Sex-Specific Actuarial and Reproductive Senescence in Zoo-Housed Tiger

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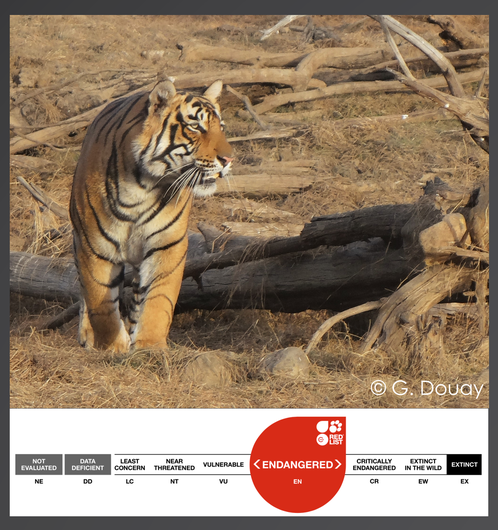
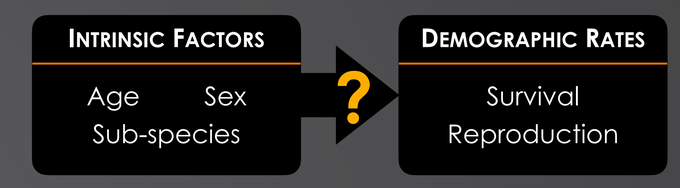
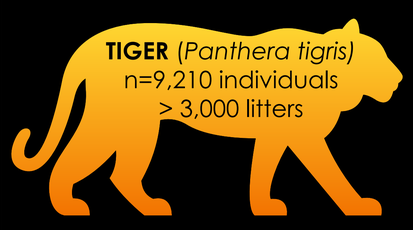


ABSTRACT: Biodiversity rate loss is rapid, continuous, and mostly due to anthropogenic activities [1]. To slow down this decline, accurate estimation of demographic parameters of threatened species is critical, but hard to obtain in the wild for many species. With this aim, zoo institutions play an important role, giving access to data on zoo-housed animals to researchers working on species' life-history traits and intrinsic factors influencing the fitness of both sexes, such as age. While tigers (*Panthera tigris*) are particularly threatened in their natural environment [2,3], few demographic parameters have yet been determined because of their solitary and elusive nature [4] as well as low-density populations [3]. Using information of more than 9,200 individuals (from 1938 to 2018) recorded in the International Studbook of Tiger [5], **we aimed to determine sub-species and sex-specific variability of survival and reproductive parameters with age**. No significant sex-difference in actuarial senescence (i.e. decline of survival probabilities with age) was observed but males tended to have a higher juvenile mortality and a faster senescence than females. Reproductive senescence (i.e. decline of reproductive parameters with age) was more pronounced in females than males. Moreover, we observed sub-species-specific variation in mortality and reproductive parameters, pointing out the necessity to consider them independently for conservation goals. Our study provides meaningful findings to improve husbandry of zoo-housed tigers, emphasising the importance of adult breeding females of 7-9 years-old to increase zoo-housed population size, but also providing accurate demographic estimates, crucial to set up effective conservation plans.

Following survival and recruitment changes through time and age, and their variability according to the sex and the sub-species, should allow biologists to delve deeper into factors driving them.
It would help improve wild population dynamic models and population viability analysis, critical to help decision makers for conservation goals.



DATA



Sex
- 4,695 females
- 4,506 males

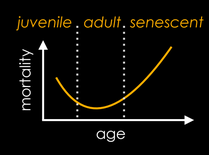
International Tiger Studbook [5]
From 1938 to November 30th 2018

Sub-species
- 5,618 Amur tigers (*P.t. altaica*)
- 560 South China tigers (*P.t. amoyensis*)
- 294 Malayan tigers (*P.t. jacksoni*)
- 1,564 Sumatran tigers (*P.t. sumatrae*)
- 1,125 Bengal tigers (*P.t. tigris*)

MORTALITY PATTERN DETERMINATION

Variable date of birth → date of death or lost to follow up

Model Bayesian model Siler [6] + Gompertz [7]



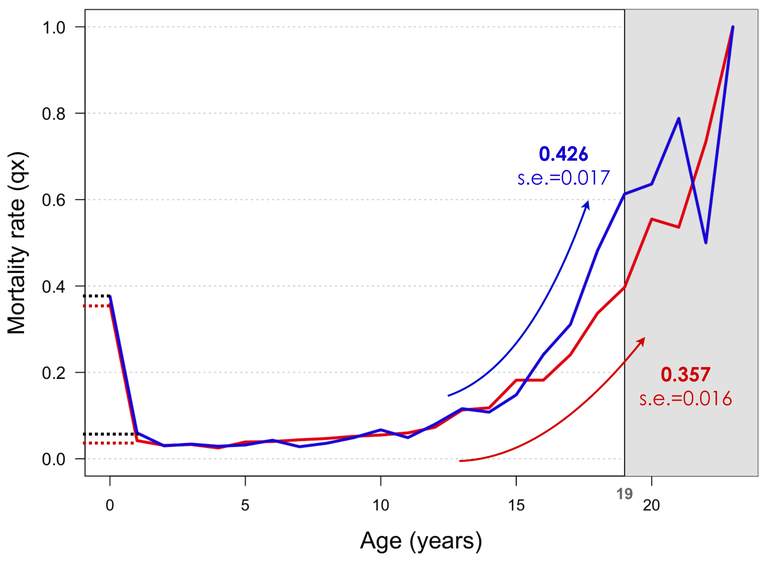
Package BaSTA [8]

Software R version 3.5.1 [9]

REPRODUCTIVE PATTERN DETERMINATION

Variables	LITTER SIZE at birth	CUB SURVIVAL probability at birth to reach sexual maturity (3.7 years-old)
Distribution	Poisson (log link)	Binomial (logit link)
Model	Generalised Linear Model with Effects Random	
Explanatory variables	Female age; Male age; Sub-species	
Random effects	Female ID; Male ID; Zoo ID	

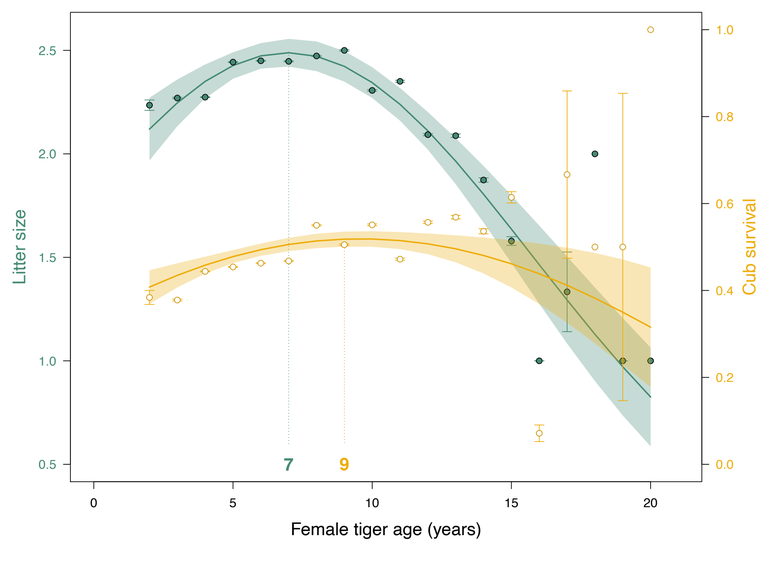
(A) Sex-specific mortality pattern



ACTUARIAL SENESCENCE OCCURS IN ZOO-HOUSED TIGERS

- Tigers have an overall longevity of 19 yrs under human care
- Males tend to have a higher juvenile mortality and to senesce faster than Females
- No significant differences between sub-species except on cub mortality - see (C)

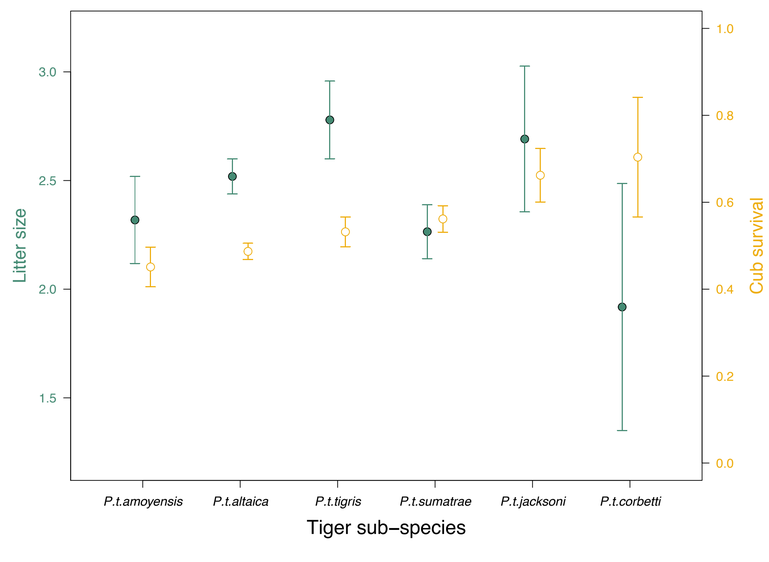
(B) Females reproductive pattern



REPRODUCTIVE SENESCENCE OCCURS IN ZOO-HOUSED TIGERS AND IS MORE PRONOUNCED IN FEMALES

- Reproductive parameters increase with female's age until they reach 7-9 years of age, and decrease after this age
- Litter size tends to decrease with male's age increasing (-0.006 [-0.013;0.001]) but not cub survival

(C) Sub-species reproductive parameters



DEMOGRAPHIC PARAMETERS DIFFER BETWEEN SUB-SPECIES

- Malayan and Bengal tigers have larger, while Indochinese tigers smaller, **litter size** than other sub-species
- Cubs of Malayan and Indochinese tigers have higher, while Amur and South China tigers lower, **probability to reach sexual maturity** than other sub-species

TAKE HOME MESSAGE

- **ACCURATE ESTIMATION OF TIGER DEMOGRAPHIC PARAMETERS IS NEEDED TO DEFINE EFFECTIVE CONSERVATION PLANS**
- **BREEDING FEMALES OF 7-9 YEARS OF AGE ARE CRUCIAL TO CONTROL *EX SITU* AND INCREASE *IN SITU* POPULATIONS SIZE**
- **TIGER SUB-SPECIES MIGHT BE CONSIDERED SEPARATELY FOR CONSERVATION GOALS**

If you want to learn more, follow the research of the Species360 | Conservation Science Alliance at: https://conservation.species360.org
or contact the author at: morgane.tidiere@species360.org | mow_ty

[1] Hoffman et al. 2010, Science 330:1503-1509; [2] Horev et al. 2012, Biological Conservation 147:22-31; [3] Goodrich et al. 2015, IUCN Red List Threat Species; [4] Sunquist and Sunquist 2002, University of Chicago Press, Chicago and London; [5] Müller 2018, Zoological Garden Leipzig; [6] Siler 1979, Ecology 60:750-757; [7] Gompertz 1825, Philosophical Trans. R. Soc. Lond. 115:513-583; [8] Colchero et al. 2012, Methods in Ecology and Evolution 3:466-470; [9] R Development Core Team 2016, R Foundation for Statistical Computing, Vienna, Austria;