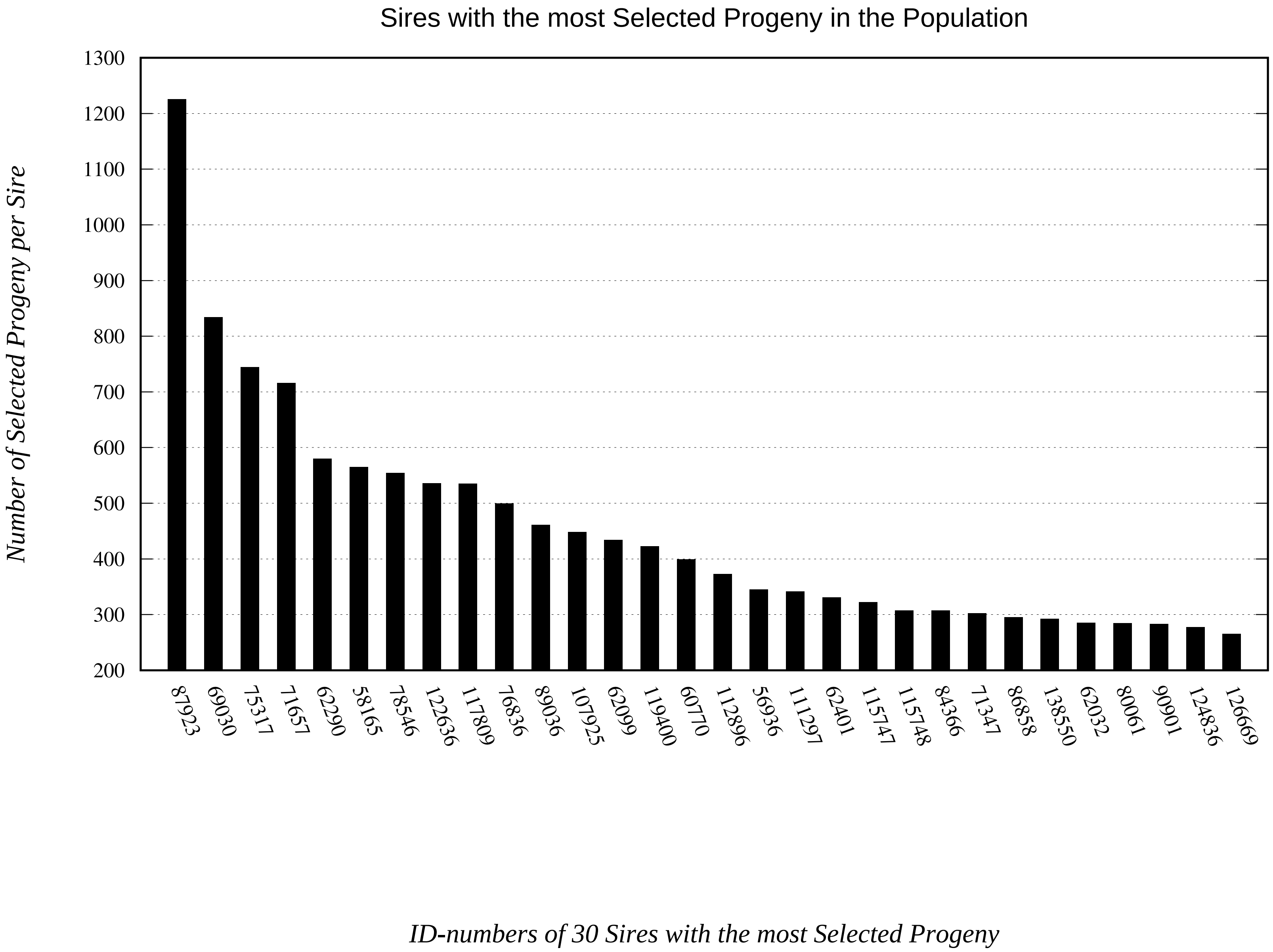


Figure 7: Sires with the most Selected Progeny in the Population

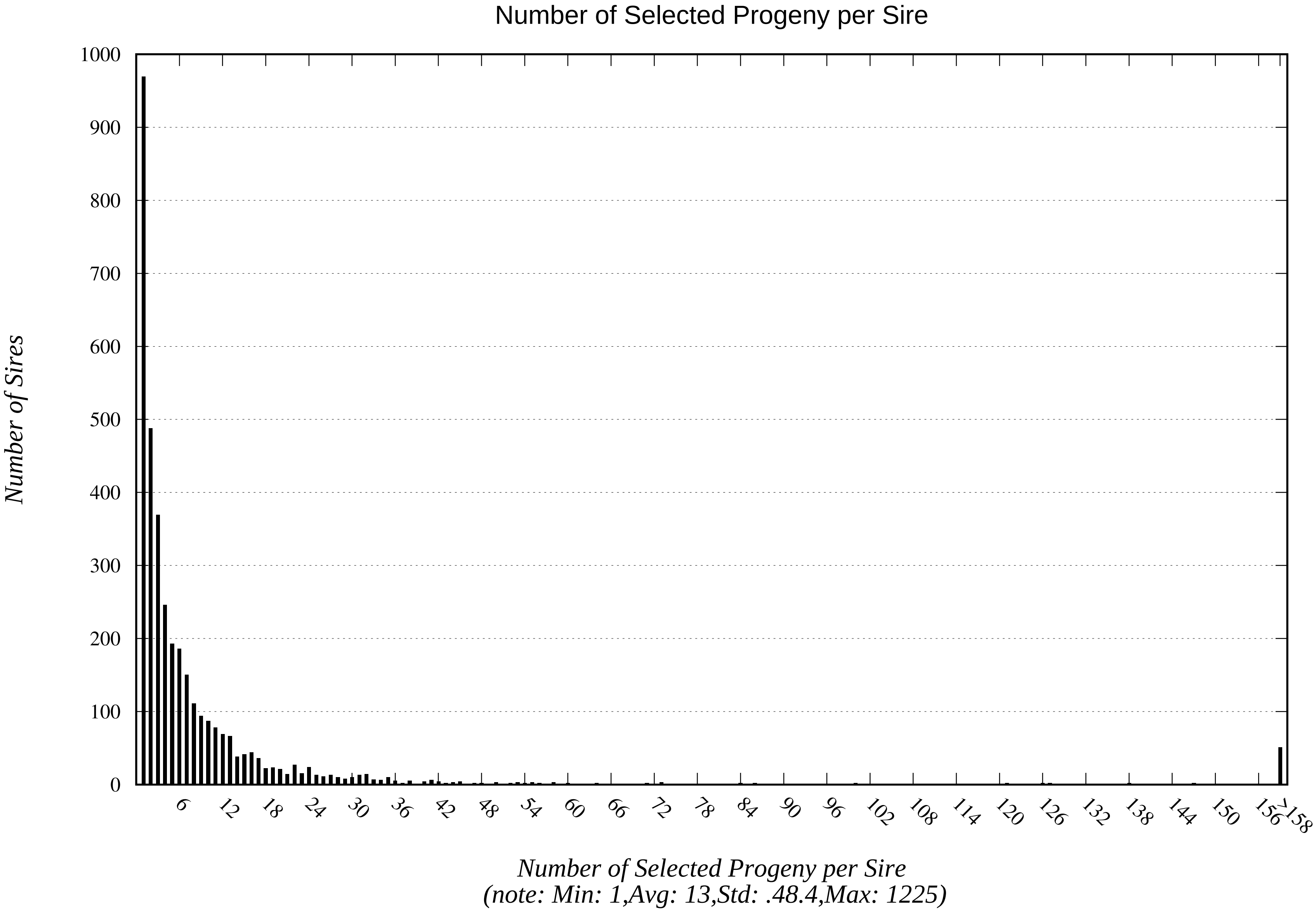


Figure 8: Number of Selected Progeny per Sire