Service PopReport at Institute of Farm Animal Genetics

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Bundesforschungsinstitut für Tiergesundheit

PopReport
A Pedigree Analysis Report

Population: UNKNOWN
Inputfile: POPREP.TXT
Initiated by: quaglia@anabic.it
Submitted at: 2019-08-02 12:35:54
Started at: 2019-08-02 12:36:01
Finished at: 2019-08-02 13:13:43

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

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Some Notes About Your PopReport Job:

- INFO: This job ran on machine rie-ex-web160 with 12 CPUs and MemTotal: 32950668 kB
- INFO: Your entered dateformat was 'YYYYMMDD', your dateseparator 'undef'.
  112988 input lines processed.
  112988 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	744	744	7192	5376
1974	884	884	8927	4525
1975	985	985	10506	4061
1976	1038	1038	11929	3854
1977	1087	1087	12939	3680
1978	1108	1108	13963	3610
1979	1077	1077	14125	3714
1980	1129	1129	14734	3543
1981	1128	1128	15068	3546
1982	1112	1112	15166	3597
1983	1137	1137	15398	3518
1984	1196	1196	15627	3344
1985	1234	1234	16087	3241
1986	1300	1300	16495	3077
1987	1371	1371	17047	2918
1988	1392	1392	17396	2874
1989	1392	1392	17522	2874
1990	1370	1370	17419	2920
1991	1310	1310	17188	3053
1992	1267	1267	17043	3157
1993	1225	1225	17080	3265
1994	1177	1177	16969	3398
1995	1115	1115	16611	3587
1996	1067	1067	16033	3749
1997	1045	1045	15675	3828
1998	1014	1014	15684	3945
1999	1034	1034	16069	3868
2000	1005	1005	16631	3980
2001	1034	1034	17197	3868

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Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	1053	1053	18105	3799
2003	1086	1086	19081	3683
2004	1152	1152	20165	3472
2005	1240	1240	21530	3226
2006	1368	1368	23026	2924
2007	1429	1429	23923	2799
2008	1526	1526	24343	2621
2009	1539	1539	24231	2599
2010	1553	1553	23779	2576
2011	1567	1567	23142	2553
2012	1539	1539	22632	2599
2013	1476	1476	21967	2710
2014	1400	1400	21030	2857
2015	1352	1352	20173	2959
2016	1271	1271	18550	3147
2017	1130	1130	16056	3540
2018	955	955	13473	4188

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Pedigree Analysis Report for Population: UNKNOWN

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Contents

List of Tables

List of Figures

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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):

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

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

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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	2053	84.6	79.9	75.7	71.6	65.9	58.7
1993	2222	79.2	75.0	71.4	68.0	63.4	57.1
1994	2274	82.4	78.6	75.0	71.8	67.4	61.2
1995	2186	83.8	80.5	77.4	74.5	70.5	64.6
1996	1981	86.0	83.4	80.4	77.8	74.1	68.5
1997	1924	82.7	80.3	77.6	75.3	72.2	67.4
1998	2083	84.3	82.0	79.5	77.2	74.4	70.1
1999	2380	84.2	81.6	79.1	76.9	74.3	70.5
2000	2586	81.5	78.6	76.1	73.9	71.6	68.2
2001	2817	83.6	80.0	77.3	75.0	72.7	69.5
2002	3201	83.6	79.6	76.7	74.4	72.1	69.2
2003	3195	86.4	81.9	78.8	76.4	74.2	71.5
2004	3131	89.5	84.2	80.8	78.2	75.9	73.4
2005	3377	89.8	84.8	81.4	78.8	76.6	74.2
2006	3707	91.5	86.0	82.3	79.6	77.4	75.0
2007	3338	90.8	85.5	81.9	79.2	77.0	74.7
2008	3103	94.4	88.7	84.8	82.0	79.7	77.5
2009	2718	95.7	89.9	85.8	83.0	80.7	78.5
2010	2763	96.2	90.5	86.3	83.4	81.1	79.0
2011	2572	97.2	91.7	87.5	84.7	82.4	80.3
2012	2593	98.2	93.0	89.0	86.1	83.9	81.9
2013	2649	98.3	93.3	89.3	86.5	84.3	82.3
2014	2694	99.0	94.2	90.1	87.2	85.0	83.0
2015	2433	99.4	95.9	92.6	90.1	88.2	86.3
2016	1399	99.6	97.0	94.4	92.3	90.6	88.9
2017	83	100.0	97.7	95.1	92.9	91.3	89.8
2018	5	100.0	100.0	100.0	100.0	100.0	99.4

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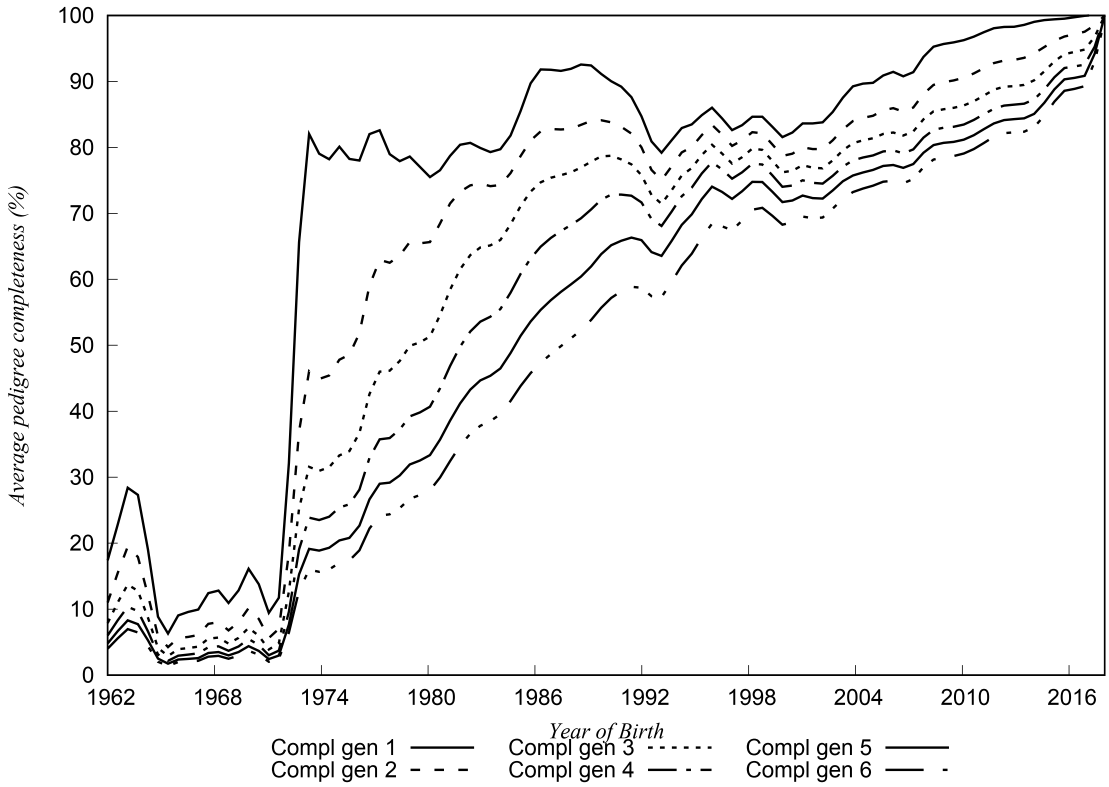
The average pedigee completeness for animals born within the last 10 years: 1 generations deep = 97.8%. 2 generations deep = 92.9%. 3 generations deep = 89%. 4 generations deep = 86.3%. 5 generations deep = 84.1%. 6 generations deep = 82.1%.

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 1962 and 2018 for the UNKNOWN breed.

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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	-	-	-	-	-

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	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	1890	100	26	8	13	15	1	-	-	-	-
1993	2080	77	29	10	15	10	-	1	-	-	-
1994	2121	82	31	14	6	19	1	-	-	-	-
1995	2060	77	22	3	5	19	-	-	-	-	-
1996	1842	65	35	6	3	30	-	-	-	-	-
1997	1795	73	30	9	1	16	-	-	-	-	-
1998	1910	90	34	15	2	29	3	-	-	-	-
1999	2221	87	32	12	-	27	1	-	-	-	-
2000	2417	94	30	12	-	33	-	-	-	-	-
2001	2632	87	25	26	3	44	-	-	-	-	-
2002	2971	112	32	14	1	67	1	3	-	-	-
2003	2973	120	39	11	2	49	-	1	-	-	-
2004	2932	115	29	9	3	41	1	1	-	-	-
2005	3126	126	29	16	1	73	2	4	-	-	-
2006	3465	113	34	13	3	75	3	1	-	-	-
2007	3125	110	34	8	-	57	4	-	-	-	-
2008	2925	95	19	10	-	53	1	-	-	-	-
2009	2557	91	36	5	-	29	-	-	-	-	-
2010	2529	139	23	9	-	60	2	1	-	-	-
2011	2374	105	22	5	2	62	-	2	-	-	-
2012	2376	109	39	7	-	58	2	2	-	-	-
2013	2401	145	35	9	-	57	1	1	-	-	-
2014	2445	121	35	19	-	67	5	2	-	-	-
2015	2163	162	32	9	-	64	2	-	1	-	-
2016	1233	107	23	6	-	28	2	-	-	-	-
2017	72	8	1	1	-	1	-	-	-	-	-
2018	5	-	-	-	-	-	-	-	-	-	-

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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
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

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	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	2053	1162	0.0147	341	210	0.0172	1872	500	0.0096
1993	2222	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	2186	1440	0.0128	352	283	0.0212	1904	773	0.0119
1996	1981	1430	0.0161	344	290	0.0216	1710	749	0.0128
1997	1924	1374	0.0156	340	293	0.0201	1598	767	0.0127
1998	2083	1559	0.0190	377	342	0.0204	1768	954	0.0131
1999	2380	1774	0.0164	385	354	0.0201	2030	1180	0.0147
2000	2586	1870	0.0169	395	374	0.0203	2170	1265	0.0143
2001	2817	2039	0.0182	442	426	0.0189	2443	1460	0.0136
2002	3201	2279	0.0196	477	463	0.0191	2817	1725	0.0143
2003	3195	2324	0.0187	480	470	0.0200	2883	1814	0.0141
2004	3131	2311	0.0187	491	482	0.0213	2893	1877	0.0146
2005	3377	2521	0.0217	549	545	0.0233	3131	2075	0.0159
2006	3707	2780	0.0207	609	602	0.0226	3505	2315	0.0155
2007	3338	2494	0.0202	616	612	0.0238	3147	2076	0.0159
2008	3103	2391	0.0202	639	635	0.0241	3003	1991	0.0152
2009	2718	2117	0.0199	674	670	0.0254	2634	1769	0.0163
2010	2763	2172	0.0242	687	683	0.0248	2678	1776	0.0172
2011	2572	2068	0.0244	694	690	0.0242	2513	1666	0.0162
2012	2593	2138	0.0257	709	707	0.0242	2547	1711	0.0179
2013	2649	2199	0.0262	702	699	0.0270	2606	1761	0.0177
2014	2694	2259	0.0281	687	686	0.0249	2671	1796	0.0182
2015	2433	2155	0.0299	677	676	0.0266	2406	1741	0.0188
2016	1399	1282	0.0305	462	460	0.0275	1387	1076	0.0202
2017	83	77	0.0288	60	60	0.0298	83	65	0.0178
2018	5	5	0.0315	4	4	0.0198	5	5	0.0217

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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

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		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	2053	0.0000	0.3019	0.0147	0.0371
1993	2222	0.0000	0.3750	0.0137	0.0353
1994	2274	0.0000	0.3172	0.0139	0.0355
1995	2186	0.0000	0.2742	0.0128	0.0324
1996	1981	0.0000	0.2916	0.0161	0.0391
1997	1924	0.0000	0.2871	0.0156	0.0333
1998	2083	0.0000	0.3301	0.0190	0.0409
1999	2380	0.0000	0.3133	0.0164	0.0358
2000	2586	0.0000	0.2871	0.0169	0.0359
2001	2817	0.0000	0.2927	0.0182	0.0391
2002	3201	0.0000	0.3830	0.0196	0.0434
2003	3195	0.0000	0.3790	0.0187	0.0380
2004	3131	0.0000	0.3532	0.0187	0.0363
2005	3377	0.0000	0.3813	0.0217	0.0441
2006	3707	0.0000	0.3878	0.0207	0.0418
2007	3338	0.0000	0.3233	0.0202	0.0395
2008	3103	0.0000	0.3009	0.0202	0.0376
2009	2718	0.0000	0.2767	0.0199	0.0326
2010	2763	0.0000	0.3594	0.0242	0.0427
2011	2572	0.0000	0.3795	0.0244	0.0438
2012	2593	0.0000	0.3825	0.0257	0.0438
2013	2649	0.0000	0.3857	0.0262	0.0426
2014	2694	0.0000	0.3884	0.0281	0.0471
2015	2433	0.0000	0.4213	0.0299	0.0459
2016	1399	0.0000	0.3160	0.0305	0.0425
2017	83	0.0000	0.2970	0.0288	0.0388
2018	5	0.0121	0.0389	0.0315	0.0110

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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

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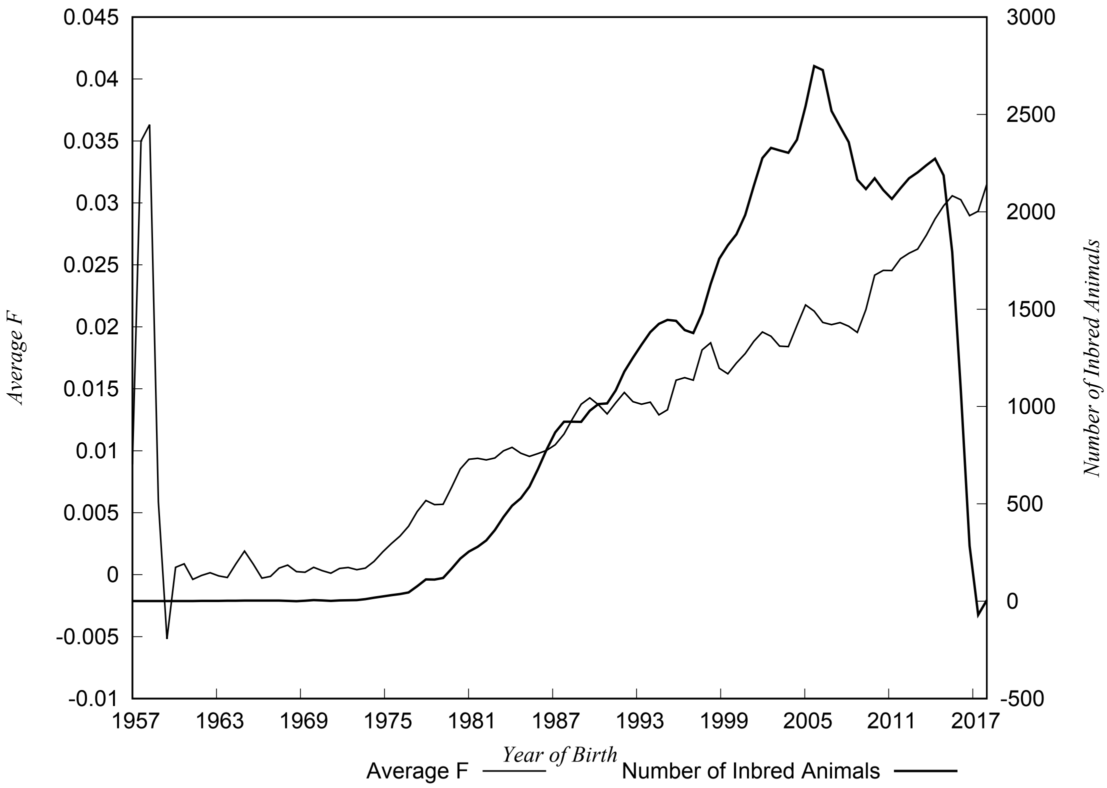
		F			
Year	No of Animals	Min	Max	Avg	Std
2003	2324	0.0002	0.3790	0.0257	0.0425
2004	2311	0.0000	0.3532	0.0253	0.0402
2005	2521	0.0001	0.3813	0.0291	0.0489
2006	2780	0.0001	0.3878	0.0276	0.0462
2007	2494	0.0001	0.3233	0.0270	0.0437
2008	2391	0.0001	0.3009	0.0262	0.0410
2009	2117	0.0001	0.2767	0.0255	0.0350
2010	2172	0.0000	0.3594	0.0307	0.0460
2011	2068	0.0015	0.3795	0.0304	0.0470
2012	2138	0.0006	0.3825	0.0311	0.0464
2013	2199	0.0001	0.3857	0.0316	0.0449
2014	2259	0.0001	0.3884	0.0335	0.0496
2015	2155	0.0001	0.4213	0.0338	0.0475
2016	1282	0.0004	0.3160	0.0333	0.0434
2017	77	0.0037	0.2970	0.0310	0.0395
2018	5	0.0121	0.0389	0.0315	0.0110

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



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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	0.0016	0.0000	0.0000	0.0000	0.0016	304
1958	0.0074	0.0000	0.0000	0.0000	0.0074	67
1959	0.0066	0.0031	0.0000	0.0016	0.0051	99
1960	0.0065	0.0142	0.0000	0.0074	-0.0009	-534
1961	0.0052	0.0136	0.0000	0.0069	-0.0017	-286
1962	0.0040	0.0130	0.0000	0.0065	-0.0025	-198
1963	0.0031	0.0108	0.0000	0.0055	-0.0024	-208
1964	0.0020	0.0089	0.0000	0.0045	-0.0025	-199
1965	0.0018	0.0088	0.0000	0.0045	-0.0027	-182
1966	0.0006	0.0069	0.0000	0.0035	-0.0029	-173
1967	0.0004	0.0084	0.0000	0.0043	-0.0039	-128
1968	0.0005	0.0043	0.0000	0.0022	-0.0016	-305
1969	0.0004	0.0037	0.0000	0.0019	-0.0015	-343
1970	0.0005	0.0037	0.0000	0.0019	-0.0014	-363
1971	0.0003	0.0041	0.0000	0.0021	-0.0018	-285
1972	0.0004	0.0050	0.0001	0.0026	-0.0022	-228

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	Avg F					
Year	Animals	Sires	Dams	Parents	ΔF	*Ne*
1973	0.0004	0.0047	0.0001	0.0024	-0.0021	-241
1974	0.0005	0.0063	0.0002	0.0032	-0.0028	-181
1975	0.0008	0.0072	0.0002	0.0037	-0.0030	-169
1976	0.0011	0.0076	0.0002	0.0039	-0.0028	-176
1977	0.0015	0.0079	0.0003	0.0041	-0.0026	-194
1978	0.0022	0.0078	0.0003	0.0041	-0.0019	-264
1979	0.0029	0.0082	0.0006	0.0044	-0.0015	-329
1980	0.0038	0.0087	0.0007	0.0047	-0.0010	-525
1981	0.0049	0.0102	0.0010	0.0056	-0.0007	-718
1982	0.0060	0.0117	0.0015	0.0066	-0.0005	-939
1983	0.0070	0.0126	0.0021	0.0073	-0.0003	-1494
1984	0.0079	0.0134	0.0028	0.0081	-0.0002	-3091
1985	0.0085	0.0142	0.0037	0.0089	-0.0004	-1192
1986	0.0089	0.0147	0.0045	0.0096	-0.0006	-775
1987	0.0095	0.0147	0.0051	0.0099	-0.0004	-1217
1988	0.0100	0.0146	0.0060	0.0103	-0.0003	-1645
1989	0.0105	0.0145	0.0068	0.0106	0.0000	-13704
1990	0.0111	0.0141	0.0073	0.0107	0.0004	1204
1991	0.0115	0.0140	0.0079	0.0109	0.0006	845
1992	0.0120	0.0138	0.0083	0.0110	0.0010	504
1993	0.0125	0.0135	0.0087	0.0111	0.0014	348
1994	0.0130	0.0140	0.0094	0.0116	0.0014	354
1995	0.0134	0.0150	0.0100	0.0124	0.0010	499
1996	0.0140	0.0165	0.0105	0.0134	0.0006	863
1997	0.0142	0.0178	0.0110	0.0143	-0.0001	-4588
1998	0.0148	0.0190	0.0116	0.0152	-0.0004	-1322
1999	0.0153	0.0203	0.0122	0.0161	-0.0009	-569
2000	0.0156	0.0217	0.0128	0.0172	-0.0016	-308
2001	0.0162	0.0229	0.0131	0.0179	-0.0018	-286
2002	0.0170	0.0234	0.0135	0.0183	-0.0013	-375
2003	0.0178	0.0234	0.0138	0.0185	-0.0007	-683
2004	0.0180	0.0228	0.0140	0.0183	-0.0003	-1716
2005	0.0188	0.0226	0.0144	0.0184	0.0004	1259
2006	0.0191	0.0221	0.0147	0.0183	0.0008	665
2007	0.0195	0.0218	0.0148	0.0183	0.0012	406
2008	0.0198	0.0216	0.0149	0.0182	0.0016	303
2009	0.0200	0.0217	0.0152	0.0184	0.0016	306
2010	0.0205	0.0220	0.0155	0.0187	0.0018	276
2011	0.0211	0.0225	0.0158	0.0191	0.0021	240
2012	0.0219	0.0230	0.0162	0.0195	0.0025	203
2013	0.0225	0.0232	0.0164	0.0198	0.0027	182
2014	0.0234	0.0237	0.0167	0.0202	0.0033	152
2015	0.0247	0.0242	0.0171	0.0206	0.0041	122
2016	0.0258	0.0247	0.0176	0.0212	0.0047	106
2017	0.0267	0.0249	0.0178	0.0214	0.0055	91
2018	0.0272	0.0250	0.0180	0.0215	0.0059	85

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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):

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

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	35	13	13	26	18
1956	35	14	14	28	20
1957	38	16	16	32	22
1958	42	16	17	33	23
1959	47	19	20	39	27
1960	48	19	21	40	28
1961	60	20	23	43	30
1962	78	23	25	48	34
1963	101	26	29	55	38
1964	159	37	43	80	56
1965	352	44	53	97	67
1966	619	63	78	141	98
1967	937	82	105	187	129
1968	1406	113	167	280	189
1969	2060	155	242	397	265

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	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
1970	2951	226	390	616	401
1971	4774	281	557	838	523
1972	6291	363	875	1238	718
1973	7936	516	2136	2652	1164
1974	9811	613	3396	4009	1454
1975	11491	703	4410	5113	1698
1976	12967	787	5327	6114	1920
1977	14026	899	6191	7090	2198
1978	15071	975	7101	8076	2400
1979	15202	1060	7984	9044	2620
1980	15863	1103	8815	9918	2745
1981	16196	1096	9090	10186	2739
1982	16278	1091	9218	10309	2732
1983	16535	1101	9375	10476	2759
1984	16823	1076	9416	10492	2704
1985	17321	1077	9656	10733	2713
1986	17795	1107	10145	11252	2795
1987	18418	1153	10739	11892	2915
1988	18788	1183	11181	12364	2995
1989	18914	1254	11479	12733	3165
1990	18789	1269	11584	12853	3202
1991	18498	1284	11603	12887	3237
1992	18310	1310	11776	13086	3301
1993	18305	1322	11949	13271	3333
1994	18146	1319	11840	13159	3323
1995	17726	1293	11461	12754	3253
1996	17100	1266	10945	12211	3177
1997	16720	1208	10536	11744	3034
1998	16698	1184	10374	11558	2976
1999	17103	1169	10484	11653	2945
2000	17636	1171	10770	11941	2957
2001	18231	1159	11069	12228	2938
2002	19158	1169	11614	12783	2974
2003	20167	1174	12238	13412	2999
2004	21317	1198	12912	14110	3070
2005	22770	1254	13895	15149	3221
2006	24394	1315	14980	16295	3385
2007	25352	1391	15745	17136	3579
2008	25869	1508	16307	17815	3865
2009	25770	1589	16608	18197	4061
2010	25332	1667	16679	18346	4243
2011	24709	1740	16638	18378	4411
2012	24171	1803	16555	18358	4553
2013	23443	1847	16358	18205	4647
2014	22430	1859	15827	17686	4658
2015	21525	1875	15340	17215	4678
2016	19821	1818	14292	16110	4516
2017	17186	1681	12755	14436	4159

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	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
2018	14428	1532	11138	12670	3771

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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	35	0.01420	-	0.00000	-	3 (3.0)
1956	35	0.01575	0.01575	0.00000	0.00000	8 (-)
1957	38	0.01383	0.01383	0.00890	0.00890	2 (2.0)

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		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
1958	42	0.01200	0.01200	0.04170	0.04170	8 (-)
1959	47	0.01018	0.00426	0.00000	0.00000	3 (2.7)
1960	48	0.00896	0.00147	0.00000	0.00000	4 (4.2)
1961	60	0.00649	-0.00617	0.00000	0.00000	2 (2.0)
1962	78	0.00423	-0.00883	0.00000	0.00000	3 (3.0)
1963	101	0.00338	-0.01098	0.00000	0.00000	3 (3.4)
1964	159	0.00210	-0.01387	0.00000	0.00000	3 (3.2)
1965	352	0.00076	-0.01326	0.00190	-0.00706	4 (3.5)
1966	619	0.00042	-0.01172	0.00000	-0.04351	3 (2.6)
1967	937	0.00029	-0.00999	0.00000	0.00000	3 (3.1)
1968	1406	0.00023	-0.00881	0.00080	0.00080	3 (3.0)
1969	2060	0.00017	-0.00636	0.00010	0.00010	3 (3.4)
1970	2951	0.00015	-0.00410	0.00060	0.00060	4 (3.6)
1971	4774	0.00010	-0.00329	0.00010	0.00010	4 (4.1)
1972	6291	0.00010	-0.00201	0.00060	0.00060	4 (4.1)
1973	6120	0.00020	-0.00055	0.00040	-0.00150	5 (4.8)
1974	5409	0.00030	-0.00011	0.00080	0.00080	5 (5.4)
1975	5046	0.00038	0.00009	0.00200	0.00200	6 (5.6)
1976	4892	0.00047	0.00024	0.00300	0.00220	6 (5.7)
1977	4767	0.00059	0.00042	0.00440	0.00430	6 (5.7)
1978	4718	0.00073	0.00059	0.00600	0.00540	6 (6.0)
1979	4791	0.00099	0.00089	0.00550	0.00540	6 (6.0)
1980	4672	0.00125	0.00115	0.00760	0.00700	6 (6.0)
1981	4674	0.00154	0.00134	0.00930	0.00890	6 (6.3)
1982	4709	0.00196	0.00166	0.00930	0.00851	6 (6.1)
1983	4655	0.00235	0.00197	0.00950	0.00752	6 (6.2)
1984	4540	0.00285	0.00238	0.01030	0.00732	6 (6.4)
1985	4475	0.00329	0.00270	0.00960	0.00522	6 (6.1)
1986	4377	0.00374	0.00301	0.00980	0.00382	6 (6.3)
1987	4289	0.00441	0.00343	0.01030	0.00483	6 (6.2)
1988	4266	0.00498	0.00374	0.01170	0.00413	6 (6.4)
1989	4266	0.00599	0.00446	0.01370	0.00444	7 (6.5)
1990	4290	0.00655	0.00460	0.01410	0.00485	7 (6.5)
1991	4363	0.00719	0.00485	0.01300	0.00353	6 (5.8)
1992	4424	0.00785	0.00502	0.01470	0.00445	6 (5.5)
1993	4490	0.00875	0.00548	0.01370	0.00414	6 (5.7)
1994	4575	0.00963	0.00590	0.01390	0.00414	6 (5.6)
1995	4702	0.01035	0.00597	0.01280	0.00253	6 (5.8)
1996	4816	0.01064	0.00568	0.01610	0.00445	6 (6.0)
1997	4873	0.01147	0.00551	0.01560	0.00193	6 (5.7)
1998	4959	0.01202	0.00550	0.01900	0.00497	6 (6.0)
1999	4902	0.01242	0.00526	0.01640	0.00344	6 (6.0)
2000	4985	0.01305	0.00524	0.01690	0.00223	6 (6.2)
2001	4902	0.01371	0.00500	0.01820	0.00456	6 (6.4)
2002	4852	0.01433	0.00475	0.01960	0.00578	7 (6.5)
2003	4769	0.01492	0.00461	0.01870	0.00598	6 (6.4)
2004	4624	0.01585	0.00527	0.01870	0.00264	6 (6.4)
2005	4466	0.01654	0.00513	0.02170	0.00620	6 (6.4)

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		AGR		F		Generation Interval
Year	No Animals	Avg	Δf	Avg	ΔF	() = True GI
2006	4292	0.01692	0.00497	0.02070	0.00173	7 (6.6)
2007	4228	0.01778	0.00543	0.02020	0.00386	7 (6.8)
2008	4147	0.01889	0.00592	0.02020	0.00336	7 (6.6)
2009	4138	0.01923	0.00559	0.01990	0.00173	7 (6.8)
2010	4129	0.01987	0.00562	0.02420	0.00469	7 (6.7)
2011	4120	0.02033	0.00550	0.02440	0.00581	7 (6.7)
2012	4138	0.02081	0.00504	0.02570	0.00713	7 (7.0)
2013	4186	0.02169	0.00523	0.02620	0.00460	8 (7.5)
2014	4257	0.02194	0.00511	0.02810	0.00756	7 (7.0)
2015	4311	0.02299	0.00531	0.02990	0.00990	7 (7.1)
2016	4418	0.02347	0.00468	0.03050	0.01051	8 (-)
2017	4670	0.02401	0.00488	0.02880	0.00908	8 (-)
2018	5143	0.02460	0.00483	0.03150	0.00748	8 (-)

Fixed Time interval used to calculate Delta AGR: 8

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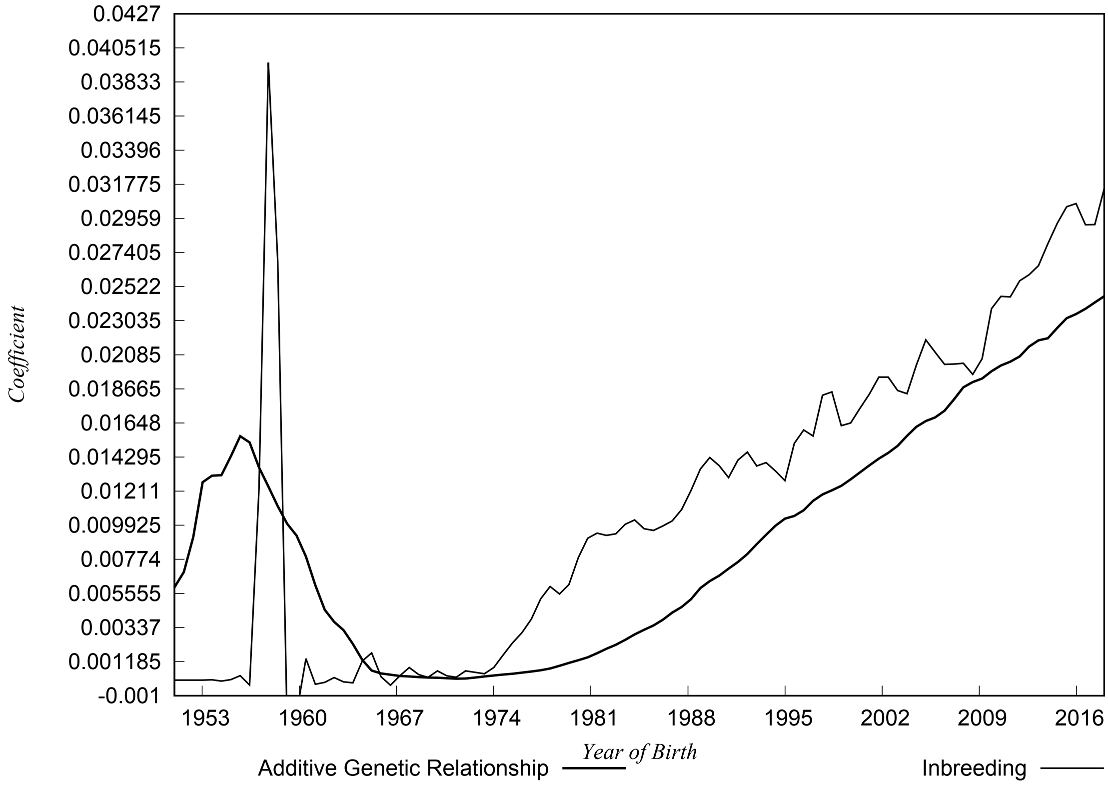
Figure 3: Average Additive Genetic Relationships and Inbreeding Coefficients by year of birth



The average rate of change of the additive genetic relationships between 1951 and 2018 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 0.00204. The rate of change of the average inbreeding coefficients based on the slope of the regression between 1951 and 2018 was 0.00043, which represents a ΔF per generation of 0.00354. The effective population sizes for the UNKNOWN breed, based on Δf and ΔF were 245 and 141, respectively.

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Figure 4: Average Log(1-F) by year of birth for animals born between 1948 and 2018.

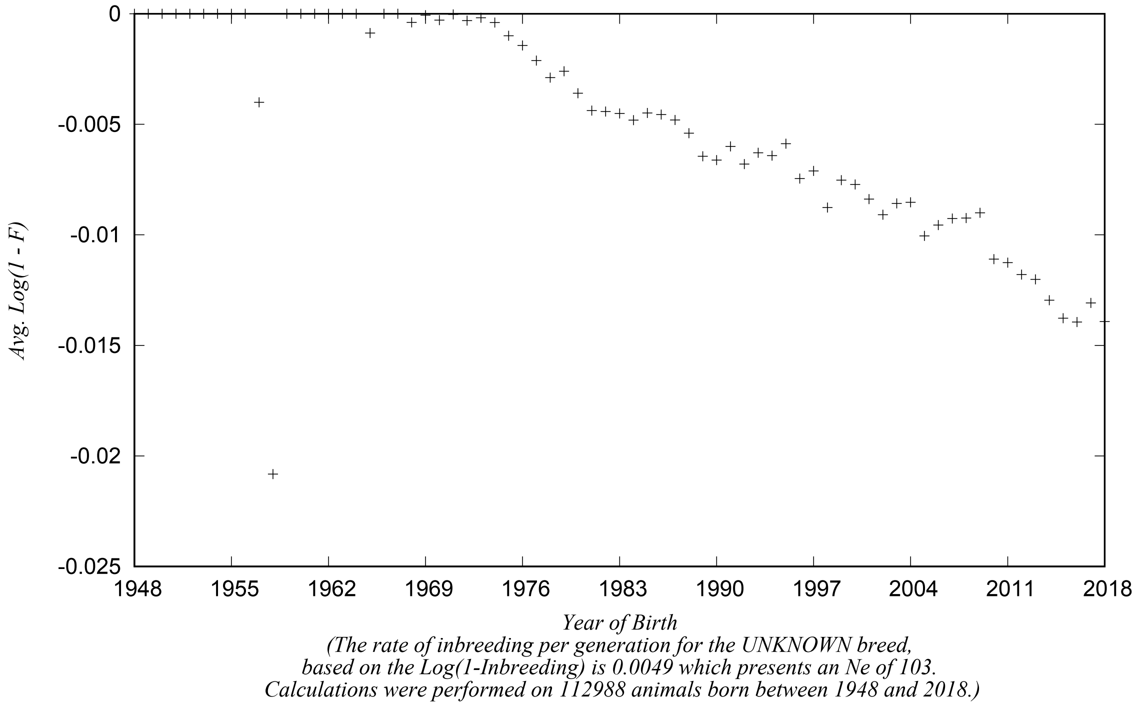

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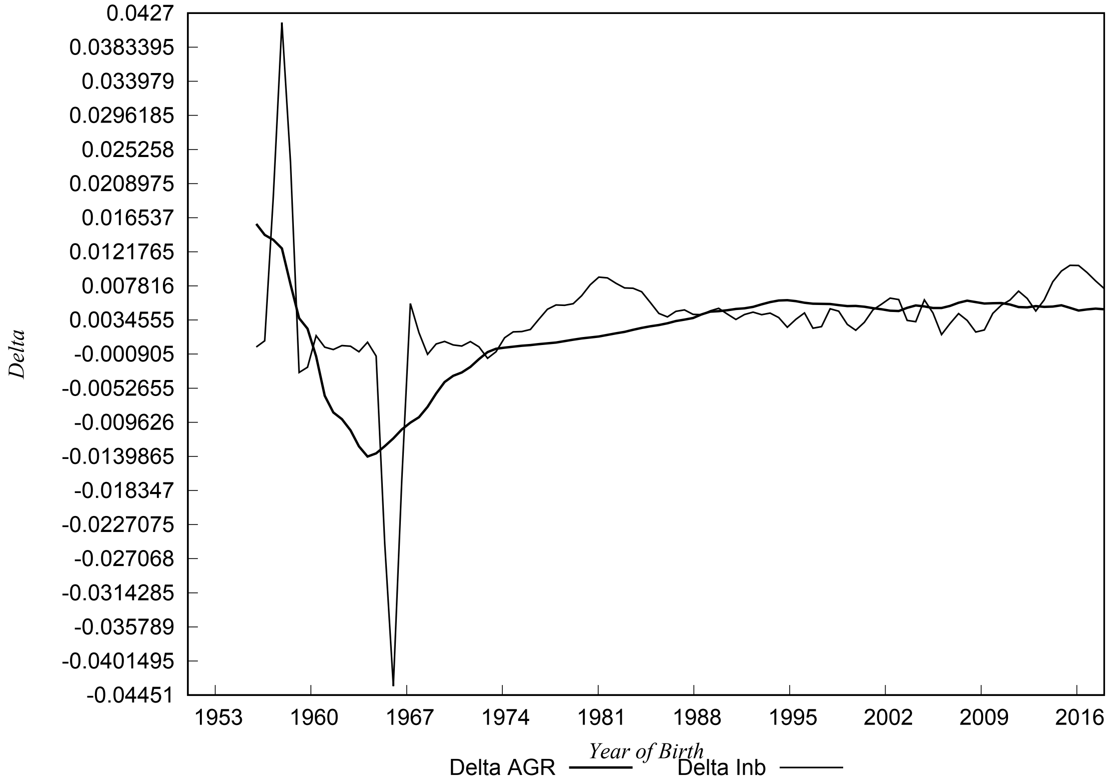
Figure 5: The Rate of Inbreeding and Increase in the Additive Genetic Relationships by year of birth



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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:	2019-08-02 12:35:54
Started at:	2019-08-02 12:36:01
Finished at:	2019-08-02 13:13:43

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

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Some Notes About Your PopReport Job:

- INFO: This job ran on machine rie-ex-web160 with 12 CPUs and MemTotal: 32950668 kB
- INFO: Your entered dateformat was 'YYYYMMDD', your dateseparator 'undef'.
  112988 input lines processed.
  112988 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	744	744	7192	5376
1974	884	884	8927	4525
1975	985	985	10506	4061
1976	1038	1038	11929	3854
1977	1087	1087	12939	3680
1978	1108	1108	13963	3610
1979	1077	1077	14125	3714
1980	1129	1129	14734	3543
1981	1128	1128	15068	3546
1982	1112	1112	15166	3597
1983	1137	1137	15398	3518
1984	1196	1196	15627	3344
1985	1234	1234	16087	3241
1986	1300	1300	16495	3077
1987	1371	1371	17047	2918
1988	1392	1392	17396	2874
1989	1392	1392	17522	2874
1990	1370	1370	17419	2920
1991	1310	1310	17188	3053
1992	1267	1267	17043	3157
1993	1225	1225	17080	3265
1994	1177	1177	16969	3398
1995	1115	1115	16611	3587
1996	1067	1067	16033	3749
1997	1045	1045	15675	3828
1998	1014	1014	15684	3945
1999	1034	1034	16069	3868
2000	1005	1005	16631	3980
2001	1034	1034	17197	3868

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Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	1053	1053	18105	3799
2003	1086	1086	19081	3683
2004	1152	1152	20165	3472
2005	1240	1240	21530	3226
2006	1368	1368	23026	2924
2007	1429	1429	23923	2799
2008	1526	1526	24343	2621
2009	1539	1539	24231	2599
2010	1553	1553	23779	2576
2011	1567	1567	23142	2553
2012	1539	1539	22632	2599
2013	1476	1476	21967	2710
2014	1400	1400	21030	2857
2015	1352	1352	20173	2959
2016	1271	1271	18550	3147
2017	1130	1130	16056	3540
2018	955	955	13473	4188

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Monitoring the Population UNKNOWN

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Developers at FLI:
Carina Apelt – Implementation of Monitoring Module
Helmut Lichtenberg – Integration and WEB service
Eildert Groeneveld – Project Leader

August 2, 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.

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

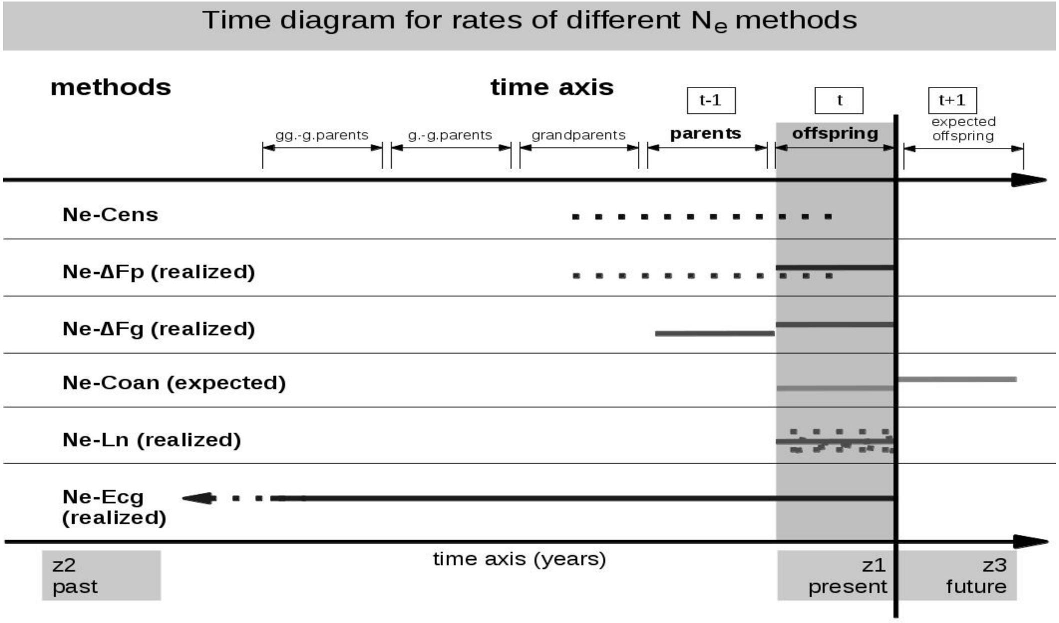

Table 2: Order of methods in cascade

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

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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.

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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 • 112988 pedigree records • generation interval: 8 • August 2, 2019

Figure 2: Number of breeding animals

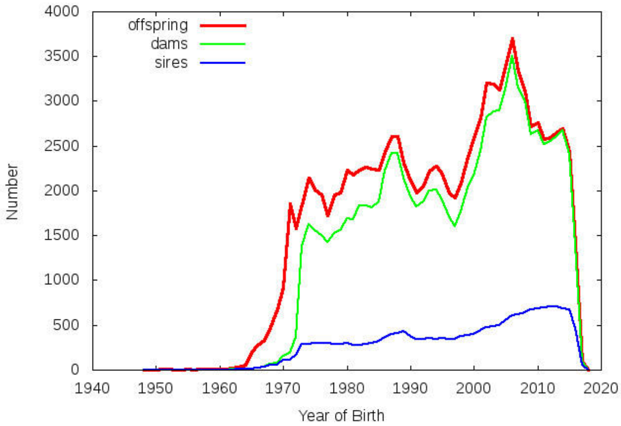

Figure 3: Average pedigree completeness for 1 to 6 generations

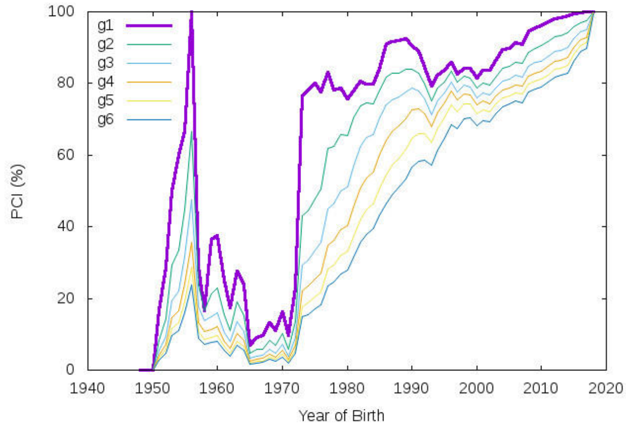

Figure 4: Average Additiv Genetic Relationship (Coan) and Inbreeding (F)

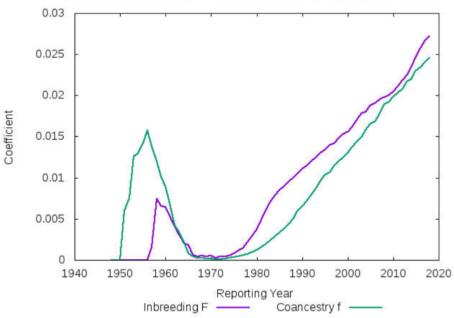

Figure 5: Average ln(1-F) by year of birth

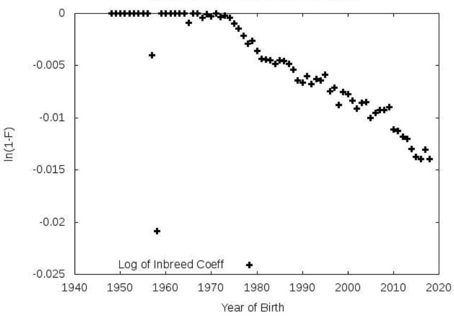

Figure 6: Ne with different calculation methods by reporting year

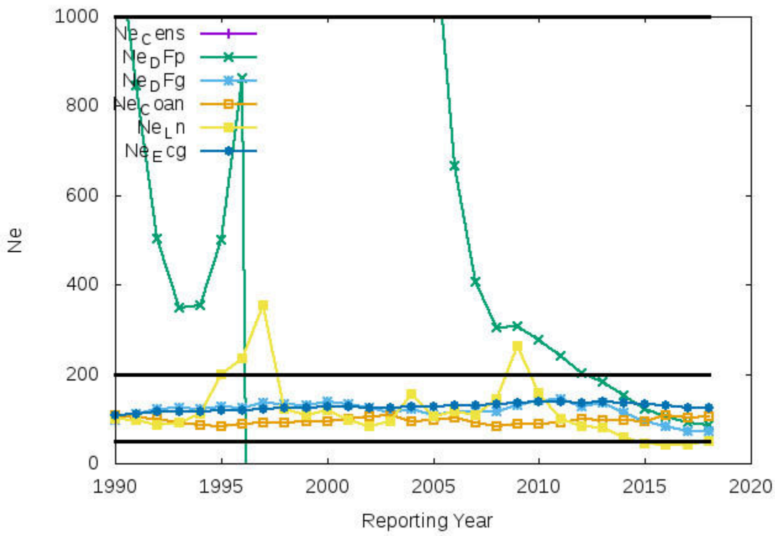

Table 3: Effective Population Size $\mathbf{N_e}$

N_e-Method	2018	2017	2016	2015	2014	2013	data history
N_e-Cens	3771	4159	4516	4678	4658	4647	2010 – 2003
N_e-ΔF_p	85	91	106	122	152	182	2018 – 2003
N_e-ΔF_g	73	73	82	94	113	134	2018 – 2003
N_e-Coan	104	102	107	94	98	96	2026 – 2011
N_e-Ln	50	41	42	45	57	81	2018 – 2011
N_e-Ecg	124	125	129	132	136	137	2018 – 1948

Proposed $\mathbf{N_e}$: $\mathbf{N_e}$-Ln = 50

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

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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
2018	3771	85	73	104	50	124
2017	4159	91	73	102	41	125
2016	4516	106	82	107	42	129
2015	4678	122	94	94	45	132
2014	4658	152	113	98	57	136
2013	4647	182	134	96	81	137
2012	4553	203	126	99	84	136
2011	4411	240	145	91	100	138
σ	262.6	11.3	7.5	3.8	10.9	1.8

Table 5: Decision cascade – side conditions

Method	Completeness [Years]	Stability [σ]	Diff	OK
N_e-Coan[a]	16/16	3.8|7.5/20	-6.12	no
N_e-Ln	8/8	10.9/20	-	yes
N_e-ΔF_p	8/8	11.3/20	-	yes
N_e-ΔF_g	8/8	7.5/20	-	yes
N_e-Coan	8/8	3.8/20	-	yes
N_e-Ecg	8/8	1.8/20	-	yes
N_e-Cens	8/8	262.6/20	-	no

[a]Avg N_e-Coan – Avg N_e-ΔF_g: 98.88 - 105.00 = -6.12

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Service PopReport at Institute of Farm Animal Genetics

FRIEDRICH-LOEFFLER-INSTITUT

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PopReport
A Population Structure Report

Population:	UNKNOWN
Inputfile:	POPREP.TXT
Initiated by:	quaglia@anabic.it
Submitted at:	2019-08-02 12:35:54
Started at:	2019-08-02 12:36:01
Finished at:	2019-08-02 13:13:43

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

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Some Notes About Your PopReport Job:

- INFO: This job ran on machine rie-ex-web160 with 12 CPUs and MemTotal: 32950668 kB
- INFO: Your entered dateformat was 'YYYYMMDD', your dateseparator 'undef'.
  112988 input lines processed.
  112988 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	744	744	7192	5376
1974	884	884	8927	4525
1975	985	985	10506	4061
1976	1038	1038	11929	3854
1977	1087	1087	12939	3680
1978	1108	1108	13963	3610
1979	1077	1077	14125	3714
1980	1129	1129	14734	3543
1981	1128	1128	15068	3546
1982	1112	1112	15166	3597
1983	1137	1137	15398	3518
1984	1196	1196	15627	3344
1985	1234	1234	16087	3241
1986	1300	1300	16495	3077
1987	1371	1371	17047	2918
1988	1392	1392	17396	2874
1989	1392	1392	17522	2874
1990	1370	1370	17419	2920
1991	1310	1310	17188	3053
1992	1267	1267	17043	3157
1993	1225	1225	17080	3265
1994	1177	1177	16969	3398
1995	1115	1115	16611	3587
1996	1067	1067	16033	3749
1997	1045	1045	15675	3828
1998	1014	1014	15684	3945
1999	1034	1034	16069	3868
2000	1005	1005	16631	3980
2001	1034	1034	17197	3868

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Year	No. of Male		No. of Female	
	orig.	cut	orig.	cut
2002	1053	1053	18105	3799
2003	1086	1086	19081	3683
2004	1152	1152	20165	3472
2005	1240	1240	21530	3226
2006	1368	1368	23026	2924
2007	1429	1429	23923	2799
2008	1526	1526	24343	2621
2009	1539	1539	24231	2599
2010	1553	1553	23779	2576
2011	1567	1567	23142	2553
2012	1539	1539	22632	2599
2013	1476	1476	21967	2710
2014	1400	1400	21030	2857
2015	1352	1352	20173	2959
2016	1271	1271	18550	3147
2017	1130	1130	16056	3540
2018	955	955	13473	4188

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Population Structure Report for Population: UNKNOWN

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Contents

List of Tables

List of Figures

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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

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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	1112	2053
1993	-	354	285	-	2000	1189	2222
1994	-	339	290	-	2014	1216	2274
1995	-	352	308	-	1904	1226	2186
1996	-	344	301	-	1710	1132	1981
1997	-	340	308	-	1598	1060	1924
1998	-	377	315	-	1768	1142	2083
1999	-	385	329	-	2030	1348	2380
2000	-	395	325	-	2170	1320	2586
2001	-	442	377	-	2443	1480	2817
2002	-	477	395	-	2817	1658	3201
2003	-	480	400	-	2883	1662	3195
2004	-	491	390	-	2893	1519	3131
2005	-	549	424	-	3131	1618	3377
2006	-	609	452	-	3505	1644	3707
2007	-	616	435	-	3147	1416	3338
2008	-	639	429	-	3003	1243	3103
2009	-	674	415	-	2634	1053	2718
2010	-	687	410	-	2678	946	2763

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Continue...

Year	sires			dams			Number of animals
	services	births	select	services	births	select	born
2011	-	694	340	-	2513	699	2572
2012	-	709	267	-	2547	498	2593
2013	-	702	169	-	2606	287	2649
2014	-	687	66	-	2671	85	2694
2015	-	677	7	-	2406	7	2433
2016	-	462	-	-	1387	-	1399
2017	-	60	-	-	83	-	83
2018	-	4	-	-	5	-	5
Total	-	5994	4624	-	56675	31600	112988

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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

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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	10	–	–	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	136	103	87	59	46	33	22	18	11	4	7	5	3	15	5.2
2010	14	102	116	123	95	67	43	35	21	27	14	3	1	5	3	18	5.3
2011	9	97	118	110	109	75	55	37	20	16	13	6	2	2	5	20	5.4
2012	10	78	111	99	101	107	59	46	30	12	6	16	6	3	–	25	5.8
2013	9	91	86	96	99	92	77	58	28	16	8	5	9	3	3	22	5.9
2014	5	99	85	79	92	68	78	66	38	24	12	4	3	6	3	25	6.1
2015	12	74	99	90	73	77	59	64	33	34	16	7	3	2	6	28	6.3
2016	5	58	54	60	57	47	45	25	32	21	14	10	2	3	1	28	6.6
2017	–	6	11	14	6	3	7	4	1	–	3	1	1	–	–	3	6.1
2018	–	1	1	–	1	–	1	–	–	–	–	–	–	–	–	–	4.3
Total	800	3852	3700	3052	2303	1690	1231	885	586	424	260	170	111	95	72	375	5.3

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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

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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	7	204	243	228	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	266	281	273	276	252	213	159	138	119	78	54	33	22	6.7
2003	8	326	357	327	264	243	254	252	212	186	134	118	80	52	36	34	6.6
2004	8	331	353	351	296	234	253	230	219	159	147	101	87	58	31	35	6.6
2005	11	378	388	371	362	329	233	224	202	167	143	117	71	57	36	42	6.4
2006	13	420	448	425	387	373	286	229	216	170	164	133	100	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	343	373	356	341	266	251	186	131	111	107	73	45	35	38	6.4
2009	5	293	331	302	297	260	246	223	187	130	97	76	75	51	23	38	6.5
2010	6	241	331	340	335	280	262	211	173	164	109	83	59	31	24	29	6.4
2011	6	234	261	328	314	255	275	205	186	126	107	81	52	44	21	18	6.5
2012	6	199	252	278	299	290	266	228	199	174	119	99	58	35	20	25	6.7

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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	199	258	278	309	312	287	233	185	178	128	95	54	36	22	29	6.8
2014	3	214	236	297	276	306	281	247	201	161	164	97	81	57	24	26	6.9
2015	3	215	191	265	263	243	247	222	207	152	126	115	69	42	22	24	6.9
2016	1	128	136	137	153	140	147	131	114	102	61	49	39	21	13	15	6.8
2017	–	7	13	9	10	10	7	8	5	4	4	–	3	1	1	1	6.4
2018	–	–	1	–	2	1	–	–	1	–	–	–	–	–	–	–	5.6
Total	3297	10499	12158	11666	11030	9982	8675	7328	6015	4711	3641	2576	1763	1064	586	662	6.1

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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 $\geq$ 16 are often few in the population and they are conveniently placed together in one group i.e. $\geq$ 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	–	–	–	–

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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	1279	540	223	89	33	6	5	2	–	–
2001	1429	589	274	112	37	13	1	2	–	–
2002	1643	724	292	119	32	11	4	1	1	–
2003	1642	755	301	131	46	9	7	–	–	–
2004	1574	795	333	130	44	18	5	1	–	–
2005	1783	805	335	140	54	15	6	1	–	–
2006	1988	912	372	143	69	23	3	1	–	–
2007	1786	790	348	149	59	18	7	–	–	–
2008	1670	776	360	128	48	20	4	1	–	–
2009	1512	642	292	119	41	21	9	1	1	–
2010	1500	703	282	138	47	14	5	1	1	–
2011	1440	657	259	104	39	15	4	3	–	–
2012	1451	632	282	110	52	17	5	3	1	–
2013	1512	665	272	102	37	14	5	5	–	–
2014	1536	720	258	104	28	17	6	4	2	–
2015	1364	655	250	85	34	14	6	2	2	1
2016	784	344	165	57	22	9	5	1	–	–
2017	40	23	14	5	1	–	–	–	–	–
2018	1	3	1	–	–	–	–	–	–	–
Total	56675	23926	9713	3797	1361	449	133	38	10	2

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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

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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	123	4.4	928	6.6	123	6.5	993	4.3	1051	6.5	1116	5.5	1118
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	1033	6.3	106	7.1	1045	4.9	1139	7.0	1151	6.0	1154
1999	4.6	130	5.1	1203	6.3	130	7.0	1225	5.1	1333	6.9	1355	6.0	1359
2000	4.8	104	5.3	1179	7.1	104	7.1	1224	5.2	1283	7.1	1328	6.2	1333
2001	5.3	138	5.6	1283	6.8	138	7.2	1353	5.5	1421	7.2	1491	6.4	1495
2002	5.4	152	5.8	1441	6.8	152	7.2	1518	5.8	1593	7.2	1670	6.5	1681
2003	5.5	144	5.6	1452	6.4	144	7.2	1528	5.6	1596	7.1	1672	6.4	1679
2004	5.1	160	5.7	1315	6.9	160	7.2	1370	5.6	1475	7.1	1530	6.4	1535
2005	6.2	190	6.0	1373	6.7	190	6.8	1438	6.1	1563	6.8	1628	6.4	1632
2006	6.4	211	6.2	1381	6.5	211	6.9	1438	6.3	1592	6.9	1649	6.6	1656
2007	6.1	171	6.7	1202	6.5	171	6.9	1251	6.7	1373	6.9	1422	6.8	1428
2008	6.7	179	6.4	1041	6.5	179	6.8	1067	6.5	1220	6.8	1246	6.6	1248
2009	6.8	137	6.8	907	6.6	137	6.8	922	6.8	1044	6.7	1059	6.8	1062
2010	6.9	143	6.5	791	6.2	143	6.9	812	6.6	934	6.8	955	6.7	955
2011	6.0	134	6.7	563	6.4	134	7.1	565	6.5	697	6.9	699	6.7	701
2012	6.9	119	7.1	382	6.6	119	7.1	382	7.1	501	6.9	501	7.0	503
2013	8.0	72	7.9	214	6.6	72	7.2	215	7.9	286	7.0	287	7.5	287

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Year	Generation interval and number of animal													
	ss	Nss	sd	Nsd	ms	Nms	md	Nmd	male	Nmale	female	Nfemale	pop	Npop
2014	6.8	32	6.9	53	6.0	32	7.9	53	6.9	85	7.2	85	7.0	85
2015	10.9	4	3.1	3	5.9	4	7.6	3	7.6	7	6.6	7	7.1	7
Total	5.8	-	5.9	-	6.2	-	6.4	-	5.9	-	6.4	-	6.1	-

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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

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	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	355	15.1	8	1.7	197	10.3	8	1.5	16	3.7	4	1.3	182	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	1173	24.3	8	1.8	664	15.0	6	1.6	62	6.3	3	1.2	602	14.0	6	1.5
1989	515	24.7	8	1.8	287	15.5	7	1.6	38	5.1	5	1.2	249	13.9	5	1.5
1990	373	19.2	9	1.8	209	12.4	7	1.6	19	3.8	4	1.1	191	11.3	7	1.5
1991	514	22.6	7	1.8	285	14.6	7	1.5	32	4.3	5	1.2	253	13.6	6	1.5
1992	126	12.0	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	8	1.6	8	2.4	5	1.3	60	7.7	6	1.5
1994	1339	38.2	7	1.8	778	24.3	6	1.5	99	6.3	3	1.3	679	22.2	6	1.4
1995	186	21.3	7	1.9	90	13.4	6	1.6	14	3.2	5	1.3	86	12.4	5	1.4
1996	219	18.5	8	1.8	112	10.8	7	1.5	18	3.0	4	1.3	94	10.0	6	1.4
1997	415	20.0	9	1.9	207	12.3	8	1.5	23	3.3	5	1.2	184	11.1	4	1.4
1998	371	18.9	9	1.9	142	10.3	8	1.5	18	2.6	5	1.2	124	9.4	5	1.4
1999	887	32.7	9	1.9	431	17.4	6	1.5	92	6.1	3	1.3	339	15.7	5	1.4
2000	980	28.6	10	1.8	478	14.7	6	1.4	68	5.8	3	1.3	410	13.1	5	1.3
2001	487	21.8	8	1.7	210	10.5	6	1.4	41	3.6	4	1.2	169	9.6	5	1.3
2002	80	14.8	9	1.7	56	7.2	7	1.3	12	2.4	5	1.2	44	6.4	5	1.3
2003	395	17.2	8	1.6	134	7.6	6	1.3	34	3.8	4	1.2	100	6.7	4	1.2
2004	51	12.6	8	1.6	30	4.6	4	1.3	9	1.8	4	1.2	25	4.1	3	1.2
2005	401	16.7	8	1.6	80	5.5	6	1.2	13	2.9	2	1.1	67	4.8	6	1.2
2006	276	12.6	8	1.5	52	4.3	4	1.2	20	2.5	2	1.1	50	3.9	3	1.1
2007	170	11.8	6	1.4	48	3.5	4	1.1	15	2.0	3	1.2	33	3.1	3	1.1
2008	302	11.5	6	1.4	50	3.5	5	1.1	12	2.2	5	1.2	38	3.0	2	1.0
2009	58	10.2	5	1.3	11	2.2	3	1.1	4	1.4	2	1.1	7	1.9	2	1.0
2010	31	8.6	4	1.3	7	1.8	2	1.0	3	1.3	1	1.0	5	1.7	1	1.0
2011	67	6.5	3	1.2	5	1.6	1	1.0	2	1.1	1	1.0	5	1.5	1	1.0
2012	55	5.6	3	1.1	2	1.3	1	1.0	1	1.0	-	-	2	1.3	1	1.0
2013	35	4.2	3	1.0	1	1.0	-	-	1	1.0	-	-	1	1.0	-	-
2014	8	2.5	2	1.0	-	-	-	-	-	-	-	-	-	-	-	-
2015	2	1.3	1	1.0	-	-	-	-	-	-	-	-	-	-	-	-
Total	1339	15.7	10	1.7	778	9.8	8	1.5	99	3.2	5	1.2	679	9.1	7	1.4

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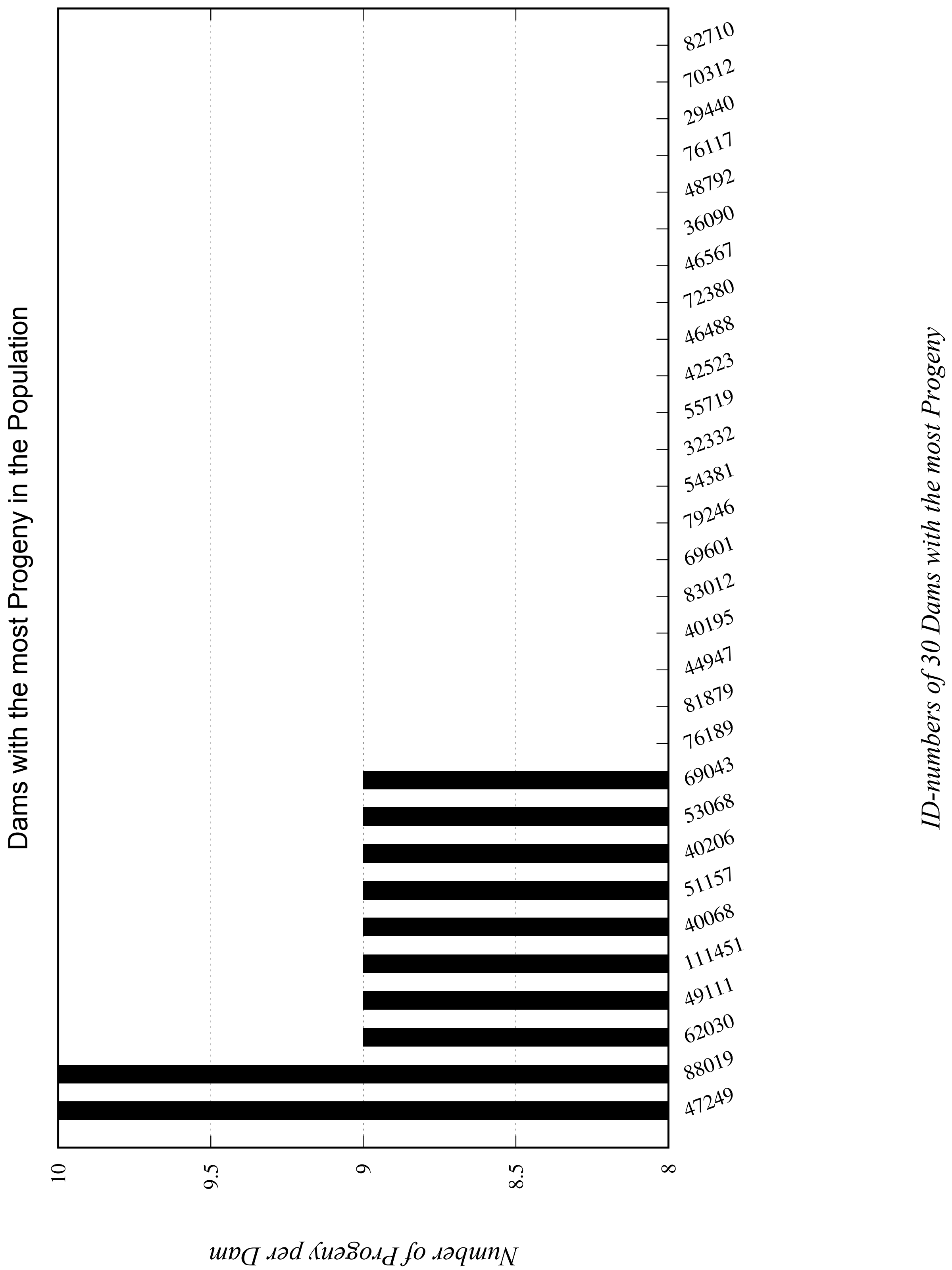
Figure 1: Dams with the most Progeny in the Population



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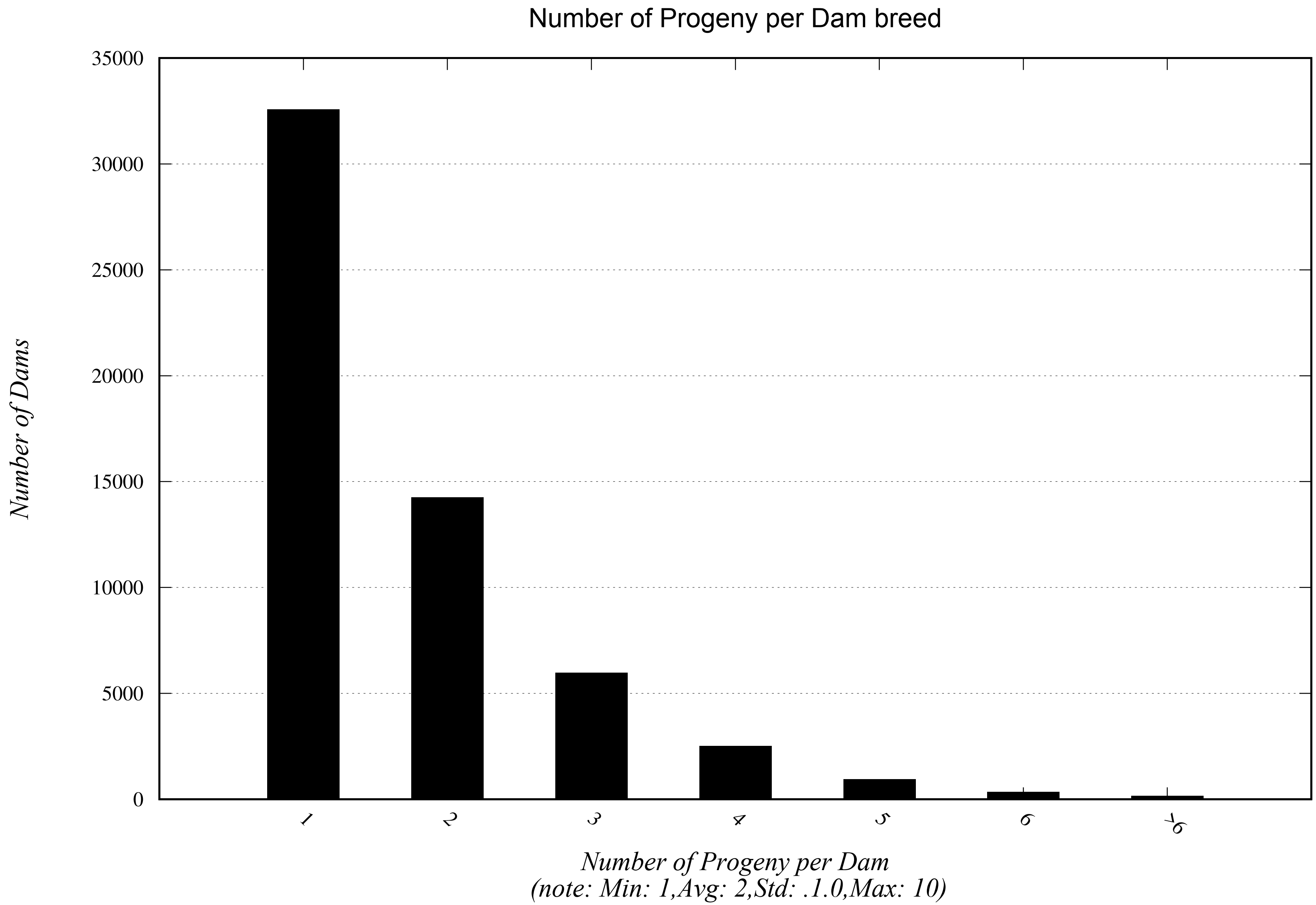

Figure 2: Number of Progeny per Dam

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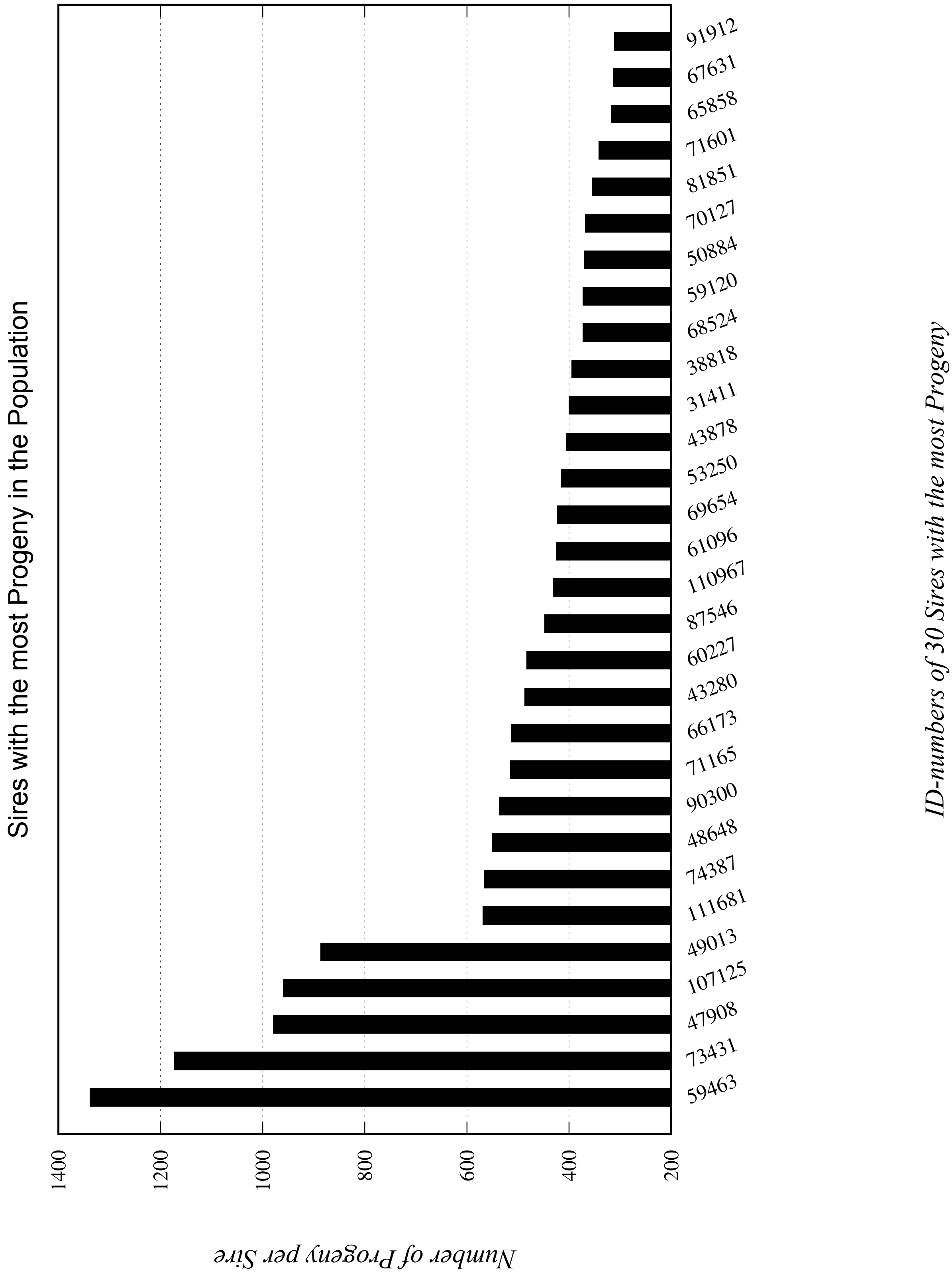
Figure 3: Sires with the most Progeny in the Population



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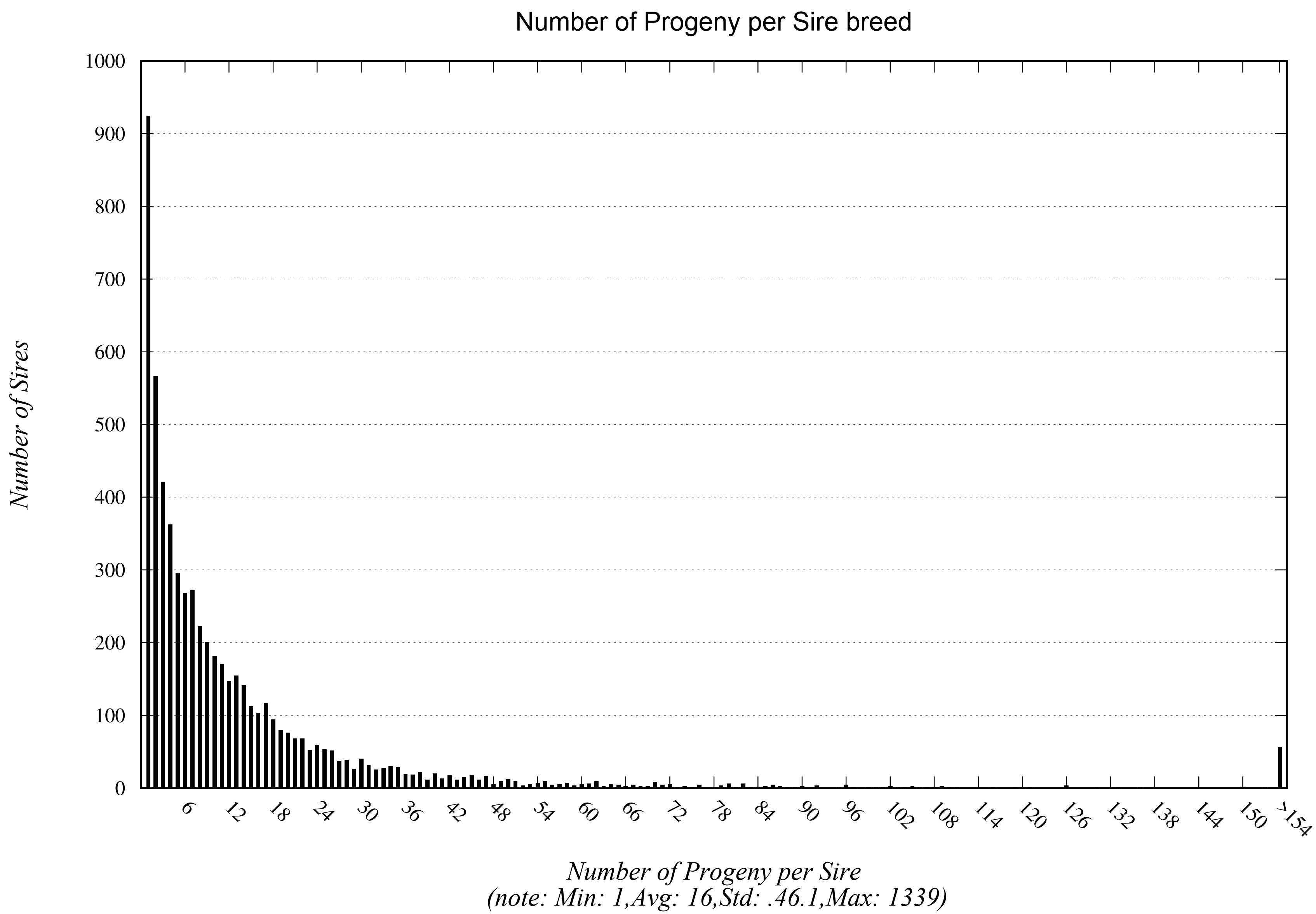

Figure 4: Number of Progeny per Sire

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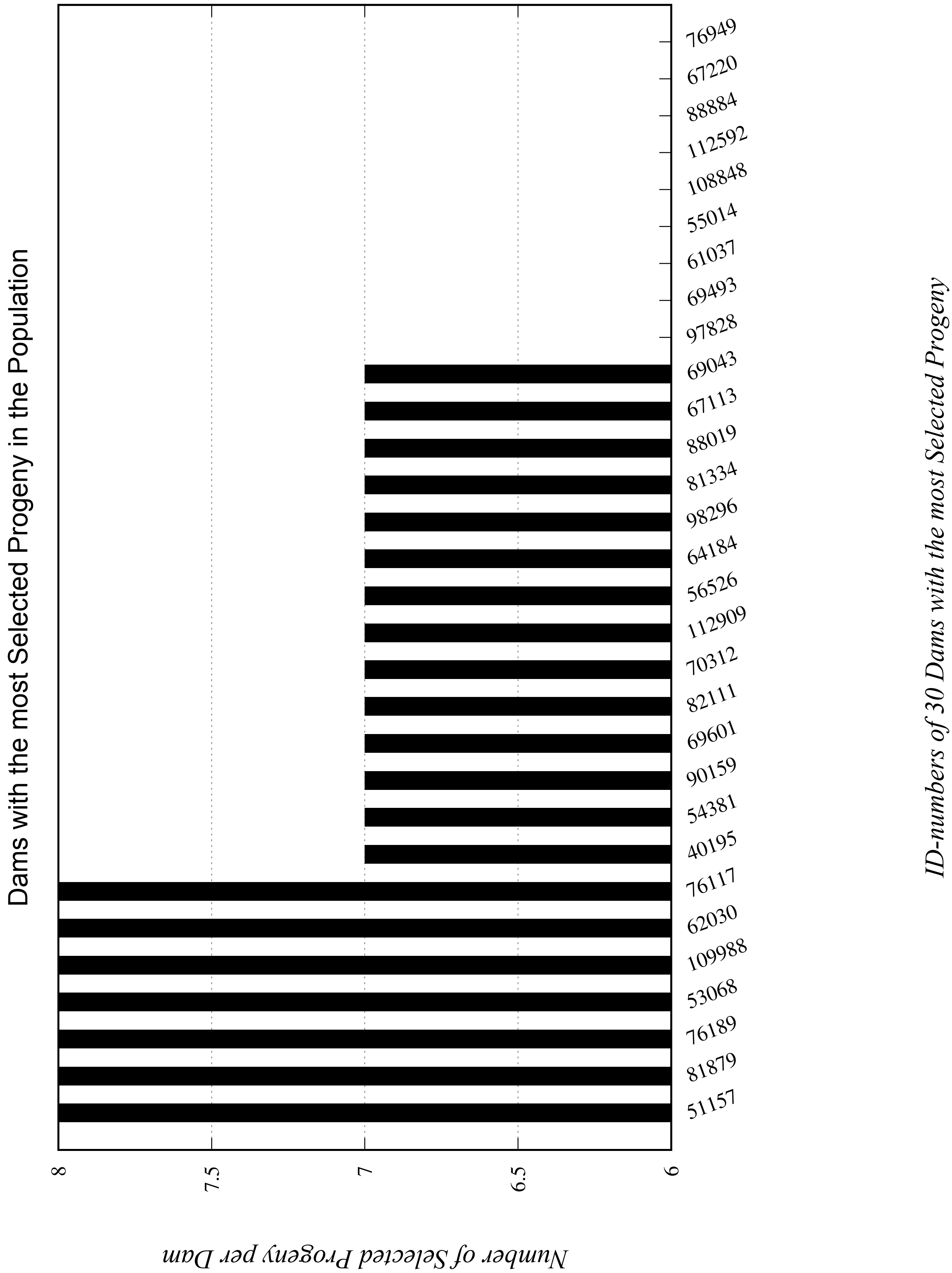
Figure 5: Dams with the most Selected Progeny in the Population



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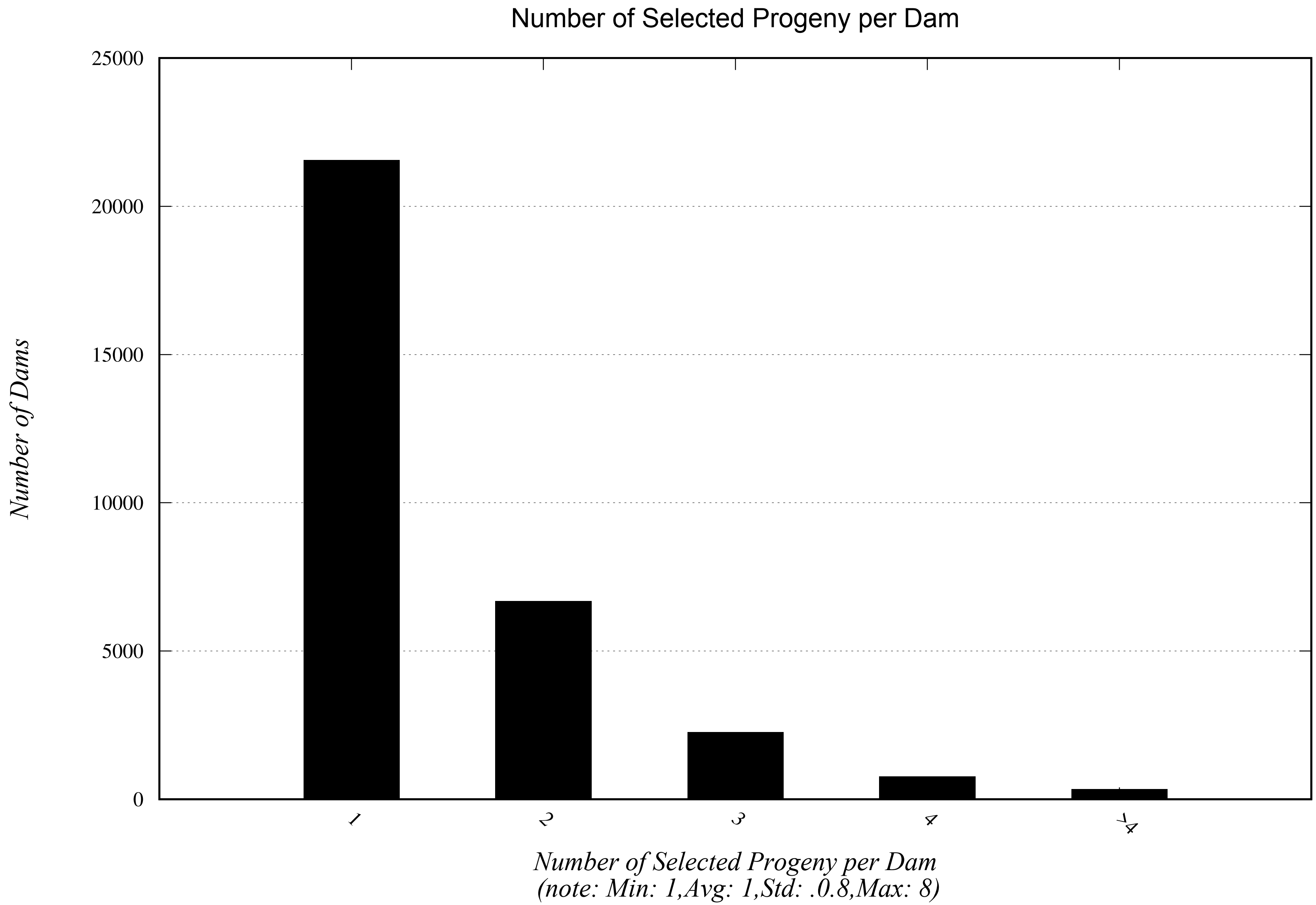

Figure 6: Number of Selected Progeny per Dam

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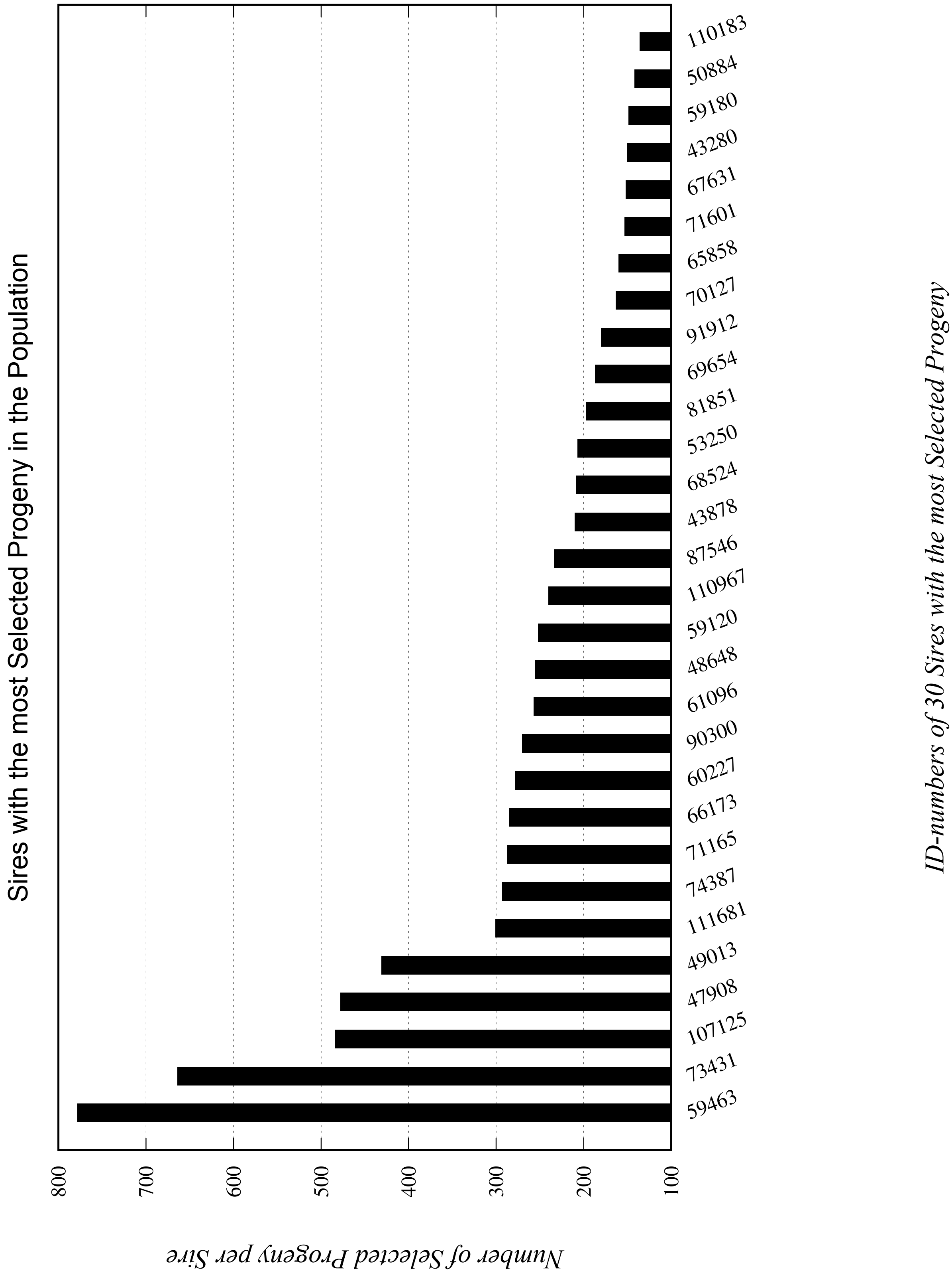
Figure 7: Sires with the most Selected Progeny in the Population



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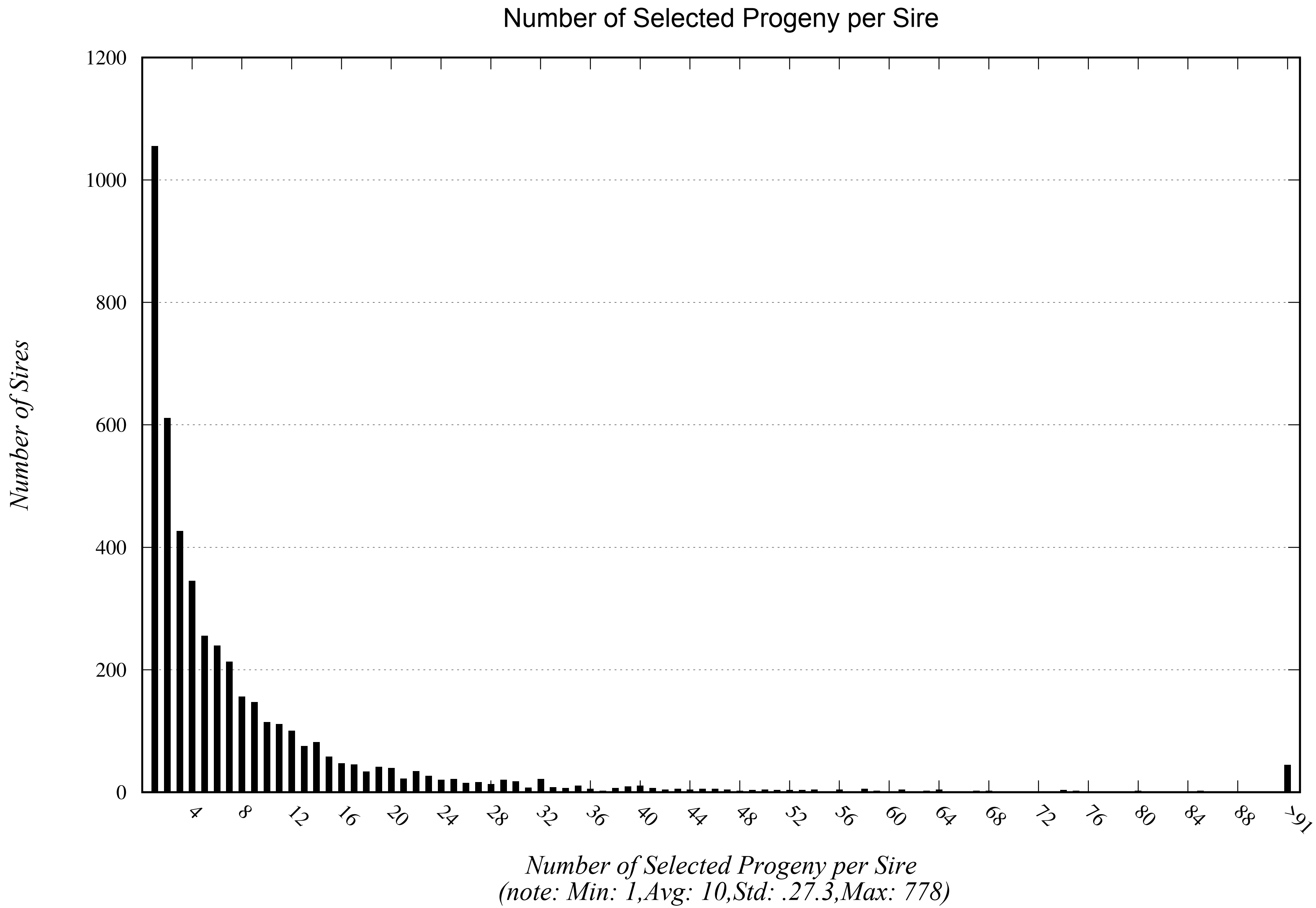

Figure 8: Number of Selected Progeny per Sire

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