FRIEDRICH-LOEFFLER-INSTITUT

FLI

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Software und Populations Management

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Die Gliederung

- Das ProblemDie wichtigsten KomponentenDefinition der ZielÜberprüfen der UmsetzungPopRep als Hilfmittel

Das Problem

- Verlust von Allelen →genetische VariabilitätReduziert künftige SelektionsmöglichkeitenAnstieg der Homozygotie→genetische DefekteKritische Faktor: Inzuchtrate ΔFMagische Zahl: ΔF kleiner als .5-1% pro Generation

Das Problem

Es gibt einfache VerfahrenUnd kompliziertereHier und heute: die einfachenSpäter: OCAlso jetzt: einfach erreichbare Ziele

Inzucht und Populationsgröße

Populationsgröße ~ 1/ΔFAngenommen 1 ml x 1 wblAngenommen 1 ml x 10000 wbl

Inzucht und effektive Populationsgröße

Annahmen:

Inzucht und effektive Populationsgröße

- Ne = (4*Nm*Nf)/(Nm+Nf)ΔF = 1/2Ne

Faktoren der Inzucht

PopulationsgrößeGeschlechtsverhältnis

Inzucht und effektive Populationsgröße

$$1.Ne = (4*Nm*Nf)/(Nm+Nf)\Delta F = 1/2Ne$$

$$Ne = 8N/(Vm+Vw+4)$$

Vm – Varianz der ml. Nachkommengruppen

Vw – Varianz der wbl. Nachkommengruppen

Faktoren der Inzucht

PopulationsgrößeGeschlechtsverhältnisVarianz der FamiliengrößeGenerationsintervall (ΔF/Jahr)

Inzucht

Zahl der wbl Tiere ist oft gegebenZahl der ml Tiere ist von bestimmender Bedeutung!Was hier verloren wird kann durch keine späteren “Tricks” wieder gewonnen werden!!

Populationsgröße und Ne

Tab. 1. Populationsstruktur und effektive Populationsgröße N_e und Inzuchtsteigerung ΔF in %
Population structure and effective population size N_e and rise of inbreeding

	N_W = 200		N_W = 300		N_W = 4000	
N_m	N_e	ΔF	N_e	ΔF	N_e	ΔF
3	8,3	6,0	8,3	6,0	8,4	6,0
7	18,9	2,6	19,2	2,6	19,6	2,6
10	26,7	1,9	27,1	1,8	27,9	1,8
15	39,1	1,3	40,0	1,3	41,8	1,2
20	50,9	1,0	52,5	1,0	55,7	0,9
30	73,0	0,7	76,4	0,7	83,4	0,6
40	93,3	0,5	98,8	0,5	110,9	0,5
50	112,0	0,4	120,0	0,4	138,3	0,4
60	129,2	0,4	140,0	0,4	165,5	0,3

Zitate

“Mit speziellem Programm zur Berechnung des möglichen Inzuchtgrades und regem Stierentausch wird Inzucht verhindert”“gezielte Paarungen < Inzuchtgrad”“Inzuchtkontrolle vor der Anpaarung”“Mittels Pop.plan.prog wird mittels gezielter Anpaarung .. Inzucht verhindert”

Inzucht: das Wichtigste!!

- Ne = (4*Nm*Nf)/(Nm+Nf)ΔF = 1/2Ne

Zahl der männlichen Zuchttiere

Ihr Fehlen kann später durch nichts ausgeglichen werden

Populationsmanagement Definition der Ziele

Definition der maximalen InzuchtrateDefinition der angestrebten Populationsstruktur Definition des Generationsintervalls(Andere Zuchtziele)

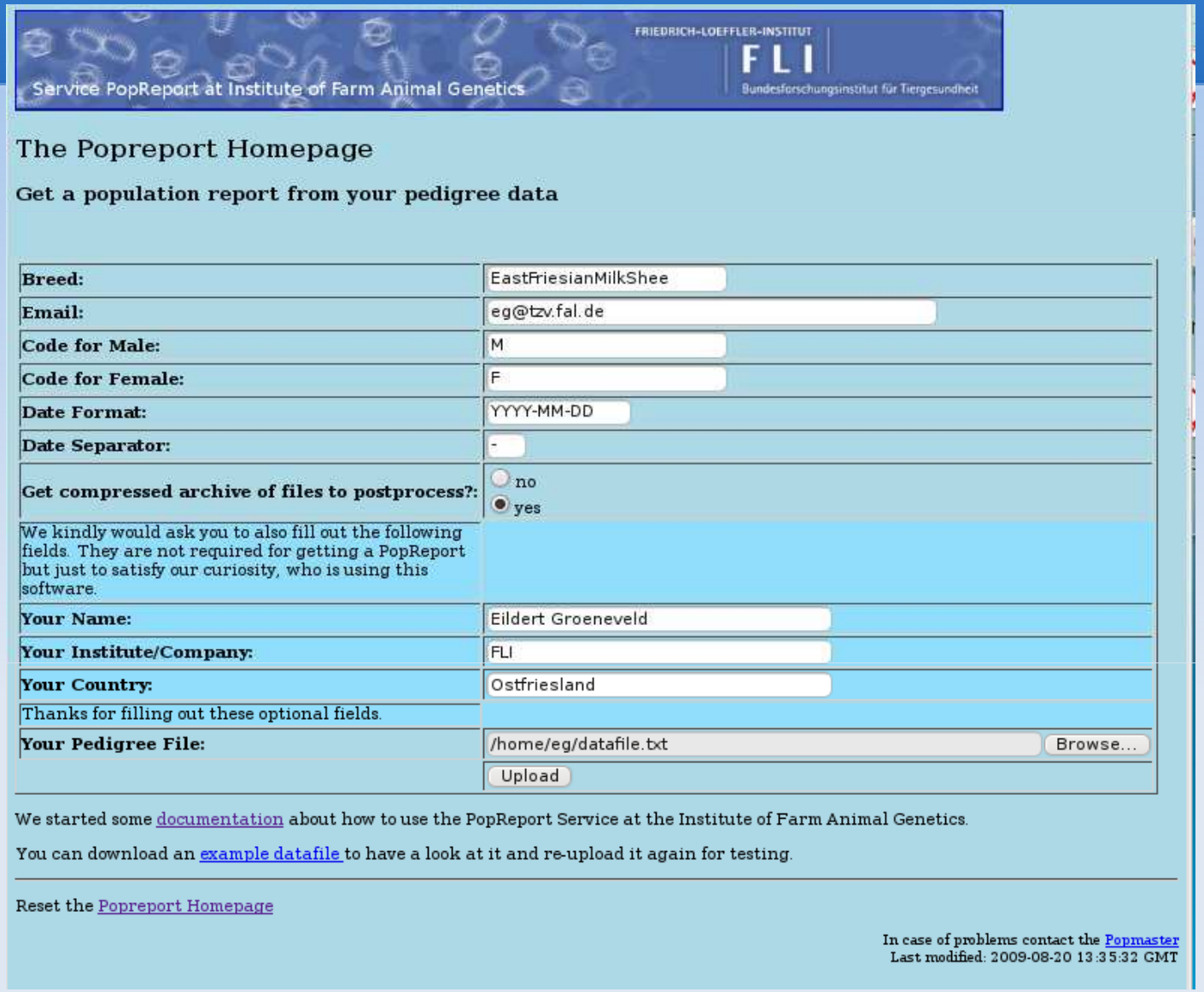
Populationsmanagement:Ziel erreicht?

Annahme: wir haben AbstammungsdatenPedigree:

Wie:poprep.tzv.fal.de

WEBsiteZugang mit Standard browsers→ Pedigreedaten hochladen← Ergebnisse landen in der emailNutze Ergebnisse zum Population Management

poprep.tzv.fal.de



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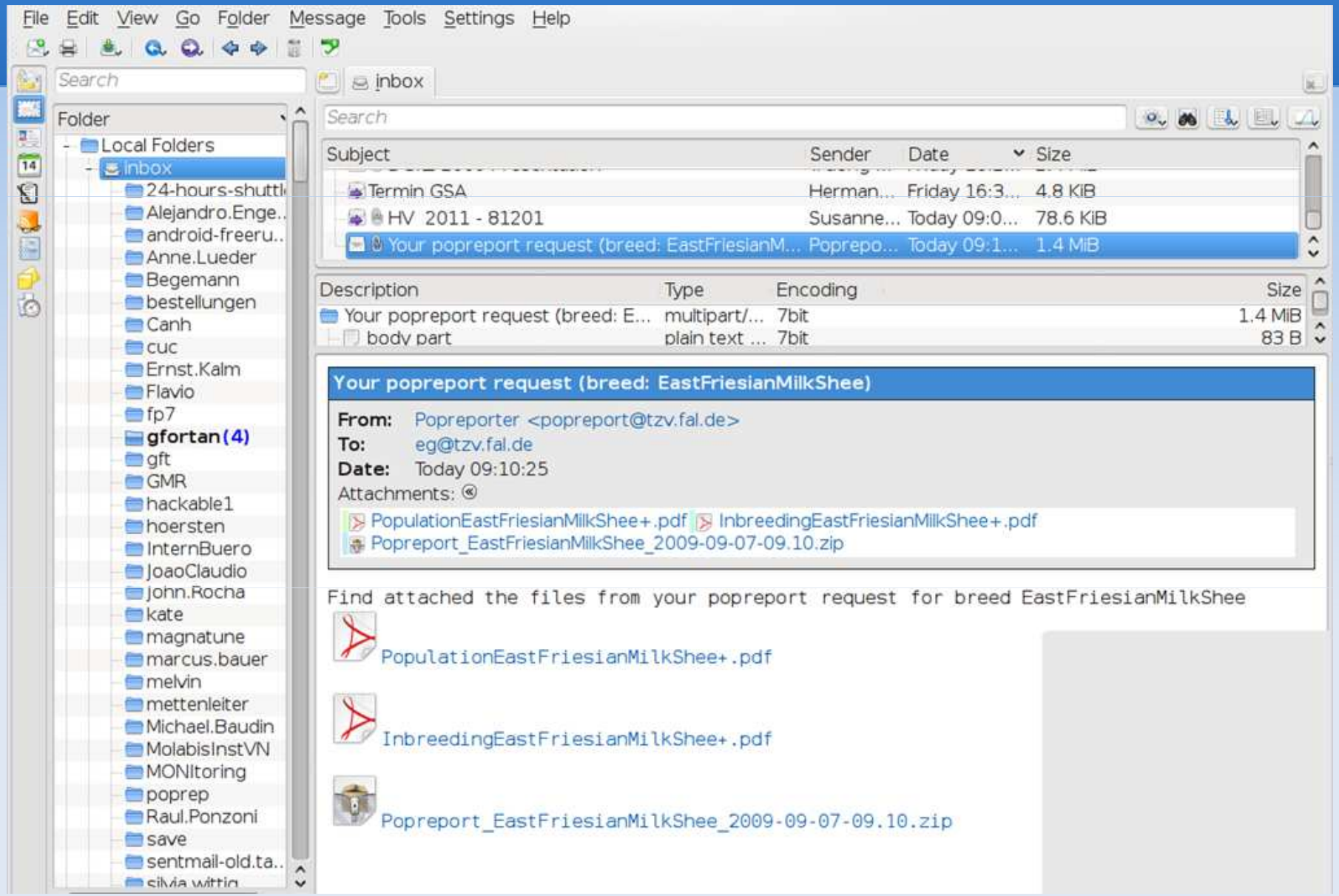

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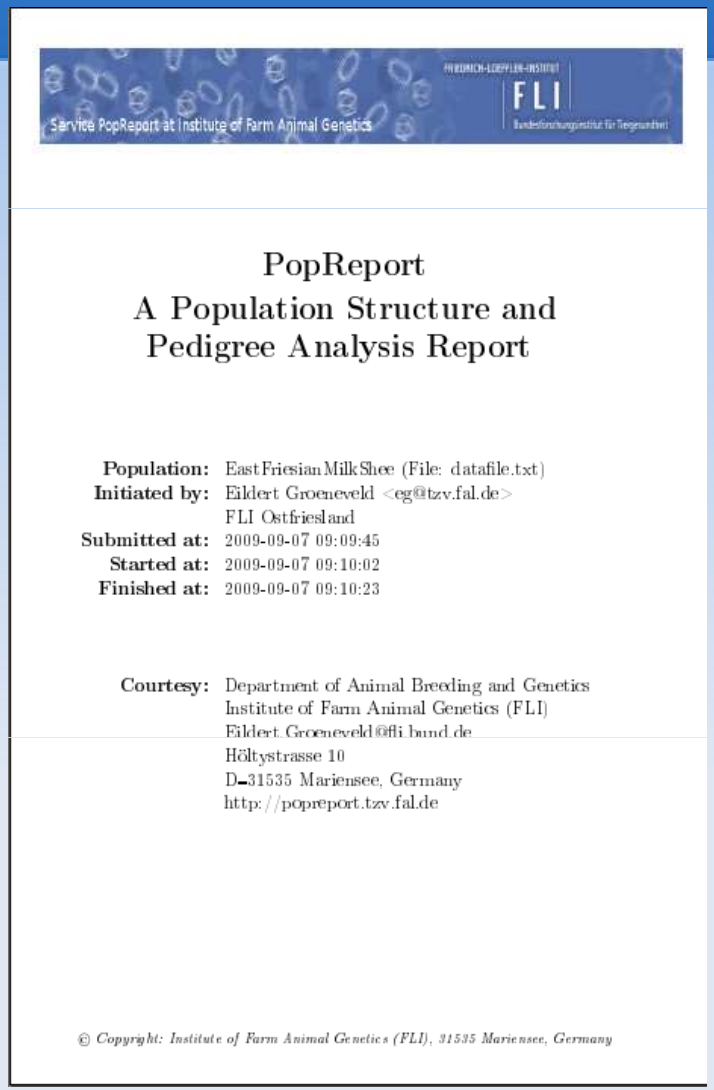

Populationsstruktur

Developers

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Populationsstruktur

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Populationsstruktur: Zahl der Zuchttiere

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, the term breeding refers to year of *actual* service (if date of natural or artificial insemination is available in the database). Also, a selected animal is defined as an animal that has participated in first service (if service data is available) or has already become a parent. The number of breeding males and females used in the population in a given year is presented in the table. For ease of presentation the table is partitioned into two parts i.e. for the males and the females. Each part is further subdivided into three columns. The description for each column is:

Services: The number of males/females that participated in services in a given year the corresponding year.

Births: The number of males/females with offspring in a given year.

Select: The number of males/females that have selected offspring in a given year.

For example: For the EastFriesianMilkShee breed in 1988, 11 males produced 22 offspring while offspring of 12 males were selected to become parents in the next generations. Similarly, 18 females produced 22 offspring during the same year while offspring of 20 females were selected to become parents in the generations to follow.

Note: No service data were used in the calculations for this section.

Populationsstruktur:Zahl der ml & wbl Zuchttiere

For example: For the EastFriesianMilkShee breed in 1988, 11 males produced 22 offspring while offspring of 12 males were selected to become parents in the next generations. Similarly, 18 females produced 22 offspring during the same year while offspring of 20 females were selected to become parents in the generations to follow.

Table 1: Number of males and females in reproduction by year of birth of offspring

(select=the number of males/females whose offspring become parents in following generations)

Year	males			females			Number of animals
	services	births	select	services	births	select	born
1953	-	2	8				
1988	-	11	12	-	18	20	22
1989	-	7	6	-	12	15	21
1990	-	8	9	-	13	21	26
1991	-	12	11	-	17	24	31
1992	-	12	12	-	28	30	47
1993	-	24	13	-	40	28	61

Ist die geplante Zahl von Zuchttieren zum Einsatz gekommen?

PopulationsstrukturAltersstruktur

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

Year	age of males in years																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	≥ 16	Avg
1953	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.0
1954	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.0
1955	2	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1.9
1988	1	1	–	–	–	–	–	–	2	1	1	–	–	–	1	4	14.2
1989	–	1	–	–	1	–	–	–	1	1	–	1	–	–	1	1	10.4
1990	–	–	–	–	–	1	–	–	1	1	–	1	–	1	–	3	14.0
1991	–	–	2	1	–	–	–	1	–	–	1	2	–	–	–	5	14.4
1992	–	2	1	1	–	–	–	1	1	–	–	–	–	1	–	5	12.8
1993	–	1	2	1	3	–	–	–	2	–	–	–	–	1	2	12	15.8
1994	–	3	2	–	2	1	–	–	–	–	–	–	1	–	1	8	14.5
1995	–	–	3	2	–	1	–	–	–	–	–	–	–	–	2	8	15.1
1996	–	2	6	1	3	–	2	–	–	–	–	–	–	–	1	10	13.3
1997	–	1	3	5	2	2	–	2	–	–	–	–	–	–	–	–	4.6
1998	–	–	1	3	4	1	2	1	1	1	–	–	–	–	–	–	5.9
1999	–	–	–	1	2	4	1	3	–	–	–	–	–	–	–	–	6.3
2000	–	–	–	–	–	3	1	1	1	–	–	–	–	–	–	–	7.0
2001	–	–	–	–	–	–	2	1	1	1	–	–	–	–	–	–	8.2
2002	–	–	–	–	–	–	1	3	1	3	1	–	–	–	–	–	9.0
2003	–	–	–	–	–	–	1	3	1	3	2	1	–	–	–	–	9.5
2004	–	–	–	–	–	–	–	–	3	3	1	1	1	–	–	–	10.3
2005	–	–	–	–	–	1	–	–	2	4	4	–	–	1	–	–	10.2

Ist das anvisierte Generationsintervall erreicht worden?

Populationsstruktur Generationsintervall

"Durchschnittsalter von Eltern bei Geburt ihrer selektierten Nachkommen (Falconer)

Alle Tiere eines Geburtsjahres werden betrachtet.Tiere in 1. die in späteren Jahren Eltern wurden, werden markiertEltern der Tiere in 2. were identifiziertDas Generationintervall: das Durchschnittliche Alter der Tiere in 3. bei Geburt ihrer Nko

Populationsstruktur Generationsintervall

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
1961	5.7	3	6.3	2	3.6	2	3.9	1	6.0	5	3.7	3	5.0	7
1968	9.0	5	8.8	3	4.9	2	6.2	1	8.9	8	5.3	3	8.2	8
1970	9.0	5	6.6	2	6.7	3	4.9	1	8.3	7	6.2	4	7.5	8
1971	7.0	1	11.1	2	3.3	1	2.9	1	9.7	3	3.1	2	7.6	4
1972	8.1	3	9.1	1	2.3	1	3.2	3	8.4	4	3.0	4	6.0	6
1978	9.2	3	8.6	7	6.9	3	2.9	3	8.7	10	4.9	6	7.3	10
1980	9.0	3	7.0	7	8.2	1	3.4	4	7.6	10	4.4	5	7.2	10
1983	7.9	2	8.1	9	8.1	2	3.6	6	8.1	11	4.7	8	7.5	12
1987	6.6	1	7.8	14	6.2	1	4.9	9	7.7	15	5.0	10	6.8	15
1988	23.7	6	11.2	13	3.6	4	4.4	13	15.1	19	4.2	17	11.0	19
1989	14.4	3	10.6	11	8.1	1	3.2	8	11.4	14	3.7	9	9.4	14
1990	13.6	4	14.8	16	5.4	2	3.2	9	14.5	20	3.6	11	11.9	21
1991	22.1	5	6.5	19	6.6	3	3.9	10	9.7	24	4.5	13	8.2	24
1992	7.9	4	13.9	25	5.2	4	4.4	15	13.1	29	4.5	19	10.6	30
1993	16.9	8	7.6	21	7.3	7	5.4	14	10.2	29	6.1	21	8.4	29
1994	17.0	5	12.0	17	6.3	5	5.3	14	13.1	22	5.6	19	9.3	22
1995	23.0	6	15.4	13	6.0	6	4.9	12	17.8	19	5.3	18	12.0	19
Total	14.3	-	10.5	-	6.0	-	4.4	-	11.5	-	4.8	-	9.1	-

Ist das geplante Generationsintervall erreicht worden?

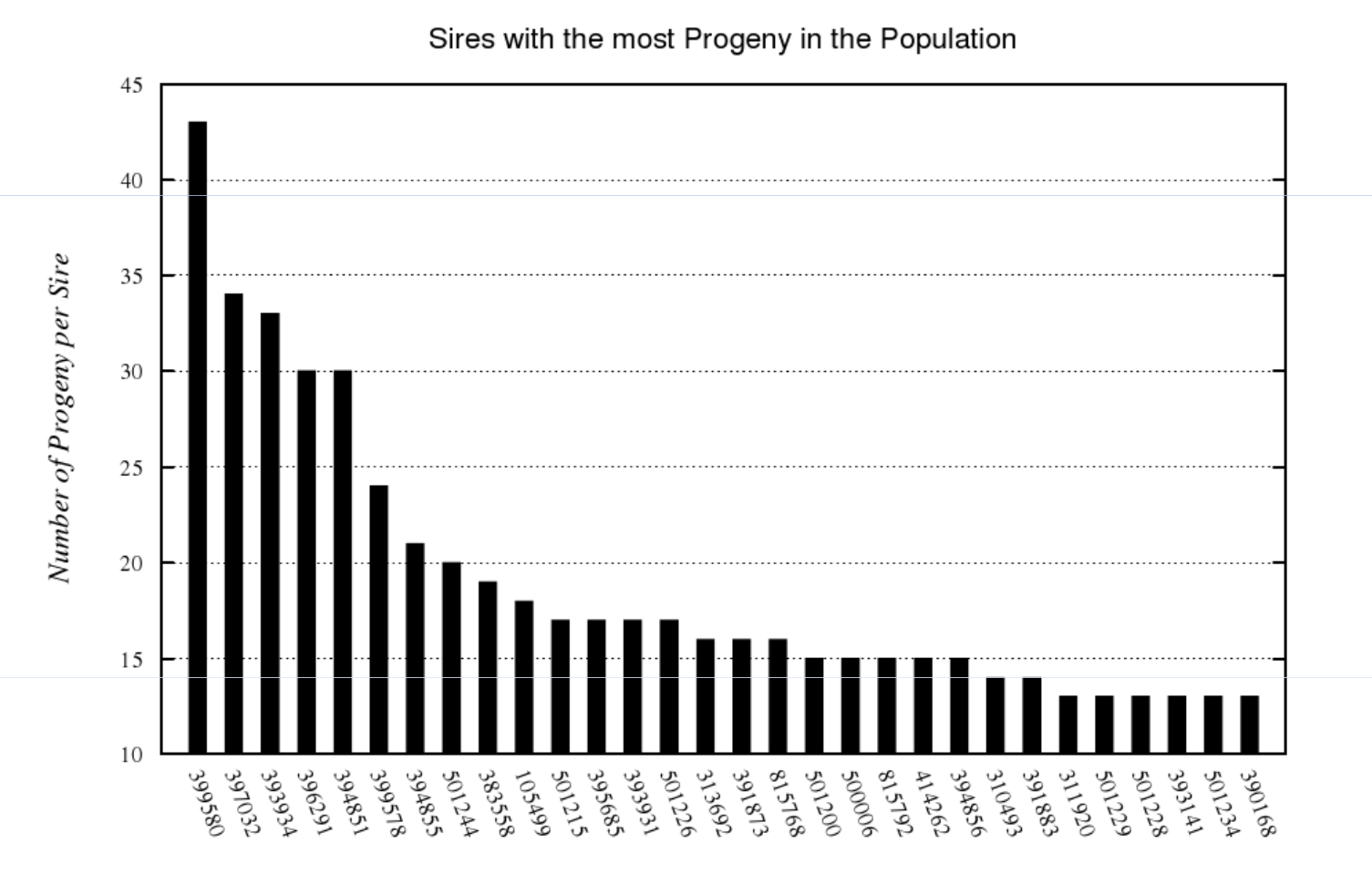
Populationsstruktur: Varianz der Familiengröße

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
1950	1	1.0	1	1.0	1	1.0	-	-	1	1.0	-	-	-	-	-	-
1951	1	1.0	-	-	1	1.0	-	-	1	1.0	-	-	1	1.0	-	-
1952	2	1.3	-	-	1	1.0	-	-	1	1.0	-	-	-	-	-	-
1953	2	1.3	2	1.5	2	1.2	1	1.0	1	1.0	1	1.0	1	1.0	-	-
1954	1	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1955	8	1.9	-	-	8	2.0	-	-	5	1.7	-	-	3	2.0	-	-
1956	10	4.0	-	-	9	3.7	-	-	7	4.0	-	-	2	1.5	-	-
1957	4	2.7	2	1.7	3	2.0	2	1.7	2	1.7	2	2.0	1	1.0	1	1.0
1958	1	1.0	1	1.0	1	1.0	1	1.0	1	1.0	1	1.0	-	-	1	1.0
1959	2	1.2	1	1.0	1	1.0	1	1.0	1	1.0	1	1.0	-	-	1	1.0
1960	2	1.3	1	1.0	2	1.3	1	1.0	1	1.0	1	1.0	2	1.5	-	-
1961	7	2.5	1	1.0	7	2.3	1	1.0	5	2.8	1	1.0	2	1.3	1	1.0
1962	5	3.0	1	1.0	3	2.3	1	1.0	2	1.7	1	1.0	2	2.0	-	-
1963	4	1.8	1	1.0	3	1.7	1	1.0	2	1.5	1	1.0	1	1.0	-	-
1964	10	3.0	1	1.0	2	1.4	1	1.0	2	1.6	1	1.0	1	1.0	1	1.0
1965	2	1.6	1	1.0	2	1.3	1	1.0	2	1.3	1	1.0	-	-	-	-
1966	14	5.5	1	1.0	9	3.5	1	1.0	3	2.0	1	1.0	6	3.3	1	1.0
1967	18	3.7	1	1.0	15	3.3	1	1.0	3	2.3	1	1.0	12	3.2	-	-
1968	13	4.0	1	1.0	9	3.0	1	1.0	5	3.0	1	1.0	4	2.0	1	1.0
1969	5	2.8	1	1.0	2	1.3	1	1.0	1	1.0	1	1.0	2	1.3	1	1.0

Sind die Nachkommengruppen gleich groß?

Populationsstruktur: Väter mit den meisten Nachkommen

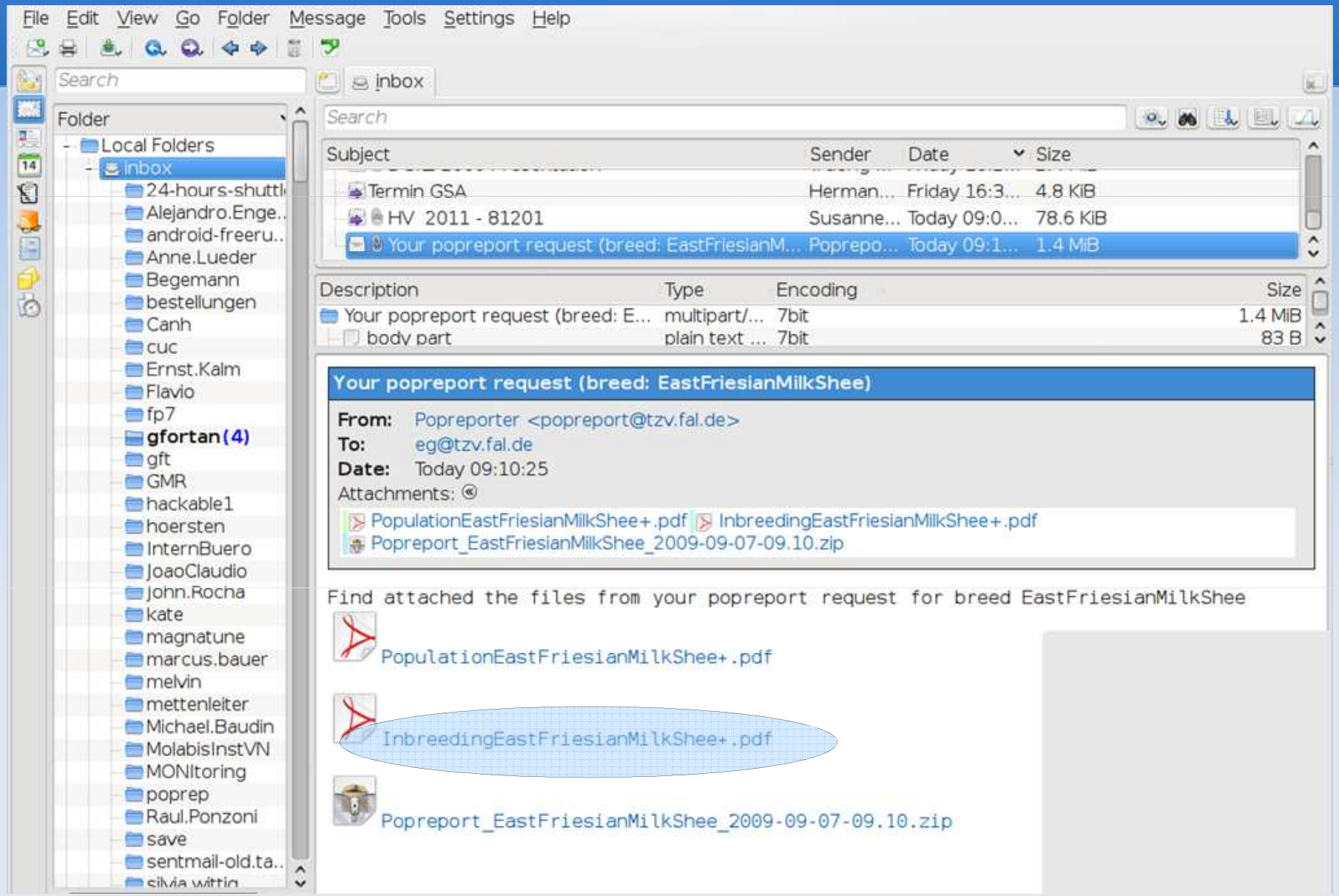


Sind die Nachkommengruppen gleich groß?

ZusammenfassungKontrolle der Populationsstruktur

Zeitnahe Erfassung der AbstammungsdatenAlle 3 oder 6 Monate einen PopRep LaufZielgrößen mit realisierten vergleichen:Bei Abweichungen kann und sollte jetzt gegengesteuert werden!!

Inzuchtpoprep.tzv.fal.de



Pedigree Vollständigkeit

The following formula was used to compute pedigree completeness (MacCluer *et al.*, 1983):

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

and

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

Pedigree Vollständigkeit

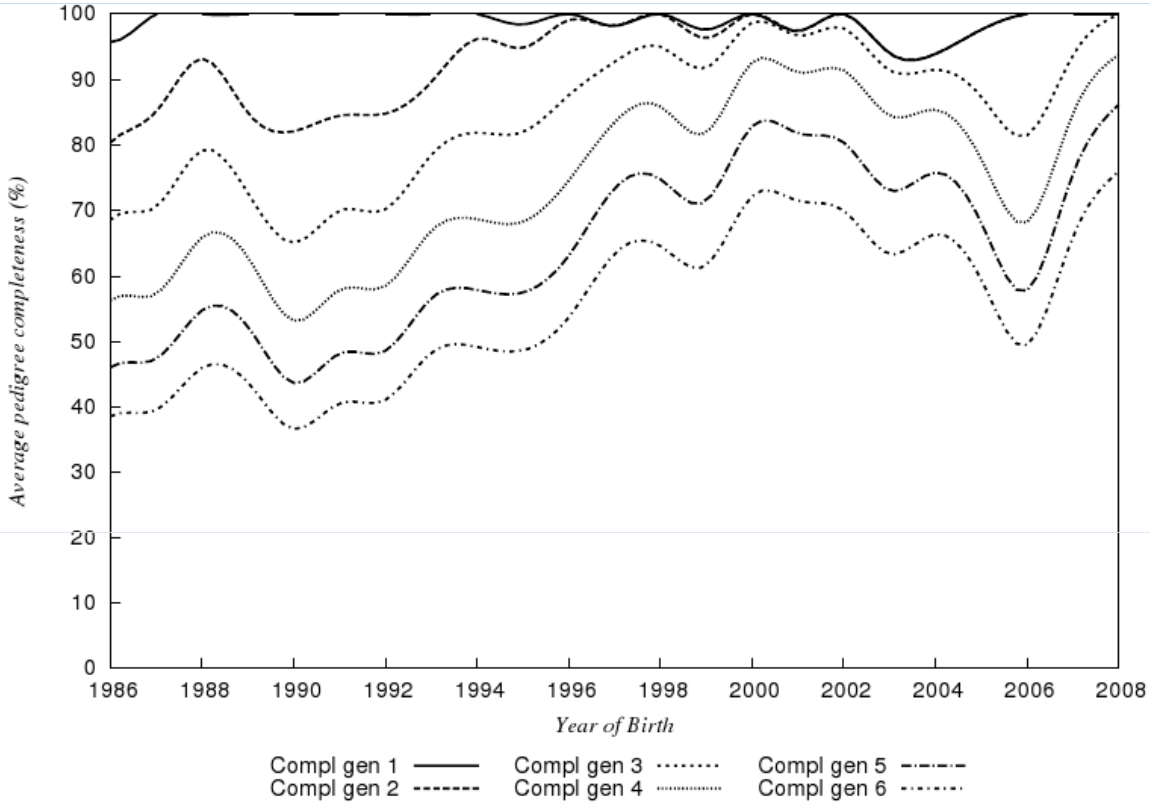
Table 1: The average pedigree completeness (%) for 1 to 6 generations deep by year

Year	No of Animals	Compl. gen 1	Compl. gen 2	Compl. gen 3	Compl. gen 4	Compl. gen 5	Compl. (%) gen 6(%)
1950	4	100.0	50.0	33.3	25.0	20.0	16.7
1951	3	100.0	50.0	33.3	25.0	20.0	16.7
1952	10	90.0	46.7	31.1	23.3	18.7	15.6
1953	10	100.0	53.3	35.6	26.7	21.3	17.8
1954	4	100.0	54.2	36.1	27.1	21.7	18.1
1955	10	100.0	63.3	42.5	31.9	25.5	21.3
1956	6	100.0	69.4	49.3	37.4	29.9	24.9
1957	8	100.0	58.3	40.1	30.1	24.0	20.0
1958	4	100.0	54.2	36.9	27.7	22.1	18.4
1959	9	100.0	63.0	44.9	34.2	27.4	22.8
1960	7	100.0	57.1	39.0	29.4	23.5	19.6
1961	12	83.3	51.4	35.4	26.8	21.4	17.8
2000	35	100.0	100.0	98.7	92.6	82.9	72.2
2001	38	97.4	97.4	96.7	91.1	81.8	71.5
2002	42	100.0	100.0	97.8	91.4	80.4	70.0
2003	50	94.0	94.0	91.4	84.5	73.1	63.4
2004	33	93.9	93.9	91.5	85.4	75.8	66.4
2005	41	97.6	97.6	87.4	77.9	68.2	59.5
2006	27	100.0	100.0	81.5	68.2	57.8	49.5
2007	22	100.0	100.0	93.7	84.8	75.6	66.0
2008	1	100.0	100.0	100.0	93.8	86.2	76.0

Pedigree Vollständigkeit

The average pedigee completeness for animals born within the last 10 years: 1 generations deep = 97.6%. 2 generations deep = 97.4%. 3 generations deep = 92.5%. 4 generations deep = 84.6%. 5 generations deep = 74.5%. 6 generations deep = 64.8%.

Figure 1: Average pedigree completeness for 1 to 6 generations



Sind wir wirklich nicht besser?

Inzuchtniveau

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
1950	4	-	-	-	-	-	-	-	-	-	-
1951	3	-	-	-	-	-	-	-	-	-	-
1952	10	-	-	-	-	-	-	-	-	-	-
1953	10	-	-	-	-	-	-	-	-	-	-
1954	4	-	-	-	-	-	-	-	-	-	-
1955	10	-	-	-	-	-	-	-	-	-	-
1996	55	3	-	-	-	-	-	-	-	-	-
1997	54	2	-	-	-	-	-	-	-	-	-
1998	52	1	1	-	-	-	-	-	-	-	-
1999	40	1	-	-	-	-	-	-	-	-	-
2000	33	2	-	-	-	-	-	-	-	-	-
2001	32	5	-	-	-	1	-	-	-	-	-
2002	39	3	-	-	-	-	-	-	-	-	-
2003	48	-	2	-	-	-	-	-	-	-	-

Ist enge Inzucht vermieden worden?

Effektive Populationsgröße

3.2 Effective population size based on the number of parents

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

$$Ne = \frac{4N_m N_f}{N_m + N_f}$$

where N_m and N_f are the number of male and female parents, respectively. The columns in the table are:

Number of animals : born in a given year.

Number of sires : of animals born in a given year.

Number of dams : of animals born in a given year.

Number of parents : number of sires and dams of animals born in a given year.

Ne : effective population size.

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

	Number of				
Year	Animals	Sires	Dams	Parents	*Ne*
1950	4	3	4	7	7
1951	3	3	3	6	6
1952	10	6	10	16	15
1953	10	10	10	20	20
1954	4	4	4	8	8
1955	10	10	10	20	20
1956	6	6	6	12	12
1957	8	8	8	16	16
1958	4	4	4	8	8
1959	9	8	9	17	17
1960	7	7	7	14	14
1961	12	10	11	21	21

Effektive Populationsgröße Methode 1

Census based

Method 1: Assuming discrete generations and equal numbers of breeding males and females N_e can be determined directly as

$$N_e = \frac{4N_m N_f}{N_m + N_f} \tag{7}$$

The number of males and females are usually easy to determine, therefore this expression is often used where other ways of computing N_e are not possible. However, the assumptions that the ratio between breeding males and females is 1:1 and that all individuals in a real population have an equal chance to contribute genetically to next generation are usually not met. Therefore 7 tends to overestimate N_e considerably.

Effective Population Size Method 2 - 6

All other methods are based on the rate of inbreeding

The relevant quantity for the assessment of inbreeding is the inbreeding coefficient F and its rate of change $\triangle F$. The latter is defined as Falconer & Mackay (1996):

$$\triangle F = \frac{F_t - F_{t-1}}{1 - F_{t-1}} \qquad (2)$$

where t is the t^{th} generation. As has been stated the cohort are those animals born in a given year. To compute $\triangle F$ actually two cohorts i.e. sets of animals need to be defined: $cohort_t$ at generation t and $cohort_{t-1}$at generation $t-1$ have to be defined.

$$N_e = 1/2\Delta F$$

Effective Population SizeMethod 2-6

Method 2: based on actual parents of the current birth year (inbreeding F)Method 3: based on all animals of the year GI prior to the current (inbreeding F)Method 4: based on all animals of the year GI prior to the current (inbreeding f)Method 5:Method 6:

$$ln(1 - F_{u+t}) = t * ln(1 - \Delta F) + ln(1 - F_u)$$

$$N_e = 1/2(1 - (1 - F_t)^{(1/t)})$$

Effective Population Sizes

Table 5: Effective population sizes based on the period 1990–2008

Breed[a]	method 1	method 2	method 3	method 4	method 5	method 6[b]
Nellore	502	–[c]	–	–	476	1293
Bonsmara	6901	106	162	324	190	231
Jersey	3545	203	79	83	67	208
Holstein	4803	–	318	282	408	794
Duroc	247	40	119	99	219	143
Landrace	546	50	13??	44	222	102
Merino	861	241	562	5588	447	601
Skudden	280	–	528	391	–	210

[a] 5 generations with min PCI .8; based on arithmetic mean of ΔF_p ΔF_g Δf_g

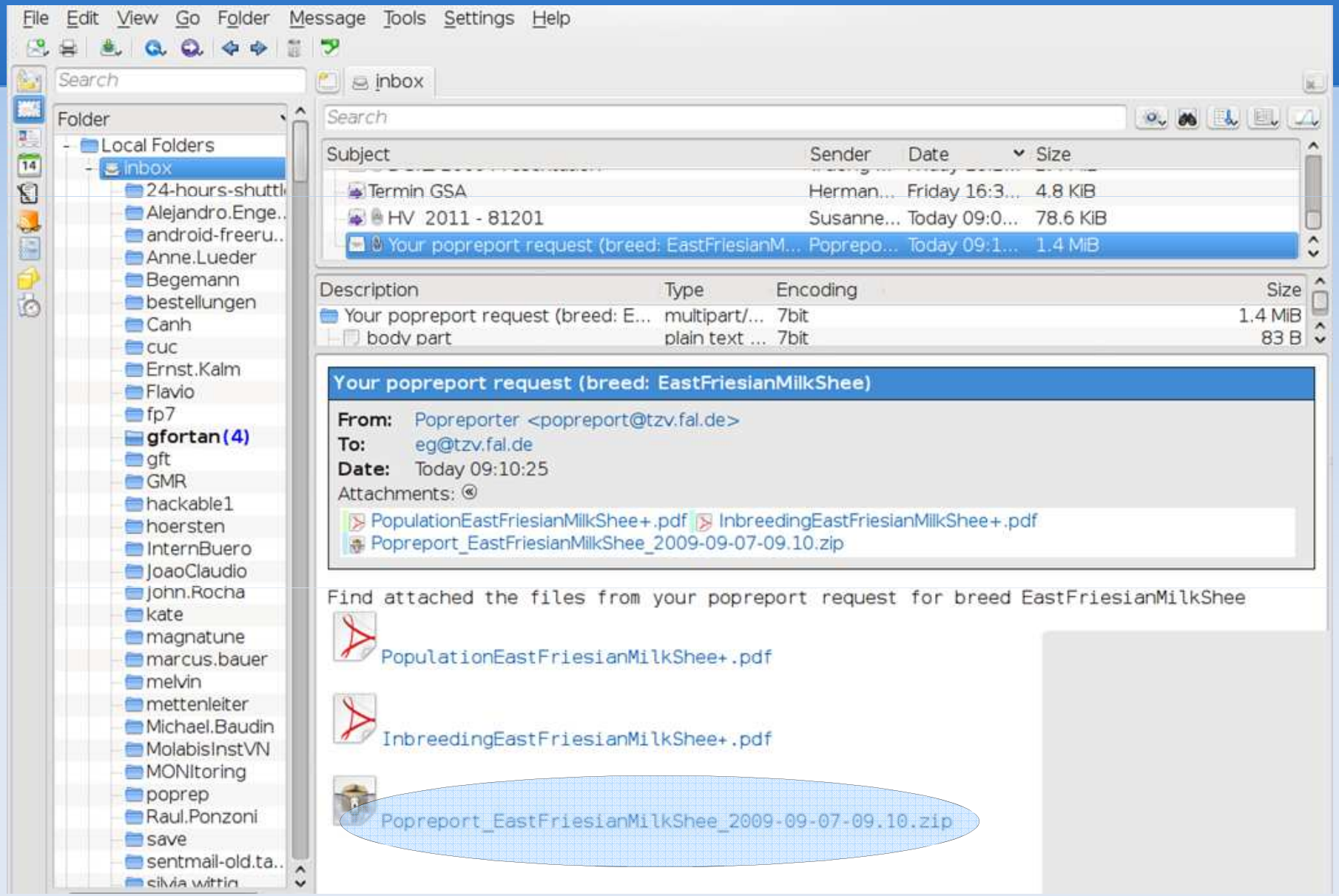
[b] N_e was taken from the most recent full birth year

[c] – negative N_e

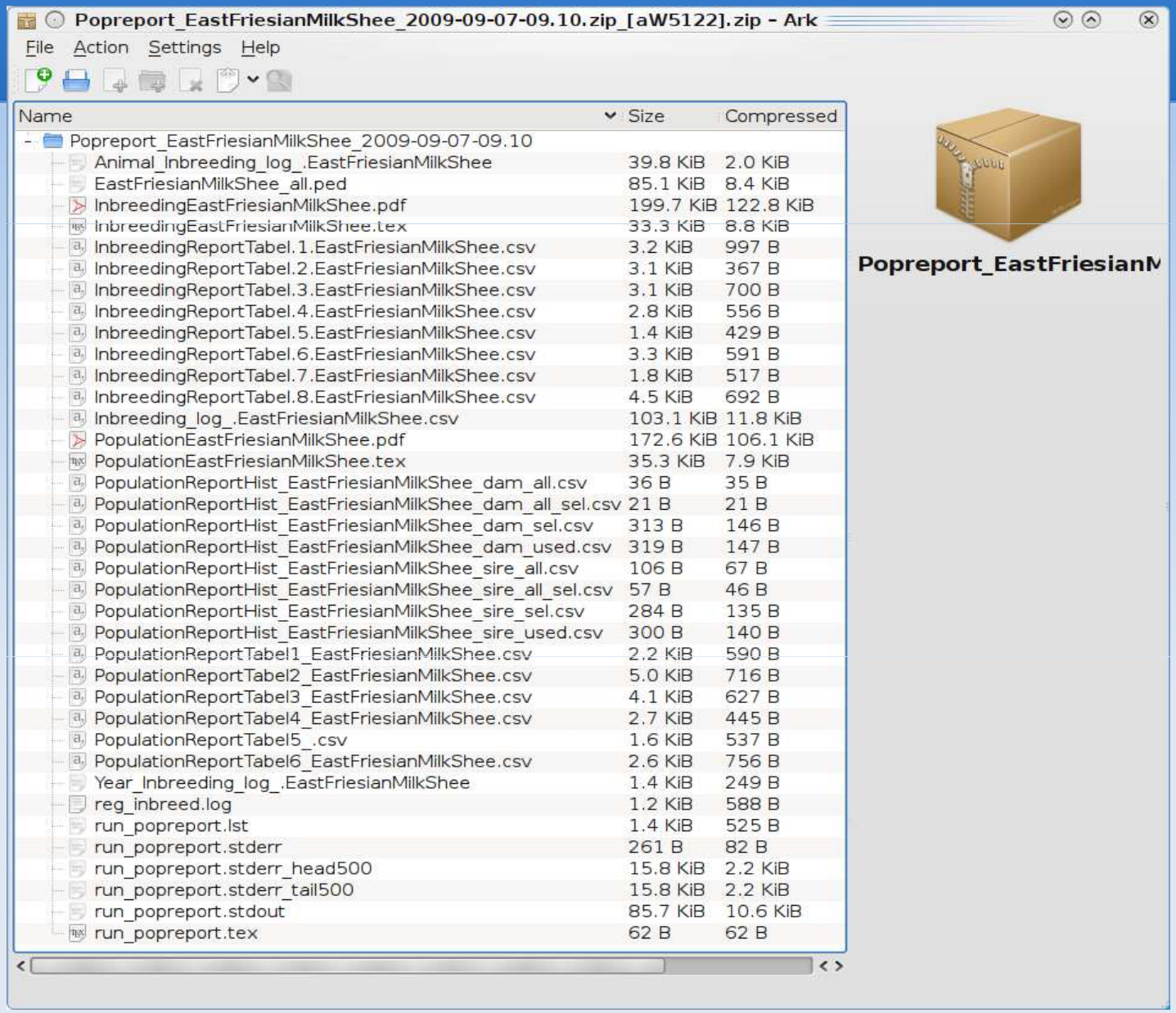
Reference

POPREP: A Generic Report for Population Management,
E Groeneveld, B v.d. Westhuizen A Maiwashe, F Voordewind, JBS Ferraz
Genetics and Molecular Research (GMR) 2009, 8(3)

poprep.tzv.fal.de



Daten zur Nachbearbeitung



Nachverarbeitung

CSV Datei für jede Tabelle→ jeder kann ihre eigene Nachverarbeitung machen

Zusammenfassung

Populationsmanagement Erhaltungs- und Hochleistungszucht

Workshop “Tiergenetische Ressourcen” Bern – 26. Mai 2010

Vielen Dank für Ihre Aufmerksamkeit

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