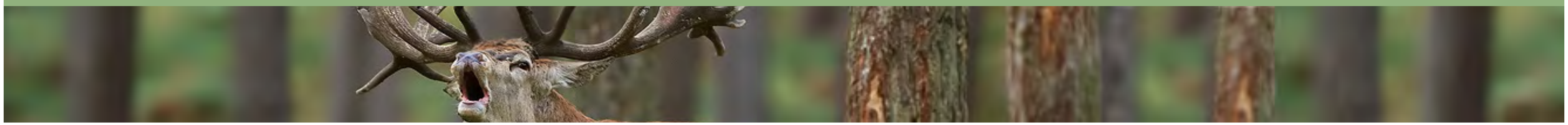
Clinic
of Zoo Animals, Exotic Pets and Wildlife

ISIS
International Species
Information System

WORLD ASSOCIATION
OF ZOOS AND AQUARIUMS

Do animals get older in captivity? The example of comparative life expectancy in captive ruminants - a possibility to evaluate husbandry management in zoos

Dennis W.H. Müller, Laurie Bingaman Lackey, W. Jürgen Streich,
Jean-Michel Hatt and Marcus Clauss



WAZA
Code of Ethics and Animal Welfare

WORLD ASSOCIATION OF ZOOS AND AQUARIUMS

Preamble

The continued existence of zoological parks and aquariums depends upon recognition that our profession is based on respect for the dignity of the animals in our care. the people we serve and other members of the international zoo profession. Acceptance of the WAZA World Zoo Conservation Strategy is implicit in involvement in the WAZA.

Whilst recognising that each region may have formulated its own code of ethics. and a code of animal welfare. the WAZA will strive to develop an ethical tradition which is strong and which will form the basis of a standard of conduct for our profession. Members will deal with each other to the highest standard of ethical conduct.

Basic principles for the guidance of all members of the World Association of Zoos and Aquariums:

(i) Assisting in achieving the conservation and survival of species must be the aim of all members of the profession. Any actions taken in relation to an individual animal. e.g. euthanasia or contraception. must be undertaken with this higher ideal of species survival in mind. but the welfare of the individual animal should not be compromised.

(ii) Promote the interests of wildlife conservation. biodiversity and animal welfare to colleagues and to society at large.

(iii) Co-operate with the wider conservation community including wildlife agencies. conservation organisations and research institutions to assist in maintaining global biodiversity.

(iv) Co-operate with governments and other appropriate bodies to improve standards of animal welfare and ensure the welfare of all animals in our care.

(v) Encourage research and dissemination of achievements and results in appropriate publications and forums.

(vi) Deal fairly with members in the dissemination of professional information and advice.

(vii) Promote public education programs and cultural recreational activities of zoos and aquariums.

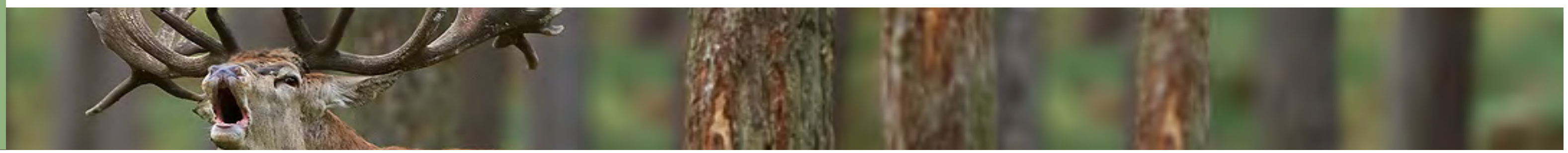
(viii) Work progressively towards achieving all professional guidelines established by the WAZA.

At all times members will act in accordance with all local. national and international law and will strive for the highest standards of operation in all areas including the following:

1. Animal Welfare

Whilst recognising the variation in culture and customs within which the WAZA operates. it is incumbent upon all members to exercise the highest standards of animal welfare and to encourage these standards in others. Training staff to the highest level possible represents one method of ensuring this aim.

Members of WAZA will ensure that all animals in their care are treated with the utmost care and their welfare should be paramount all times. At all times. any legislated codes for animal welfare should be regarded as minimum standards. Appropriate animal husbandry practices must be in place and sound veterinary care available. When an animal has no reasonable quality of life. it should be euthanased quickly and without suffering.



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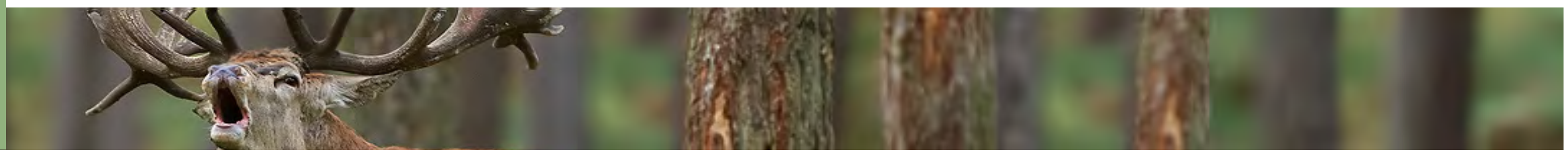
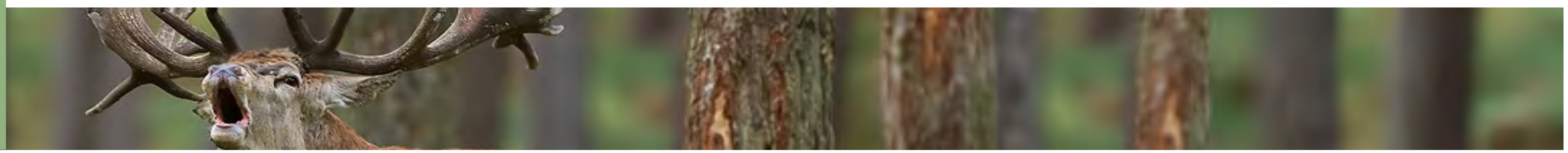


How can we measure animal welfare?

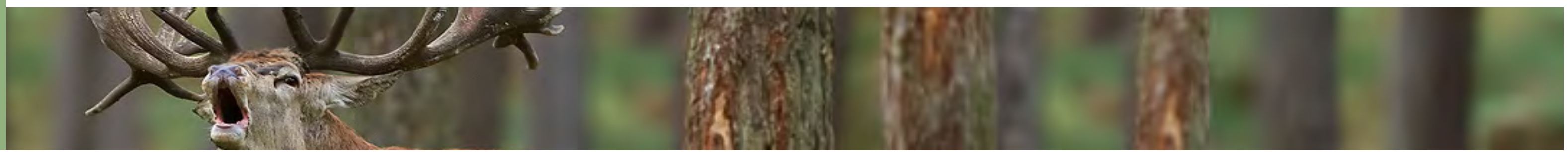
- Behavioural observation

- Health status determination



How can we measure animal welfare?

- Behavioural observation
    - Do animals display species-specific behaviour?
    - Complex behavioural repertoires?
    - Stereotypies?
- Health status determination
    - Do certain diseases occur frequently?
    - Stress hormone level abnormalities?
    - High parasite loads?



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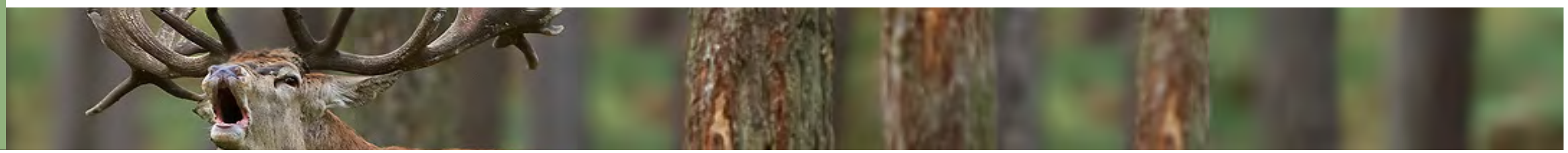
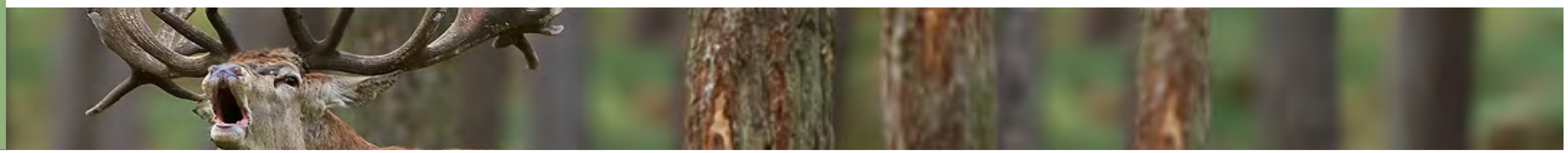
- Analyse population data



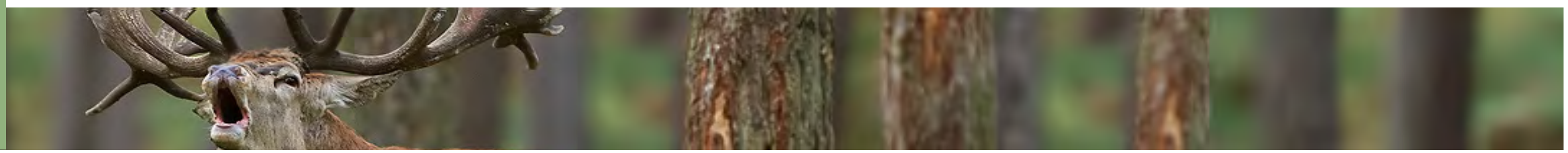
How can we measure animal welfare?

- Behavioural observation
  - Do animals display species-specific behaviour?
  - Complex behavioural repertoires?
  - Stereotypies?
- Health status determination
  - Do certain diseases occur frequently?
  - Stress hormone level abnormalities?
  - High parasite loads?
- Analyse population data
  - Reproductive output?
  - Life expectancy?



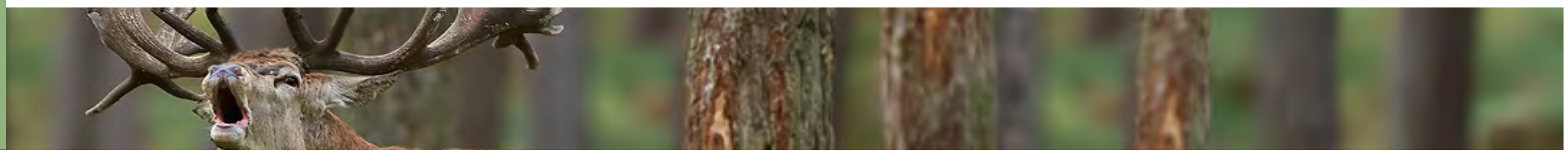
How can we measure animal welfare?

- Life expectancy:
  - Large datasets available
  - Independent of investigator/study design
  - Straight-forward evaluation
  - No field- or labwork involved

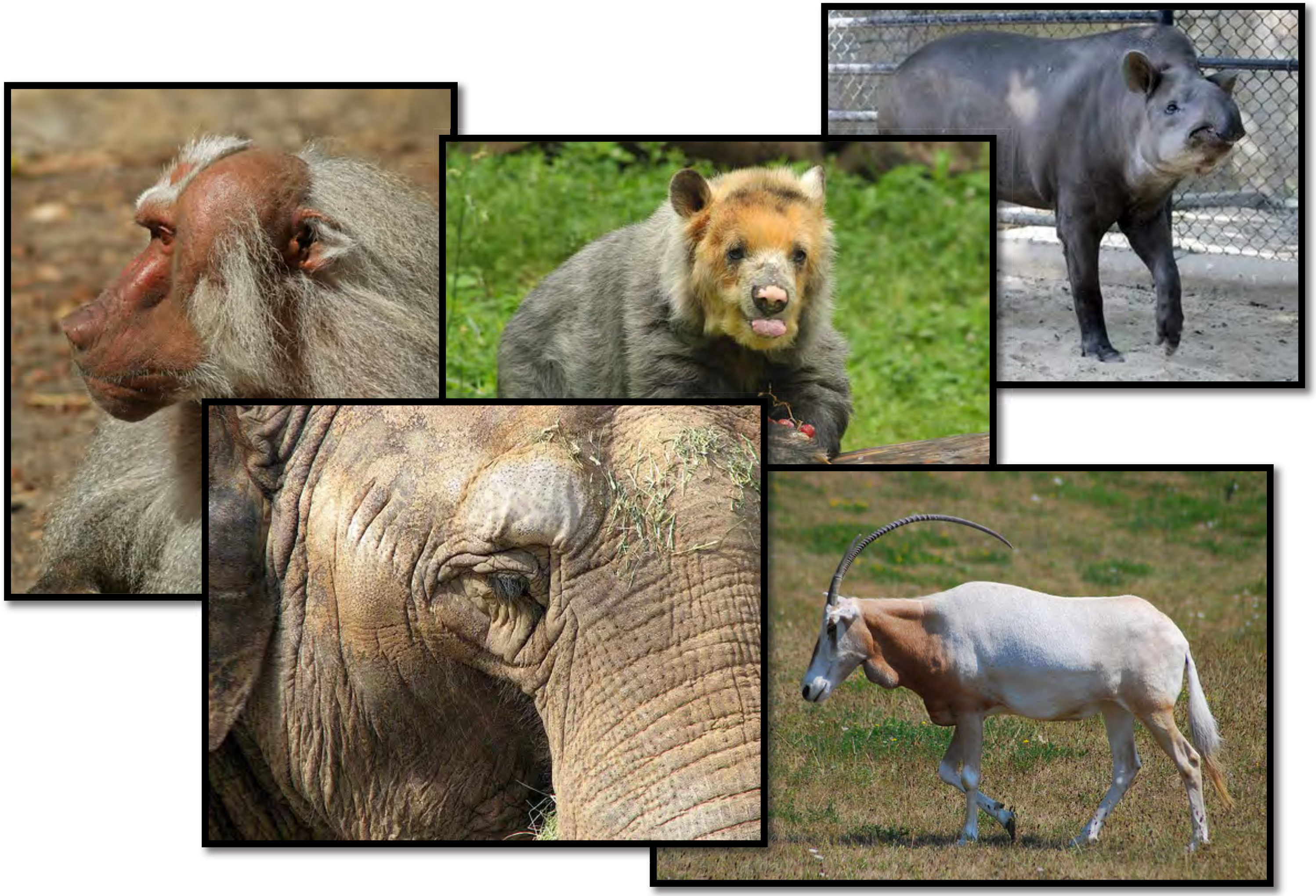


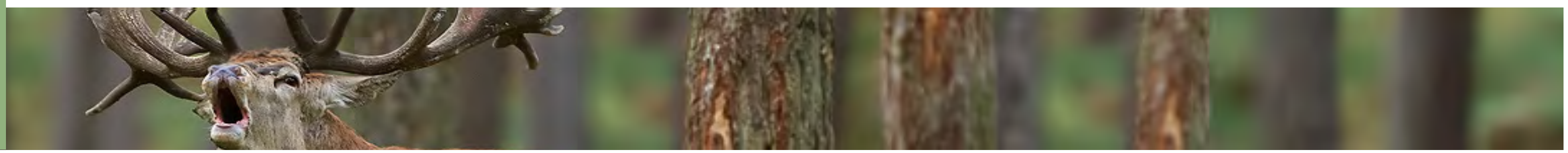
Aims of the study

- What is the mean life expectancy of zoo ruminants?
- Are there evident differences between species?
- Can we identify causes for these differences?



Life expectancy at the zoo





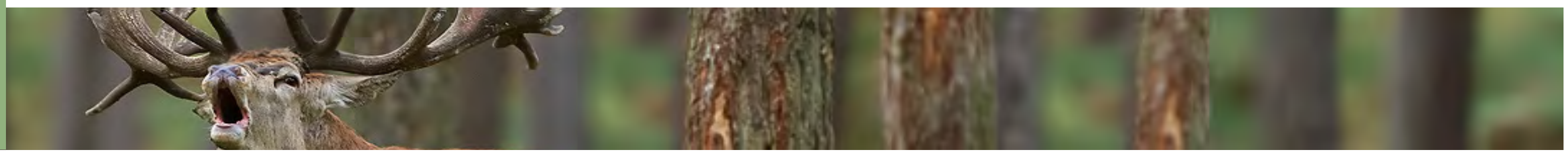
Definitions

- How old does a human get?

Methusalem 969 years

recently: up to 115 years

Jeanne Calment 122.5 years

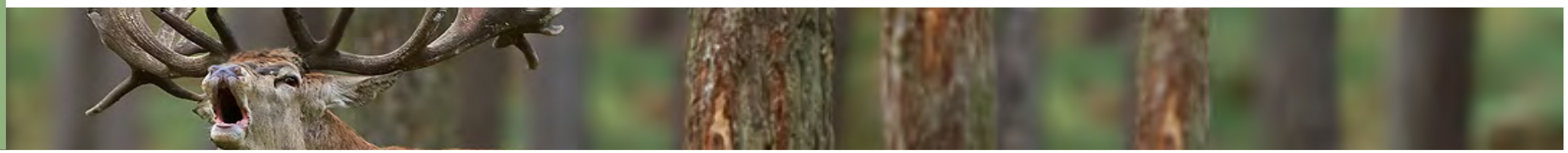


Cave: Average age

- Epidemiologically relevant
- Definition:

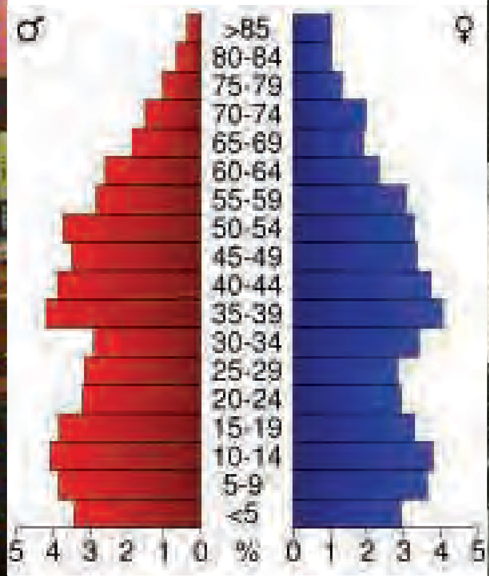
  The life expectancy is the survival time statistically expected for an individual from a given time point up to its death.

  Mean ‘age at death’ = life expectancy of the respective group.



Cave:

Men vs. Women

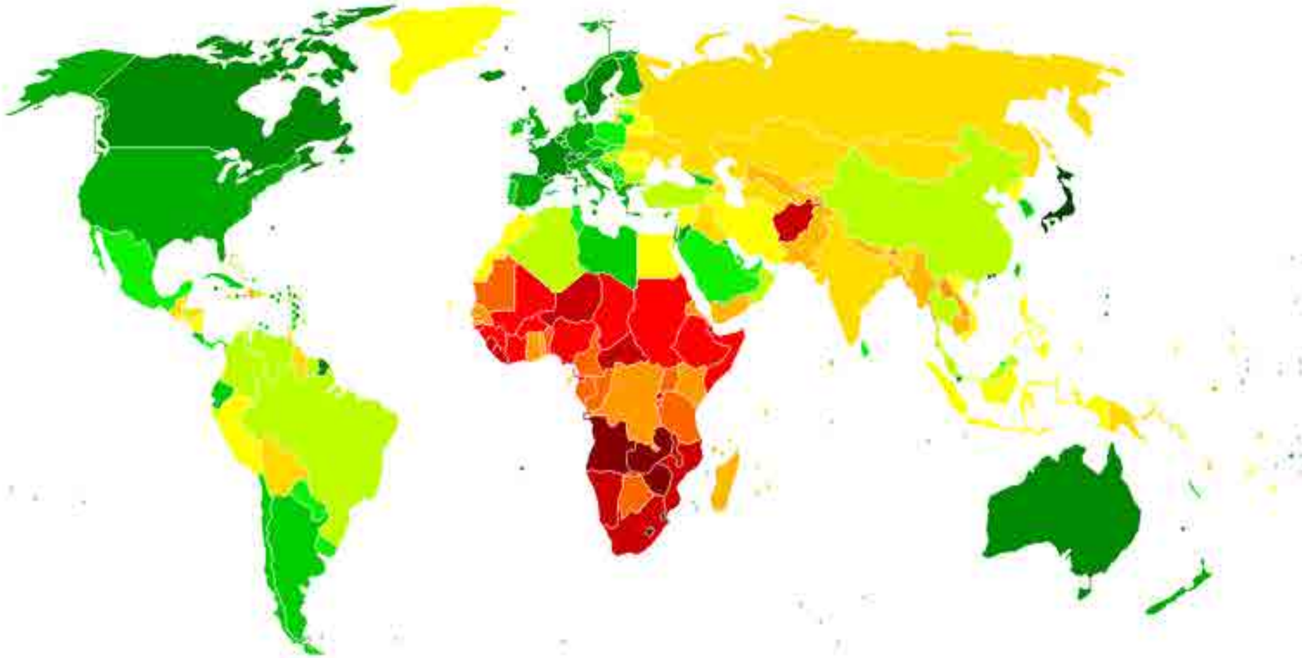


76.6 Years

82.1 Years

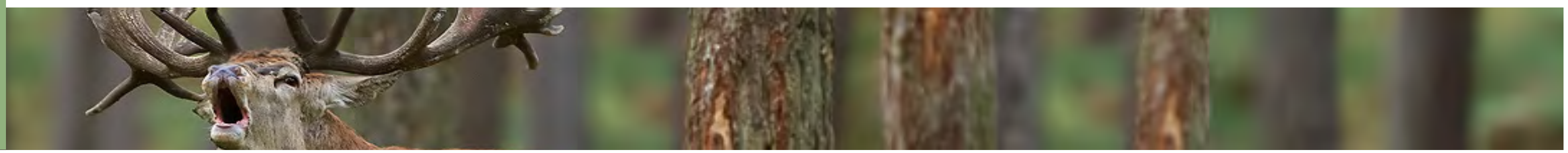
Cave:

- Geographical differences



Commonly accessible knowledge

- A collection of longevity records:
    - Jones (1980)
    - Carey and Judge (2000)
    - Weigl (2005)
    - AnAge and PenTheria databases



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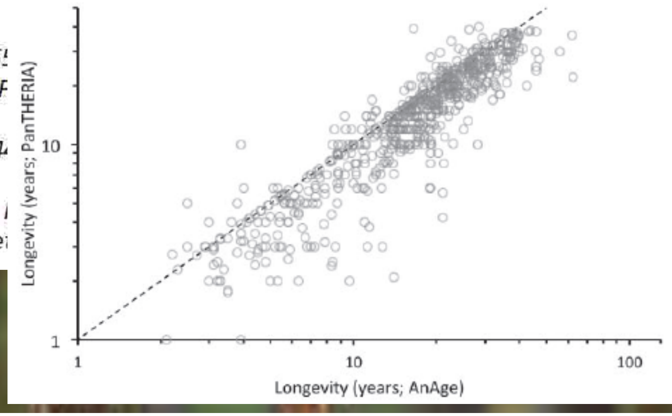
Mammal Review

Mammal Review ISSN 0305-1838

REVIEW

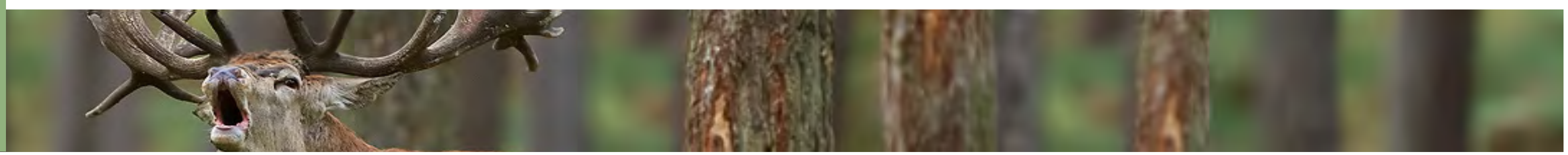
A test of the metabolic theory of ecology with two longevity data sets reveals no common cause of scaling in biological times

Jean-François LEMAÎTRE* *Université de Lyon, F-69000 Lyon, CNRS, UMR55*
Biométrie et Biologie Evolutive, Université Lyon 1, F-69622 Villeurbanne, F
E-mail: jeff.lemaitre@gmail.com
Dennis W. H. MÜLLER *National Park 'Bavarian Forest', Freyunger Str. 2, 94*
E-mail: Dennis.Mueller@npv-bw.bayern.de
Marcus CLAUSS *Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse*
Zurich, Winterthurerstr. 260, 8057 Zurich, Switzerland. E-mail: mclauss@ve



Record age

	Species	Record age
		Years
1	Red deer	27.0
2	Moose	27.0
3	European bison	27.0
4	Fallow deer	25.4
5	Sika deer	25.0
6	Alpine ibex	20.4
7	Roe deer	17.0



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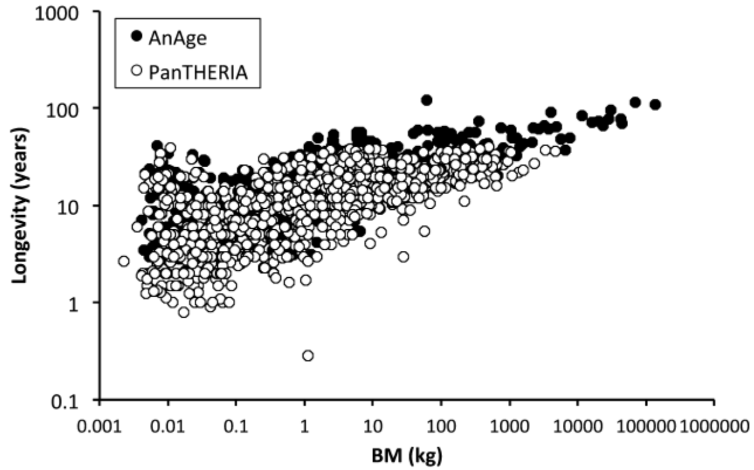

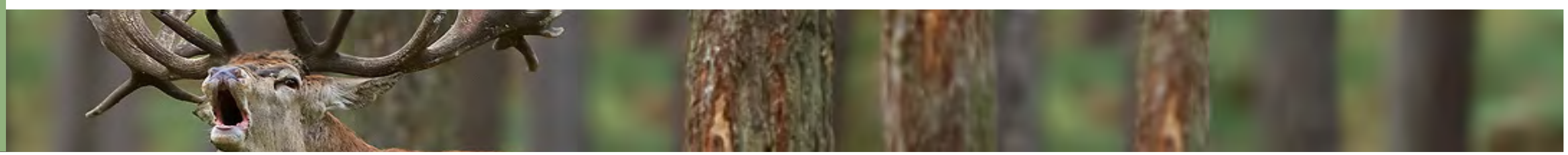

Commonly accessible knowledge

- A collection of longevity records:
  - Jones (1980)
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  - Weigl (2005)
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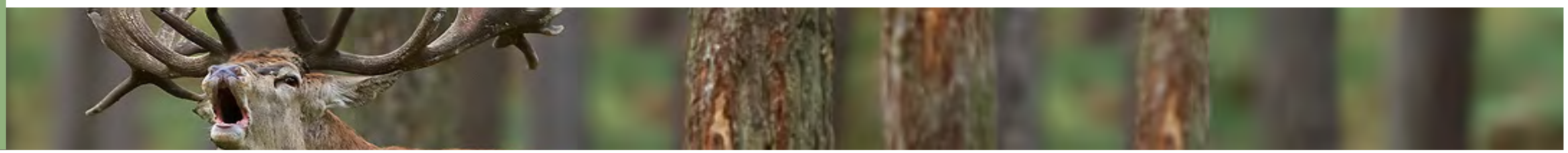
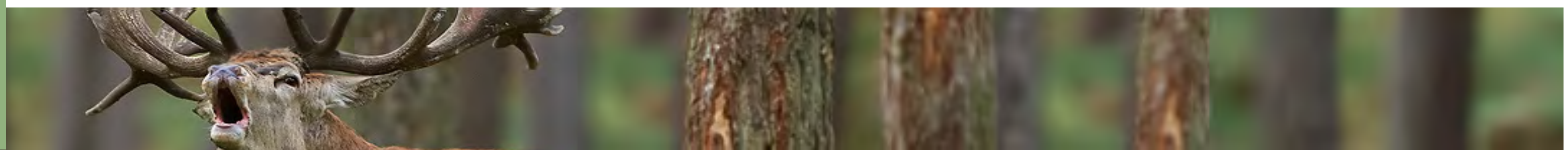
- Few authors calculated the mean life expectancy of some zoo animal species:
  - Lindemann (1983) – black rhino
  - Clubb et al. (2008) - elephants



Material

- Database of ISIS:

  International Species Information System

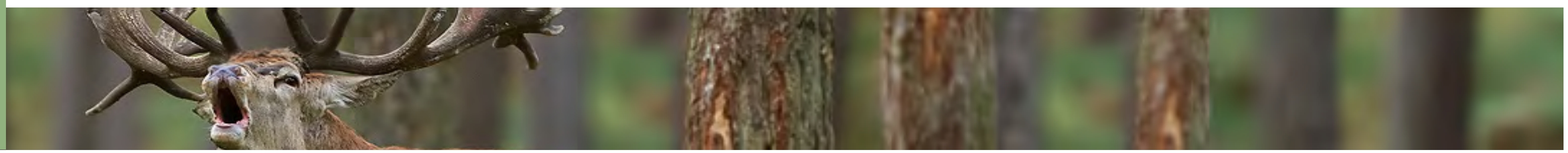


Material

- Database of ISIS:

  International Species Information System

  - More than 2’000’000 records (20’000 deer)
  - App. 10’000 species (31 deer)
  - More than 750 members
  - Data collection for 30 years



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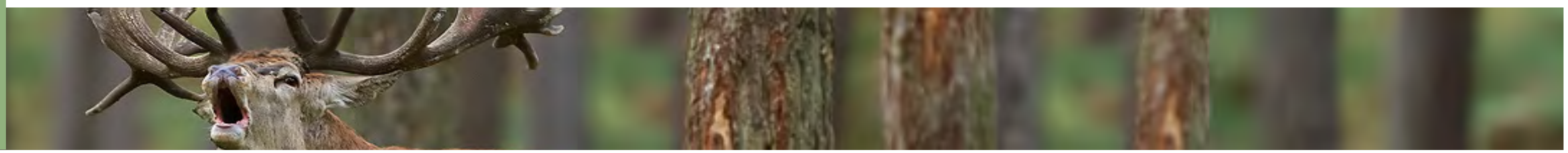
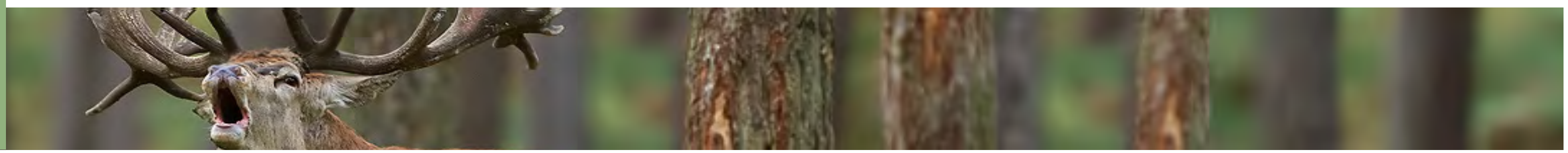
First time that such an analysis is possible



Method

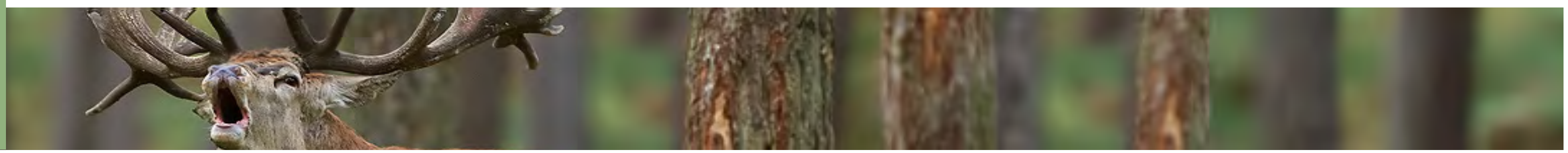
- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)



Method

- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)
- Calculate mean age at death for various sex and age groups

Example: calculate the mean age at death for 4 cervid species



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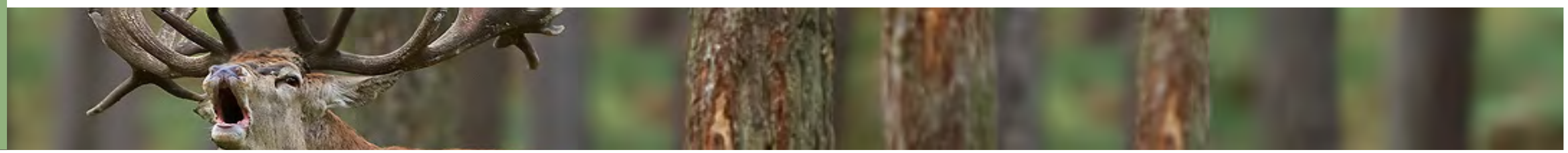
- Calculate mean age at death for various sex and age groups

Neonate/juvenile mortality



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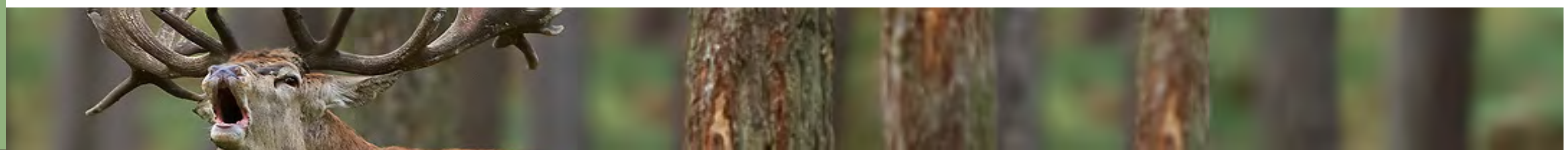
Neonate/juvenile mortality

Population control



Method

- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)

- Calculate mean age at death for various sex and age groups

Neonate/juvenile mortality

most relevant

Population control

Mean life expectancy

	Species	Life expectancy	
		max.	ISIS
		age	Ø years
1	Red deer	27.0	13.4
2	European bison	27.0	12.7
3	Fallow deer	25.4	10.5
4	Sika deer	25.0	10.0
5	Alpine ibex	20.4	9.2
6	Roe deer	17.0	7.9
7	Moose	27.0	7.3

So what now?

	Species	Life expectancy	
		max.	ISIS
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Mean life expectancy

	Species	Life expectancy		
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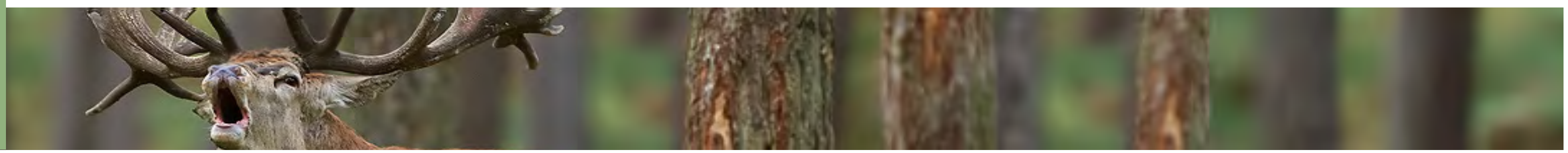

Mean life expectancy

	Species	Life expectancy		
		max.	ISIS	Wild
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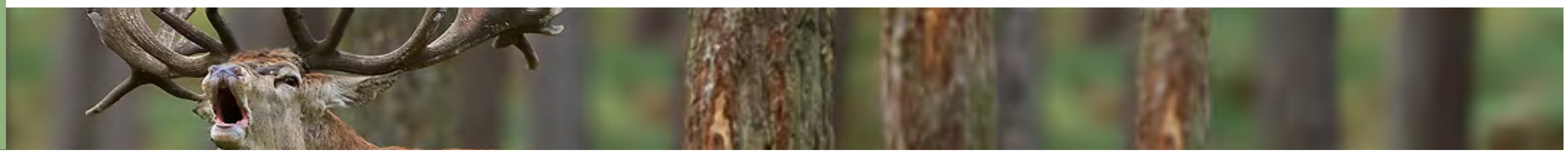

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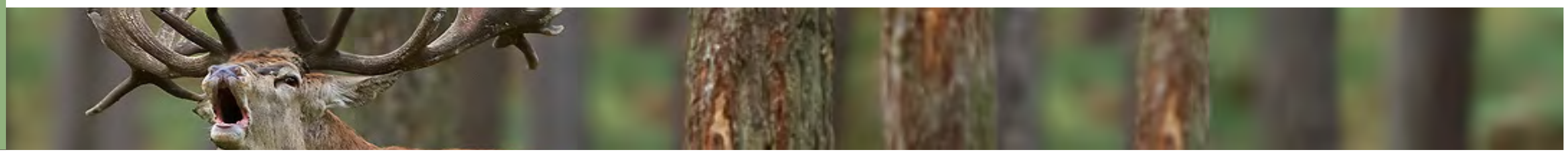

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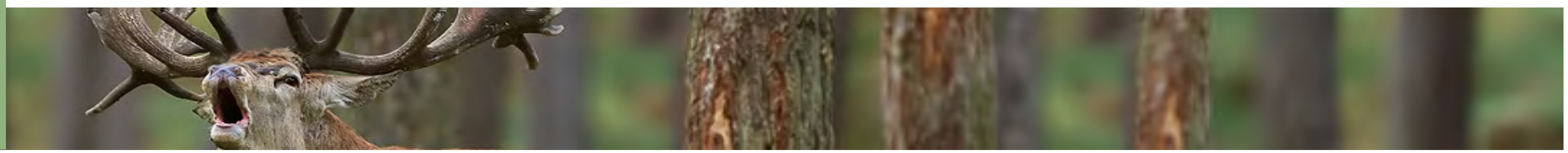


Mean life expectancy

Eur J Wildl Res (2010) 56:205–208
DOI 10.1007/s10344-009-0342-8

SHORT COMMUNICATION

Comparing life expectancy of three deer species between captive and wild populations

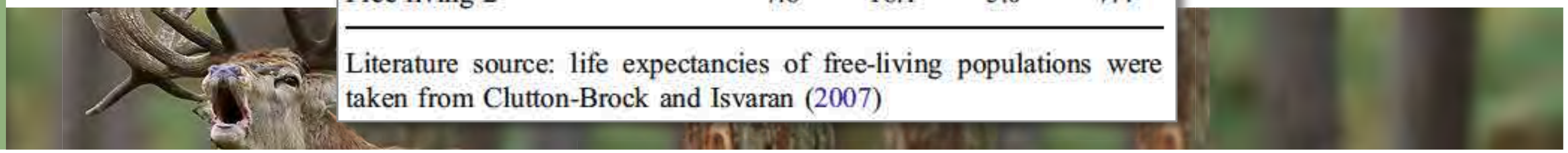
Dennis W. H. Müller · Jean-Michel Gaillard · Laurie Bingaman Lackey · Jean-Michel Hatt · Marcus Clauss

Table 1 Life expectancy at the age of first female parturition (in years) for males and females of three deer species for captive and free-living populations

Population	Life expectancy					
	Rangifer tarandus		*Cervus elaphus*		*Capreolus capreolus*	
	Male	Female	Male	Female	Male	Female
Captive	5.5	7.7	9.3	12.0	3.6	6.7
Free-living 1	2.2[a]	4.6[a]	8.0[b]	10.6[b]	5.7[d]	9.3[d]
Free-living 2			7.6[c]	16.1[c]	5.0[e]	7.4[e]

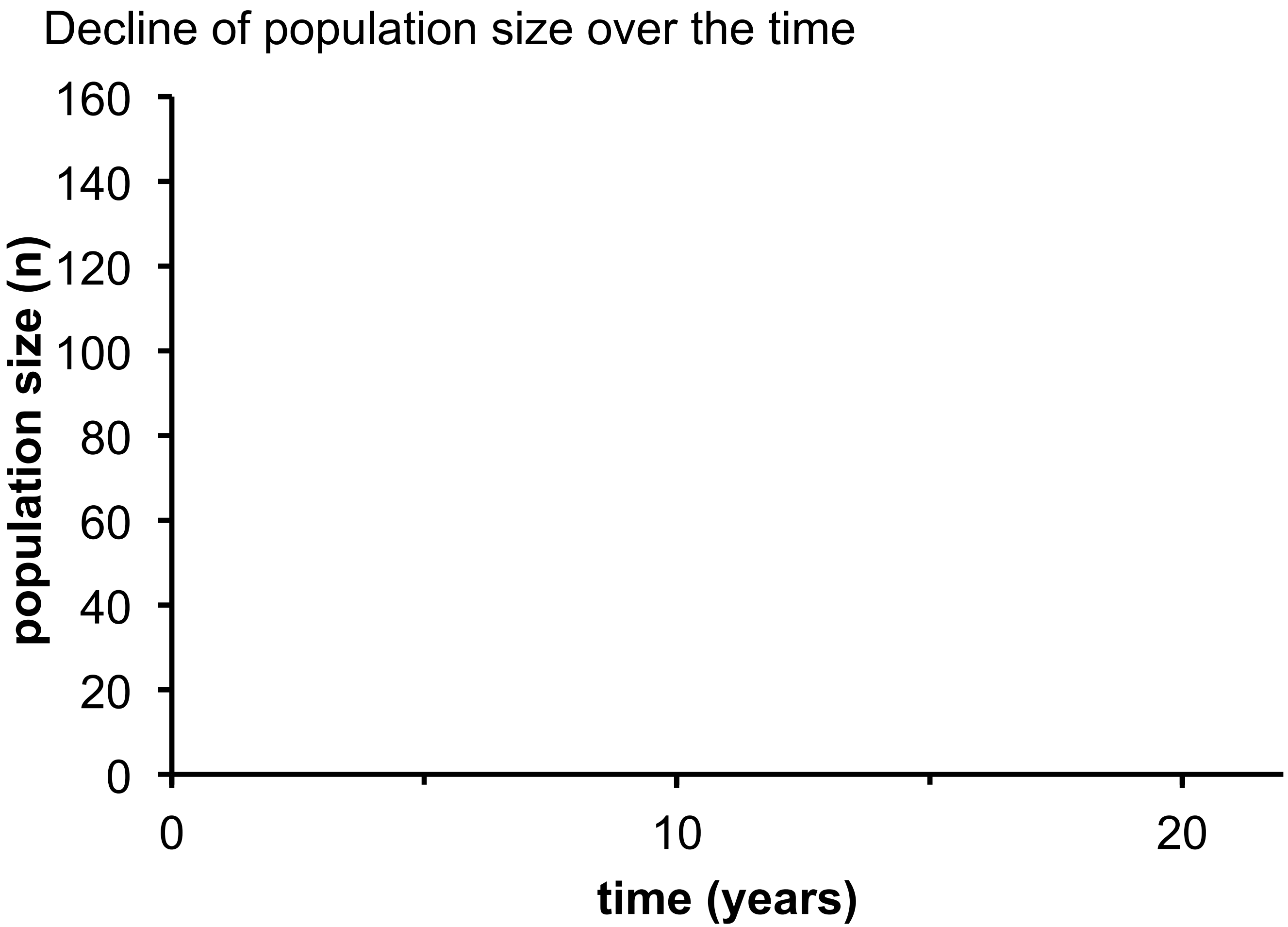
Literature source: life expectancies of free-living populations were taken from Clutton-Brock and Isvaran (2007)

1		
2		
3		
4	Sika deer	??
5	Alpine ibe	??
6	Roe deer	.5
7	Moose	??

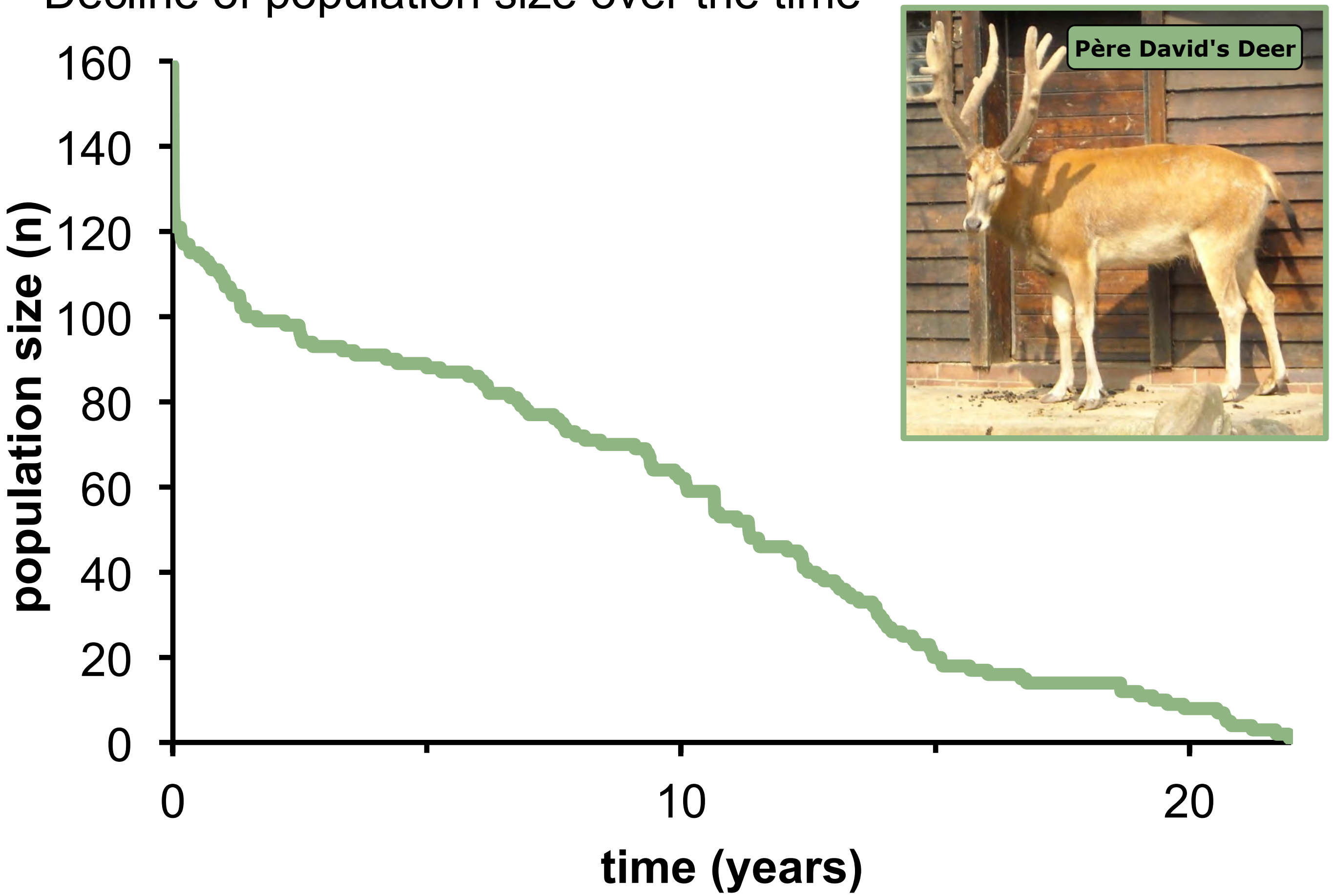


But how to compare species ?

Standard method

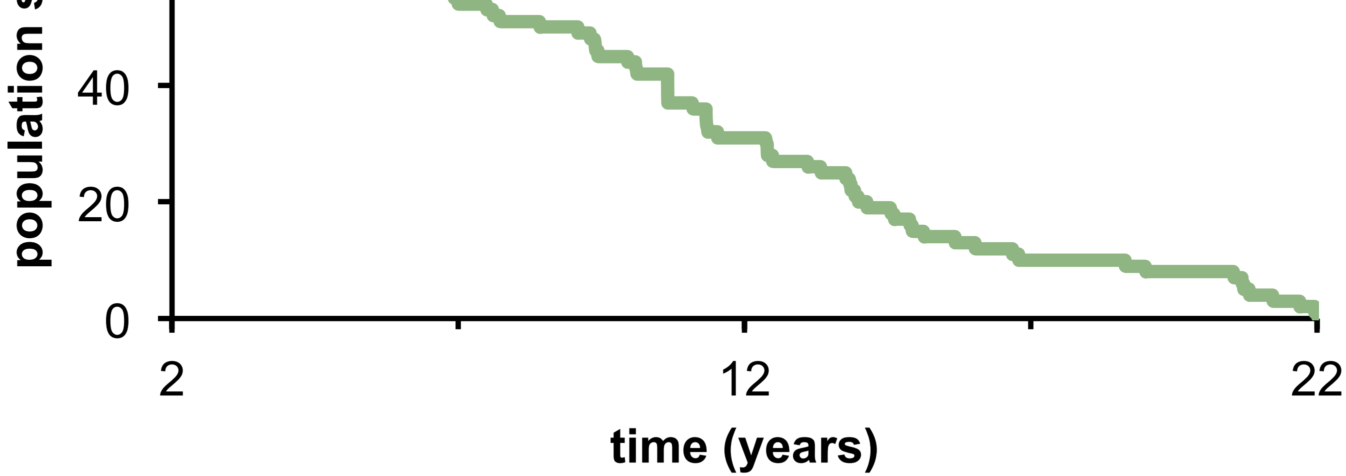


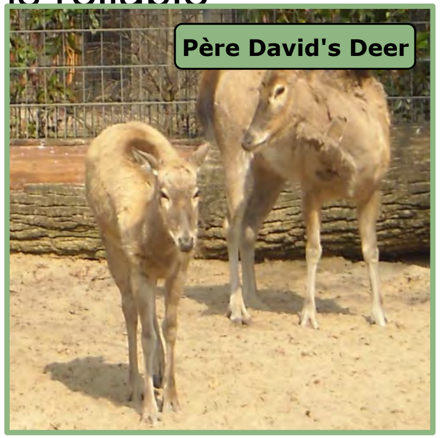
Standard method



Standard method

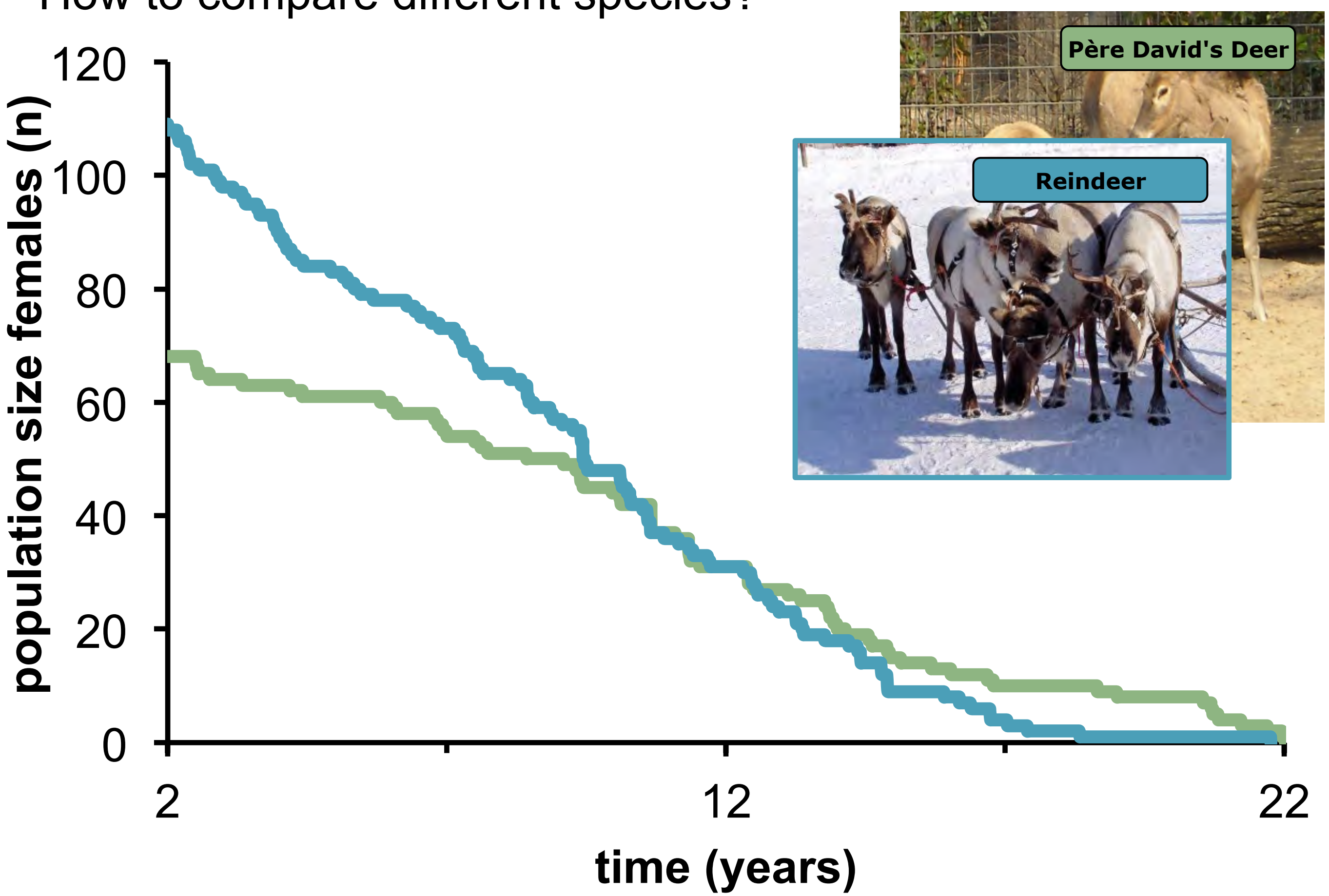
Population development of adult females is reliable

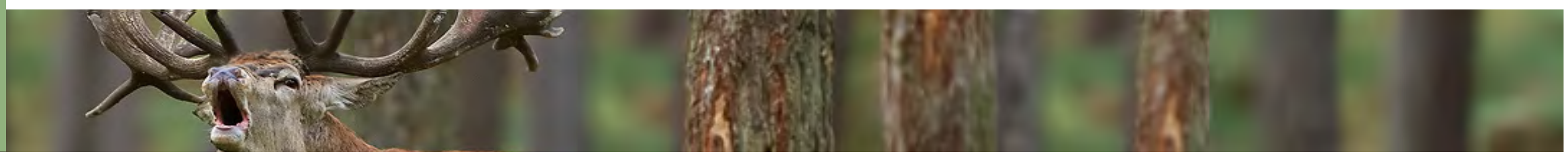




Standard method

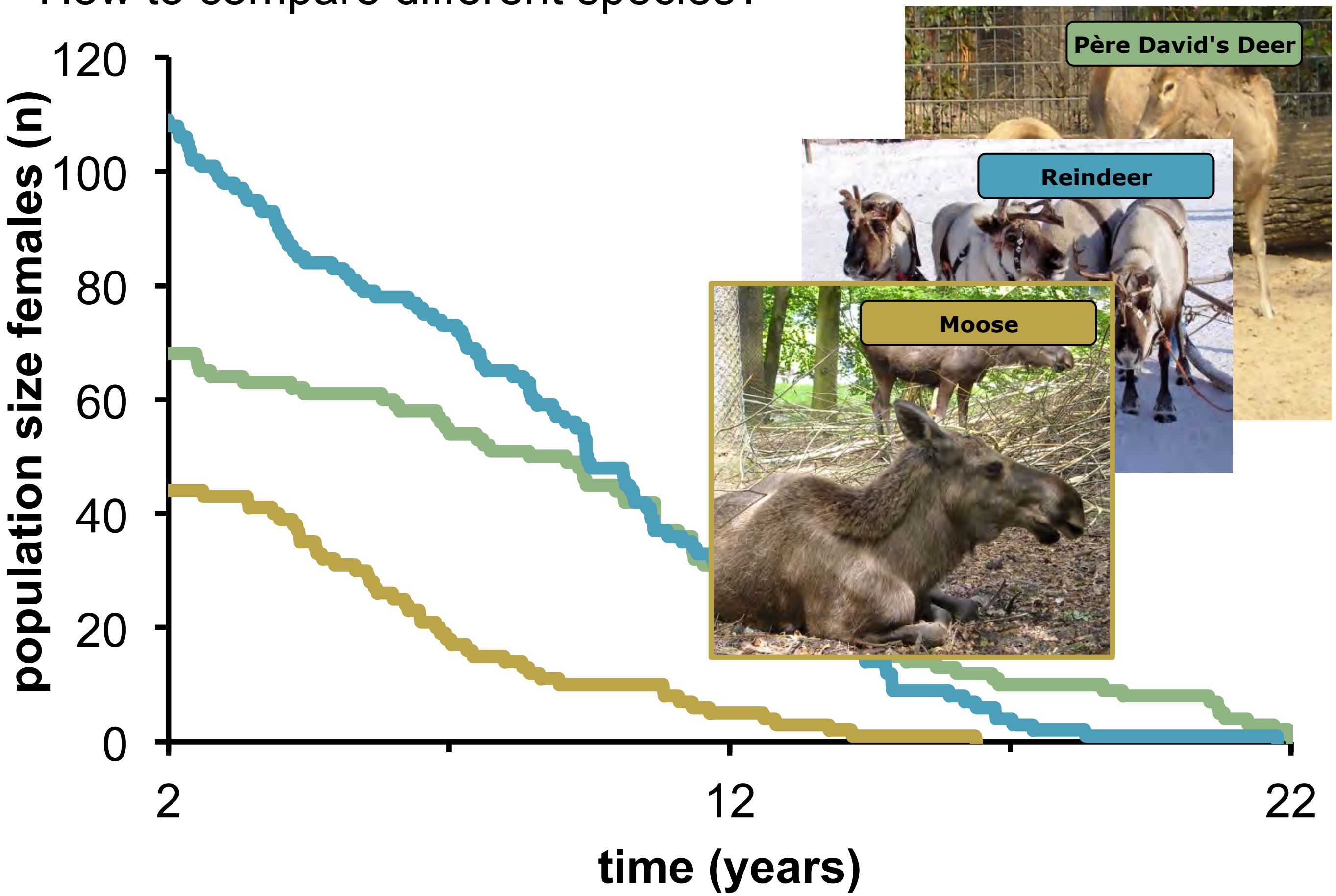
How to compare different species?

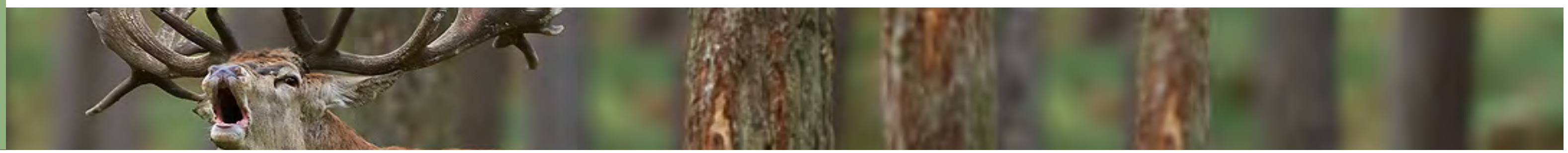




Standard method

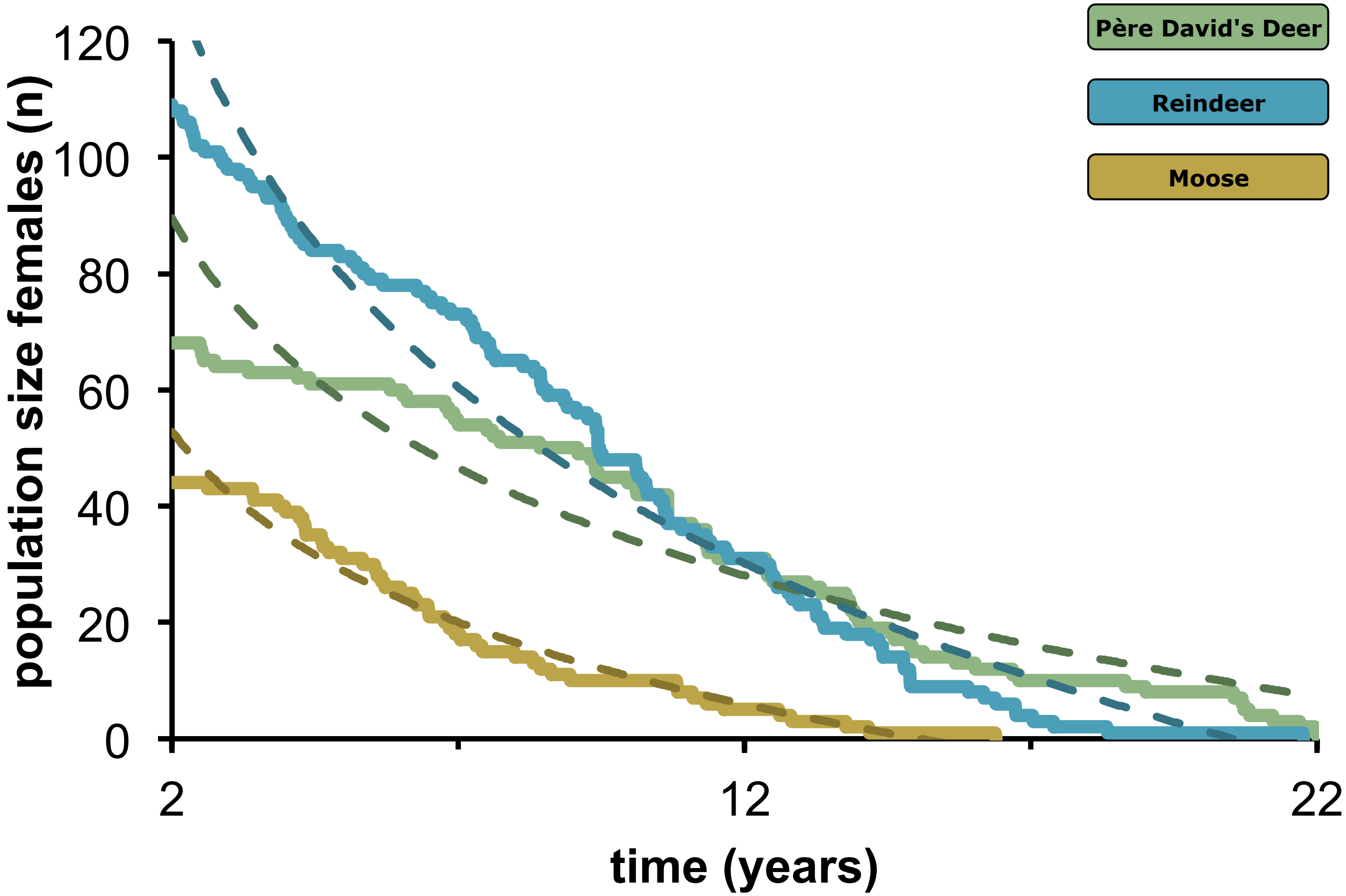
How to compare different species?

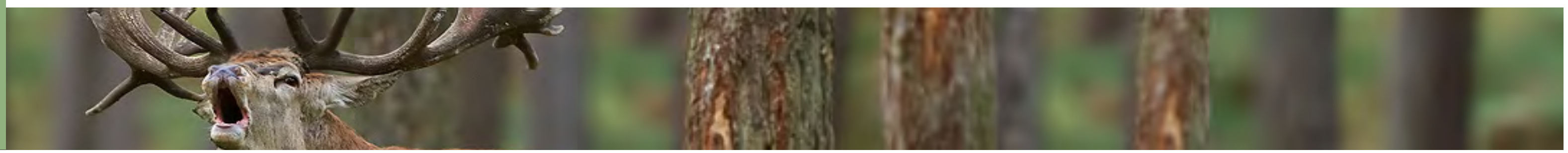




Standard method

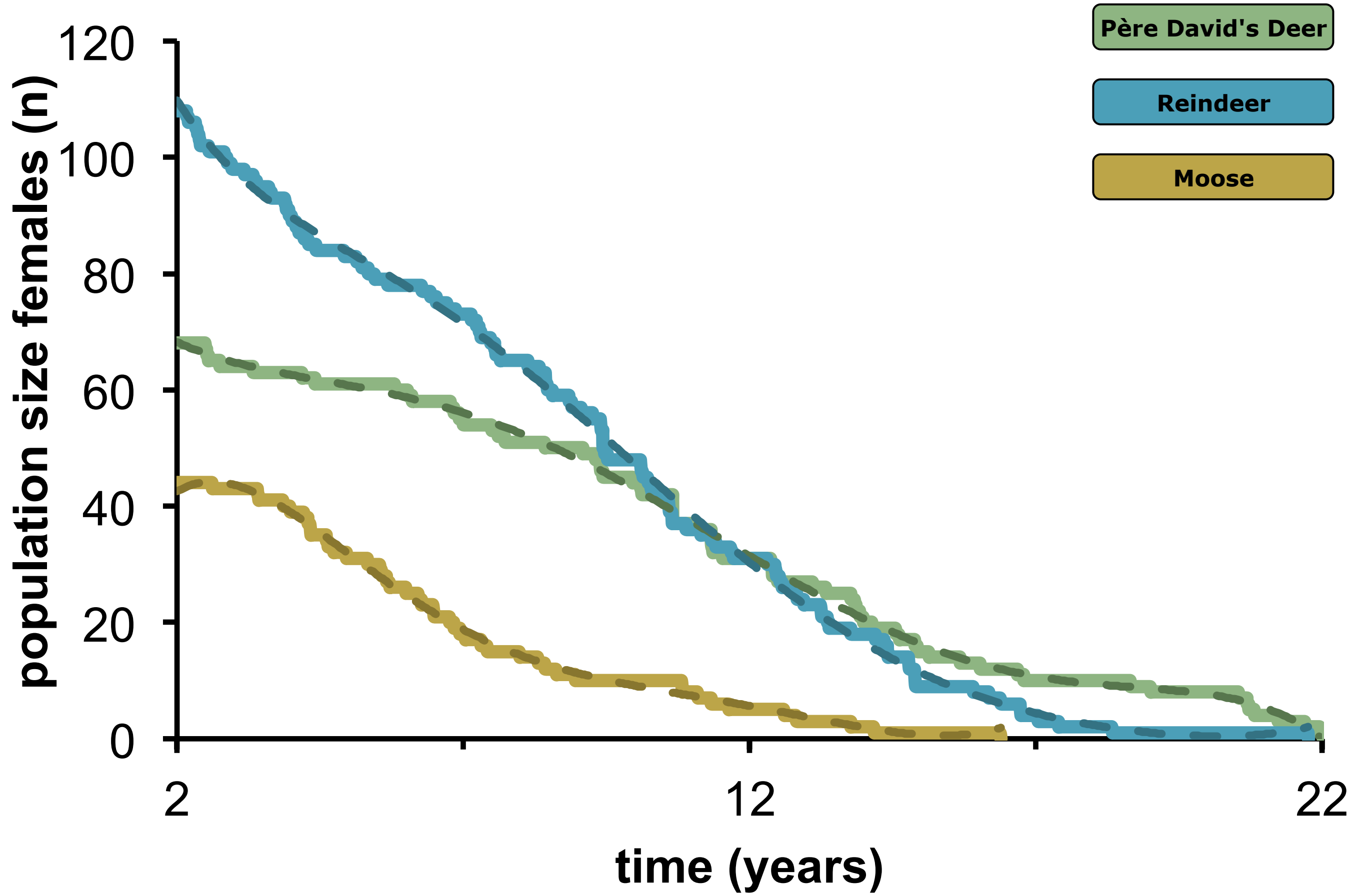
Model does not reflect data intimately ("loose fit")

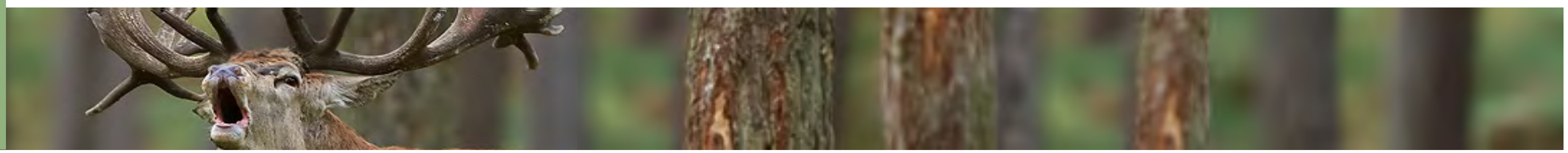




Standard method

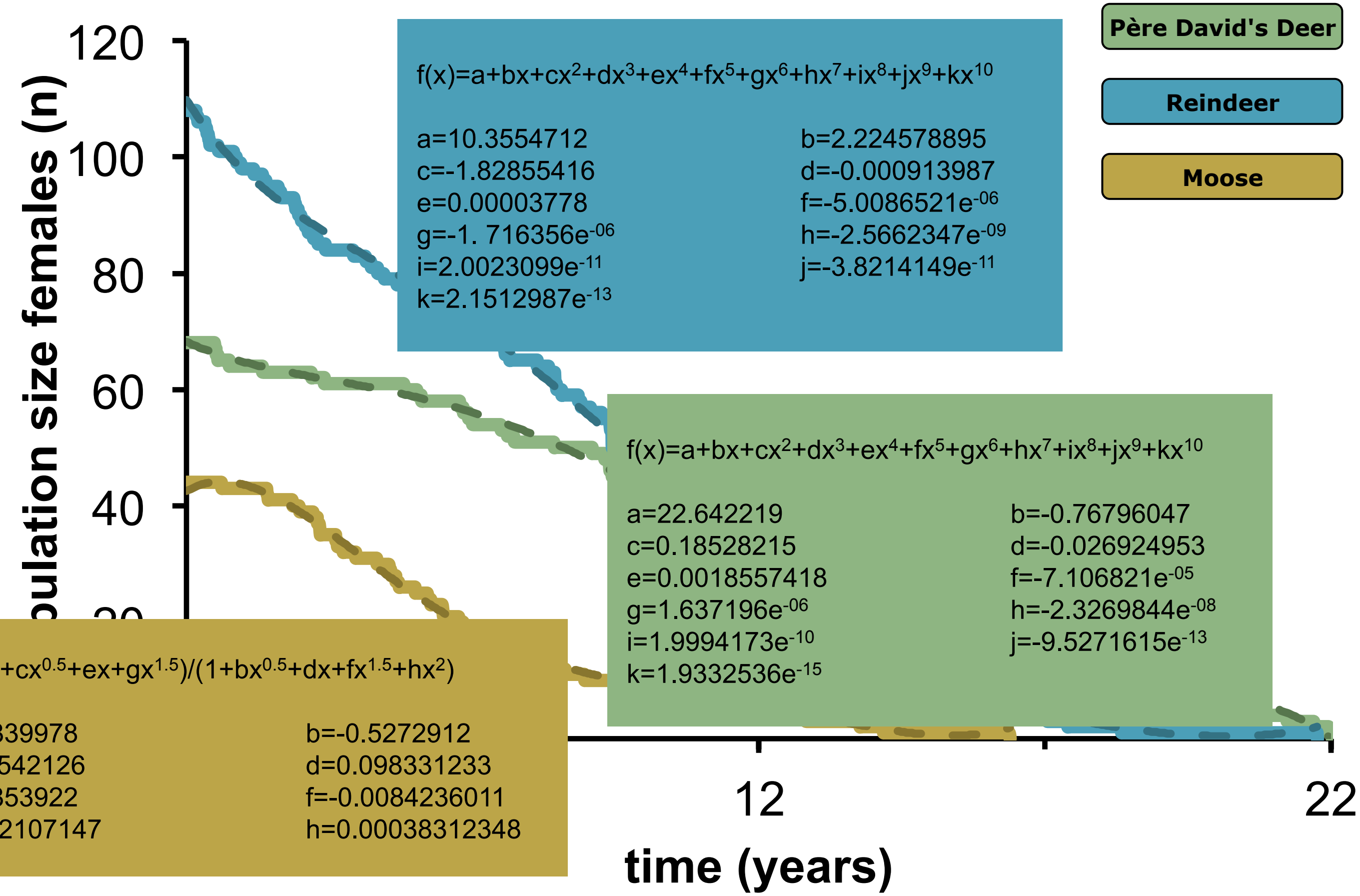
Functions?





Standard method

Functions too complicate



$f(x)=a+bx+cx^2+dx^3+ex^4+fx^5+gx^6+hx^7+ix^8+jx^9+kx^{10}$

a=10.3554712 b=2.224578895
c=-1.82855416 d=-0.000913987
e=0.00003778 f=-5.0086521e^{-06}
g=-1. 716356e^{-06} h=-2.5662347e^{-09}
i=2.0023099e^{-11} j=-3.8214149e^{-11}
k=2.1512987e^{-13}

$f(x)=a+bx+cx^2+dx^3+ex^4+fx^5+gx^6+hx^7+ix^8+jx^9+kx^{10}$

a=22.642219 b=-0.76796047
c=0.18528215 d=-0.026924953
e=0.0018557418 f=-7.106821e^{-05}
g=1.637196e^{-06} h=-2.3269844e^{-08}
i=1.9994173e^{-10} j=-9.5271615e^{-13}
k=1.9332536e^{-15}

$f(x)=(a+cx^{0.5}+ex+gx^{1.5})/(1+bx^{0.5}+dx+fx^{1.5}+hx^2)$

a=25.839978 b=-0.5272912
c=-13.542126 d=0.098331233
e=2.2853922 f=-0.0084236011
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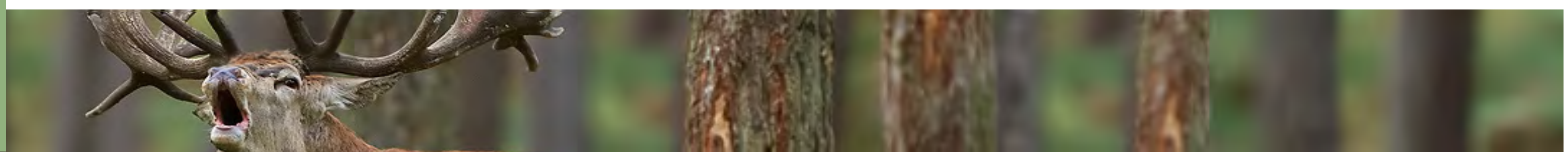
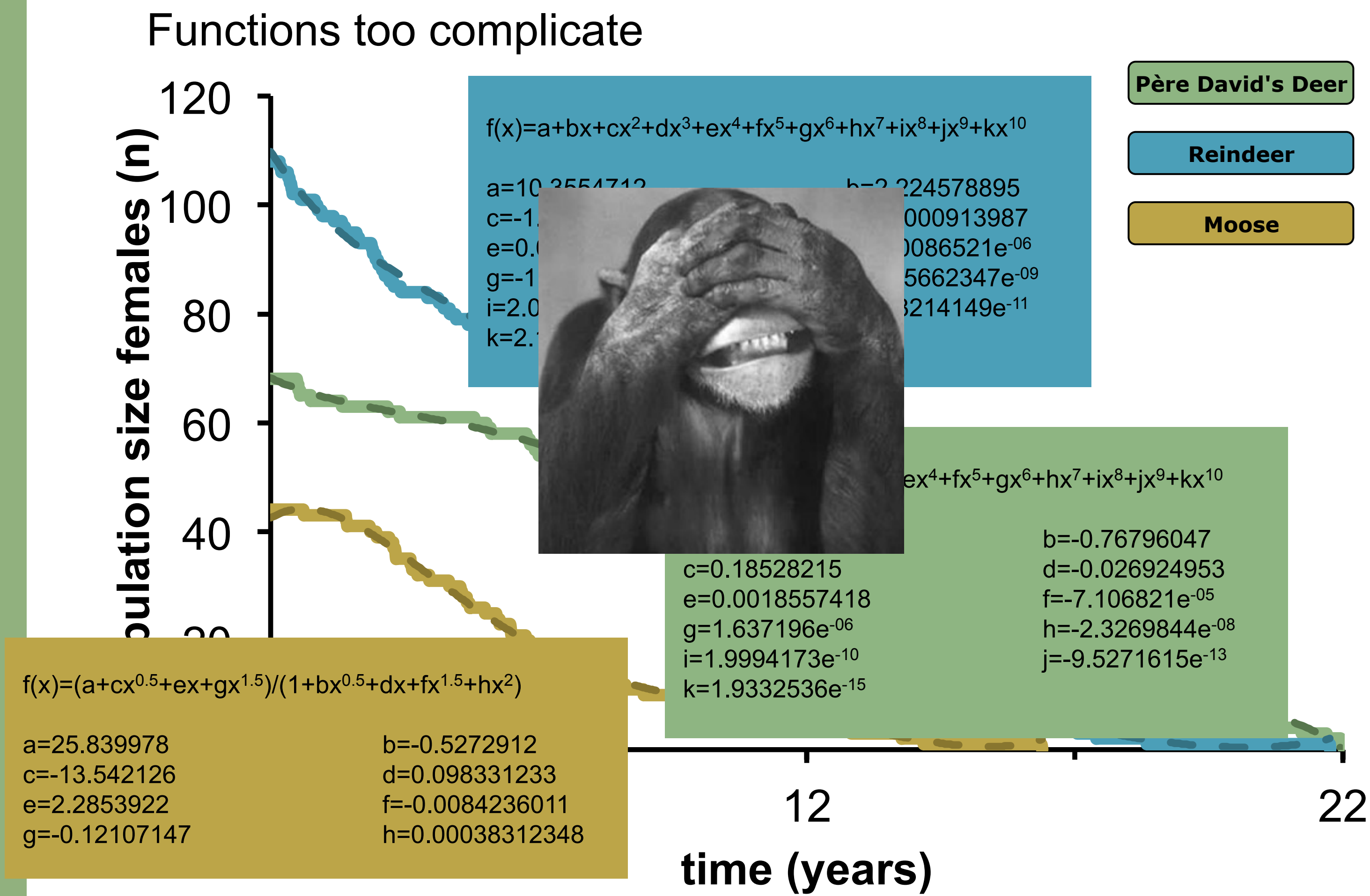
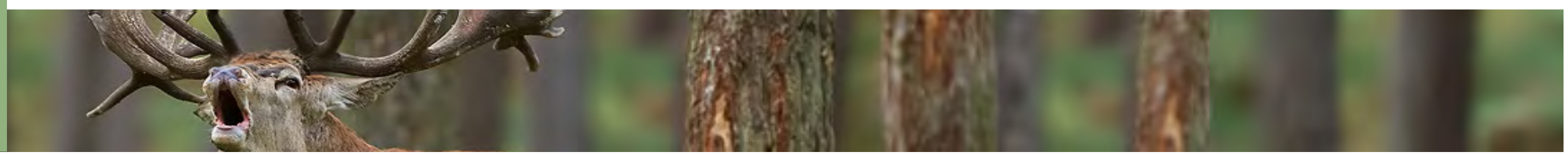


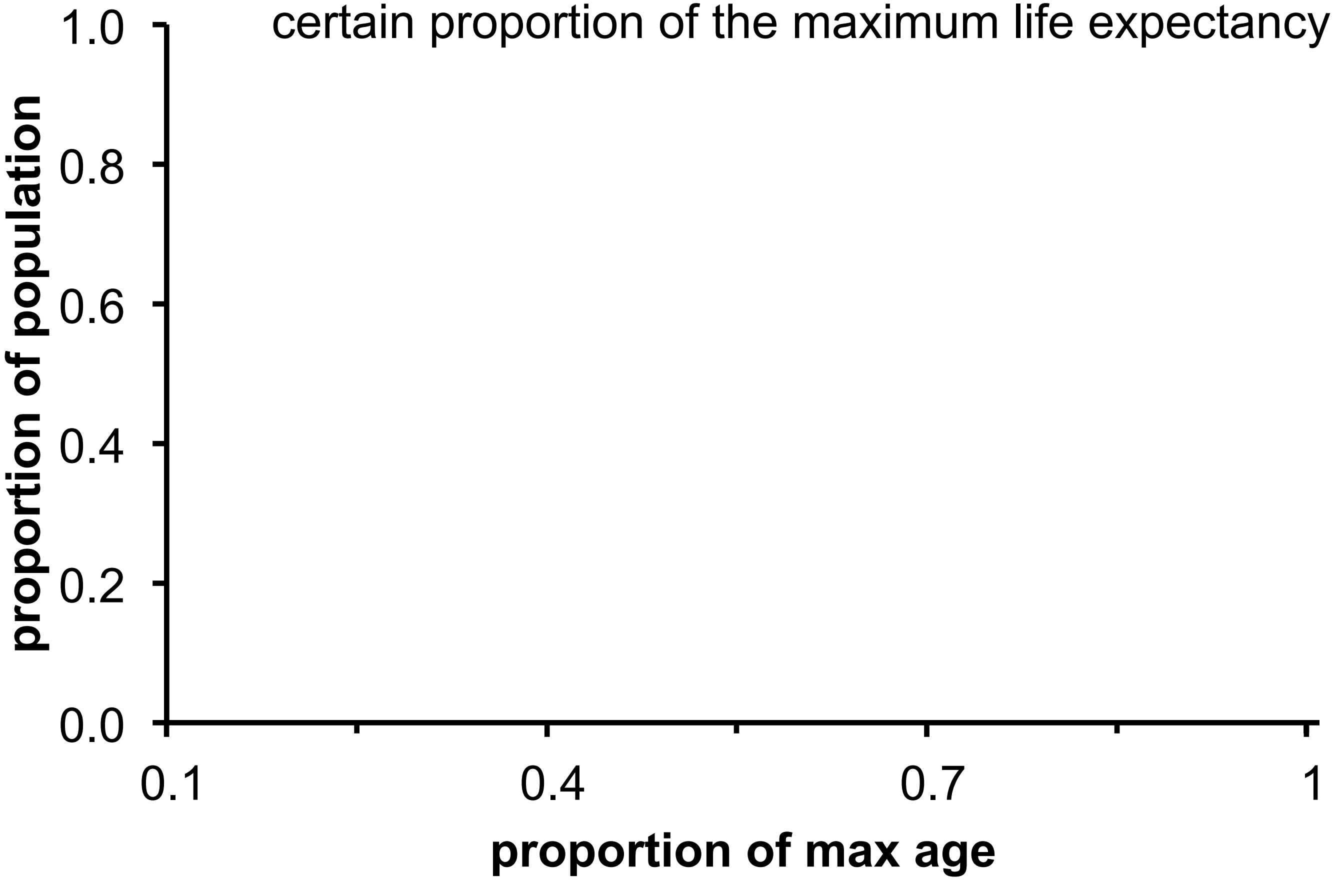
Standard method

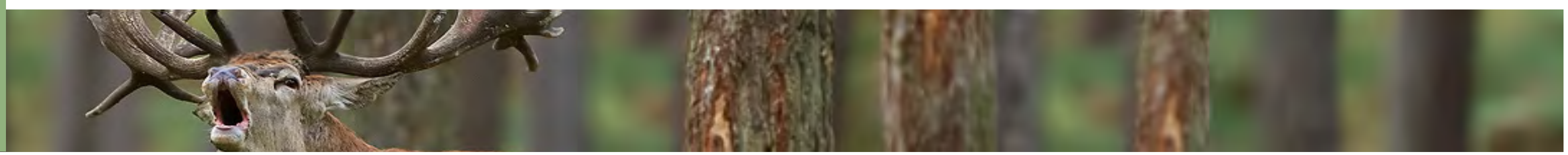




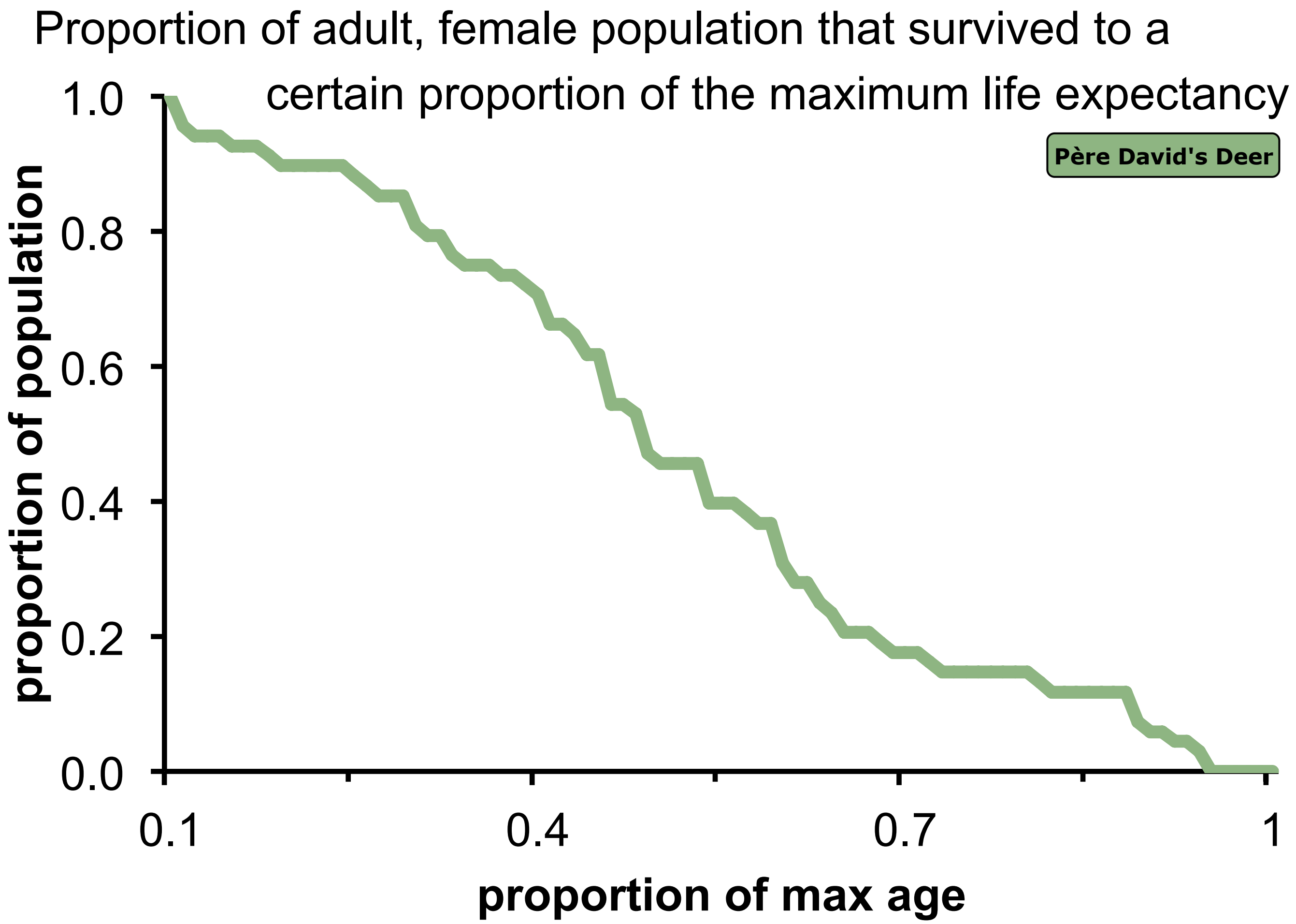
Our approach

Proportion of adult, female population that survived to a certain proportion of the maximum life expectancy



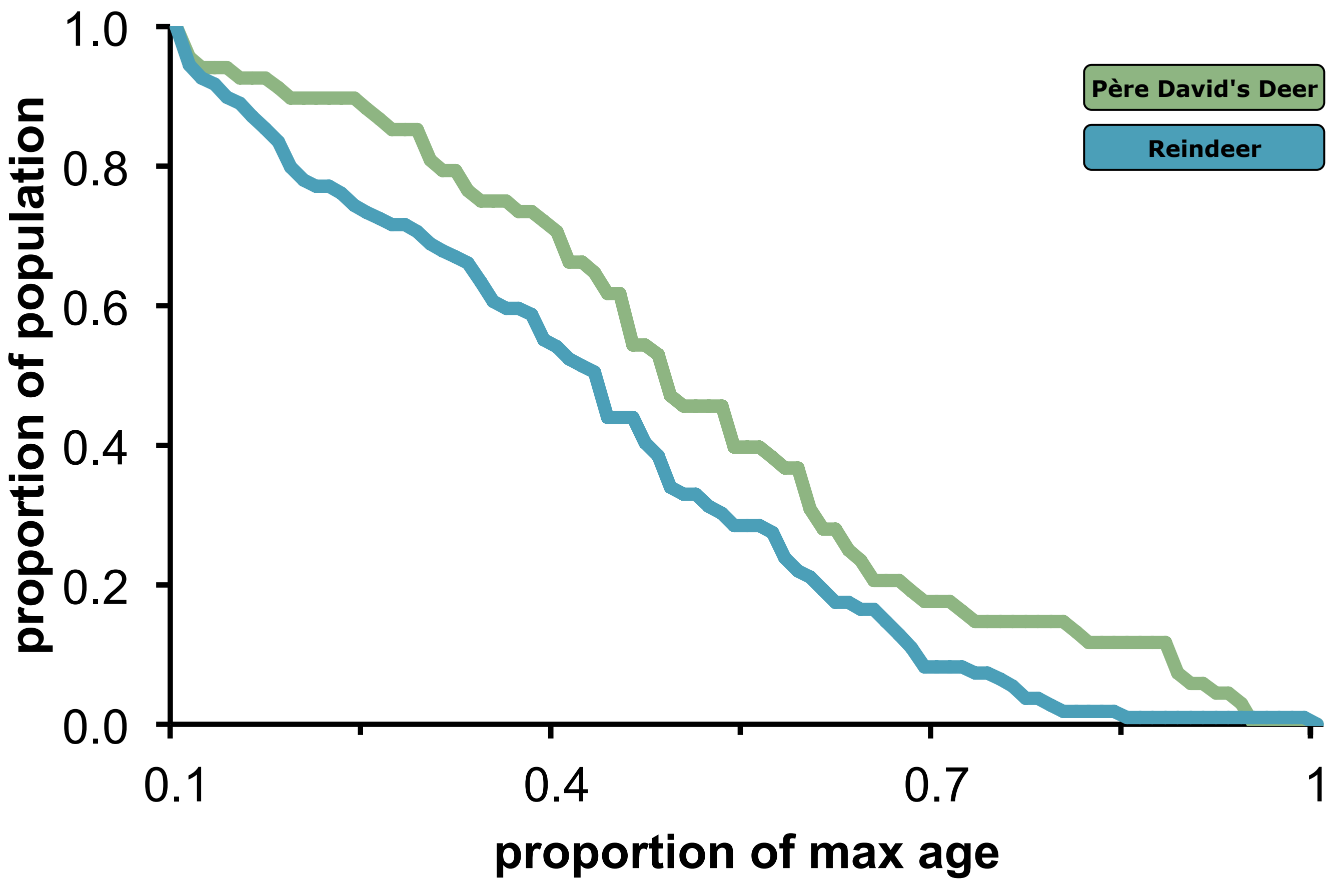


Our approach



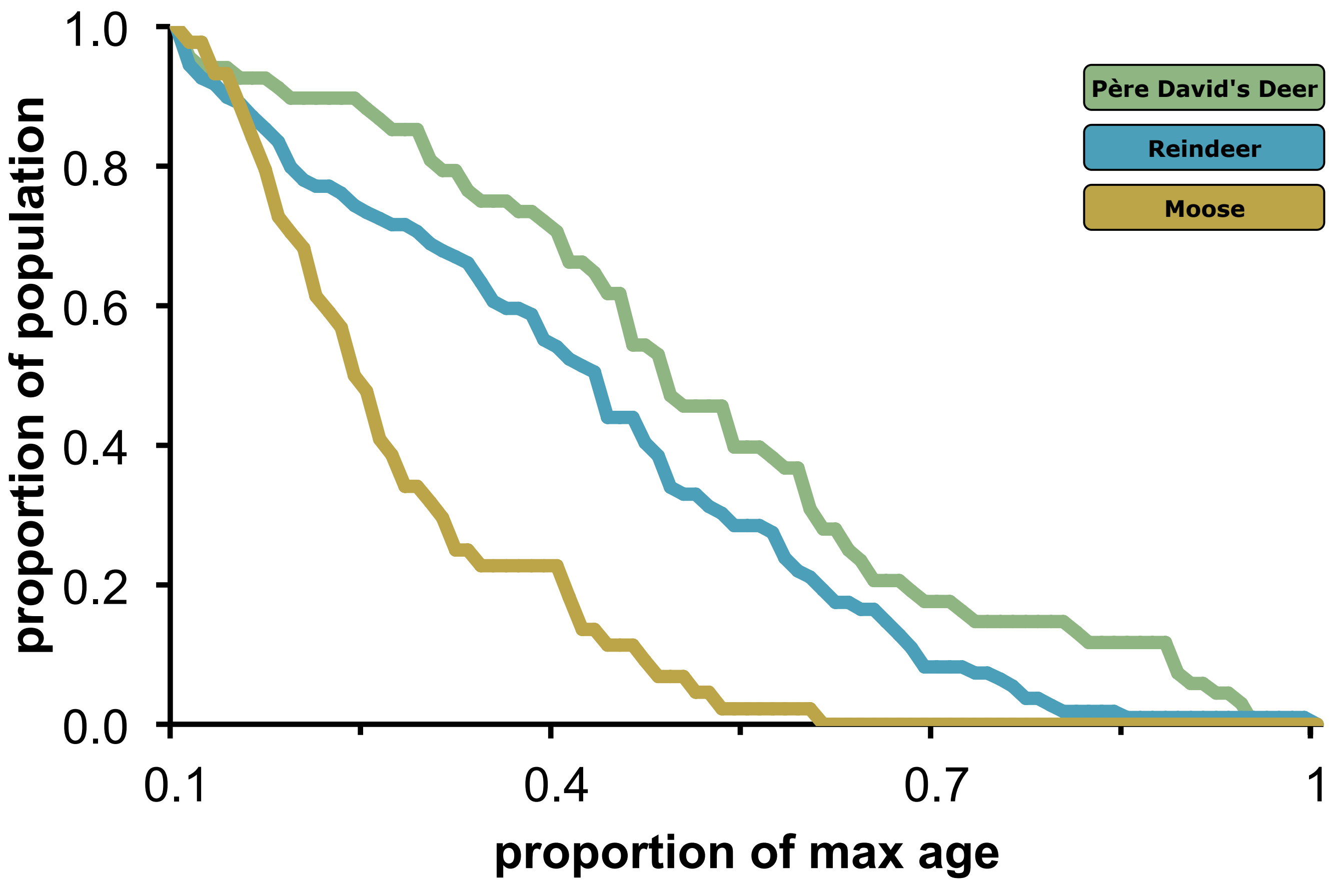
Our approach

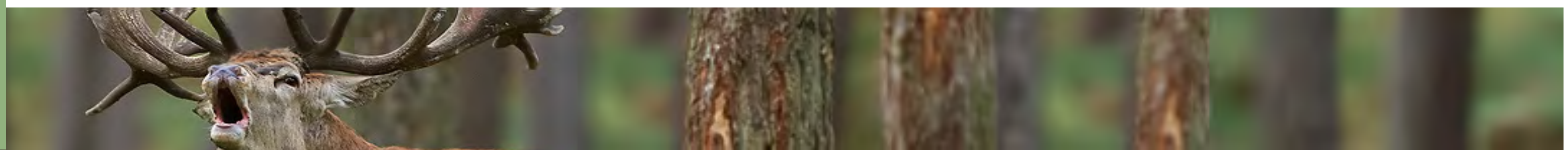
How to compare different species?



Our approach

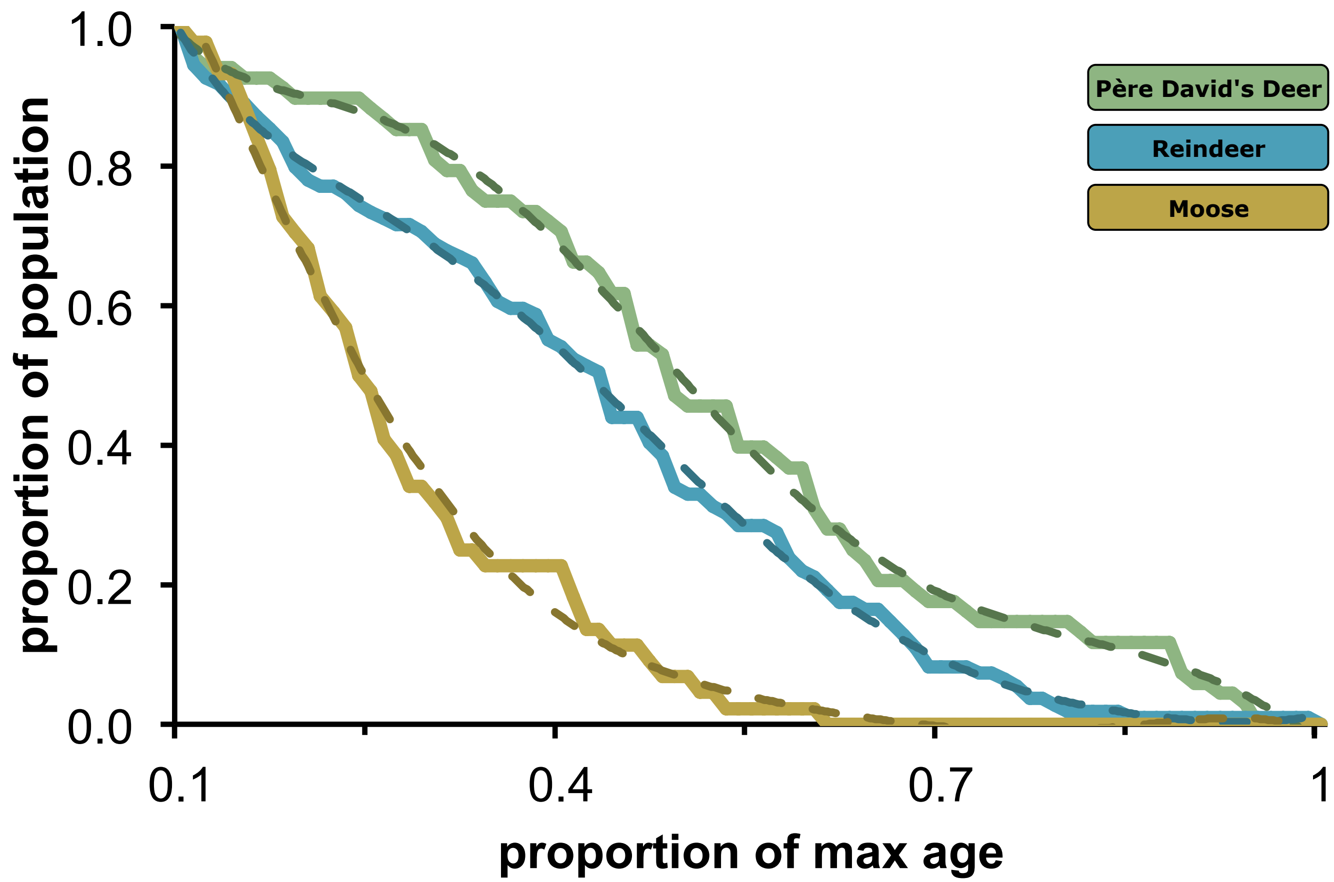
How to compare different species?

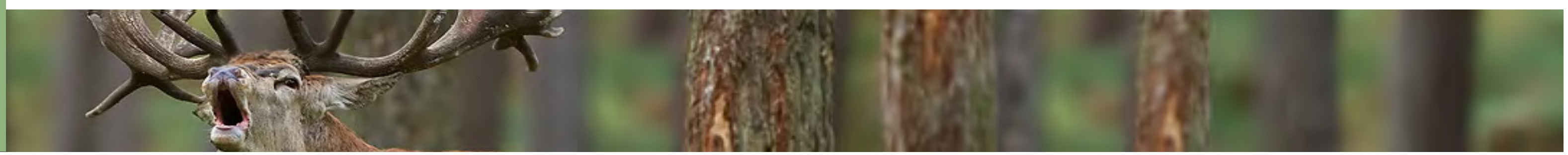




Our approach

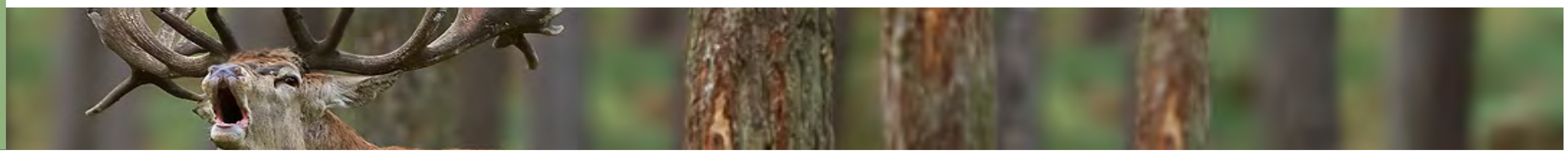
Functions too complicate and models are imprecise





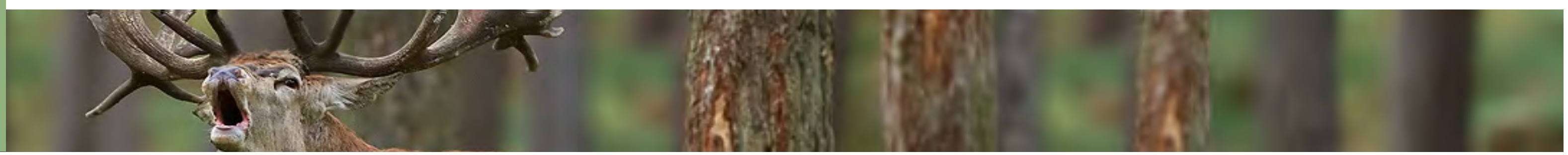
Our approach

The area under the curve ⇨ The “**relative life expectancy**”



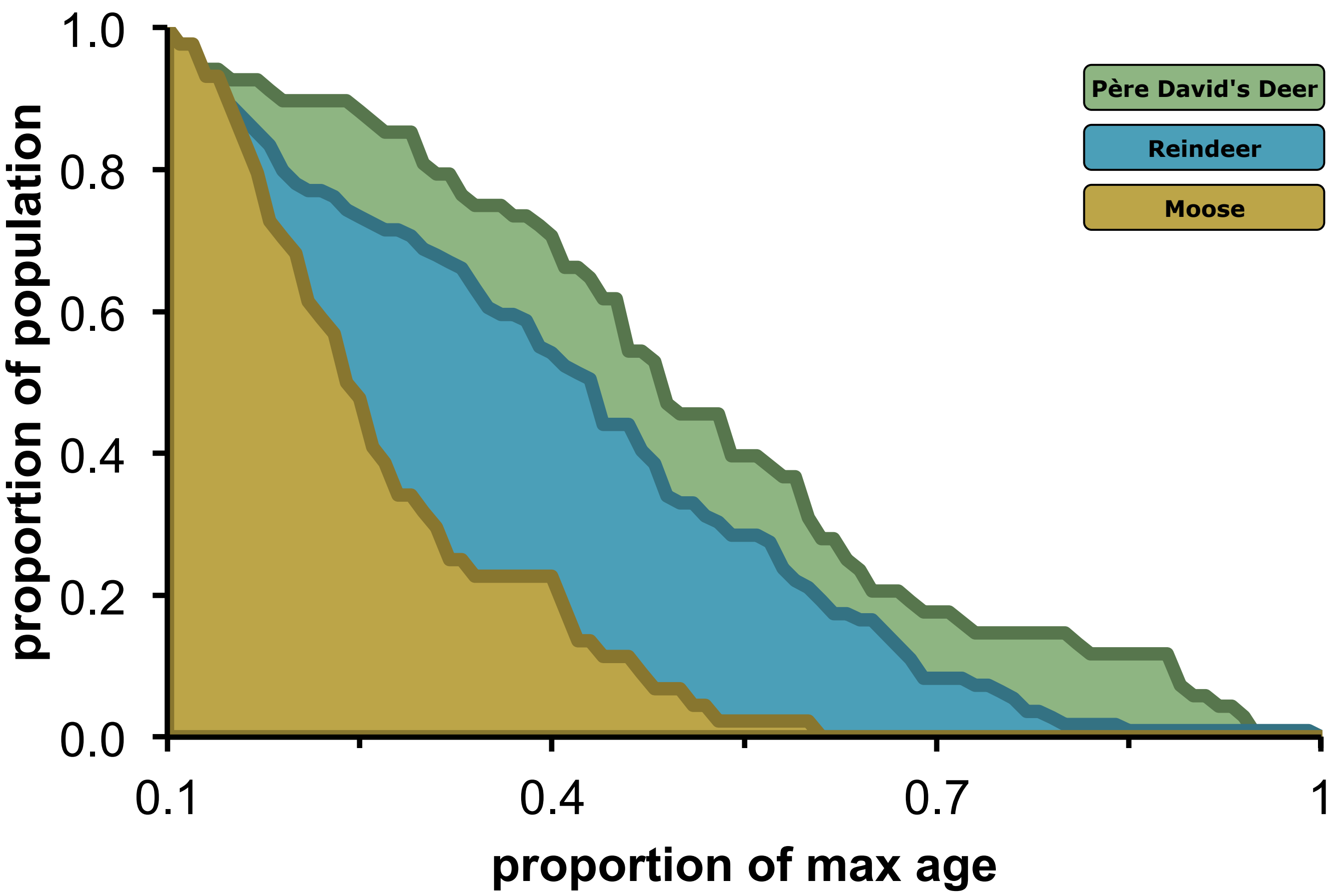
Our approach

Comparison possible



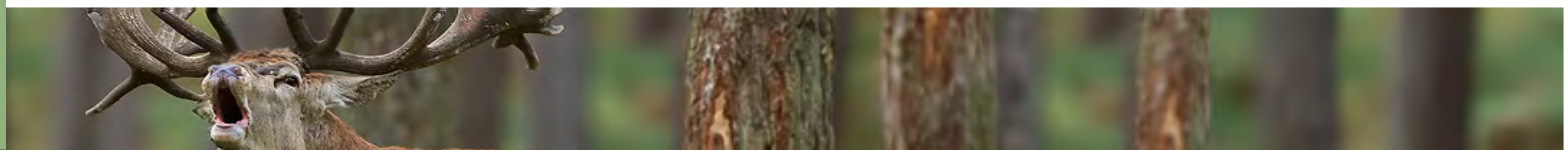
Our approach

Comparison possible



Method

- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)
- Calculate mean age at death for various sex and age groups
- Express mean life expectancy as a proportion of the maximum longevity recorded in the species



Method

- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)
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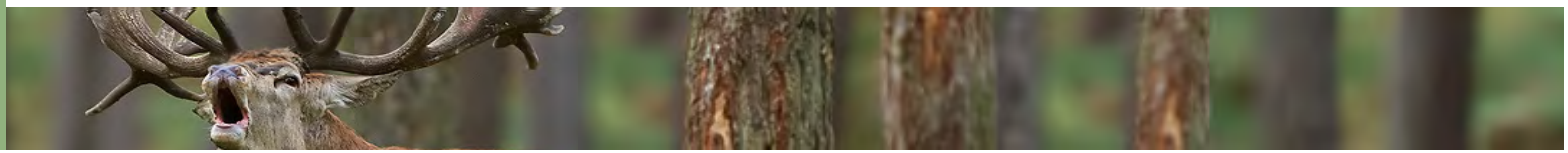
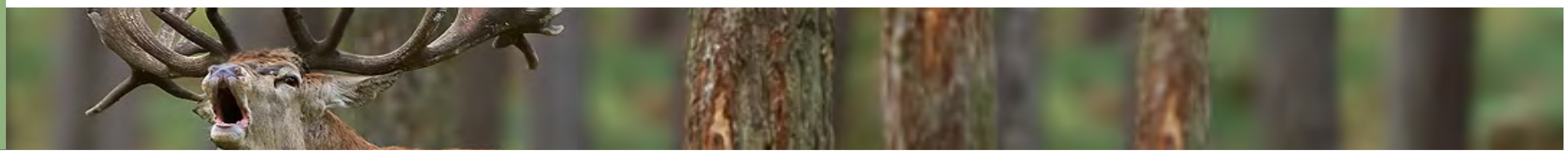
‘relative life expectancy’



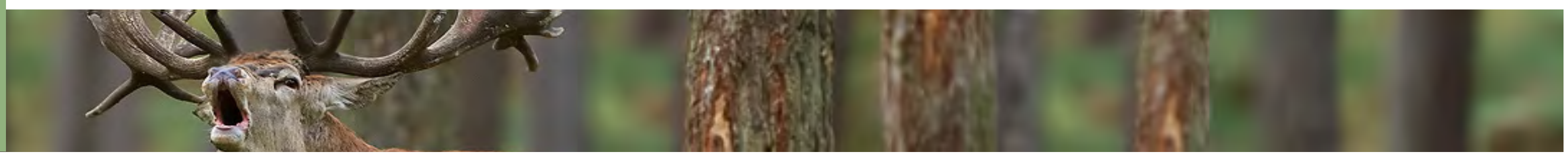
Relative life expectancy

	Species	Life expectancy		
		max.	Western Europe	
		age	Ø years	%
	Man	**125**	**87.5**	**70.0**



Relative life expectancy

	Species	Life expectancy		
		max.	Western Europe	
		age	Ø years	%
	Man	125	87.5	70.0
			ISIS	
1	Red deer	27.0	13.4	49.7
2	European bison	27.0	12.7	47.1
3	Roe deer	17.0	7.9	46.7
4	Alpine ibex	20.4	9.2	45.2
5	Fallow deer	25.4	10.5	41.8
6	Sika deer	25.0	10.0	39.1
7	Moose	27.0	7.3	27.1



Relative life expectancy

	Species	Life expectancy		
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		age	Ø years	%
	Man	125	87.5	70.0
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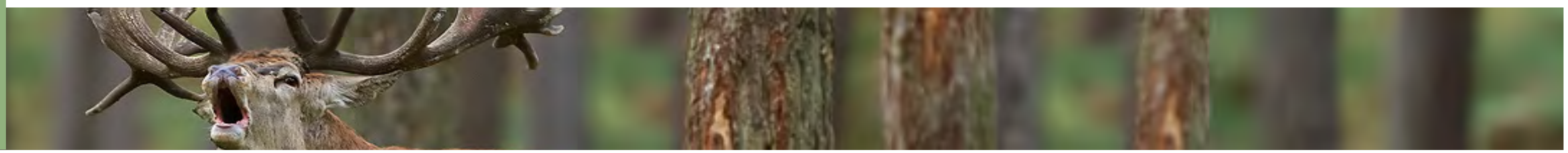
3	Roe deer			46.7
4	Alpine ibex			45.2
5	Fallow deer			41.8
6	Sika deer			39.1
7	**Moose**	**27.0**	**7.3**	**27.1**



Relative life expectancy

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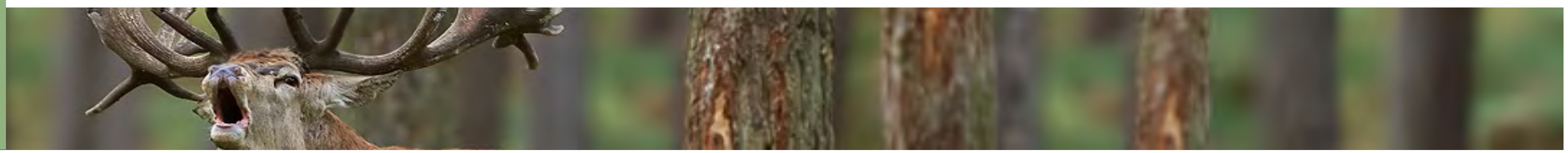
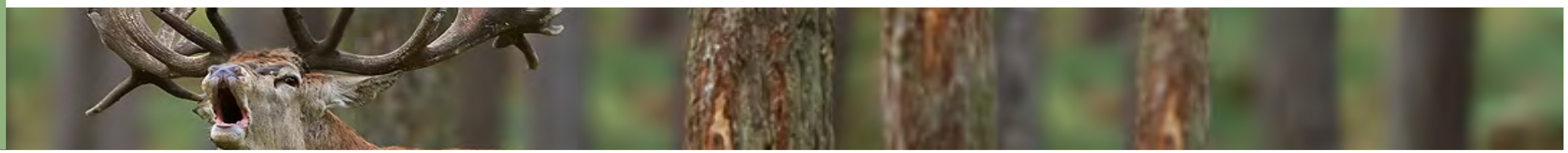
6	Sika deer			39.1
7	**Moose**	**27.0**	**7.3**	**27.1**

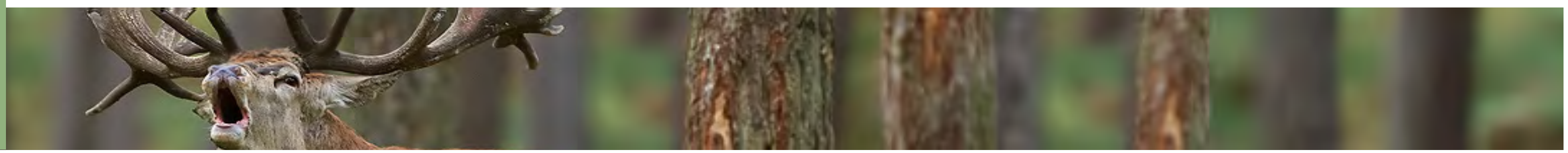


Relative life expectancy

- Measures mean age at death as proportion of record longevity (in %)
- Allows a ranking of species
- Allows a control of husbandry success
- Allows investigating other factors that may influence husbandry success

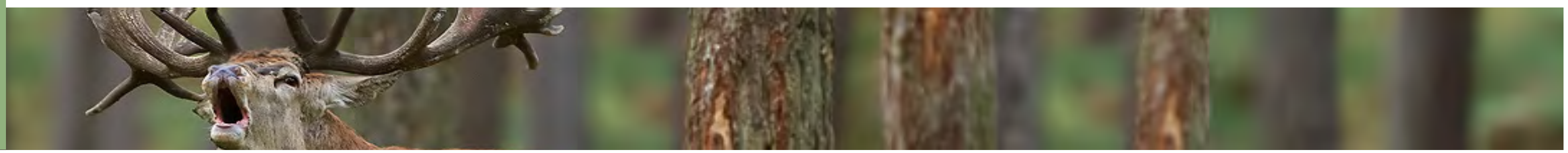


Which other factors would you evaluate against relative life expectancy?



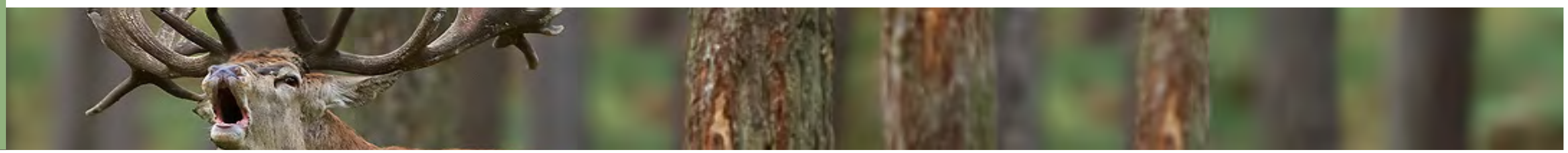
Which other factors would you evaluate against relative life expectancy?

- Body mass



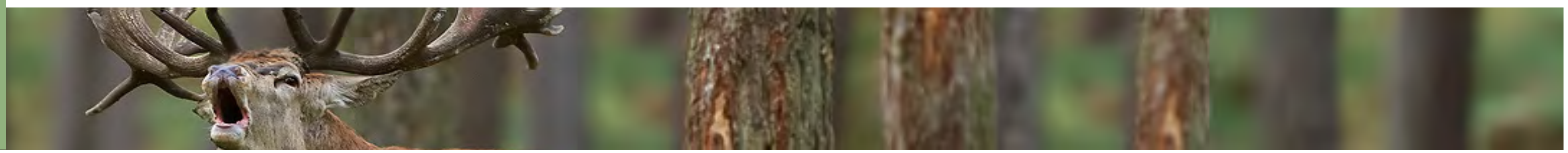
Which other factors would you evaluate against relative life expectancy?

- Body mass
- Social system
- Mating type



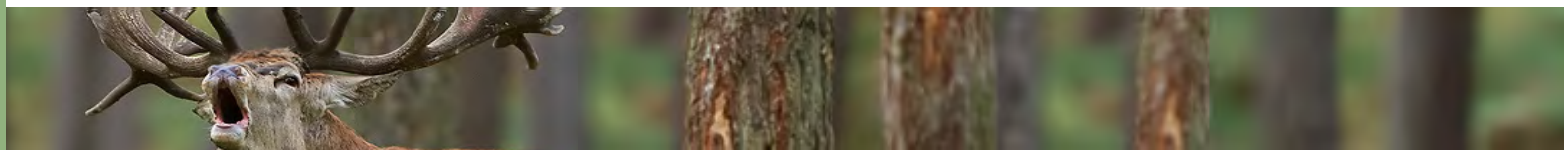
Which other factors would you evaluate against relative life expectancy?

- Body mass
- Social system
- Mating type
- Habitat (temperate/(sub)tropical)



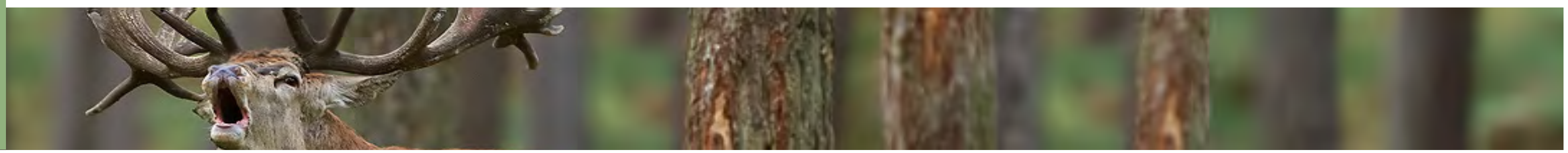
Which other factors would you evaluate against relative life expectancy?

- Body mass
- Social system
- Mating type
- Habitat (temperate/(sub)tropical)
- Natural diet



Which other factors would you evaluate against relative life expectancy?

- Body mass
- Social system
- Mating type
- Habitat (temperate/(sub)tropical)
- Natural diet
- Presence of an international studbook



Method

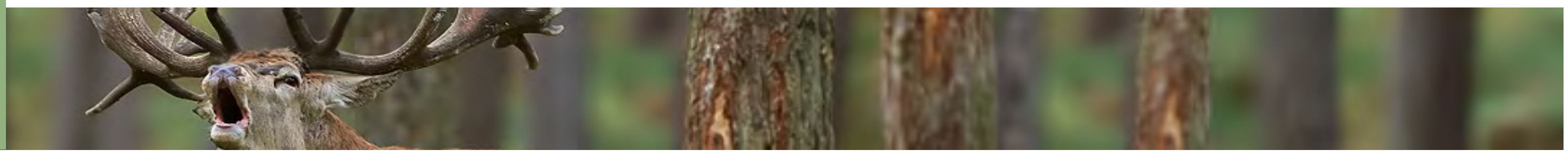
- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)

- Calculate mean age at death for various sex and age groups

Neonate/juvenile mortality

most relevant

Population control



Method

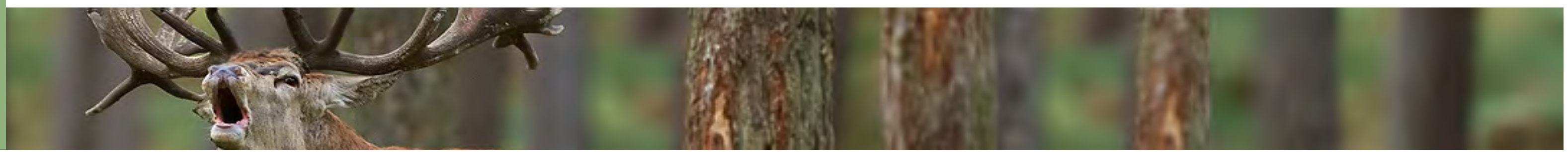
- Using birth and death dates to calculate the age at death (app. 200‘000 individuals)

- Calculate mean age at death for various sex and age groups

Neonate/juvenile mortality

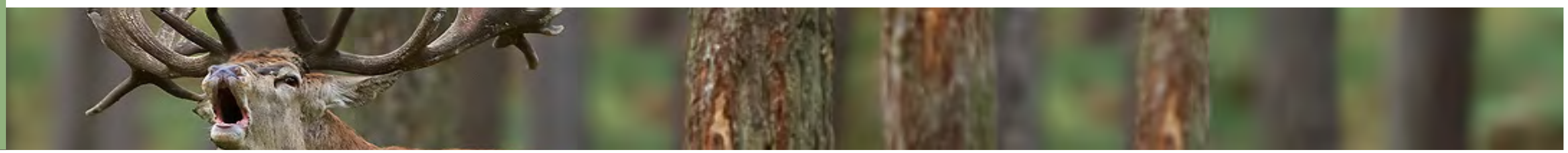
most relevant

ok once older than 2 years



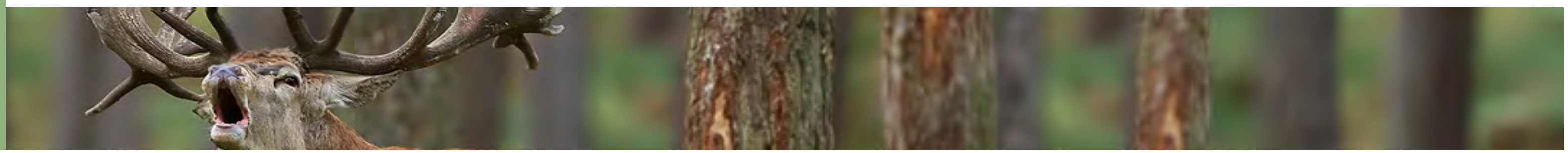
Predictions?

- Body mass
- Social system
- Mating type
- Habitat (temperate/(sub)tropical)
- Natural diet
- Presence of an international studbook



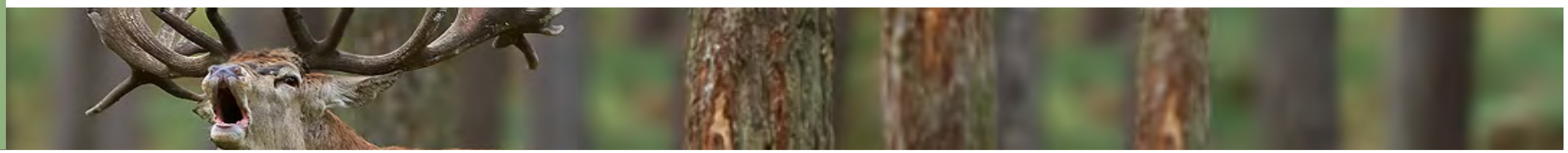
Predictions?

- Body mass – no effect
- Social system
- Mating type
- Habitat (temperate/(sub)tropical)
- Natural diet
- Presence of an international studbook



Predictions?

- Body mass – no effect
- Social system – effect in males?
- Mating type – effect in males?
- Habitat (temperate/(sub)tropical)
- Natural diet
- Presence of an international studbook



Predictions?

- Body mass – no effect
- Social system – effect in males?
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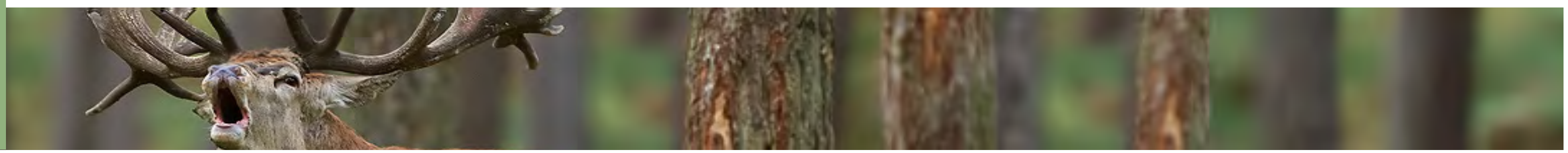
- Habitat (temperate/(sub)tropical) – tropic species ↓
- Natural diet
- Presence of an international studbook



Predictions?

- Body mass – no effect
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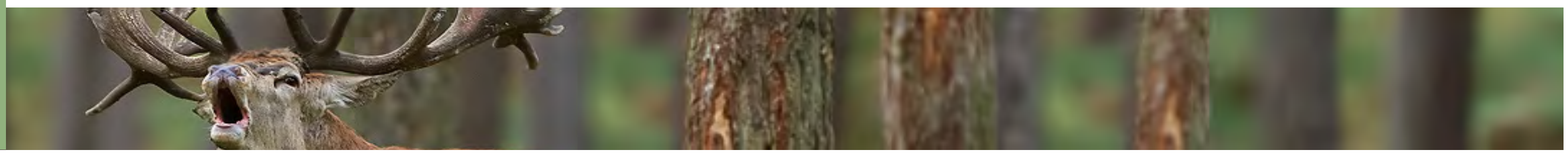
- Natural diet – browsing species ↓
- Presence of an international studbook

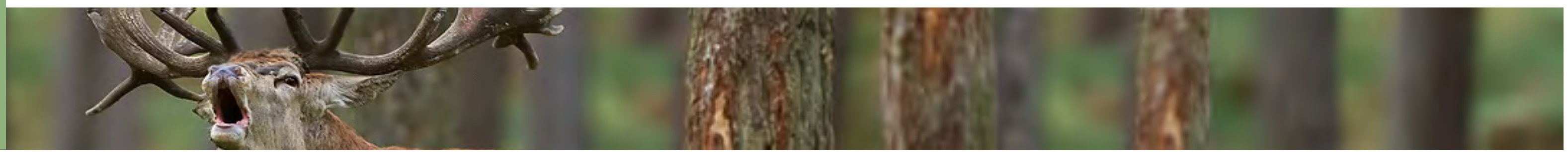
ZOO AND WILD ANIMAL MEDICINE
Current Therapy

CHAPTER 55
The Nutrition of "Browsers"
MARCUS CLAUSS AND ELLEN S. DIERENFELD

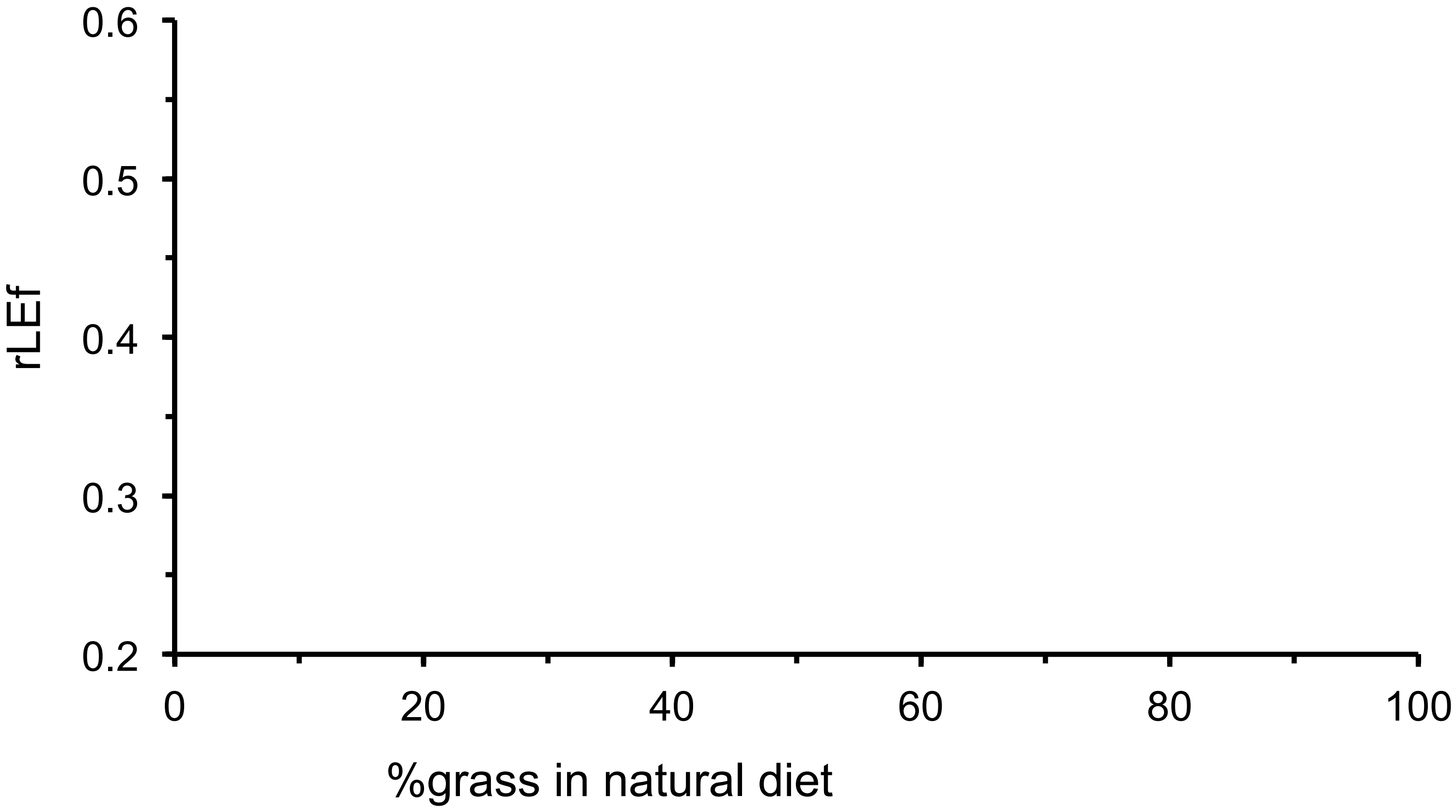


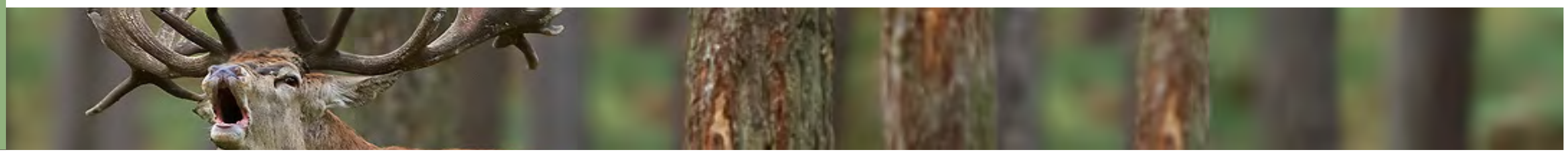
Predictions?

- Body mass – no effect
- Social system – effect in males?
- Mating type – effect in males?
- Habitat (temperate/(sub)tropical) – tropic species ↓
- Natural diet – browsing species ↓
- Presence of an international studbook - ↑

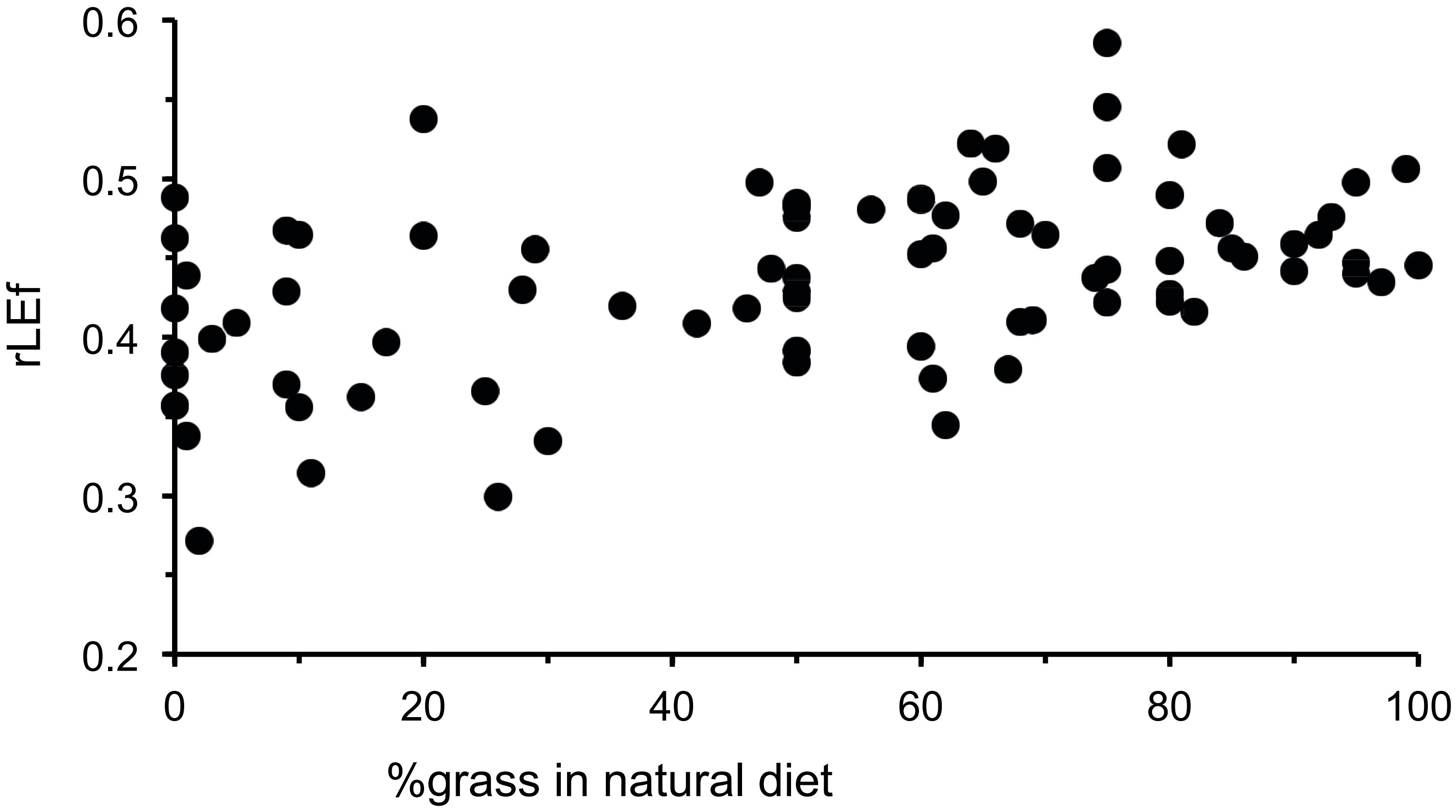


Natural diet

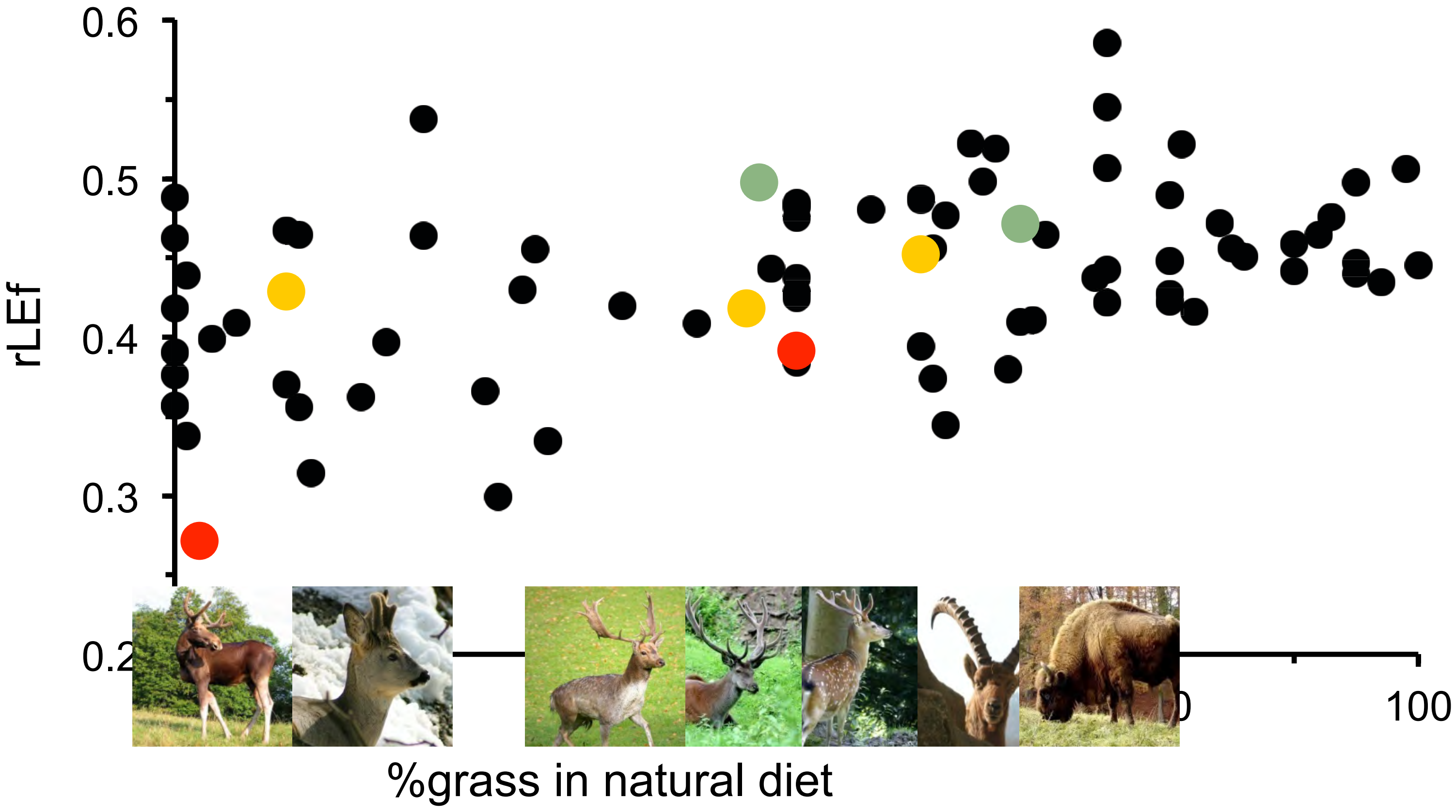


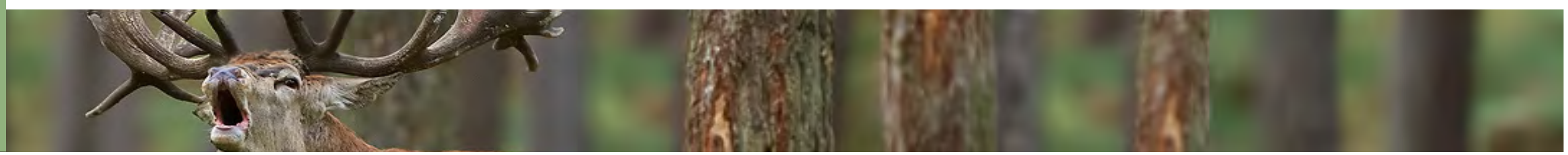


Natural diet

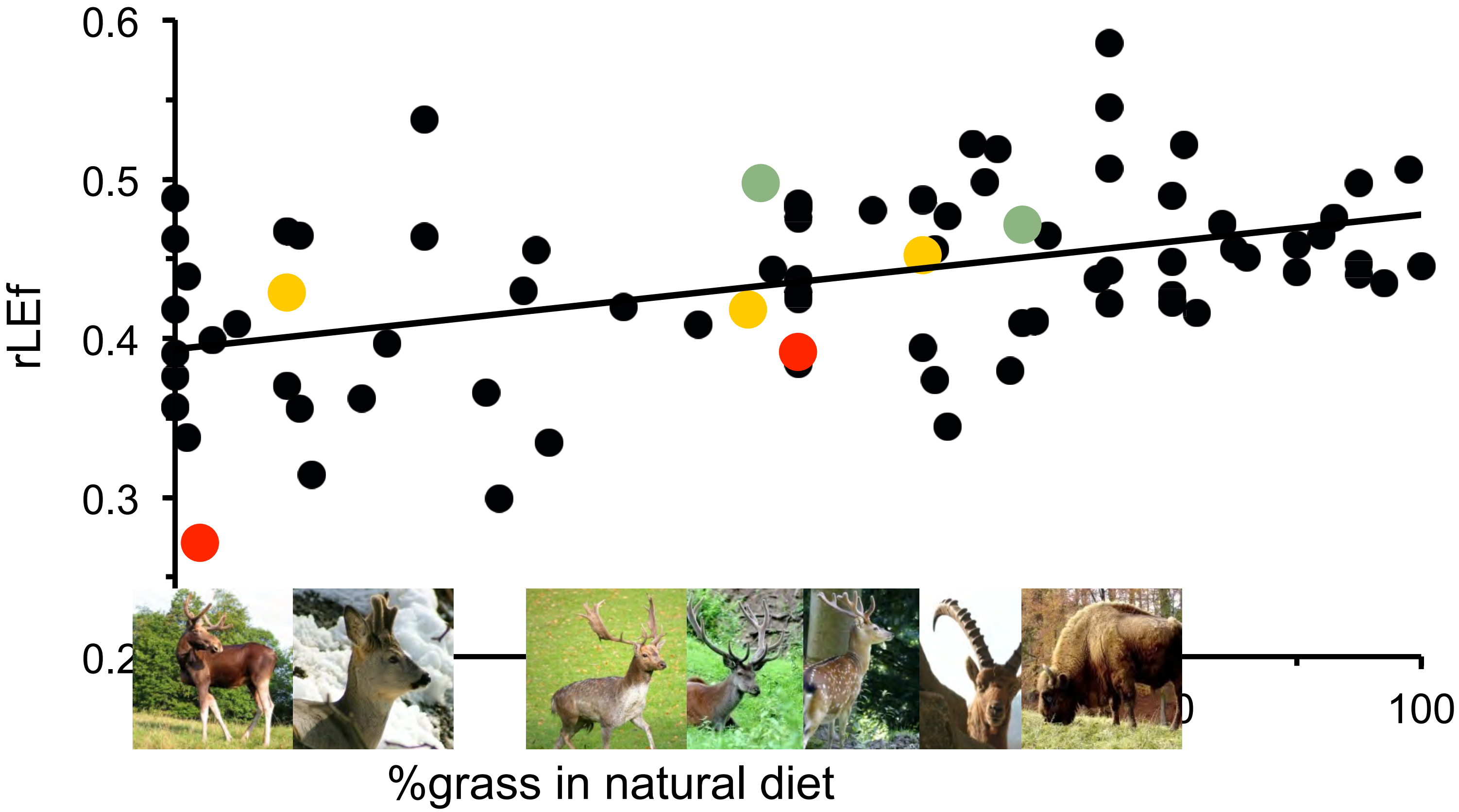


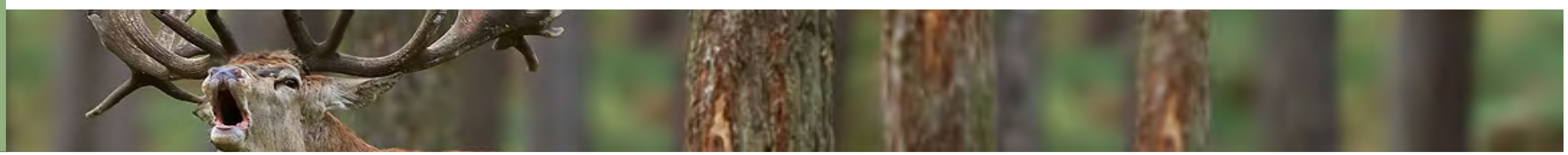
Natural diet



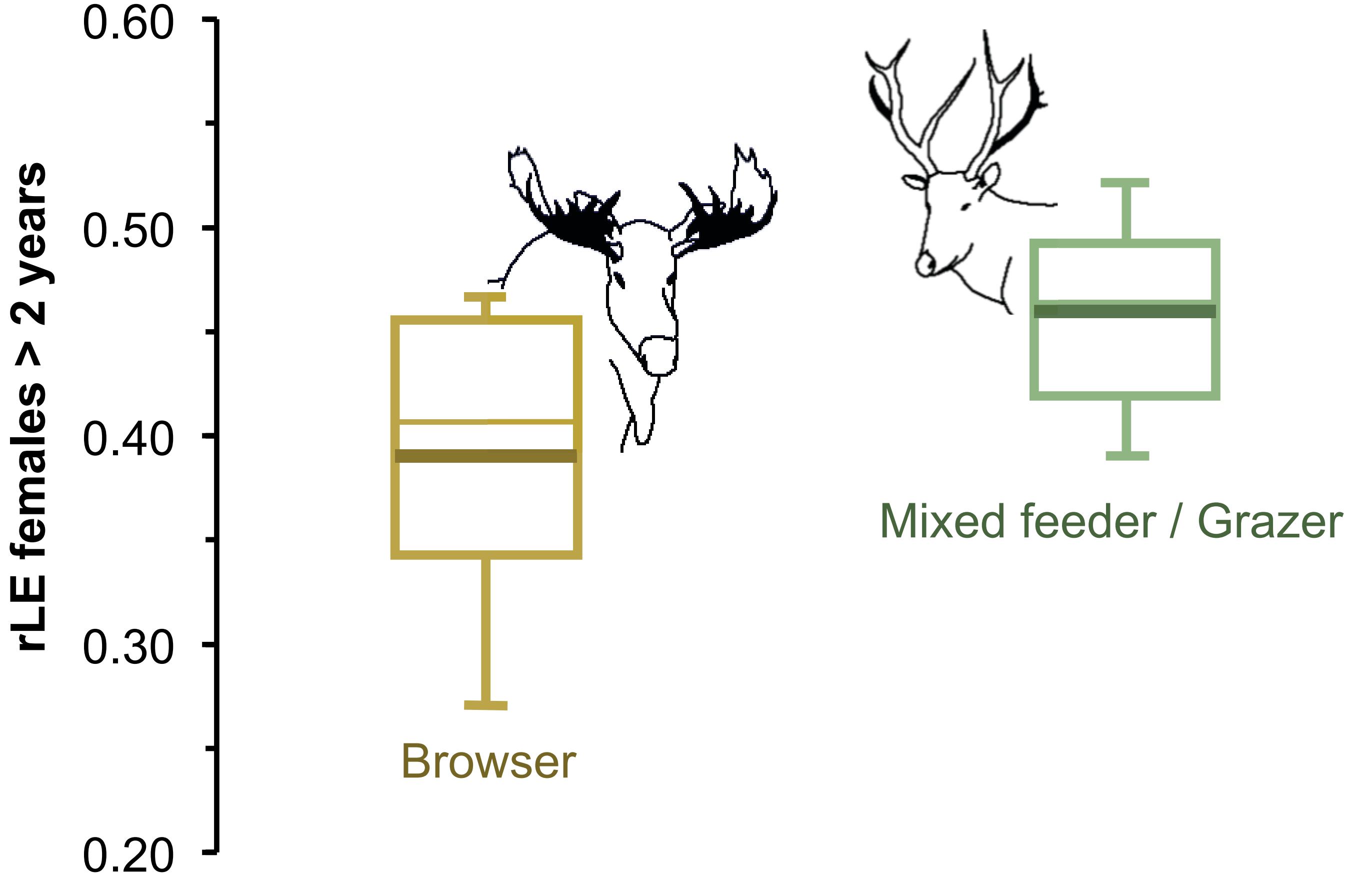


Natural diet

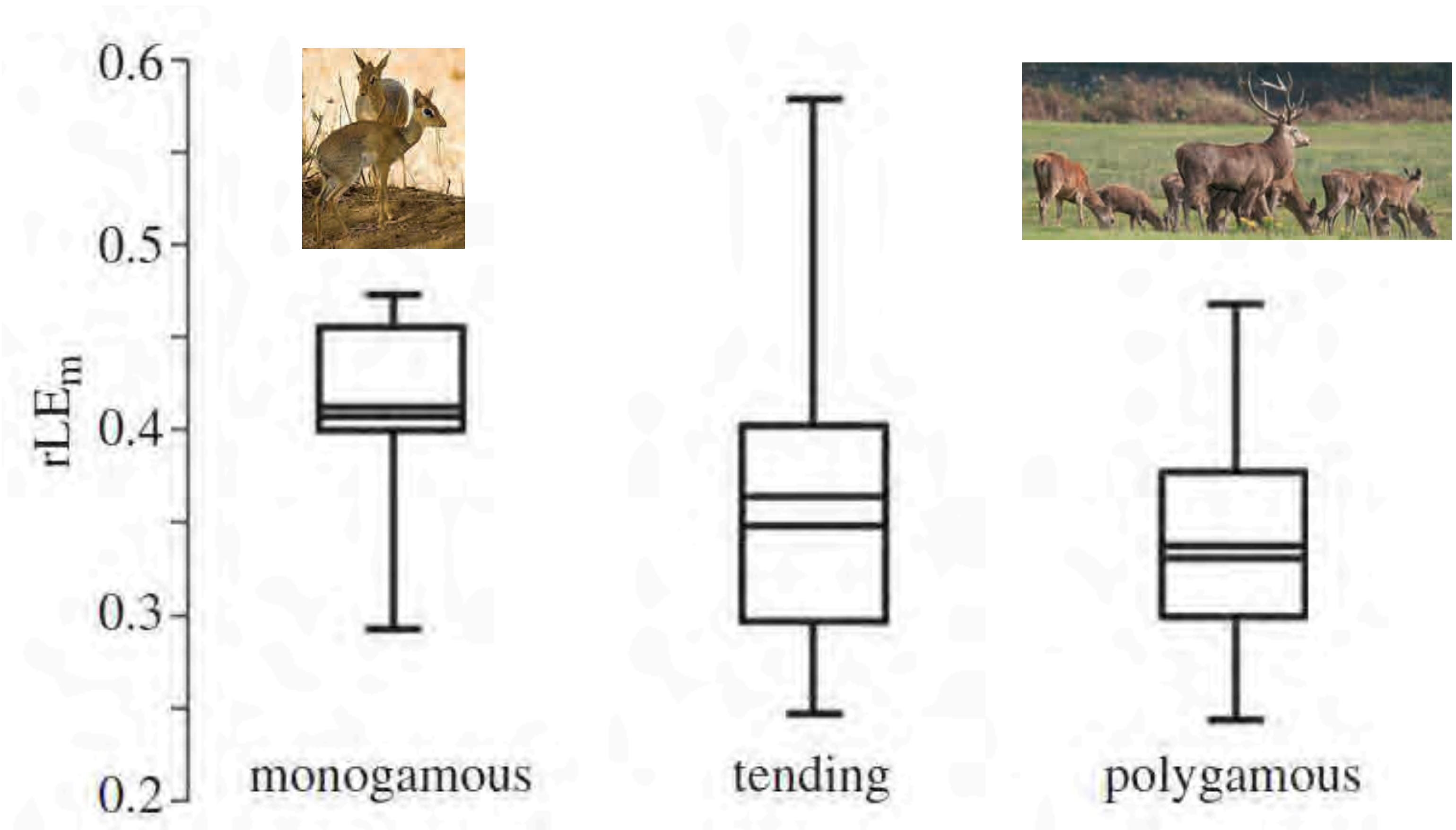


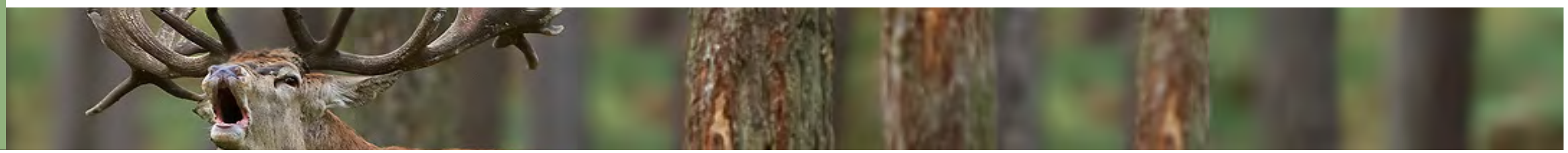


Natural diet



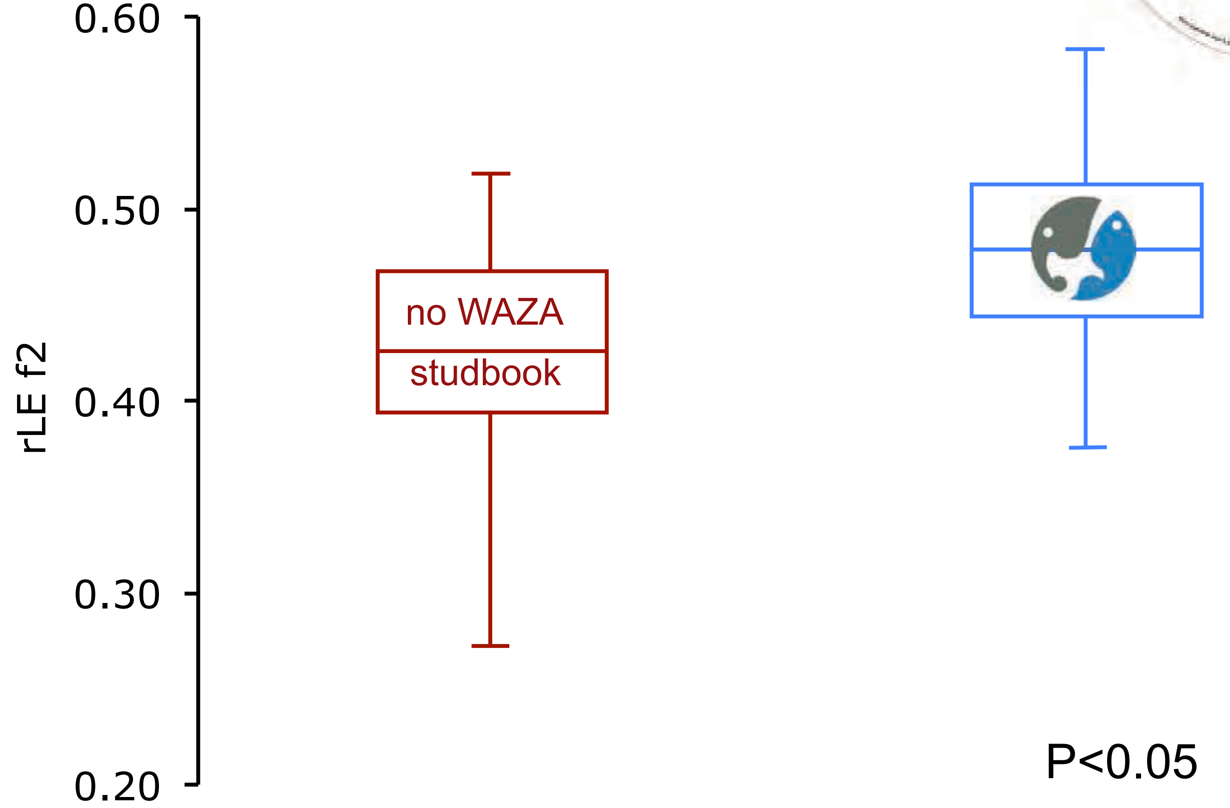
Mating type





Studbook


Studbook Library
Version 2011
ISIS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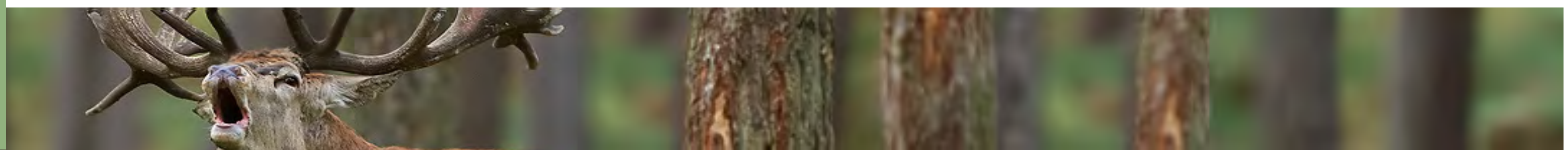
PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2011) 278, 2076–2080
doi:10.1098/rspb.2010.2275
Published online 8 December 2010

Mating system, feeding type and *ex situ* conservation effort determine life expectancy in captive ruminants

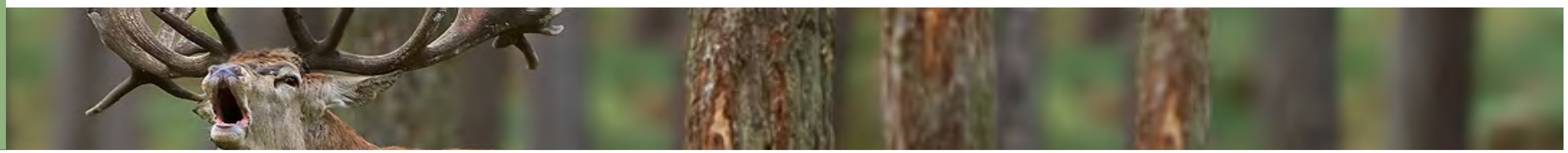
Dennis W. H. Müller[1,*], Laurie Bingaman Lackey[2], W. Jürgen Streich[3], Jörns Fickel[3], Jean-Michel Hatt[1] and Marcus Clauss[1]

	GLM F, p
dependent variable: rLE_{2f}	
%grass	$F_{1,75} = 19.84$, $p < 0.001$
studbook	$F_{1,75} = 7.69$, $p = 0.007$
dependent variable: rLE_{2m}	
mating system	$F_{2,74} = 6.719$, $p = 0.002$
studbook	$F_{1,74} = 6.745$, $p = 0.011$



Conclusions

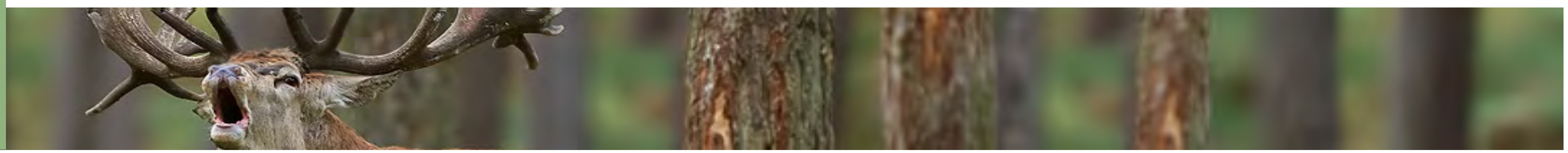
- The rLE is a feasible parameter to:
    - Evaluate husbandry success
    - Identify factors influencing the life expectancy



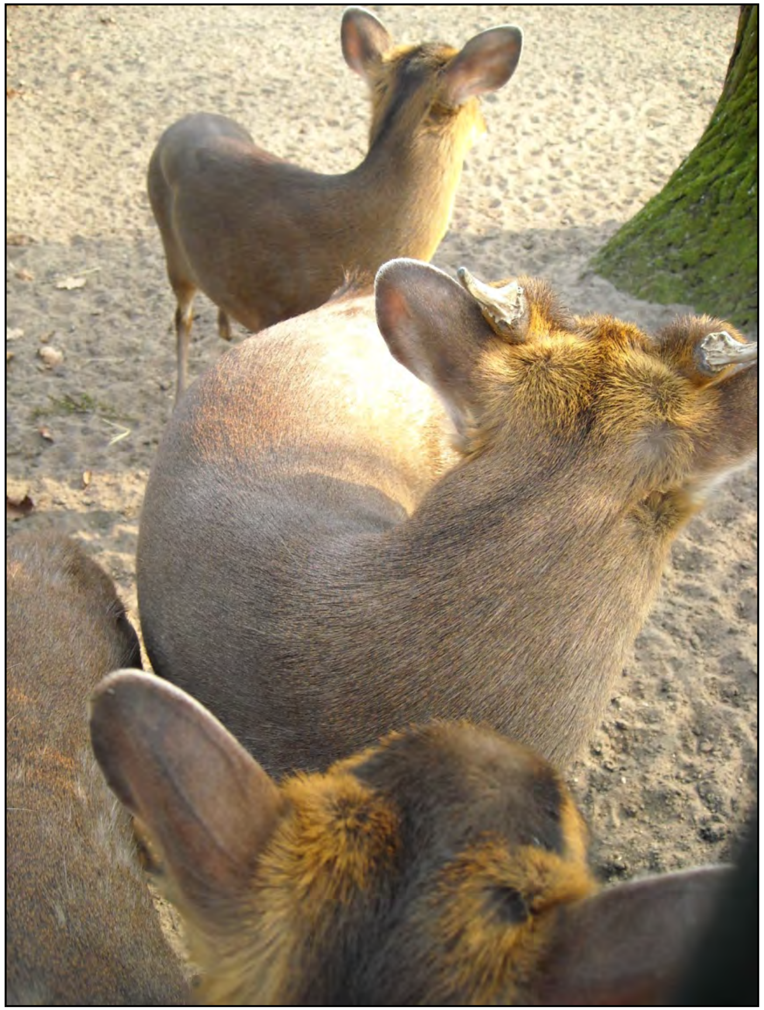
Conclusions

- The rLE is a feasible parameter to:
    - Evaluate husbandry success
    - Identify factors influencing the life expectancy

The rLE can help to increase animal welfare in zoological institutions



Thank you for your attention



PROCEEDINGS OF THE ROYAL SOCIETY B

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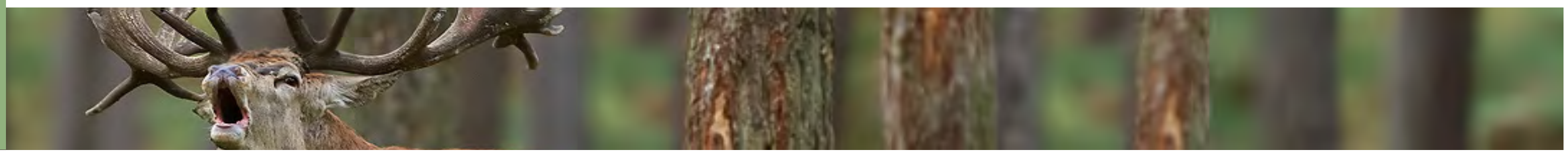
Dennis W. H. Müller[1,*], Laurie Bingaman Lackey[2], W. Jürgen Streich[3], Jörns Fickel[3], Jean-Michel Hatt[1] and Marcus Clauss[1]

	GLM F, p
dependent variable: rLE_{2f}	
%grass	$F_{1,75} = 19.84$, $p < 0.001$
studbook	$F_{1,75} = 7.69$, $p = 0.007$
dependent variable: rLE_{2m}	
mating system	$F_{2,74} = 6.719$, $p = 0.002$
studbook	$F_{1,74} = 6.745$, $p = 0.011$



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	GLM F, p	GLM (PGLS) χ^2, p
dependent variable: rLE_{2f}		
%grass	$F_{1,75} = 19.84$, $p < 0.001$	$\chi^2 = 8.28$, d.f. = 1, $p = 0.004$
studbook	$F_{1,75} = 7.69$, $p = 0.007$	$\chi^2 = 8.80$, d.f. = 1, $p = 0.003$
dependent variable: rLE_{2m}		
mating system	$F_{2,74} = 6.719$, $p = 0.002$	$\chi^2 = 9.92$, d.f. = 2, $p = 0.007$
studbook	$F_{1,74} = 6.745$, $p = 0.011$	$\chi^2 = 5.52$, d.f. = 1, $p = 0.019$