Guide Dogs

Analysis of semen traits

Tom Lewis

Guide Dogs UK

Background - media take on male fertility

NEWS

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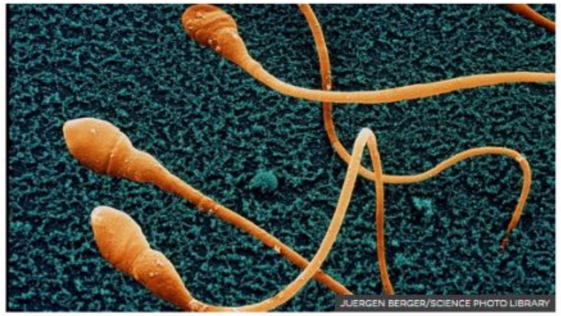
Health

Sperm count drop 'could make humans extinct'

By Pallab Ghosh
Science correspondent, BBC News

25 July 2017



JUERGEN BERGER/SCIENCE PHOTO LIBRARY

Humans could become extinct if sperm counts in men continue to fall at current rates, a doctor has warned.

Researchers assessing the results of nearly 200 studies say sperm counts among men from North America, Europe, Australia, and New Zealand, seem to have halved in less than 40 years.

Some experts are sceptical of the **Human Reproduction Update** findings.

But lead researcher Dr Hagai Levine said he was "very worried" ab... might happen in the future.

Spermageddon

Sophie Johnson | 16th August 2021 | © Creative Commons 4.0

Sperm levels among men in Western countries has more than halved during the past 40 year... and, according to one study, could deplete to zero by 2045.

THE CUT

STYLE | SELF | CULTURE | POWER

SCIENCE OF US | OCT. 2, 2018

Why Is Everybody Freaking Out About Sperm Counts? The new penis panic says a lot more about male anxiety than fertility.

By Daniel Engber

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Sperm quality has been declining for 16 years among men in the US

HEALTH 21 October 2021

By Alice Klein

Toxic America

Sperm counts are on the decline – could plastics be to blame?

A recent study that tested both men and dogs added to concerns that chemicals in the environment are damaging the quality and quantity of sperm

Help us reach our $150,000 goal to fund this series. ***Make a contribution***

by Teresa Carr

Surprising new research into dog sperm has reproductive biologists concerned about the fate of their own species. In a March study, scientists at Nottingham University found that two chemicals common in home environments damage the quality of sperm in both men and dogs.

Falling sperm counts 'threaten human survival', expert warns

Epidemiologist Shanna Swan says low counts and changes to sexual development could endanger human species

Miranda Bryant

Falling sperm counts and changes to sexual development are "threatening human survival" and leading to a fertility crisis, a leading epidemiologist has warned.

Writing in a new book, Shanna Swan, an environmental and reproductive epidemiologist at Icahn School of Medicine at Mount Sinai in New York, warns that the impending fertility crisis poses a global threat comparable to that of the climate crisis.

The Atlantic

Sperm Counts Continue to Fall

Scientists are coming to a consensus that men in America and Europe are experiencing a worsening decrease in fertility. They disagree, however, about why.

By Ashley Fetters

OCTOBER 12, 2018

Men's sperm have been decreasing in number and getting worse at swimming for some time now—and, at least in the United States and Europe, new research says it's getting worse. A pair of new studies unveiled this week at the Scientific Congress of the American Society for Reproductive Medicine (ASRM) in Denver suggest that American and European men's sperm count

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Background - the science behind the story

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Research Article

Evidence for decreasing quality of semen during past 50 years.

British Medical Journal 1992 ; 305 doi: https://doi.org/10.1136/bmj.305.6854.609 (Published 12 September 1992)
Cite this as: *British Medical Journal* 1992;305:609

Article | Related content | Metrics | Responses | Peer review

E. Carlsen, A. Giwercman, N. Keiding, N. E. Skakkebaek
Author affiliations

Abstract

OBJECTIVE--To investigate whether semen quality has changed during the past 50 years. DESIGN--Review of publications on semen quality in men without a history of infertility selected by means of Cumulated Index Medicus and Current List (1930-1965) and MEDLINE Silver Platter database (1966-A
14,947 men included in a total of 61 papers published between 1938 and 1991. MAI
Mean sperm density and mean seminal volume. RESULTS--Linear regression of data
men in each study showed a significant decrease in mean sperm count from 113 x 1
10(6)/ml in 1990 (p < 0.0001) and in seminal volume from 3.40 ml to 2.75 ml (p = 0.0
more pronounced decrease in sperm production than expressed by the decline in sp
CONCLUSIONS--There has been a genuine decline in semen quality over the past 50
to some extent correlated with sperm count the results may reflect an overall reduc
biological significance of these changes is emphasised by a concomitant increase in
genitourinary abnormalities such as testicular cancer and possibly also cryptorchidis
suggesting a growing impact of factors with serious effects on male gonadal functio

Temporal trends in sperm count: a systematic review and meta-regression analysis FREE

Hagai Levine, Niels Jørgensen, Anderson Martino-Andrade, Jaime Mendiola, Dan Weksler-Derri, Irina Mindlis, Rachel Pinotti, Shanna H Swan

Human Reproduction Update, Volume 23, Issue 6, November-December 2017, Pages 646–659, https://doi.org/10.1093/humupd/dmx022
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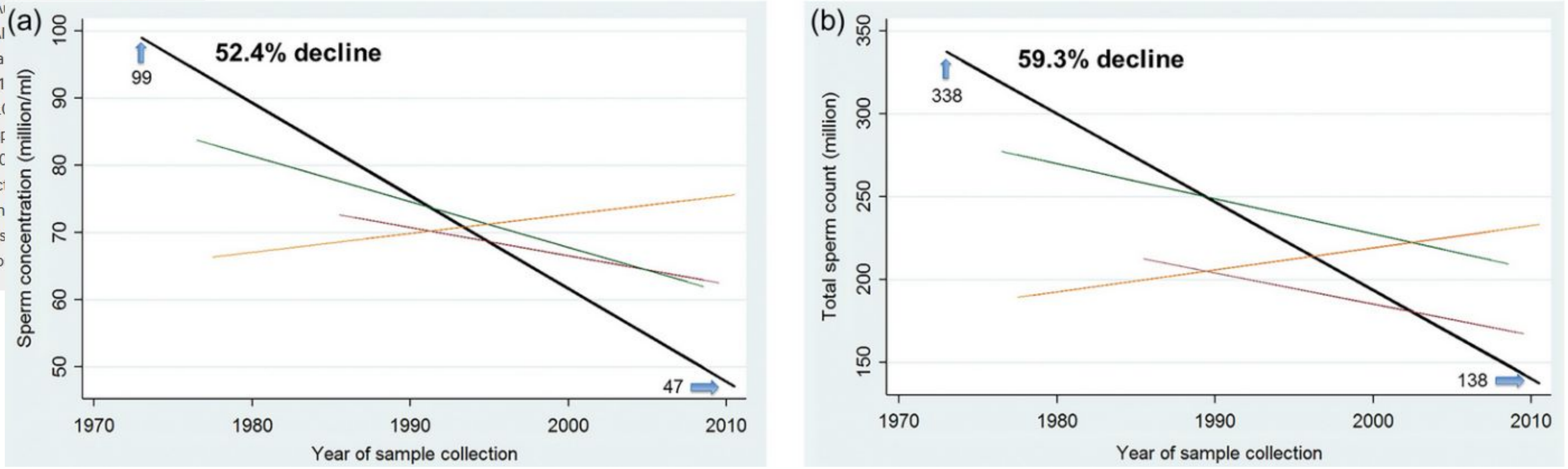

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Background - previous work from GDUK

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Theriogenology 74 (2010) 1136–1140
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ELSEVIER

Heritability of semen characteristics in dogs

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Received 17 December 2009; received in revised form 29 April 2010; accepted 7 May 2010

Abstract

Retrospective analysis was performed on semen collected from 24 dogs (parents: 14 Labrador retrieve
retrievers) aged between 16 and 28 months of age. The dogs were part of a large breeding programme but liv
volunteer families. The semen was subjected to a standardised examination procedure including assessment of:
motility, sperm concentration, total sperm output, percentage of live normal sperm, and total number of live nor
was subsequently collected from one son of each of the parents when the offspring were aged between 16 and
14 Labrador retrievers and 10 Golden retrievers), and was subjected to the same examination procedures cond
technician. Examination of breeding records demonstrated that each of the 48 dogs achieved at least one pregnar
of 3 months before to 3 months after the semen collection.

There was a weak correlation between parents and offspring for each of the 5 semen parameters, although
statistically significant. Narrow sense heritability measures were low for all parameters except for the heritabi
motility (rN2 = 0.57) and the heritability of low total sperm output (rN2 = 0.57).

It is plausible that breeding selection procedures may be useful in dog breeding programmes in an attempt
quality, although any impact upon fertility is yet to be proven.

Keywords: Heritability; Semen quality; Sperm; Dogs

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Environmental chemicals impact dog semen quality in vitro and may be associated with a temporal decline in sperm motility and increased cryptorchidism

Received: 28 January 2016
Accepted: 15 July 2016
Published: 09 August 2016

Richard G. Lea[1,2], Andrew S. Byers[1], Rebecca N. Sumner[1], Stewart M. Rhind[3,*], Zulin Zhang[3], Sarah L. Freeman[1], Rachel Moxon[4], Holly M. Richardson[1], Martin Green[1], Jim Craigon[5] & Gary C. W. England[1]

Adverse temporal trends in human semen quality and cryptorchidism in infants have been associated with exposure to environmental chemicals (ECs) during development. Here we report that a population of breeding dogs exhibit a 26 year (1988–2014) decline in sperm quality and a concurrent increased incidence of cryptorchidism in male offspring (1995–2014). A decline in the number of males born relative to the number of females was also observed. ECs, including diethylhexyl phthalate (DEHP) and polychlorinated biphenyl 153 (PCB153), were detected in adult dog testes and commercial dog foods at concentrations reported to perturb reproductive function in other species. Testicular concentrations of DEHP and PCB153 perturbed sperm viability, motility and DNA integrity *in vitro* but did not affect LH stimulated testosterone secretion from adult testis explants. The direct effects of chemicals on sperm may therefore contribute to the decline in canine semen quality that parallels that reported in the human.

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Independent and combined effects of diethylhexyl phthalate and polychlorinated biphenyl 153 on sperm quality in the human and dog

ceived: 4 October 2018
cepted: 4 February 2019
lished online: 04 March 2019

Rebecca N. Sumner[1,4], Mathew Tomlinson[2], Jim Craigon[3], Gary C.W. England[1] & Richard G. Lea[1]

A temporal decline in human and dog sperm quality is thought to reflect a common environmental aetiology. This may reflect direct effects of seminal chemicals on sperm function and quality. Here we report the effects of diethylhexyl phthalate (DEHP) and polychlorinated biphenyl 153 (PCB153) on DNA fragmentation and motility in human and dog sperm. Human and dog semen was collected from registered donors (n = 9) and from stud dogs (n = 11) and incubated with PCB153 and DEHP, independently and combined, at 0x, 2x, 10x and 100x dog testis concentrations. A total of 16 treatments reflected a 4 × 4 factorial experimental design. Although exposure to DEHP and/or PCB153 alone increased DNA fragmentation and decreased motility, the scale of dose-related effects varied with the presence and relative concentrations of each chemical (DEHP.PCB interaction for: DNA fragmentation; human p < 0.001, dog p < 0.001; Motility; human p < 0.001, dog p < 0.05). In both human and dog sperm, progressive motility negatively correlated with DNA fragmentation regardless of chemical presence (Human: P < 0.0001, r = −0.36; dog P < 0.0001, r = −0.29). We conclude that DEHP and PCB153, at known tissue concentrations, induce similar effects on human and dog sperm supporting the contention of the dog as a sentinel species for human exposure.

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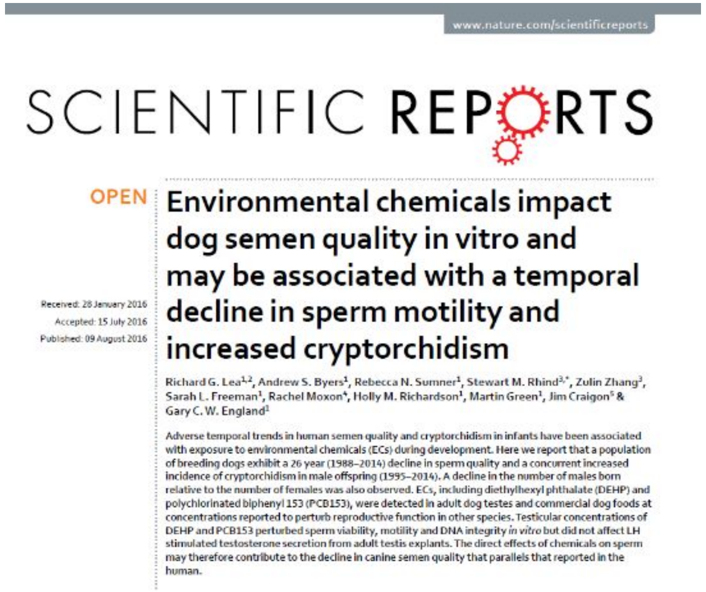
Background - changes in GD populations



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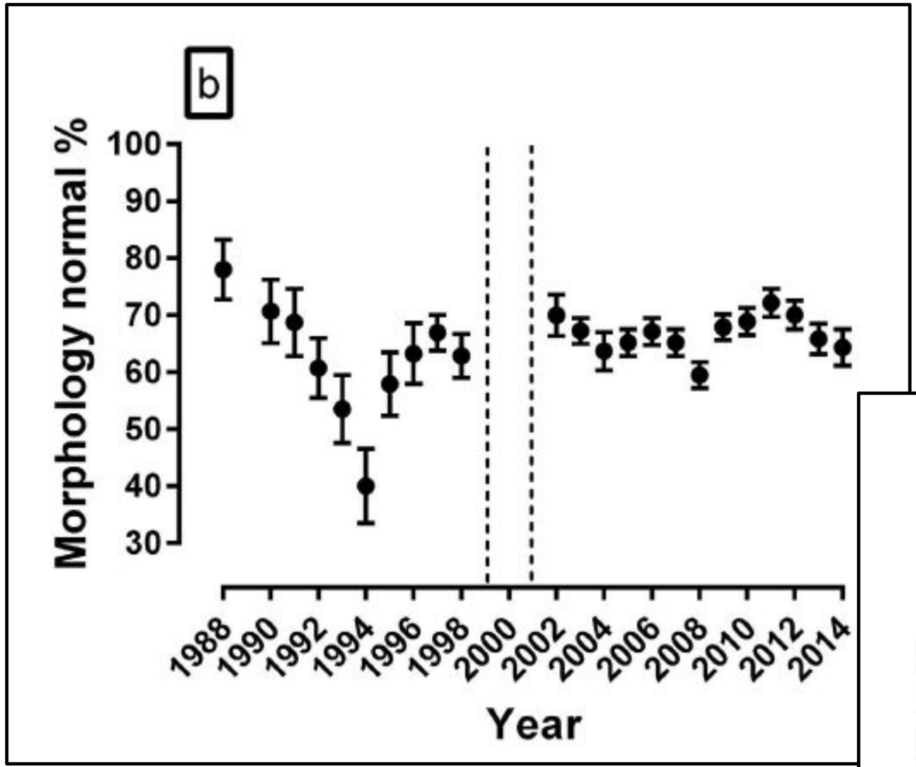

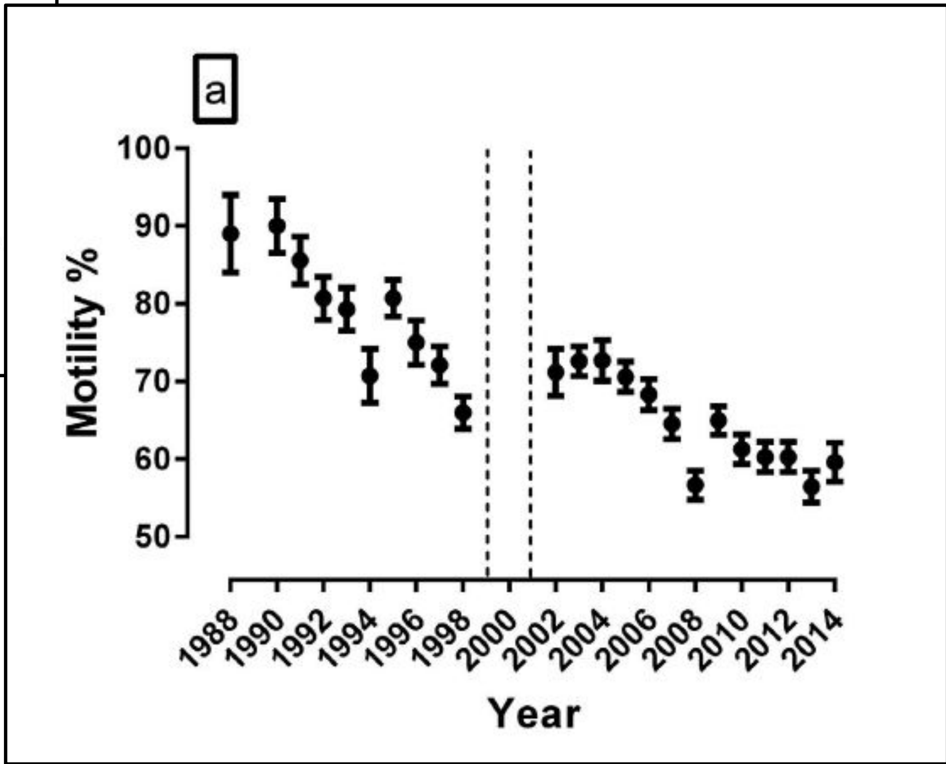

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Background - objectives

Determine heritability estimates for a series of semen traits

Determine *repeatability* (genetics + permanent environment - later!)

Any indication that the traits are related to each other?

Any indication of trends with age / time / inbreeding?

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Methods –semen collection

Semen collected from every stud dog for ‘insurance’, fertility checks, export, etc

Collected at various time points over dog’s life

Stud dogs are all ‘purebred’ (use crosses for working or as broods)

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Methods - data

3 ejaculate fractions collected separately, 5 traits:

VOL - second fraction recorded in ml

MOT - % sperm with fast forward progressive motility

CONC - assessed using haemocytometer counting chamber, millions/ml

TSO = CONC x VOL

TNLS - % total normal live sperm

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Methods - analysis

Individual breeds analysed separately

Pedigree information used to form ‘relationship matrix’ between all individuals per breed with data

Mixed linear models fitted using ASReml-R

Animal model, include age(m), date and inbreeding coefficient as covariates.

Repeated measures ¤ permanent environment

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Methods - repeated measures

Genetics / heritability

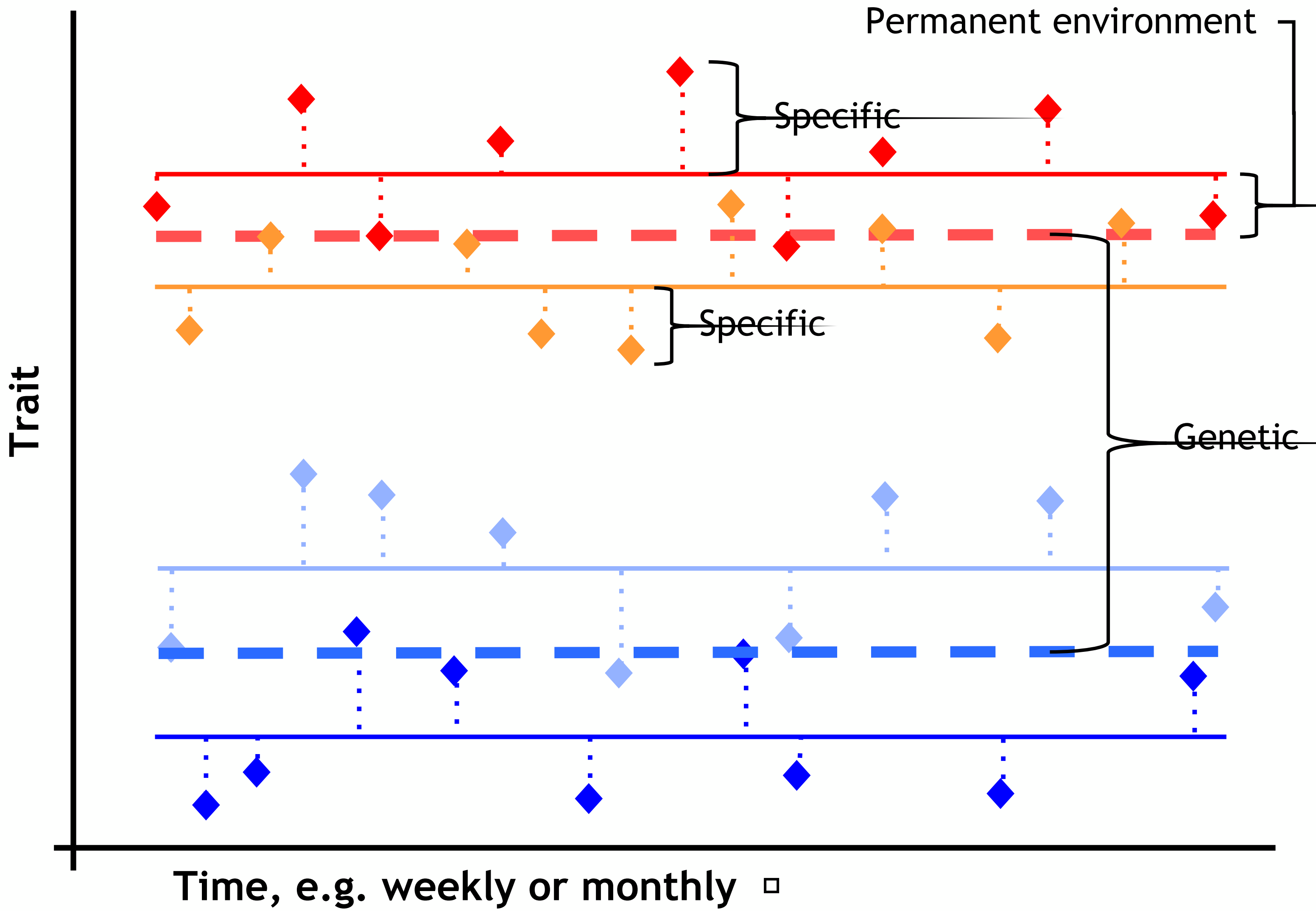
- lifelong, inherited, shared

Permanent environment

- lifelong, individual, acquired

Specific environment

- mutable, unique to time



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Data description

n=4,016 repeat records, from n = 423 unique dogs

Rec/dog: mean=9.5, sd=6.7, mode=1, median=9, IQR=3.5-14.0, range=1-40

Age(m): mean=54.0, median=51, IQR=30-75, range=11-163

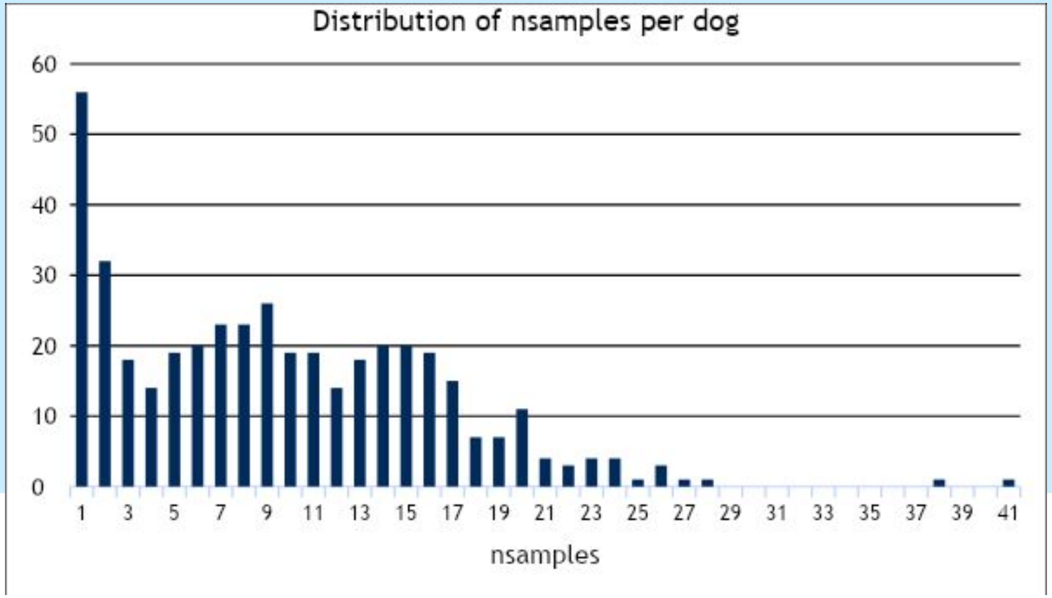
Year: 1990-2022, 75% since 2004, 50% since 2011, 25% since 2016

Inbreeding: mean=6.2%, median 6.3%, IQR=3.7-8.8%, range=0-23.3%

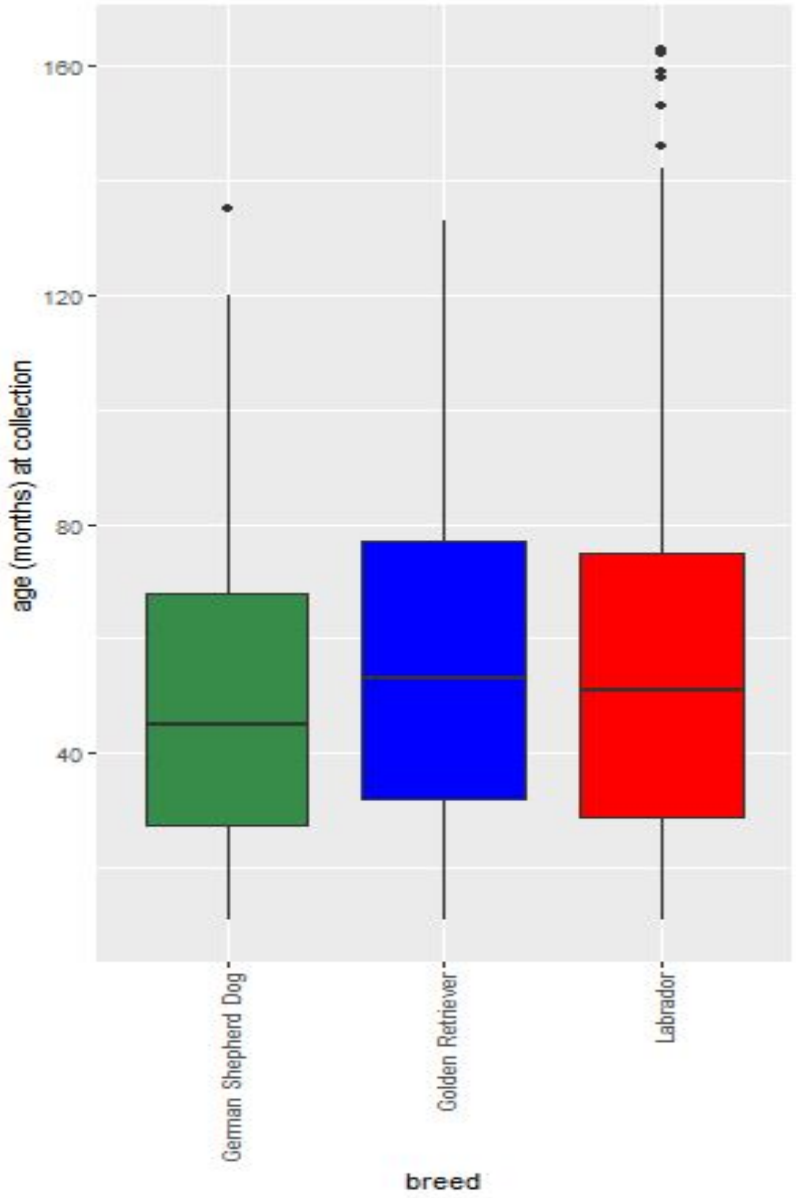
Labs: 2,058 records, 223 dogs

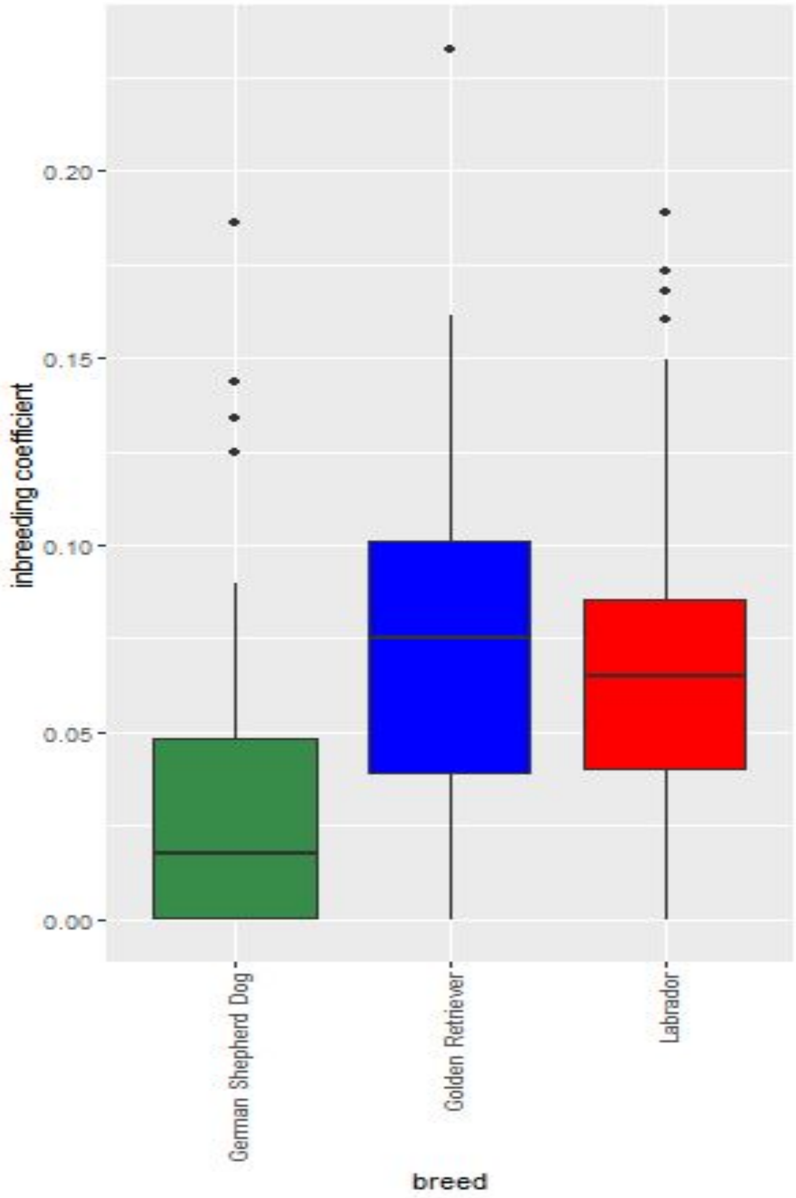
GRs: 1,479 records, 138 dogs

GSDs: 479 records, 62 dogs



Data description - breed differences





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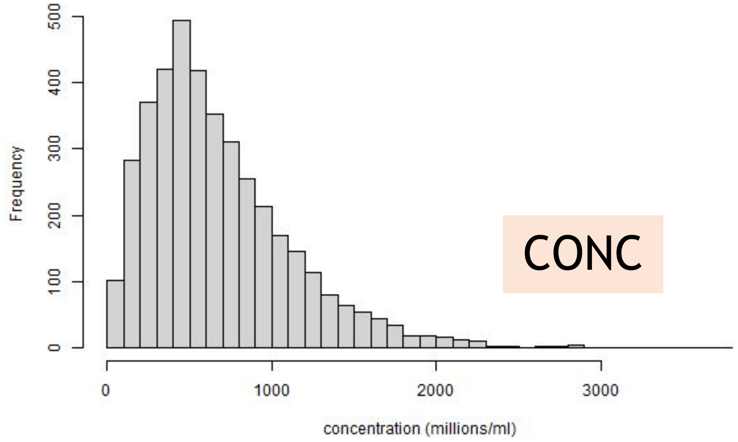
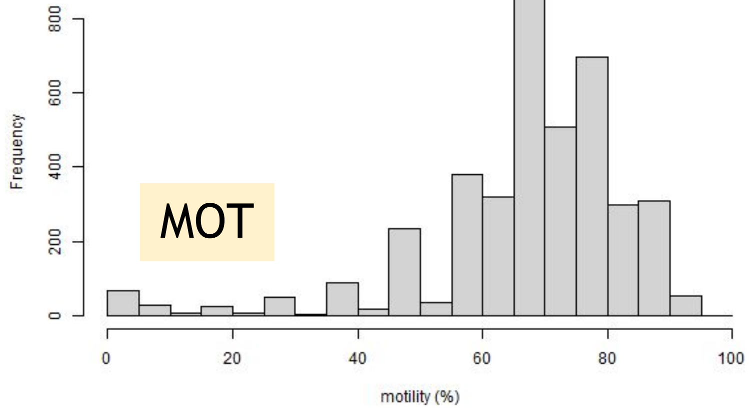
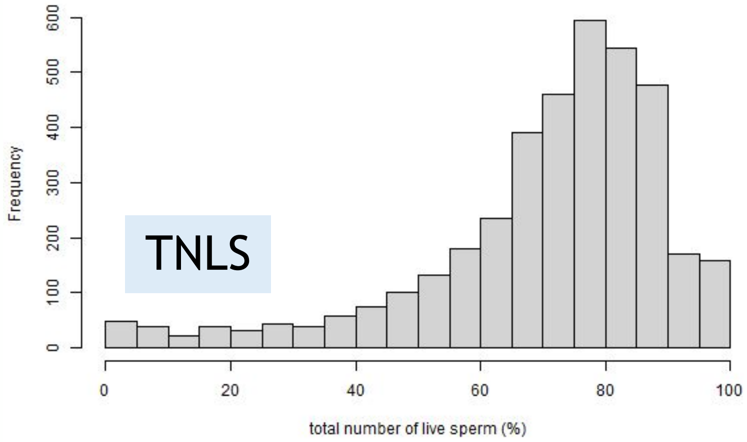
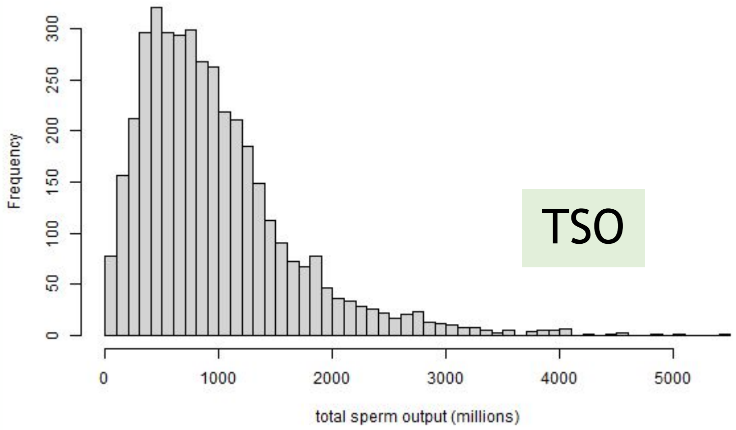
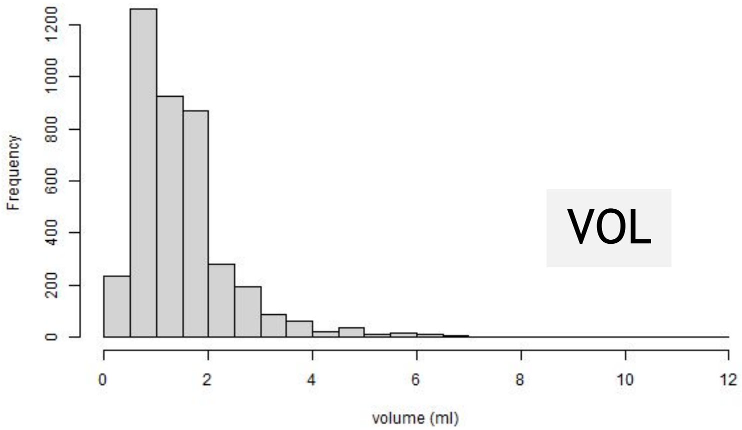
Traits - distributions











CONCentration - millions / ml

MOTility - percent

Tot. Num. Live Sperm - percent

Tot. Sperm Output - millions (CONC x VOL)

VOLume - ml

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Traits - general correlations

	CONC	MOT	TNLS	TSO	VOL
CONC		0.096	0.035	0.687	-0.288
MOT	***		0.561	0.148	0.036
TNLS	*	***		0.051	-0.012
TSO	***	***	**		0.310
VOL	***	*	ns	***	

TSO function of CONC and VOL

TNLS and MOT □ indicator of health?

CONC and VOL □ seminal fluid production?

MOT and TSO □ indicator of health?

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Traits - general effects 1 - age

	regr coef	p-val	adj Rsq	yearly	3-years	mean
CONC	-1.494	***	0.0089	-17.92	-53.77	683.5
MOT	-0.059	***	0.0098	-0.71	-2.13	69.34
TNLS	-0.148	***	0.0454	-1.78	-5.34	71.13
TSO	-1.038	**	0.0016	-12.46	-37.37	917.3
VOL	0.0037	***	0.0102	0.04	0.13	1.613

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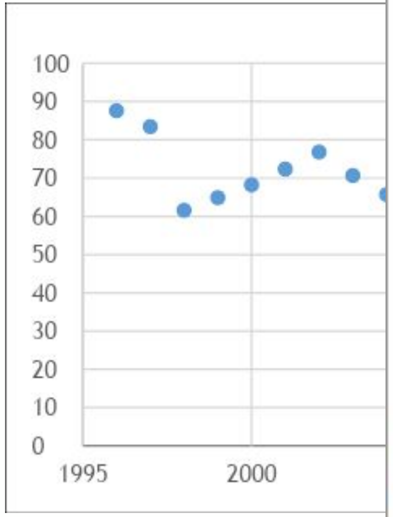
Traits - general effects 2 - inbreeding

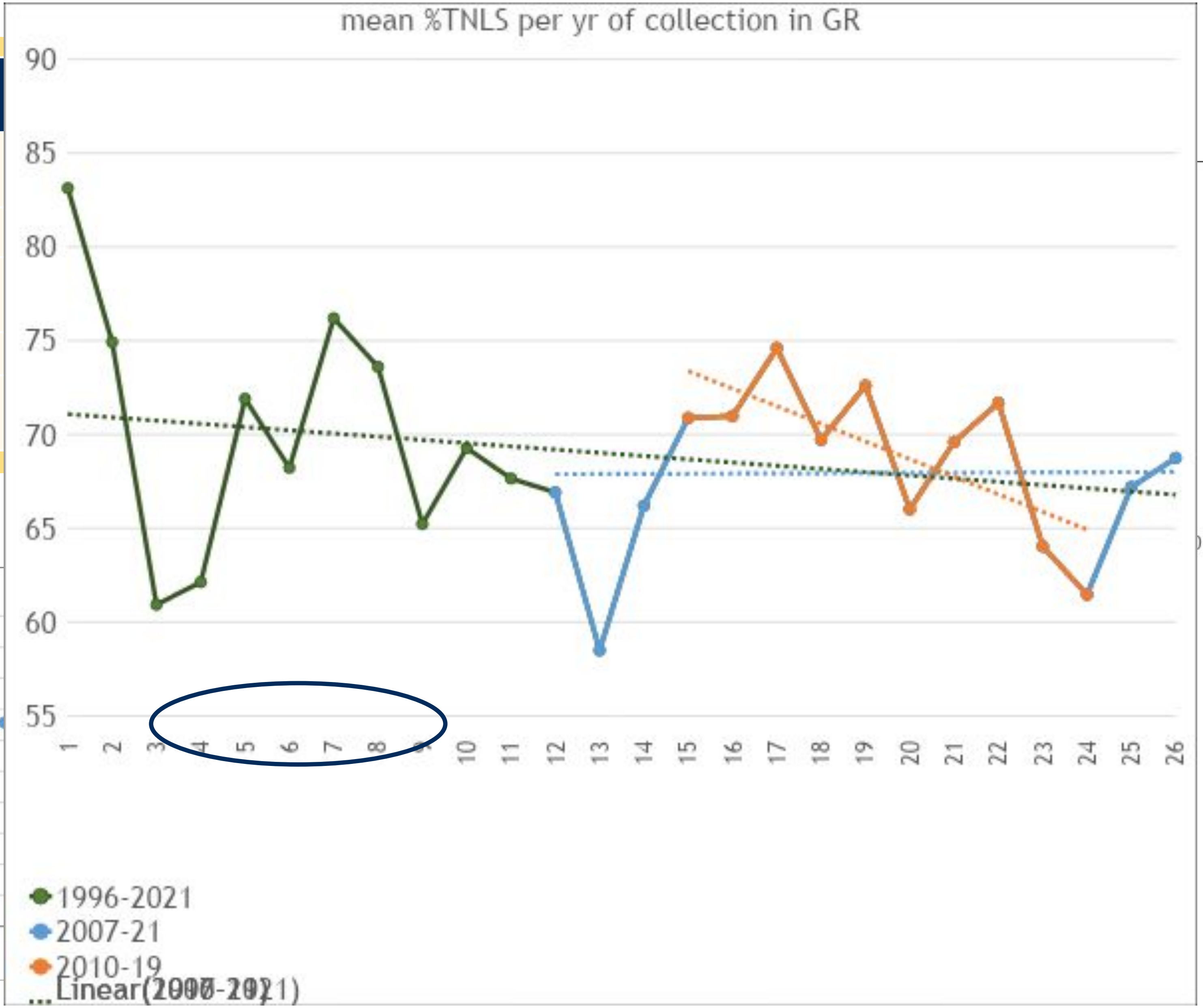
	regr coef	p-val	adj Rsq		+10%	+25%		mean
CONC	202.5	ns	0.00007		n/a	n/a		683.5
MOT	-10.33	ns	0.00033		n/a	n/a		69.34
TNLS	-38.85	***	0.0057		-3.89	-9.71		71.13
TSO	-636.2	*	0.0011		-63.62	-159.05		917.3
VOL	-2.329	***	0.0078		-0.23	-0.58		1.613

Traits - general effects 3 - temporal

TNLS	regr coef	p-val	adj Rsq
ALL	-0.0019	***	0.0754
LAB	-0.0018	***	0.0306
GR	-0.0023	***	0.1140

NB: 2010-19 inclusive, adjusted for age(m) and F (and





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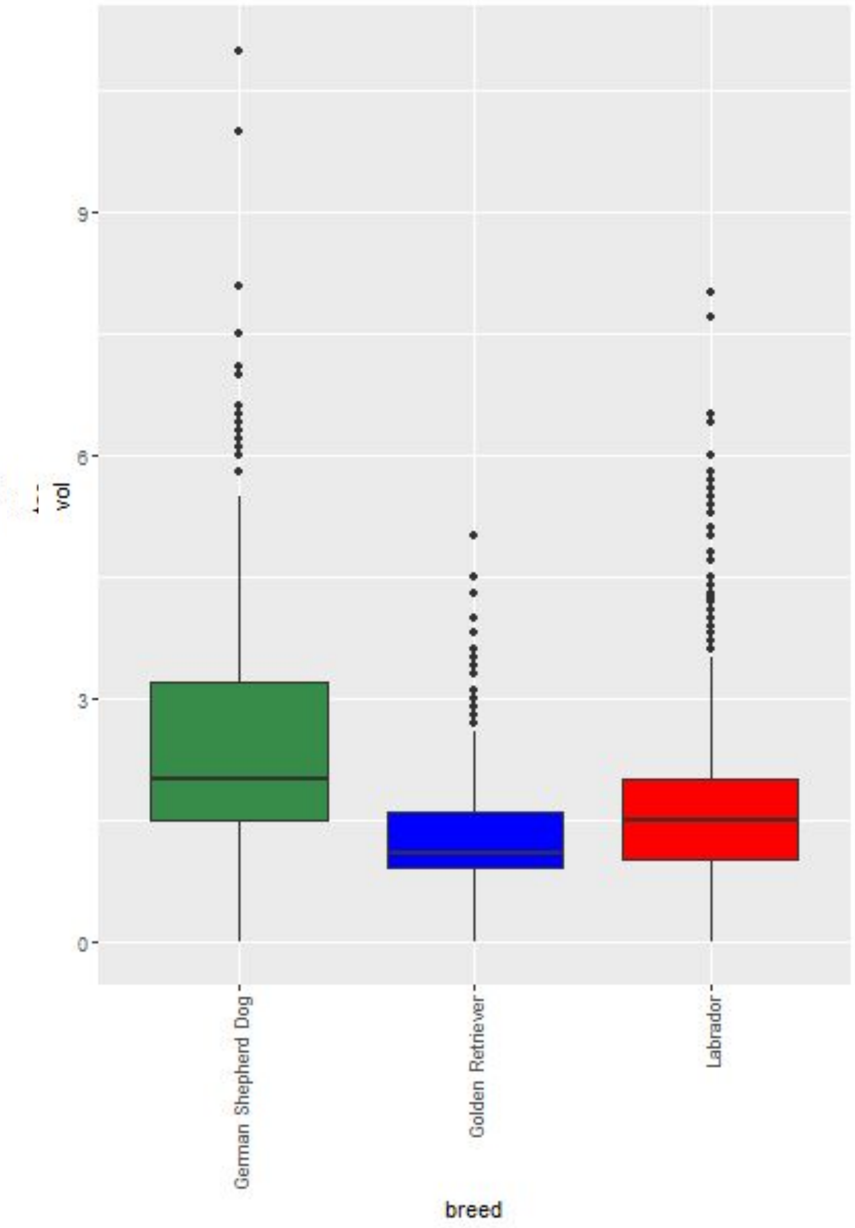
But - trait differences across breeds...

TRAIT	BREED	MIN	Q1	MEDIAN	MEAN	Q3	MAX	SD
CONC	Lab	0	372	566.5	662.3	863.8	2950	415.9
	GR	0	450	700	789	1040	3750	478.5
	GSD	0	210	350	448.8	580	2260	345.1
MOT	Lab	0	65	75	71.21	80	98	15.31
	GR	0	60	70	66.34	80	95	18.82
	GSD	0	65	70	70.57	80	95	15.75
TNLS	Lab	0	65	77	72.44	85	100	19.52
	GR	0	61	74	68.33	82	100	20.50
	GSD	0	68	77	74.15	85	100	16.97
TSO	Lab	0	510	840.2	966.7	1239.8	5040	653.8
	GR	0	455.5	803	981.8	1291	5453	734.3
	GSD	0	472.5	817.5	958.7	1216	4520	677.1
VOL	Lab	0	1	1.5	1.632	2	8	0.933
	GR	0	0.9	1.1	1.277	1.6	5	0.605
	GSD	0	1.5	2	2.567	3.2	11	1.620



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Results - heritabilities & repeatabilities

	Lab					GR					GSD				
	CONC	MOT	TNLS	TSO	VOL	CONC	MOT	TNLS	TSO	VOL	CONC	MOT	TNLS	TSO	VOL
Vp	156,479	236.07	362.5	435,685	0.8300	239,039	362.42	427.6	574,930	0.3838	110,792	238.21	336.7	456,008	2.8017
se	7,207	10.34	19.1	19,255	0.0388	12,814	30.54	34.8	31,556	0.0217	9,541	21.43	40.2	38,522	0.3277
h^2	0.144	0.060	0.060	0.086	0.115	0.130	0.381	0.354	0.077	0.172	0.00	0.00	0.454	0.00	0.457
se	0.063	0.057	0.070	0.056	0.053	0.068	0.111	0.108	0.073	0.072	0.00	0.158	0.067	0.00	0.065
p-val	**	ns	ns		**	*	**	**	ns	***	ns	ns	*	ns	**
pe	0.130	0.206	0.334	0.180	0.198	0.117	0.069	0.061	0.196	0.082	0.279	0.268	0.00	0.264	0.00
se	0.051	0.055	0.068	0.050	0.047	0.055	0.081	0.078	0.065	0.053	0.057	0.150	0.00	0.056	0.00
p-val	**	***	***	***	***	*	ns	ns	***	.	**	.	ns	***	ns
rpt	0.273	0.266	0.394	0.266	0.313	0.247	0.450	0.415	0.273	0.254	0.279	0.268	0.454	0.264	0.457
se	0.031	0.030	0.032	0.030	0.031	0.037	0.047	0.048	0.037	0.039	0.057	0.062	0.067	0.056	0.065

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General declining effect of age (m)

		Age (months)			
		regr coef	p-val	12m age	
	CONC	-2.14	***	-25.70	million
	MOT	-0.069	***	-0.83	%
Lab	TNLS	-0.182	***	-2.19	%
	TSO	0.043	ns	n/a	
	VOL	0.007	***	0.084	ml
	CONC	0.72	ns	n/a	
	MOT	-0.081	***	-0.98	%
GR	TNLS	-0.174	***	-2.09	%
	TSO	0.358	ns	n/a	
	VOL	0.0002	ns	n/a	
	CONC	-1.33	**	-15.80	million
	MOT	-0.112	***	-1.349	%
GSD	TNLS	-0.081	***	-0.975	%
	TSO	-1.731	ns	n/a	
	VOL	0.003	ns	n/a	

12m effect
-17.92
-0.71
-1.78
-12.46
0.04

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Breed differences in temporal effect

		Effect of time (days)			
		regr coef	p-val	1 year	
Lab	CONC	0.031	***	11.35	million
	MOT	-0.00028	ns	n/a	
	TNLS	-0.00064	*	-0.23	%
	TSO	0.032	**	11.69	million
	VOL	1.63E-05	ns	n/a	
GR	CONC	0.027	**	9.78	million
	MOT	-0.00106	*	-0.39	%
	TNLS	-0.0016	**	-0.59	%
	TSO	0.018	ns	n/a	
	VOL	1.80E-05	ns	n/a	
GSD	CONC	0.027	**	9.95	million
	MOT	0.00081	*	0.30	%
	TNLS	-0.00033	ns	n/a	
	TSO	0.143	ns	n/a	
	VOL	-7.40E-05	ns	n/a	

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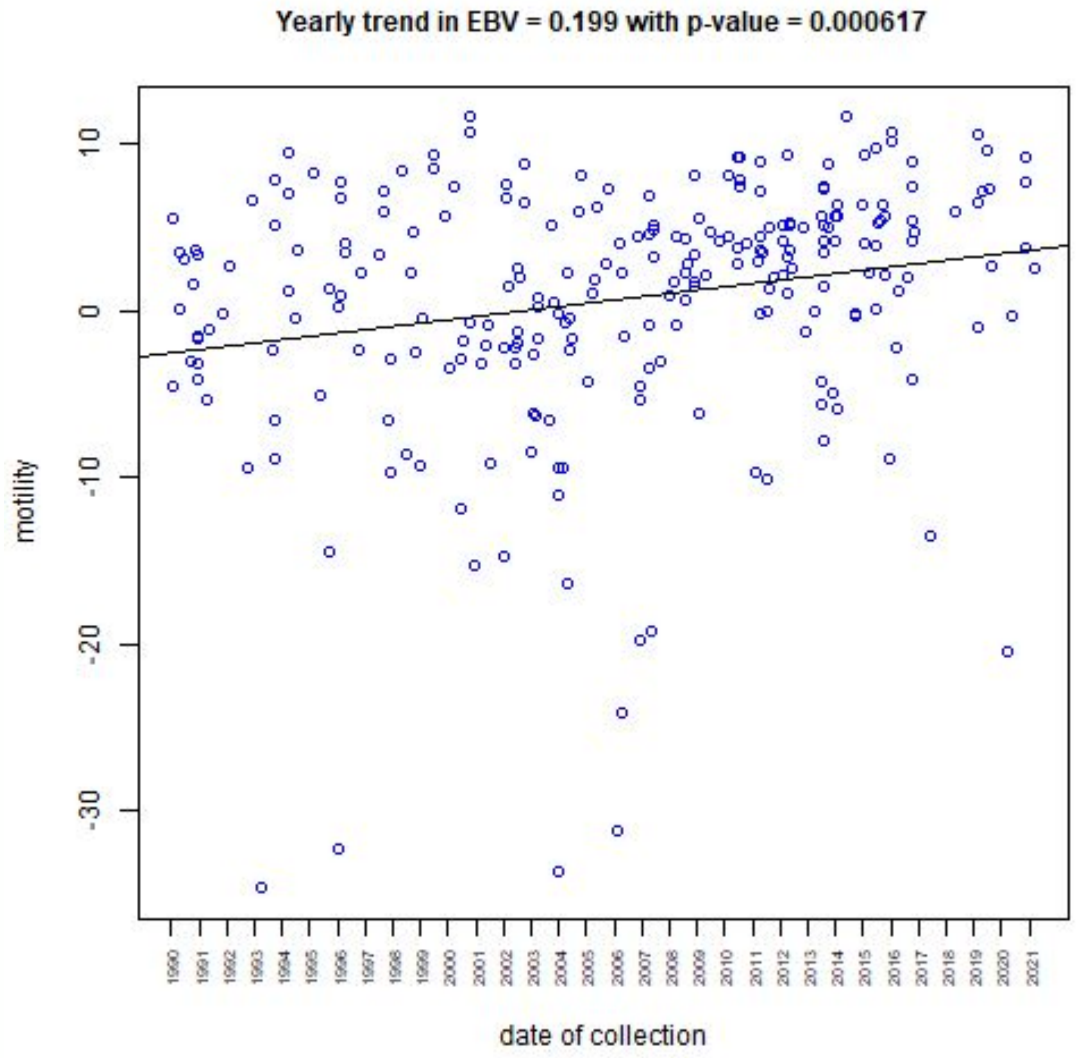
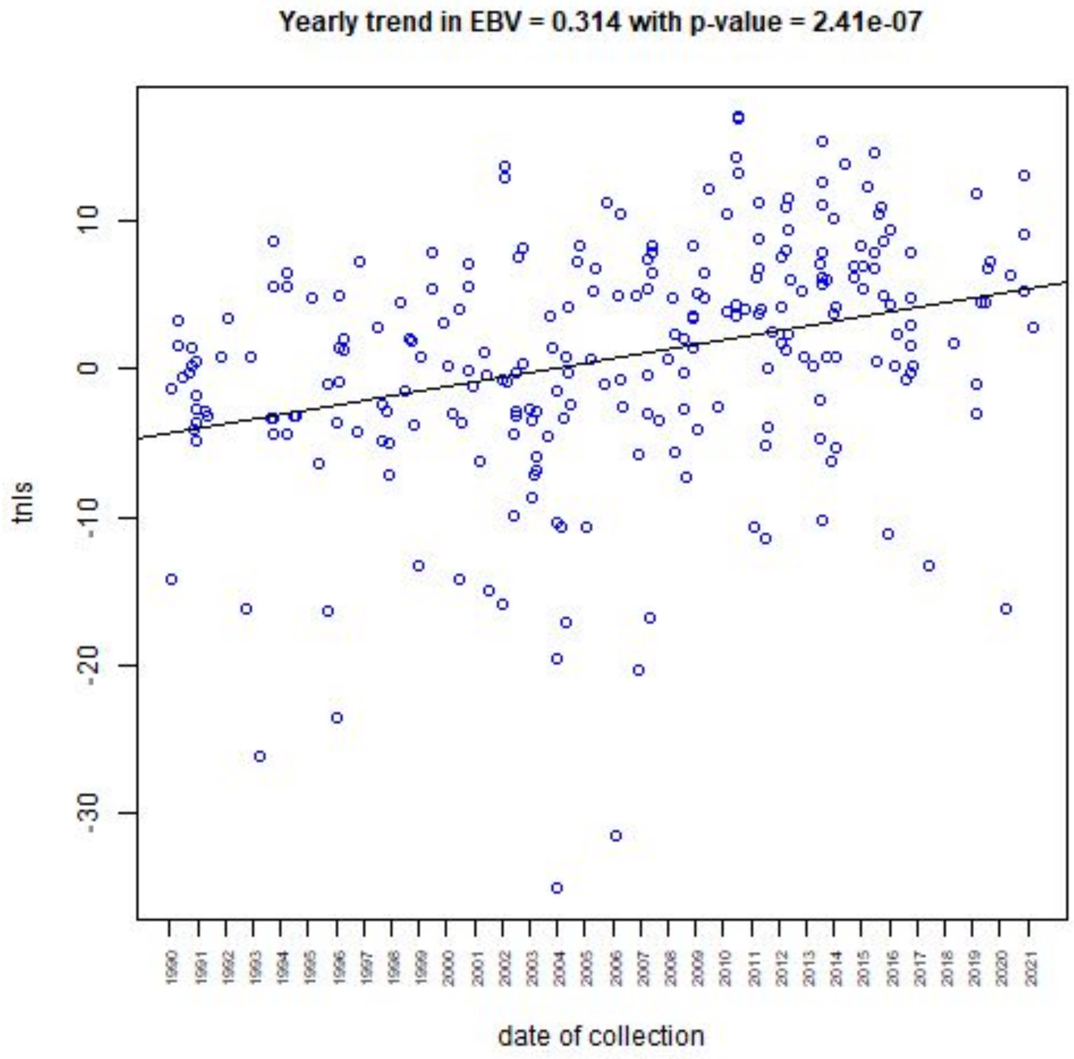
Results – genetic trends





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Caveats & limitations

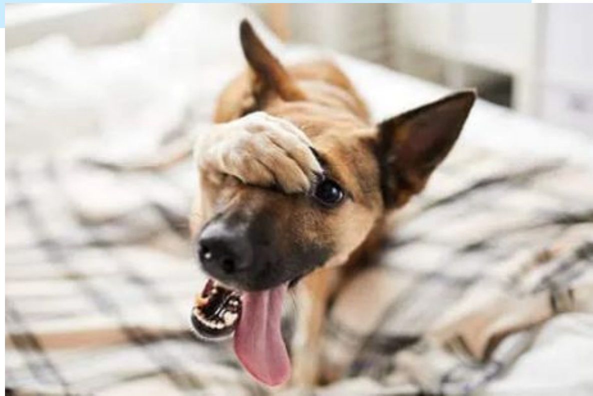
Breed differences in traits & covariates - should be analysed separately?

Possible differences in n records / relationships affected model

Paucity of data for GSD (only actually 62 dogs!)

Some repeat collections very close together - thin out?

Detected trends are linear - do not capture changes in rates over 30+ years



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Conclusions & summary

Semen traits show some degree of repeatability / consistency

Heritability estimates range 0.11-0.46, but variability across breeds and traits

Some difficulty in identifying genetics from perm. env., particularly in MOT and TNLS in Lab & GR

Likely downward effect of age on traits, particularly MOT & TNLS - more work?

Some indication of temporal trends, particularly MOT & TNLS on GR

GR EBVs ‘improving’, so evidence of breed specific env. influence?

Guide Dogs

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Thank you.

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The University of Nottingham