Service PopReport at Institute of Farm Animal Genetics

FRIEDRICH-LOEFFLER-INSTITUT
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Bundesforschungsinstitut für Tiergesundheit

PopReport
A Pedigree Analysis Report

Population: UNKNOWN
Inputfile: POPREP.TXT
Initiated by: quaglia@anabic.it
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Started at: 2019-01-11 10:39:01
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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'.
  111314 input lines processed.
  111314 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
1973	706	706	6957	5666
1974	830	830	8652	4819
1975	915	915	10099	4372
1976	958	958	11339	4175
1977	979	979	12133	4086
1978	961	961	12258	4162
1979	982	982	12644	4073
1980	977	977	13041	4094
1981	950	950	13098	4211
1982	957	957	13312	4180
1983	1014	1014	13568	3945
1984	1067	1067	14027	3749
1985	1105	1105	14257	3620
1986	1184	1184	14628	3378
1987	1224	1224	14957	3268
1988	1241	1241	15369	3223
1989	1230	1230	15454	3252
1990	1190	1190	15333	3361
1991	1128	1128	15129	3546
1992	1100	1100	14982	3636
1993	1030	1030	14840	3883
1994	990	990	14548	4040
1995	947	947	14169	4224
1996	916	916	13876	4367
1997	905	905	13705	4420
1998	894	894	13822	4474
1999	895	895	14148	4469
2000	880	880	14526	4545
2001	887	887	15059	4510

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	928	928	16033	4310
2003	966	966	17205	4141
2004	1023	1023	18352	3910
2005	1131	1131	19537	3537
2006	1228	1228	20759	3257
2007	1319	1319	21415	3033
2008	1372	1372	21643	2915
2009	1373	1373	21155	2913
2010	1394	1394	20695	2869
2011	1380	1380	20142	2899
2012	1321	1321	19402	3028
2013	1237	1237	18407	3234
2014	1191	1191	17697	3359
2015	1121	1121	16638	3568
2016	1033	1033	14532	3872
2017	861	861	11960	4646

Pedigree Analysis Report
for Population: UNKNOWN

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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

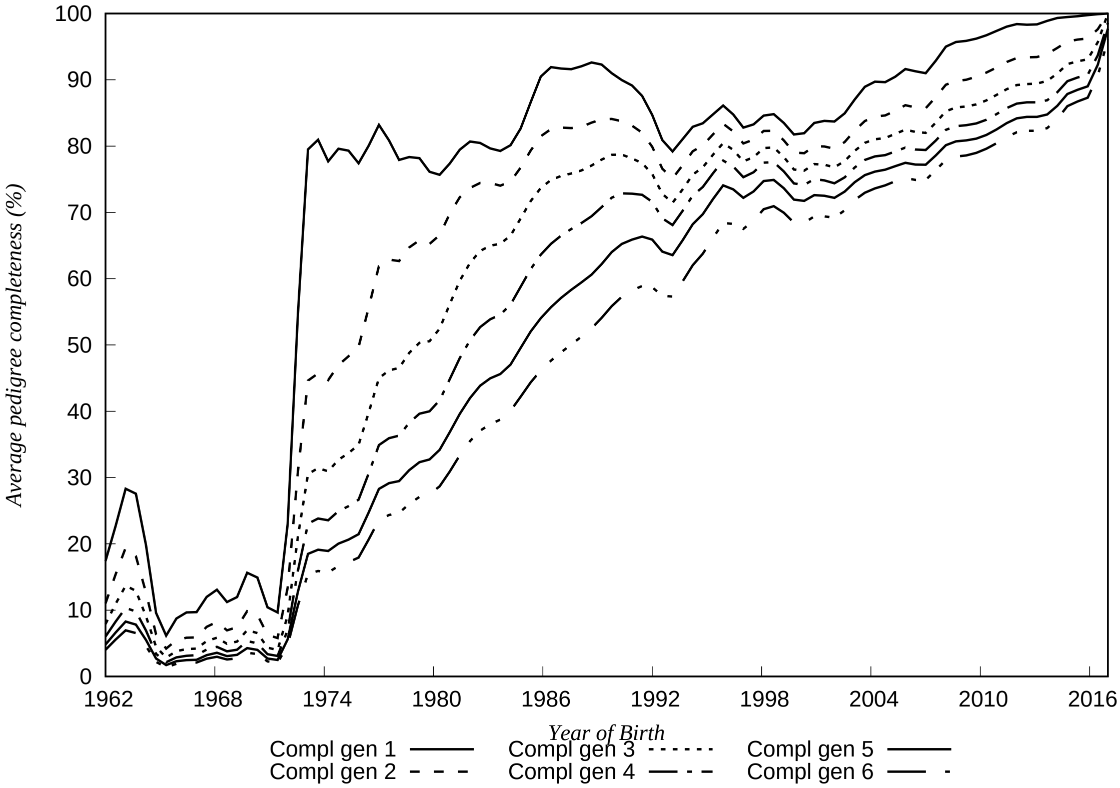
Year	No of Animals	Compl. gen 1	Compl. gen 2	Compl. gen 3	Compl. gen 4	Compl. gen 5	Compl. (%) gen 6(%)
1948	1	0.0	0.0	0.0	0.0	0.0	0.0
1949	4	0.0	0.0	0.0	0.0	0.0	0.0
1950	2	0.0	0.0	0.0	0.0	0.0	0.0
1951	6	16.7	8.3	5.6	4.2	3.3	2.8
1952	7	28.6	14.3	9.5	7.1	5.7	4.8
1953	4	50.0	29.2	19.4	14.6	11.7	9.7
1954	5	60.0	33.3	22.2	16.7	13.3	11.1
1955	6	66.7	44.8	31.8	23.9	19.1	15.9
1956	1	100.0	66.7	47.6	35.7	28.6	23.8
1957	7	28.6	23.8	17.6	13.4	10.7	8.9
1958	6	16.7	16.7	13.9	10.9	8.7	7.3
1959	11	36.4	21.2	14.9	11.4	9.2	7.6
1960	8	37.5	22.9	16.0	12.1	9.8	8.1
1961	16	25.0	15.6	10.6	8.1	6.5	5.4
1962	23	17.4	11.0	7.9	6.0	4.8	4.0
1963	29	27.6	19.0	13.4	10.1	8.1	6.8
1964	59	23.7	15.2	10.9	8.3	6.6	5.5
1965	200	7.0	4.8	3.3	2.5	2.0	1.6
1966	273	9.2	5.7	4.0	3.0	2.4	2.0
1967	329	9.7	5.9	4.2	3.2	2.5	2.1
1968	477	13.2	8.3	5.9	4.5	3.6	3.0
1969	670	11.0	6.8	4.8	3.7	3.0	2.5
1970	914	16.2	10.2	7.2	5.5	4.4	3.7
1971	1852	9.7	5.8	4.0	3.1	2.5	2.1
1972	1576	23.0	13.4	9.2	7.0	5.6	4.7
1973	1845	76.6	43.0	29.4	22.2	17.8	14.9
1974	2148	78.2	44.6	30.8	23.4	18.8	15.6

Continue...

Year	No of Animals	Compl. 1 gen	Compl. 2 gen	Compl. 3 gen	Compl. 4 gen	Compl. 5 gen	Compl. (%) 6 gen (%)
1975	2009	80.1	47.8	33.3	25.4	20.4	17.0
1976	1953	77.5	50.5	35.6	27.2	21.9	18.3
1977	1729	83.2	61.9	45.0	34.9	28.3	23.6
1978	1959	78.2	62.5	46.3	36.1	29.3	24.5
1979	1983	78.6	65.7	50.0	39.3	32.0	26.8
1980	2237	75.6	65.4	51.0	40.4	33.1	27.8
1981	2178	77.8	70.4	56.9	45.5	37.4	31.4
1982	2230	80.7	73.7	62.4	50.7	42.0	35.5
1983	2266	79.8	74.5	64.9	53.7	44.8	37.9
1984	2241	79.6	74.2	65.8	55.3	46.3	39.4
1985	2227	84.1	77.8	70.2	59.9	50.6	43.1
1986	2433	91.0	81.8	74.0	64.0	54.4	46.5
1987	2606	91.7	82.8	75.5	66.5	57.1	48.9
1988	2607	91.9	82.8	76.2	68.2	59.2	51.0
1989	2304	92.6	83.9	77.6	70.2	61.5	53.4
1990	2105	90.5	84.0	78.8	72.6	64.6	56.5
1991	1975	88.9	82.9	78.0	72.8	66.0	58.4
1992	2052	84.7	79.9	75.8	71.6	65.9	58.7
1993	2221	79.2	75.1	71.4	68.0	63.4	57.1
1994	2274	82.4	78.6	75.0	71.8	67.4	61.2
1995	2185	83.8	80.6	77.4	74.5	70.5	64.6
1996	1980	86.1	83.4	80.5	77.9	74.2	68.6
1997	1923	82.8	80.4	77.7	75.3	72.2	67.5
1998	2081	84.4	82.1	79.5	77.3	74.5	70.2
1999	2379	84.2	81.6	79.1	76.9	74.3	70.5
2000	2584	81.5	78.7	76.1	74.0	71.6	68.2
2001	2814	83.7	80.1	77.4	75.1	72.7	69.5
2002	3200	83.7	79.6	76.8	74.4	72.2	69.2
2003	3190	86.6	82.0	79.0	76.5	74.3	71.6
2004	3127	89.6	84.3	80.9	78.3	76.0	73.4
2005	3374	89.8	84.8	81.4	78.8	76.6	74.3
2006	3698	91.7	86.2	82.5	79.8	77.5	75.2
2007	3331	91.0	85.7	82.0	79.4	77.2	74.9
2008	3095	94.7	89.0	85.0	82.2	79.9	77.7
2009	2713	95.8	89.9	85.9	83.1	80.8	78.5
2010	2751	96.4	90.7	86.5	83.6	81.3	79.2
2011	2560	97.5	92.0	87.9	85.0	82.7	80.6
2012	2575	98.4	93.3	89.2	86.4	84.2	82.1
2013	2619	98.3	93.4	89.4	86.6	84.4	82.3
2014	2575	99.2	94.4	90.4	87.5	85.4	83.4
2015	1966	99.5	96.0	92.7	90.2	88.3	86.5
2016	519	99.8	96.4	93.4	91.1	89.4	87.7
2017	7	100.0	100.0	100.0	98.6	97.7	96.1

The average pedigee completeness for animals born within the last 10 years: 1 generations deep = 97.4%. 2 generations deep = 92.2%. 3 generations deep = 88.3%. 4 generations deep = 85.5%. 5 generations deep = 83.3%. 6 generations deep = 81.2%.

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 1962 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
1948	1	-	-	-	-	-	-	-	-	-	-
1949	4	-	-	-	-	-	-	-	-	-	-
1950	2	-	-	-	-	-	-	-	-	-	-
1951	6	-	-	-	-	-	-	-	-	-	-
1952	7	-	-	-	-	-	-	-	-	-	-
1953	4	-	-	-	-	-	-	-	-	-	-
1954	5	-	-	-	-	-	-	-	-	-	-
1955	6	-	-	-	-	-	-	-	-	-	-
1956	1	-	-	-	-	-	-	-	-	-	-
1957	6	1	-	-	-	-	-	-	-	-	-
1958	5	-	-	-	1	-	-	-	-	-	-
1959	11	-	-	-	-	-	-	-	-	-	-
1960	8	-	-	-	-	-	-	-	-	-	-
1961	16	-	-	-	-	-	-	-	-	-	-
1962	23	-	-	-	-	-	-	-	-	-	-
1963	29	-	-	-	-	-	-	-	-	-	-
1964	59	-	-	-	-	-	-	-	-	-	-
1965	197	-	3	-	-	-	-	-	-	-	-
1966	273	-	-	-	-	-	-	-	-	-	-
1967	329	-	-	-	-	-	-	-	-	-	-
1968	475	-	1	-	1	-	-	-	-	-	-
1969	669	1	-	-	-	-	-	-	-	-	-
1970	909	1	4	-	-	-	-	-	-	-	-
1971	1851	-	1	-	-	-	-	-	-	-	-
1972	1571	1	-	1	3	-	-	-	-	-	-
1973	1842	-	1	-	2	-	-	-	-	-	-
1974	2138	3	2	-	5	-	-	-	-	-	-
1975	1988	1	8	1	10	-	1	-	-	-	-
1976	1921	-	18	-	14	-	-	-	-	-	-
1977	1682	8	20	4	14	-	1	-	-	-	-
1978	1879	21	33	5	21	-	-	-	-	-	-
1979	1905	25	34	6	11	-	2	-	-	-	-
1980	2114	43	56	3	18	-	3	-	-	-	-
1981	2032	53	65	4	22	1	1	-	-	-	-
1982	2103	41	44	8	32	2	-	-	-	-	-
1983	2148	33	44	11	20	9	1	-	-	-	-
1984	2102	45	63	7	19	5	-	-	-	-	-

Continue...

	Classes										
Year	1	2	3	4	5	6	7	8	9	10	11
1985	2099	56	40	10	18	4	-	-	-	-	-
1986	2296	66	36	8	22	3	2	-	-	-	-
1987	2457	72	38	11	18	8	2	-	-	-	-
1988	2428	89	50	17	9	14	-	-	-	-	-
1989	2134	85	36	4	29	11	5	-	-	-	-
1990	1964	55	42	7	22	8	6	1	-	-	-
1991	1847	67	24	15	10	10	2	-	-	-	-
1992	1889	100	26	8	13	15	1	-	-	-	-
1993	2079	77	29	10	15	10	-	1	-	-	-
1994	2121	82	31	14	6	19	1	-	-	-	-
1995	2059	77	22	3	5	19	-	-	-	-	-
1996	1841	65	35	6	3	30	-	-	-	-	-
1997	1794	73	30	9	1	16	-	-	-	-	-
1998	1908	90	34	15	2	29	3	-	-	-	-
1999	2220	87	32	12	-	27	1	-	-	-	-
2000	2415	94	30	12	-	33	-	-	-	-	-
2001	2629	87	25	26	3	44	-	-	-	-	-
2002	2970	112	32	14	1	67	1	3	-	-	-
2003	2968	120	39	11	2	49	-	1	-	-	-
2004	2928	115	29	9	3	41	1	1	-	-	-
2005	3124	126	29	16	1	72	2	4	-	-	-
2006	3458	113	34	13	3	74	2	1	-	-	-
2007	3118	110	34	8	-	57	4	-	-	-	-
2008	2917	95	19	10	-	53	1	-	-	-	-
2009	2553	91	36	5	-	28	-	-	-	-	-
2010	2518	139	23	9	-	59	2	1	-	-	-
2011	2363	105	22	5	2	61	-	2	-	-	-
2012	2358	109	39	7	-	58	2	2	-	-	-
2013	2375	144	34	8	-	56	1	1	-	-	-
2014	2336	117	34	19	-	62	5	2	-	-	-
2015	1751	131	24	8	-	51	1	-	-	-	-
2016	459	43	7	1	-	9	-	-	-	-	-
2017	6	1	-	-	-	-	-	-	-	-	-

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

This section presents the number of <u>*all*</u> and <u>*inbred*</u> 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
1948	1	-	-	-	-	-	-	-	-
1949	4	-	-	-	-	-	-	-	-
1950	2	-	-	-	-	-	-	-	-
1951	6	-	-	2	-	-	1	-	-
1952	7	-	-	2	-	-	2	-	-
1953	4	-	-	3	-	-	2	-	-
1954	5	-	-	3	-	-	3	-	-
1955	6	-	-	4	-	-	4	-	-
1956	1	-	-	1	-	-	1	-	-
1957	7	1	0.0089	2	-	-	2	-	-
1958	6	1	0.0417	1	-	-	1	-	-
1959	11	-	-	4	1	0.0156	4	-	-
1960	8	-	-	4	1	0.0625	3	-	-
1961	16	-	-	4	-	-	4	-	-
1962	23	-	-	4	-	-	5	-	-
1963	29	-	-	8	-	-	8	-	-
1964	59	-	-	14	1	0.0045	15	-	-
1965	200	3	0.0019	13	1	0.0048	12	-	-
1966	273	-	-	24	1	0.0026	26	-	-
1967	329	-	-	32	3	0.0098	31	-	-
1968	477	2	0.0008	50	1	0.0013	66	-	-
1969	670	1	0.0001	59	1	0.0011	81	-	-
1970	914	6	0.0006	112	3	0.0040	156	-	-
1971	1852	2	0.0001	108	3	0.0041	185	-	-
1972	1576	5	0.0006	169	6	0.0048	365	1	0.0002
1973	1845	6	0.0004	290	5	0.0024	1380	1	0.0001
1974	2148	15	0.0008	291	5	0.0030	1626	2	0.0002
1975	2009	26	0.0020	302	4	0.0025	1561	4	0.0004
1976	1953	36	0.0030	294	6	0.0036	1503	5	0.0003
1977	1729	56	0.0044	301	9	0.0042	1425	9	0.0006
1978	1959	113	0.0060	286	8	0.0042	1521	5	0.0005
1979	1983	112	0.0055	283	11	0.0058	1556	22	0.0020
1980	2237	186	0.0076	292	19	0.0070	1694	24	0.0016
1981	2178	254	0.0093	274	26	0.0090	1684	32	0.0022
1982	2230	296	0.0093	272	31	0.0106	1838	61	0.0037
1983	2266	378	0.0095	286	47	0.0161	1831	89	0.0048
1984	2241	482	0.0103	293	51	0.0128	1814	134	0.0055
1985	2227	550	0.0096	319	77	0.0141	1873	175	0.0076
1986	2433	686	0.0098	363	97	0.0150	2220	225	0.0067

Continue...

	Animal			Sires			Dams		
Year	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F	Tot No	Inbred No	Avg F
1987	2606	842	0.0103	395	115	0.0134	2416	288	0.0071
1988	2607	928	0.0117	406	135	0.0127	2415	369	0.0085
1989	2304	919	0.0137	427	156	0.0155	2146	380	0.0084
1990	2105	1006	0.0141	376	178	0.0179	1931	421	0.0088
1991	1975	1022	0.0130	347	194	0.0196	1824	449	0.0100
1992	2052	1162	0.0147	341	210	0.0172	1872	500	0.0096
1993	2221	1278	0.0137	354	233	0.0153	2000	649	0.0107
1994	2274	1385	0.0139	339	246	0.0184	2014	710	0.0119
1995	2185	1440	0.0128	352	283	0.0212	1904	773	0.0119
1996	1980	1430	0.0161	344	290	0.0216	1710	749	0.0128
1997	1923	1374	0.0156	340	293	0.0201	1598	767	0.0127
1998	2081	1559	0.0190	377	342	0.0204	1768	954	0.0131
1999	2379	1774	0.0164	385	354	0.0201	2030	1180	0.0147
2000	2584	1870	0.0169	395	374	0.0203	2168	1265	0.0144
2001	2814	2039	0.0183	442	426	0.0189	2443	1460	0.0136
2002	3200	2279	0.0196	477	463	0.0191	2816	1725	0.0143
2003	3190	2324	0.0187	480	470	0.0200	2882	1813	0.0141
2004	3127	2311	0.0187	491	482	0.0213	2894	1877	0.0146
2005	3374	2519	0.0216	549	545	0.0233	3129	2074	0.0159
2006	3698	2779	0.0206	608	601	0.0225	3503	2314	0.0154
2007	3331	2494	0.0202	616	612	0.0238	3147	2076	0.0159
2008	3095	2391	0.0203	639	635	0.0241	3004	1991	0.0152
2009	2713	2114	0.0198	673	669	0.0254	2631	1768	0.0163
2010	2751	2167	0.0241	688	684	0.0248	2672	1773	0.0172
2011	2560	2066	0.0244	693	689	0.0242	2510	1666	0.0163
2012	2575	2131	0.0258	705	703	0.0242	2534	1705	0.0179
2013	2619	2176	0.0261	695	692	0.0270	2577	1744	0.0179
2014	2575	2170	0.0281	670	669	0.0251	2552	1727	0.0181
2015	1966	1743	0.0298	609	608	0.0267	1945	1408	0.0189
2016	519	462	0.0290	241	239	0.0268	512	392	0.0195
2017	7	7	0.0278	7	7	0.0270	7	7	0.0236

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
1948	1	0.0000	0.0000	0.0000	-
1949	4	0.0000	0.0000	0.0000	0.0000
1950	2	0.0000	0.0000	0.0000	0.0000
1951	6	0.0000	0.0000	0.0000	0.0000
1952	7	0.0000	0.0000	0.0000	0.0000
1953	4	0.0000	0.0000	0.0000	0.0000
1954	5	0.0000	0.0000	0.0000	0.0000
1955	6	0.0000	0.0000	0.0000	0.0000
1956	1	0.0000	0.0000	0.0000	-
1957	7	0.0000	0.0625	0.0089	0.0236
1958	6	0.0000	0.2500	0.0417	0.1021
1959	11	0.0000	0.0000	0.0000	0.0000
1960	8	0.0000	0.0000	0.0000	0.0000
1961	16	0.0000	0.0000	0.0000	0.0000
1962	23	0.0000	0.0000	0.0000	0.0000
1963	29	0.0000	0.0000	0.0000	0.0000
1964	59	0.0000	0.0000	0.0000	0.0000
1965	200	0.0000	0.1250	0.0019	0.0152
1966	273	0.0000	0.0000	0.0000	0.0000
1967	329	0.0000	0.0000	0.0000	0.0000
1968	477	0.0000	0.2500	0.0008	0.0130
1969	670	0.0000	0.0938	0.0001	0.0036
1970	914	0.0000	0.1250	0.0006	0.0085
1971	1852	0.0000	0.1250	0.0001	0.0029
1972	1576	0.0000	0.2500	0.0006	0.0120
1973	1845	0.0000	0.2500	0.0004	0.0088
1974	2148	0.0000	0.2500	0.0008	0.0129
1975	2009	0.0000	0.3125	0.0020	0.0208
1976	1953	0.0000	0.2500	0.0030	0.0242
1977	1729	0.0000	0.3125	0.0044	0.0283
1978	1959	0.0000	0.2500	0.0060	0.0318
1979	1983	0.0000	0.3125	0.0055	0.0289
1980	2237	0.0000	0.3442	0.0076	0.0335
1981	2178	0.0000	0.3442	0.0093	0.0358
1982	2230	0.0000	0.2813	0.0093	0.0373
1983	2266	0.0000	0.3125	0.0095	0.0373
1984	2241	0.0000	0.2832	0.0103	0.0355
1985	2227	0.0000	0.2832	0.0096	0.0336
1986	2433	0.0000	0.3125	0.0098	0.0340

Continue...

		F			
Year	No of Animals	Min	Max	Avg	Std
1987	2606	0.0000	0.3125	0.0103	0.0344
1988	2607	0.0000	0.2813	0.0117	0.0351
1989	2304	0.0000	0.3125	0.0137	0.0418
1990	2105	0.0000	0.3750	0.0141	0.0417
1991	1975	0.0000	0.3223	0.0130	0.0357
1992	2052	0.0000	0.3019	0.0147	0.0371
1993	2221	0.0000	0.3750	0.0137	0.0353
1994	2274	0.0000	0.3172	0.0139	0.0355
1995	2185	0.0000	0.2742	0.0128	0.0324
1996	1980	0.0000	0.2916	0.0161	0.0391
1997	1923	0.0000	0.2871	0.0156	0.0334
1998	2081	0.0000	0.3301	0.0190	0.0409
1999	2379	0.0000	0.3133	0.0164	0.0358
2000	2584	0.0000	0.2871	0.0169	0.0359
2001	2814	0.0000	0.2927	0.0183	0.0392
2002	3200	0.0000	0.3830	0.0196	0.0434
2003	3190	0.0000	0.3790	0.0187	0.0381
2004	3127	0.0000	0.3532	0.0187	0.0363
2005	3374	0.0000	0.3813	0.0216	0.0439
2006	3698	0.0000	0.3878	0.0206	0.0413
2007	3331	0.0000	0.3233	0.0202	0.0396
2008	3095	0.0000	0.3009	0.0203	0.0376
2009	2713	0.0000	0.2767	0.0198	0.0323
2010	2751	0.0000	0.3594	0.0241	0.0425
2011	2560	0.0000	0.3795	0.0244	0.0436
2012	2575	0.0000	0.3825	0.0258	0.0439
2013	2619	0.0000	0.3857	0.0261	0.0424
2014	2575	0.0000	0.3884	0.0281	0.0468
2015	1966	0.0000	0.3290	0.0298	0.0446
2016	519	0.0000	0.2703	0.0290	0.0383
2017	7	0.0149	0.0512	0.0278	0.0128

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.

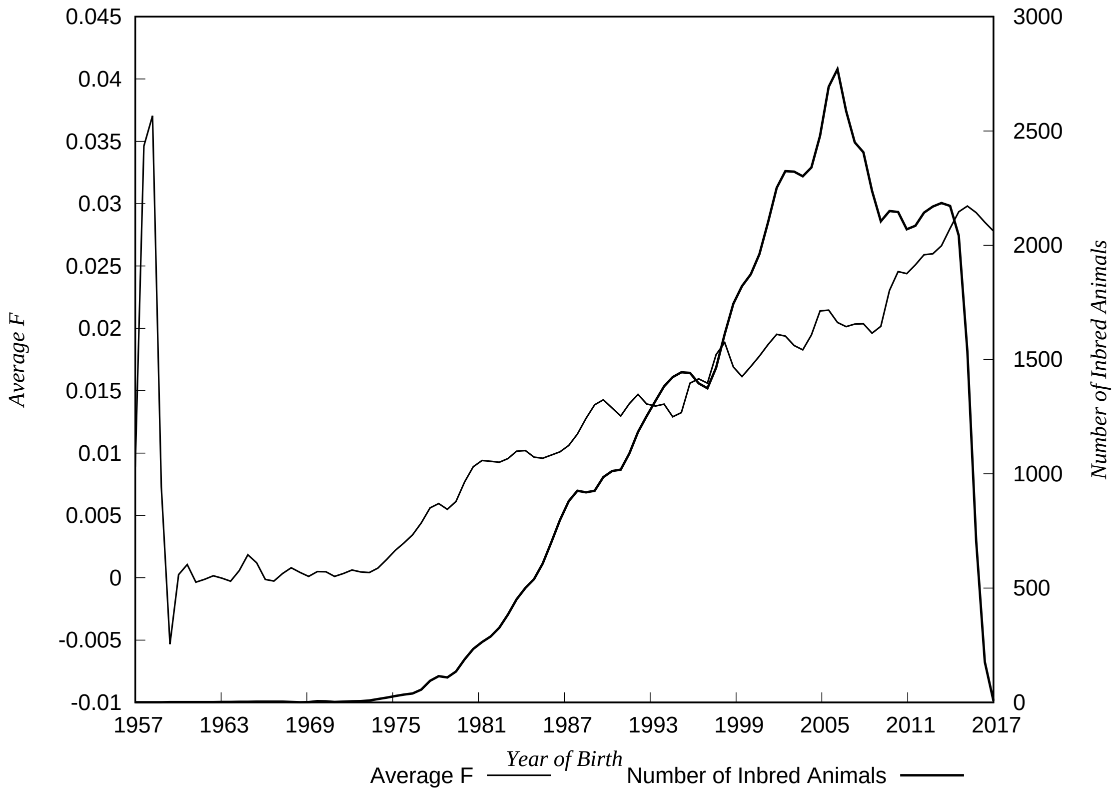
Table 5: Inbreeding coefficients (F) of INBRED animals by year

		F			
Year	No of Animals	Min	Max	Avg	Std
1957	1	0.0625	0.0625	0.0625	-
1958	1	0.2500	0.2500	0.2500	-
1965	3	0.1250	0.1250	0.1250	0.0000
1968	2	0.1328	0.2500	0.1914	0.0829
1969	1	0.0938	0.0938	0.0938	-
1970	6	0.0059	0.1250	0.0947	0.0502
1971	2	0.0020	0.1250	0.0635	0.0870
1972	5	0.0625	0.2500	0.2000	0.0815
1973	6	0.0029	0.2500	0.1151	0.1128
1974	15	0.0039	0.2500	0.1159	0.1054
1975	26	0.0020	0.3125	0.1572	0.0976
1976	36	0.0010	0.2500	0.1601	0.0817
1977	56	0.0015	0.3125	0.1356	0.0845
1978	113	0.0001	0.2500	0.1047	0.0851
1979	112	0.0007	0.3125	0.0970	0.0770
1980	186	0.0001	0.3442	0.0912	0.0768
1981	254	0.0001	0.3442	0.0798	0.0732
1982	296	0.0001	0.2813	0.0702	0.0789
1983	378	0.0000	0.3125	0.0570	0.0751
1984	482	0.0000	0.2832	0.0479	0.0637
1985	550	0.0000	0.2832	0.0390	0.0585
1986	686	0.0000	0.3125	0.0347	0.0569
1987	842	0.0000	0.3125	0.0319	0.0546
1988	928	0.0000	0.2813	0.0327	0.0526
1989	919	0.0000	0.3125	0.0344	0.0606
1990	1006	0.0000	0.3750	0.0295	0.0564
1991	1022	0.0000	0.3223	0.0251	0.0465
1992	1162	0.0000	0.3019	0.0260	0.0462
1993	1278	0.0000	0.3750	0.0238	0.0438
1994	1385	0.0000	0.3172	0.0229	0.0431
1995	1440	0.0000	0.2742	0.0195	0.0382
1996	1430	0.0000	0.2916	0.0223	0.0445
1997	1374	0.0000	0.2871	0.0218	0.0377
1998	1559	0.0000	0.3301	0.0254	0.0455
1999	1774	0.0000	0.3133	0.0220	0.0399
2000	1870	0.0000	0.2871	0.0233	0.0404
2001	2039	0.0000	0.2927	0.0252	0.0441
2002	2279	0.0000	0.3830	0.0275	0.0493

Continue...

		F			
Year	No of Animals	Min	Max	Avg	Std
2003	2324	0.0002	0.3790	0.0257	0.0425
2004	2311	0.0000	0.3532	0.0253	0.0402
2005	2519	0.0001	0.3813	0.0290	0.0487
2006	2779	0.0001	0.3878	0.0274	0.0456
2007	2494	0.0001	0.3233	0.0270	0.0437
2008	2391	0.0001	0.3009	0.0262	0.0410
2009	2114	0.0001	0.2767	0.0254	0.0346
2010	2167	0.0000	0.3594	0.0306	0.0458
2011	2066	0.0015	0.3795	0.0303	0.0467
2012	2131	0.0006	0.3825	0.0311	0.0465
2013	2176	0.0001	0.3857	0.0315	0.0447
2014	2170	0.0005	0.3884	0.0334	0.0492
2015	1743	0.0001	0.3290	0.0336	0.0460
2016	462	0.0012	0.2703	0.0326	0.0391
2017	7	0.0149	0.0512	0.0278	0.0128

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
1948	-	-	-	-	-	-
1949	-	-	-	-	-	-
1950	-	-	-	-	-	-
1951	0.0000	0.0000	0.0000	0.0000	0.0000	-
1952	0.0000	0.0000	0.0000	0.0000	0.0000	-
1953	0.0000	0.0000	0.0000	0.0000	0.0000	-
1954	0.0000	0.0000	0.0000	0.0000	0.0000	-
1955	0.0000	0.0000	0.0000	0.0000	0.0000	-
1956	0.0000	0.0000	0.0000	0.0000	0.0000	-
1957	0.0017	0.0000	0.0000	0.0000	0.0017	288
1958	0.0087	0.0000	0.0000	0.0000	0.0087	58
1959	0.0078	0.0035	0.0000	0.0018	0.0060	83
1960	0.0071	0.0164	0.0000	0.0084	-0.0014	-369
1961	0.0057	0.0156	0.0000	0.0080	-0.0023	-213
1962	0.0043	0.0156	0.0000	0.0078	-0.0035	-143
1963	0.0031	0.0112	0.0000	0.0057	-0.0026	-194
1964	0.0016	0.0094	0.0000	0.0047	-0.0031	-164
1965	0.0011	0.0089	0.0000	0.0046	-0.0035	-142
1966	0.0006	0.0064	0.0000	0.0033	-0.0027	-188
1967	0.0004	0.0064	0.0000	0.0032	-0.0028	-176
1968	0.0005	0.0044	0.0000	0.0022	-0.0017	-297
1969	0.0004	0.0038	0.0000	0.0019	-0.0015	-336
1970	0.0005	0.0038	0.0000	0.0019	-0.0014	-354
1971	0.0003	0.0041	0.0000	0.0021	-0.0018	-286
1972	0.0004	0.0050	0.0001	0.0026	-0.0022	-226

Continue...

	Avg F					
Year	Animals	Sires	Dams	Parents	ΔF	Ne
1973	0.0004	0.0047	0.0001	0.0024	-0.0021	-241
1974	0.0005	0.0062	0.0002	0.0032	-0.0027	-184
1975	0.0008	0.0072	0.0002	0.0037	-0.0030	-167
1976	0.0011	0.0076	0.0003	0.0040	-0.0028	-177
1977	0.0016	0.0080	0.0003	0.0041	-0.0026	-196
1978	0.0025	0.0078	0.0003	0.0041	-0.0016	-307
1979	0.0031	0.0082	0.0006	0.0044	-0.0013	-385
1980	0.0042	0.0092	0.0008	0.0050	-0.0008	-617
1981	0.0055	0.0104	0.0011	0.0058	-0.0003	-1889
1982	0.0066	0.0120	0.0016	0.0068	-0.0002	-2514
1983	0.0075	0.0131	0.0023	0.0077	-0.0002	-3262
1984	0.0083	0.0139	0.0030	0.0085	-0.0002	-3300
1985	0.0088	0.0151	0.0041	0.0095	-0.0008	-651
1986	0.0094	0.0152	0.0048	0.0100	-0.0006	-798
1987	0.0098	0.0151	0.0056	0.0103	-0.0006	-875
1988	0.0101	0.0144	0.0065	0.0104	-0.0003	-1517
1989	0.0107	0.0139	0.0071	0.0105	0.0002	2214
1990	0.0113	0.0138	0.0076	0.0107	0.0006	796
1991	0.0117	0.0138	0.0082	0.0110	0.0007	710
1992	0.0123	0.0135	0.0084	0.0109	0.0014	355
1993	0.0129	0.0137	0.0090	0.0113	0.0016	306
1994	0.0135	0.0144	0.0097	0.0120	0.0015	334
1995	0.0137	0.0155	0.0102	0.0128	0.0009	539
1996	0.0140	0.0168	0.0108	0.0137	0.0003	1573
1997	0.0142	0.0182	0.0114	0.0147	-0.0004	-1184
1998	0.0151	0.0196	0.0118	0.0156	-0.0005	-1033
1999	0.0153	0.0213	0.0125	0.0168	-0.0015	-342
2000	0.0158	0.0229	0.0131	0.0179	-0.0021	-240
2001	0.0165	0.0237	0.0133	0.0185	-0.0020	-256
2002	0.0176	0.0239	0.0137	0.0187	-0.0012	-433
2003	0.0180	0.0233	0.0139	0.0185	-0.0006	-889
2004	0.0183	0.0226	0.0141	0.0183	0.0000	10094
2005	0.0188	0.0223	0.0145	0.0183	0.0004	1123
2006	0.0193	0.0219	0.0147	0.0182	0.0012	428
2007	0.0197	0.0215	0.0149	0.0181	0.0016	304
2008	0.0200	0.0214	0.0151	0.0182	0.0018	272
2009	0.0200	0.0217	0.0153	0.0185	0.0016	312
2010	0.0207	0.0222	0.0157	0.0189	0.0018	271
2011	0.0215	0.0228	0.0160	0.0193	0.0022	229
2012	0.0220	0.0230	0.0162	0.0196	0.0024	204
2013	0.0228	0.0236	0.0166	0.0200	0.0028	179
2014	0.0240	0.0241	0.0169	0.0205	0.0036	139
2015	0.0253	0.0246	0.0174	0.0210	0.0044	115
2016	0.0263	0.0248	0.0177	0.0212	0.0052	96
2017	0.0268	0.0249	0.0178	0.0213	0.0056	89

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*
1948	1	1	1	2	1
1949	5	1	1	2	1
1950	7	1	1	2	1
1951	13	3	2	5	3
1952	20	4	4	8	6
1953	24	7	6	13	9
1954	29	10	9	19	13
1955	34	13	13	26	18
1956	31	14	14	28	20
1957	36	16	16	32	22
1958	36	15	16	31	22
1959	40	17	18	35	24
1960	44	16	19	35	24
1961	55	19	20	39	27
1962	72	20	21	41	29
1963	100	26	28	54	38
1964	152	35	41	76	53
1965	346	44	52	96	67
1966	608	60	74	134	93
1967	929	79	102	181	125
1968	1390	112	163	275	186
1969	2037	152	237	389	259

Continue...

	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
1970	2922	223	384	607	395
1971	4715	277	542	819	513
1972	6091	359	863	1222	710
1973	7663	507	2116	2623	1145
1974	9482	605	3370	3975	1436
1975	11014	690	4362	5052	1668
1976	12297	767	5272	6039	1875
1977	13112	865	6105	6970	2121
1978	13219	947	7002	7949	2336
1979	13626	991	7765	8756	2461
1980	14018	996	8096	9092	2483
1981	14048	1005	8116	9121	2504
1982	14269	982	8288	9270	2458
1983	14582	969	8384	9353	2432
1984	15094	956	8558	9514	2408
1985	15362	961	8753	9714	2425
1986	15812	999	9244	10243	2524
1987	16181	1036	9717	10753	2621
1988	16610	1089	10242	11331	2756
1989	16684	1155	10479	11634	2913
1990	16523	1171	10565	11736	2952
1991	16257	1184	10650	11834	2984
1992	16082	1199	10784	11983	3021
1993	15870	1212	10685	11897	3048
1994	15538	1182	10383	11565	2971
1995	15116	1155	9996	11151	2899
1996	14792	1104	9615	10719	2773
1997	14610	1067	9380	10447	2682
1998	14716	1060	9267	10327	2663
1999	15043	1057	9454	10511	2662
2000	15406	1044	9592	10636	2636
2001	15946	1055	9918	10973	2670
2002	16961	1050	10542	11592	2674
2003	18171	1080	11299	12379	2760
2004	19375	1109	12076	13185	2844
2005	20668	1149	12954	14103	2955
2006	21987	1225	13924	15149	3153
2007	22734	1320	14608	15928	3390
2008	23015	1418	15058	16476	3629
2009	22528	1488	15153	16641	3794
2010	22089	1569	15158	16727	3981
2011	21522	1649	15068	16717	4162
2012	20723	1692	14779	16471	4251
2013	19644	1713	14215	15928	4281
2014	18888	1719	13807	15526	4280
2015	17759	1718	13089	14807	4252
2016	15565	1610	11781	13391	3966

Continue...

	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
2017	12821	1458	10122	11580	3568

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:

$2000male * 2000female = 4000000computations$

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
1948	1	0.00000	-	0.00000	-	-
1949	5	0.00000	-	0.00000	-	-
1950	7	0.00000	-	0.00000	-	-
1951	13	0.00595	-	0.00000	-	-
1952	20	0.00750	-	0.00000	-	3 (2.8)
1953	24	0.01259	-	0.00000	-	2 (2.0)
1954	29	0.01295	-	0.00000	-	2 (2.0)
1955	34	0.01503	0.01503	0.00000	0.00000	3 (3.0)
1956	31	0.01658	0.01658	0.00000	0.00000	7 (-)
1957	36	0.01413	0.01413	0.00890	0.00890	2 (2.0)

Continue...

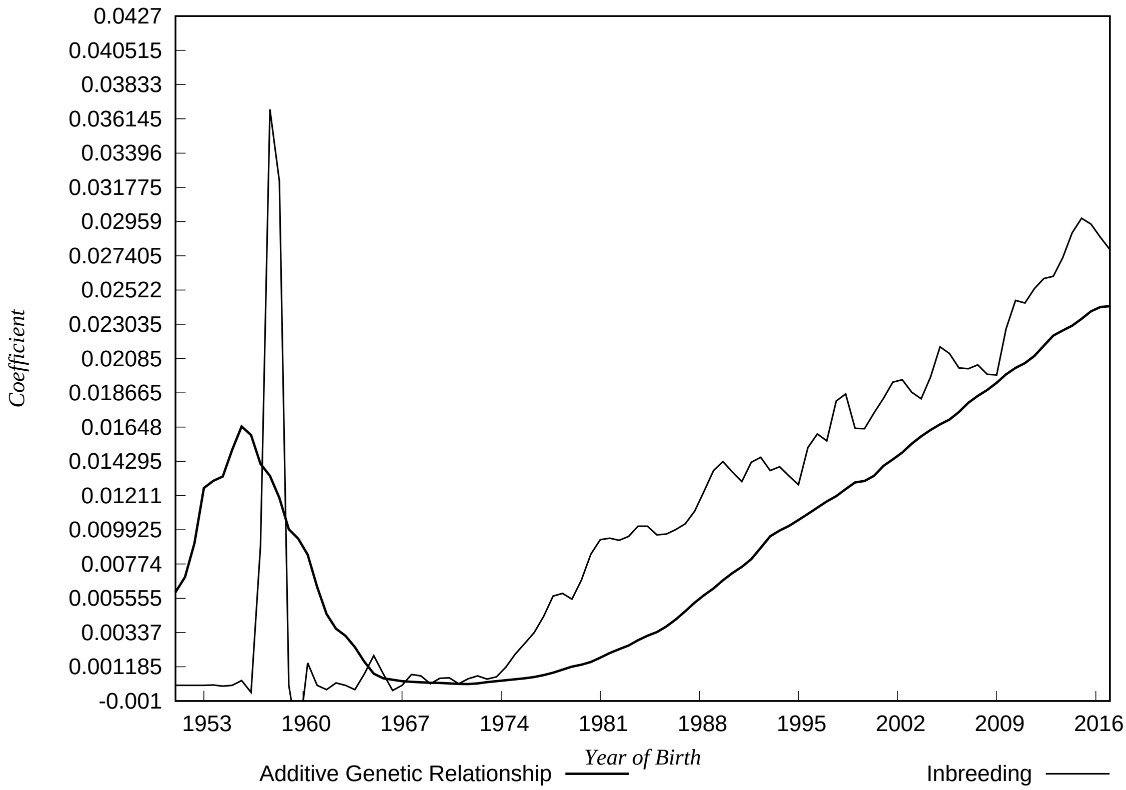
		AGR		*F*		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
1958	36	0.01288	0.00697	0.04170	0.04170	7 (-)
1959	40	0.00996	0.00247	0.00000	0.00000	3 (2.7)
1960	44	0.00904	-0.00359	0.00000	0.00000	4 (4.2)
1961	55	0.00629	-0.00674	0.00000	0.00000	2 (2.0)
1962	72	0.00397	-0.01123	0.00000	0.00000	3 (3.0)
1963	100	0.00316	-0.01364	0.00000	0.00000	3 (3.4)
1964	152	0.00198	-0.01232	0.00000	-0.00898	3 (3.2)
1965	346	0.00074	-0.01230	0.00190	-0.04153	4 (3.5)
1966	608	0.00040	-0.00965	0.00000	0.00000	3 (2.6)
1967	929	0.00027	-0.00885	0.00000	0.00000	3 (3.1)
1968	1390	0.00021	-0.00612	0.00080	0.00080	3 (3.0)
1969	2037	0.00016	-0.00382	0.00010	0.00010	3 (3.4)
1970	2922	0.00014	-0.00304	0.00060	0.00060	4 (3.6)
1971	4715	0.00009	-0.00189	0.00010	0.00010	4 (4.1)
1972	6091	0.00010	-0.00064	0.00060	-0.00130	4 (4.1)
1973	6372	0.00020	-0.00020	0.00040	0.00040	5 (4.8)
1974	5649	0.00030	0.00003	0.00080	0.00080	5 (5.4)
1975	5287	0.00039	0.00018	0.00200	0.00120	6 (5.6)
1976	5133	0.00048	0.00032	0.00300	0.00290	6 (5.7)
1977	5065	0.00065	0.00051	0.00440	0.00380	6 (5.7)
1978	5123	0.00090	0.00081	0.00600	0.00590	6 (6.0)
1979	5055	0.00119	0.00109	0.00550	0.00490	6 (6.0)
1980	5071	0.00139	0.00119	0.00760	0.00720	6 (6.0)
1981	5161	0.00176	0.00146	0.00930	0.00851	6 (6.3)
1982	5137	0.00220	0.00181	0.00930	0.00731	6 (6.1)
1983	4959	0.00254	0.00206	0.00950	0.00652	6 (6.2)
1984	4816	0.00304	0.00239	0.01030	0.00593	6 (6.4)
1985	4725	0.00340	0.00250	0.00960	0.00362	6 (6.1)
1986	4562	0.00397	0.00279	0.00980	0.00432	6 (6.3)
1987	4492	0.00472	0.00333	0.01030	0.00272	6 (6.2)
1988	4464	0.00553	0.00377	0.01170	0.00242	6 (6.4)
1989	4482	0.00618	0.00399	0.01370	0.00444	7 (6.5)
1990	4551	0.00695	0.00442	0.01410	0.00464	7 (6.5)
1991	4674	0.00756	0.00453	0.01300	0.00273	6 (5.8)
1992	4736	0.00838	0.00499	0.01470	0.00515	6 (5.5)
1993	4913	0.00951	0.00556	0.01370	0.00394	6 (5.7)
1994	5030	0.01001	0.00531	0.01390	0.00364	6 (5.6)
1995	5171	0.01055	0.00505	0.01280	0.00111	6 (5.8)
1996	5283	0.01113	0.00499	0.01610	0.00243	6 (6.0)
1997	5325	0.01173	0.00481	0.01560	0.00152	6 (5.7)
1998	5368	0.01227	0.00475	0.01900	0.00608	6 (6.0)
1999	5364	0.01295	0.00460	0.01640	0.00173	6 (6.0)
2000	5425	0.01313	0.00366	0.01690	0.00324	6 (6.2)
2001	5397	0.01400	0.00403	0.01830	0.00446	6 (6.4)
2002	5238	0.01461	0.00410	0.01960	0.00689	7 (6.5)
2003	5107	0.01542	0.00433	0.01870	0.00264	6 (6.4)
2004	4933	0.01609	0.00442	0.01870	0.00315	6 (6.4)
2005	4668	0.01665	0.00444	0.02160	0.00265	7 (6.5)

Continue...

		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
2006	4485	0.01716	0.00427	0.02060	0.00427	7 (6.6)
2007	4352	0.01803	0.00497	0.02020	0.00336	7 (6.8)
2008	4287	0.01865	0.00472	0.02030	0.00204	7 (6.6)
2009	4286	0.01930	0.00476	0.01980	0.00020	7 (6.8)
2010	4263	0.02008	0.00474	0.02410	0.00550	7 (6.7)
2011	4279	0.02056	0.00454	0.02440	0.00581	7 (6.8)
2012	4349	0.02132	0.00475	0.02580	0.00429	7 (7.1)
2013	4471	0.02231	0.00525	0.02610	0.00562	8 (7.5)
2014	4550	0.02277	0.00482	0.02810	0.00806	6 (6.1)
2015	4689	0.02339	0.00483	0.02980	0.00970	7 (-)
2016	4905	0.02404	0.00483	0.02900	0.00939	7 (-)
2017	5507	0.02419	0.00420	0.02780	0.00379	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 1951 and 2017 for the UNKNOWN breed was 0.00025 per year based on the slope of the regression fitted. This result in a Δf per generation of 0.00175. The rate of change of the average inbreeding coefficients based on the slope of the regression between 1951 and 2017 was 0.00042, which represents a ΔF per generation of 0.00301. The effective population sizes for the UNKNOWN breed, based on Δf and ΔF were 286 and 166, respectively.

Figure 4: Average Log(1-F) by year of birth for animals born between 1948 and 2017.

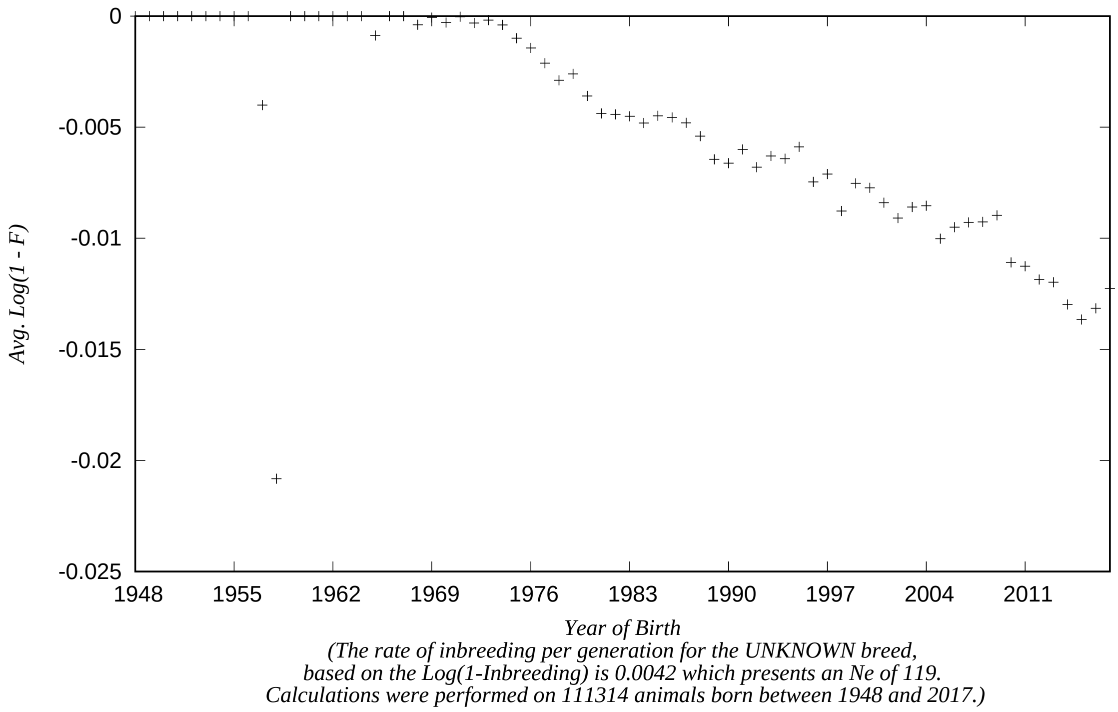
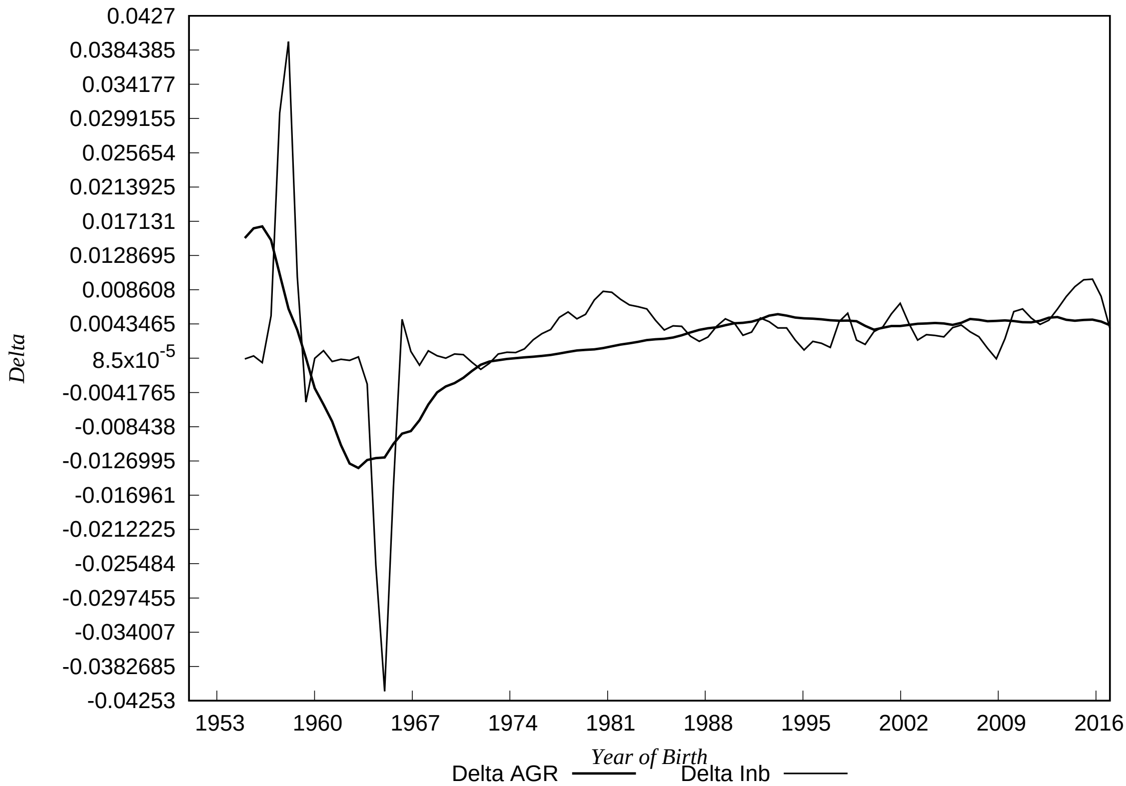


Figure 5: The Rate of Inbreeding and Increase in the Additive Genetic Relationships by year of birth



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: 2019-01-11 10:38:32
Started at: 2019-01-11 10:39:01
Finished at: 2019-01-11 11:15:06

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'.
  111314 input lines processed.
  111314 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
1973	706	706	6957	5666
1974	830	830	8652	4819
1975	915	915	10099	4372
1976	958	958	11339	4175
1977	979	979	12133	4086
1978	961	961	12258	4162
1979	982	982	12644	4073
1980	977	977	13041	4094
1981	950	950	13098	4211
1982	957	957	13312	4180
1983	1014	1014	13568	3945
1984	1067	1067	14027	3749
1985	1105	1105	14257	3620
1986	1184	1184	14628	3378
1987	1224	1224	14957	3268
1988	1241	1241	15369	3223
1989	1230	1230	15454	3252
1990	1190	1190	15333	3361
1991	1128	1128	15129	3546
1992	1100	1100	14982	3636
1993	1030	1030	14840	3883
1994	990	990	14548	4040
1995	947	947	14169	4224
1996	916	916	13876	4367
1997	905	905	13705	4420
1998	894	894	13822	4474
1999	895	895	14148	4469
2000	880	880	14526	4545
2001	887	887	15059	4510

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	928	928	16033	4310
2003	966	966	17205	4141
2004	1023	1023	18352	3910
2005	1131	1131	19537	3537
2006	1228	1228	20759	3257
2007	1319	1319	21415	3033
2008	1372	1372	21643	2915
2009	1373	1373	21155	2913
2010	1394	1394	20695	2869
2011	1380	1380	20142	2899
2012	1321	1321	19402	3028
2013	1237	1237	18407	3234
2014	1191	1191	17697	3359
2015	1121	1121	16638	3568
2016	1033	1033	14532	3872
2017	861	861	11960	4646

Monitoring the Population UNKNOWN

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Helmut Lichtenberg – Integration and WEB service
Eildert Groeneveld – Project Leader

January 11, 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

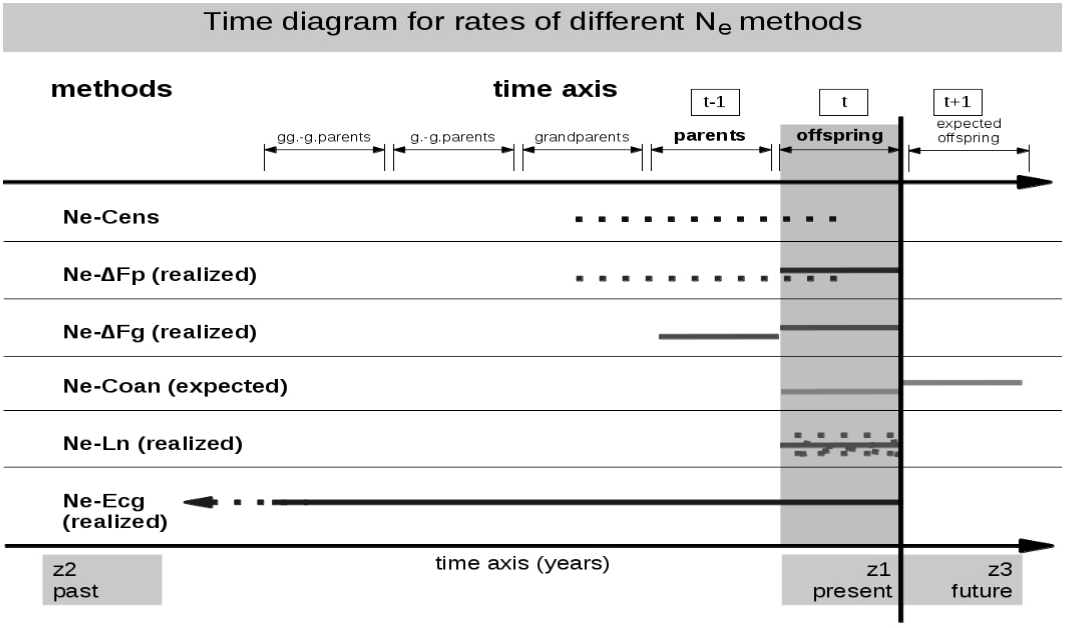

Table 2: Order of methods in cascade

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.

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Breed: UNKNOWN • 111314 pedigree records • generation interval: 7 • January 11, 2019

Figure 2: Number of breeding animals

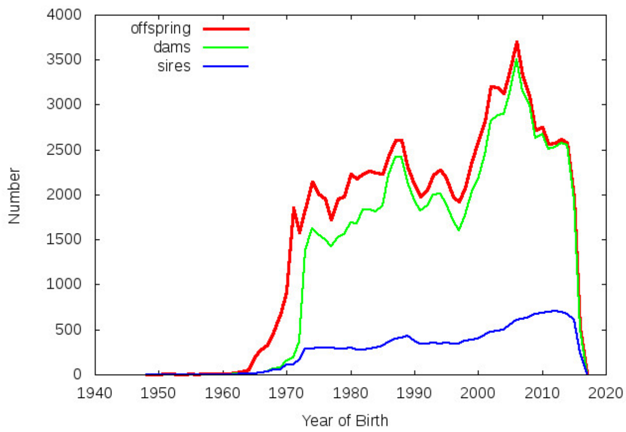

Figure 3: Average pedigree completeness for 1 to 6 generations

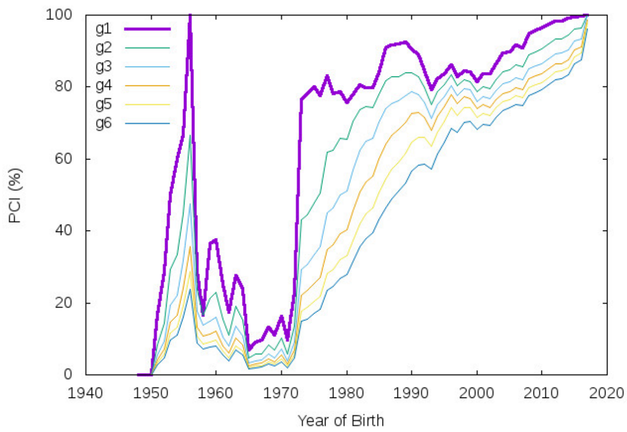

Figure 4: Average Additiv Genetic Relationship (Coan) and Inbreeding (F)

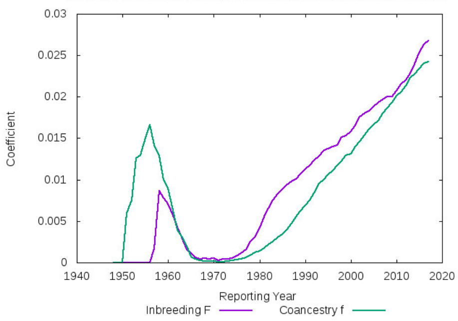

Figure 5: Average ln(1-F) by year of birth

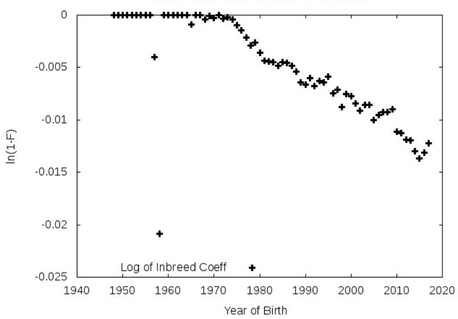

Figure 6: Ne with different calculation methods by reporting year

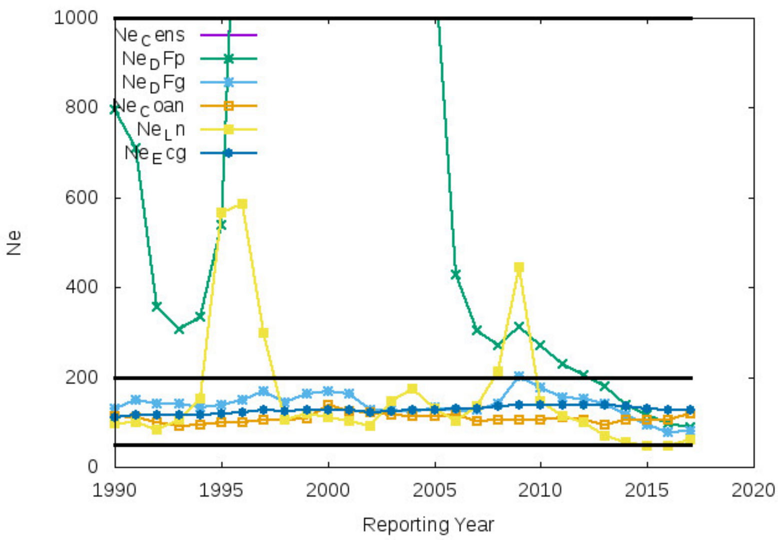

Table 3: Effective Population Size $\mathbf{N_e}$

N_e-Method	2017	2016	2015	2014	2013	2012	data history
N_e-Cens	3568	3966	4252	4280	4281	4251	2010 – 2004
N_e-ΔF_p	89	96	115	139	179	204	2017 – 2004
N_e-ΔF_g	81	78	93	116	142	153	2017 – 2004
N_e-Coan	119	104	104	104	95	105	2024 – 2011
N_e-Ln	62	48	47	54	70	99	2017 – 2011
N_e-Ecg	126	127	131	135	138	139	2017 – 1948

Proposed $\mathbf{N_e}$: $\mathbf{N_e}$-Ln = 62

Note: The last year is assumed to have complete data!

Table 4: Decision tree for 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	3568	89	81	119	62	126
2016	3966	96	78	104	48	127
2015	4252	115	93	104	47	131
2014	4280	139	116	104	54	135
2013	4281	179	142	95	70	138
2012	4251	204	153	105	99	139
2011	4162	229	155	110	112	138
σ	206.4	9.8	9.3	7.5	15.7	1.9

Table 5: Decision cascade – side conditions

Method	Completeness [Years]	Stability [σ]	Diff	OK
N_e-Coan[a]	14/14	7.5|9.3/20	-11.00	no
N_e-Ln	7/7	15.7/20	-	yes
N_e-ΔF_p	7/7	9.8/20	-	yes
N_e-ΔF_g	7/7	9.3/20	-	yes
N_e-Coan	7/7	7.5/20	-	yes
N_e-Ecg	7/7	1.9/20	-	yes
N_e-Cens	7/7	206.4/20	-	no

[a] Avg N_e-Coan – Avg N_e-ΔF_g: 105.86 - 116.86 = -11.00

Service PopReport at Institute of Farm Animal Genetics

FRIEDRICH-LOEFFLER-INSTITUT
FLI
Bundesforschungsinstitut für Tiergesundheit

PopReport
A Population Structure Report

Population: UNKNOWN
Inputfile: POPREP.TXT
Initiated by: quaglia@anabic.it
Submitted at: 2019-01-11 10:38:32
Started at: 2019-01-11 10:39:01
Finished at: 2019-01-11 11:15:06

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'.
  111314 input lines processed.
  111314 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
1973	706	706	6957	5666
1974	830	830	8652	4819
1975	915	915	10099	4372
1976	958	958	11339	4175
1977	979	979	12133	4086
1978	961	961	12258	4162
1979	982	982	12644	4073
1980	977	977	13041	4094
1981	950	950	13098	4211
1982	957	957	13312	4180
1983	1014	1014	13568	3945
1984	1067	1067	14027	3749
1985	1105	1105	14257	3620
1986	1184	1184	14628	3378
1987	1224	1224	14957	3268
1988	1241	1241	15369	3223
1989	1230	1230	15454	3252
1990	1190	1190	15333	3361
1991	1128	1128	15129	3546
1992	1100	1100	14982	3636
1993	1030	1030	14840	3883
1994	990	990	14548	4040
1995	947	947	14169	4224
1996	916	916	13876	4367
1997	905	905	13705	4420
1998	894	894	13822	4474
1999	895	895	14148	4469
2000	880	880	14526	4545
2001	887	887	15059	4510

Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	928	928	16033	4310
2003	966	966	17205	4141
2004	1023	1023	18352	3910
2005	1131	1131	19537	3537
2006	1228	1228	20759	3257
2007	1319	1319	21415	3033
2008	1372	1372	21643	2915
2009	1373	1373	21155	2913
2010	1394	1394	20695	2869
2011	1380	1380	20142	2899
2012	1321	1321	19402	3028
2013	1237	1237	18407	3234
2014	1191	1191	17697	3359
2015	1121	1121	16638	3568
2016	1033	1033	14532	3872
2017	861	861	11960	4646

Population Structure Report for Population: UNKNOWN

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Contents

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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 1964, 14 sires and 15 dams produced the 59 offspring during this year. In the batch of future parents (select) born in this year 1964 14 sires and 15 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
1951	-	2	2	-	1	1	6
1952	-	2	2	-	2	2	7
1953	-	3	3	-	2	2	4
1954	-	3	3	-	3	3	5
1955	-	4	4	-	4	4	6
1956	-	1	1	-	1	1	1
1957	-	2	2	-	2	2	7
1958	-	1	1	-	1	1	6
1959	-	4	4	-	4	4	11
1960	-	4	4	-	3	3	8
1961	-	4	4	-	4	4	16
1962	-	4	4	-	5	5	23

Continue...

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
1963	-	8	8	-	8	8	29
1964	-	14	14	-	15	15	59
1965	-	13	12	-	12	11	200
1966	-	24	24	-	26	25	273
1967	-	32	32	-	31	31	329
1968	-	50	49	-	66	65	477
1969	-	59	54	-	81	71	670
1970	-	112	105	-	156	141	914
1971	-	108	95	-	185	146	1852
1972	-	169	149	-	365	295	1576
1973	-	290	217	-	1380	730	1845
1974	-	291	216	-	1626	843	2148
1975	-	302	239	-	1561	849	2009
1976	-	294	226	-	1503	875	1953
1977	-	301	233	-	1425	789	1729
1978	-	286	229	-	1521	857	1959
1979	-	283	225	-	1556	845	1983
1980	-	292	229	-	1694	936	2237
1981	-	274	222	-	1684	968	2178
1982	-	272	220	-	1838	1068	2230
1983	-	286	232	-	1831	1053	2266
1984	-	293	239	-	1814	1017	2241
1985	-	319	254	-	1873	1044	2227
1986	-	363	289	-	2220	1109	2433
1987	-	395	293	-	2416	1203	2606
1988	-	406	300	-	2415	1249	2607
1989	-	427	318	-	2146	1153	2304
1990	-	376	306	-	1931	1154	2105
1991	-	347	287	-	1824	1100	1975
1992	-	341	275	-	1872	1111	2052
1993	-	354	285	-	2000	1189	2221
1994	-	339	290	-	2014	1216	2274
1995	-	352	308	-	1904	1226	2185
1996	-	344	301	-	1710	1132	1980
1997	-	340	308	-	1598	1060	1923
1998	-	377	315	-	1768	1140	2081
1999	-	385	329	-	2030	1347	2379
2000	-	395	325	-	2168	1316	2584
2001	-	442	377	-	2443	1474	2814
2002	-	477	390	-	2816	1647	3200
2003	-	480	397	-	2882	1651	3190
2004	-	491	388	-	2894	1498	3127
2005	-	549	415	-	3129	1590	3374
2006	-	608	443	-	3503	1587	3698
2007	-	616	427	-	3147	1361	3331
2008	-	639	416	-	3004	1161	3095
2009	-	673	390	-	2631	963	2713
2010	-	688	379	-	2672	844	2751

Continue...

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
2011	-	693	296	-	2510	573	2560
2012	-	705	215	-	2534	383	2575
2013	-	695	110	-	2577	159	2619
2014	-	670	22	-	2552	24	2575
2015	-	609	1	-	1945	1	1966
2016	-	241	-	-	512	-	519
2017	-	7	-	-	7	-	7
Total	-	5923	4548	-	55769	31002	111314

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 1966, 3 two year-old males were used in reproduction while 3 three year-old males were used. The average age of males that produced offspring during 1966 was 2.5 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
1951	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1952	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	3.0
1953	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1954	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3
1955	3	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1.8
1956	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1957	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1958	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3.0
1959	3	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2.8
1960	2	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	3.8
1961	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1962	3	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	3.5
1963	5	1	–	1	–	–	–	1	–	–	–	–	–	–	–	–	2.4
1964	8	1	–	1	–	2	–	–	1	1	–	–	–	–	–	–	3.2
1965	8	2	1	–	–	–	1	–	–	–	1	–	–	–	–	–	2.5
1966	15	3	3	–	–	1	–	1	–	–	–	–	–	–	1	–	2.5
1967	21	1	1	3	1	–	2	–	1	–	–	1	1	–	–	–	2.8
1968	27	3	6	4	5	–	1	2	–	1	–	–	–	–	–	1	2.8
1969	35	4	3	3	2	6	1	1	1	–	1	–	–	2	–	–	2.9
1970	49	17	17	7	5	3	5	4	1	–	–	1	–	–	1	2	3.1
1971	35	18	10	12	9	4	5	6	1	–	3	1	1	–	–	3	3.9

Continue...

Year	age of males in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1972	48	25	29	13	17	9	9	3	9	1	2	–	1	1	–	2	3.8
1973	27	75	48	42	21	27	16	11	7	9	2	1	–	1	1	2	4.2
1974	17	58	75	28	34	16	23	10	12	5	6	1	1	2	1	2	4.5
1975	11	48	63	54	22	28	16	20	11	11	6	6	1	1	1	3	5.0
1976	13	71	38	45	36	12	21	14	12	9	10	5	3	2	–	3	4.9
1977	17	73	72	24	32	21	7	15	11	8	6	8	1	1	1	4	4.6
1978	14	65	67	45	11	22	6	7	14	9	10	5	6	1	–	4	4.8
1979	13	71	65	49	27	6	10	6	5	7	6	6	4	4	1	3	4.5
1980	15	70	66	44	28	19	4	7	4	7	6	3	6	4	4	5	4.7
1981	17	73	54	43	24	18	11	5	3	2	3	5	4	4	1	7	4.5
1982	9	59	66	45	27	14	12	9	2	4	2	5	8	3	1	6	4.8
1983	15	85	57	40	25	18	13	6	8	–	1	4	2	4	3	5	4.3
1984	14	70	77	41	21	16	16	7	5	5	1	2	2	3	3	10	4.6
1985	18	81	66	63	32	14	7	12	3	4	3	1	2	3	3	7	4.3
1986	17	103	89	37	42	20	13	5	9	6	2	2	1	2	3	12	4.4
1987	23	111	82	79	30	32	12	2	6	1	4	1	1	1	1	9	4.0
1988	19	87	103	71	53	24	15	9	1	4	–	2	1	2	1	14	4.4
1989	26	98	82	91	43	33	18	11	7	1	2	–	1	2	1	11	4.3
1990	9	92	81	67	48	26	15	14	3	6	1	1	–	1	1	11	4.5
1991	7	83	92	59	40	21	18	9	3	4	1	1	1	–	2	6	4.3
1992	13	84	77	75	35	22	18	9	4	–	1	–	–	1	–	2	3.9
1993	11	89	92	61	45	24	14	5	7	3	2	–	–	–	–	1	3.8
1994	12	82	86	62	39	35	12	3	4	2	2	–	–	–	–	–	3.8
1995	10	84	81	68	43	23	28	7	2	5	–	1	–	–	–	–	3.9
1996	11	91	69	55	47	33	9	15	8	1	4	–	1	–	–	–	4.0
1997	7	77	90	53	41	27	17	11	9	1	1	5	–	–	–	1	4.1
1998	5	86	78	86	41	24	20	15	8	7	3	1	3	–	–	–	4.2
1999	5	84	72	75	63	35	19	12	10	2	4	1	–	3	–	–	4.3
2000	6	86	61	72	72	48	15	14	5	7	3	2	1	1	2	–	4.4
2001	7	91	69	74	69	45	44	13	9	9	7	2	2	–	–	1	4.6
2002	6	81	93	61	55	55	55	33	13	10	4	3	4	2	–	2	4.9
2003	10	94	90	64	45	49	43	28	28	10	6	3	2	3	3	2	4.9
2004	6	89	86	86	58	34	33	31	30	18	3	2	3	5	2	5	5.1

Continue...

Year	age of males in year																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
2005	8	94	96	90	77	52	24	31	26	21	14	1	1	4	3	7	5.1
2006	9	116	100	94	78	62	41	24	20	24	14	9	–	–	6	11	5.1
2007	17	108	110	89	79	56	48	34	19	17	8	13	4	–	1	13	5.1
2008	11	141	117	101	61	58	43	34	19	14	7	8	8	3	–	14	4.9
2009	5	120	135	103	87	59	46	33	22	18	11	4	7	5	3	15	5.2
2010	14	102	116	124	95	67	43	35	21	27	14	3	1	5	3	18	5.3
2011	9	97	118	110	109	74	55	36	21	16	13	6	2	2	5	20	5.4
2012	10	78	111	99	101	106	58	46	28	12	6	16	6	3	–	25	5.8
2013	8	92	87	94	96	92	76	57	27	16	8	5	9	3	3	22	5.9
2014	5	95	86	78	85	65	77	66	37	25	11	4	3	6	3	24	6.1
2015	11	69	94	81	62	70	46	59	32	30	14	7	2	1	5	26	6.2
2016	3	26	30	28	26	27	26	15	13	13	7	4	–	1	1	21	7.2
2017	–	–	2	1	1	1	–	1	–	–	–	–	–	–	–	1	8.3
Total	796	3805	3662	2996	2245	1656	1188	865	562	413	247	162	107	92	71	363	7.5

For example: For the UNKNOWN breed in 1968, 2 two year-old females were used in reproduction while 4 three year-old females were used. The avarage age of females that produced offspring during 1968 was 1.3 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
1951	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1952	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1953	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1954	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1955	3	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2.8
1956	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1957	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1958	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1959	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1960	2	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2.3
1961	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1962	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.0
1963	6	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2.3
1964	14	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1.6
1965	10	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1.6
1966	25	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1.2
1967	29	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1.2
1968	57	2	4	1	1	1	–	–	–	–	–	–	–	–	–	–	1.3
1969	70	3	5	1	1	–	–	1	–	–	–	–	–	–	–	–	1.3
1970	121	15	6	10	2	1	1	–	–	–	–	–	–	–	–	–	1.5
1971	114	12	25	11	9	9	1	1	1	1	–	1	–	–	–	–	2.2
1972	232	25	44	21	19	11	8	2	–	2	–	–	–	–	–	1	2.1
1973	618	133	170	145	118	71	59	54	4	3	1	2	–	–	1	1	2.9
1974	436	189	369	183	162	91	68	62	55	2	3	2	–	–	1	3	3.5
1975	197	153	370	278	154	146	87	65	52	43	5	5	1	2	–	3	4.2
1976	190	160	236	291	217	114	95	77	46	33	32	7	3	–	–	2	4.4
1977	161	215	219	172	197	163	83	88	42	29	32	20	2	–	–	2	4.6
1978	150	230	252	206	170	165	131	69	51	34	29	14	15	2	1	2	4.6
1979	90	183	269	235	204	148	159	102	62	54	23	6	11	5	1	4	5.0

Continue...

Year	age of females in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1980	117	175	268	228	210	188	130	124	98	62	38	16	17	13	6	4	5.3
1981	75	200	222	218	240	191	158	109	91	79	41	25	16	6	6	7	5.5
1982	100	256	255	212	220	230	175	128	84	79	47	28	14	3	4	3	5.3
1983	57	265	247	240	213	198	188	154	100	59	47	37	14	4	5	3	5.4
1984	20	246	271	231	232	184	174	154	124	73	35	35	17	11	2	5	5.6
1985	44	197	302	303	217	211	158	135	121	89	46	19	15	7	5	4	5.5
1986	56	248	342	295	302	281	162	169	123	101	81	29	13	9	4	5	5.5
1987	46	291	304	314	309	298	256	179	161	90	84	47	19	9	3	6	5.7
1988	22	287	346	307	292	276	240	218	158	105	71	51	24	12	4	2	5.7
1989	18	245	275	262	266	253	222	185	143	100	79	40	28	13	5	12	5.9
1990	15	223	264	245	226	214	171	154	137	99	75	48	27	22	10	1	6.0
1991	11	215	236	220	201	197	165	129	136	125	71	46	39	19	8	6	6.1
1992	8	224	248	257	231	174	168	144	134	91	81	50	28	18	6	10	6.0
1993	6	220	250	269	264	207	180	152	129	119	96	38	35	15	13	7	6.1
1994	10	225	220	260	256	242	189	153	144	100	79	51	38	21	6	20	6.2
1995	4	232	221	230	220	223	202	138	126	108	74	47	37	21	11	10	6.2
1996	6	187	204	184	165	218	200	158	118	85	72	49	36	12	9	7	6.3
1997	5	181	190	185	173	157	157	141	115	103	66	43	36	26	12	8	6.4
1998	6	193	210	207	192	165	161	164	129	109	85	52	50	18	11	16	6.4
1999	5	212	207	245	246	233	187	162	137	130	106	73	36	32	10	9	6.4
2000	6	204	243	227	235	261	207	159	161	147	120	88	60	25	14	11	6.6
2001	7	255	247	222	281	270	264	223	157	139	126	103	71	42	16	20	6.7
2002	10	315	328	265	281	273	276	252	213	159	138	119	78	54	33	22	6.7
2003	8	326	357	327	263	243	254	252	212	186	134	118	80	52	36	34	6.6
2004	8	331	353	351	296	234	253	231	219	159	147	101	87	58	31	35	6.6
2005	11	377	388	371	362	328	233	224	202	167	143	117	71	57	36	42	6.4
2006	13	420	448	424	387	373	286	229	216	170	164	133	99	52	36	53	6.4
2007	8	359	390	403	380	300	281	228	170	153	144	114	82	61	35	39	6.4
2008	11	336	344	373	356	341	266	251	186	131	111	107	73	45	35	38	6.4
2009	5	292	331	301	297	260	245	223	187	130	97	76	75	51	23	38	6.5
2010	6	241	329	339	335	279	262	210	173	164	109	83	59	31	24	28	6.4
2011	6	234	261	328	314	254	275	205	185	125	107	81	52	44	21	18	6.5
2012	5	199	252	278	297	287	266	227	197	174	118	97	58	35	20	24	6.7

Continue...

Year	age of females in year															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
2013	3	197	255	275	304	309	283	230	183	178	127	93	53	36	22	29	6.8
2014	3	203	234	279	261	290	271	236	194	156	155	96	74	52	24	24	6.9
2015	3	184	152	214	212	195	192	179	165	133	103	92	51	32	20	18	6.9
2016	1	38	58	53	58	53	49	47	47	34	22	17	16	9	3	7	6.8
2017	–	–	–	–	1	–	1	2	1	2	–	–	–	–	–	–	8.1
Total	3295	10356	12021	11496	10850	9811	8501	7180	5889	4616	3564	2516	1710	1036	573	643	7.5

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, 4 females were in their second parity while in 1972, 4 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
1951	1	–	–	–	–	–	–	–	–	–
1952	2	–	–	–	–	–	–	–	–	–
1953	2	–	–	–	–	–	–	–	–	–
1954	3	–	–	–	–	–	–	–	–	–
1955	4	–	–	–	–	–	–	–	–	–
1956	1	–	–	–	–	–	–	–	–	–
1957	2	–	–	–	–	–	–	–	–	–
1958	1	–	–	–	–	–	–	–	–	–
1959	4	–	–	–	–	–	–	–	–	–
1960	3	–	–	–	–	–	–	–	–	–
1961	4	–	–	–	–	–	–	–	–	–
1962	5	–	–	–	–	–	–	–	–	–
1963	8	–	–	–	–	–	–	–	–	–
1964	15	–	–	–	–	–	–	–	–	–
1965	12	1	–	–	–	–	–	–	–	–
1966	26	–	–	–	–	–	–	–	–	–
1967	31	1	–	–	–	–	–	–	–	–
1968	65	1	–	–	–	–	–	–	–	–
1969	79	4	–	–	–	–	–	–	–	–
1970	153	6	–	–	–	–	–	–	–	–
1971	171	14	–	–	–	–	–	–	–	–
1972	331	36	4	–	–	–	–	–	–	–
1973	1267	137	10	1	–	–	–	–	–	–
1974	1272	349	46	9	2	–	–	–	–	–
1975	1031	424	124	21	3	1	–	–	–	–
1976	959	380	135	39	5	1	1	–	–	–
1977	911	335	129	46	17	2	–	1	–	–
1978	988	349	125	39	21	6	1	–	1	–
1979	972	407	119	47	14	4	–	–	–	–
1980	1035	410	172	59	14	10	1	–	–	–
1981	979	451	179	67	15	3	1	1	–	–
1982	1086	458	218	59	18	3	–	–	–	–
1983	1077	448	192	103	16	5	–	–	–	–
1984	1022	480	200	81	31	9	2	–	–	–
1985	1088	480	192	86	28	7	–	–	–	–

Continue...

Year	parity number									
	1	2	3	4	5	6	7	8	9	10
1986	1384	489	230	84	31	8	2	–	–	–
1987	1483	546	236	106	43	9	2	–	–	–
1988	1455	595	226	91	39	12	5	–	–	–
1989	1223	560	231	88	38	15	1	–	–	–
1990	1095	495	219	75	32	13	5	–	–	–
1991	1031	446	218	90	32	6	4	1	–	–
1992	1116	440	202	81	30	4	1	1	–	–
1993	1154	518	208	75	31	12	4	–	1	–
1994	1140	527	214	93	29	13	3	1	–	–
1995	1056	528	180	90	34	16	1	2	–	1
1996	935	476	197	67	36	7	2	–	–	–
1997	893	416	185	66	24	16	3	1	–	–
1998	975	463	206	87	29	8	3	1	–	–
1999	1191	526	203	82	26	5	4	–	–	–
2000	1277	540	223	89	33	6	5	2	–	–
2001	1429	589	274	112	37	13	1	2	–	–
2002	1643	723	292	119	32	11	4	1	1	–
2003	1641	755	301	131	46	9	7	–	–	–
2004	1575	795	333	130	44	18	5	1	–	–
2005	1782	804	335	140	54	15	6	1	–	–
2006	1985	913	372	143	69	23	3	1	–	–
2007	1786	791	347	149	59	18	7	–	–	–
2008	1671	776	360	128	48	20	4	1	–	–
2009	1511	640	292	119	41	21	9	1	1	–
2010	1498	700	281	138	47	14	5	1	1	–
2011	1440	655	260	102	39	15	4	3	–	–
2012	1444	627	282	109	52	17	5	3	1	–
2013	1494	661	268	101	36	13	5	5	–	–
2014	1463	691	248	99	28	15	6	4	2	–
2015	1105	539	194	66	27	12	4	2	1	1
2016	282	130	64	22	9	4	1	–	–	–
2017	2	3	–	1	–	–	1	–	–	–
Total	55769	23528	9526	3730	1339	439	128	37	9	2

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 4.4 year in 1965. This values was calculated based on the avarage ages of 9 selected sons, born during 1965. 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 3.5, 2.0 and 2.9 year, respectively. During 1965, the generation interval for the males was 4.0 year and 2.4 year for the female born during this year. The generation interval in 1965 for all four selection paths together, or for the population in total (pop), was 3.5 year, based on the average age of parents of 16 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
1952	3.8	1	3.2	1	2.0	1	2.0	1	3.5	2	2.0	2	2.8	2
1953	2.0	1	2.0	2	2.0	1	2.0	1	2.0	3	2.0	2	2.0	3
1954	2.0	2	2.0	1	2.0	2	2.0	1	2.0	3	2.0	3	2.0	3
1955	2.0	3	4.0	1	2.0	3	8.0	1	2.5	4	3.5	4	3.0	4
1957	2.0	1	2.0	1	2.0	1	2.0	1	2.0	2	2.0	2	2.0	2
1959	4.0	3	2.0	1	2.0	3	2.0	1	3.5	4	2.0	4	2.7	4
1960	5.3	3	2.0	1	3.6	2	2.0	1	4.5	4	3.1	3	4.2	4
1961	2.0	1	2.0	3	2.0	1	2.0	3	2.0	4	2.0	4	2.0	4
1962	6.9	2	2.0	2	2.0	3	2.0	2	4.5	4	2.0	5	3.0	5
1963	2.2	4	3.7	5	2.0	4	4.2	4	3.1	9	3.1	8	3.4	9
1964	4.1	9	3.8	5	1.9	10	3.7	5	4.0	14	2.5	15	3.2	15
1965	4.4	9	3.5	7	2.0	7	2.9	6	4.0	16	2.4	13	3.5	16

Continue...

Year	Generation interval and number of animal													
	ss	Nss	sd	Nsd	ms	Nms	md	Nmd	male	Nmale	female	Nfemale	pop	Npop
1966	3.2	13	3.1	12	1.9	13	2.4	12	3.1	25	2.2	25	2.6	26
1967	3.3	11	3.7	23	2.3	11	2.0	21	3.5	34	2.1	32	3.1	34
1968	4.2	23	3.5	42	2.4	23	2.2	42	3.7	65	2.2	65	3.0	68
1969	4.3	17	4.4	55	2.6	18	2.1	55	4.4	72	2.2	73	3.4	79
1970	4.8	22	4.5	123	2.4	21	2.3	122	4.6	145	2.3	143	3.6	155
1971	6.4	19	4.8	137	2.7	18	2.9	130	5.0	156	2.9	148	4.1	160
1972	6.3	17	5.2	294	3.5	14	2.9	289	5.2	311	2.9	303	4.1	320
1973	6.2	81	5.9	667	4.3	81	3.6	662	6.0	748	3.7	743	4.8	750
1974	8.1	95	6.3	769	5.0	95	4.2	765	6.5	864	4.3	860	5.4	865
1975	7.5	111	6.3	759	5.5	111	4.8	754	6.4	870	4.9	865	5.6	873
1976	7.3	85	6.2	788	5.3	85	5.0	795	6.3	873	5.0	880	5.7	882
1977	6.0	99	6.3	696	6.0	99	5.1	696	6.2	795	5.2	795	5.7	799
1978	7.0	100	6.8	764	6.5	100	5.1	766	6.8	864	5.3	866	6.0	867
1979	6.4	89	6.4	756	5.9	89	5.5	762	6.4	845	5.5	851	6.0	853
1980	5.3	110	6.2	829	5.8	110	6.0	832	6.1	939	6.0	942	6.0	946
1981	6.0	121	6.5	849	6.3	121	6.2	853	6.5	970	6.2	974	6.3	974
1982	6.5	111	6.3	954	6.5	111	5.9	961	6.4	1065	5.9	1072	6.1	1073
1983	5.7	126	6.5	921	5.8	127	6.1	935	6.4	1047	6.0	1062	6.2	1062
1984	6.6	137	6.6	871	6.7	140	6.1	883	6.6	1008	6.2	1023	6.4	1031
1985	5.4	129	6.3	923	6.1	128	6.0	921	6.2	1052	6.0	1049	6.1	1058
1986	5.6	143	6.5	971	6.2	144	6.2	975	6.4	1114	6.2	1119	6.3	1126
1987	6.1	133	6.3	1063	6.1	133	6.3	1075	6.3	1196	6.2	1208	6.2	1215
1988	5.5	118	6.5	1126	6.4	118	6.4	1136	6.4	1244	6.4	1254	6.4	1258
1989	6.6	113	6.5	1039	6.1	113	6.5	1054	6.5	1152	6.5	1167	6.5	1171
1990	6.9	121	6.3	1028	6.2	121	6.6	1038	6.4	1149	6.6	1159	6.5	1162
1991	4.8	97	4.8	967	6.1	97	6.8	1007	4.8	1064	6.7	1104	5.8	1105
1992	3.8	122	4.4	928	6.7	122	6.5	993	4.3	1050	6.5	1115	5.5	1117
1993	4.0	112	4.4	964	6.4	112	6.7	1084	4.4	1076	6.6	1196	5.7	1198
1994	4.1	132	4.4	1002	6.3	132	6.7	1089	4.4	1134	6.7	1221	5.6	1221
1995	4.4	113	4.8	1068	6.8	113	6.7	1119	4.7	1181	6.7	1232	5.8	1233
1996	4.7	112	5.1	1020	6.9	112	6.8	1030	5.1	1132	6.8	1142	6.0	1142
1997	3.8	120	4.7	939	6.4	120	6.9	951	4.6	1059	6.8	1071	5.7	1073
1998	4.6	106	4.9	1031	6.3	106	7.1	1043	4.9	1137	7.0	1149	6.0	1152
1999	4.6	130	5.1	1202	6.3	130	7.0	1224	5.1	1332	6.9	1354	6.0	1358
2000	4.8	104	5.3	1177	7.1	104	7.2	1220	5.2	1281	7.2	1324	6.2	1329
2001	5.3	138	5.6	1277	6.8	138	7.2	1347	5.5	1415	7.2	1485	6.4	1489
2002	5.4	152	5.8	1432	6.8	152	7.2	1507	5.8	1584	7.2	1659	6.5	1670
2003	5.5	144	5.6	1442	6.4	144	7.2	1517	5.6	1586	7.1	1661	6.4	1668
2004	5.1	160	5.7	1294	6.9	160	7.2	1348	5.6	1454	7.1	1508	6.4	1513
2005	6.2	189	6.0	1346	6.7	189	6.8	1410	6.1	1535	6.8	1599	6.5	1603
2006	6.4	211	6.2	1328	6.5	211	6.9	1381	6.2	1539	6.8	1592	6.6	1599
2007	6.1	171	6.8	1149	6.5	171	6.9	1196	6.7	1320	6.9	1367	6.8	1373
2008	6.6	175	6.4	966	6.4	175	6.8	989	6.5	1141	6.7	1164	6.6	1166
2009	6.8	137	6.9	816	6.6	137	6.8	832	6.9	953	6.8	969	6.8	971
2010	6.7	139	6.6	698	6.1	139	6.9	714	6.6	837	6.8	853	6.7	853
2011	6.1	126	6.8	445	6.3	126	7.1	447	6.6	571	6.9	573	6.8	574
2012	7.2	109	7.4	277	6.5	109	6.9	276	7.3	386	6.8	385	7.1	387
2013	8.7	49	7.8	110	6.6	49	7.2	110	8.0	159	7.0	159	7.5	159

Continue...

Year	Generation interval and number of animal													
	ss	Nss	sd	Nsd	ms	Nms	md	Nmd	male	Nmale	female	Nfemale	pop	Npop
2014	5.6	16	4.5	8	5.8	16	9.5	8	5.3	24	7.0	24	6.1	24
Total	5.8	-	5.9	-	6.2	-	6.4	-	5.9	-	6.4	-	6.1	-

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.*

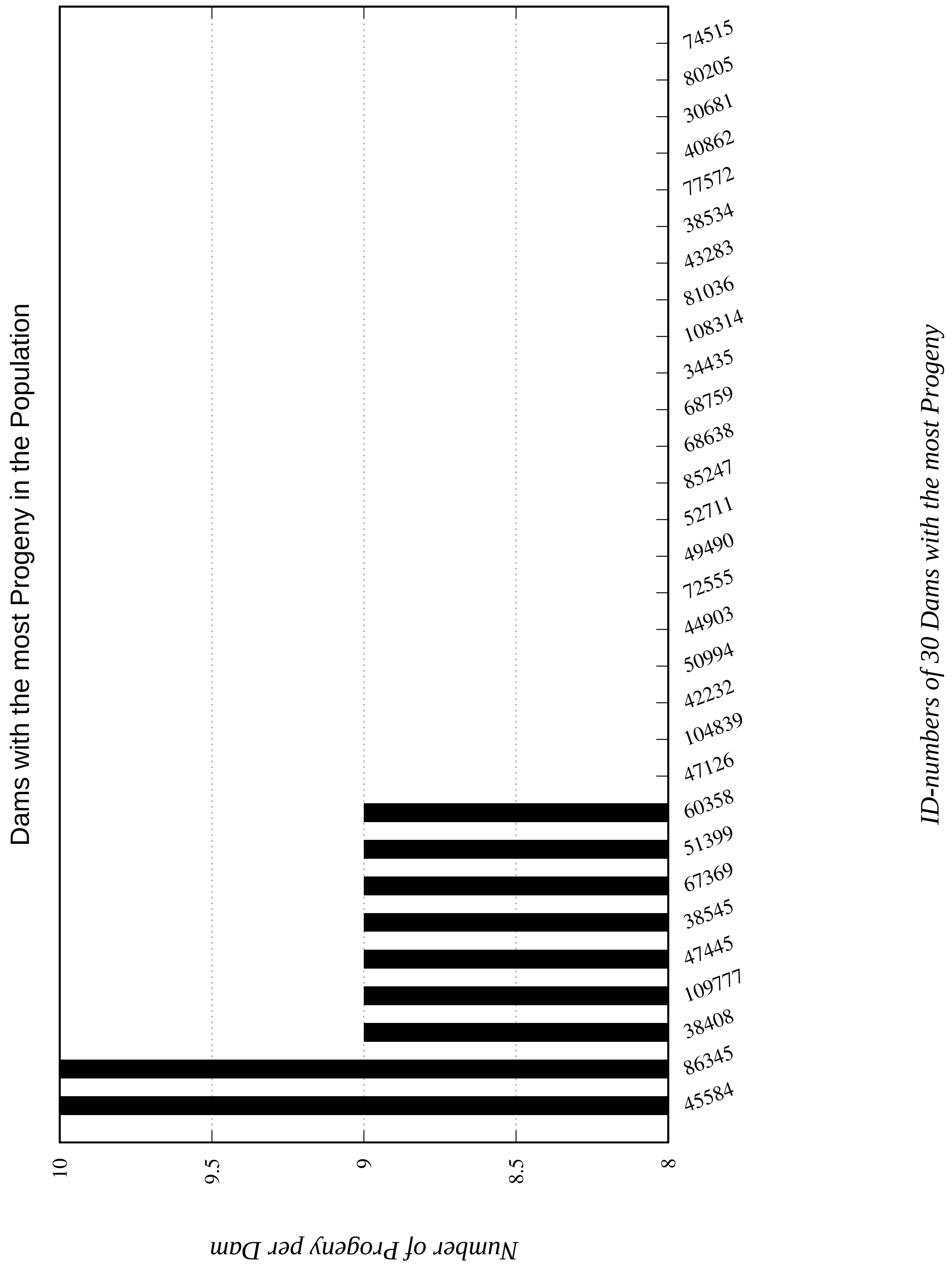
Table 6: The maximum and average number of family sizes

	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
1949	2	1.7	1	1.0	2	1.7	1	1.0	2	2.0	-	-	2	1.5	1	1.0
1951	44	12.8	5	3.0	24	7.8	5	3.0	3	1.7	3	3.0	23	8.7	2	1.5
1952	2	1.7	1	1.0	2	1.7	1	1.0	2	1.5	1	1.0	1	1.0	1	1.0
1953	1	1.0	4	2.5	1	1.0	4	2.5	1	1.0	1	1.0	-	-	3	3.0
1954	7	5.5	3	1.7	7	5.5	2	1.3	3	2.0	1	1.0	4	3.5	1	1.0
1955	46	16.3	4	2.0	33	12.0	2	1.3	9	3.7	1	1.0	24	12.5	2	2.0
1957	85	29.0	4	2.3	61	21.0	4	2.0	23	12.0	2	1.3	38	19.5	2	1.5
1958	150	50.7	2	1.3	84	28.7	1	1.0	15	8.0	1	1.0	69	35.0	1	1.0
1959	223	46.4	2	1.2	108	23.2	2	1.2	9	3.0	1	1.0	99	26.0	2	1.2
1960	7	3.5	3	2.0	6	2.5	3	2.0	3	2.0	2	1.5	3	2.0	3	2.5
1961	49	16.3	7	1.8	38	11.0	7	1.8	7	2.8	5	2.0	31	11.0	2	1.2
1962	81	22.3	5	2.0	39	12.5	3	1.5	10	4.1	2	1.2	29	9.2	3	1.3
1963	70	15.9	6	2.3	56	11.7	5	2.1	16	5.0	3	1.3	40	8.5	5	1.9
1964	229	32.3	6	2.0	127	19.5	5	1.6	25	4.6	2	1.2	121	18.8	3	1.5
1965	109	22.4	7	1.8	64	12.9	4	1.5	9	2.8	2	1.0	55	11.8	3	1.4
1966	106	22.0	6	1.7	83	14.6	6	1.4	13	4.2	2	1.1	77	12.4	5	1.4
1967	107	14.1	7	1.7	54	9.0	6	1.5	9	2.8	3	1.1	50	8.6	5	1.4
1968	569	25.3	6	1.8	301	14.2	6	1.5	32	4.1	2	1.1	269	12.8	6	1.5
1969	432	20.8	9	1.9	240	13.1	6	1.6	24	4.2	3	1.2	216	12.0	5	1.5
1970	259	11.8	8	1.7	136	8.2	8	1.5	22	3.5	3	1.1	114	7.8	5	1.5
1971	92	9.7	7	1.6	63	6.7	6	1.4	9	1.9	2	1.1	58	6.4	6	1.4
1972	960	20.8	8	1.6	484	15.9	6	1.4	45	3.9	2	1.1	439	14.8	5	1.4
1973	130	12.5	6	1.6	46	7.7	5	1.4	6	2.2	3	1.2	46	7.1	4	1.3
1974	116	8.2	7	1.7	74	6.1	5	1.5	24	2.5	4	1.2	50	5.7	5	1.4
1975	173	13.2	7	1.7	85	9.4	5	1.5	18	2.5	4	1.2	76	8.6	5	1.4

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
1976	195	14.9	7	1.8	98	10.0	6	1.5	11	2.3	3	1.2	87	9.6	6	1.4
1977	222	16.9	7	1.8	105	11.8	7	1.5	19	2.8	3	1.2	86	11.0	7	1.5
1978	80	11.2	7	1.8	51	7.5	6	1.5	9	2.0	4	1.2	48	7.3	5	1.4
1979	96	13.6	7	1.7	56	9.1	6	1.5	21	3.0	3	1.2	42	8.1	6	1.4
1980	312	16.7	8	1.8	180	11.1	6	1.5	33	2.8	3	1.2	147	10.1	6	1.4
1981	537	16.2	7	1.8	270	10.9	7	1.5	29	3.1	4	1.2	241	9.9	5	1.4
1982	448	17.5	10	1.7	234	11.0	7	1.5	18	3.8	2	1.1	220	10.2	6	1.4
1983	133	15.3	7	1.7	74	9.6	6	1.5	26	3.4	4	1.2	72	8.6	5	1.4
1984	351	15.0	8	1.7	196	10.3	8	1.5	16	3.7	4	1.3	181	9.3	6	1.4
1985	74	9.6	8	1.7	47	6.5	7	1.6	15	2.2	3	1.2	38	6.1	7	1.5
1986	70	8.1	8	1.7	34	5.5	6	1.5	8	2.3	3	1.2	33	5.1	5	1.5
1987	61	11.6	8	1.8	47	9.0	8	1.6	7	2.5	4	1.3	46	8.2	7	1.5
1988	1165	24.2	8	1.8	663	15.0	6	1.6	62	6.2	3	1.2	601	14.0	6	1.5
1989	505	24.2	8	1.8	285	15.3	7	1.6	38	5.1	5	1.2	247	13.7	5	1.5
1990	371	19.1	9	1.8	204	12.4	7	1.6	19	3.8	4	1.1	186	11.3	7	1.5
1991	508	22.5	7	1.8	279	14.5	7	1.5	31	4.2	5	1.2	248	13.4	6	1.5
1992	126	12.1	7	1.9	56	8.2	7	1.6	10	2.2	5	1.3	56	7.8	6	1.5
1993	111	12.1	9	1.9	68	8.3	7	1.6	8	2.4	5	1.3	60	7.7	6	1.5
1994	1339	38.1	7	1.8	765	24.1	6	1.5	98	6.3	3	1.3	667	22.0	6	1.4
1995	178	21.2	7	1.9	88	13.2	6	1.6	14	3.2	5	1.3	84	12.3	5	1.4
1996	218	18.4	8	1.8	108	11.0	7	1.5	17	2.9	4	1.3	91	10.2	6	1.4
1997	408	19.9	9	1.9	201	12.2	8	1.5	23	3.3	5	1.2	178	10.9	4	1.4
1998	368	18.8	8	1.9	136	10.2	7	1.5	18	2.6	5	1.2	118	9.3	5	1.4
1999	885	32.6	9	1.9	409	17.0	6	1.4	92	6.1	3	1.3	317	15.2	5	1.4
2000	978	28.5	10	1.8	465	14.3	6	1.4	68	5.8	3	1.3	397	12.7	5	1.3
2001	472	21.7	8	1.7	205	10.1	6	1.3	41	3.6	4	1.2	164	9.3	5	1.3
2002	80	14.8	9	1.7	55	7.0	6	1.3	12	2.4	5	1.2	43	6.2	5	1.2
2003	376	17.0	8	1.6	120	7.3	6	1.3	33	3.8	4	1.2	87	6.3	3	1.2
2004	51	12.2	8	1.6	28	4.4	4	1.2	9	1.8	4	1.2	23	3.9	3	1.1
2005	372	16.2	8	1.6	69	5.1	6	1.2	13	2.9	2	1.1	56	4.4	6	1.1
2006	262	12.2	7	1.5	42	3.8	4	1.1	18	2.4	2	1.1	40	3.4	3	1.1
2007	163	11.3	6	1.4	42	2.9	4	1.1	12	1.8	3	1.2	30	2.6	3	1.1
2008	276	10.9	6	1.3	34	3.1	5	1.1	9	2.0	5	1.2	25	2.6	2	1.0
2009	51	9.1	4	1.3	8	1.9	2	1.0	3	1.4	2	1.0	6	1.6	1	1.0
2010	28	7.5	4	1.2	4	1.4	2	1.0	2	1.2	1	1.0	3	1.3	1	1.0
2011	52	5.6	3	1.1	3	1.6	1	1.0	2	1.2	1	1.0	3	1.8	1	1.0
2012	38	4.3	3	1.1	1	1.0	-	-	1	1.0	-	-	-	-	-	-
2013	28	3.3	2	1.0	1	1.0	-	-	-	-	-	-	1	1.0	-	-
2014	5	1.7	1	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Total	1339	15.7	10	1.7	765	9.8	8	1.5	98	3.2	5	1.2	667	9.1	7	1.4

Figure 1: Dams with the most Progeny in the Population



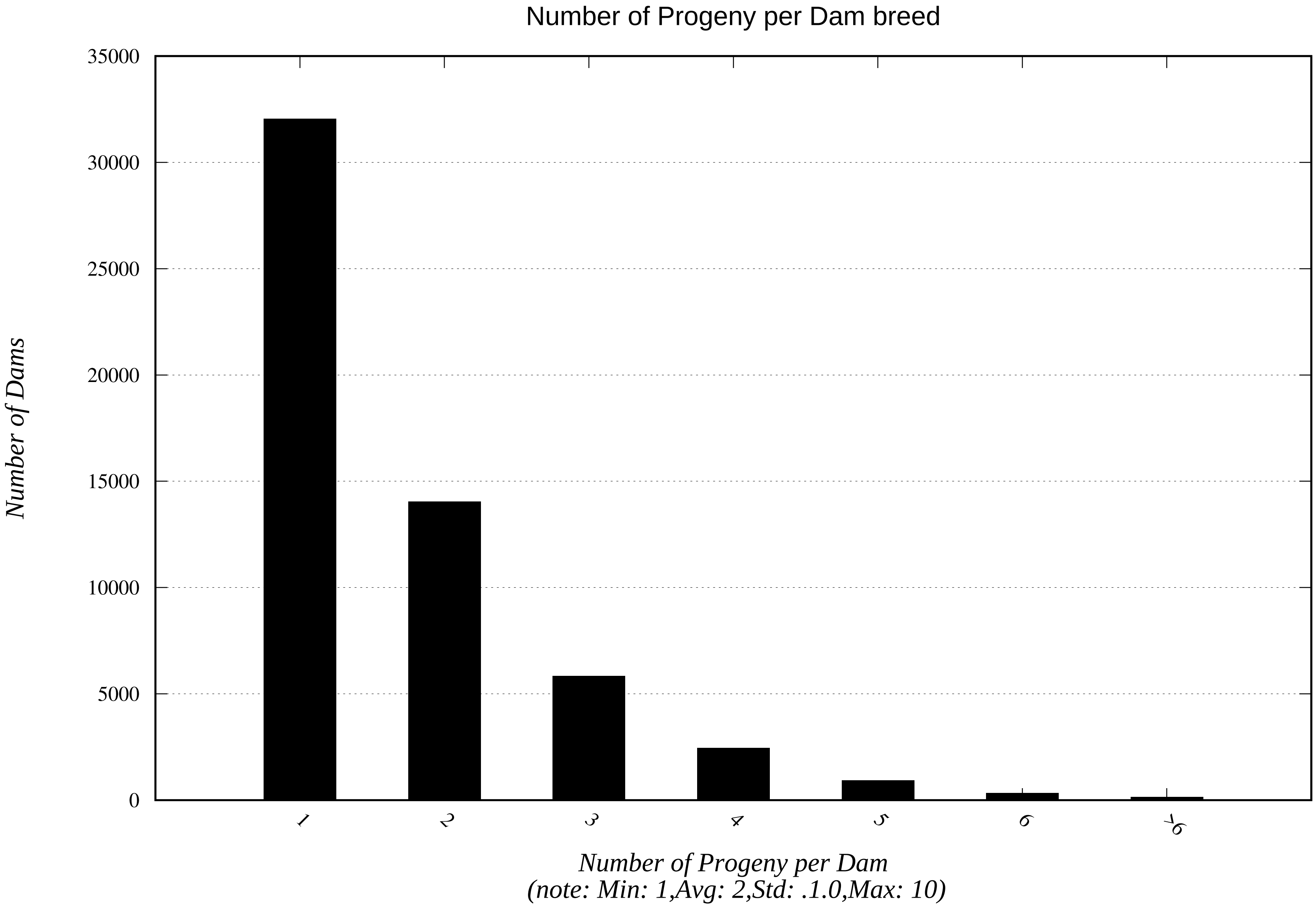
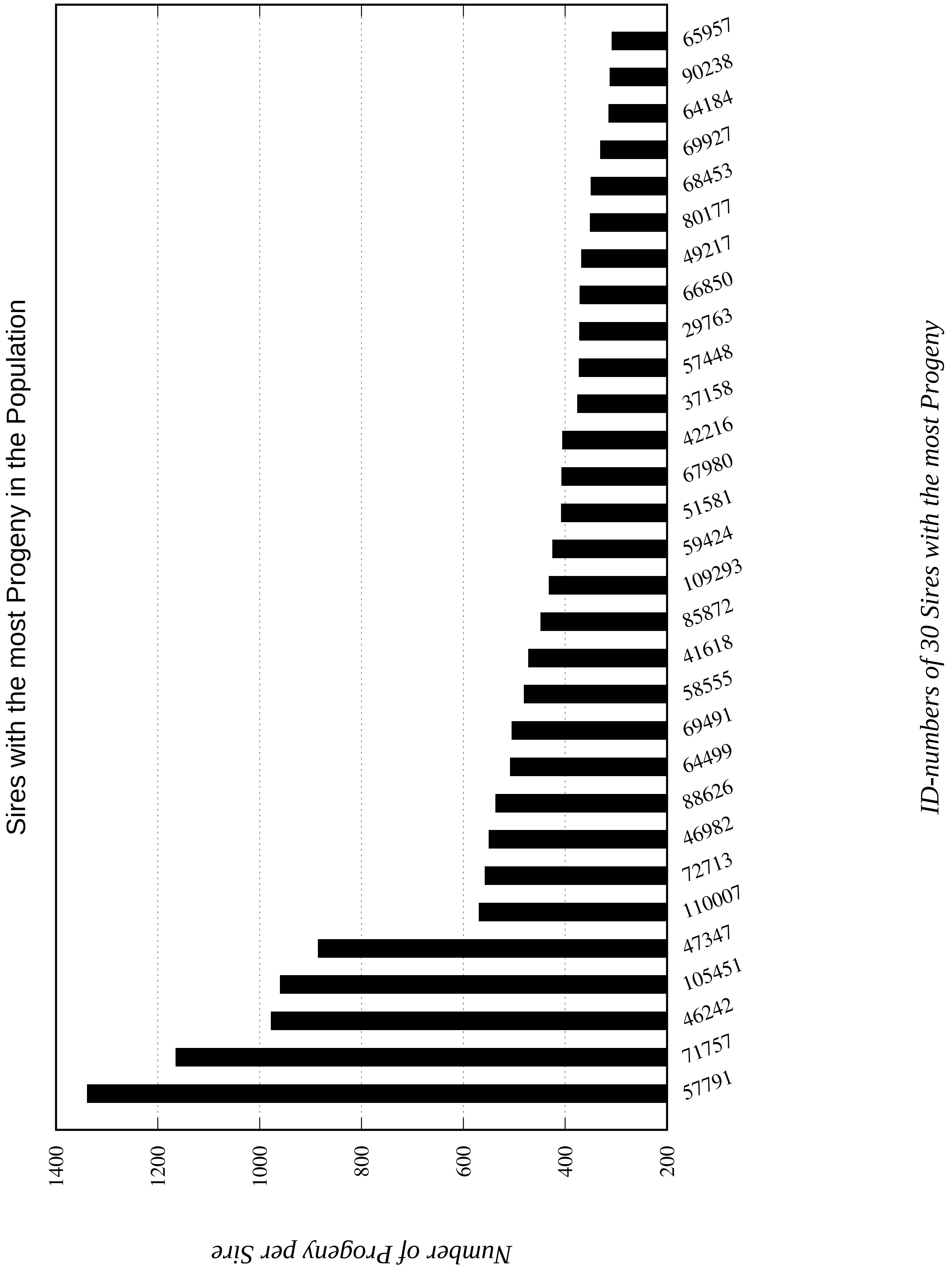


Figure 2: Number of Progeny per Dam

Figure 3: Sires with the most Progeny in the Population



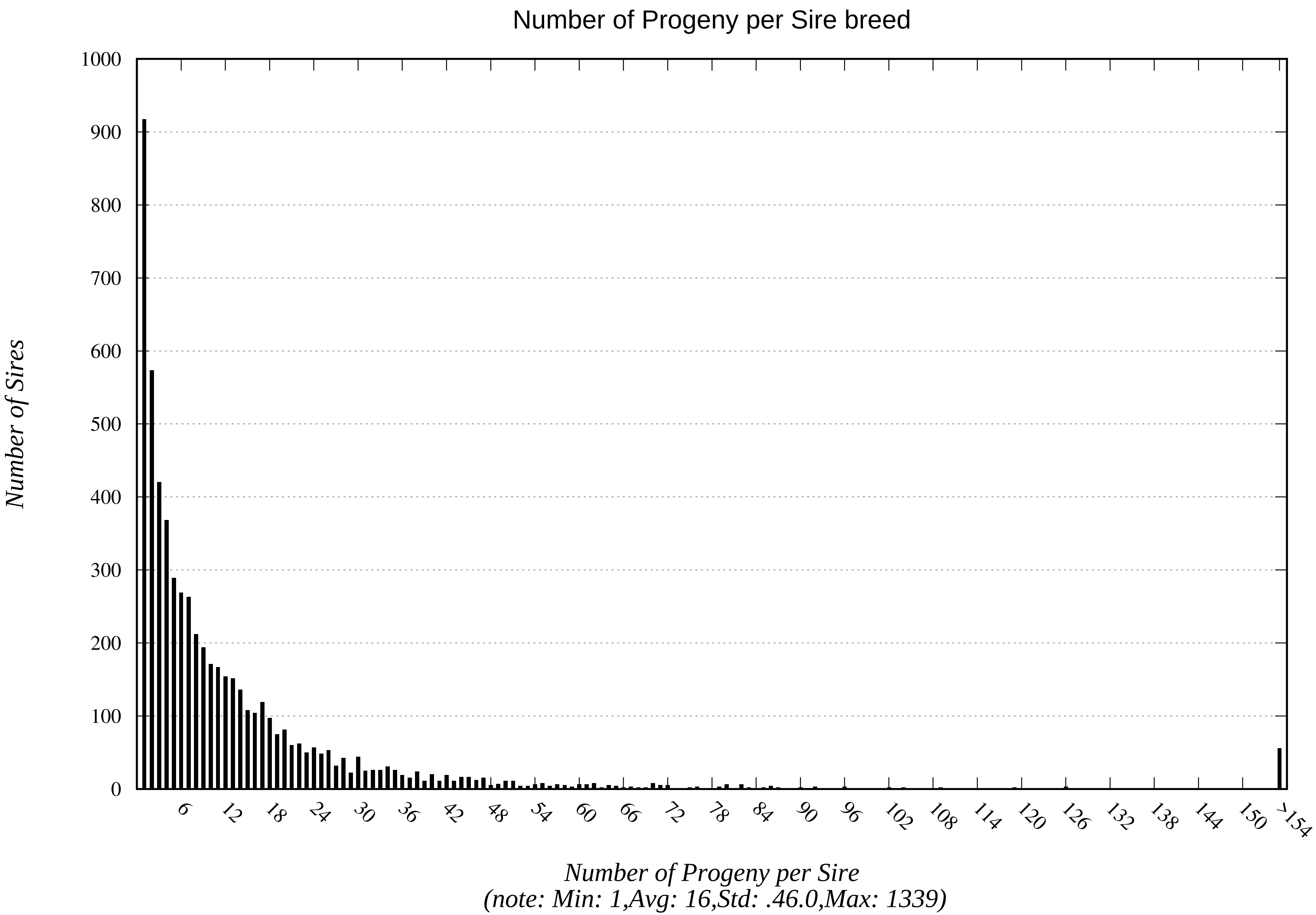


Figure 4: Number of Progeny per Sire

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

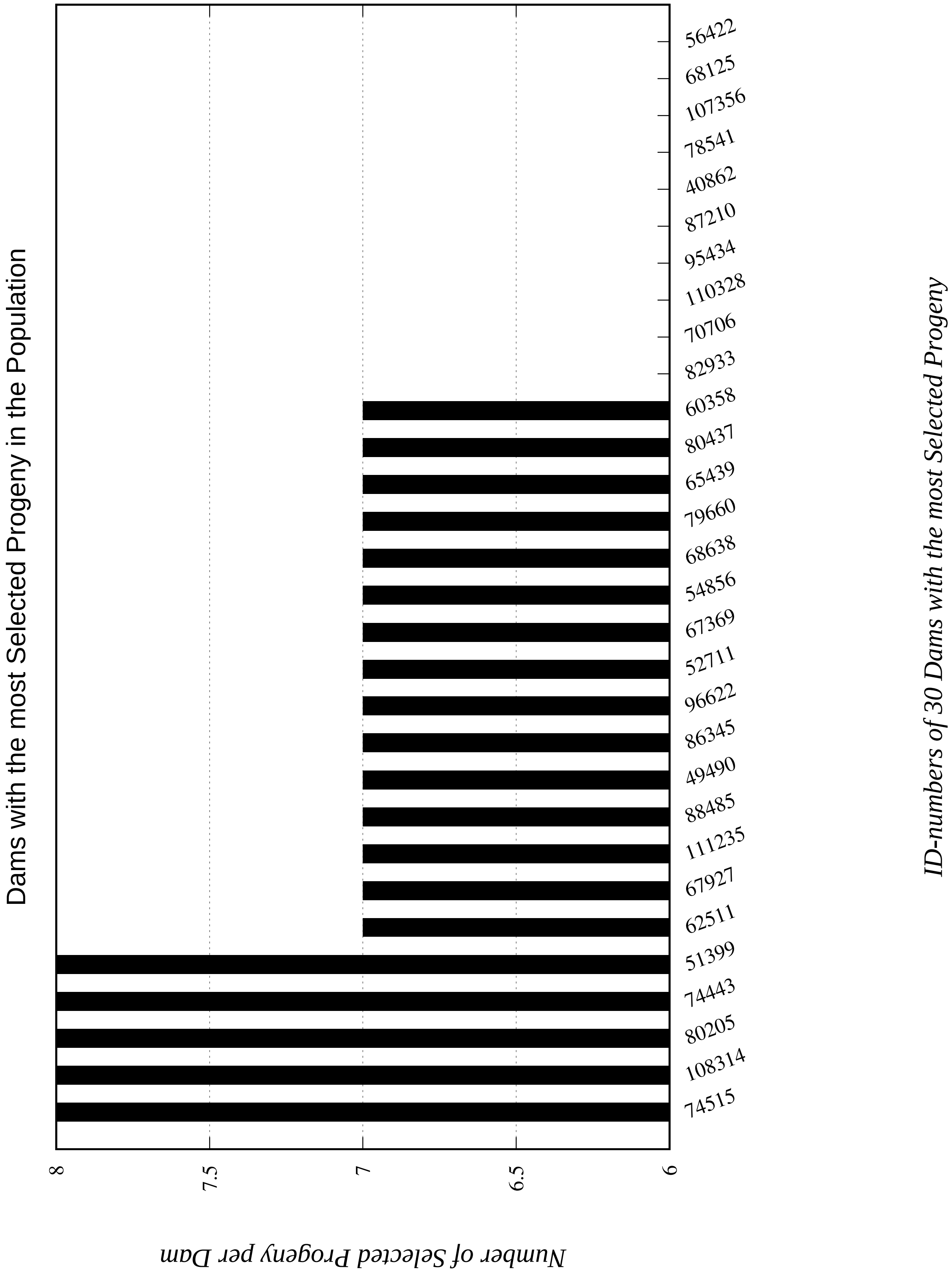


Figure 6: Number of Selected Progeny per Dam

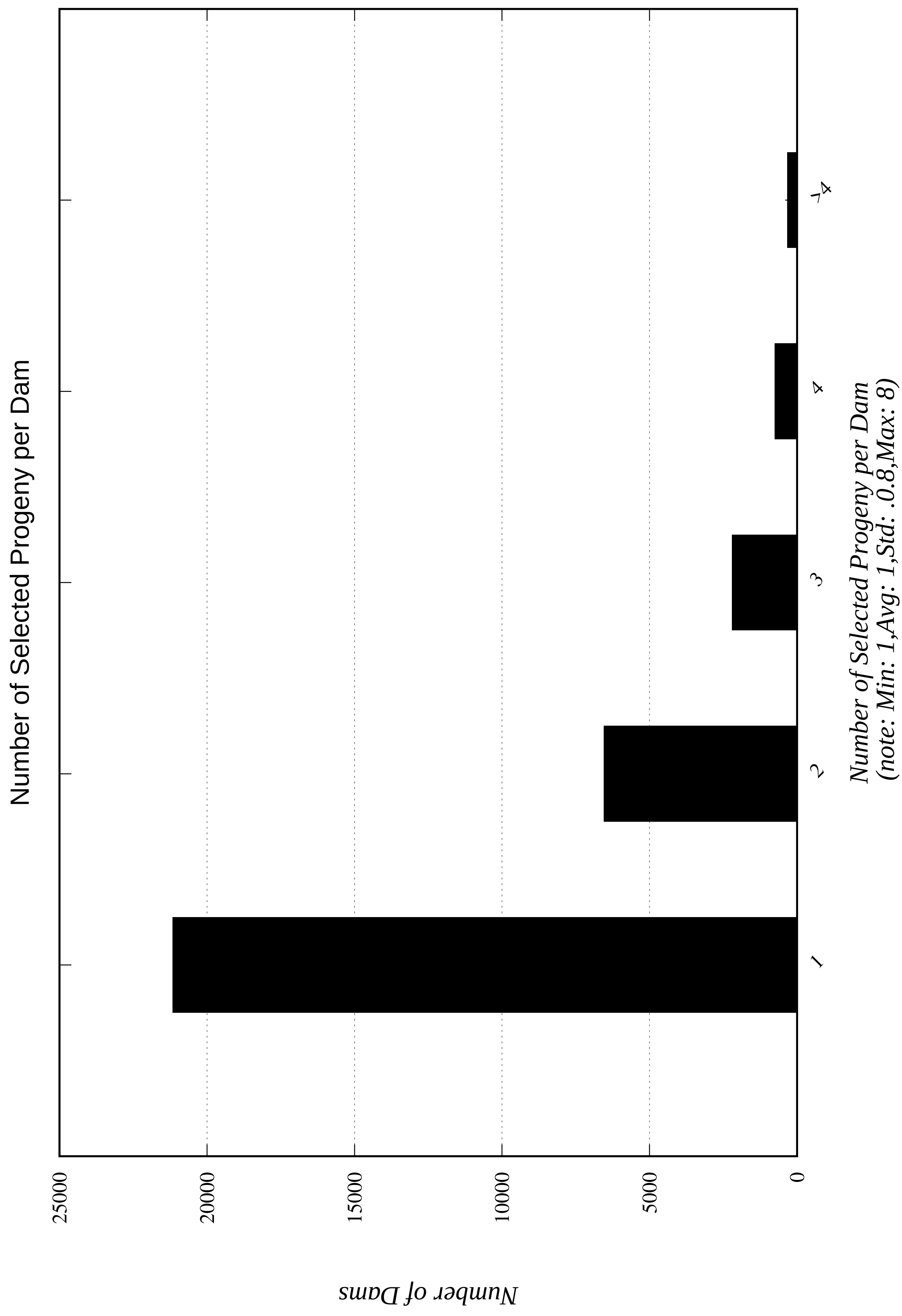


Figure 7: Sires with the most Selected Progeny in the Population

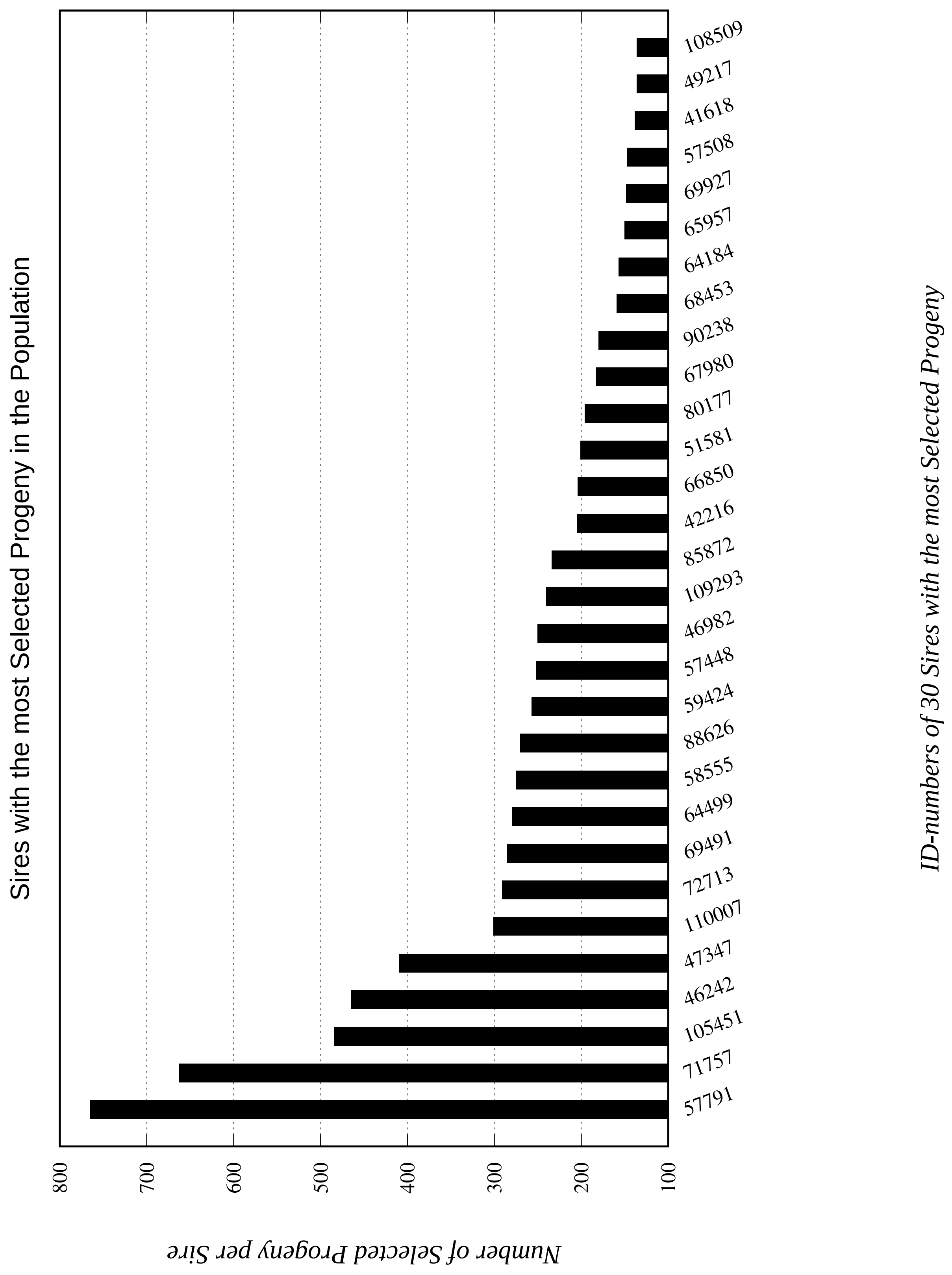


Figure 8: Number of Selected Progeny per Sire