The historical development of zoo elephant survivorship

Lara Scherer | Laurie Bingaman Lackey | **Marcus Clauss** | Katrin Gries | David Hagan | Arne Lawrenz | Dennis W. H. Müller | Marco Roller | **Christian Schiffmann** | Ann-Kathrin Oerke

*Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Switzerland

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VegNews

UK TO BAN KEEPING ELEPHANTS CAPTIVE IN ZOOS

The British government is slated to prohibit the captivity of elephants in zoos and safaris under the broader Kept Animals Bill set to be passed this year.

by ANNA STAROSTINETSKAYA

JUNE 24, 2021

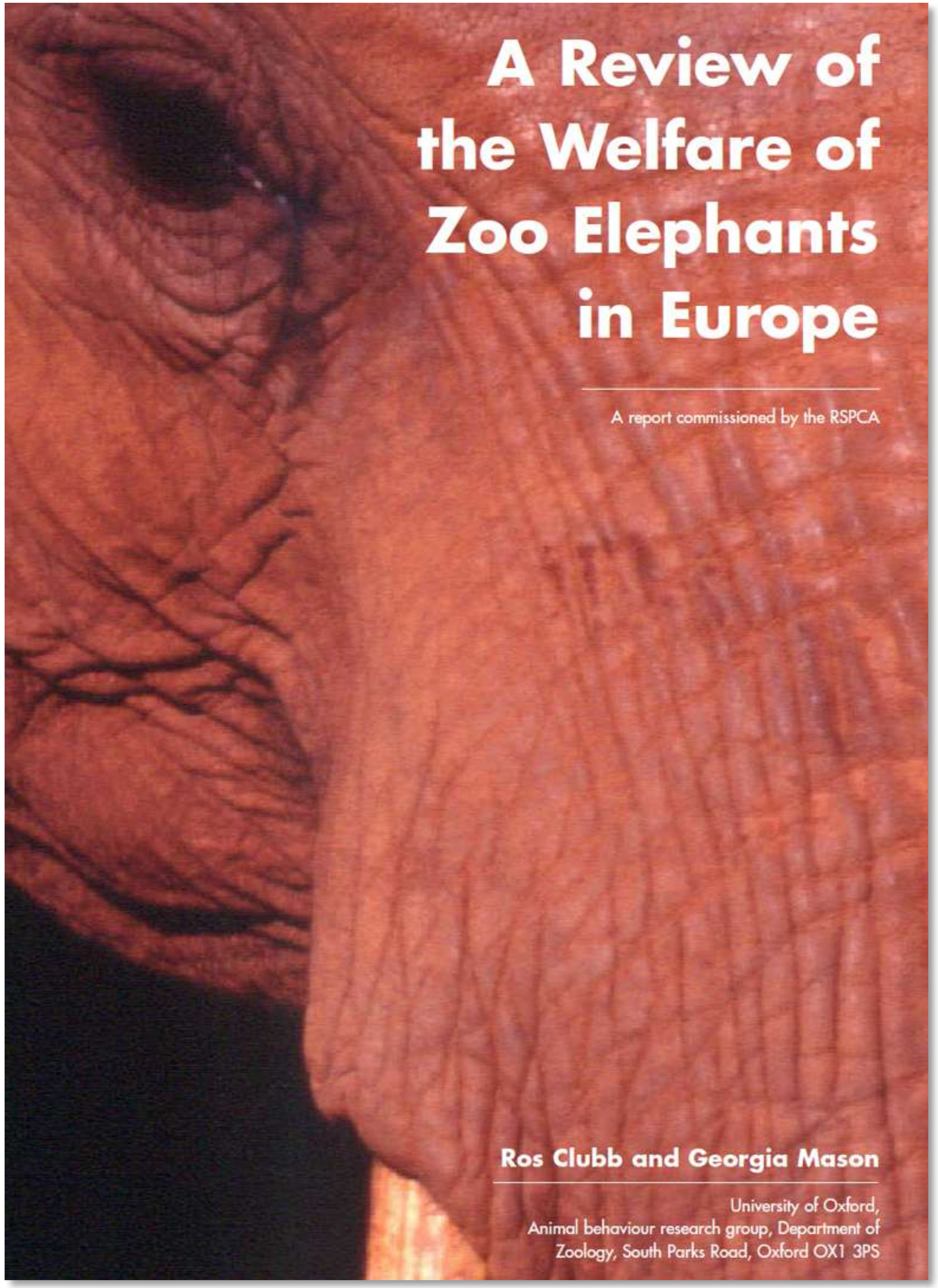
First Session, Forty-fourth Parliament,
70-71 Elizabeth II, 2021-2022

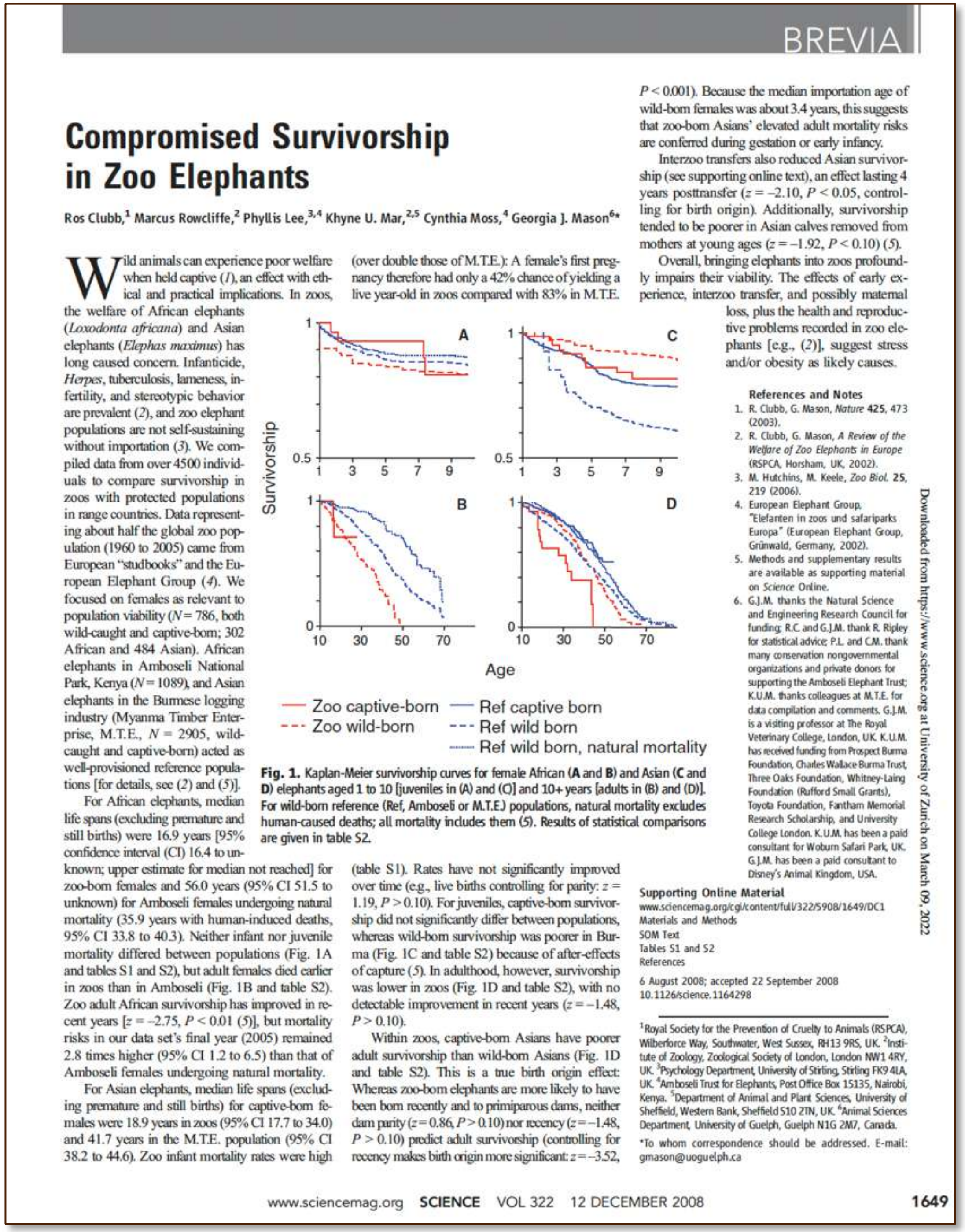
SENATE OF CANADA

BILL S-241

An Act to amend the Criminal Code and the Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (great apes, elephants and certain other animals)

FIRST READING, MARCH 22, 2022


A Review of the Welfare of Zoo Elephants in Europe
A report commissioned by the RSPCA
Ros Clubb and Georgia Mason
University of Oxford,
Animal behaviour research group, Department of Zoology, South Parks Road, Oxford OX1 3PS



Compromised Survivorship in Zoo Elephants

Ros Clubb,[1] Marcus Rowcliffe,[2] Phyllis Lee,[3,4] Khyne U. Mar,[2,5] Cynthia Moss,[4] Georgia J. Mason[6]*

Wild animals can experience poor welfare when held captive (*1*), an effect with ethical and practical implications. In zoos, the welfare of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) has long caused concern. Infanticide, *Herpes*, tuberculosis, lameness, infertility, and stereotypic behavior are prevalent (*2*), and zoo elephant populations are not self-sustaining without importation (*3*). We compiled data from over 4500 individuals to compare survivorship in zoos with protected populations in range countries. Data representing about half the global zoo population (1960 to 2005) came from European "studbooks" and the European Elephant Group (*4*). We focused on females as relevant to population viability ($N = 786$, both wild-caught and captive-born; 302 African and 484 Asian). African elephants in Amboseli National Park, Kenya ($N = 1089$), and Asian elephants in the Burmese logging industry (Myanma Timber Enterprise, M.T.E., $N = 2905$, wild-caught and captive-born) acted as well-provisioned reference populations [for details, see (*2*) and (*5*)].

For African elephants, median life spans (excluding premature and still births) were 16.9 years [95% confidence interval (CI) 16.4 to unknown; upper estimate for median not reached] for zoo-born females and 56.0 years (95% CI 51.5 to unknown) for Amboseli females undergoing natural mortality (35.9 years with human-induced deaths, 95% CI 33.8 to 40.3). Neither infant nor juvenile mortality differed between populations (Fig. 1A and tables S1 and S2), but adult females died earlier in zoos than in Amboseli (Fig. 1B and table S2). Zoo adult African survivorship has improved in recent years [$z = -2.75$, $P < 0.01$ (*5*)], but mortality risks in our data set's final year (2005) remained 2.8 times higher (95% CI 1.2 to 6.5) than that of Amboseli females undergoing natural mortality.

For Asian elephants, median life spans (excluding premature and still births) for captive-born females were 18.9 years in zoos (95% CI 17.7 to 34.0) and 41.7 years in the M.T.E. population (95% CI 38.2 to 44.6). Zoo infant mortality rates were high (over double those of M.T.E.): A female's first pregnancy therefore had only a 42% chance of yielding a live year-old in zoos compared with 83% in M.T.E. (table S1). Rates have not significantly improved over time (e.g., live births controlling for parity: $z = 1.19$, $P > 0.10$). For juveniles, captive-born survivorship did not significantly differ between populations, whereas wild-born survivorship was poorer in Burma (Fig. 1C and table S2) because of after-effects of capture (*5*). In adulthood, however, survivorship was lower in zoos (Fig. 1D and table S2), with no detectable improvement in recent years ($z = -1.48$, $P > 0.10$).

Within zoos, captive-born Asians have poorer adult survivorship than wild-born Asians (Fig. 1D and table S2). This is a true birth origin effect: Whereas zoo-born elephants are more likely to have been born recently and to primiparous dams, neither dam parity ($z = 0.86$, $P > 0.10$) nor recency ($z = -1.48$, $P > 0.10$) predict adult survivorship (controlling for recency makes birth origin more significant: $z = -3.52$, $P < 0.001$). Because the median importation age of wild-born females was about 3.4 years, this suggests that zoo-born Asians' elevated adult mortality risks are conferred during gestation or early infancy.

Interzoo transfers also reduced Asian survivorship (see supporting online text), an effect lasting 4 years posttransfer ($z = -2.10$, $P < 0.05$, controlling for birth origin). Additionally, survivorship tended to be poorer in Asian calves removed from mothers at young ages ($z = -1.92$, $P < 0.10$) (*5*).

Overall, bringing elephants into zoos profoundly impairs their viability. The effects of early experience, interzoo transfer, and possibly maternal loss, plus the health and reproductive problems recorded in zoo elephants [e.g., (*2*)], suggest stress and/or obesity as likely causes.

Survivorship (panels A–D); Age

— Zoo captive-born
--- Zoo wild-born
— Ref captive born
--- Ref wild born
······ Ref wild born, natural mortality

Fig. 1. Kaplan-Meier survivorship curves for female African (**A** and **B**) and Asian (**C** and **D**) elephants aged 1 to 10 [juveniles in (A) and (C)] and 10+ years [adults in (B) and (D)]. For wild-born reference (Ref, Amboseli or M.T.E.) populations, natural mortality excludes human-caused deaths; all mortality includes them (*5*). Results of statistical comparisons are given in table S2.

References and Notes

1. R. Clubb, G. Mason, *Nature* **425**, 473 (2003).
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5. Methods and supplementary results are available as supporting material on *Science* Online.
6. G.J.M. thanks the Natural Science and Engineering Research Council for funding; R.C. and G.J.M. thank R. Ripley for statistical advice; P.L. and C.M. thank many conservation nongovernmental organizations and private donors for supporting the Amboseli Elephant Trust; K.U.M. thanks colleagues at M.T.E. for data compilation and comments. G.J.M. is a visiting professor at The Royal Veterinary College, London, UK. K.U.M. has received funding from Prospect Burma Foundation, Charles Wallace Burma Trust, Three Oaks Foundation, Whitney-Laing Foundation (Rufford Small Grants), Toyota Foundation, Fantham Memorial Research Scholarship, and University College London. K.U.M. has been a paid consultant for Woburn Safari Park, UK. G.J.M. has been a paid consultant to Disney's Animal Kingdom, USA.

Supporting Online Material
www.sciencemag.org/cgi/content/full/322/5908/1649/DC1
Materials and Methods
SOM Text
Tables S1 and S2
References

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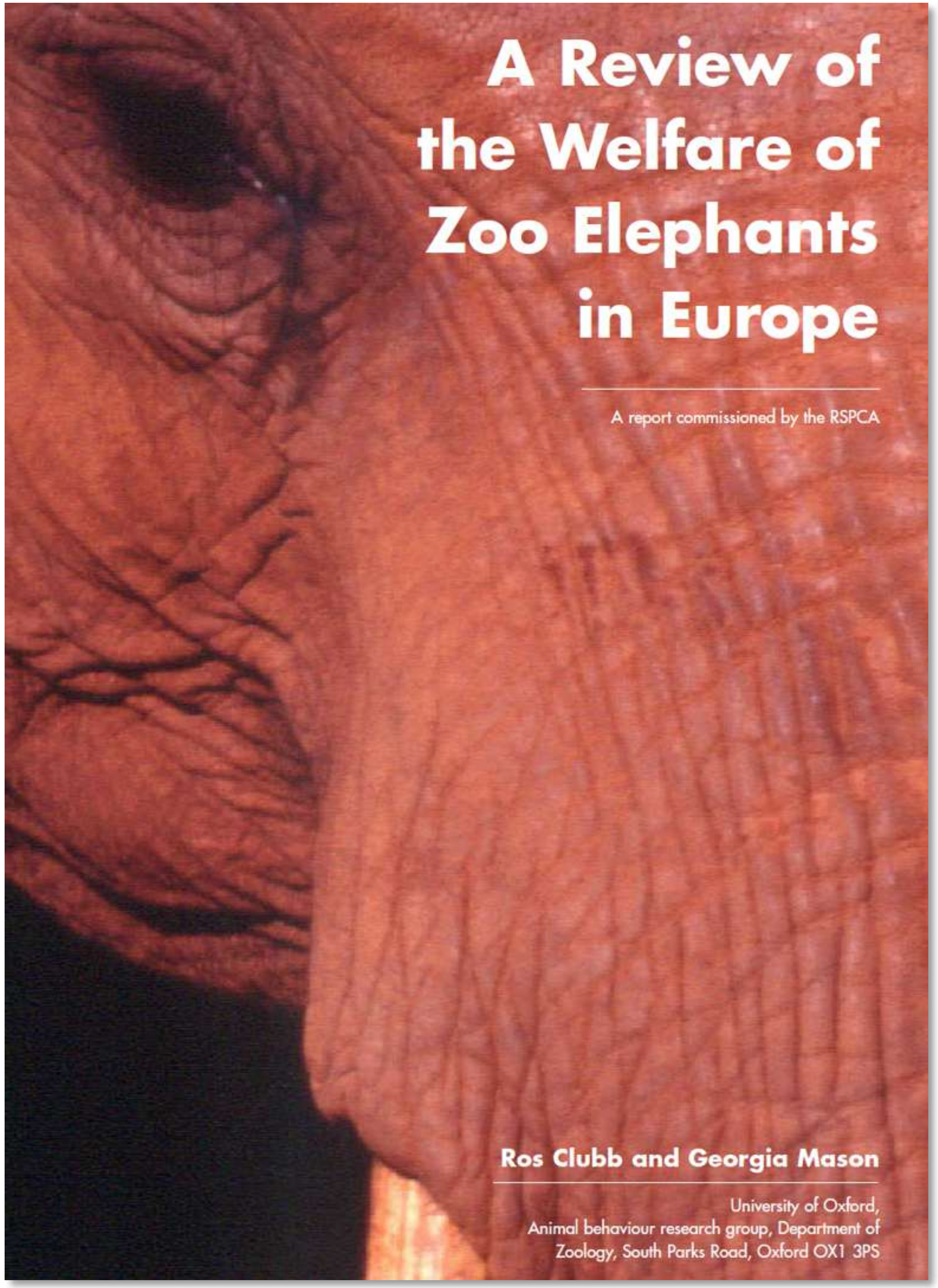
10.1126/science.1164298

[1]Royal Society for the Prevention of Cruelty to Animals (RSPCA), Wilberforce Way, Southwater, West Sussex, RH13 9RS, UK. [2]Institute of Zoology, Zoological Society of London, London NW1 4RY, UK. [3]Psychology Department, University of Stirling, Stirling FK9 4LA, UK. [4]Amboseli Trust for Elephants, Post Office Box 15135, Nairobi, Kenya. [5]Department of Animal and Plant Sciences, University of Sheffield, Western Bank, Sheffield S10 2TN, UK. [6]Animal Sciences Department, University of Guelph, Guelph N1G 2M7, Canada.
*To whom correspondence should be addressed. E-mail: gmason@uoguelph.ca




BREVIA

Compromised Survivorship in Zoo Elephants

Zoo Biology 29 : 237–255 (2010)

How Should the Psychological Well-Being of Zoo Elephants be Objectively Investigated?

Georgia J. Mason[1]* and Jake S. Veasey[2]

[1]Canada Research Chair in Animal Welfare, Animal Science Department, University of Guelph, Guelph, Ontario, Canada
[2]Department of Animal Management and Conservation, Woburn Safari Park, Woburn, Bedfordshire, United Kingdom

Animal welfare (sometimes termed "well-being") is about feelings – states such as "suffering" or "contentment" that we can infer but cannot measure directly. Welfare indices have been developed from two main sources: studies of suffering humans, and of research animals deliberately subjected to challenges known to affect emotional state. We briefly review the resulting indices here, and discuss how well they are understood for elephants, since objective welfare assessment should play a central role in evidence-based elephant management. We cover behavioral and cognitive responses (approach/avoidance; intention, redirected and displacement activities; vigilance/startle; warning signals; cognitive biases, apathy and depression-like changes; stereotypic behavior); physiological responses (sympathetic responses; corticosteroid output – often assayed non-invasively via urine, feces or even hair; other aspects of HPA function, e.g. adrenal hypertrophy); and the potential negative effects of prolonged stress on reproduction (e.g. reduced gametogenesis; low libido; elevated still-birth rates; poor maternal care) and health (e.g. poor wound-healing; enhanced disease rates; shortened lifespans). The best validated, most used welfare indices for elephants are corticosteroid outputs and stereotypic behavior. Indices suggested as valid, partially validated, and/or validated but not yet applied within zoos include: measures of preference/avoidance; displacement movements; vocal/postural signals of affective (emotional) state; startle/vigilance; apathy; salivary and urinary epinephrine; female acyclity; infant mortality rates; skin/foot infections;

Grant sponsor: NSERC.
*Correspondence to: Georgia J. Mason, Canada Research Chair in Animal Welfare, Animal Science Department, University of Guelph, Guelph, Ontario, Canada N1G 2W1. E-mail: gmason@uoguelph.ca

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Routledge
Taylor & Francis Group

An Epidemiological Approach to Welfare Research in Zoos: The Elephant Welfare Project

Kathy Carlstead,[1] Joy A. Mench,[2] Cheryl Meehan,[3] and Janine L. Brown[4]

[1]*Honolulu Zoo Society, Honolulu, Hawaii*
[2]*Center for Animal Welfare, University of California, Davis*
[3]*Vistalogic Inc., Portland, Oregon*
[4]*Center for Species Survival, Smithsonian Conservation Biology Institute, National Zoological Park, Front Royal, Virginia*

Multi-institutional studies of welfare have proven to be valuable in zoos but are hampered by limited sample sizes and difficulty in evaluating more than just a few welfare indicators. To more clearly understand how interactions of husbandry factors influence the interrelationships among welfare outcomes, epidemiological approaches are needed as well as multifactorial assessments of welfare. Many questions have been raised about the housing and care of elephants in zoos and whether their environmental and social needs are being met in a manner that promotes good welfare. This article describes the background and rationale for a large-scale study of elephant welfare in North American zoos funded by the (U.S.) Institute of Museum and Library Services. The goals of this project are to document the prevalence of positive and negative welfare states in 291 elephants exhibited in 72 Association of Zoos and Aquariums zoos and then determine the environmental, management, and husbandry factors that impact elephant welfare. This research is the largest scale nonhuman animal welfare project ever undertaken by the zoo community, and the scope of environmental variables and welfare outcomes measured is unprecedented.

Keywords: *elephant, welfare, husbandry, management, epidemiology*

Correspondence should be sent to Kathy Carlstead, Honolulu Zoo Society, 151 Kapahulu Ave., Honolulu, HI 96815. Email: KCarlstead@honzoosoc.org

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OVERVIEW

Determining Connections between the Daily Lives of Zoo Elephants and Their Welfare: An Epidemiological Approach

Abstract

Introduction

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RESEARCH ARTICLE

Elephant Management in North American Zoos: Environmental Enrichment, Feeding, Exercise, and Training

Abstract

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RESEARCH ARTICLE

Assessment of Body Condition in African (*Loxodonta africana*) and Asian (*Elephas maximus*) Elephants in North American Zoos and Management Practices Associated with High Body Condition Scores

Abstract

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RESEARCH ARTICLE

Reproductive Health Assessment of Female Elephants in North American Zoos and Association of Husbandry Practices with Reproductive Dysfunction in African Elephants (*Loxodonta africana*)

Abstract

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RESEARCH ARTICLE

Housing and Demographic Risk Factors Impacting Foot and Musculoskeletal Health in African Elephants [*Loxodonta africana*] and Asian Elephants [*Elephas maximus*] in North American Zoos

Abstract

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RESEARCH ARTICLE

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Abstract


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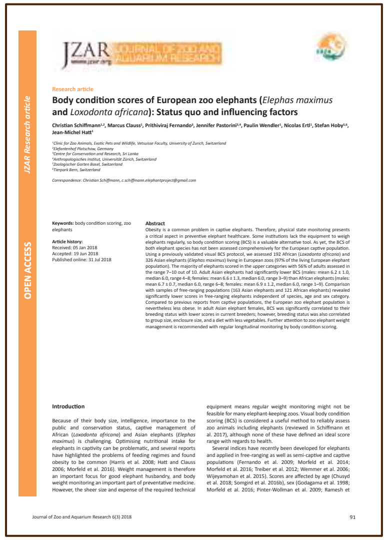
Compromised Survivorship in Zoo Elephants


JZAR JOURNAL OF ZOO AND AQUARIUM RESEARCH
Review article
Visual body condition scoring in zoo animals – composite, algorithm and overview approaches in captive Asian and African elephants
Christian Schiffmann, Marcus Clauss, Stefan Hoby and Jean-Michel Hatt
OPEN ACCESS
JZAR Review article
Introduction
Journal of Zoo and Aquarium Research 5(1) 2017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Research article
Body condition scores of European zoo elephants (Elephas maximus and Loxodonta africana): Status quo and influencing factors
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JZAR Research article
Introduction
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JZAR JOURNAL OF ZOO AND AQUARIUM RESEARCH
Evidence-based practice
Impact of a new exhibit on stereotypic behaviour in an elderly captive African elephant (Loxodonta africana).
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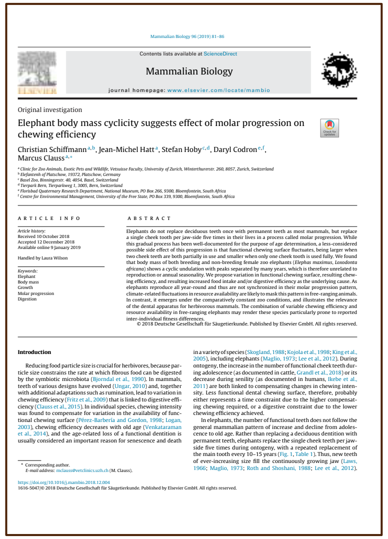
RESEARCH REVIEW WITH CASE STUDIES
WILEY ZOOBIOLOGY
When elephants fall asleep: A literature review on elephant rest with case studies on elephant falling bouts, and practical solutions for zoo elephants
Christian Schiffmann | Stefan Hoby | Christian Wenker | Therese Hård | Robert Scholz | Marcus Clauss | Jean-Michel Hatt
1 | INTRODUCTION
Zoo Biology. 2018;37:133–145.


Mammalian Biology
Original investigation
Elephant body mass cyclicity suggests effect of molar progression on chewing efficiency
Christian Schiffmann, Jean-Michel Hatt, Stefan Hoby, Daryl Codron, Marcus Clauss
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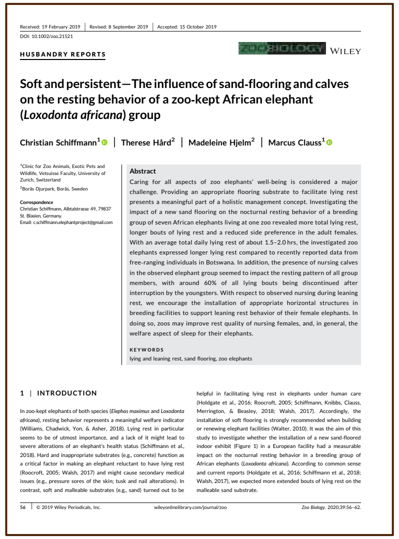
RESEARCH ARTICLE
ZOOBIOLOGY WILEY
Weigh and see—Body mass recordings versus body condition scoring in European zoo elephants (Loxodonta africana and Elephas maximus)
Christian Schiffmann | Marcus Clauss | Stefan Hoby | Jean-Michel Hatt
Abstract
1 | INTRODUCTION
Zoo Biology. 2020;39:97–108.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ZOOBIOLOGY WILEY
Soft and persistent—The influence of sand-flooring and calves on the resting behavior of a zoo-kept African elephant (Loxodonta africana) group
Christian Schiffmann | Therese Hård | Madeleine Hjelm | Marcus Clauss
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1 | INTRODUCTION
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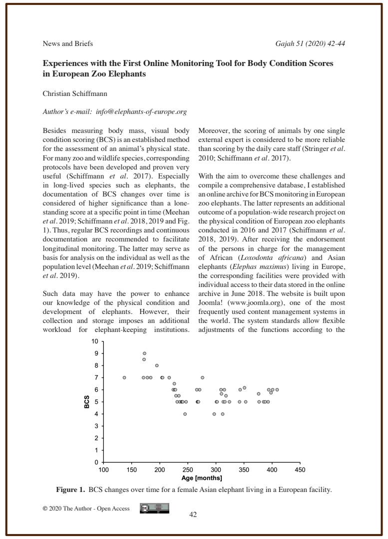
News and Briefs
Gajah 51 (2020) 42-44
Experiences with the First Online Monitoring Tool for Body Condition Scores in European Zoo Elephants
Christian Schiffmann
Figure 1. BCS changes over time for a female Asian elephant living in a European facility.
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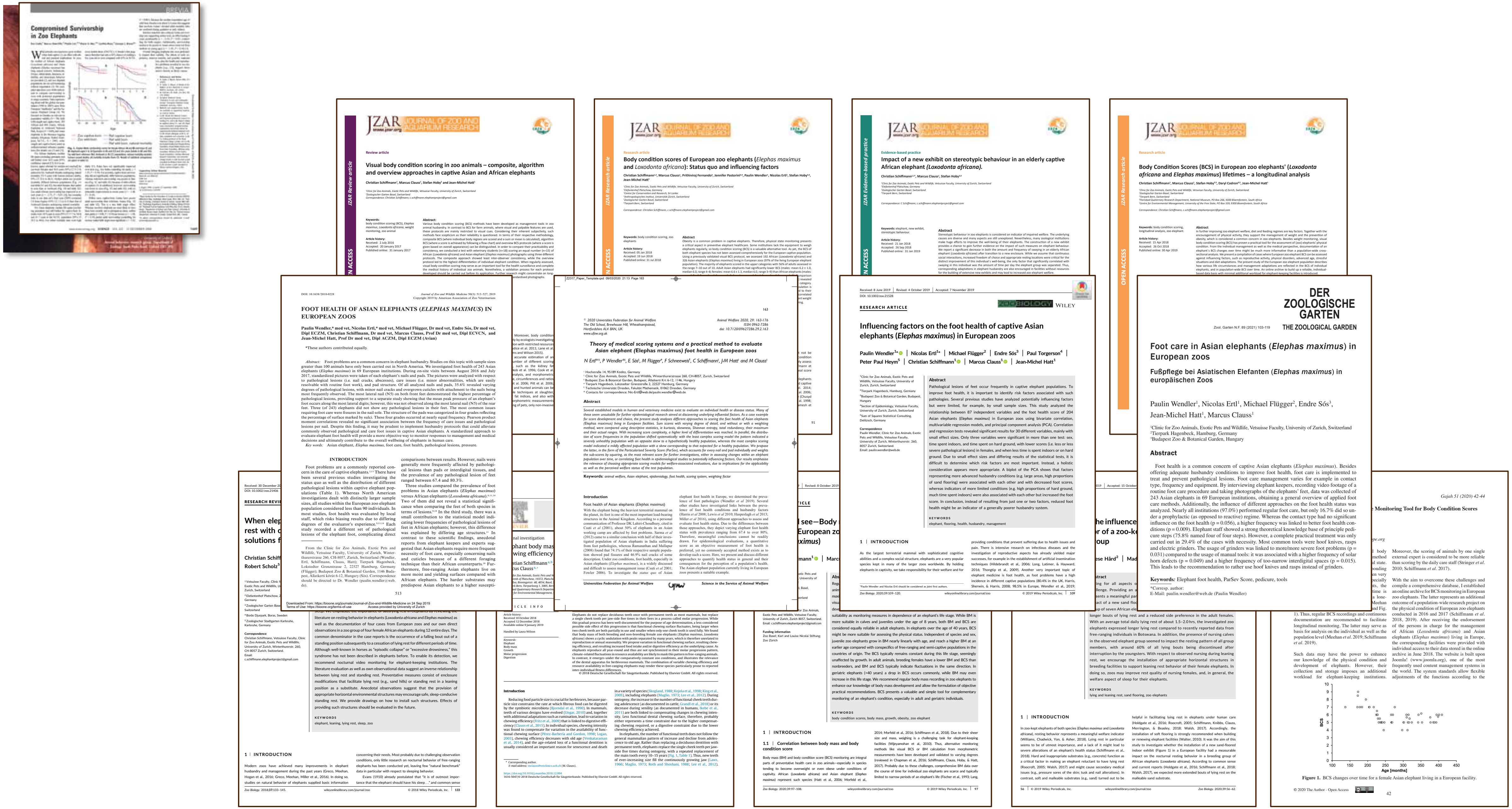
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FOOT HEALTH OF ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*) IN EUROPEAN ZOOS

Paulin Wendler, Nicolas Ertl, Michael Flügger, Endre Sós, Christian Schiffmann, Marcus Clauss, Jean-Michel Hatt

Theory of medical scoring systems and a practical method to evaluate Asian elephant (Elephas maximus) foot health in European zoos

N Ertl, P Wendler, E Sós, M Flügger, F Schneeweis, C Schiffmann, J-M Hatt and M Clauss

RESEARCH ARTICLE

Influencing factors on the foot health of captive Asian elephants (*Elephas maximus*) in European zoos

Paulin Wendler, Nicolas Ertl, Michael Flügger, Endre Sós, Paul Torgerson, Peter Paul Heyms, Christian Schiffmann, Marcus Clauss, Jean-Michel Hatt

DER ZOOLOGISCHE GARTEN

THE ZOOLOGICAL GARDEN

Zool. Garten N.F. 89 (2021) 103-119

Foot care in Asian elephants (*Elephas maximus*) in European zoos

Fußpflege bei Asiatischen Elefanten (*Elephas maximus*) in europäischen Zoos

Paulin Wendler, Nicolas Ertl, Michael Flügger, Endre Sós, Jean-Michel Hatt, Marcus Clauss

Abstract

Foot health is a common concern of captive Asian elephants (*Elephas maximus*). Besides offering adequate husbandry conditions to improve foot health, foot care is implemented to treat and prevent foot problems. Foot care management varies for example in control type, frequency and equipment. By interviewing elephant keepers, recording video footage of a routine foot care procedure and taking photographs of the elephants' feet, data was collected of 243 Asian elephants in 69 European institutions, obtaining a general overview of applied foot care methods. Additionally, the influence of different approaches on the foot health status was analyzed. Nearly all institutions (97.0%) performed regular foot care, but only 16.7% did so under a prophylactic (as opposed to reactive) regime. Whereas the contact type had no significant influence on the foot health (p = 0.056), a higher frequency was linked to better foot health conditions (p = 0.009). Elephant staff showed a strong theoretical knowledge base of pedicure steps (75.8% named four of four steps). However, a complete practical treatment was only carried out in 29.4% of the cases with necessity. Most common tools were hoof knives, rasps and electric grinders. The usage of grinders was linked to more/more severe foot problems (p = 0.031) compared to the usage of manual tools: a higher frequency of too-narrow interdigital spaces (p = 0.015). This leads to the recommendation to rather use hoof knives and rasps instead of grinders.

Keywords: Elephant foot health, ParSev Score, pedicure, tools

When elephants rest with ... solutions

Elephant body mass ... chewing efficiency

Gajah 51 (2020) 42-44

Monitoring Tool for Body Condition Scores

Figure 1. BCS changes over time for a female Asian elephant living in a European facility.


BREVIA

Compromised Survivorship in Zoo Elephants

Zoo captive-born
Zoo wild-born
Park captive-born
Park wild-born
Park wild-born, natural mortality

SCIENCE

Compromised Survivorship in Zoo Elephants

Ros Clubb,[1] Marcus Rowcliffe,[2] Phyllis Lee,[3,4] Khyne U. Mar,[2,5] Cynthia Moss,[4] Georgia J. Mason[6]*

Wild animals can experience poor welfare when held captive (*1*), an effect with ethical and practical implications. In zoos, the welfare of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) has long caused concern. Infanticide, *Herpes*, tuberculosis, lameness, infertility, and stereotypic behavior are prevalent (*2*), and zoo elephant populations are not self-sustaining without importation (*3*). We compiled data from over 4500 individuals to compare survivorship in zoos with protected populations in range countries. Data representing about half the global zoo population (1960 to 2005) came from European "studbooks" and the European Elephant Group (*4*). We focused on females as relevant to population viability ($N = 786$, both wild-caught and captive-born; 302 African and 484 Asian). African elephants in Amboseli National Park, Kenya ($N = 1089$), and Asian elephants in the Burmese logging industry (Myanma Timber Enterprise, M.T.E., $N = 2905$, wild-caught and captive-born) acted as well-provisioned reference populations [for details, see (*2*) and (*5*)].

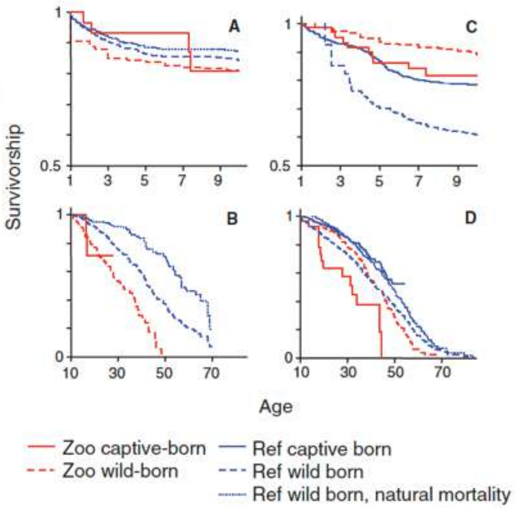

Fig. 1. Kaplan-Meier survivorship curves for female African (**A** and **B**) and Asian (**C** and **D**) elephants aged 1 to 10 [juveniles in (A) and (C)] and 10+ years [adults in (B) and (D)]. For wild-born reference (Ref, Amboseli or M.T.E.) populations, natural mortality excludes human-caused deaths; all mortality includes them (*5*). Results of statistical comparisons are given in table S2.

For African elephants, median life spans (excluding premature and still births) were 16.9 years [95% confidence interval (CI) 16.4 to unknown; upper estimate for median not reached] for zoo-born females and 56.0 years (95% CI 51.5 to unknown) for Amboseli females undergoing natural mortality (35.9 years with human-induced deaths, 95% CI 33.8 to 40.3). Neither infant nor juvenile mortality differed between populations (Fig. 1A and tables S1 and S2), but adult females died earlier in zoos than in Amboseli (Fig. 1B and table S2). Zoo adult African survivorship has improved in recent years [$z = -2.75$, $P < 0.01$ (*5*)], but mortality risks in our data set's final year (2005) remained 2.8 times higher (95% CI 1.2 to 6.5) than that of Amboseli females undergoing natural mortality.

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Within zoos, captive-born Asians have poorer adult survivorship than wild-born Asians (Fig. 1D and table S2). This is a true birth origin effect: Whereas zoo-born elephants are more likely to have been born recently and to primiparous dams, neither dam parity ($z = 0.86$, $P > 0.10$) nor recency ($z = -1.48$, $P > 0.10$) predict adult survivorship (controlling for recency makes birth origin more significant: $z = -3.52$, $P < 0.001$). Because the median importation age of wild-born females was about 3.4 years, this suggests that zoo-born Asians' elevated adult mortality risks are conferred during gestation or early infancy.

Interzoo transfers also reduced Asian survivorship (see supporting online text), an effect lasting 4 years posttransfer ($z = -2.10$, $P < 0.05$, controlling for birth origin). Additionally, survivorship tended to be poorer in Asian calves removed from mothers at young ages ($z = -1.92$, $P < 0.10$) (*5*).

Overall, bringing elephants into zoos profoundly impairs their viability. The effects of early experience, interzoo transfer, and possibly maternal loss, plus the health and reproductive problems recorded in zoo elephants [e.g., (*2*)], suggest stress and/or obesity as likely causes.

References and Notes

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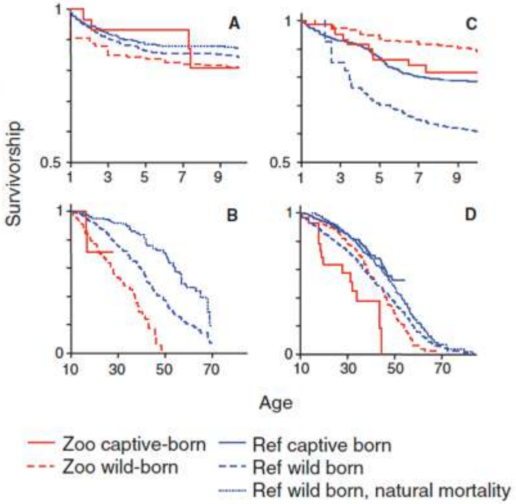

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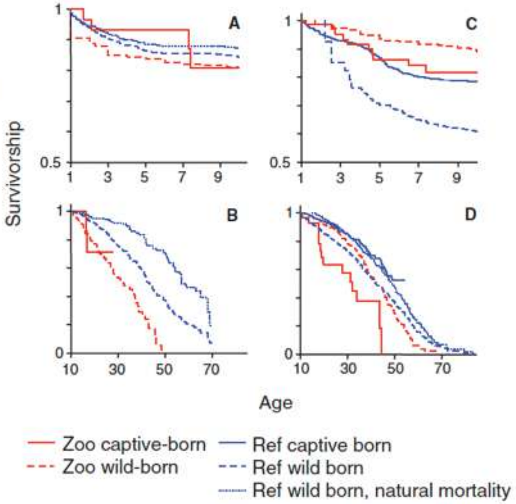

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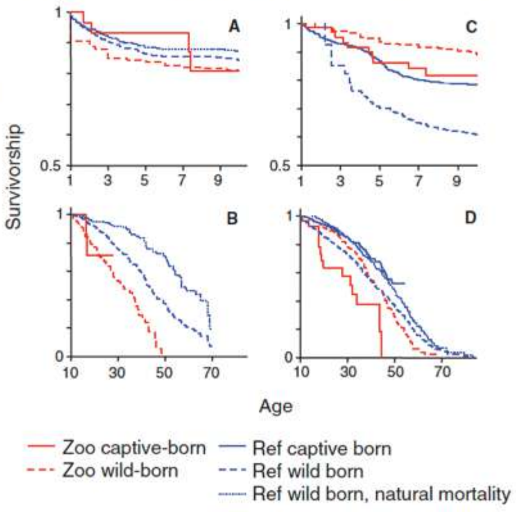

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For Asian elephants, median life spans (excluding premature and still births) for captive-born females were 18.9 years in zoos (95% CI 17.7 to 34.0) and 41.7 years in the M.T.E. population (95% CI 38.2 to 44.6). Zoo infant mortality rates were high (over double those of M.T.E.): A female's first pregnancy therefore had only a 42% chance of yielding a live year-old in zoos compared with 83% in M.T.E. (table S1). Rates have not significantly improved over time (e.g., live births controlling for parity: $z = 1.19$, $P > 0.10$). For juveniles, captive-born survivorship did not significantly differ between populations, whereas wild-born survivorship was poorer in Burma (Fig. 1C and table S2) because of after-effects of capture (*5*). In adulthood, however, survivorship was lower in zoos (Fig. 1D and table S2), with no detectable improvement in recent years ($z = -1.48$, $P > 0.10$).

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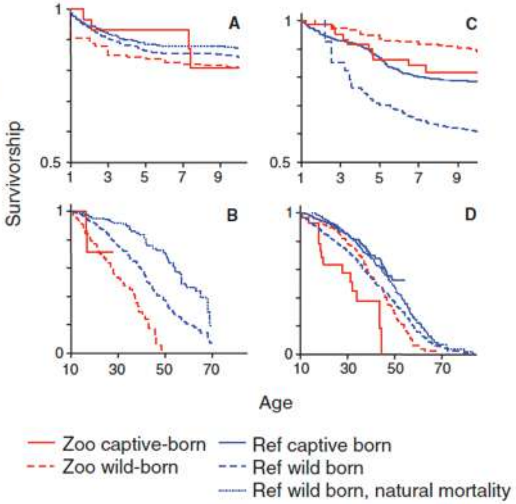

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*To whom correspondence should be addressed. E-mail: gmason@uoguelph.ca

Compromised Survivorship in Zoo Elephants

as Compared to Some Selected *in situ* Populations Declared ‘Benchmarks’

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Wild animals can experience poor welfare when held captive (*1*), an effect with ethical and practical implications. In zoos, the welfare of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) has long caused concern. Infanticide, *Herpes*, tuberculosis, lameness, infertility, and stereotypic behavior are prevalent (*2*), and zoo elephant populations are not self-sustaining without importation (*3*). We compiled data from over 4500 individuals to compare survivorship in zoos with protected populations in range countries. Data representing about half the global zoo population (1960 to 2005) came from European “studbooks” and the European Elephant Group (*4*). We focused on females as relevant to population viability ($N = 786$, both wild-caught and captive-born; 302 African and 484 Asian). African elephants in Amboseli National Park, Kenya ($N = 1089$), and Asian elephants in the Burmese logging industry (Myanma Timber Enterprise, M.T.E., $N = 2905$, wild-caught and captive-born) acted as well-provisioned reference populations [for details, see (*2*) and (*5*)].

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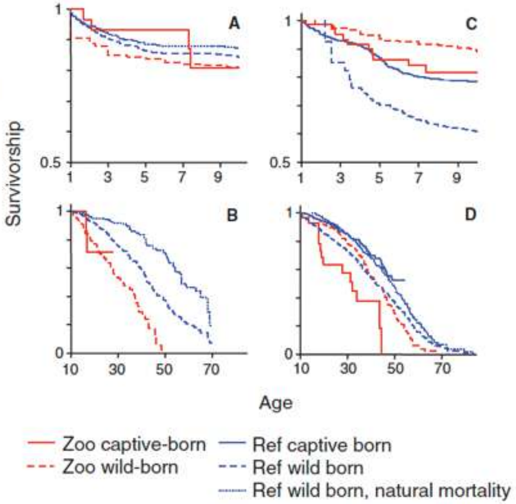

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Data from 1960-2008

1. Average lifespan is lower in zoos than *in situ*
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3. Although there was some improvement in survivorship in African elephants since 1960, there was no such improvement in Asian elephants

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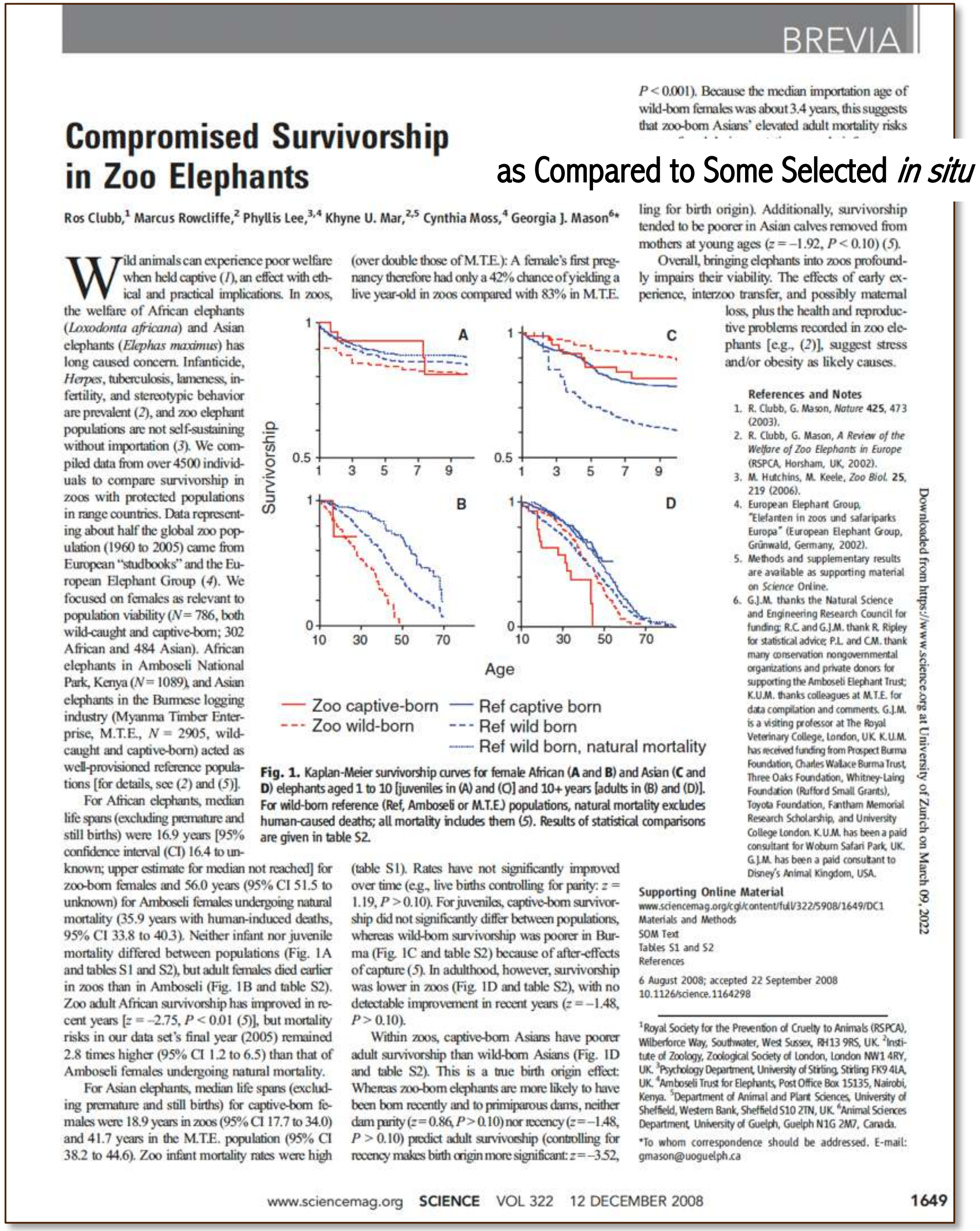

BREVIA

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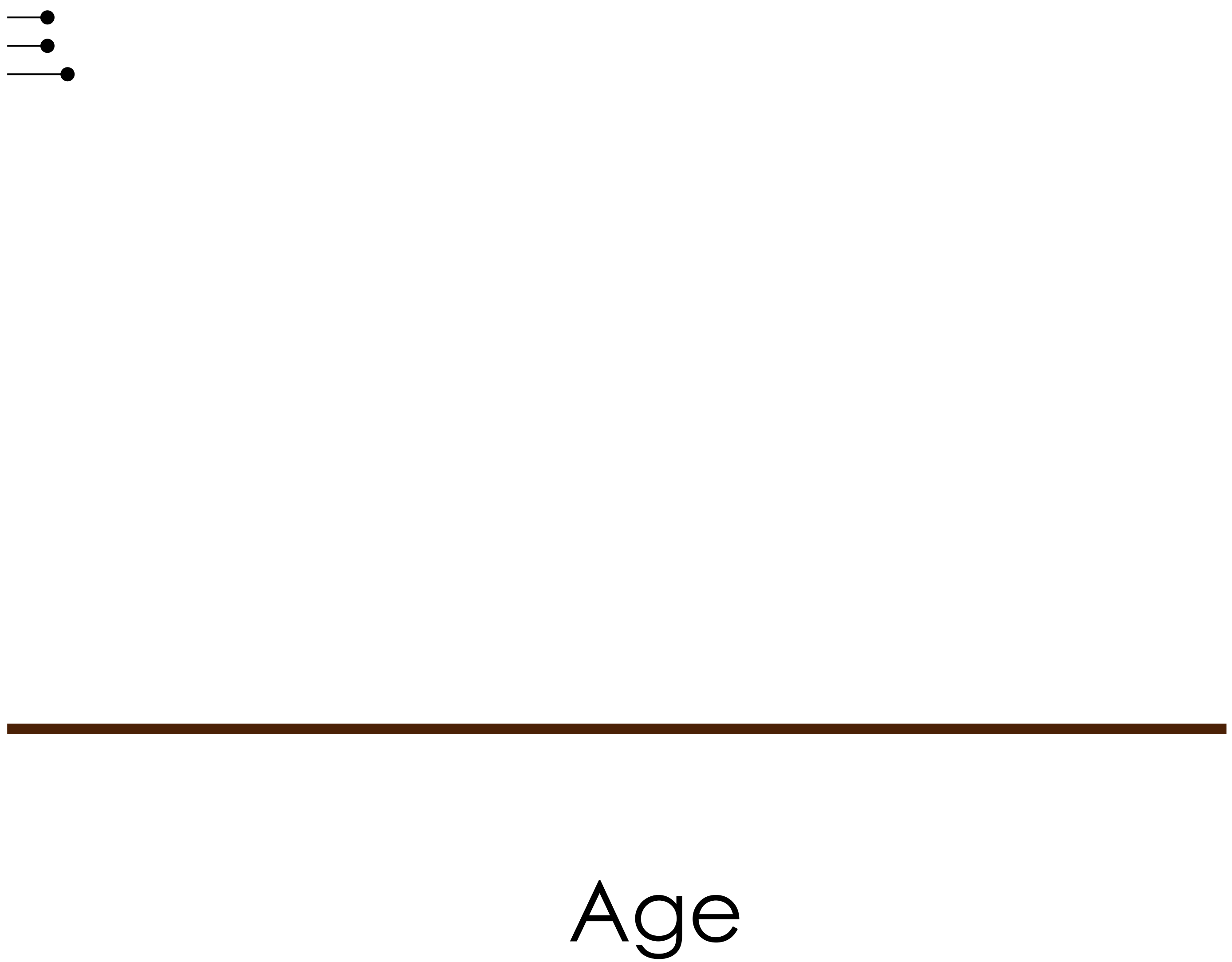

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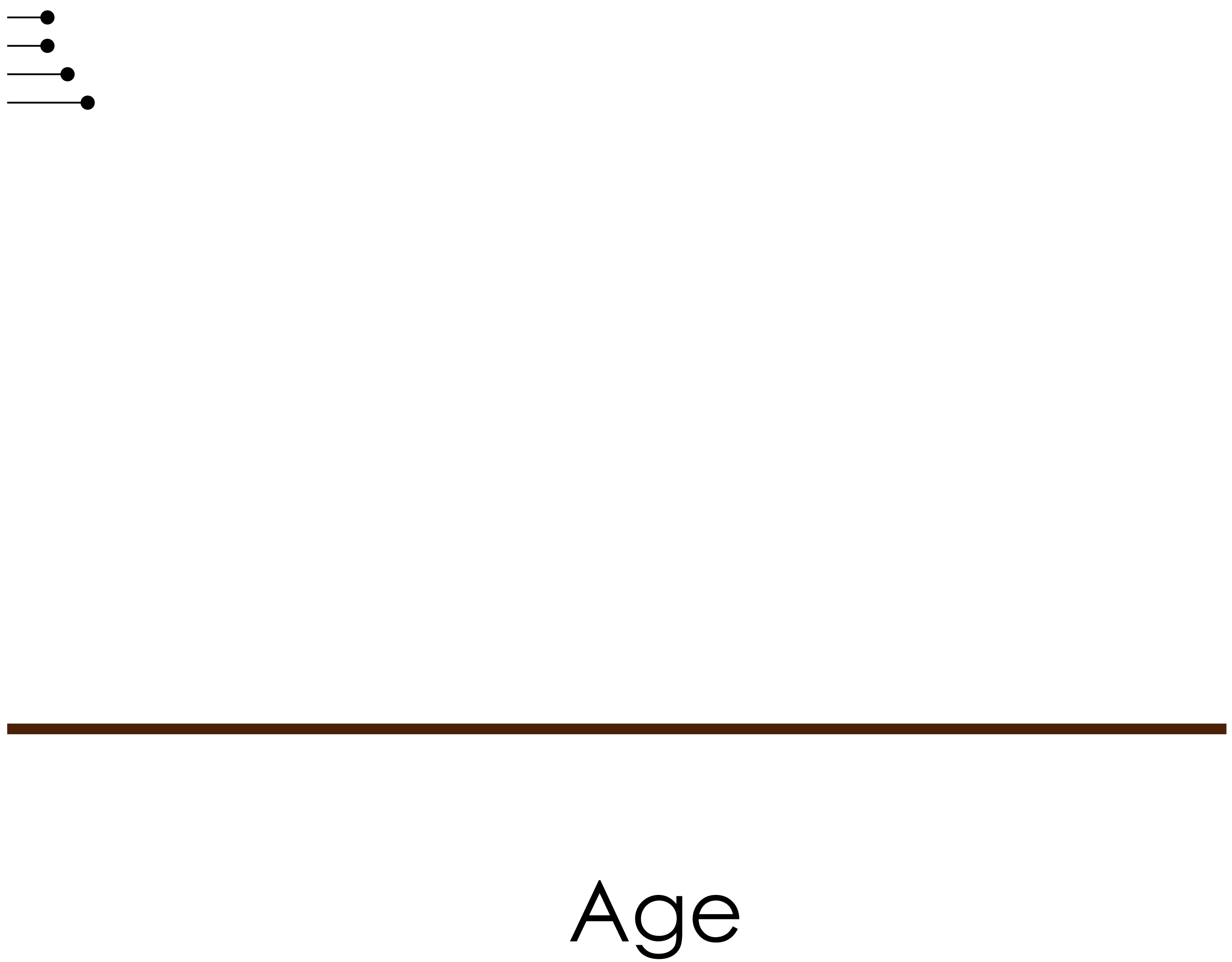

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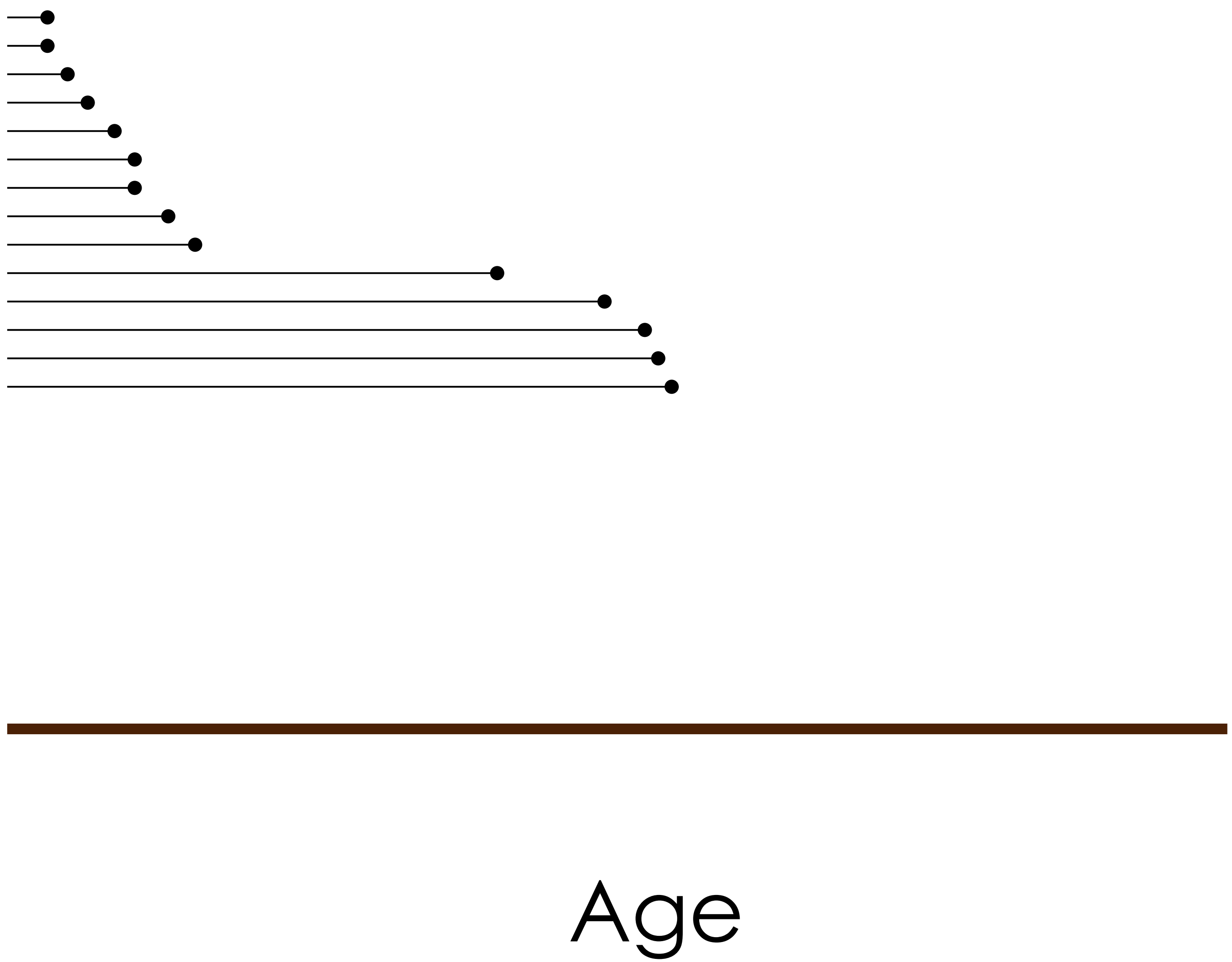

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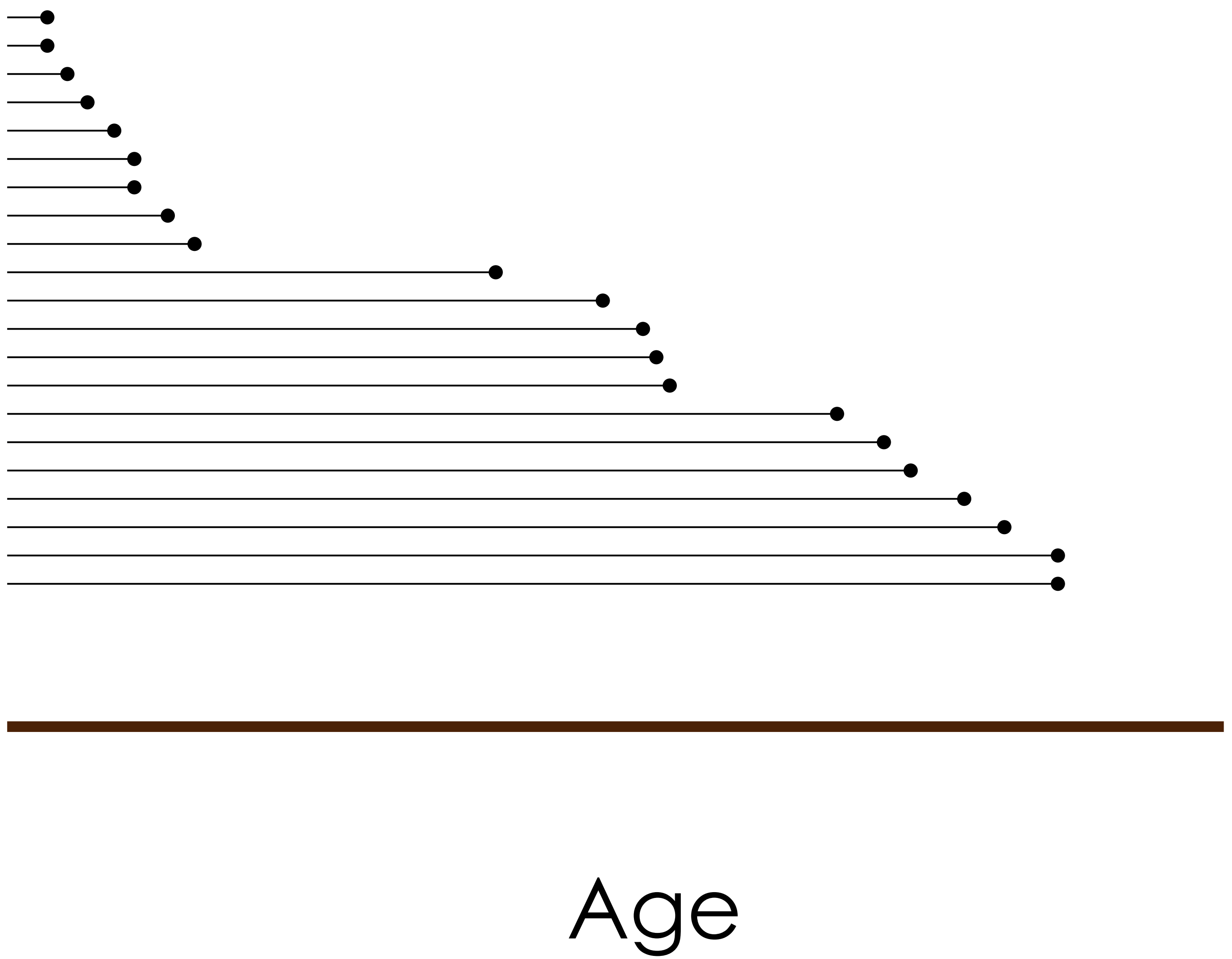

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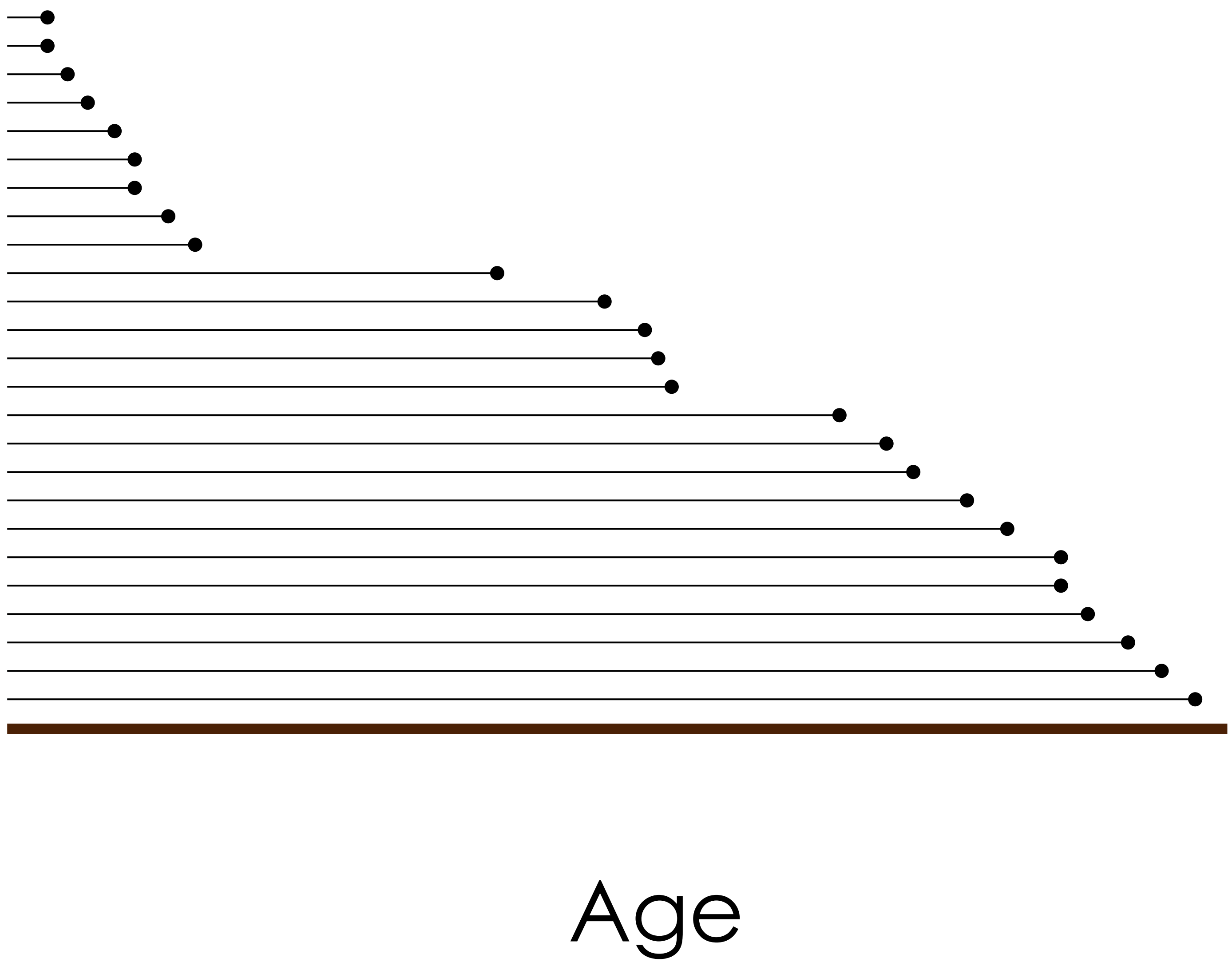

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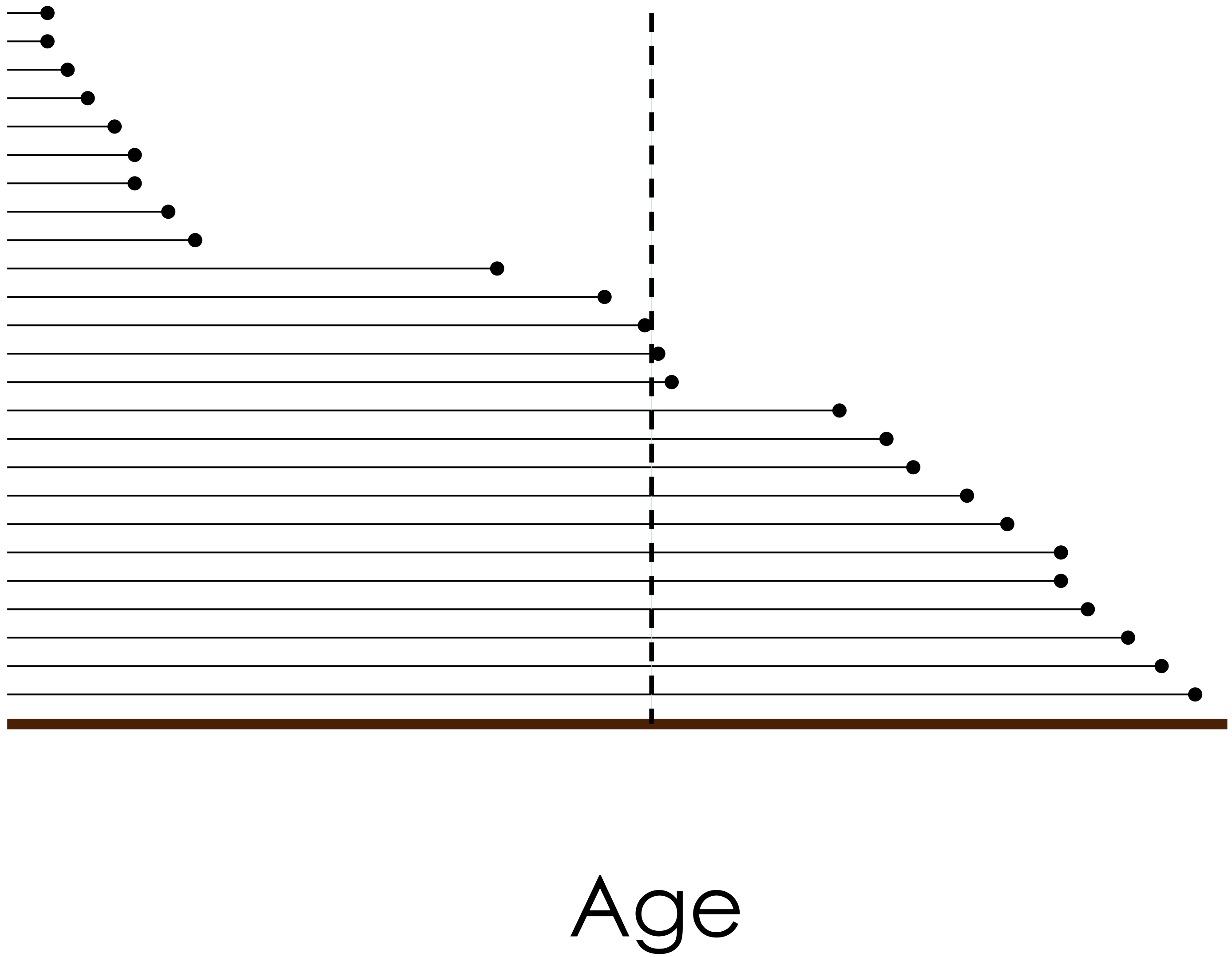

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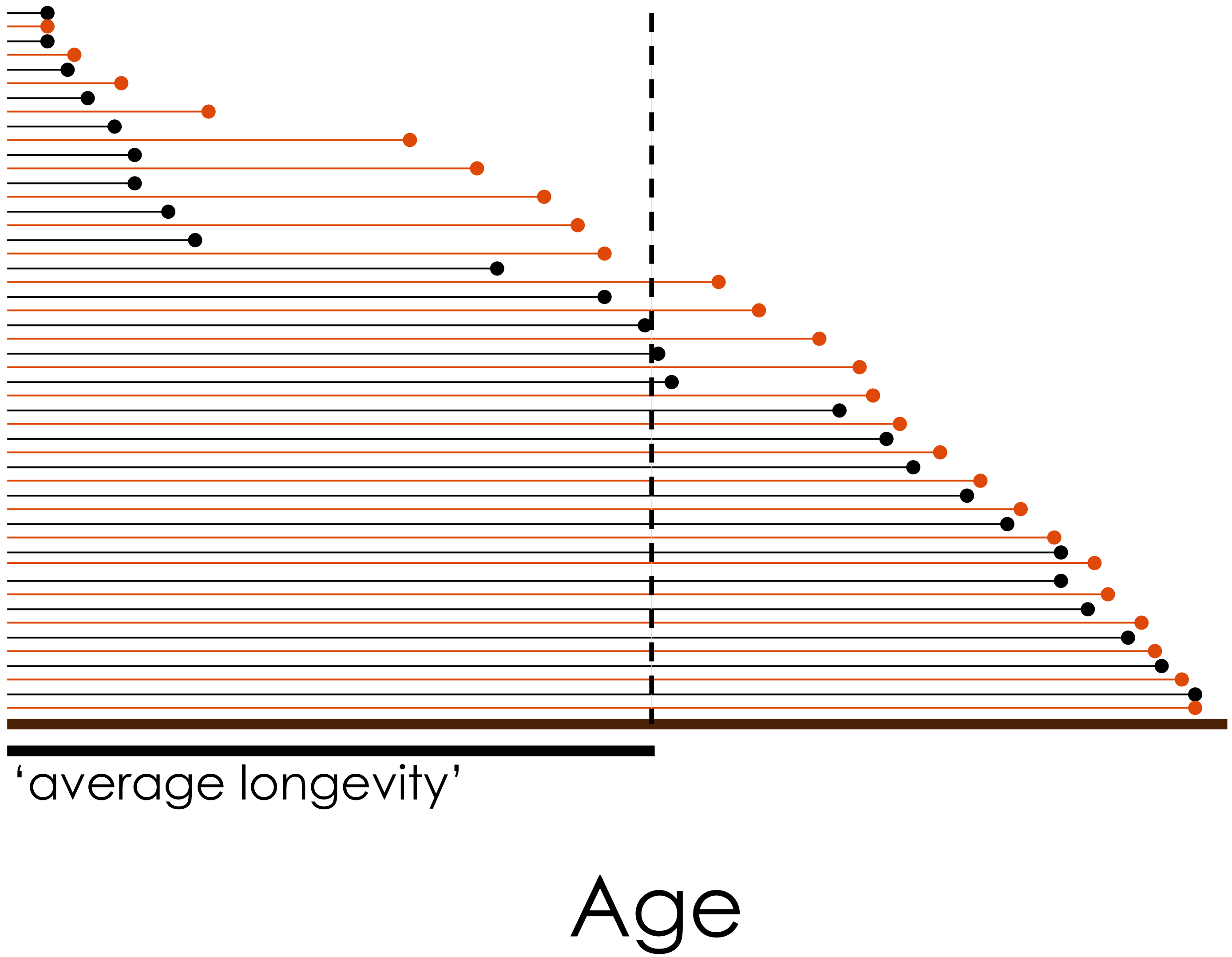

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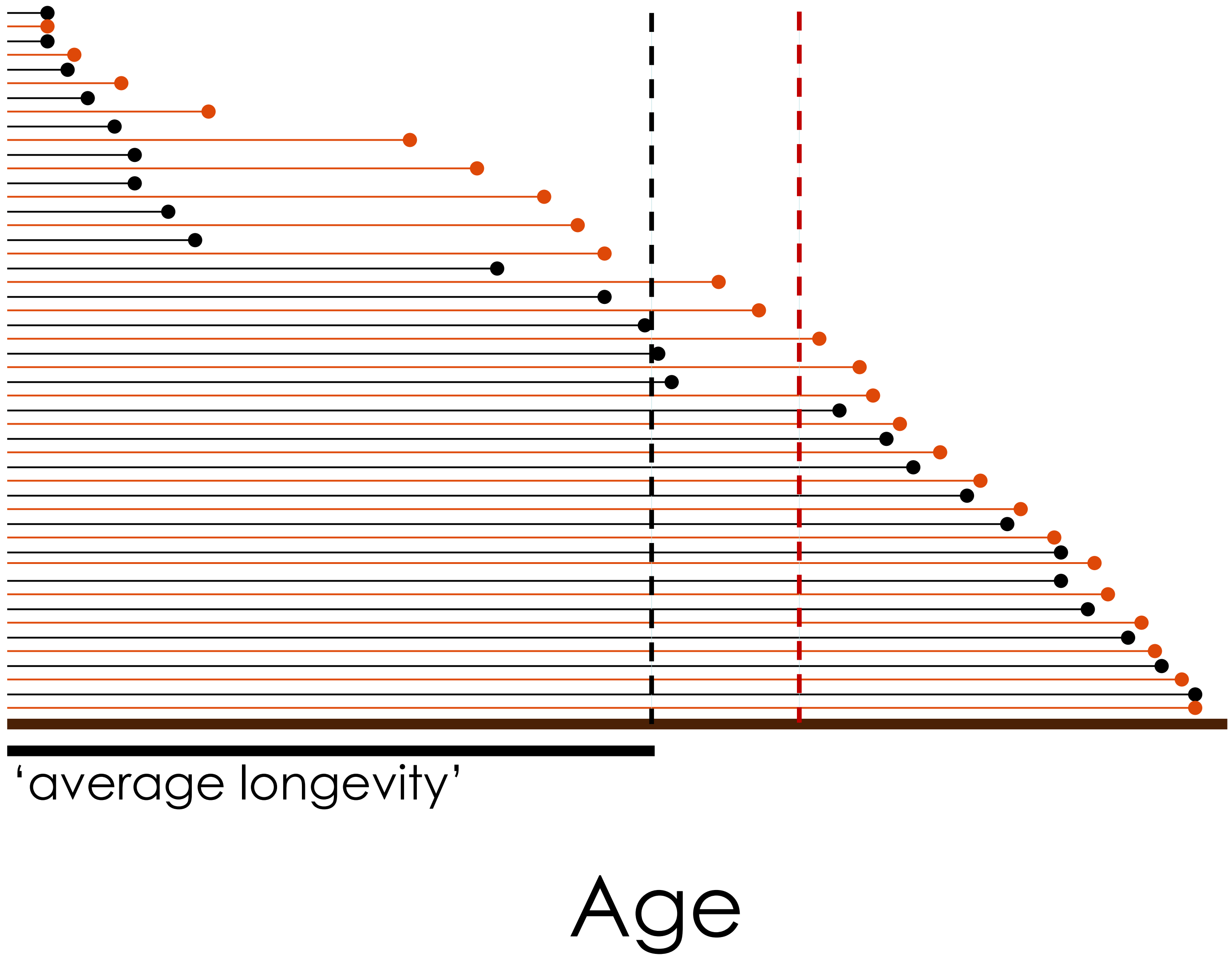

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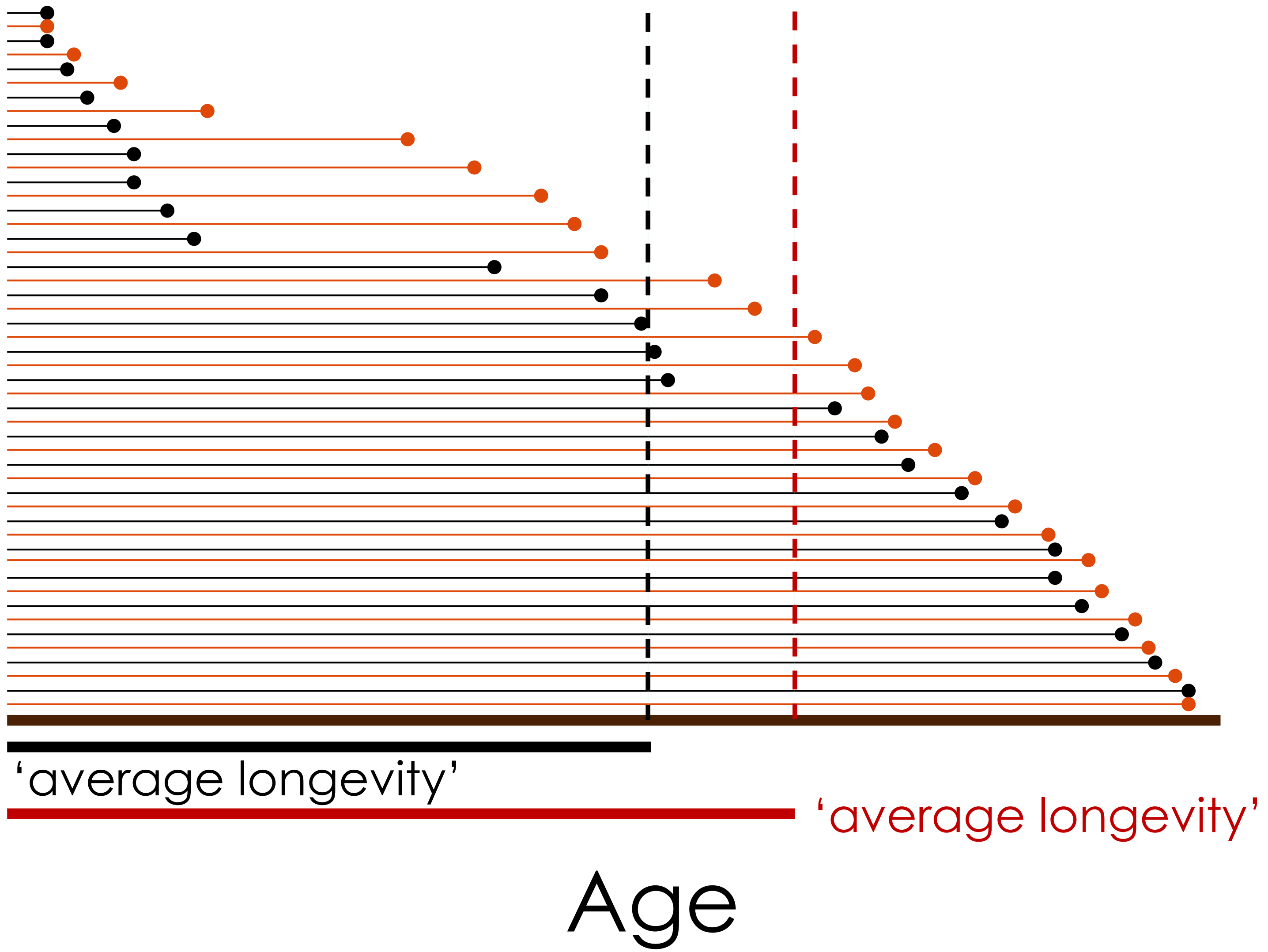

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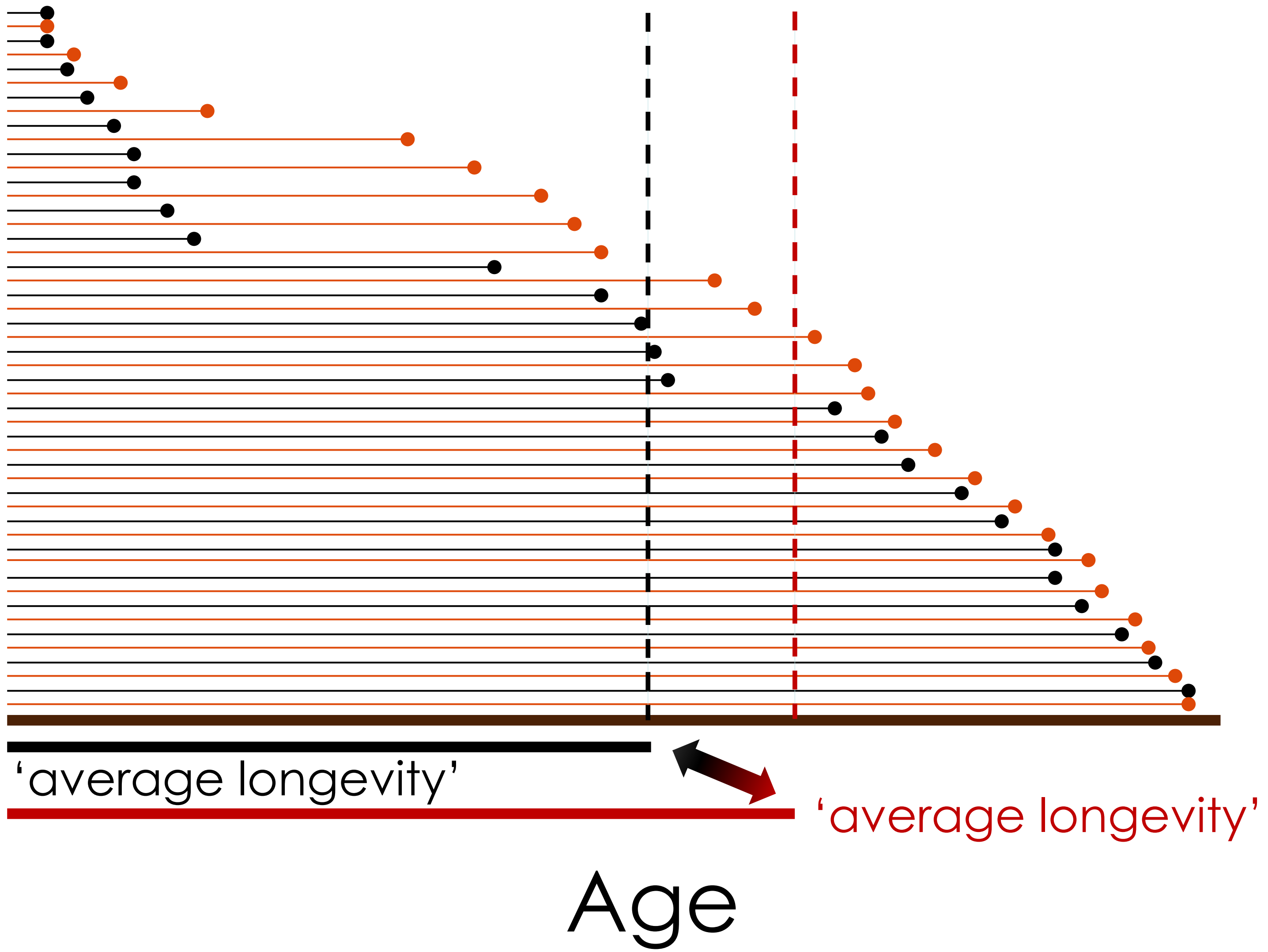

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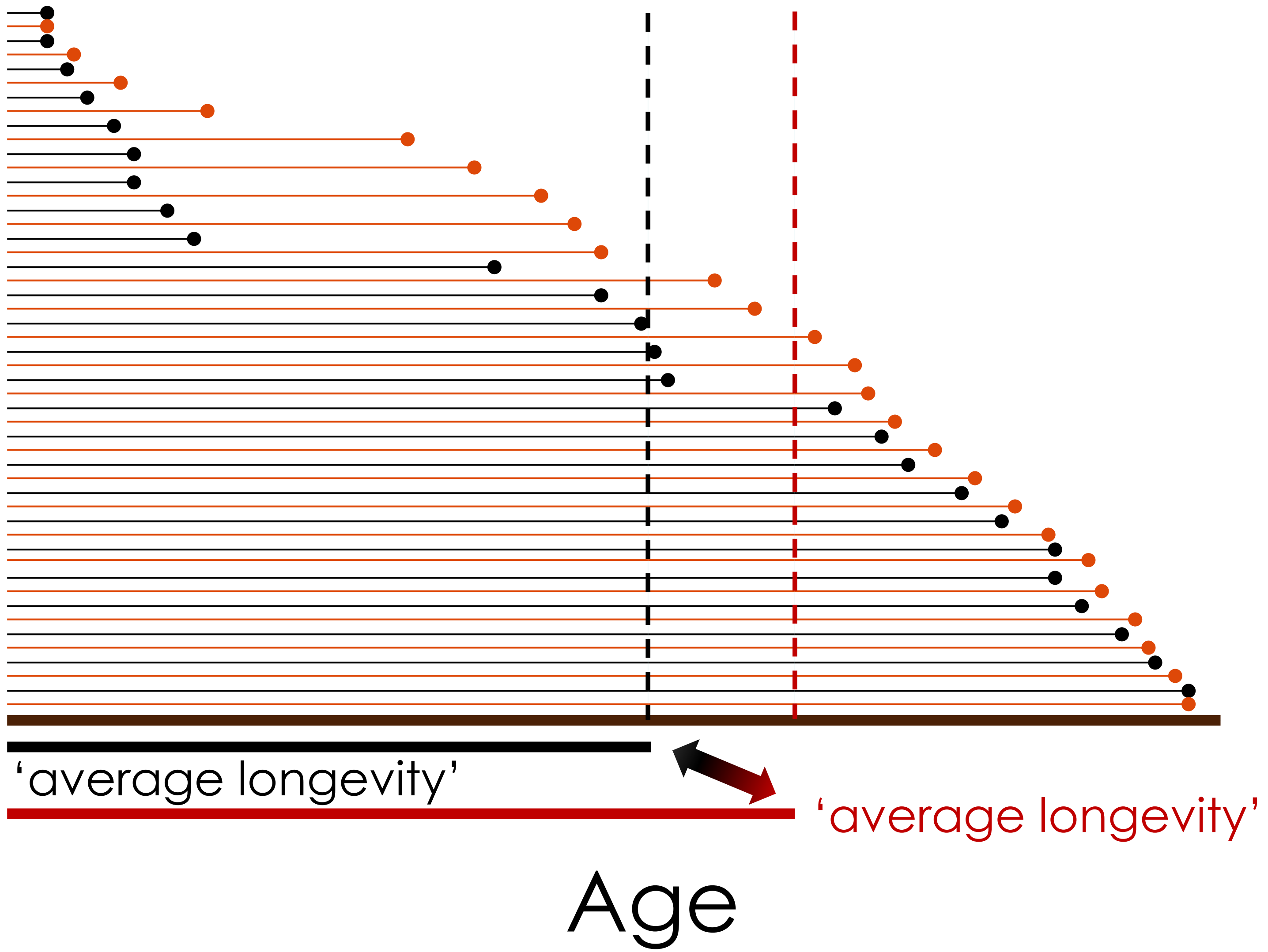

'complete cohorts' (all animals died)

impractical in long-lived species if more recent developments should be investigated

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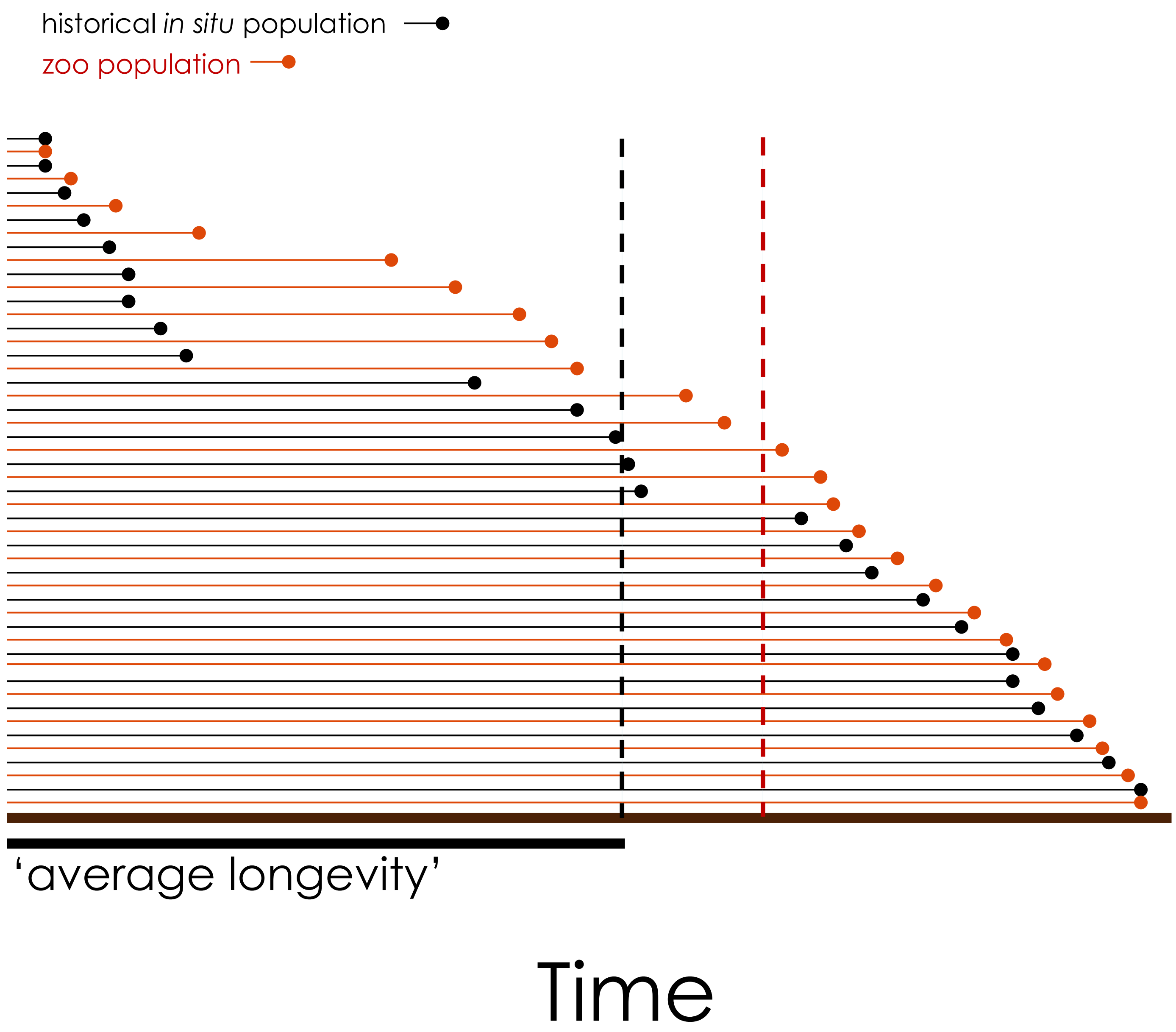

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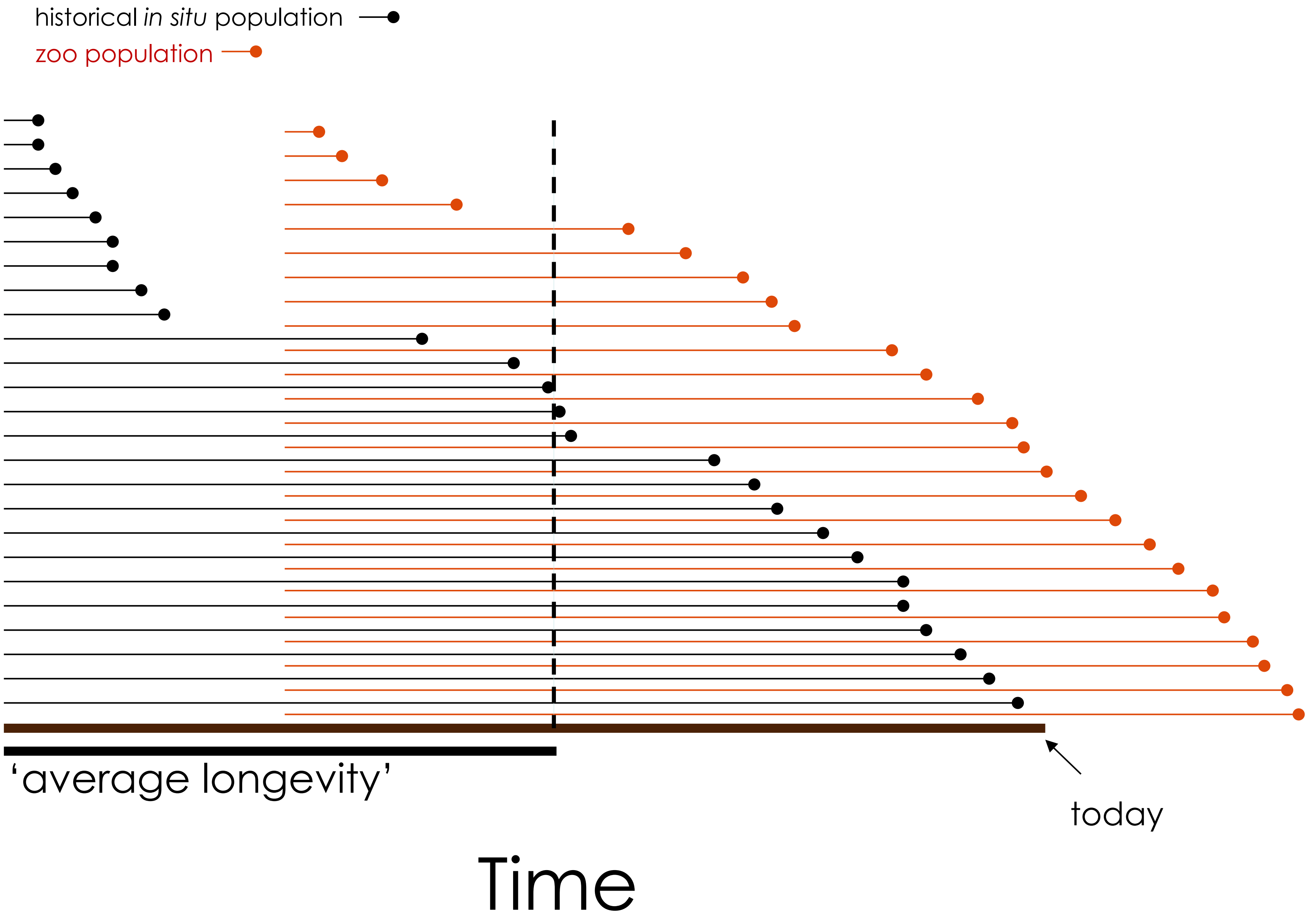

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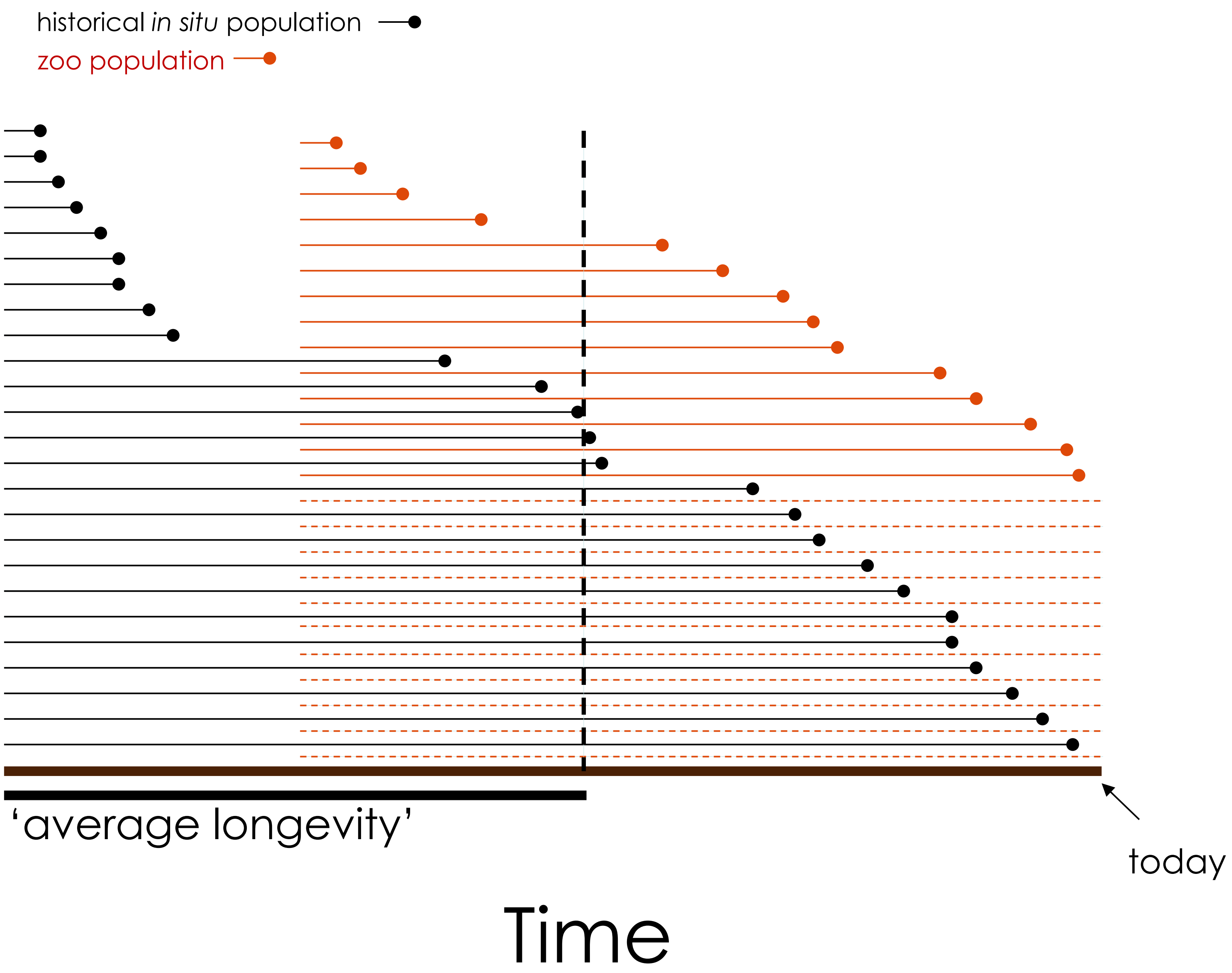

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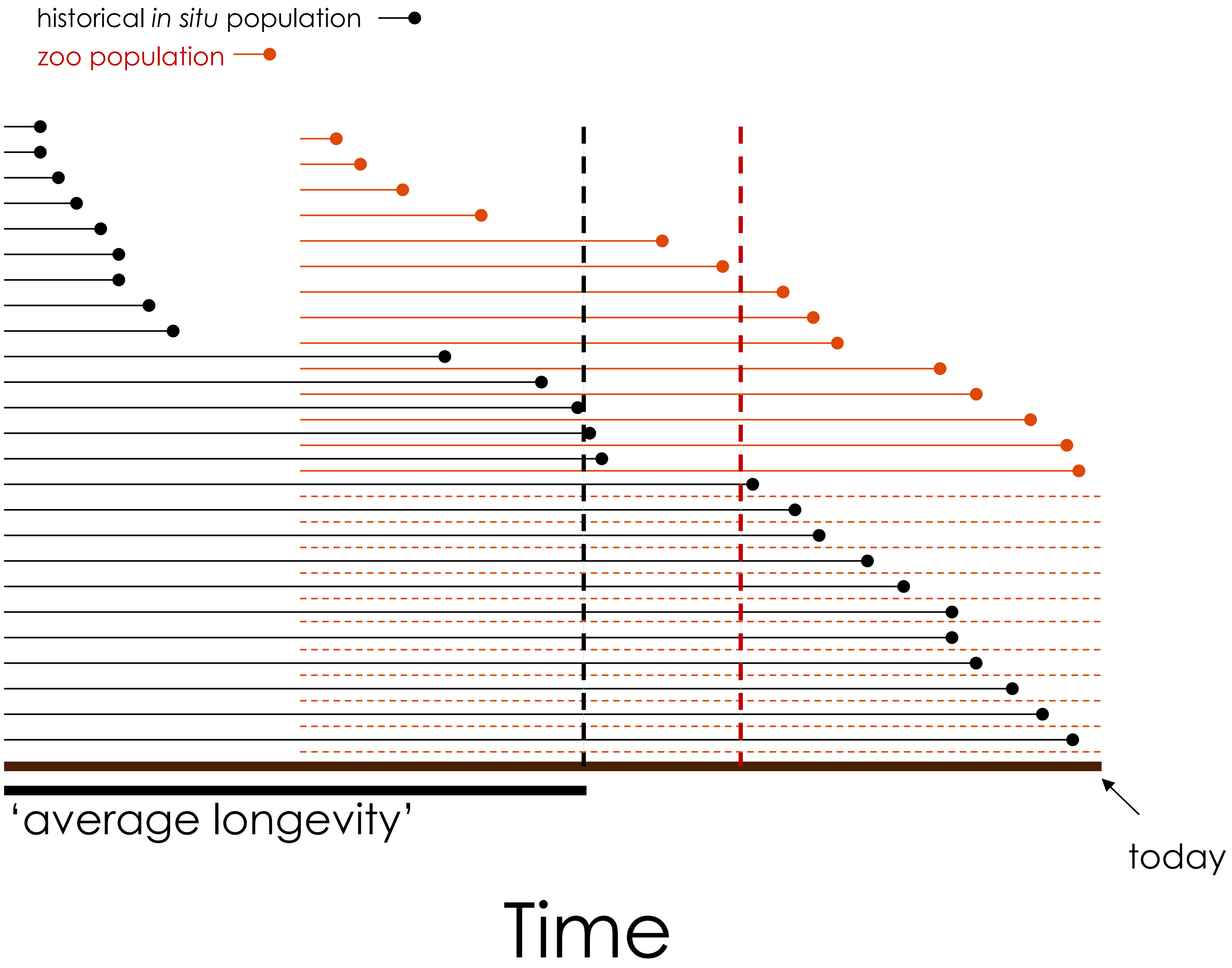

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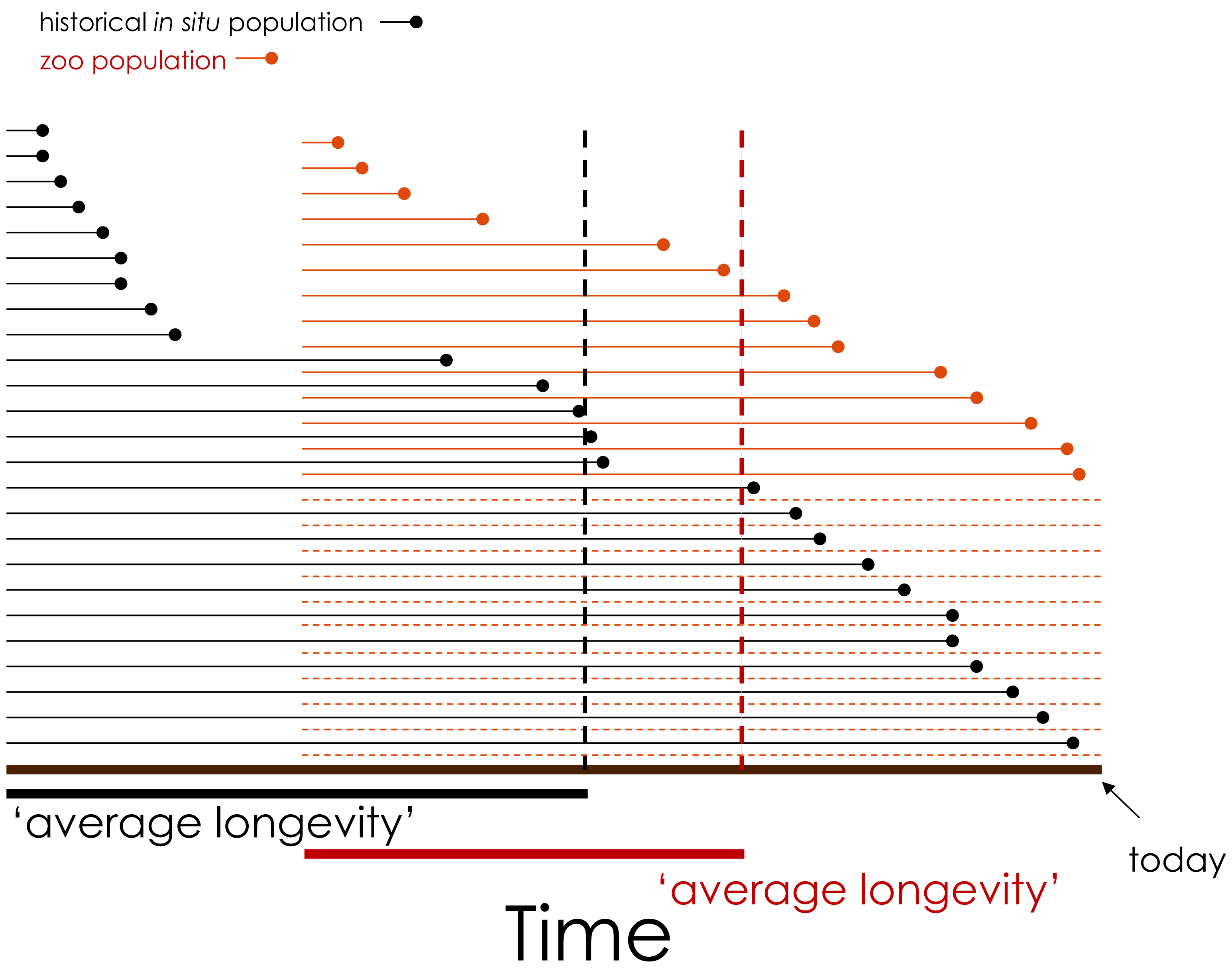

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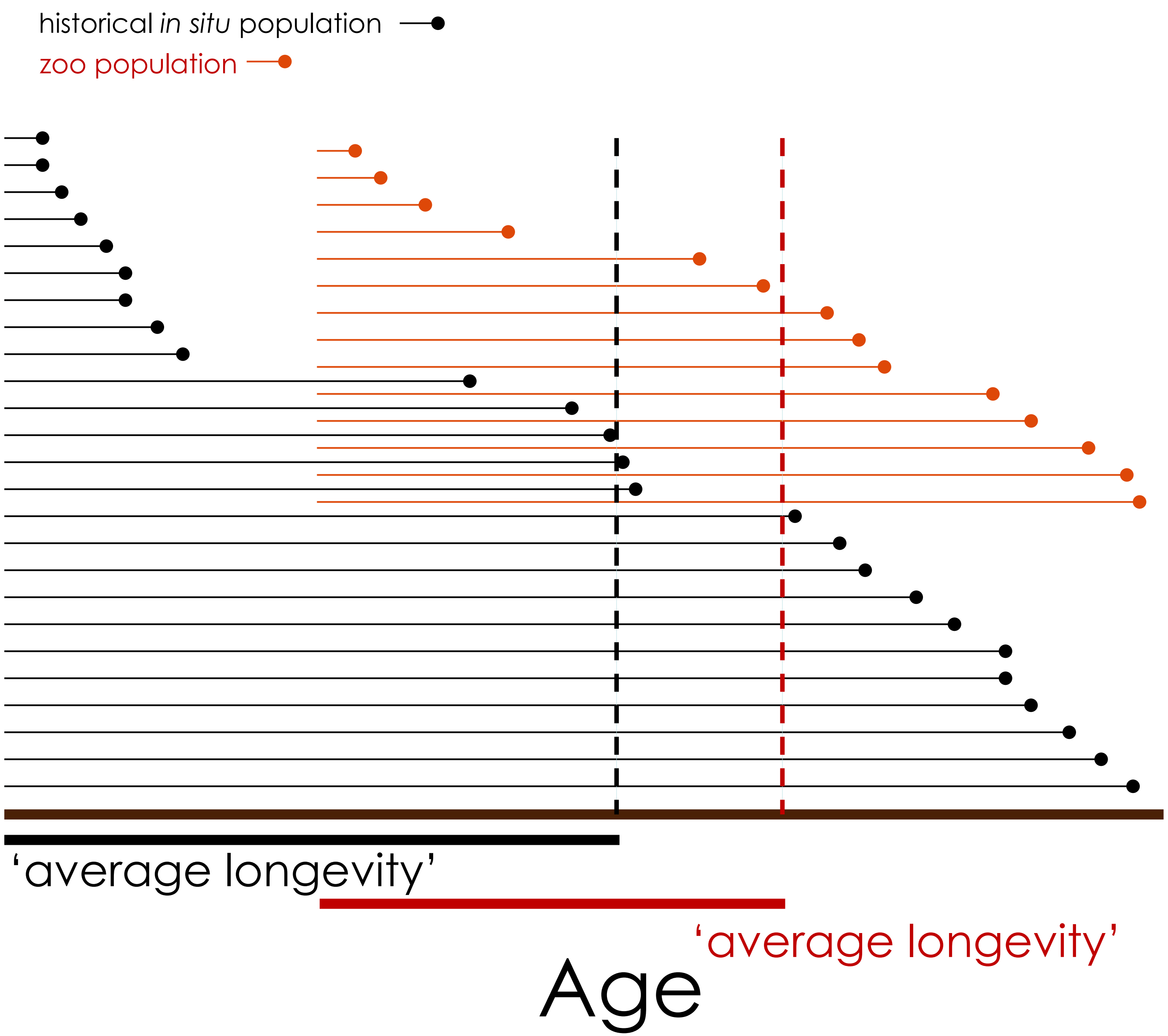

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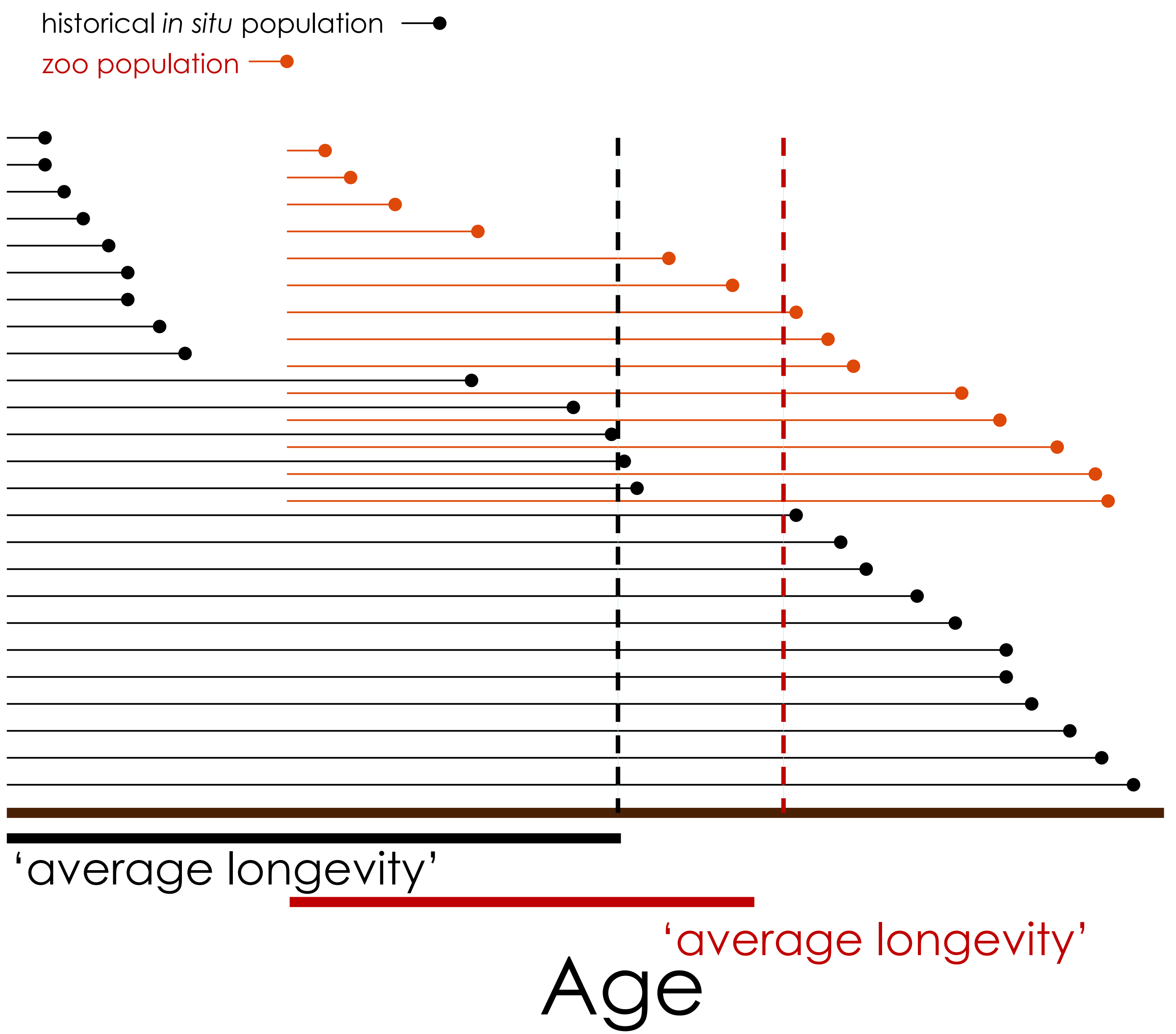

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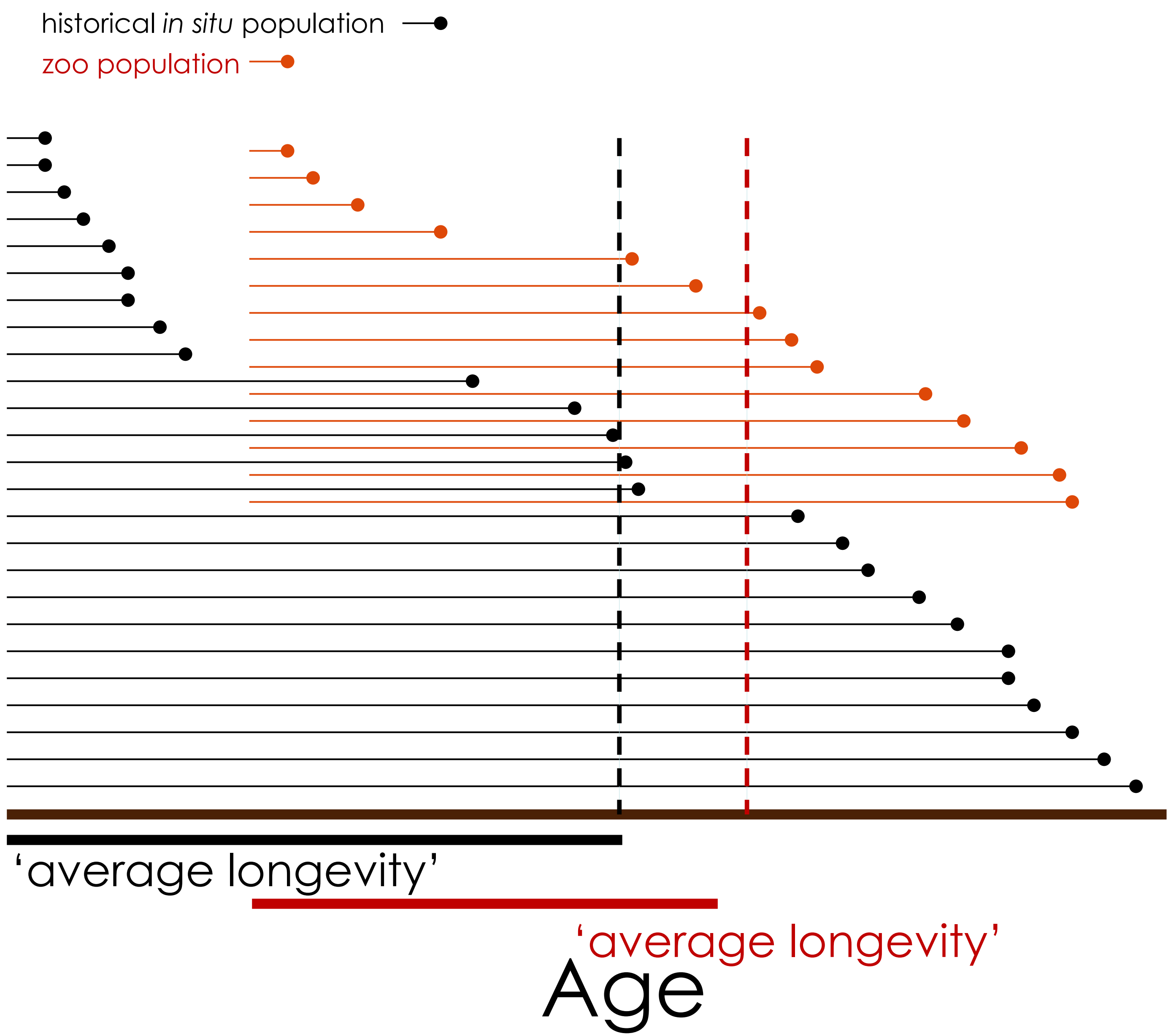

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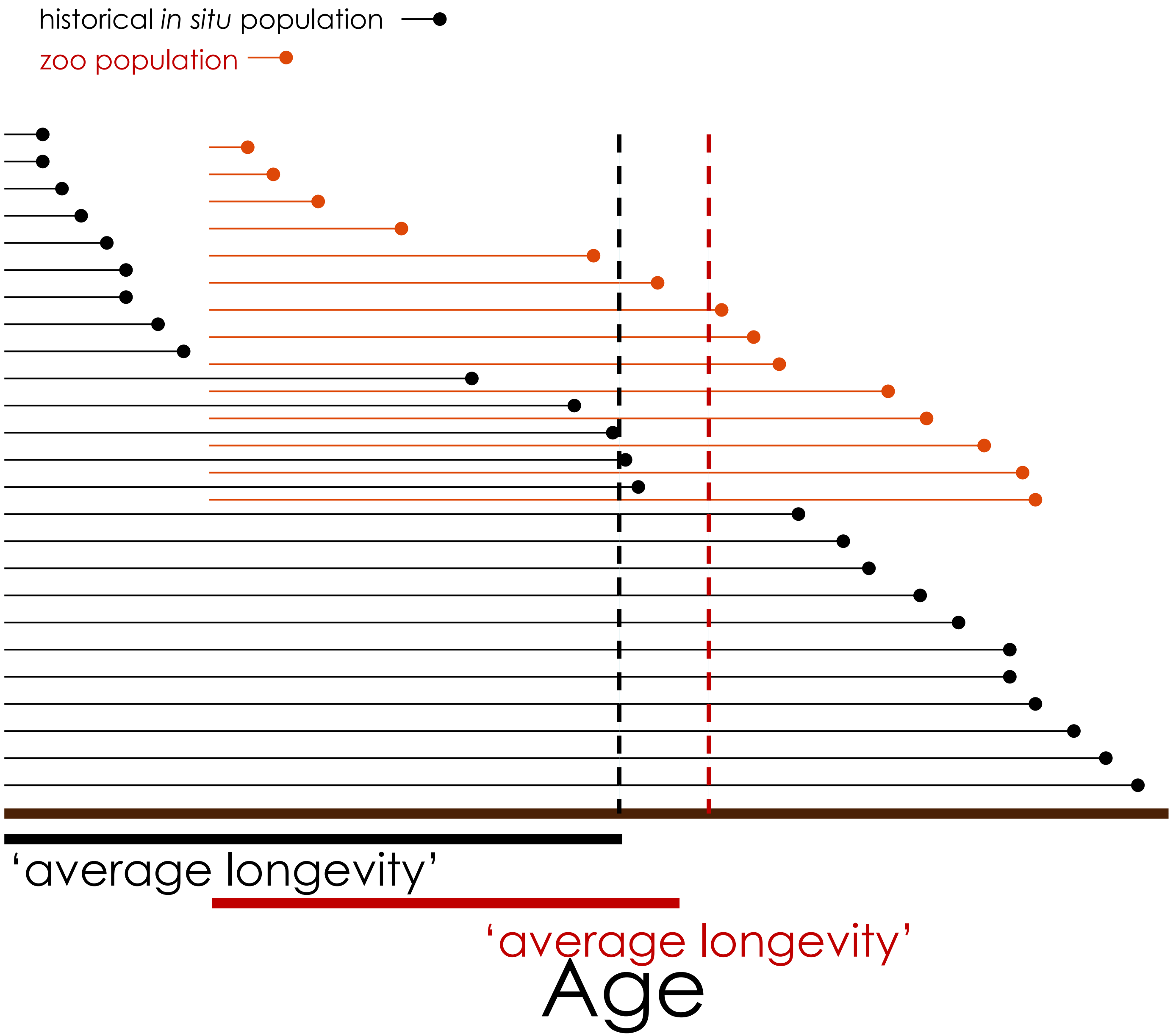

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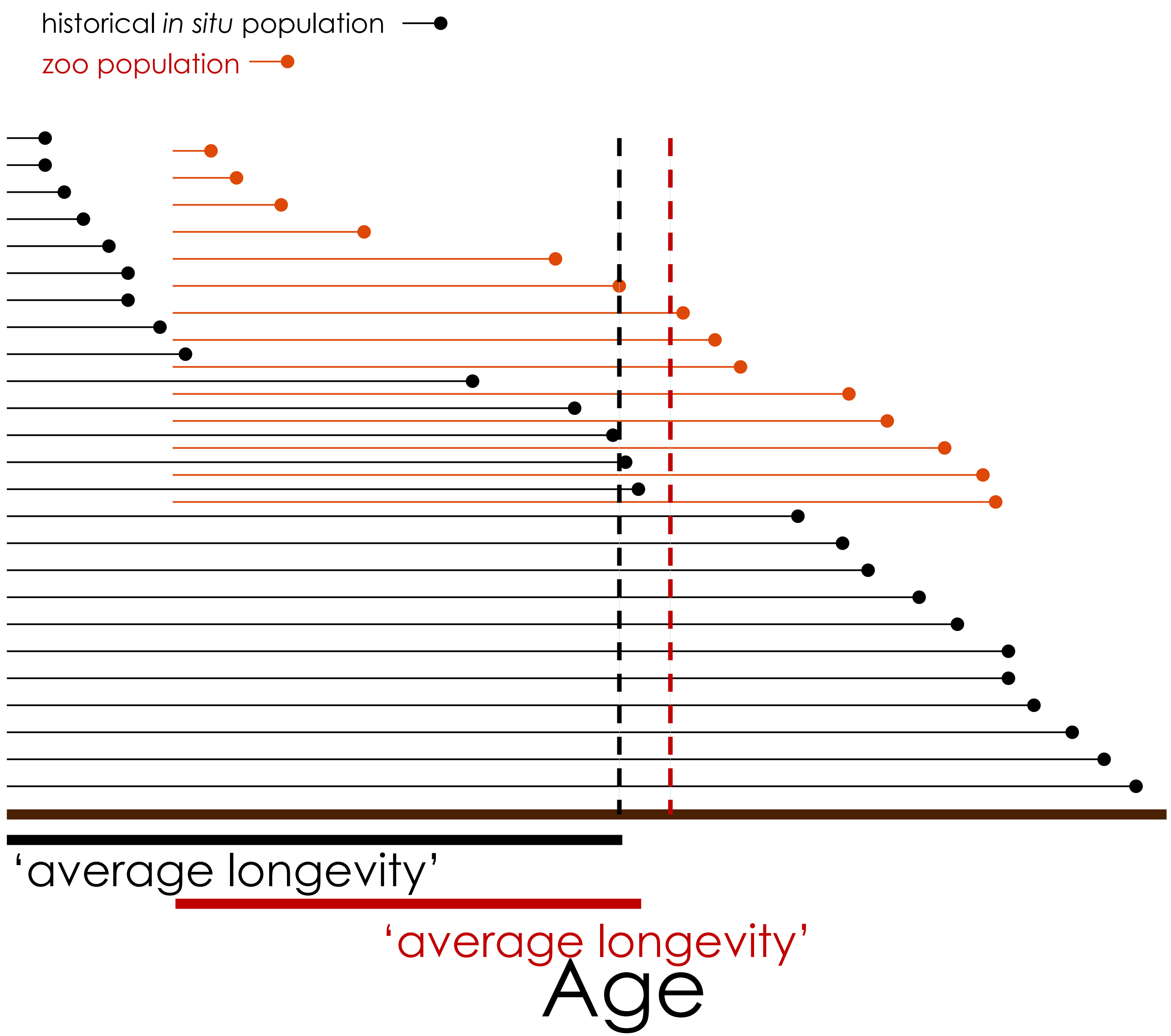

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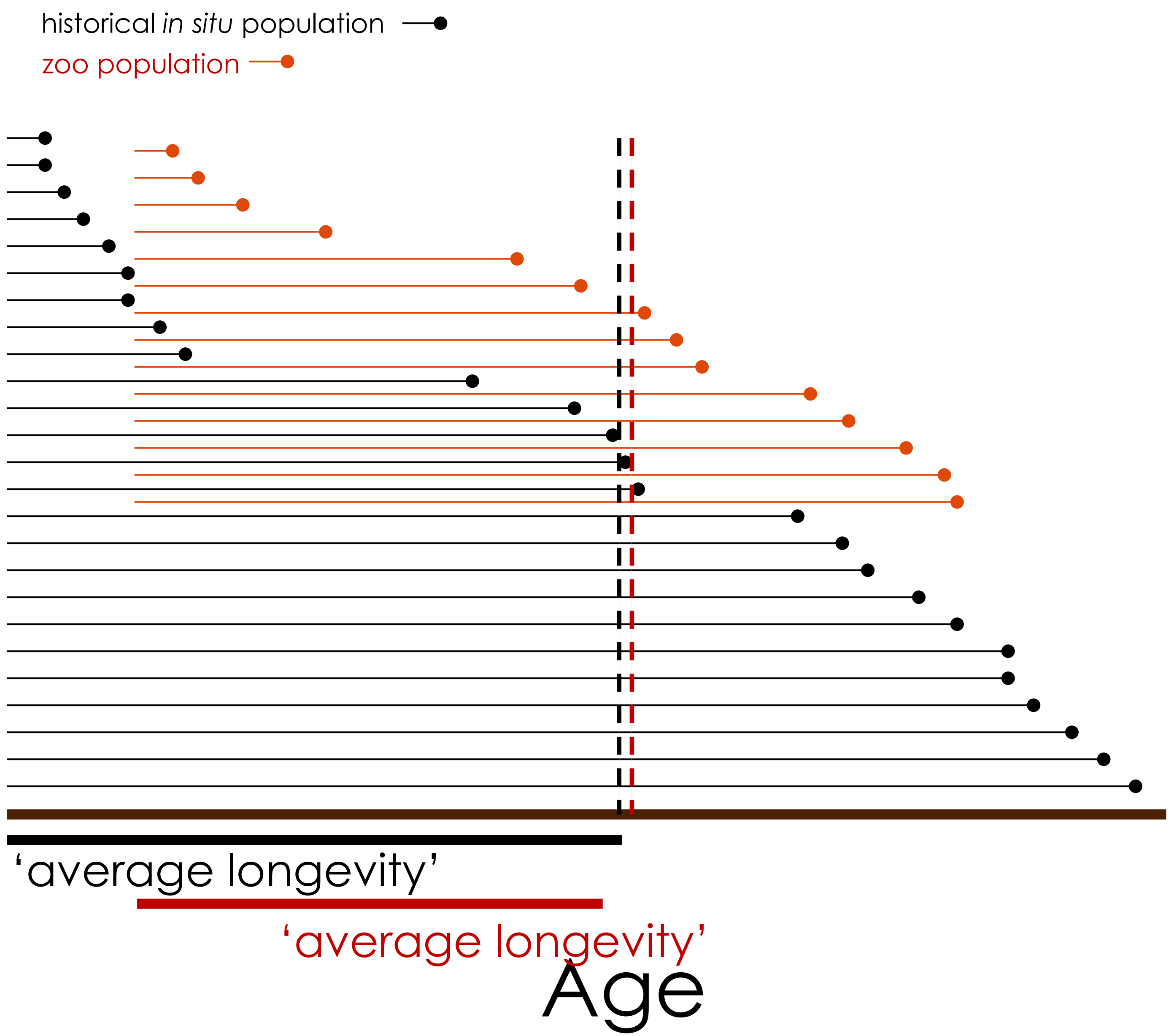

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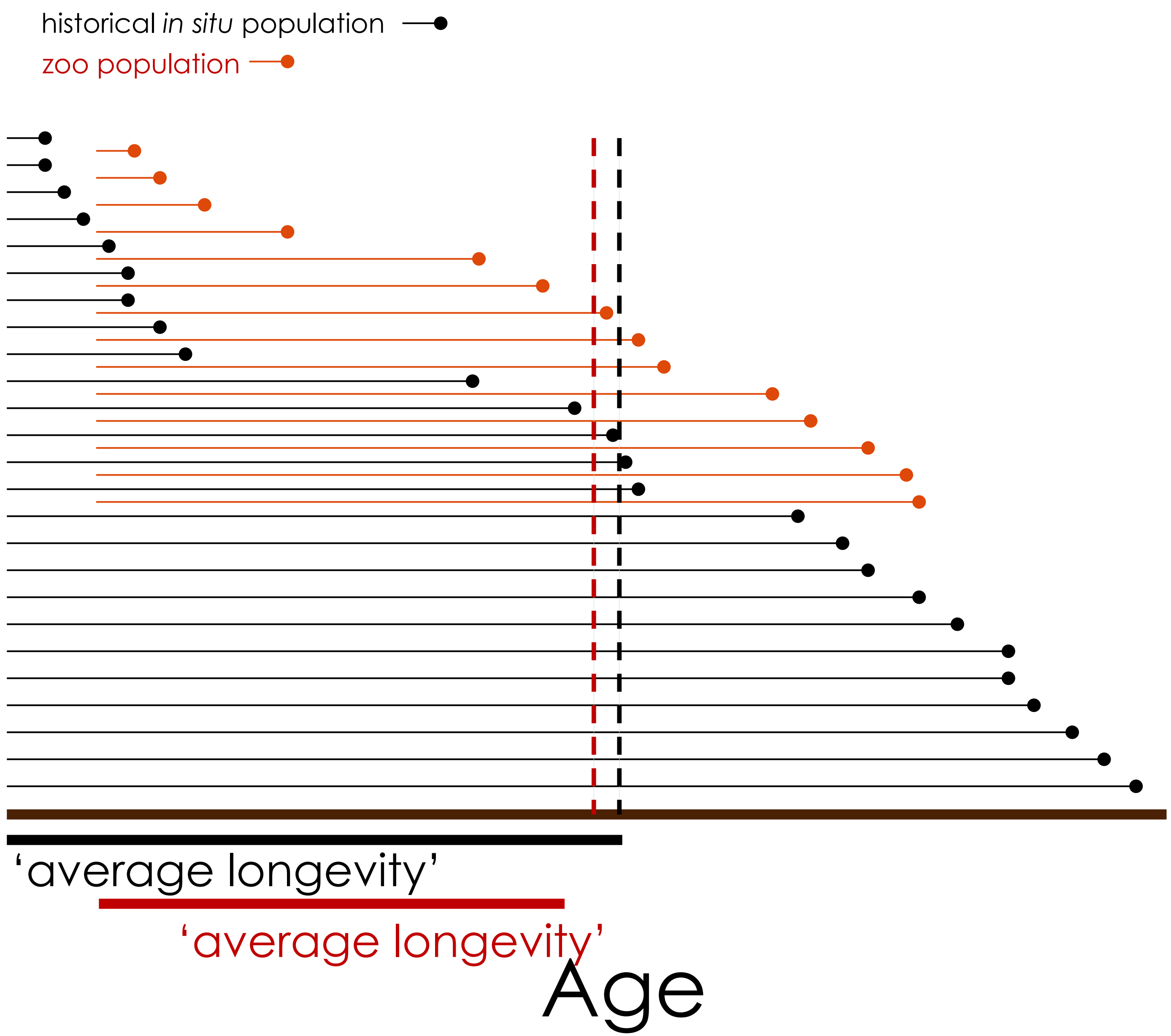

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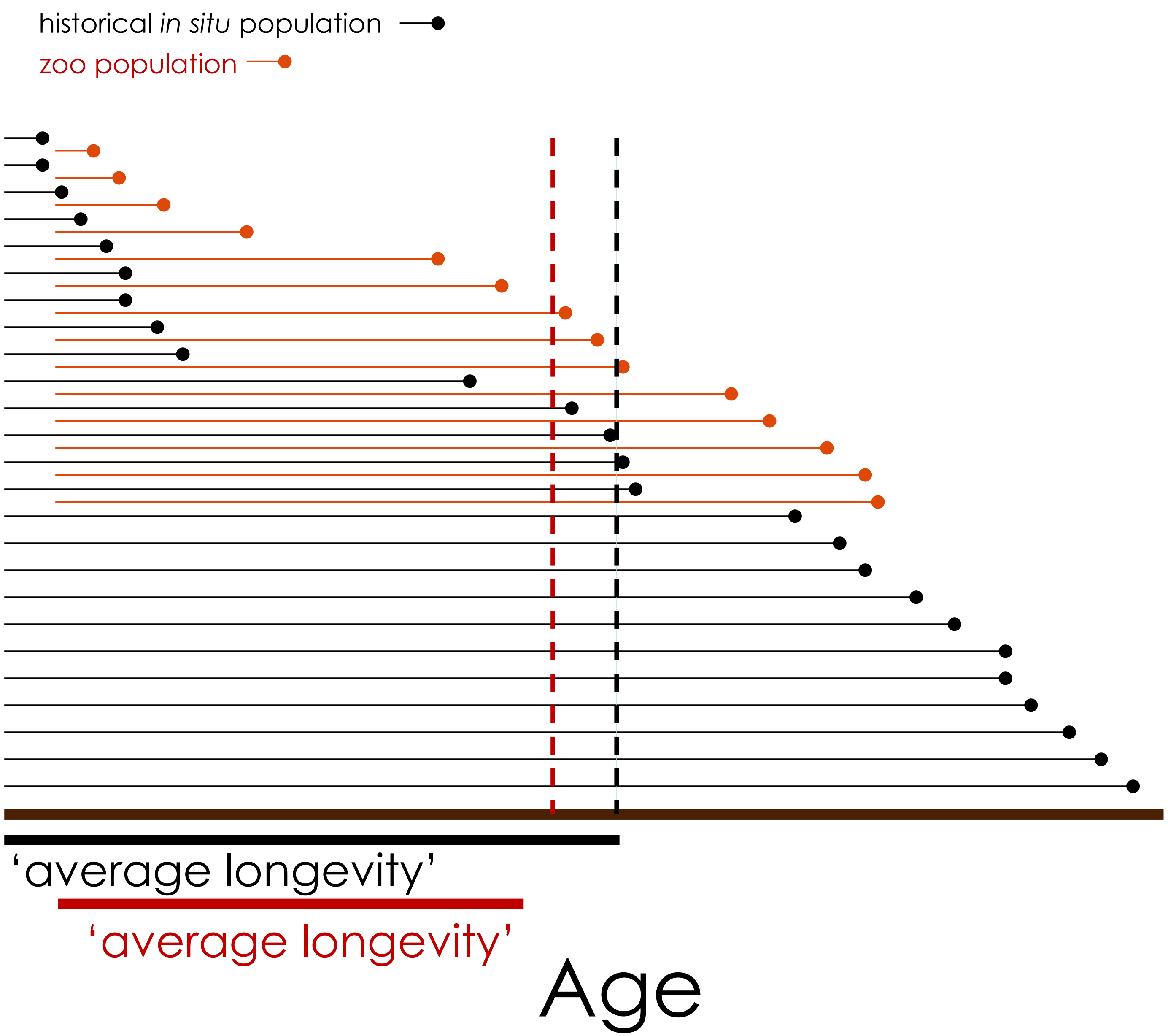

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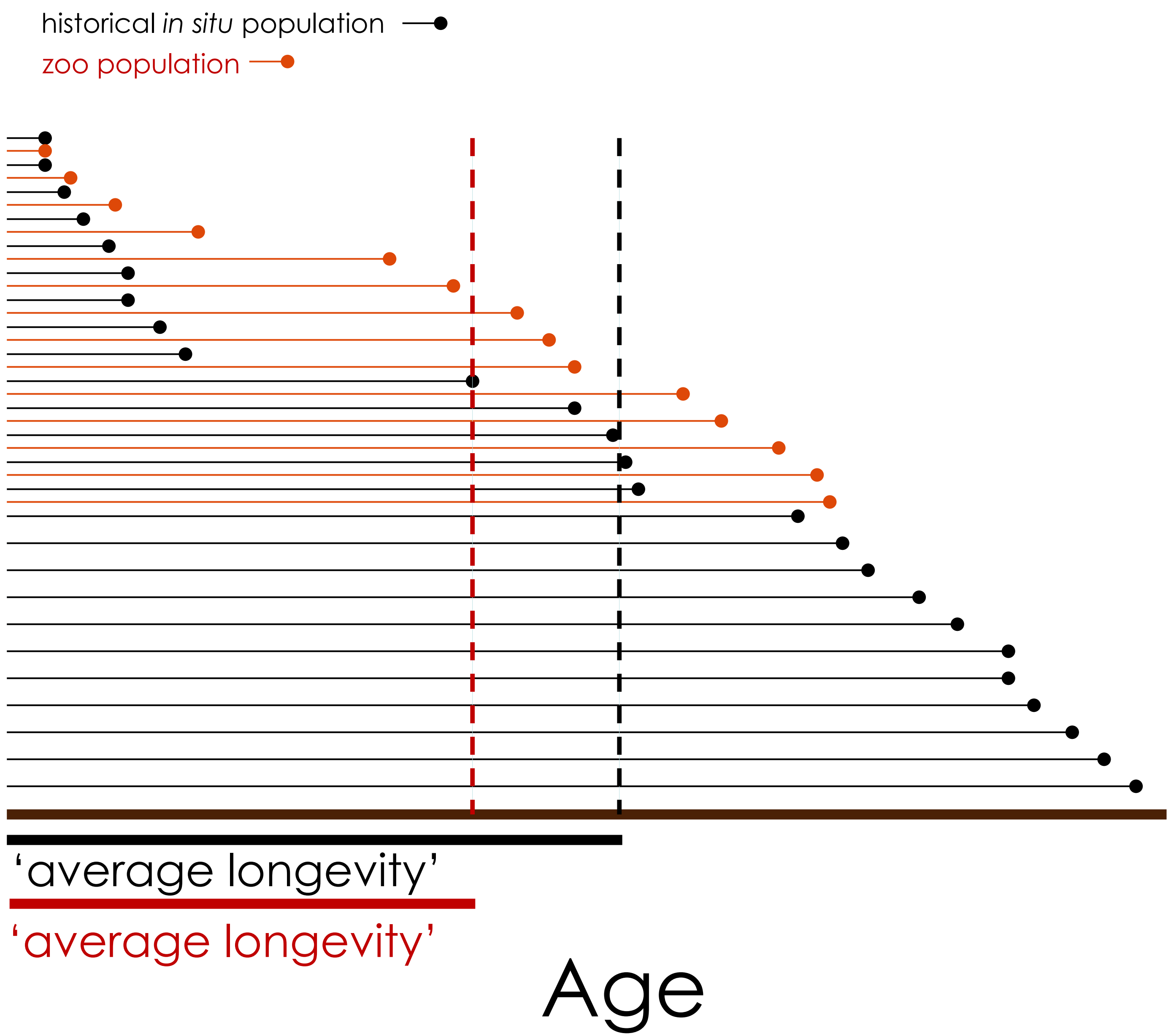

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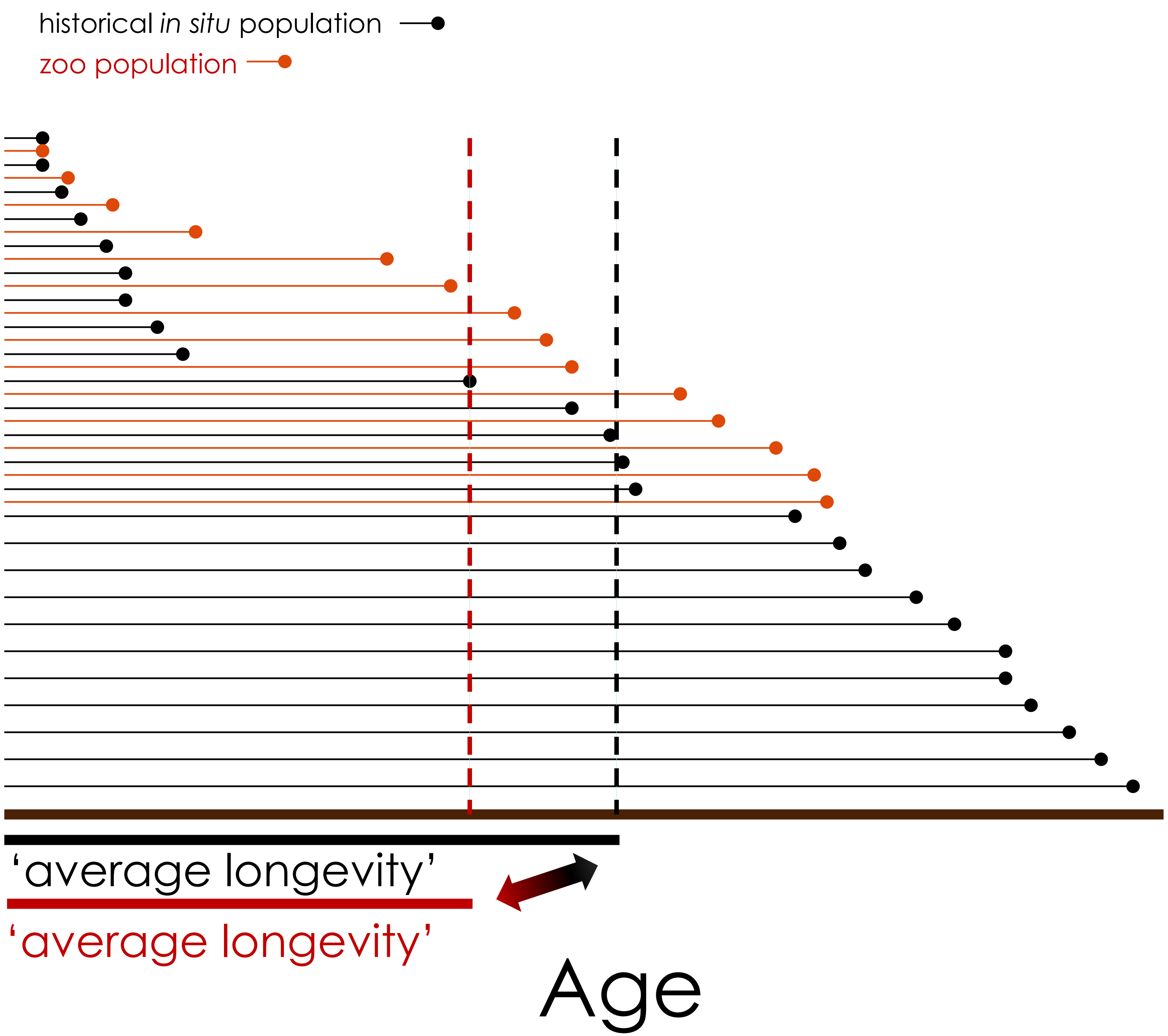

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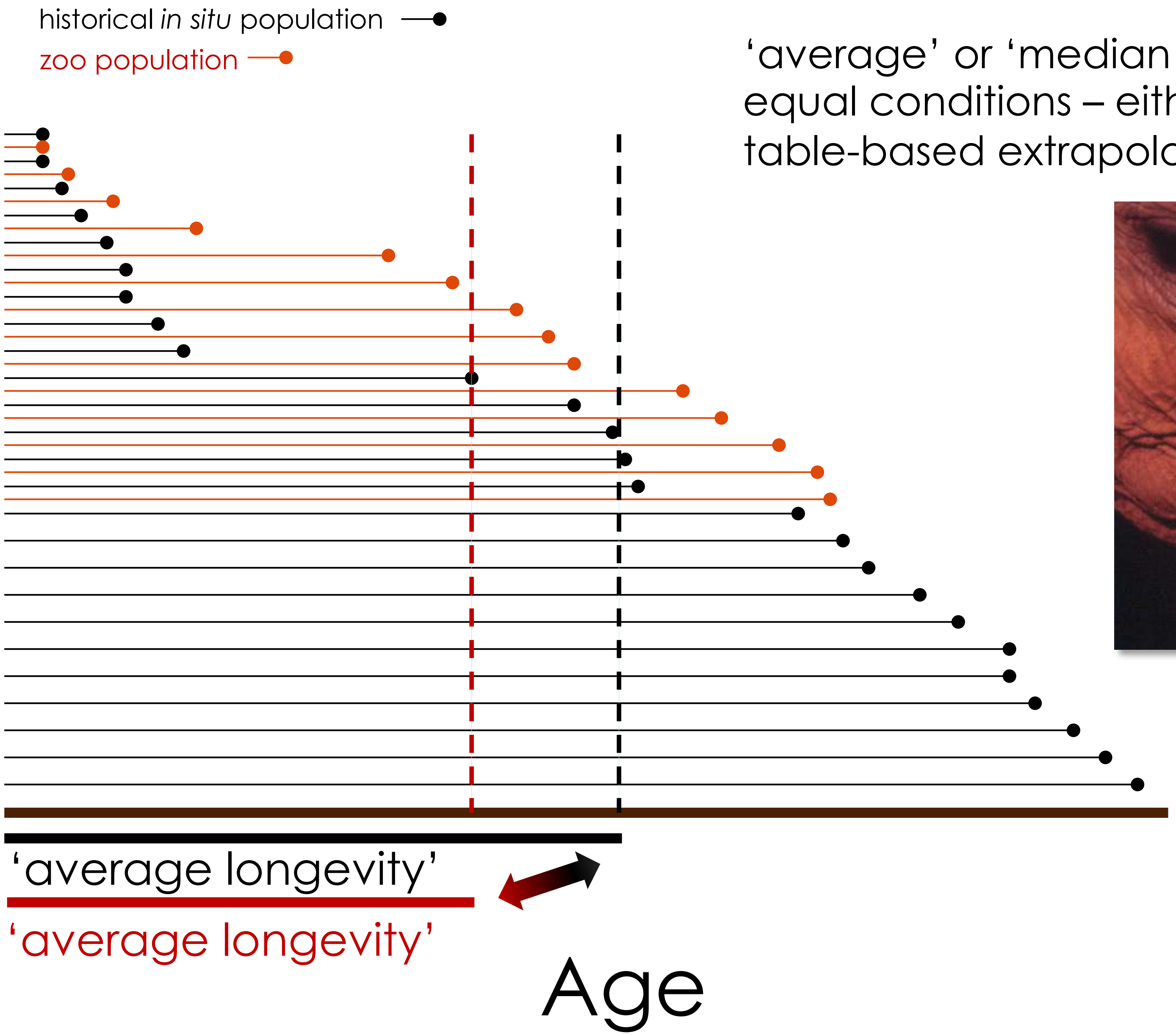
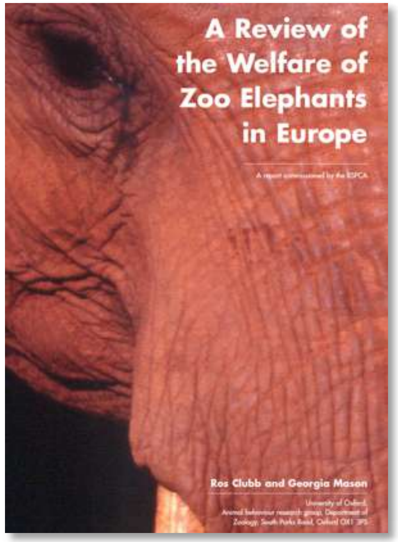
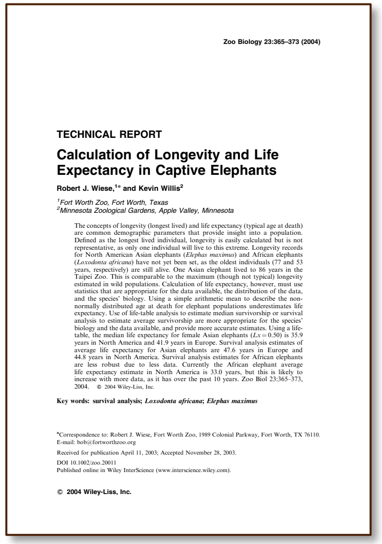


‘average’ or ‘median’ lifespan can only be compared on equal conditions – either similar cohorts, or only using life table-based extrapolation





Zoo Biology 23:365–373 (2004)

TECHNICAL REPORT

Calculation of Longevity and Life Expectancy in Captive Elephants

Robert J. Wiese,[1*] and Kevin Willis[2]

[1]*Fort Worth Zoo, Fort Worth, Texas*
[2]*Minnesota Zoological Gardens, Apple Valley, Minnesota*

The concepts of longevity (longest lived) and life expectancy (typical age at death) are common demographic parameters that provide insight into a population. Defined as the longest lived individual, longevity is easily calculated but is not representative, as only one individual will live to this extreme. Longevity records for North American Asian elephants (*Elephas maximus*) and African elephants (*Loxodonta africana*) have not yet been set, as the oldest individuals (77 and 53 years, respectively) are still alive. One Asian elephant lived to 86 years in the Taipei Zoo. This is comparable to the maximum (though not typical) longevity estimated in wild populations. Calculation of life expectancy, however, must use statistics that are appropriate for the data available, the distribution of the data, and the species' biology. Using a simple arithmetic mean to describe the non-normally distributed age at death for elephant populations underestimates life expectancy. Use of life-table analysis to estimate median survivorship or survival analysis to estimate average survivorship are more appropriate for the species' biology and the data available, and provide more accurate estimates. Using a life-table, the median life expectancy for female Asian elephants ($Lx = 0.50$) is 35.9 years in North America and 41.9 years in Europe. Survival analysis estimates of average life expectancy for Asian elephants are 47.6 years in Europe and 44.8 years in North America. Survival analysis estimates for African elephants are less robust due to less data. Currently the African elephant average life expectancy estimate in North America is 33.0 years, but this is likely to increase with more data, as it has over the past 10 years. Zoo Biol 23:365–373, 2004. © 2004 Wiley-Liss, Inc.

Key words: survival analysis; *Loxodonta africana*; *Elephas maximus*

*Correspondence to: Robert J. Wiese, Fort Worth Zoo, 1989 Colonial Parkway, Fort Worth, TX 76110. E-mail: bob@fortworthzoo.org

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Calculating ‘average’ or ‘median lifespan’

historical *in situ* population

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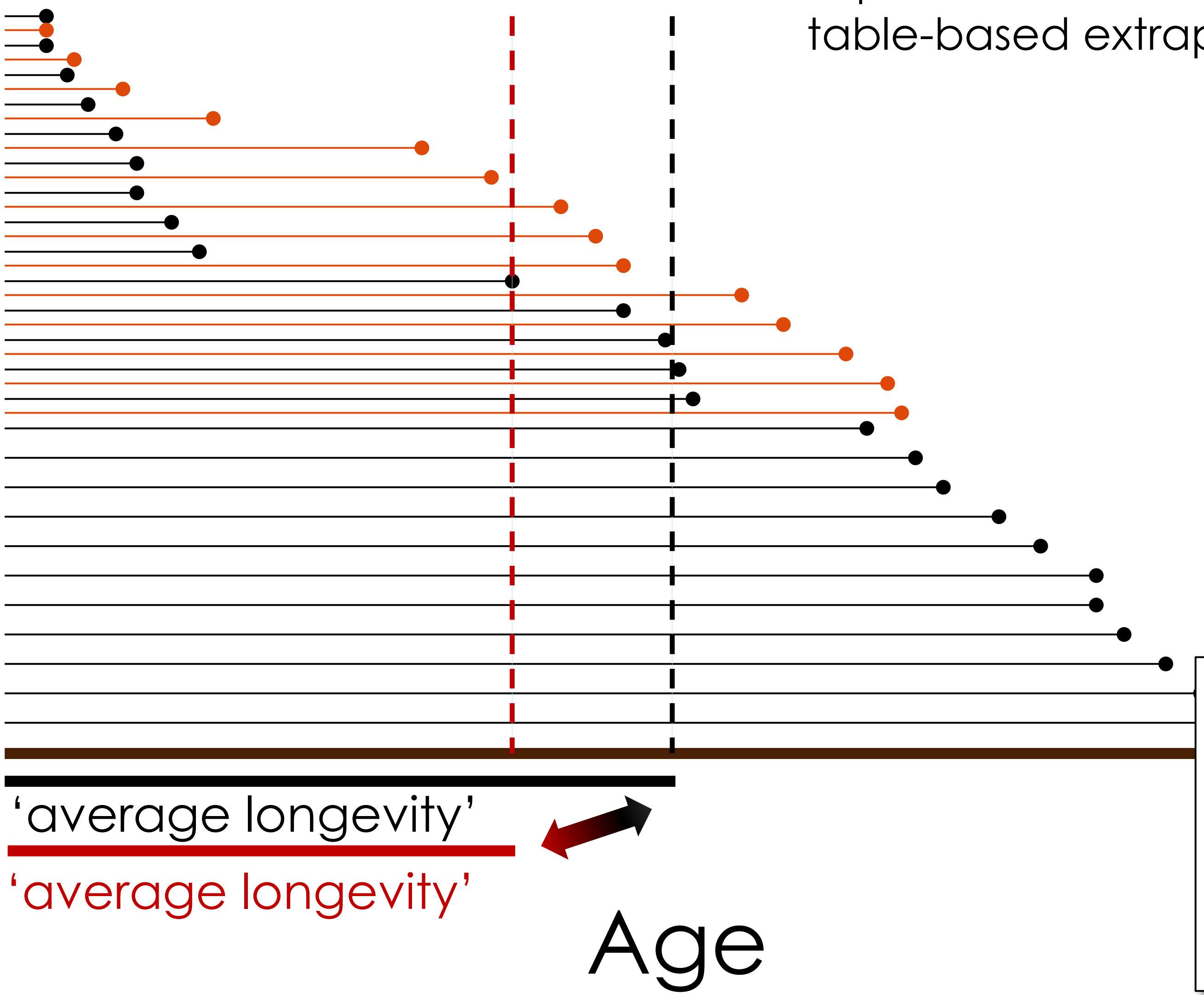

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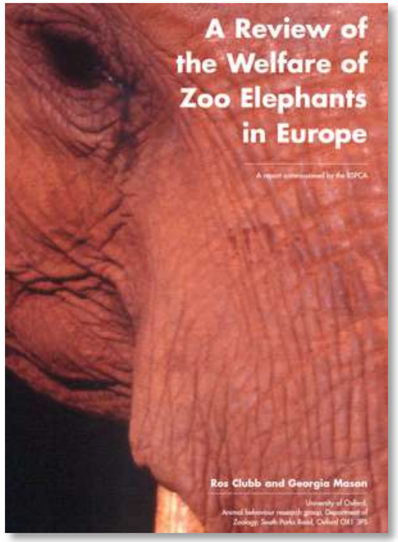

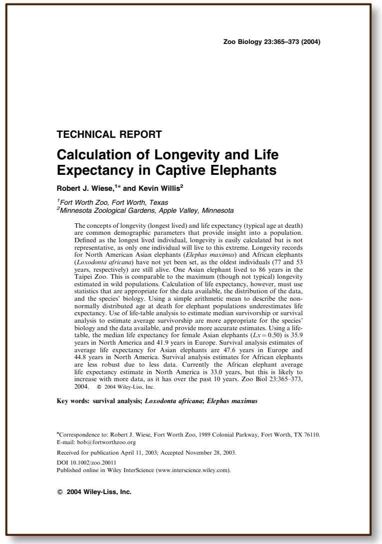

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What Do Population-Level Welfare Indices Suggest About the Well-Being of Zoo Elephants?

Georgia J. Mason[1]* and Jake S. Veasey[2]

Zoo Biology 29:256–273 (2010)

Their calculations were correctly criticized as simplistic by Wiese and Willis [2004],

Calculating ‘average’ or ‘median lifespan’

historical *in situ* population

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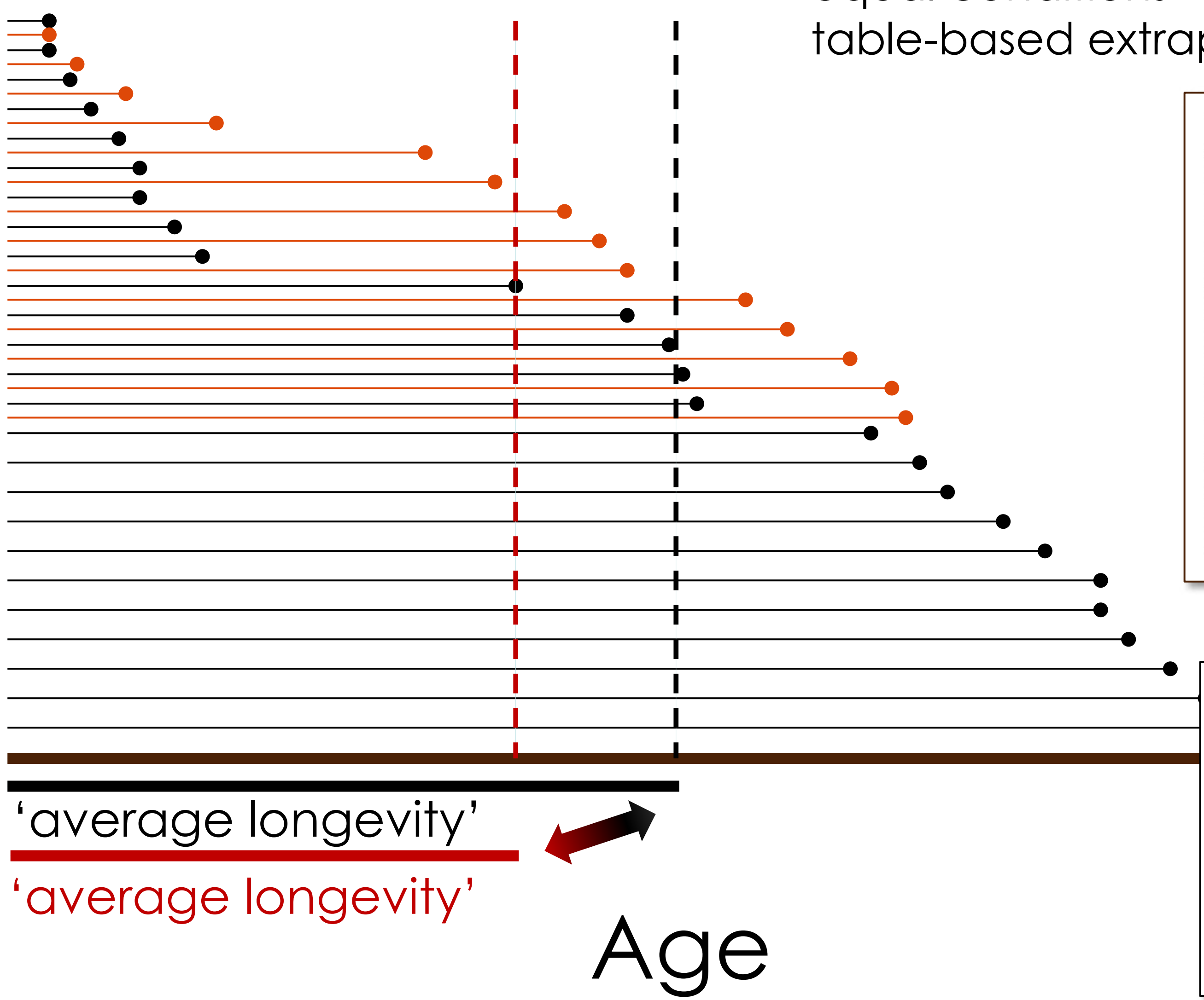

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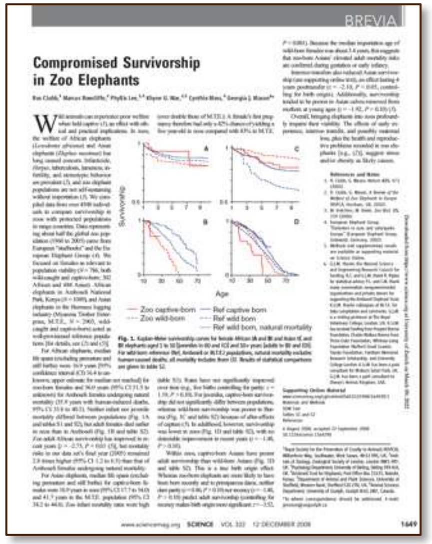

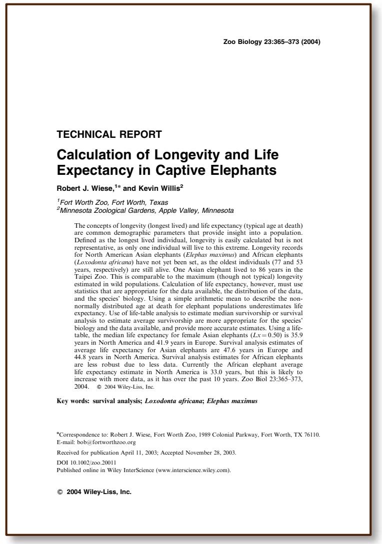

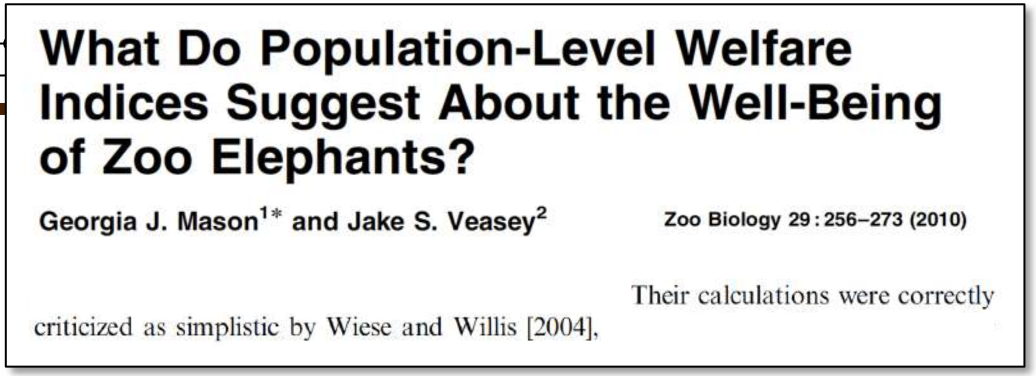

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Compromised Survivorship in Zoo Elephants

as Compared to Some Selected *in situ* Populations Declared 'Benchmarks'

Ros Clubb,[1] Marcus Rowcliffe,[2] Phyllis Lee,[3,4] Khyne U. Mar,[2,5] Cynthia Moss,[4] Georgia J. Mason[6]*

Wild animals can experience poor welfare when held captive (*1*), an effect with ethical and practical implications. In zoos, the welfare of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) has long caused concern. Infanticide, *Herpes*, tuberculosis, lameness, infertility, and stereotypic behavior are prevalent (*2*), and zoo elephant populations are not self-sustaining without importation (*3*). We compiled data from over 4500 individuals to compare survivorship in zoos with protected populations in range countries. Data representing about half the global zoo population (1960 to 2005) came from European "studbooks" and the European Elephant Group (*4*). We focused on females as relevant to population viability ($N = 786$, both wild-caught and captive-born; 302 African and 484 Asian). African elephants in Amboseli National Park, Kenya ($N = 1089$), and Asian elephants in the Burmese logging industry (Myanma Timber Enterprise, M.T.E., $N = 2905$, wild-caught and captive-born) acted as well-provisioned reference populations [for details, see (*2*) and (*5*)].

For African elephants, median life spans (excluding premature and still births) were 16.9 years [95% confidence interval (CI) 16.4 to unknown; upper estimate for median not reached] for zoo-born females and 56.0 years (95% CI 51.5 to unknown) for Amboseli females undergoing natural mortality (35.9 years with human-induced deaths, 95% CI 33.8 to 40.3). Neither infant nor juvenile mortality differed between populations (Fig. 1A and tables S1 and S2), but adult females died earlier in zoos than in Amboseli (Fig. 1B and table S2). Zoo adult African survivorship has improved in recent years [$z = -2.75$, $P < 0.01$ (*5*)], but mortality risks in our data set's final year (2005) remained 2.8 times higher (95% CI 1.2 to 6.5) than that of Amboseli females undergoing natural mortality.

For Asian elephants, median life spans (excluding premature and still births) for captive-born females were 18.9 years in zoos (95% CI 17.7 to 34.0) and 41.7 years in the M.T.E. population (95% CI 38.2 to 44.6). Zoo infant mortality rates were high (over double those of M.T.E.): A female's first pregnancy therefore had only a 42% chance of yielding a live year-old in zoos compared with 83% in M.T.E.

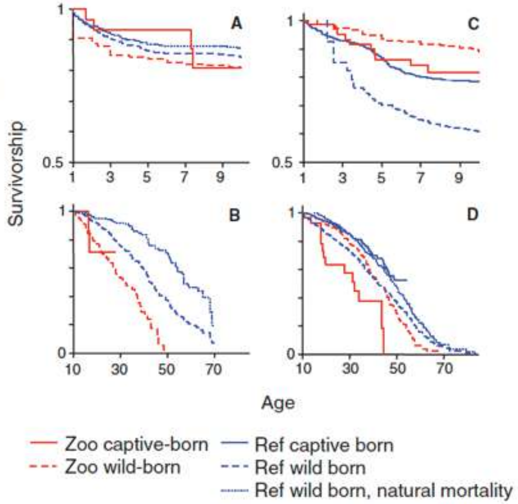


Fig. 1. Kaplan-Meier survivorship curves for female African (**A** and **B**) and Asian (**C** and **D**) elephants aged 1 to 10 [juveniles in (A) and (C)] and 10+ years [adults in (B) and (D)]. For wild-born reference (Ref, Amboseli or M.T.E.) populations, natural mortality excludes human-caused deaths; all mortality includes them (5). Results of statistical comparisons are given in table S2.

(table S1). Rates have not significantly improved over time (e.g., live births controlling for parity: $z = 1.19$, $P > 0.10$). For juveniles, captive-born survivorship did not significantly differ between populations, whereas wild-born survivorship was poorer in Burma (Fig. 1C and table S2) because of after-effects of capture (*5*). In adulthood, however, survivorship was lower in zoos (Fig. 1D and table S2), with no detectable improvement in recent years ($z = -1.48$, $P > 0.10$).

Within zoos, captive-born Asians have poorer adult survivorship than wild-born Asians (Fig. 1D and table S2). This is a true birth origin effect: Whereas zoo-born elephants are more likely to have been born recently and to primiparous dams, neither dam parity ($z = 0.86$, $P > 0.10$) nor recency ($z = -1.48$, $P > 0.10$) predict adult survivorship (controlling for recency makes birth origin more significant: $z = -3.52$, $P < 0.001$). Because the median importation age of wild-born females was about 3.4 years, this suggests that zoo-born Asians' elevated adult mortality risks

ling for birth origin). Additionally, survivorship tended to be poorer in Asian calves removed from mothers at young ages ($z = -1.92$, $P < 0.10$) (*5*).

Overall, bringing elephants into zoos profoundly impairs their viability. The effects of early experience, interzoo transfer, and possibly maternal loss, plus the health and reproductive problems recorded in zoo elephants [e.g., (*2*)], suggest stress and/or obesity as likely causes.

Data from 1960-2008

1. Average lifespan is lower in zoos than *in situ*
2. **Survivorship is lower in zoos than *in situ***
3. **Although there was some improvement in survivorship in African elephants since 1960, there was no such improvement in Asian elephants**

References and Notes

1. R. Clubb, G. Mason, *Nature* **425**, 473 (2003).
2. R. Clubb, G. Mason, *A Review of the Welfare of Zoo Elephants in Europe* (RSPCA, Horsham, UK, 2002).
3. M. Hutchins, M. Keele, *Zoo Biol.* **25**, 219 (2006).
4. European Elephant Group, "Elefanten in zoos und safariparks Europa" (European Elephant Group, Grünwald, Germany, 2002).
5. Methods and supplementary results are available as supporting material on *Science* Online.

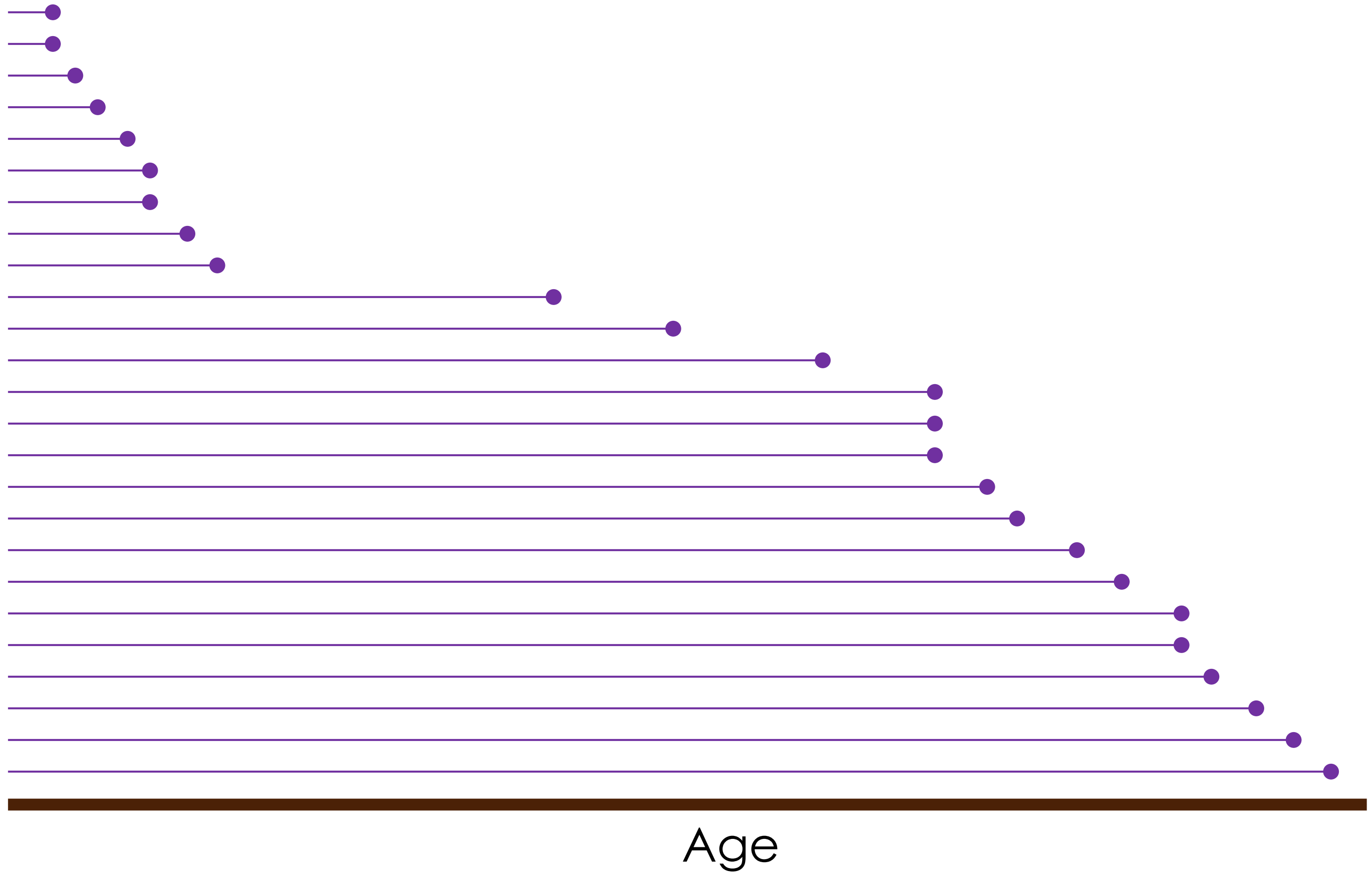
6. G.J.M. thanks the Natural Science and Engineering Research Council for funding; R.C. and G.J.M. thank R. Ripley for statistical advice; P.L. and C.M. thank many conservation nongovernmental organizations and private donors for supporting the Amboseli Elephant Trust; K.U.M. thanks colleagues at M.T.E. for data compilation and comments. G.J.M. is a visiting professor at The Royal Veterinary College, London, UK. K.U.M. has received funding from Prospect Burma Foundation, Charles Wallace Burma Trust, Three Oaks Foundation, Whitney-Laing Foundation (Rufford Small Grants), Toyota Foundation, Fantham Memorial Research Scholarship, and University College London. K.U.M. has been a paid consultant for Woburn Safari Park, UK. G.J.M. has been a paid consultant to Disney's Animal Kingdom, USA.

Supporting Online Material
www.sciencemag.org/cgi/content/full/322/5908/1649/DC1
Materials and Methods
SOM Text
Tables S1 and S2
References

6 August 2008; accepted 22 September 2008
10.1126/science.1164298

[1]Royal Society for the Prevention of Cruelty to Animals (RSPCA), Wilberforce Way, Southwater, West Sussex, RH13 9RS, UK. [2]Institute of Zoology, Zoological Society of London, London NW1 4RY, UK. [3]Psychology Department, University of Stirling, Stirling FK9 4LA, UK. [4]Amboseli Trust for Elephants, Post Office Box 15135, Nairobi, Kenya. [5]Department of Animal and Plant Sciences, University of Sheffield, Western Bank, Sheffield S10 2TN, UK. [6]Animal Sciences Department, University of Guelph, Guelph N1G 2M7, Canada.
*To whom correspondence should be addressed. E-mail: gmason@uoguelph.ca

Survivorship



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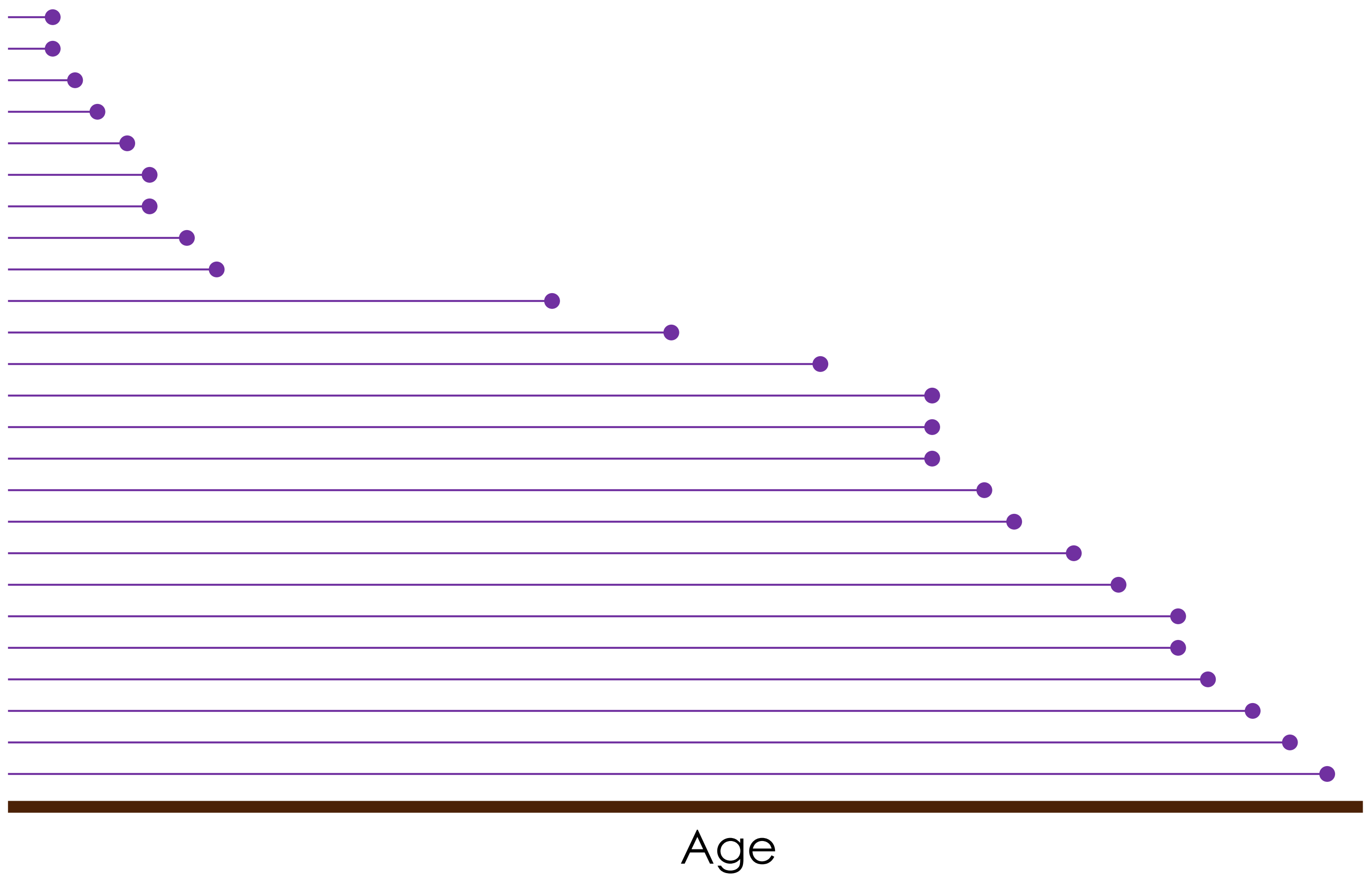

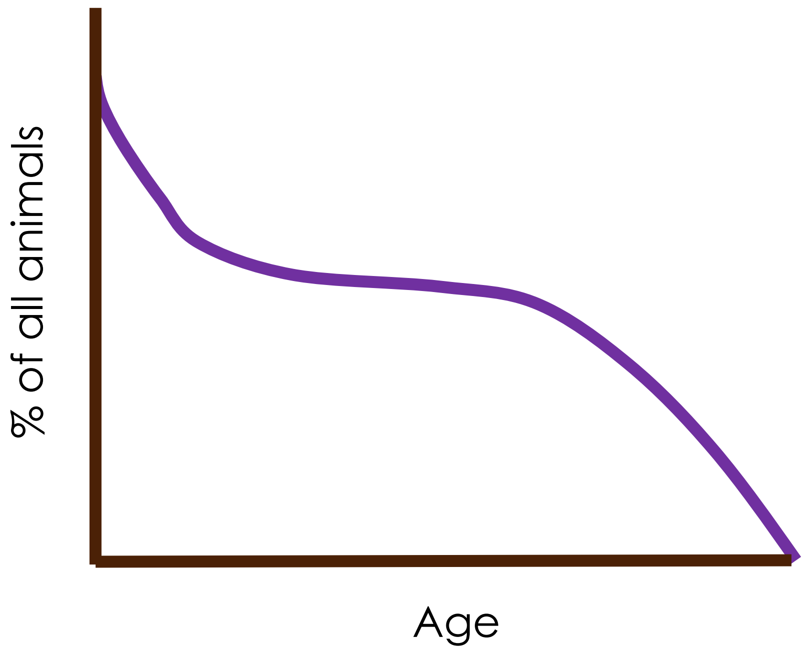

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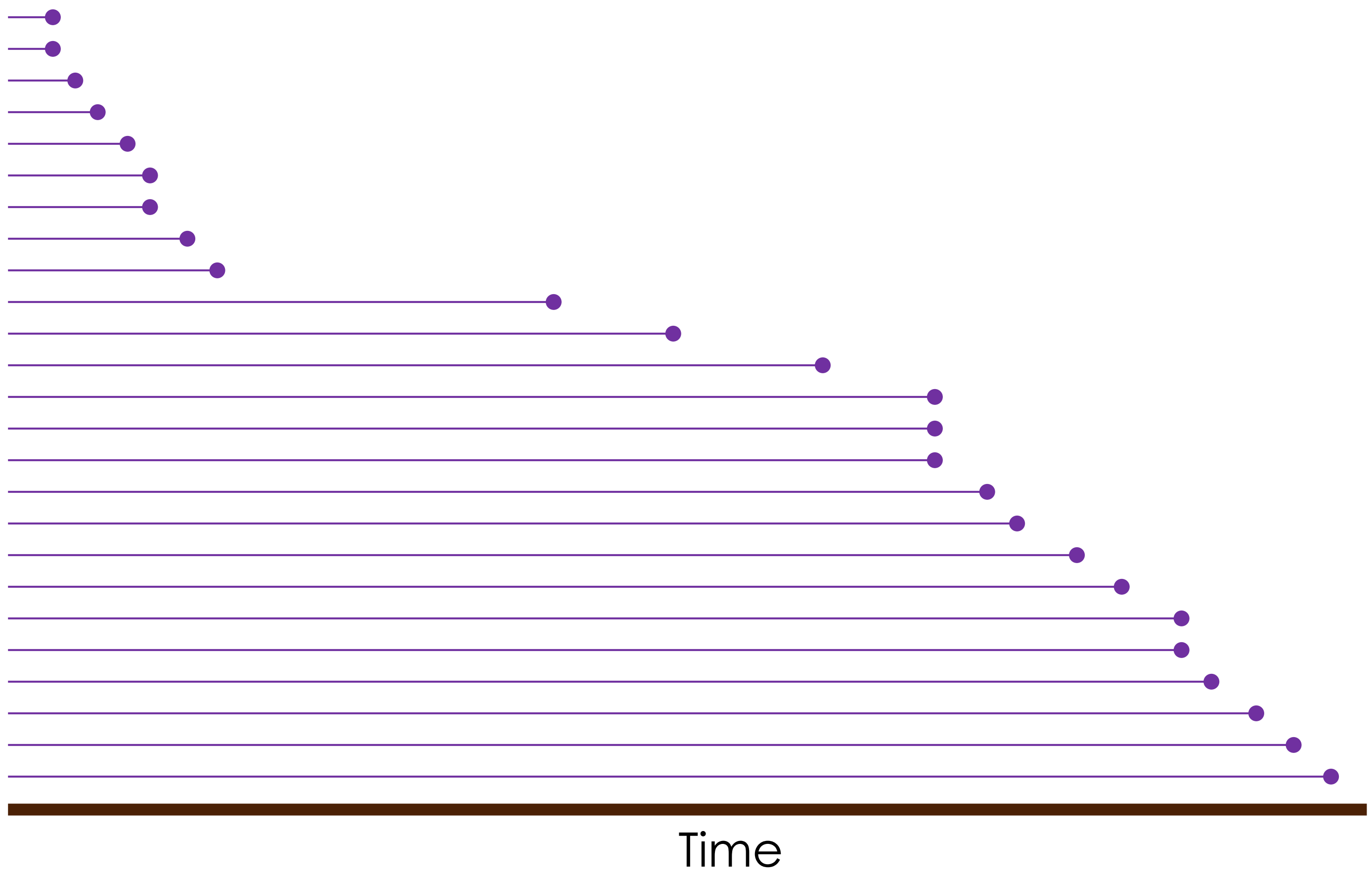

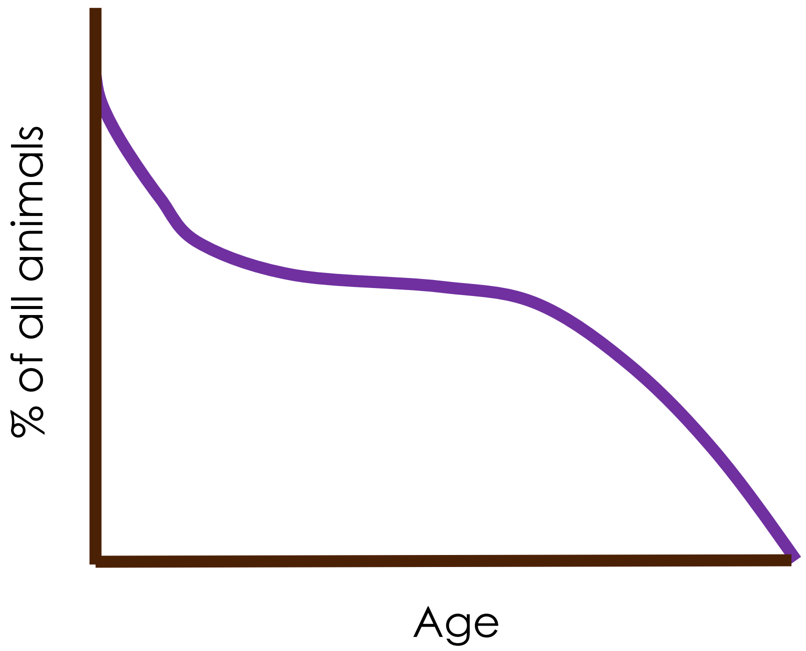

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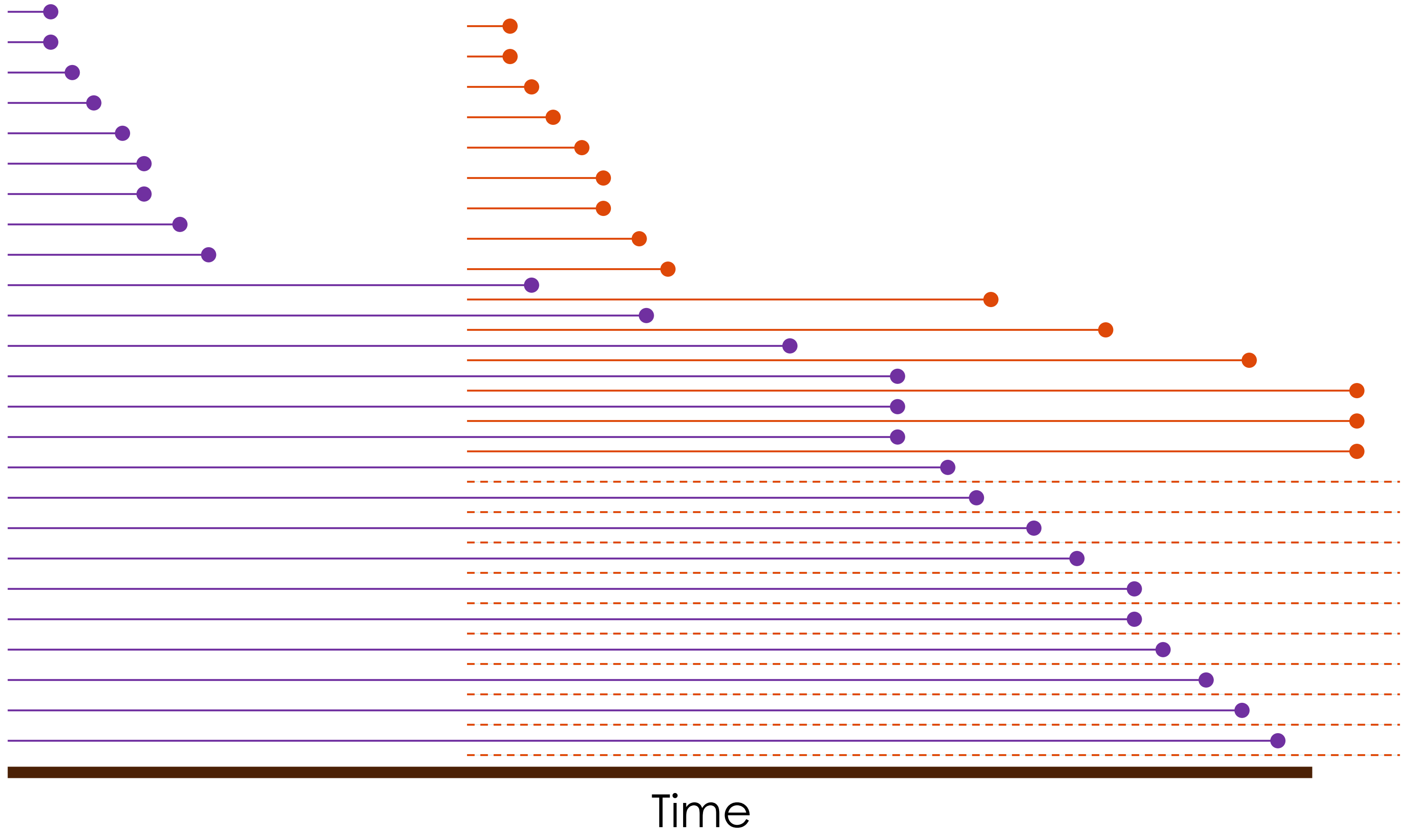

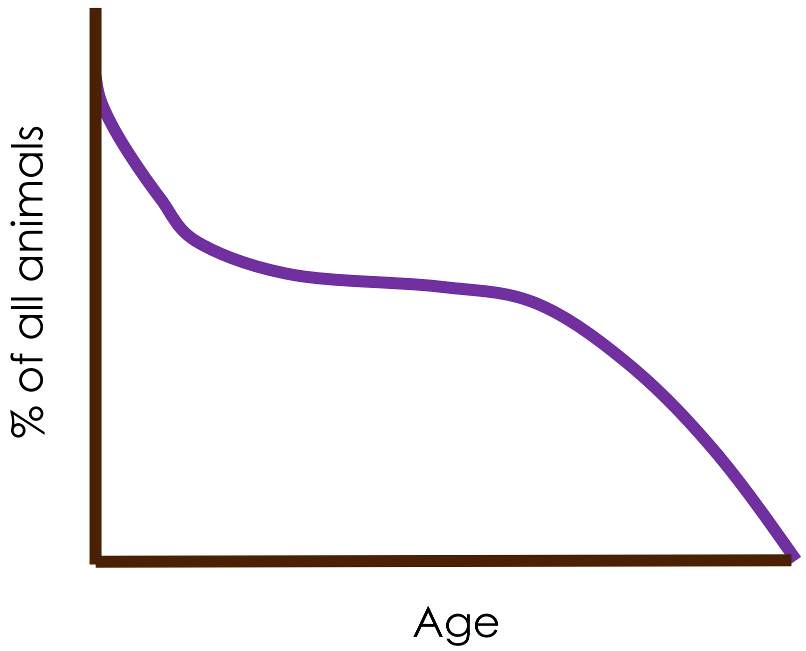

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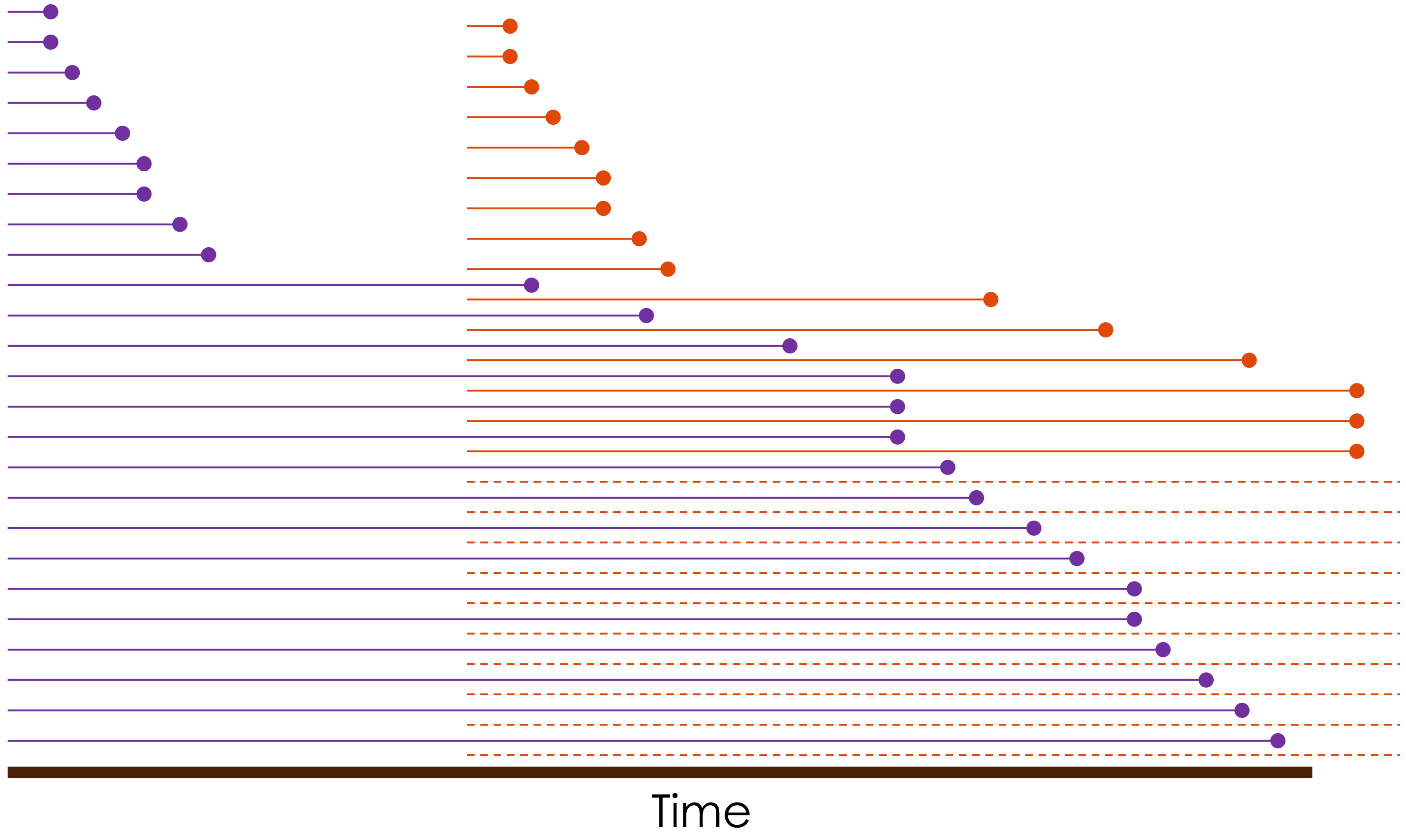

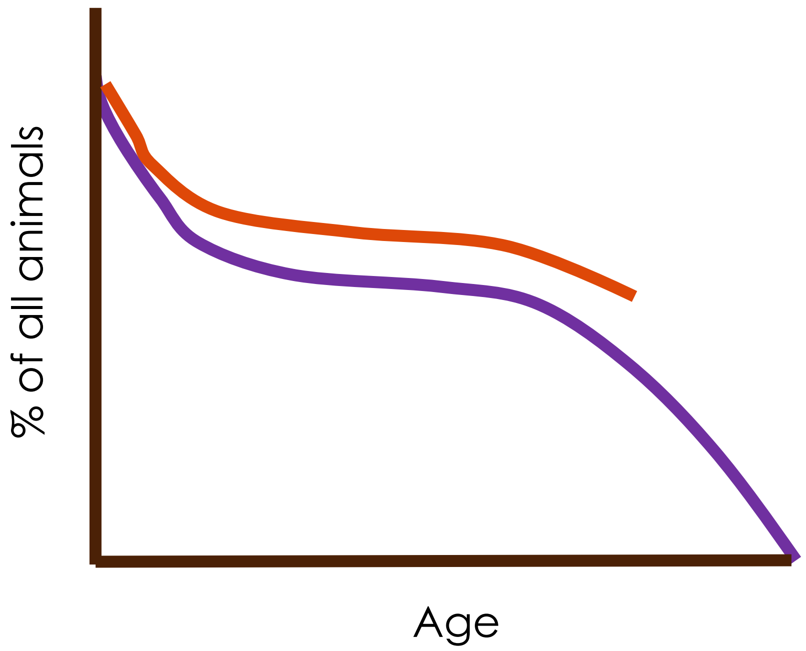

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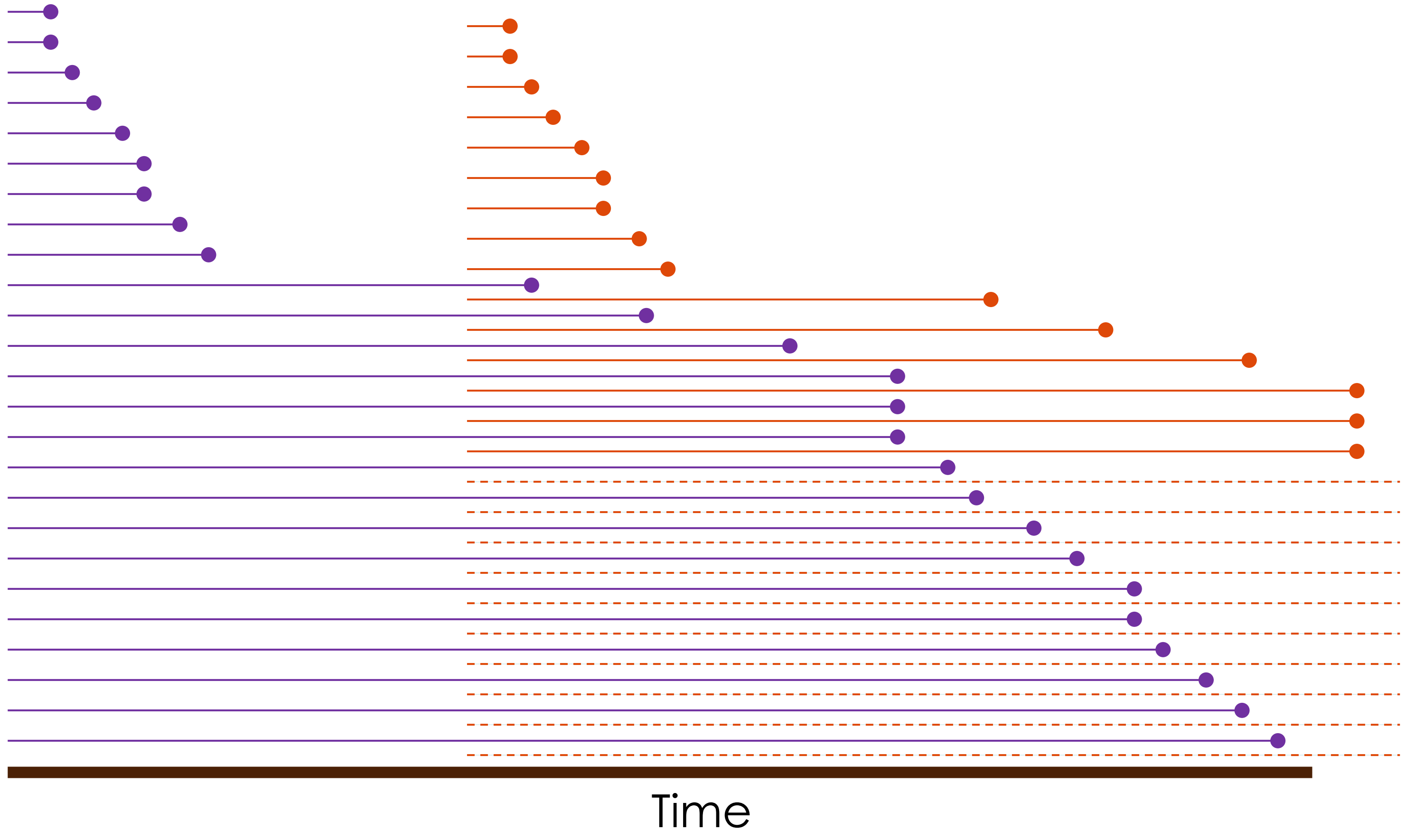
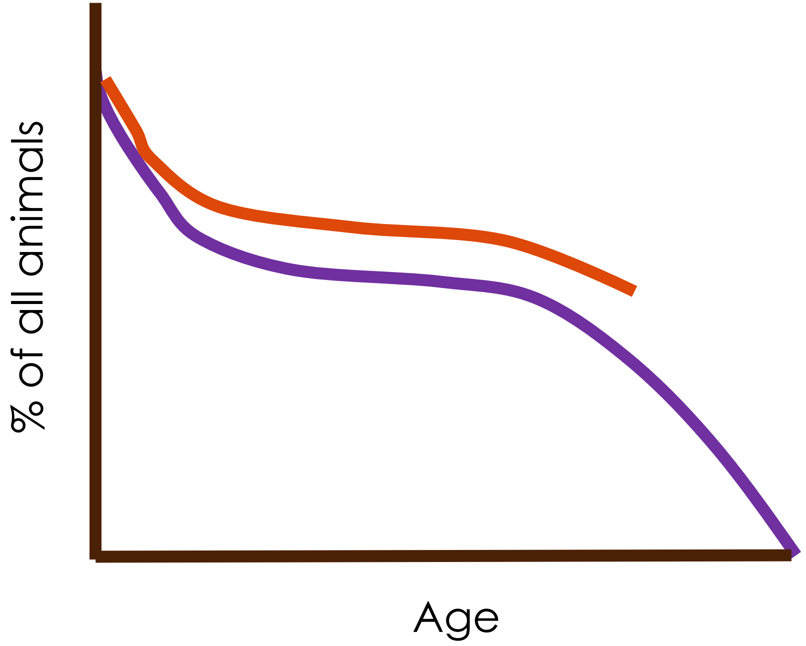
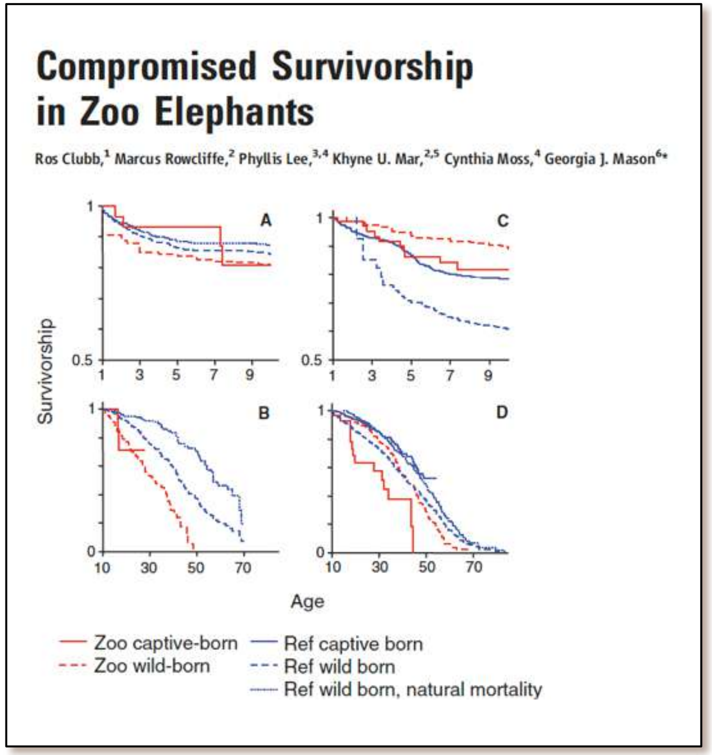
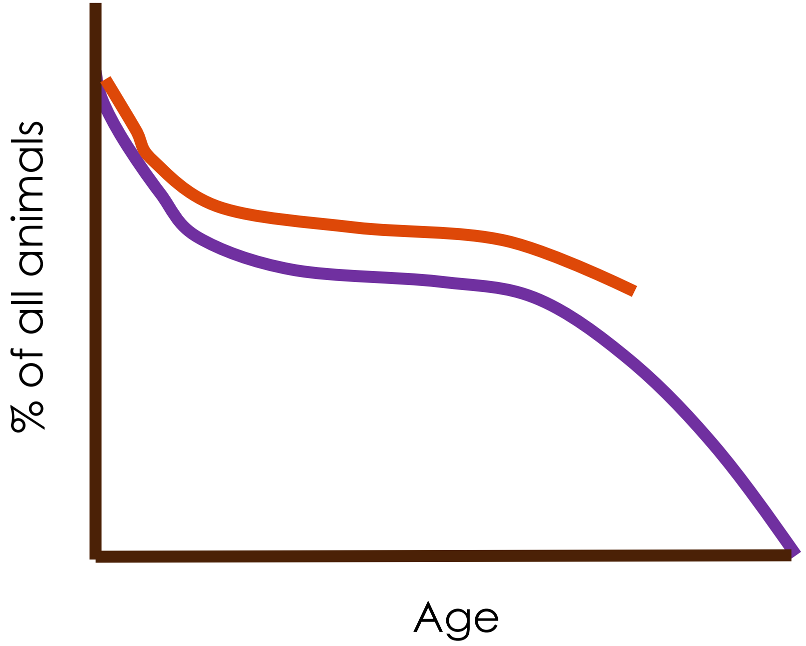




Cox Proportional Hazard analysis: is the survivorship different between the groups ?

Survivorship





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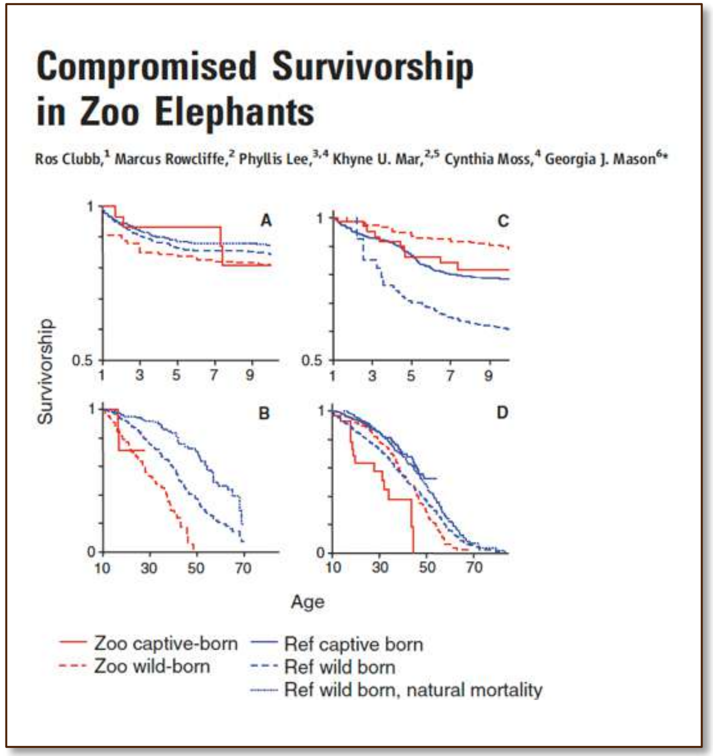

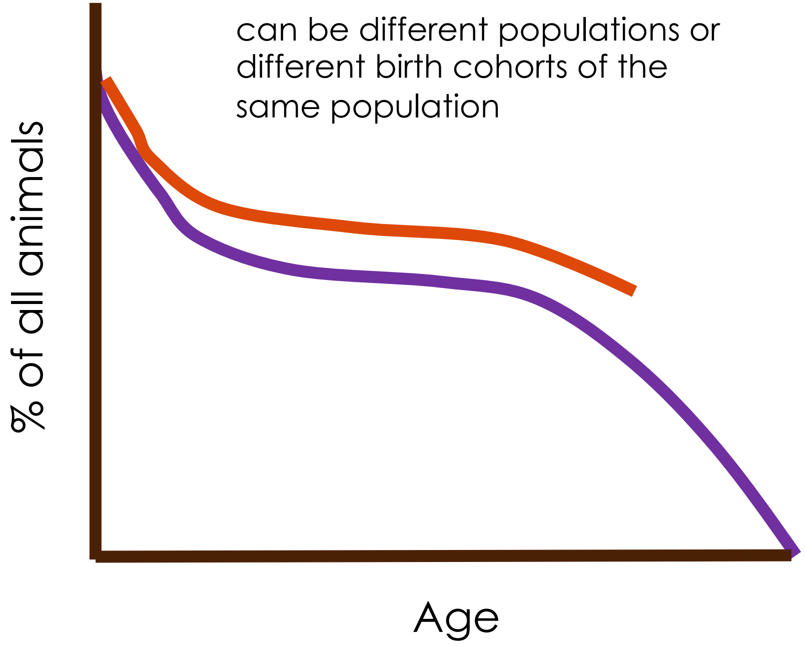

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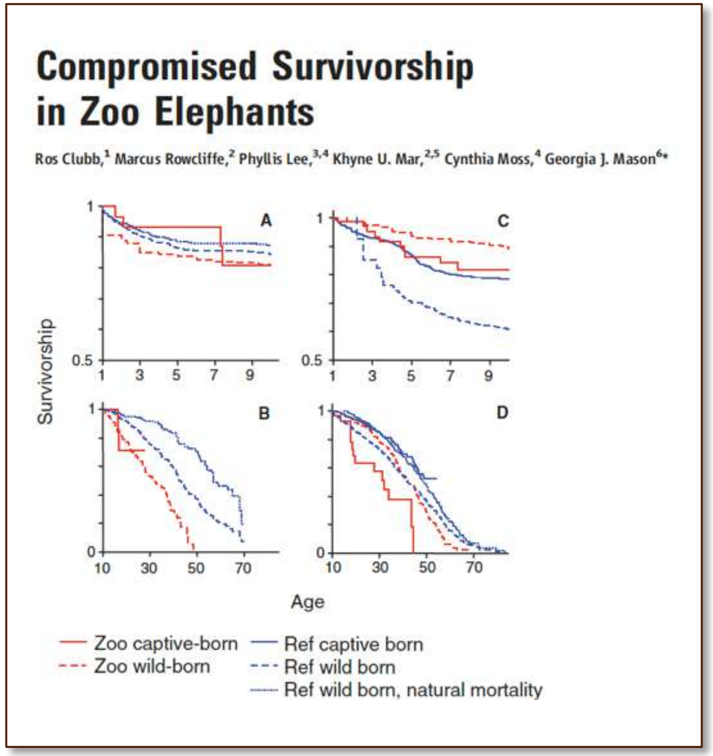
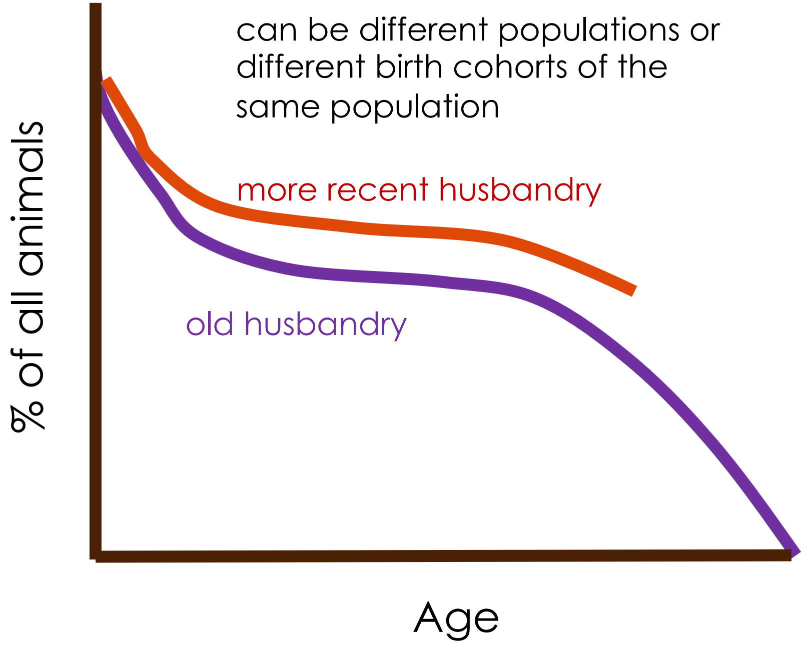
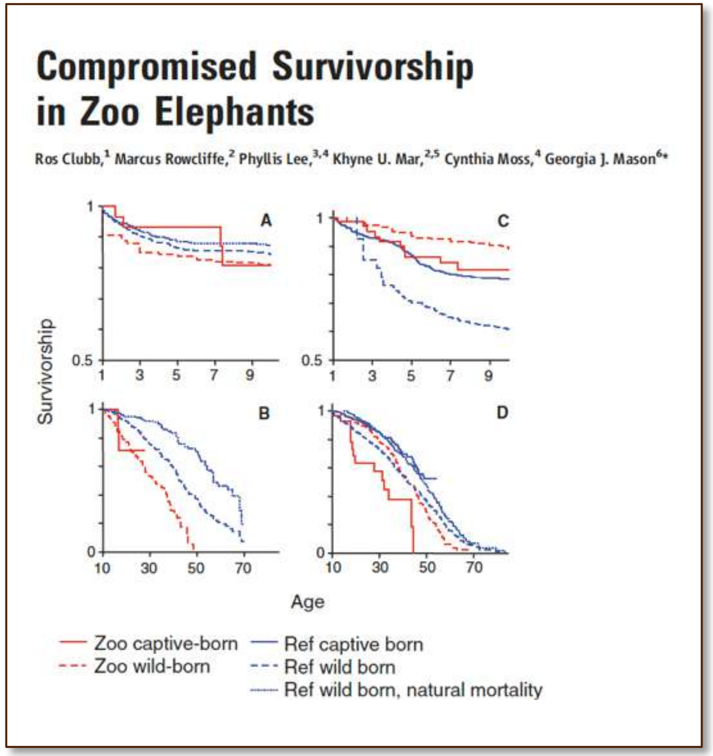




Cox Proportional Hazard analysis: is the survivorship different between the groups ?

Survivorship


Compromised Survivorship in Zoo Elephants

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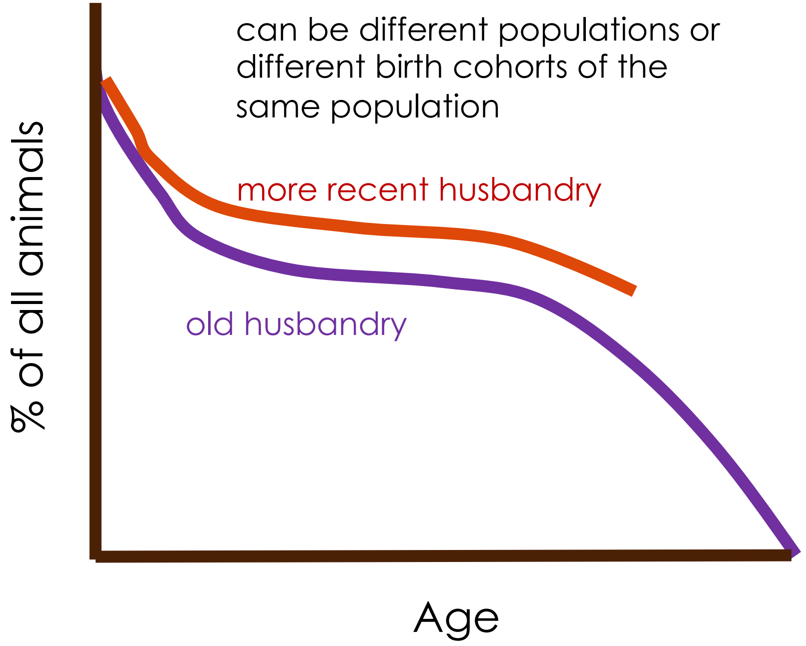
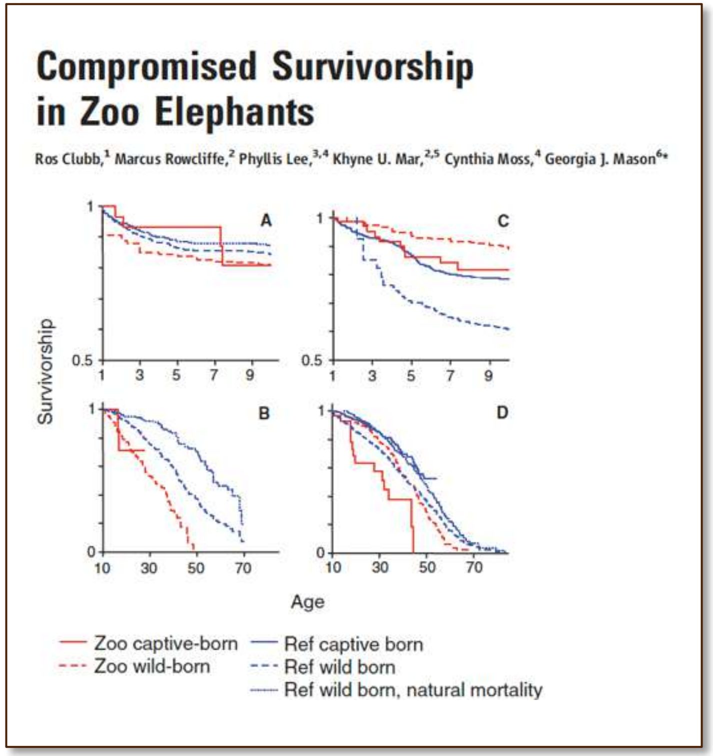
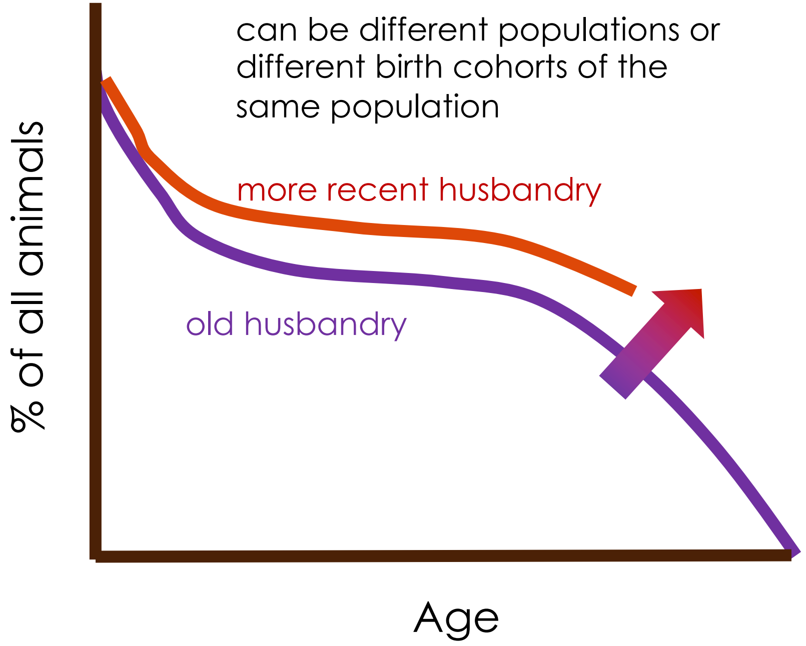


Cox Proportional Hazard analysis: is the survivorship different between the groups ?

e.g. coefficient < 1 means that the red group has better survivorship than the purple baseline

Survivorship





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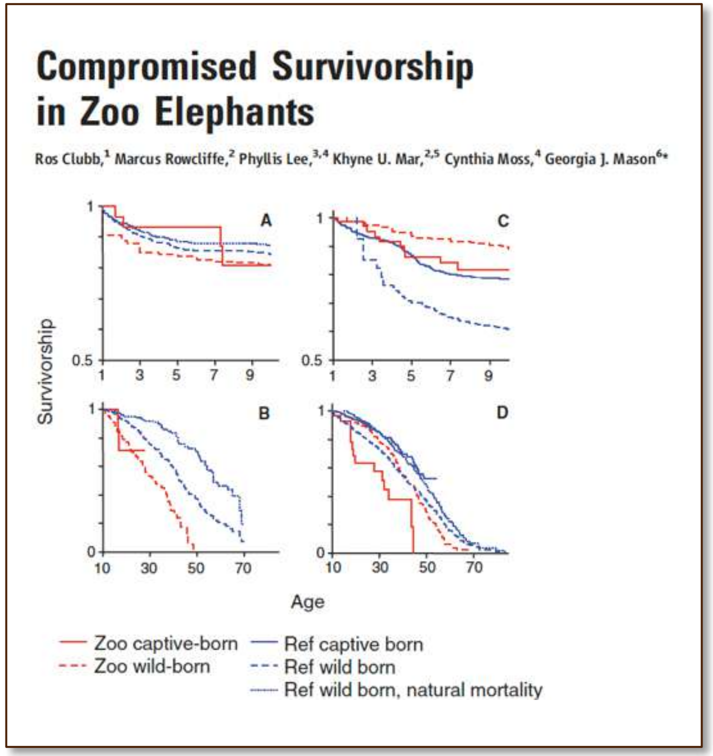
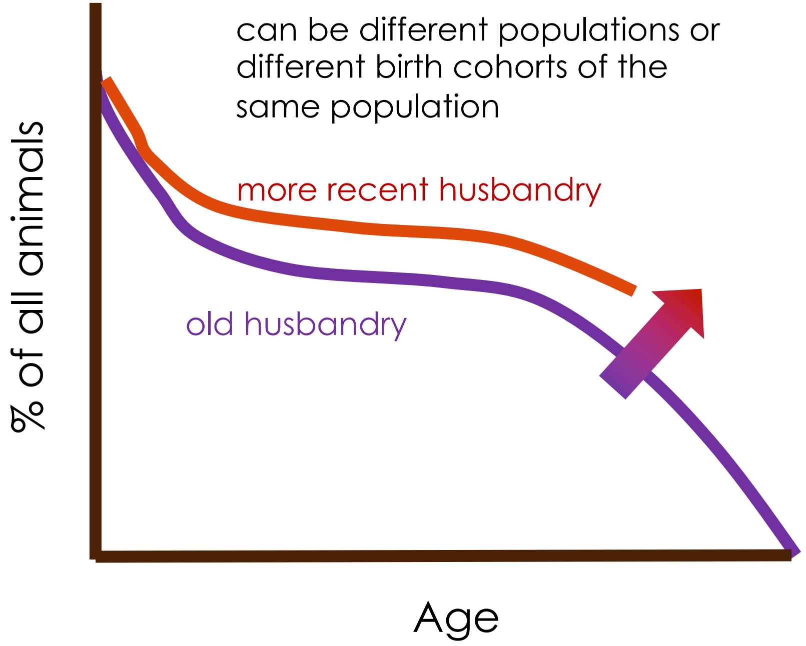
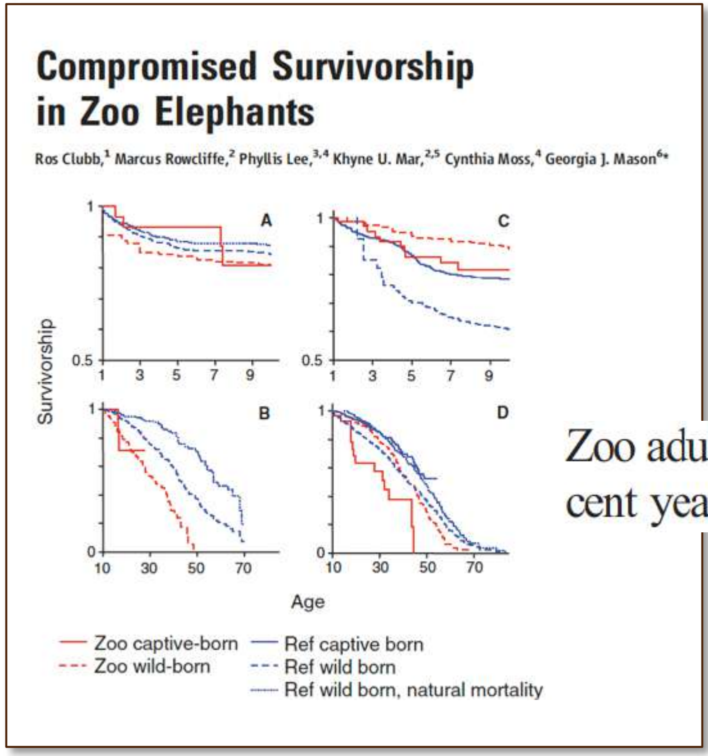




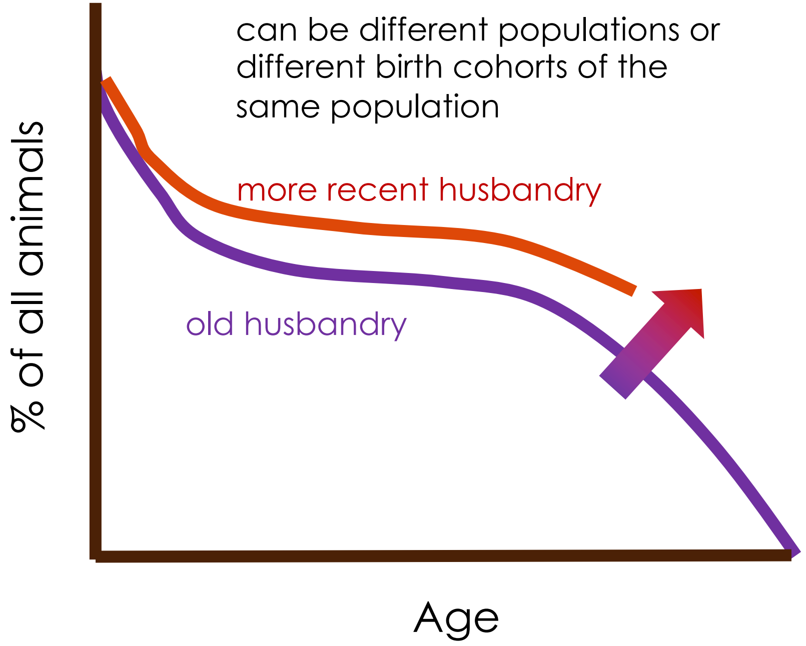
Cox Proportional Hazard analysis:

is the survivorship different between the groups ?
is there significant change with time (birth date) ?

Survivorship



Zoo adult African survivorship has improved in recent years [$z = -2.75$, $P < 0.01$ (5)]



Cox Proportional Hazard analysis:

is the survivorship different between the groups ?
is there significant change with time (birth date) ?

A fundamental distinction: science and rhetoric

Compromised Survivorship in Zoo Elephants

as Compared to Some Selected *in situ* Populations Declared 'Benchmarks'

Ros Clubb,[1] Marcus Rowcliffe,[2] Phyllis Lee,[3,4]

Wild animals can experience poor welfare when held captive (*1*), an effect with ethical and practical implications. In zoos, the welfare of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) has long caused concern. Infanticide, *Herpes*, tuberculosis, lameness, infertility, and stereotypic behavior are prevalent (*2*), and zoo elephant populations are not self-sustaining without importation (*3*). We compiled data from over 4500 individuals to compare survivorship in zoos with protected populations in range countries. Data representing about half the global zoo population (1960 to 2005) came from European "studbooks" and the European Elephant Group (*4*). We focused on females as relevant to population viability ($N = 786$, both wild-caught and captive-born; 302 African and 484 Asian). African elephants in Amboseli National Park, Kenya ($N = 1089$), and Asian elephants in the Burmese logging industry (Myanma Timber Enterprise, M.T.E., $N = 2905$, wild-caught and captive-born) acted as well-provisioned reference populations [for details, see (*2*) and (*5*)].

For African elephants, median life spans (excluding premature and still births) were 16.9 years [95% confidence interval (CI) 16.4 to unknown; upper estimate for median not reached] for zoo-born females and 56.0 years (95% CI 51.5 to unknown) for Amboseli females undergoing natural mortality (35.9 years with human-induced deaths, 95% CI 33.8 to 40.3). Neither infant nor juvenile mortality differed between populations (Fig. 1A and tables S1 and S2), but adult females died earlier in zoos than in Amboseli (Fig. 1B and table S2). Zoo adult African survivorship has improved in recent years [$z = -2.75$, $P < 0.01$ (*5*)], but mortality risks in our data set's final year (2005) remained 2.8 times higher (95% CI 1.2 to 6.5) than that of Amboseli females undergoing natural mortality.

For Asian elephants, median life spans (excluding premature and still births) for captive-born females were 18.9 years in zoos (95% CI 17.7 to 34.0) and 41.7 years in the M.T.E. population (95% CI 38.2 to 44.6). Zoo infant mortality rates were high (over double those of M.T.E.): A female's first pregnancy therefore had only a 42% chance of yielding a live year-old in zoos compared with 83% in M.T.E. (table S1). Rates have not significantly improved over time (e.g., live births controlling for parity: $z = 1.19$, $P > 0.10$). For juveniles, captive-born survivorship did not significantly differ between populations, whereas wild-born survivorship was poorer in Burma (Fig. 1C and table S2) because of after-effects of capture (*5*). In adulthood, however, survivorship was lower in zoos (Fig. 1D and table S2), with no detectable improvement in recent years ($z = -1.48$, $P > 0.10$).

Within zoos, captive-born Asians have poorer adult survivorship than wild-born Asians (Fig. 1D and table S2). This is a true birth origin effect: Whereas zoo-born elephants are more likely to have been born recently and to primiparous dams, neither dam parity ($z = 0.86$, $P > 0.10$) nor recency ($z = -1.48$, $P > 0.10$) predict adult survivorship (controlling for recency makes birth origin more significant: $z = -3.52$, $P < 0.001$). Because the median importation age of wild-born females was about 3.4 years, this suggests that zoo-born Asians' elevated adult mortality risks are conferred during gestation or early infancy.

tended to be poorer in Asian calves removed from mothers at young ages ($z = -1.92$, $P < 0.10$) (*5*).

Overall, bringing elephants into zoos profoundly impairs their viability. The effects of early experience, interzoo transfer, and possibly maternal loss, plus the health and reproductive problems recorded in zoo elephants [e.g., (*2*)], suggest stress and/or obesity as likely causes.

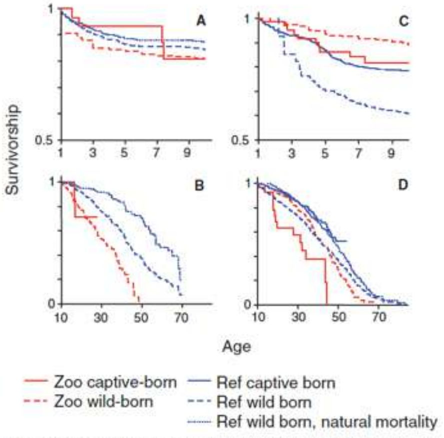


Fig. 1. Kaplan-Meier survivorship curves for female African (**A** and **B**) and Asian (**C** and **D**) elephants aged 1 to 10 [juveniles in (A) and (C)] and 10+ years [adults in (B) and (D)]. For wild-born reference (Ref, Amboseli or M.T.E.) populations, natural mortality excludes human-caused deaths; all mortality includes them (5). Results of statistical comparisons are given in table S2.

References and Notes
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5. Methods and supplementary results are available as supporting material on *Science* Online.
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Supporting Online Material
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Tables S1 and S2
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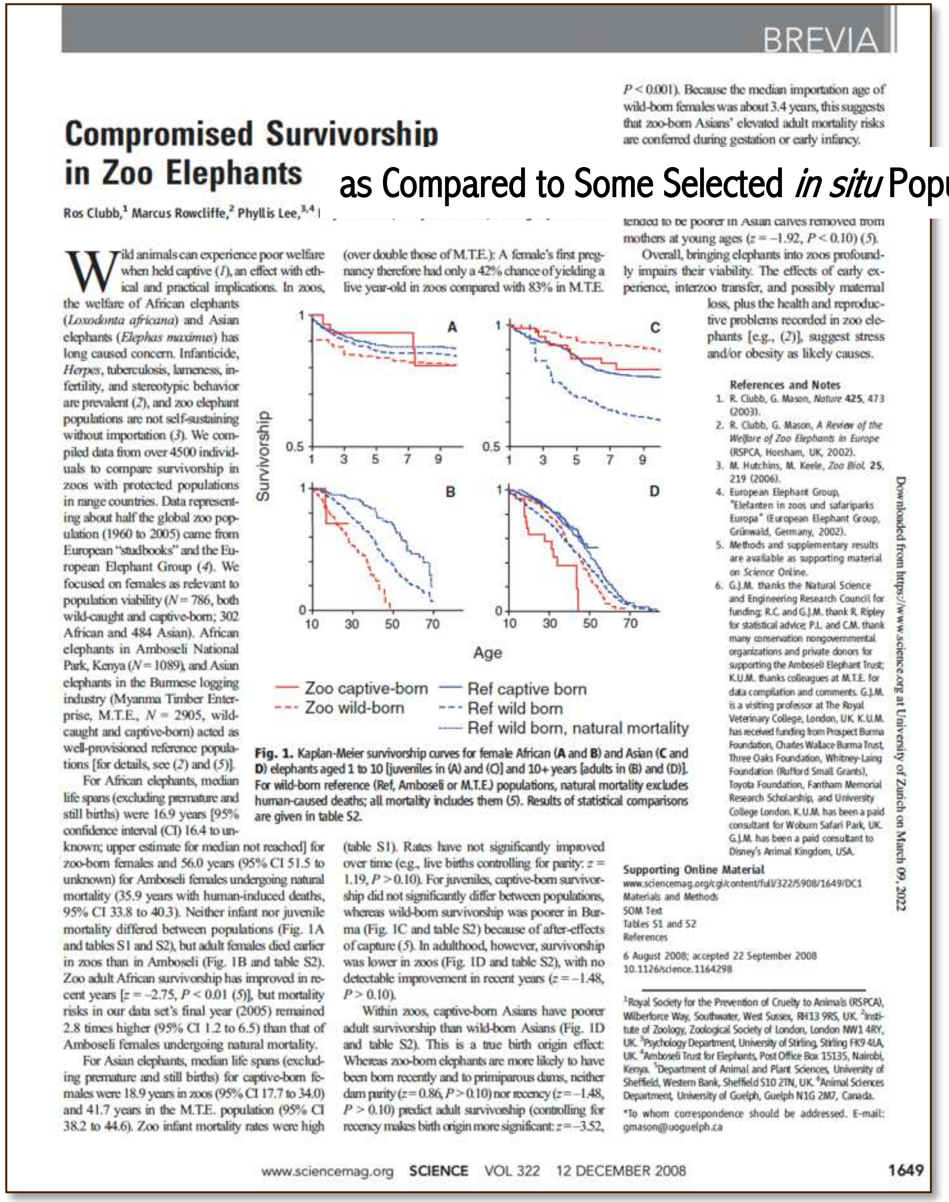
[1]Royal Society for the Prevention of Cruelty to Animals (RSPCA), Wilberforce Way, Southwater, West Sussex, RH13 9RS, UK. [2]Institute of Zoology, Zoological Society of London, London NW1 4RY, UK. [3]Psychology Department, University of Stirling, Stirling FK9 4LA, UK. [4]Amboseli Trust for Elephants, Post Office Box 15135, Nairobi, Kenya. [5]Department of Animal and Plant Sciences, University of Sheffield, Western Bank, Sheffield S10 2TN, UK. [6]Animal Sciences Department, University of Guelph, Guelph N1G 2M7, Canada.
*To whom correspondence should be addressed. E-mail: gmason@uoguelph.ca

A fundamental distinction: science and rhetoric



BREVIA

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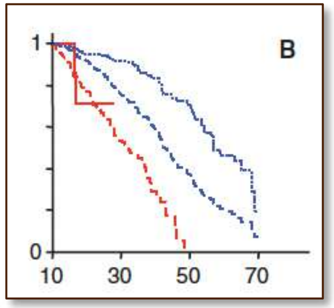
There should be little debate about the data.

<u>**The data itself is all correct (MC).**</u>

The debate is about the methods of calculation …

… but most of all about the rhetorical conclusions.

‘Benchmark’ populations ?



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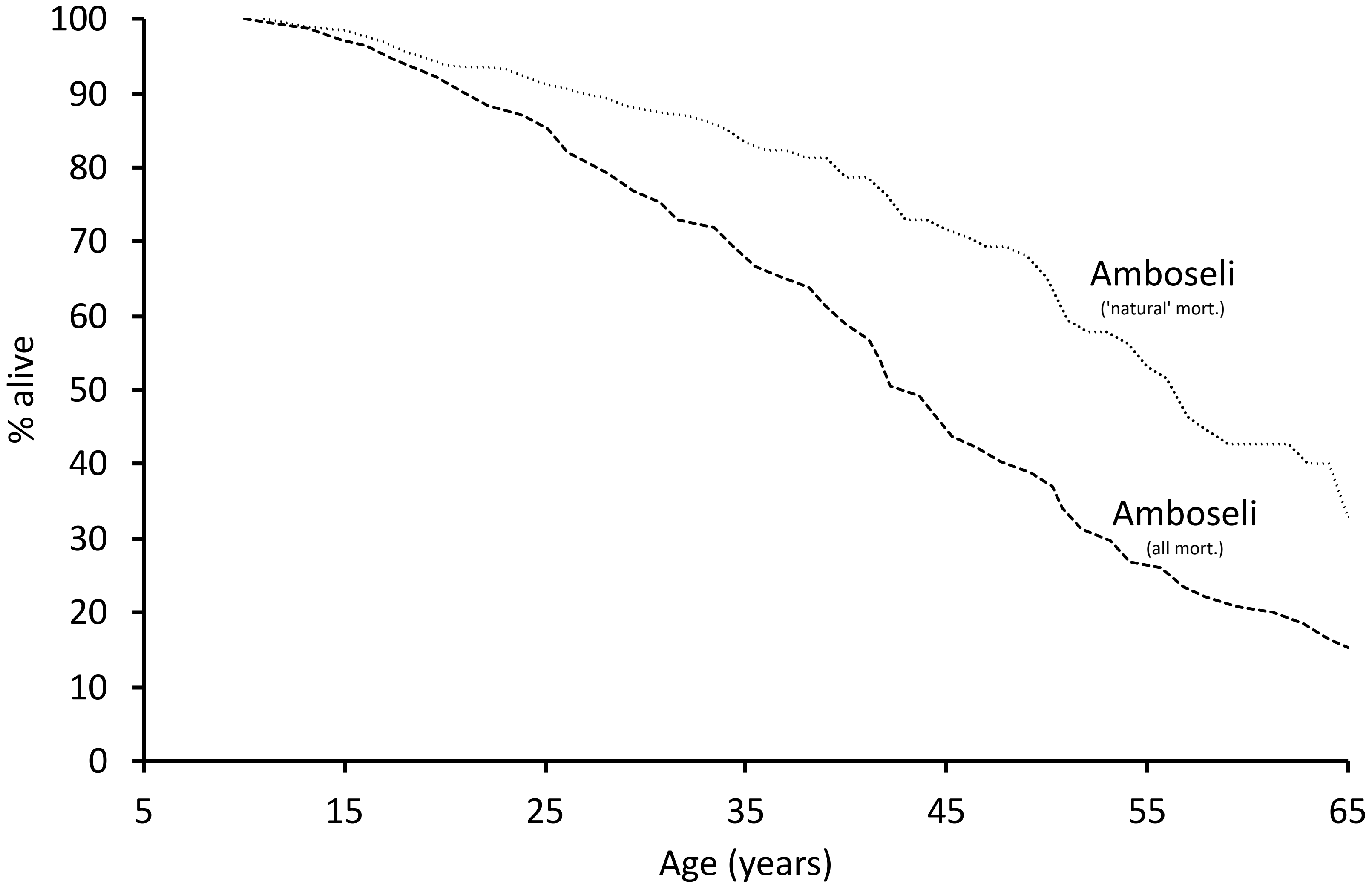

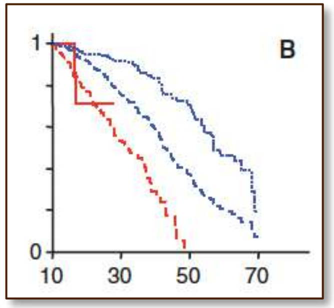

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Amboseli Natl Park,
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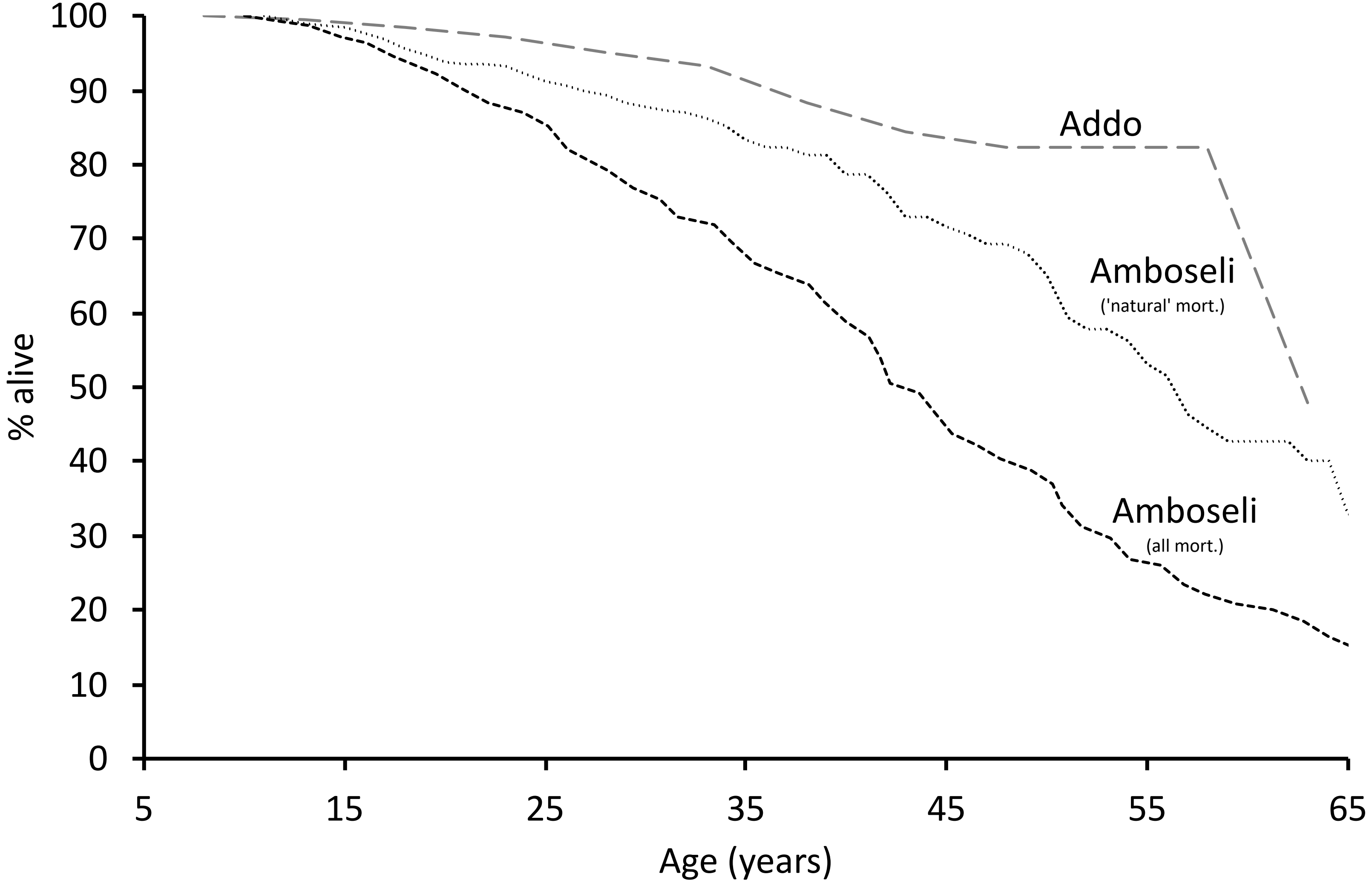

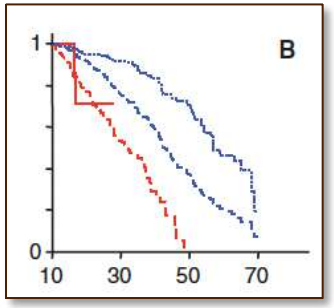

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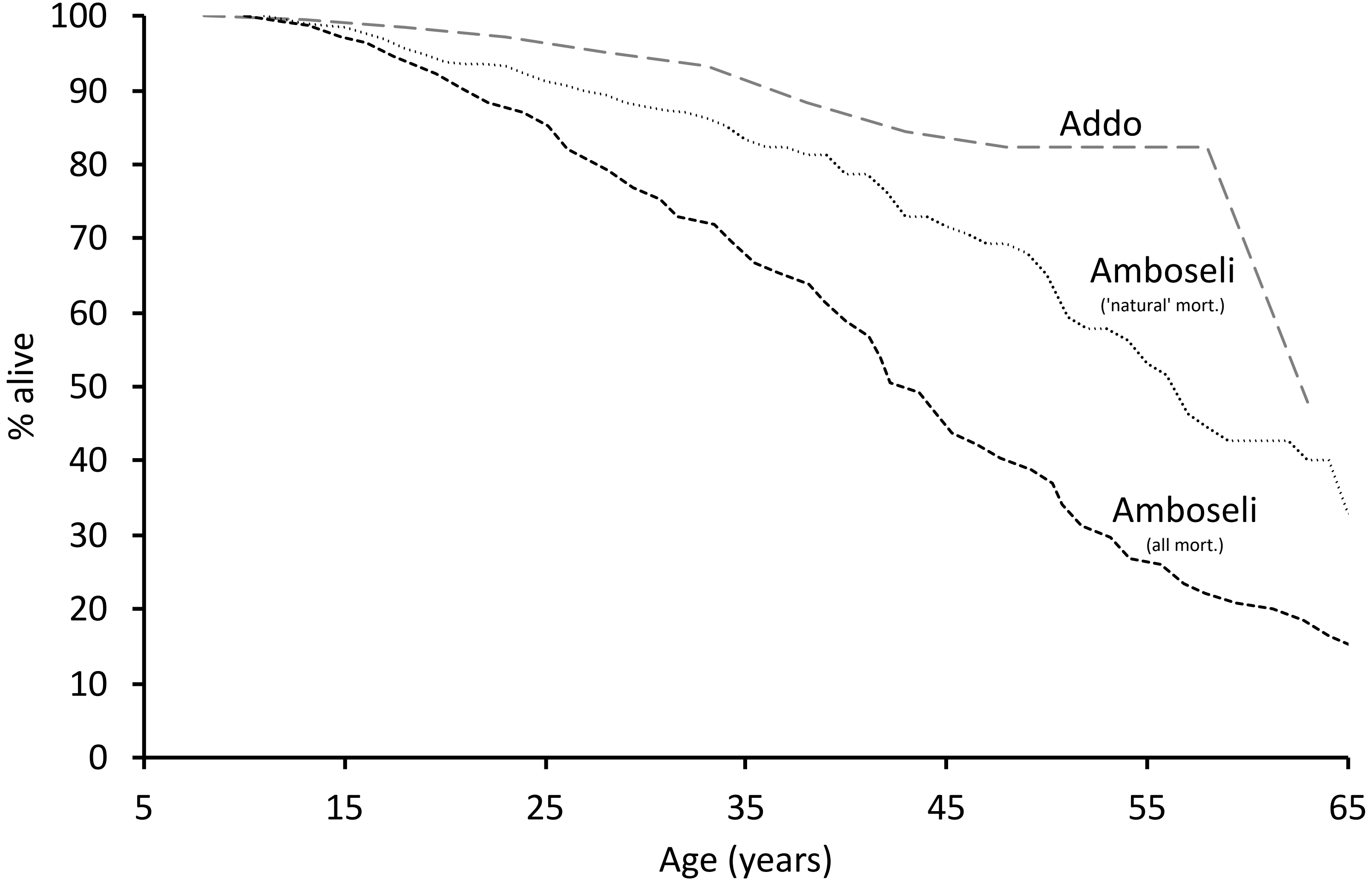

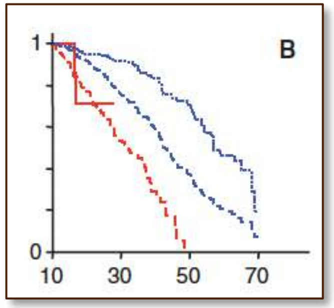

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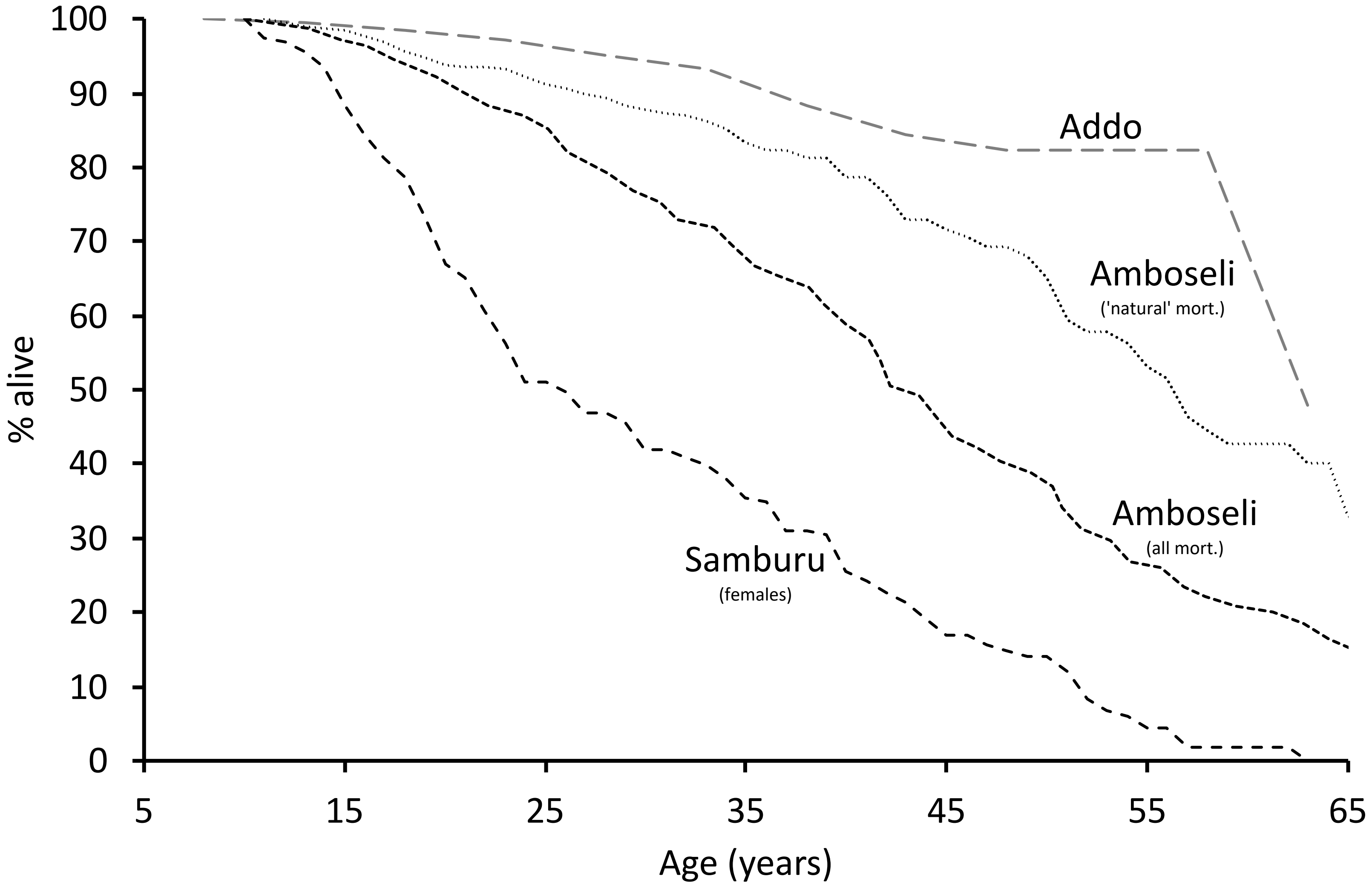

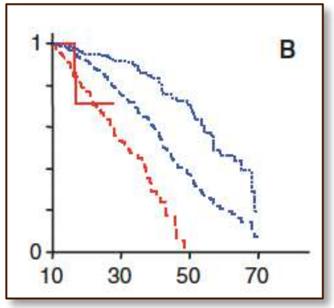

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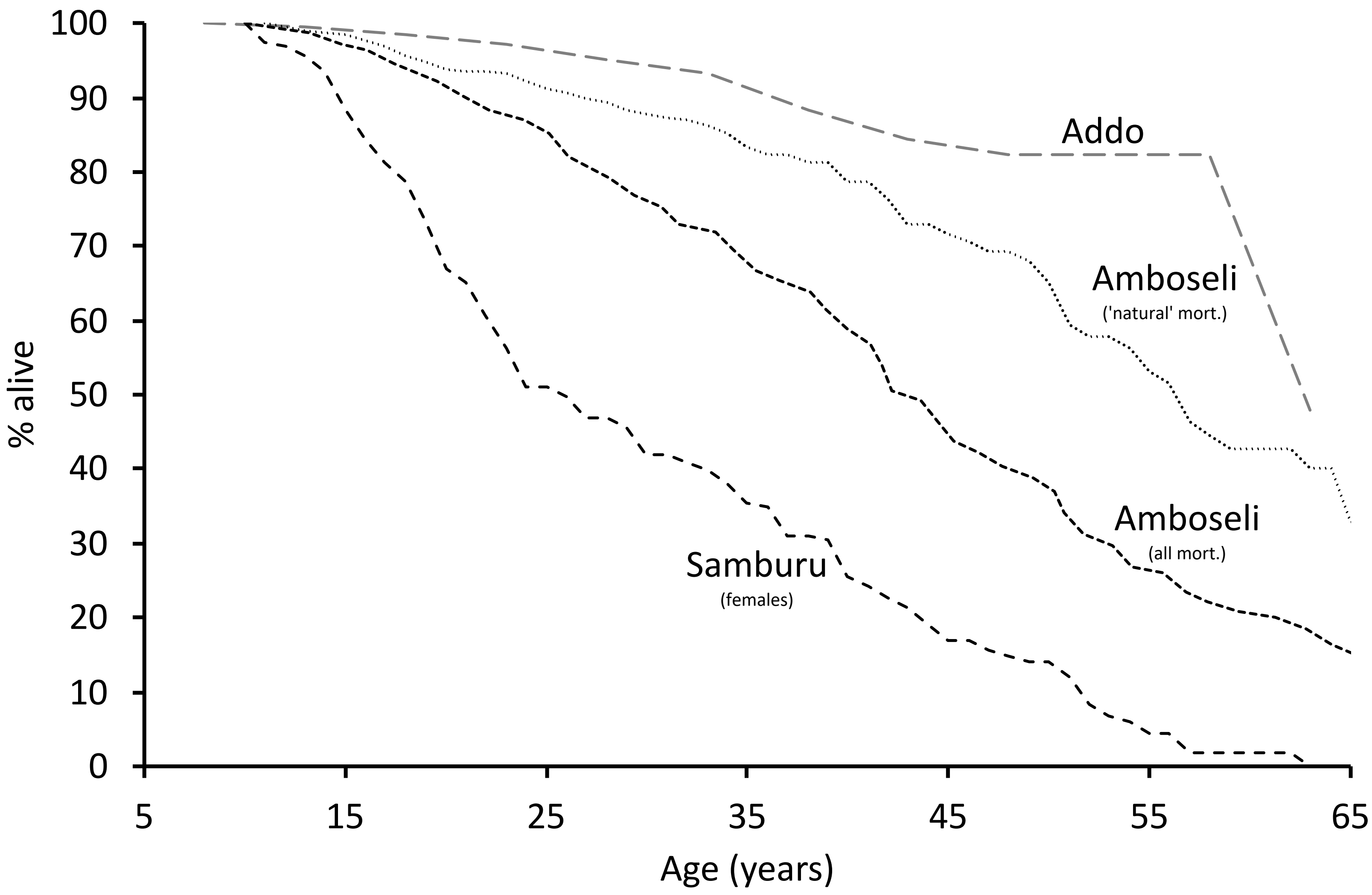

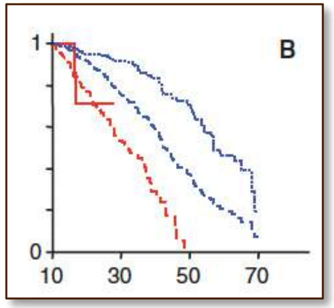

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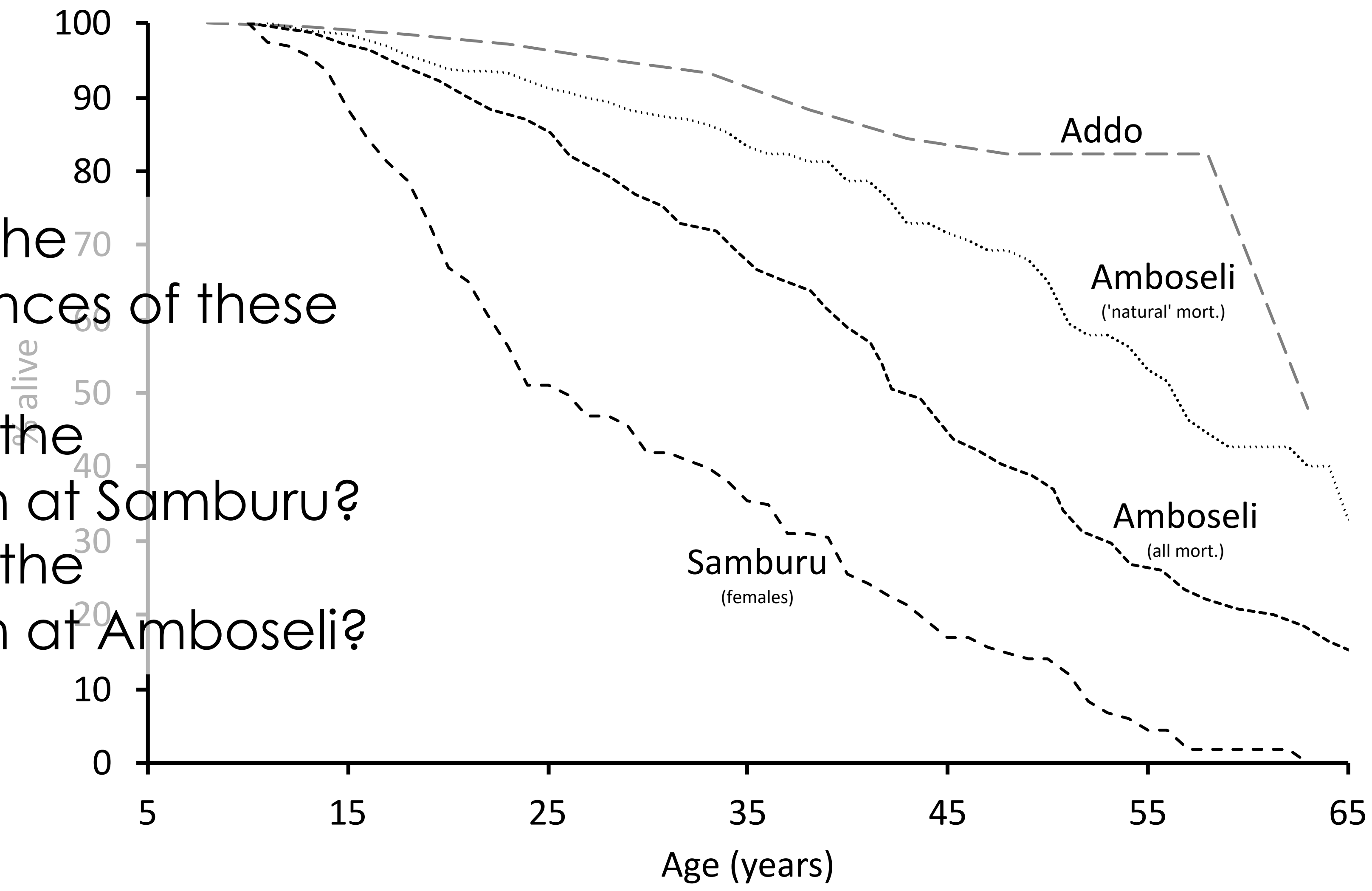
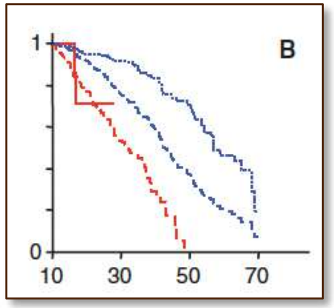


What are the consequences of these data?
Phase out the population at Samburu?
Phase out the population at Amboseli?



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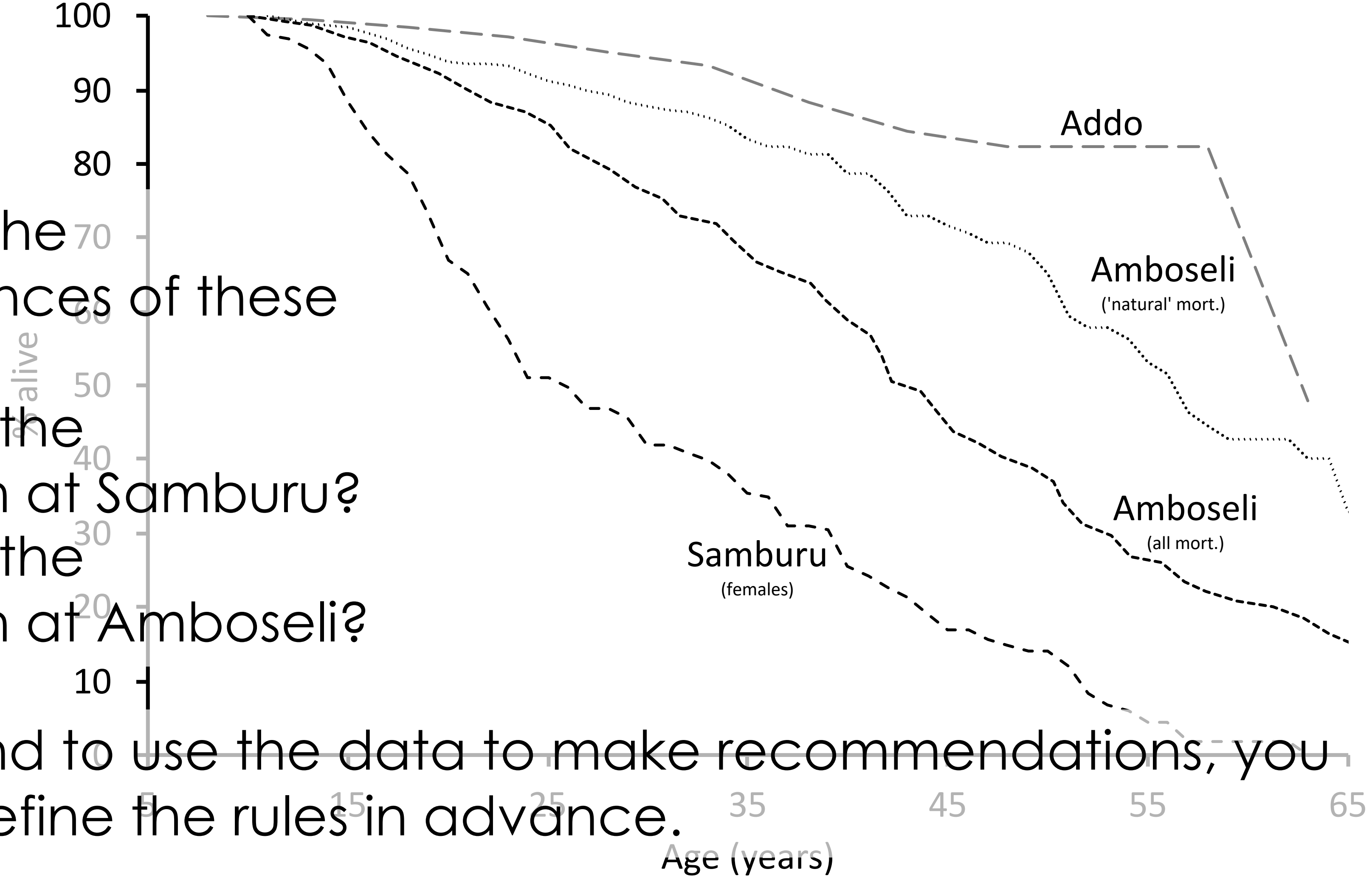

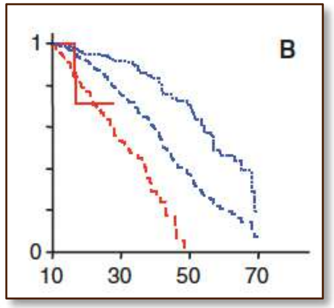

What are the consequences of these data?

Phase out the population at Samburu?

Phase out the population at Amboseli?

If you intend to use the data to make recommendations, you need to define the rules in advance.

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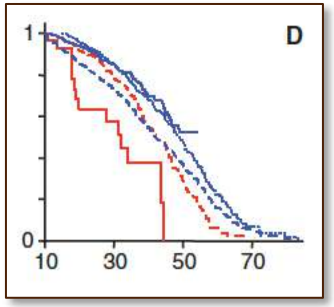

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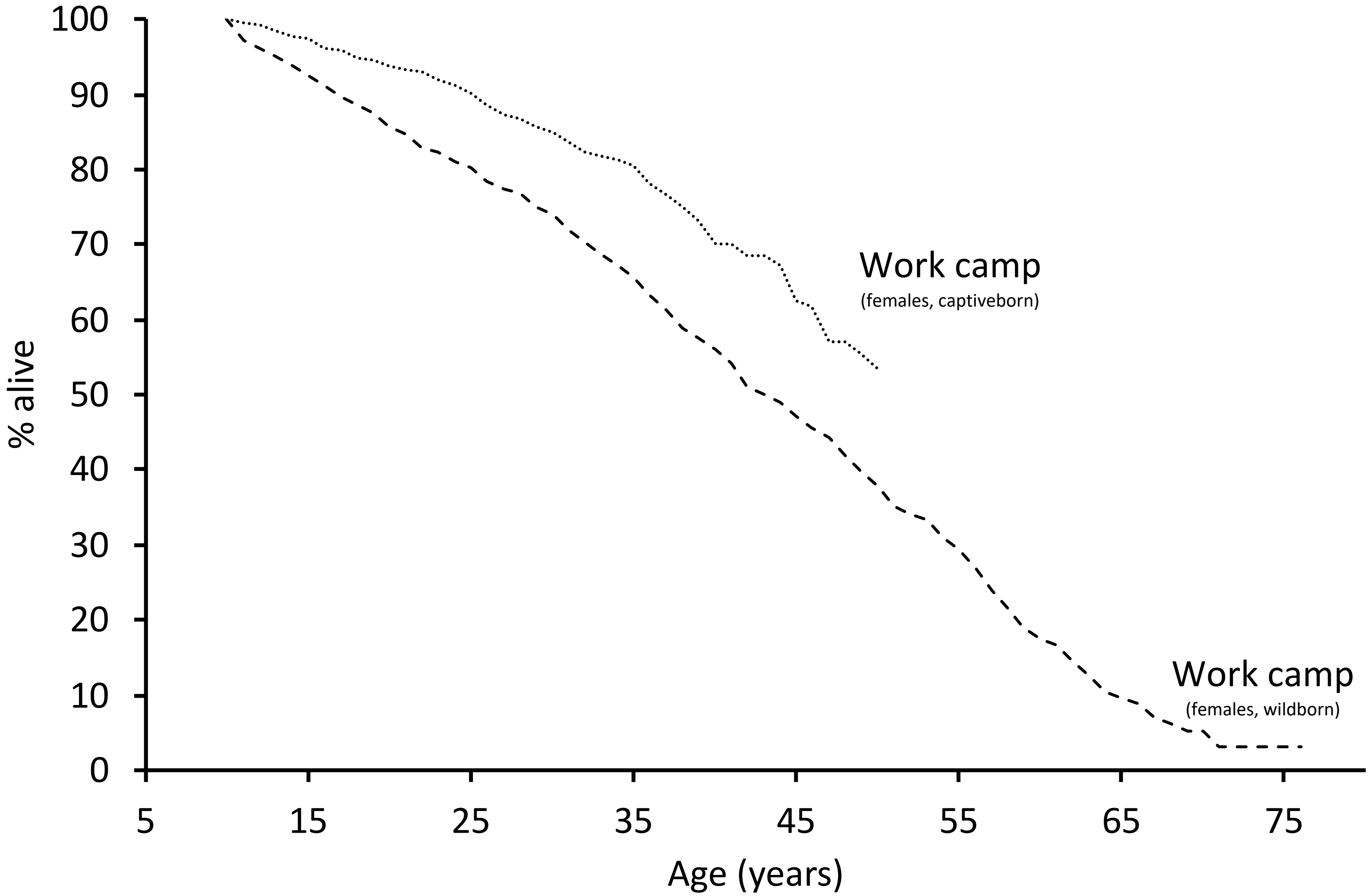

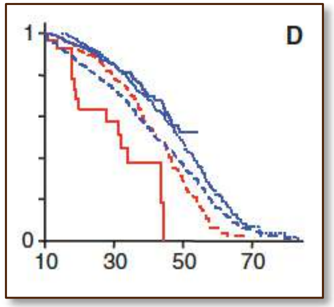

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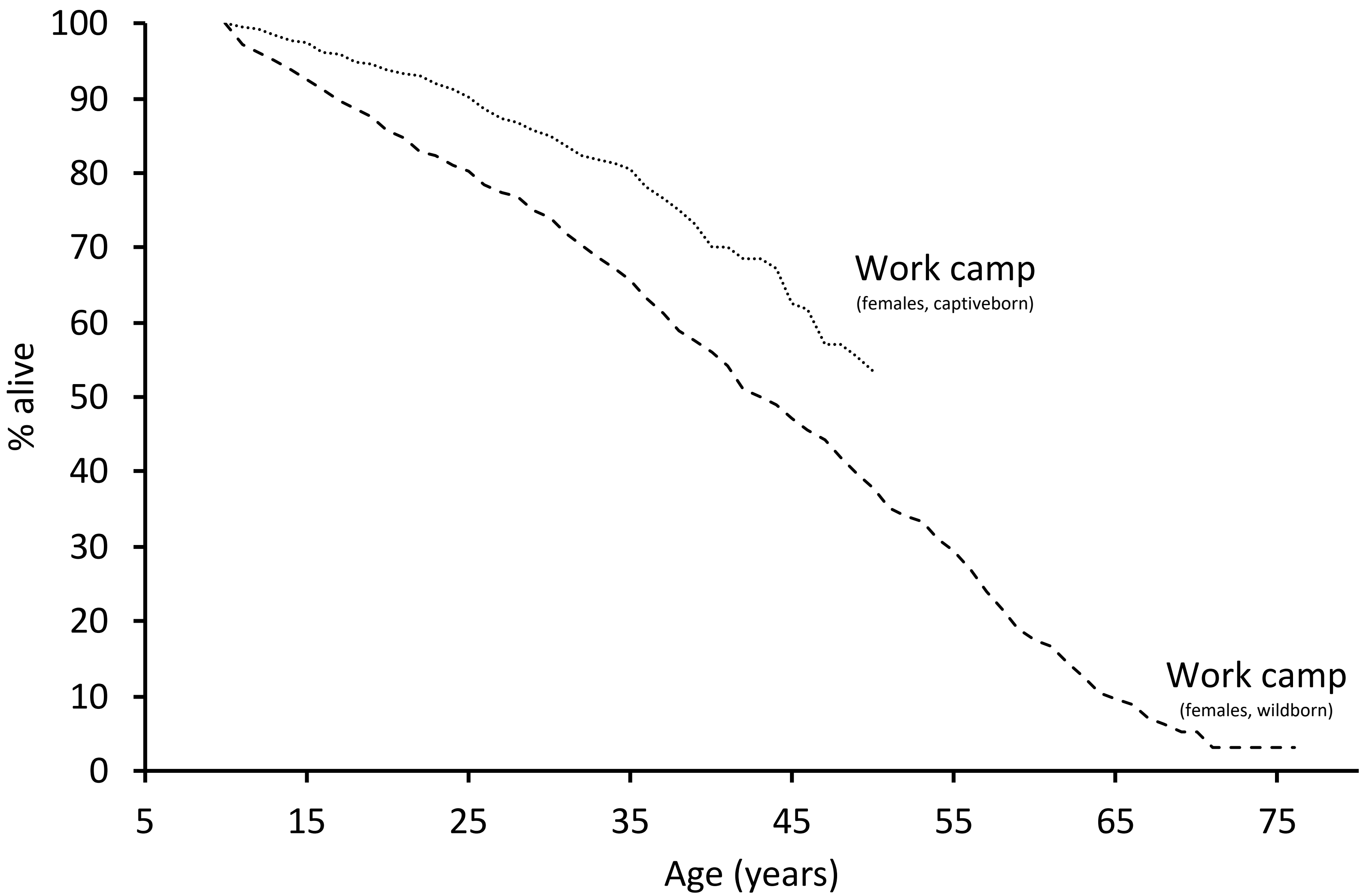
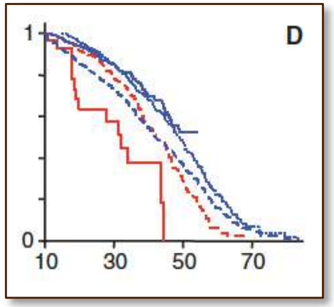
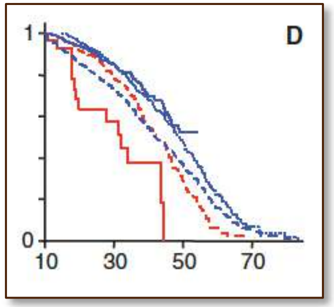




Mar (2007)
Mayanmar Timber
(1950-2000)

‘Benchmark’ populations ?



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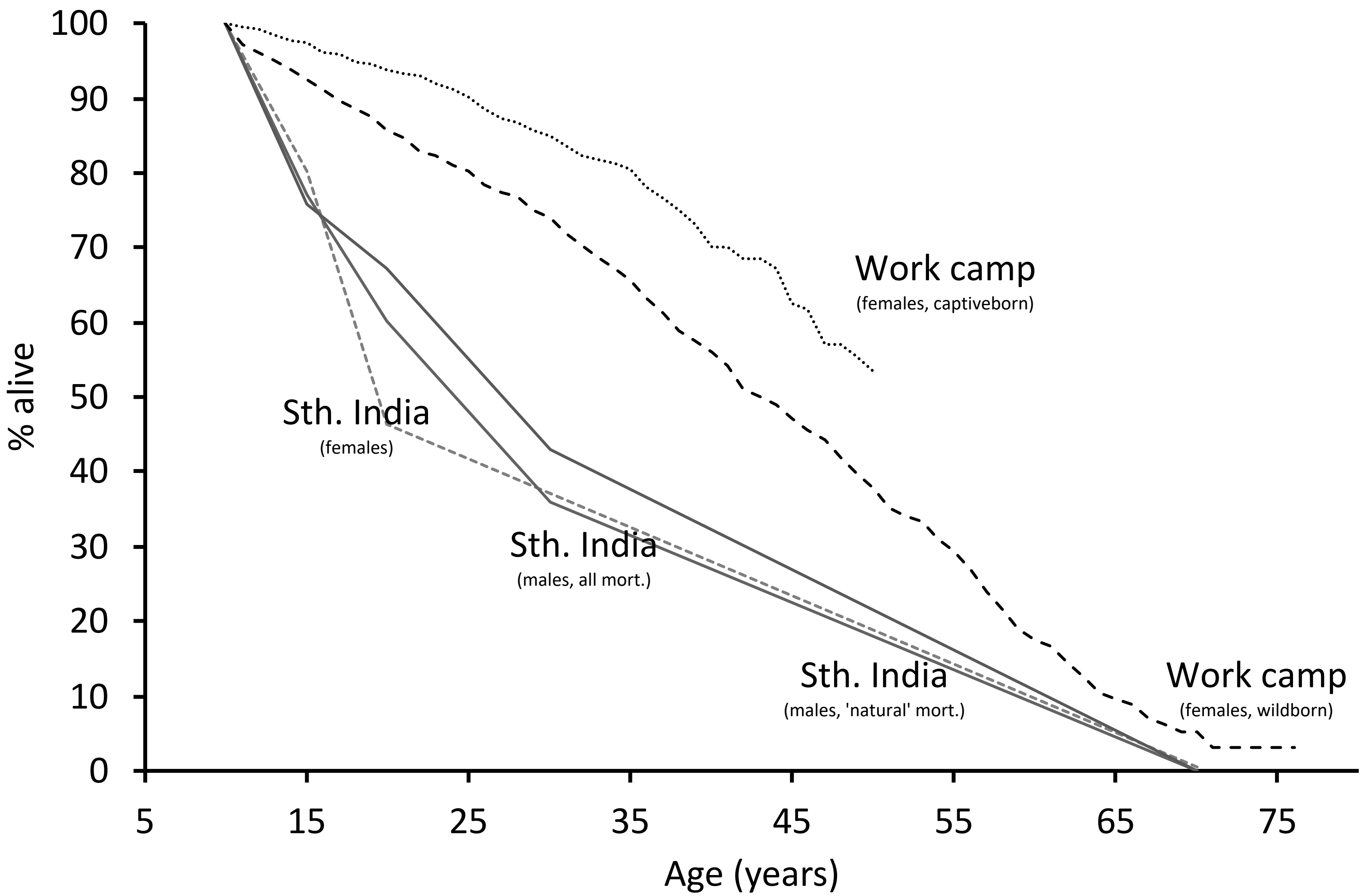

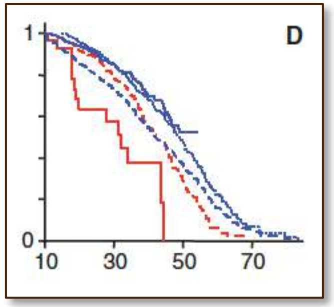

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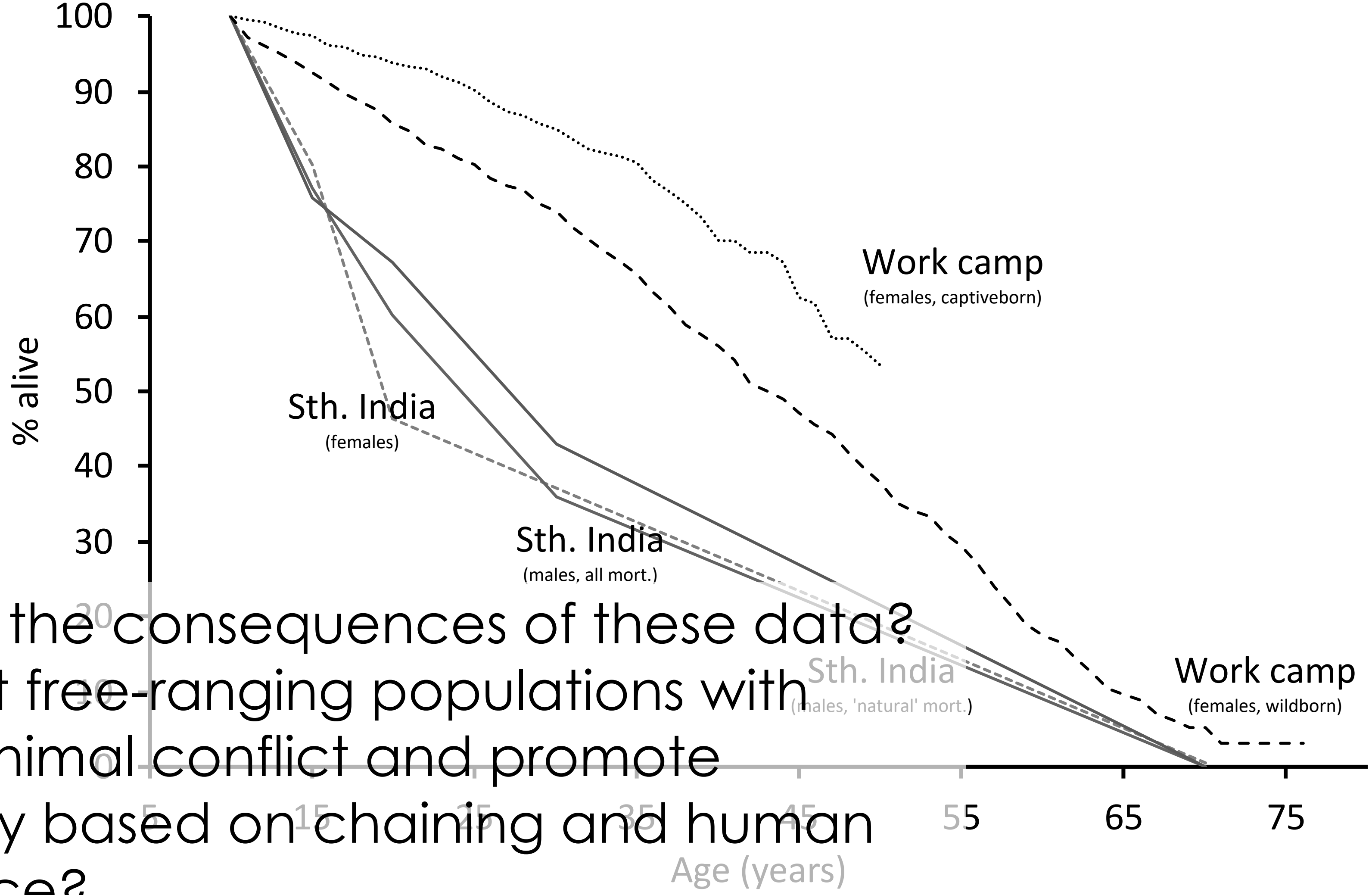

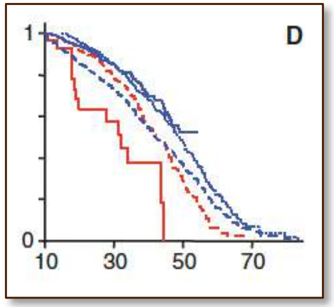

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Sukumar (1989)
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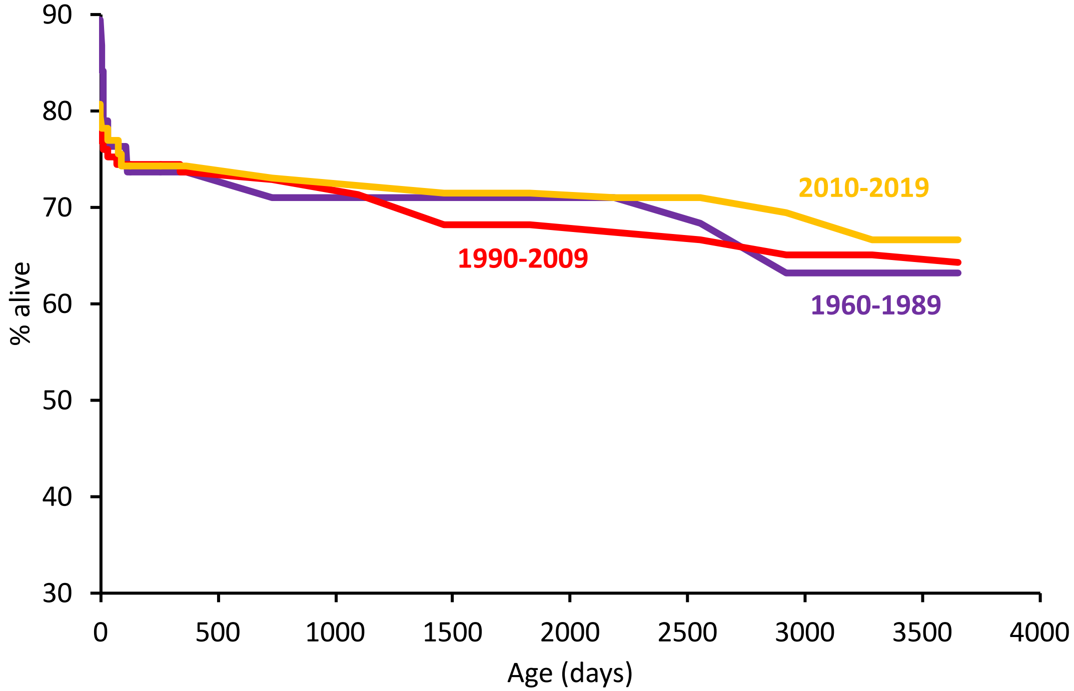
(1981-1983)

What are the consequences of these data?
Phase out free-ranging populations with human-animal conflict and promote husbandry based on chaining and human dominance?

Juvenile mortality (zooborn only)

Juvenile mortality (zooborn only)



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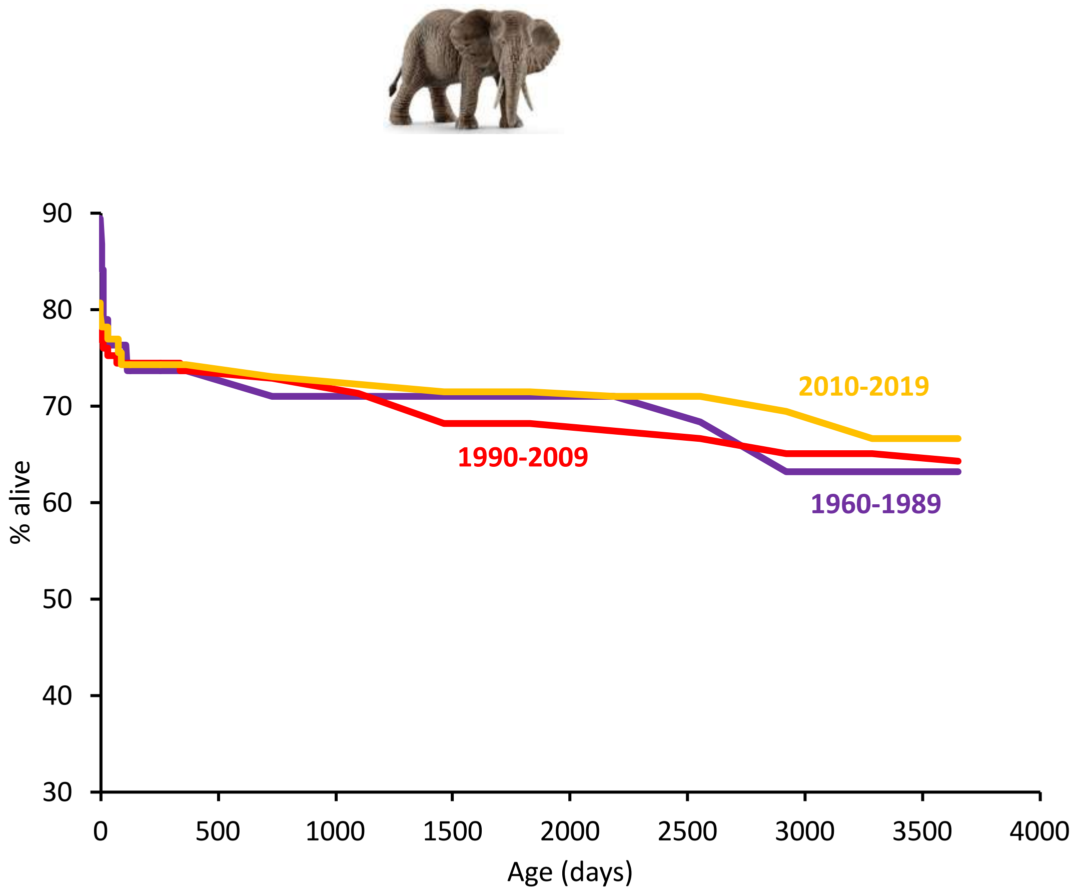

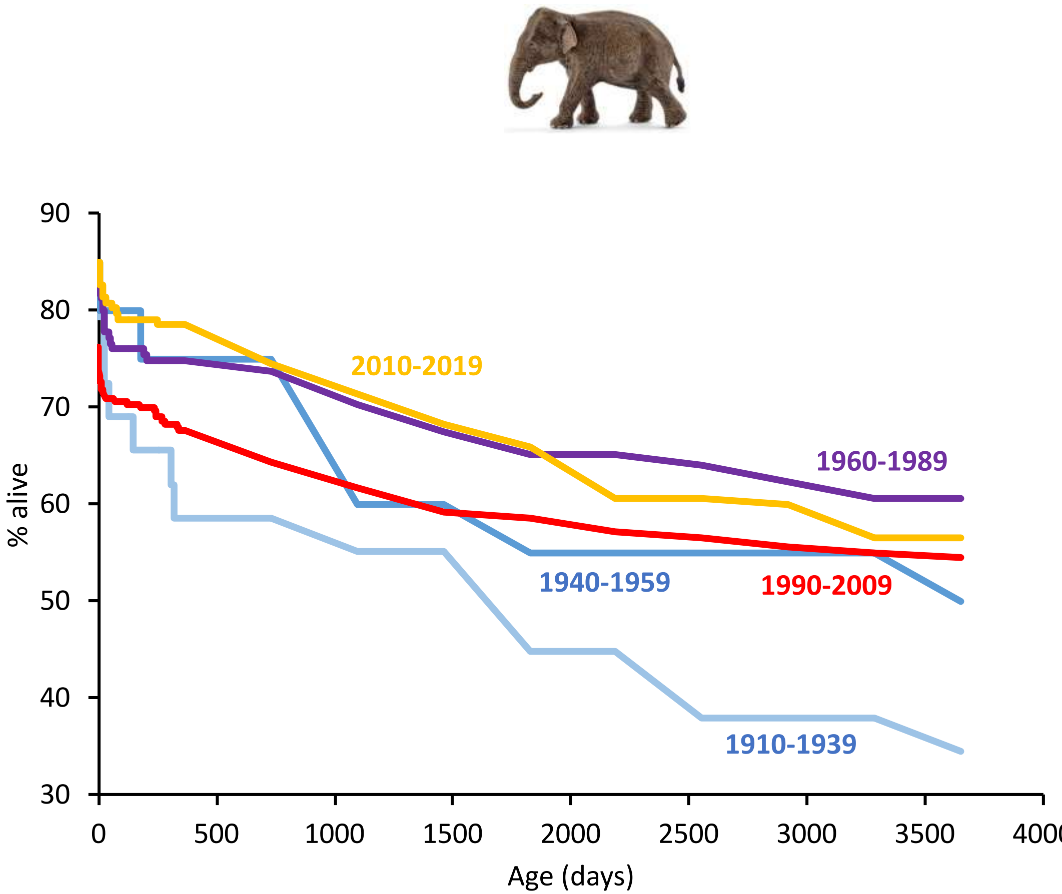

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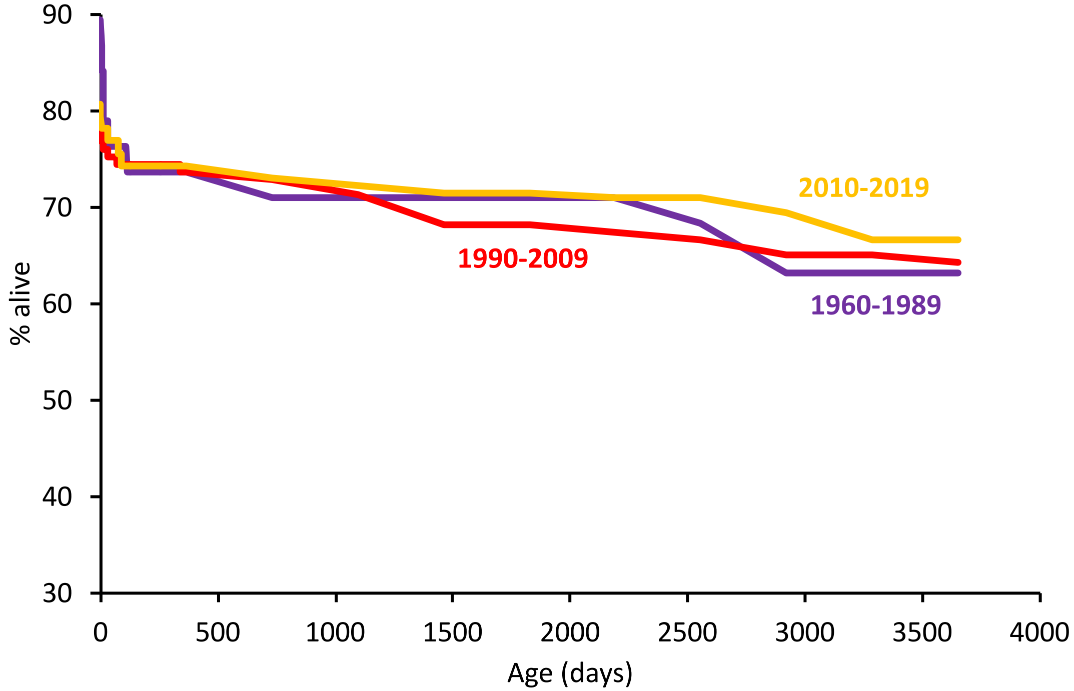

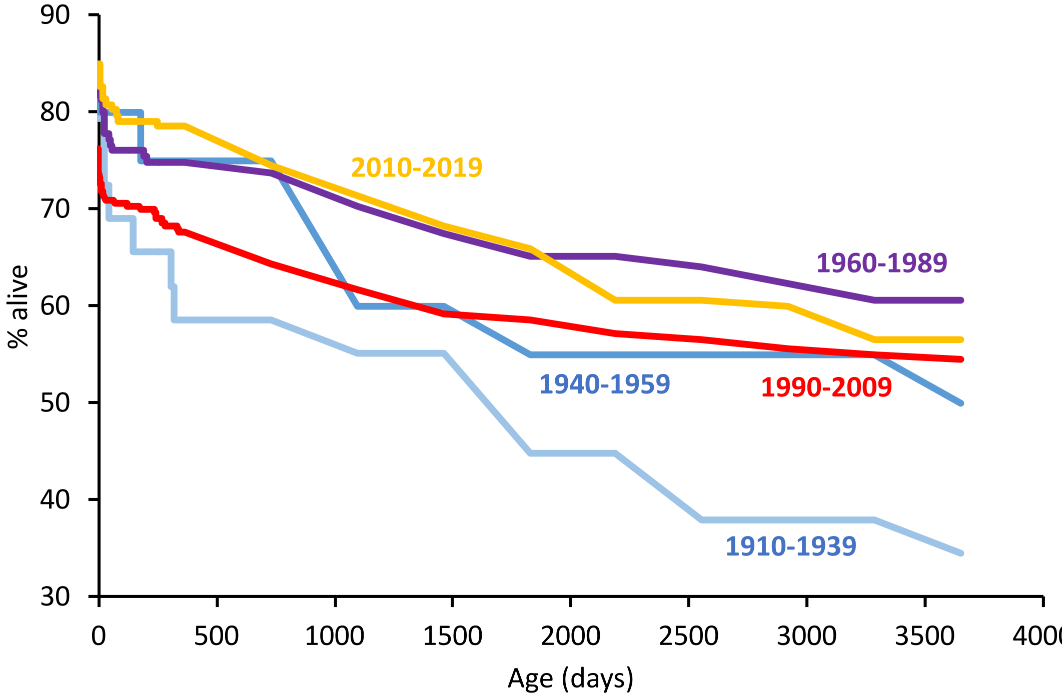

no significant change over time (except in Asians compared to 1910-1939)

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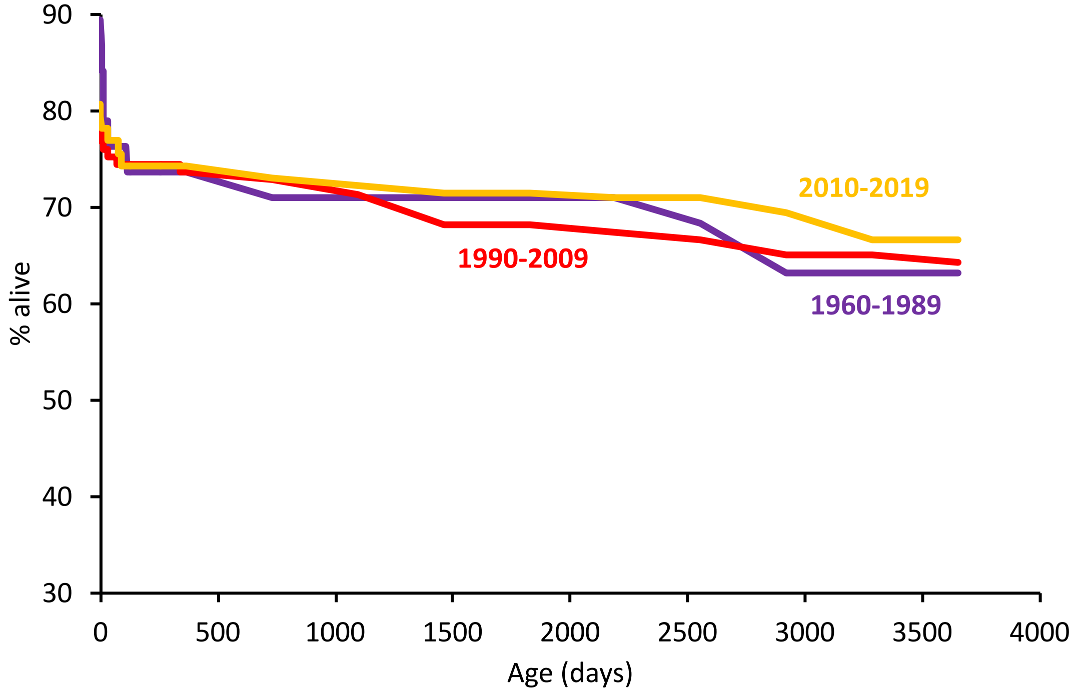
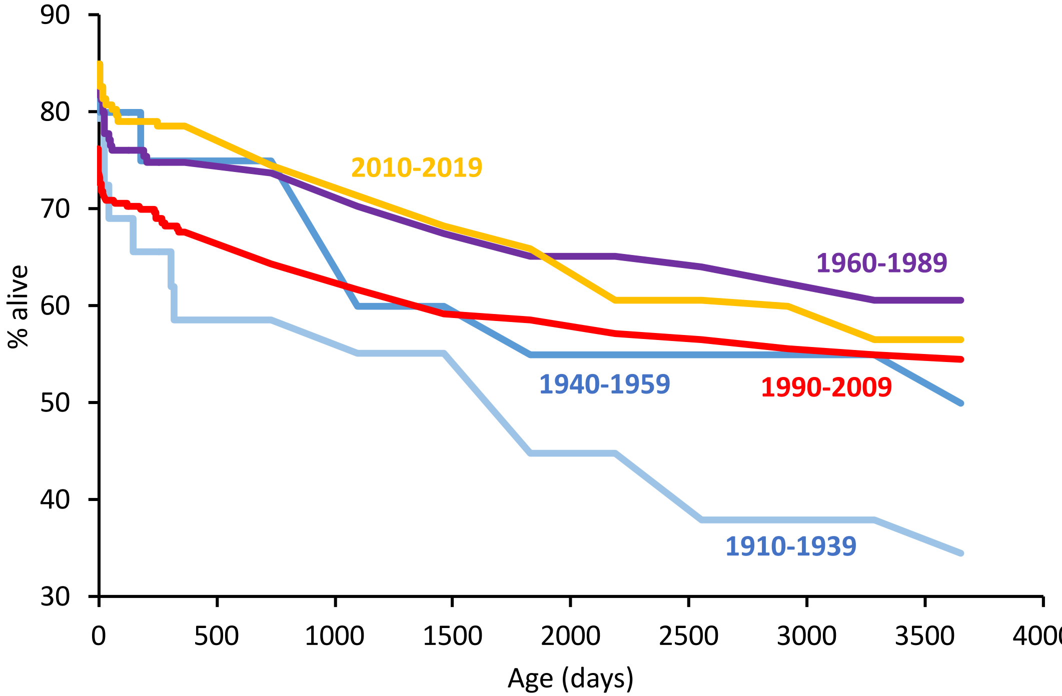
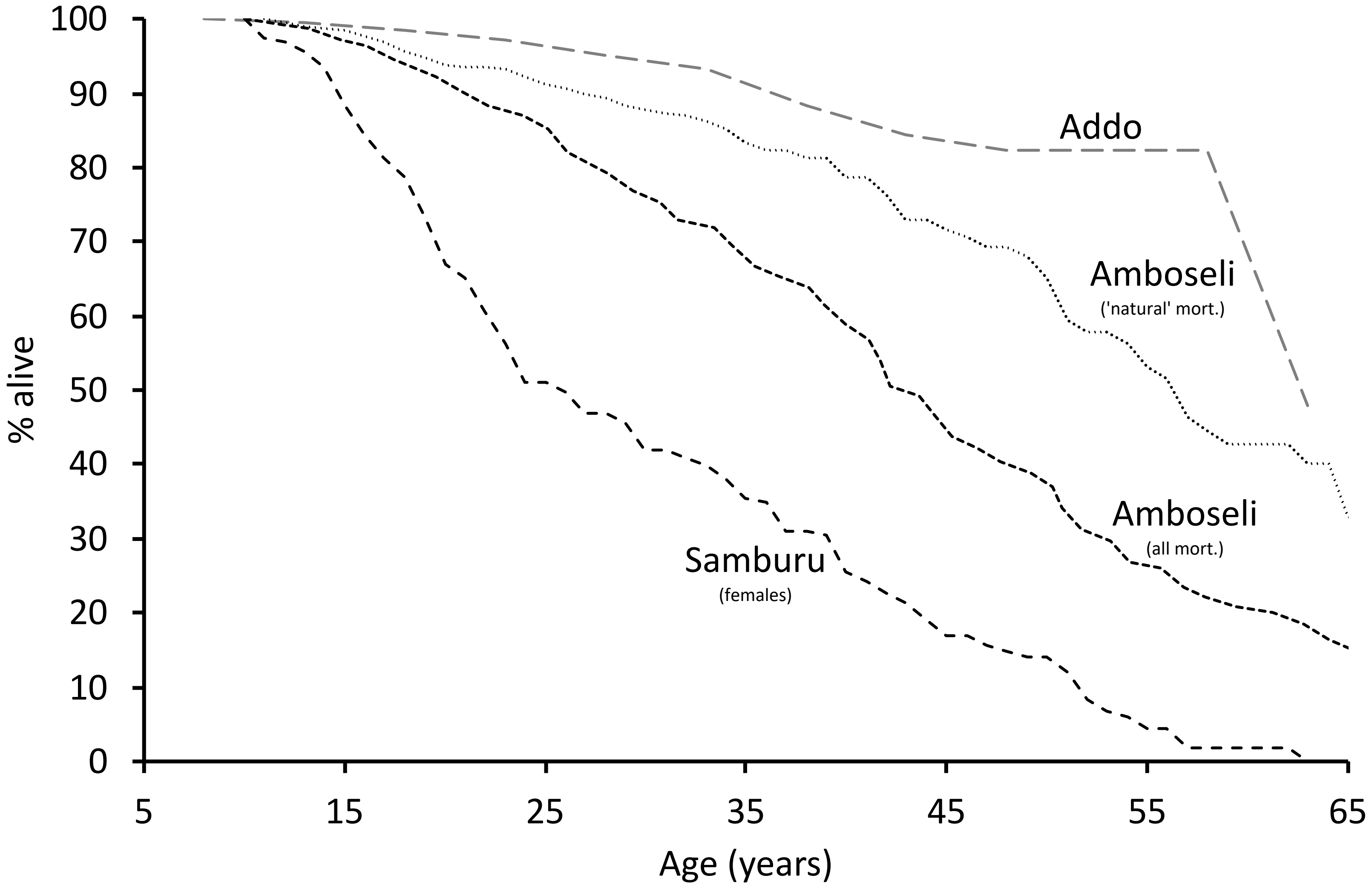
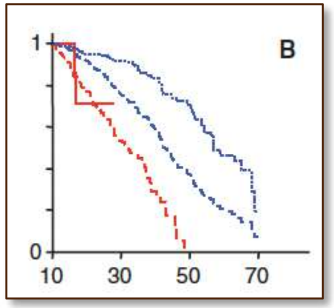




no significant change over time (except in Asians compared to 1910-1939)
since 1960: Asian elephants tend towards lower survivorship compared to African elephants (P = 0.080)

Adult survivorship – African elephants (N.Am. & EU)





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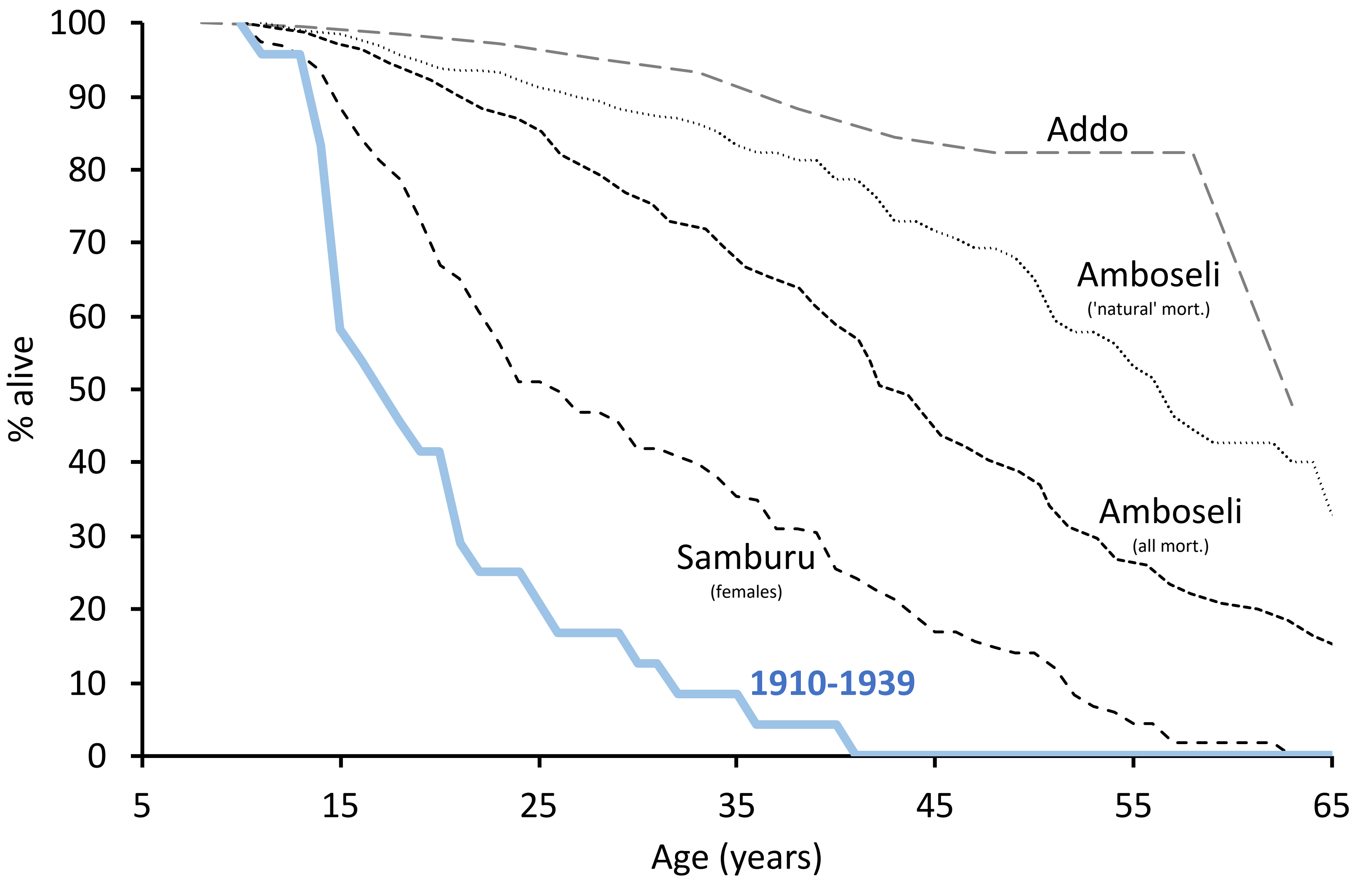

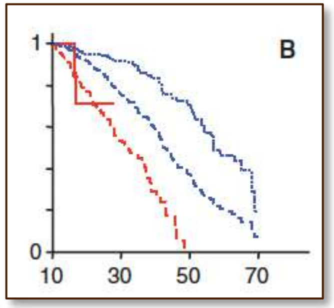

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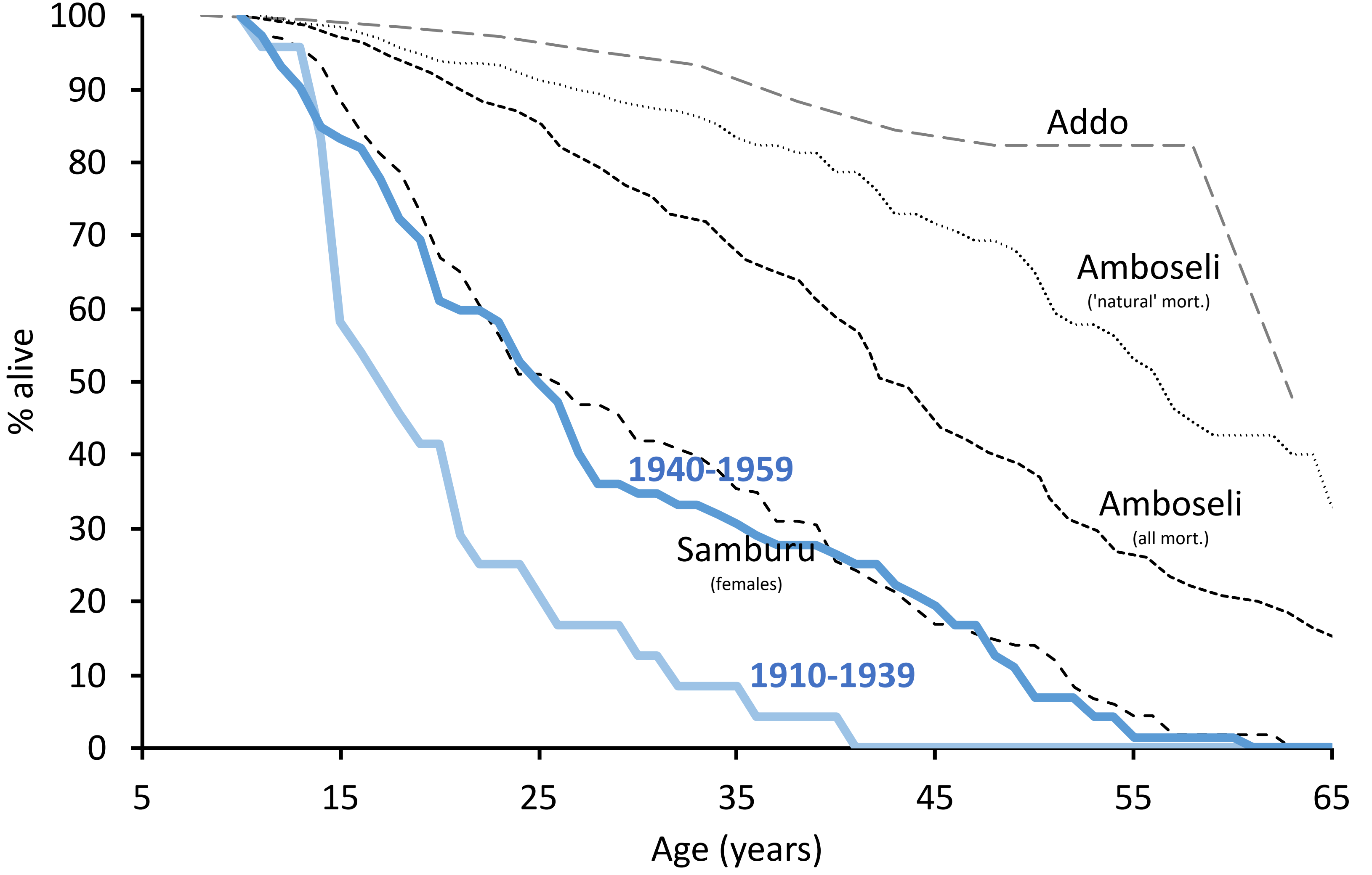

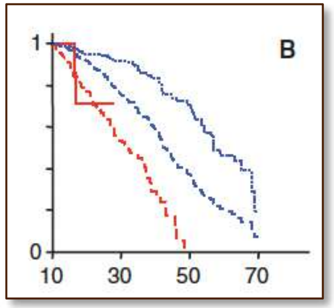

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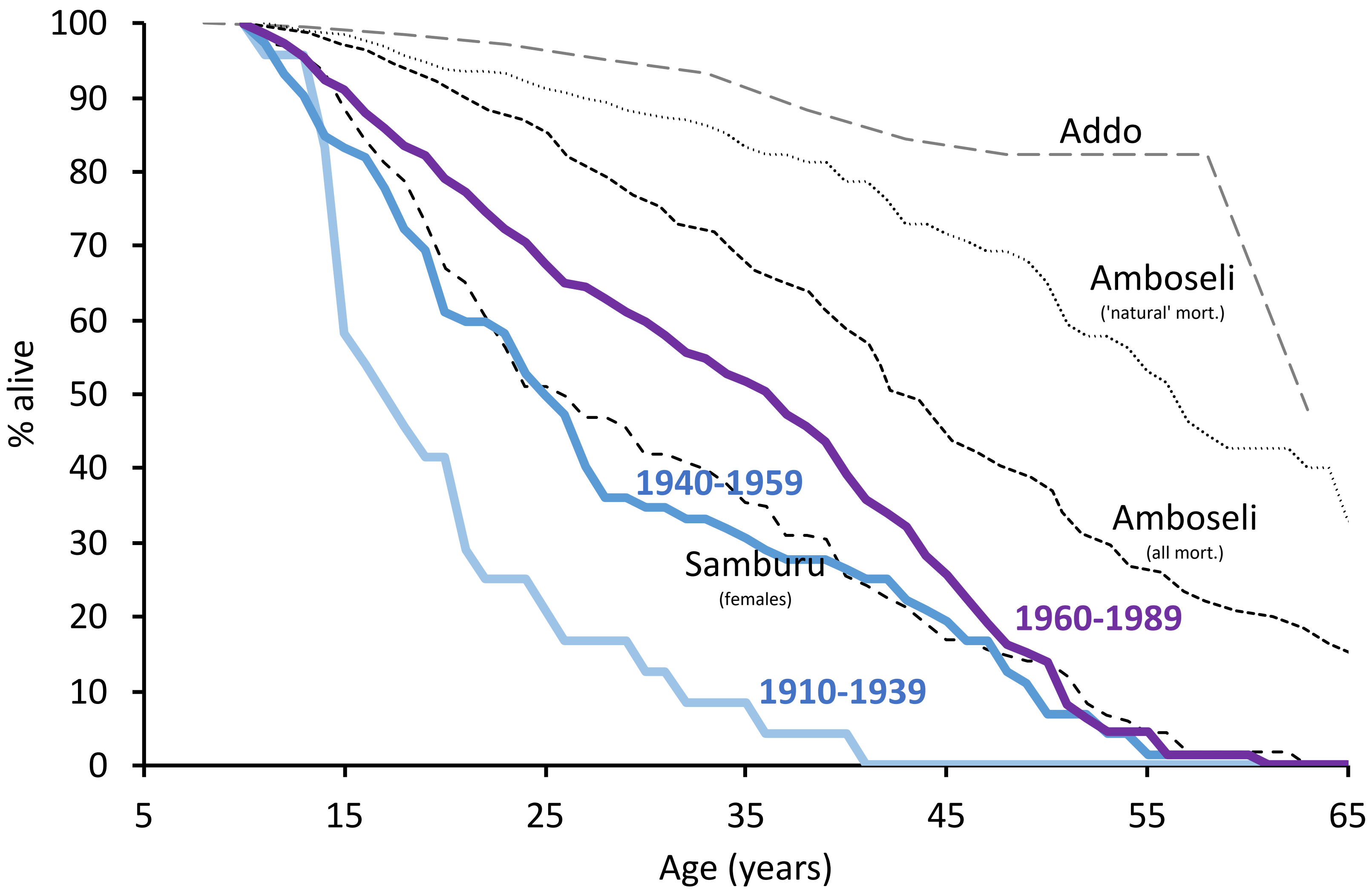

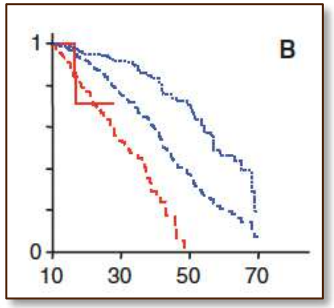

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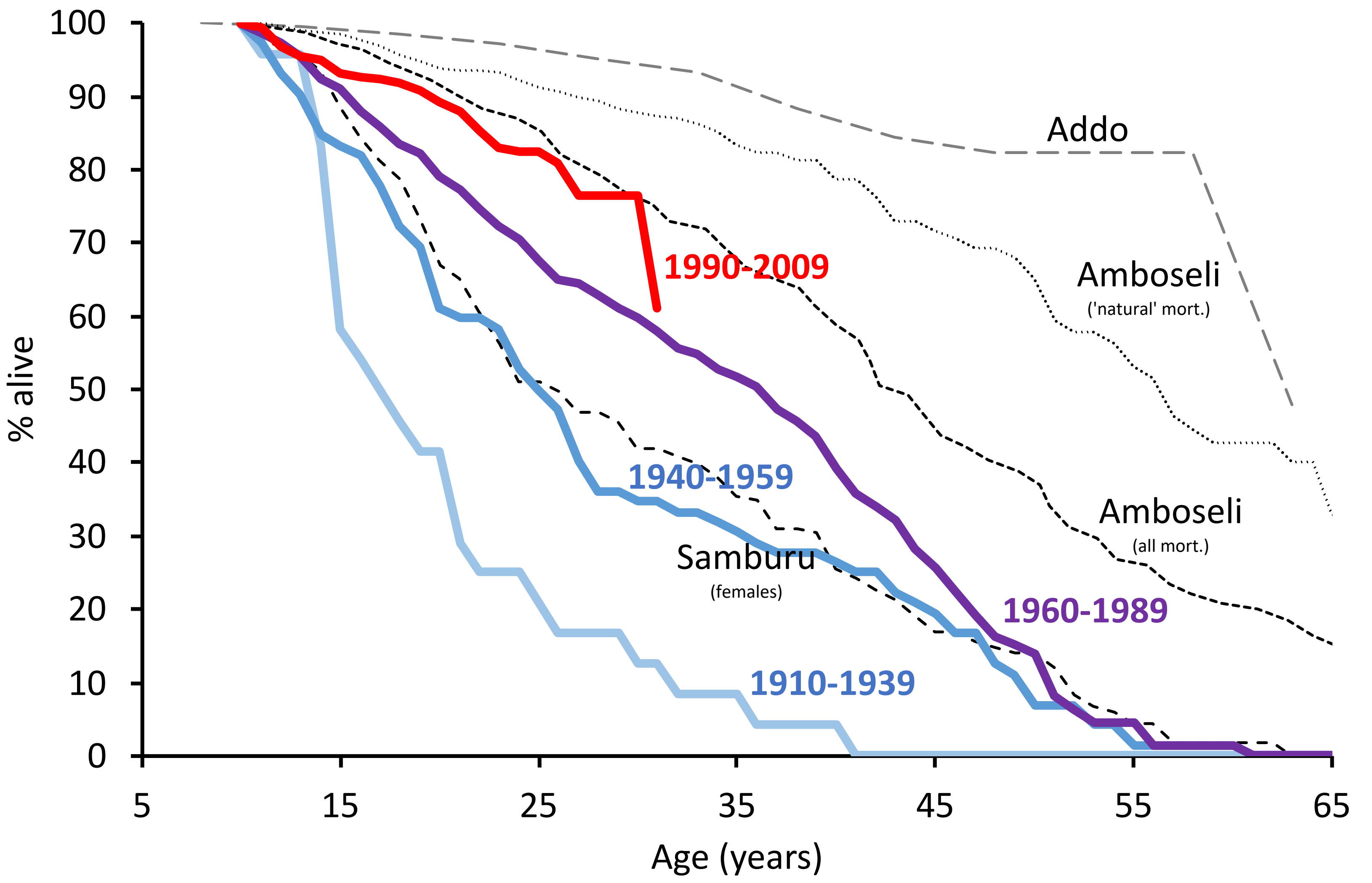

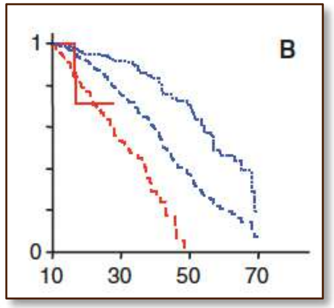

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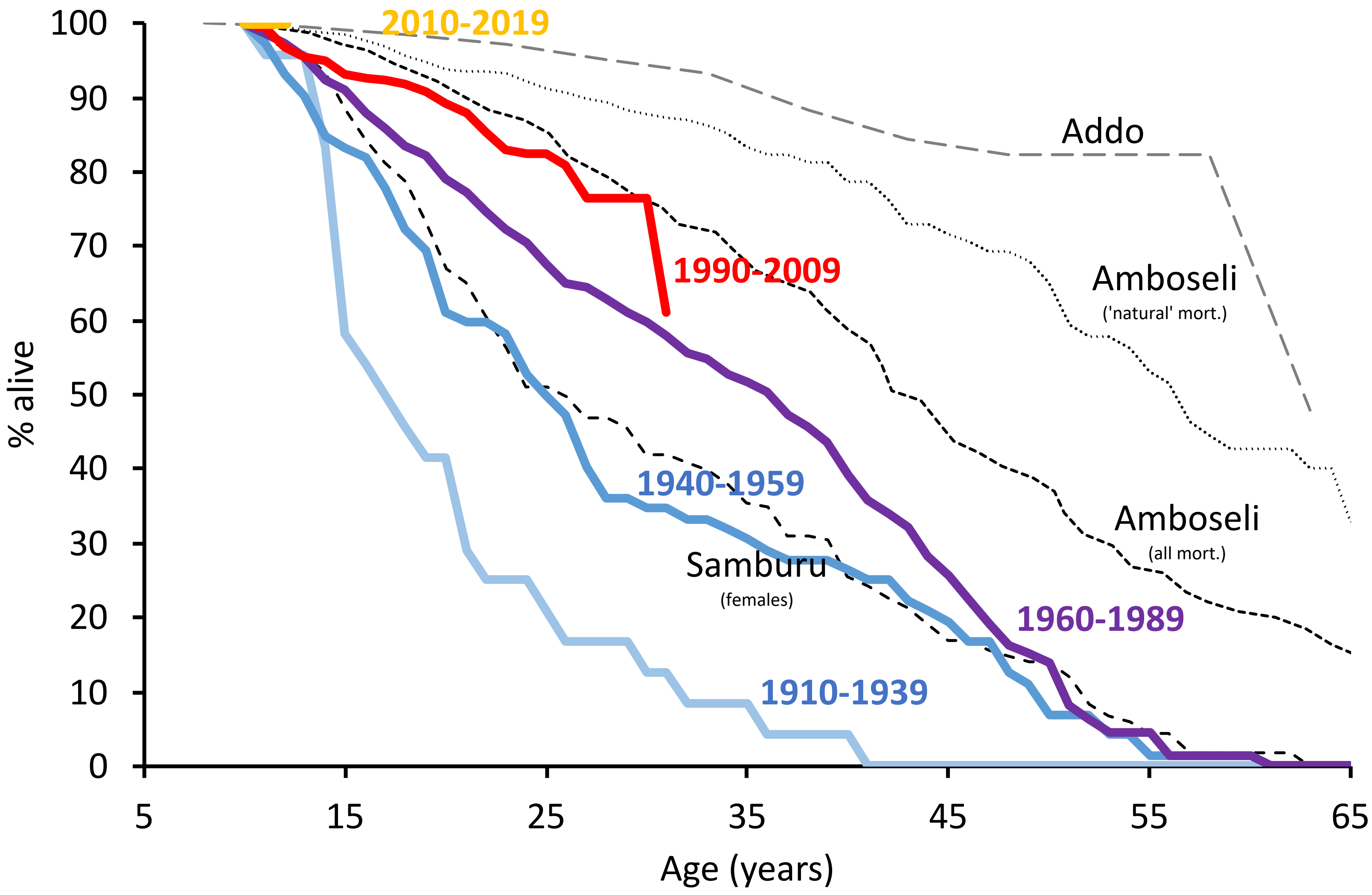

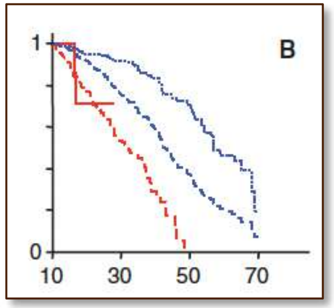

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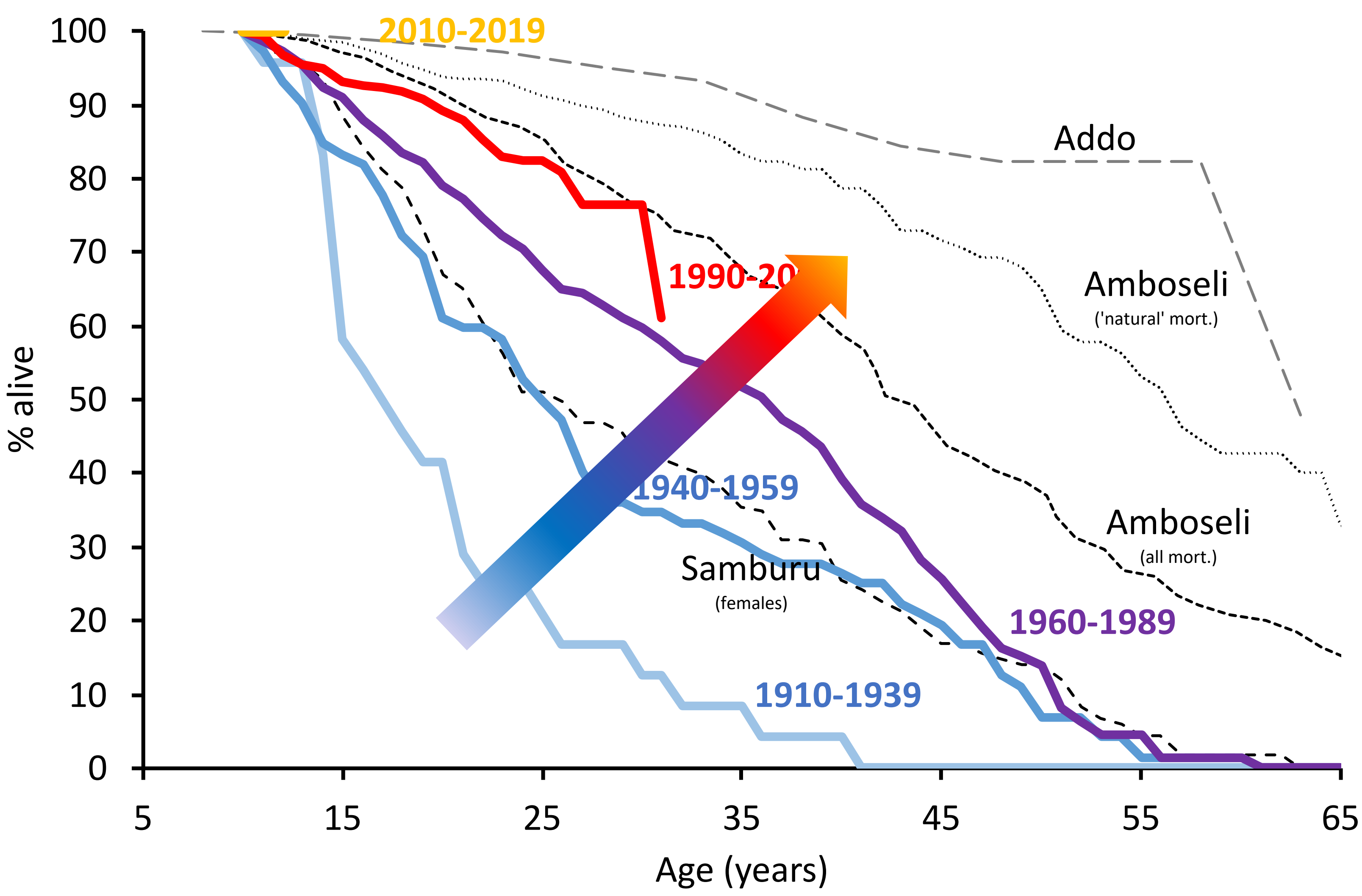

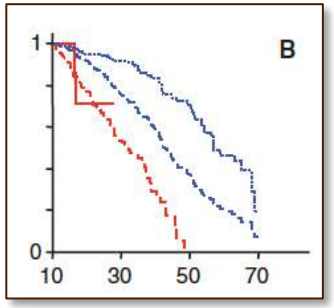

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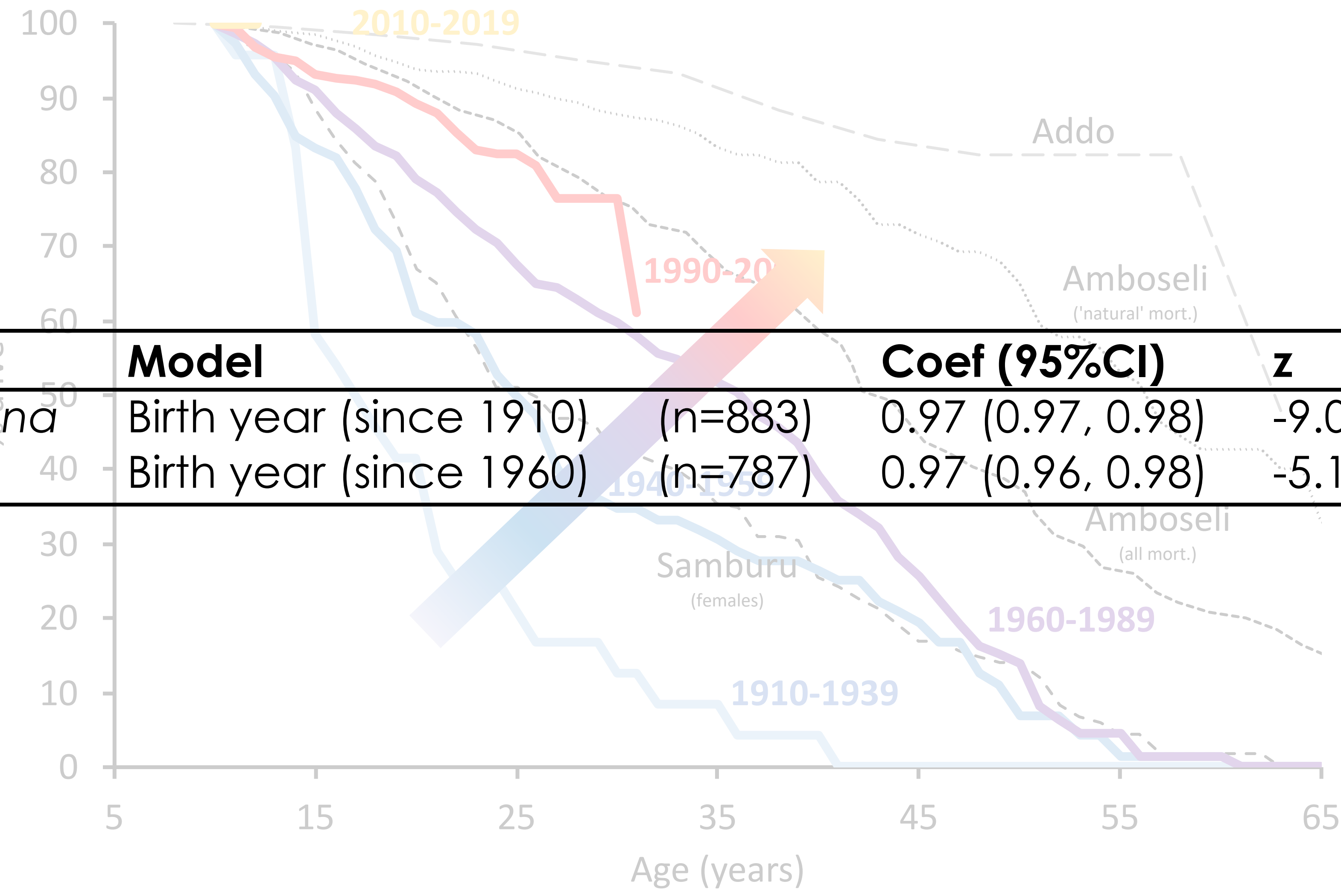

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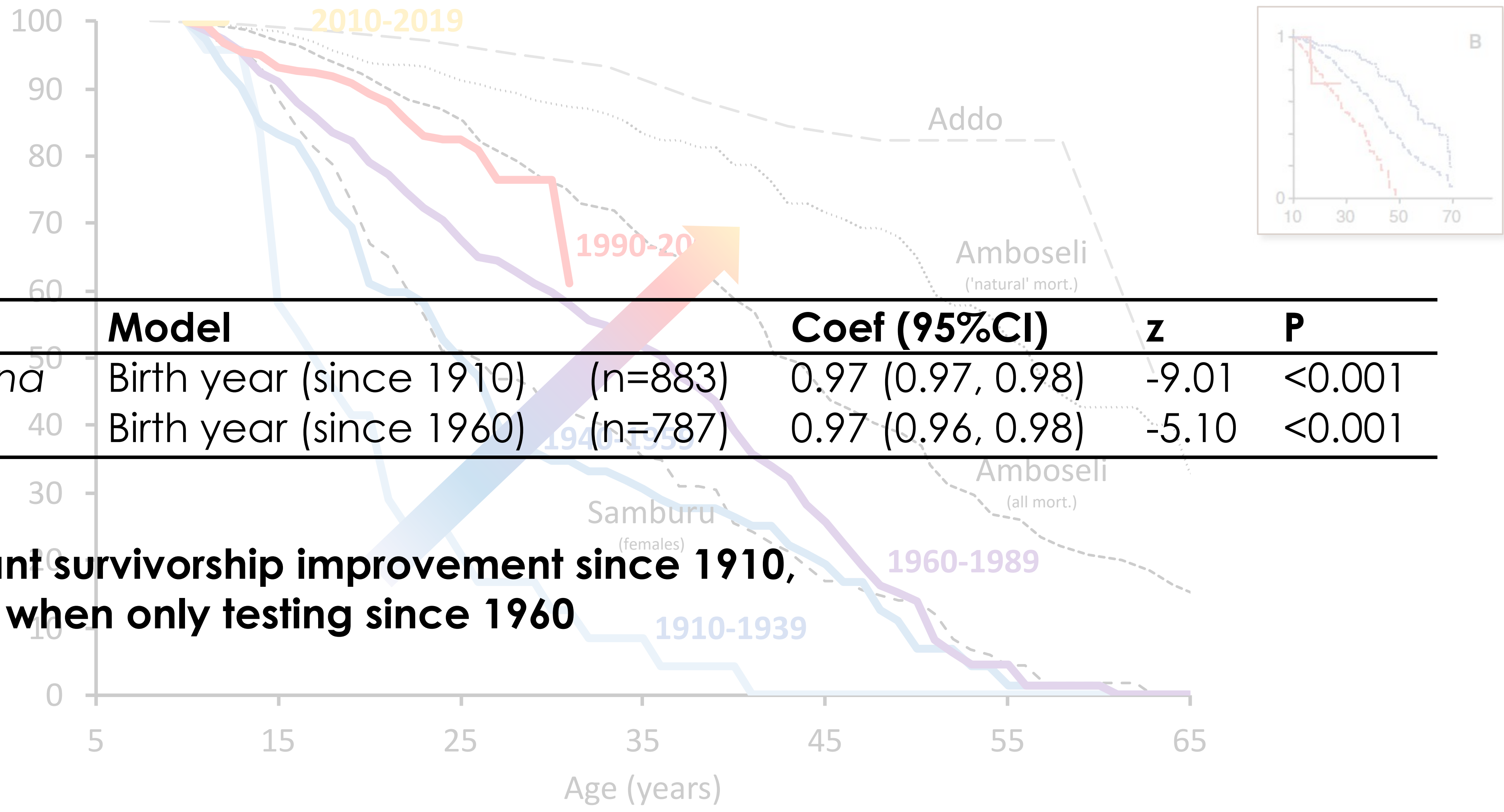

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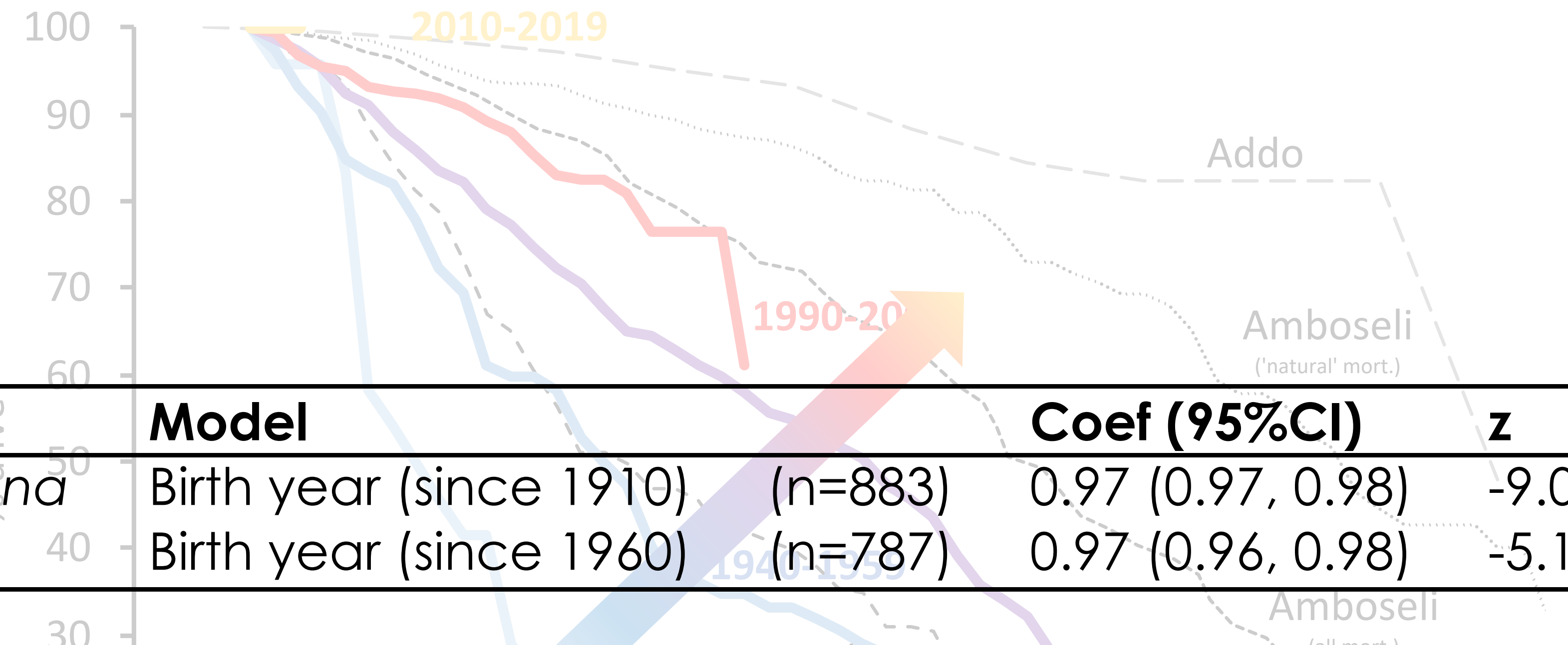

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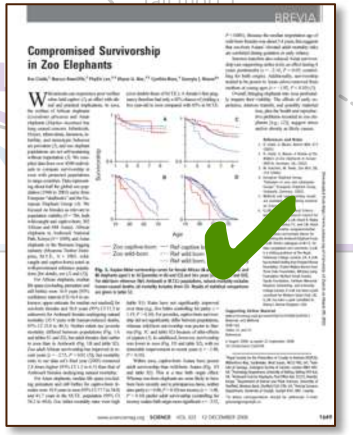

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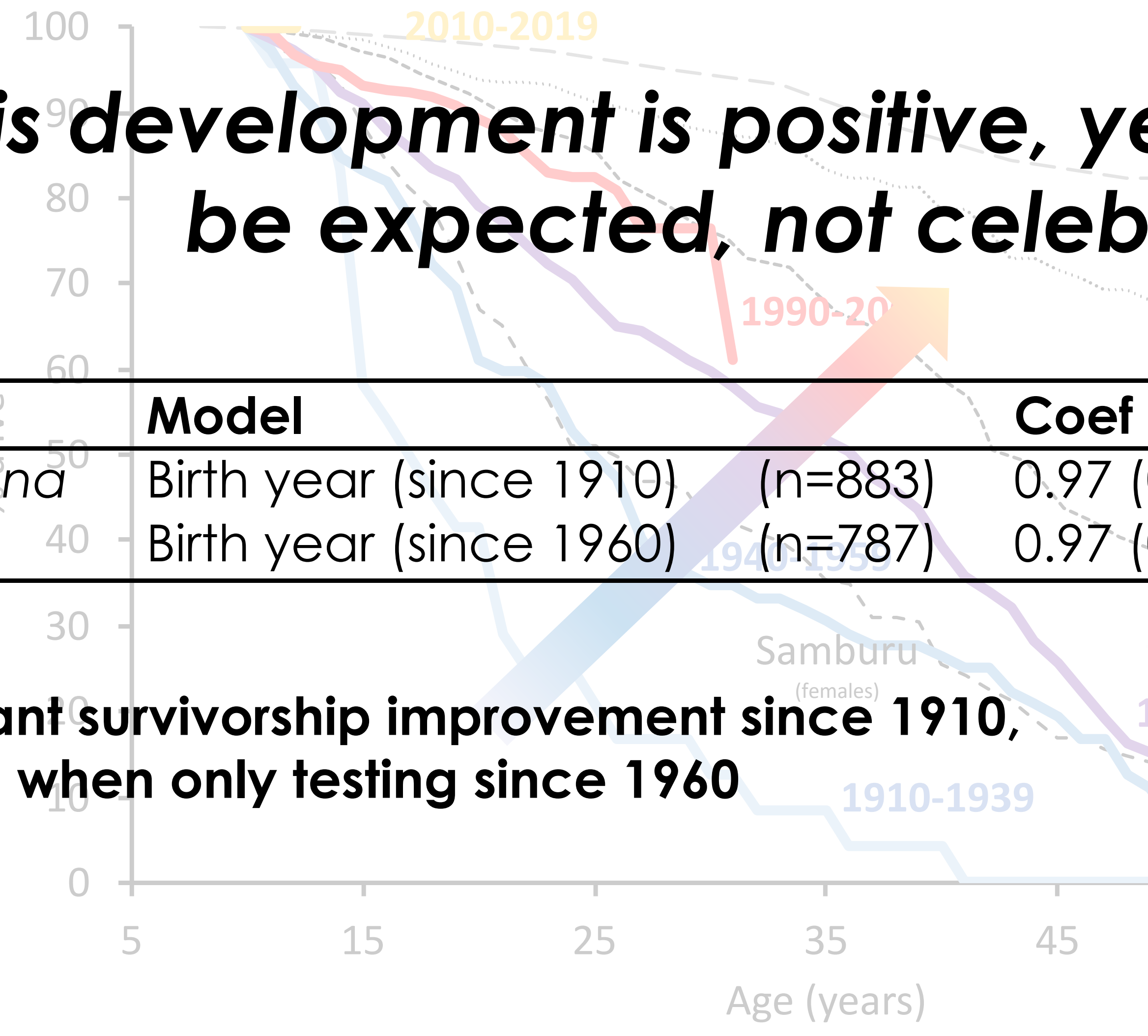

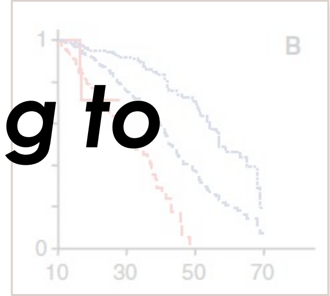

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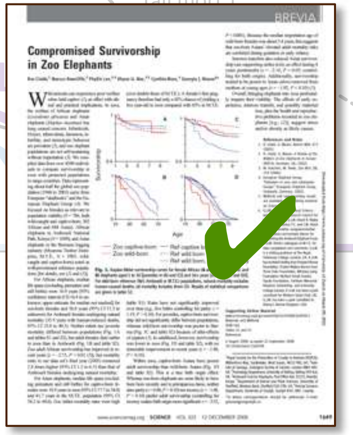

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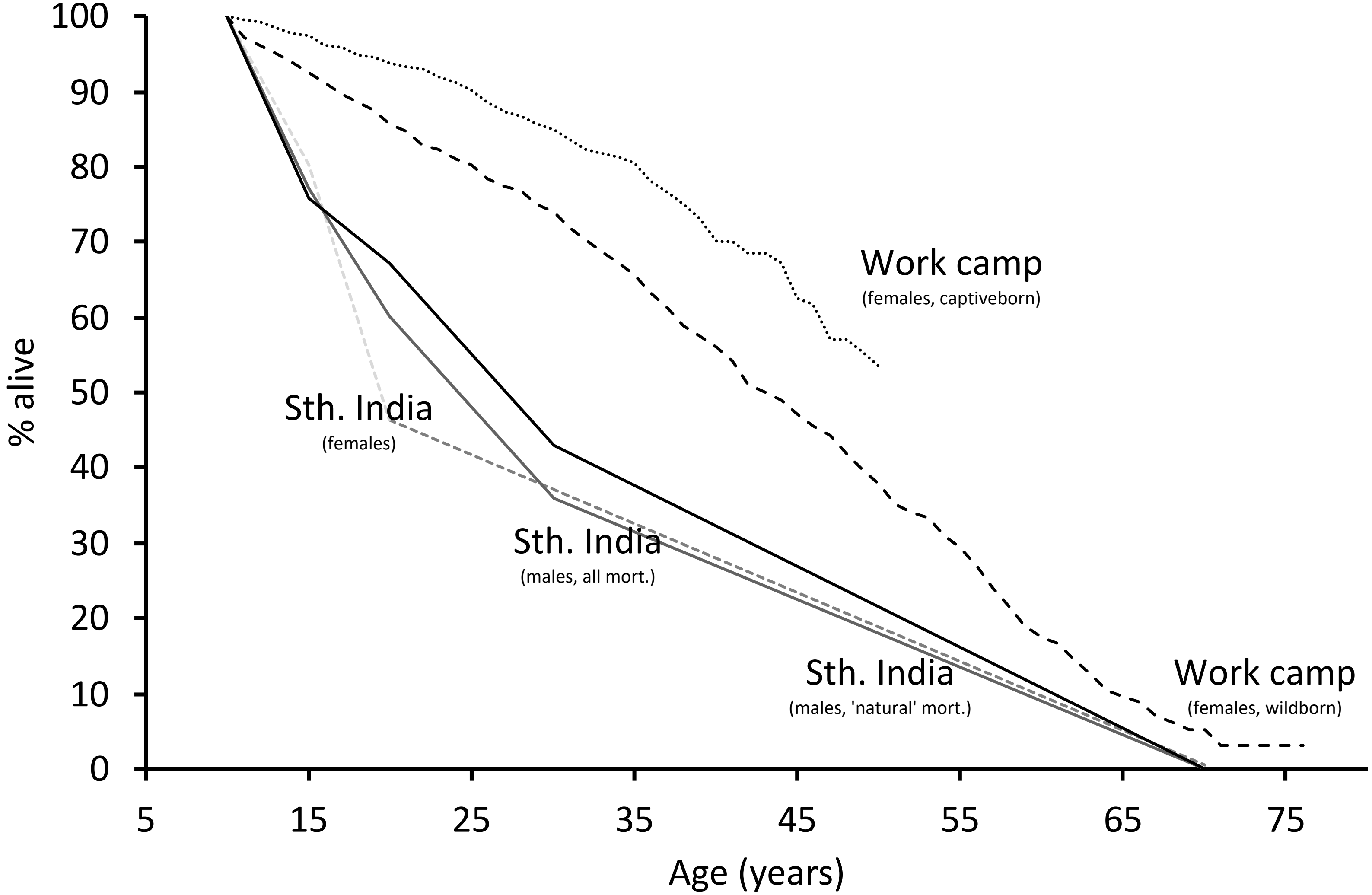

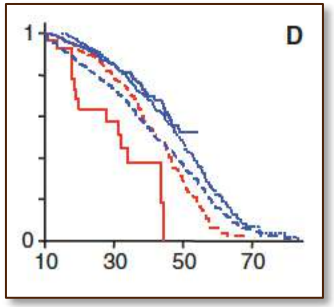

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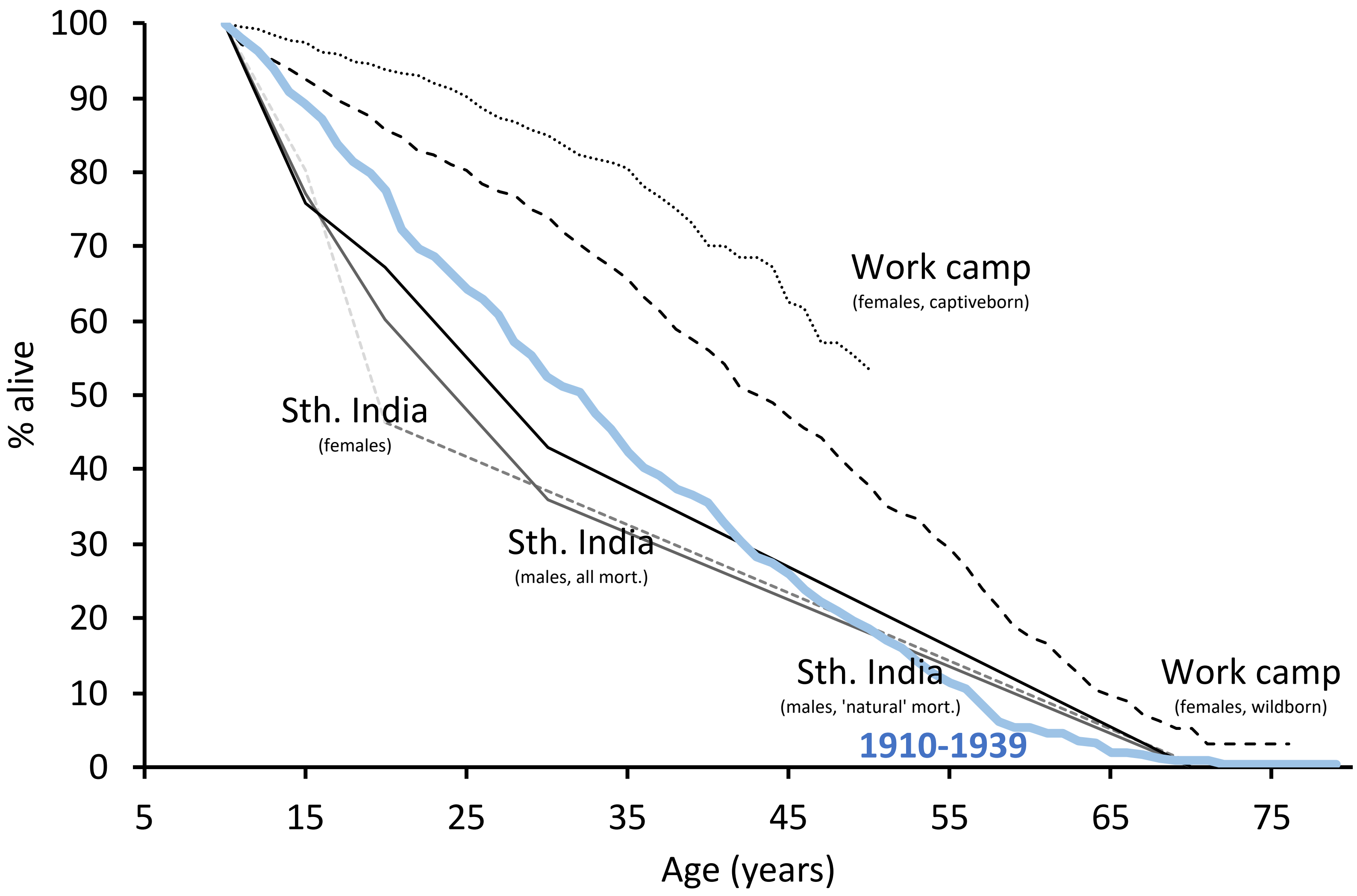

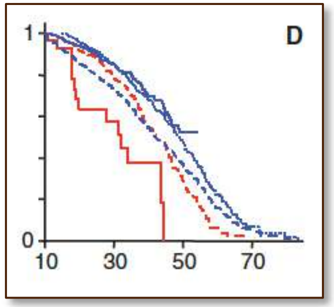

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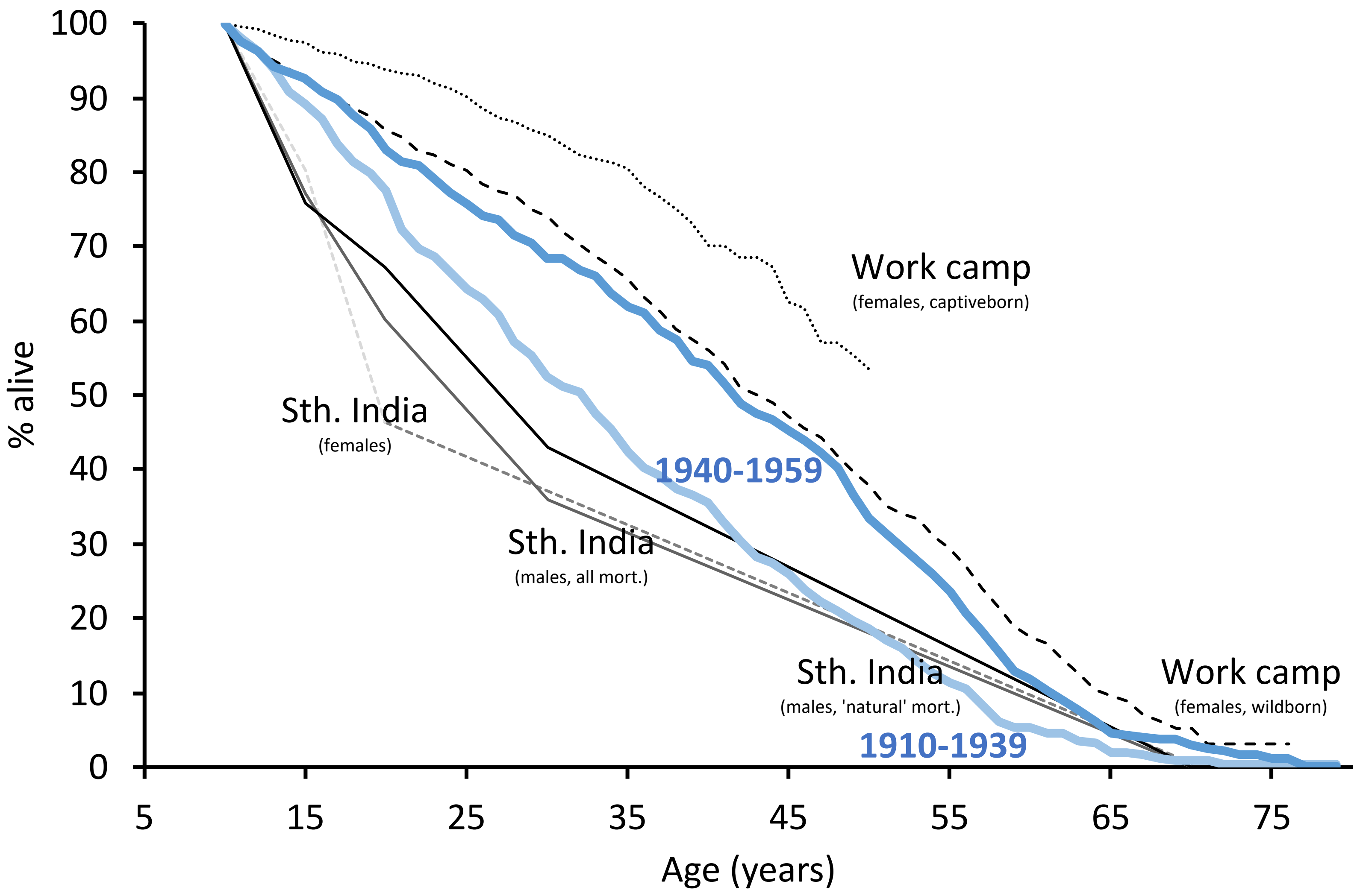

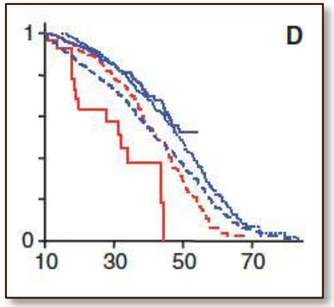

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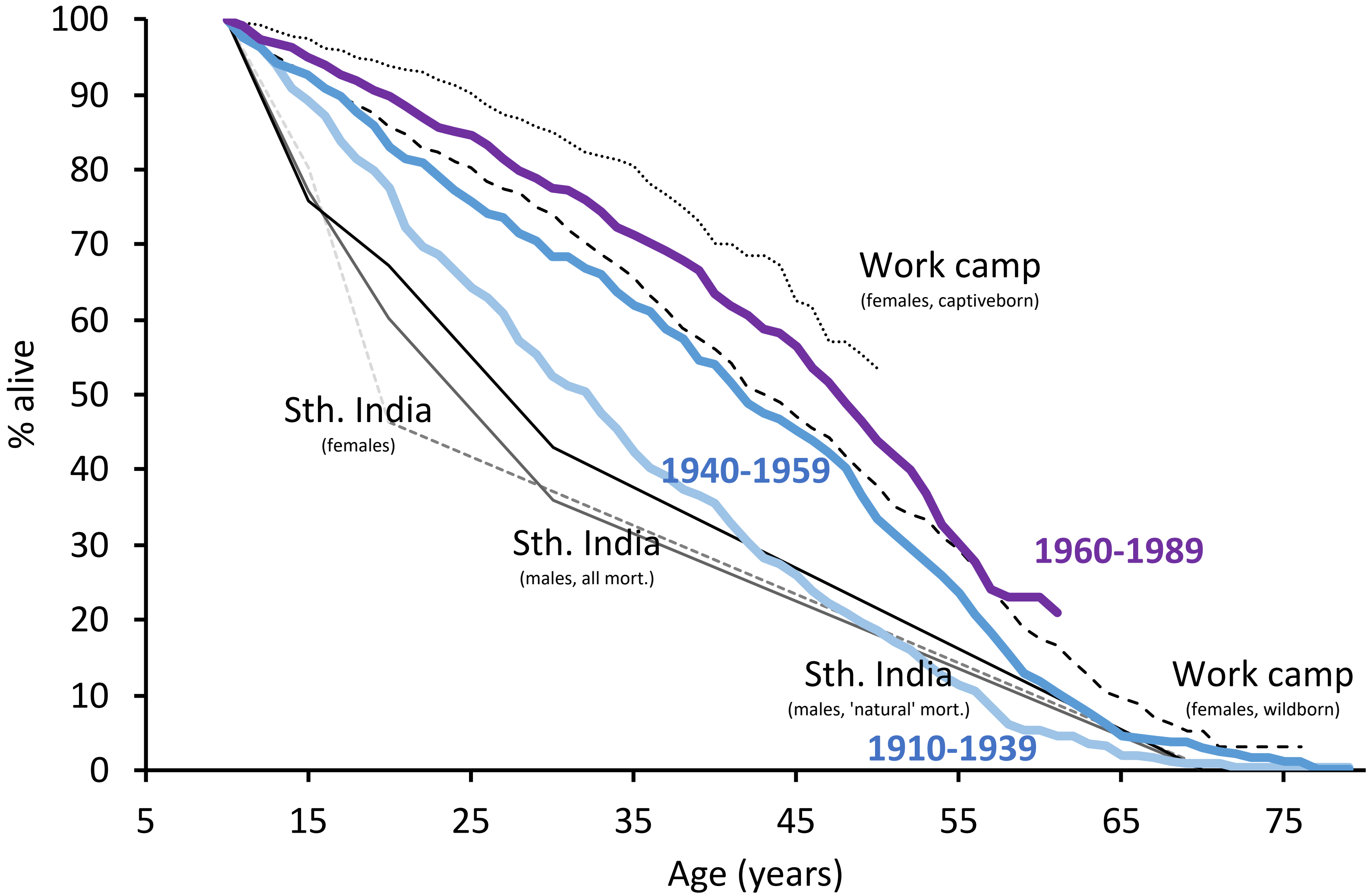

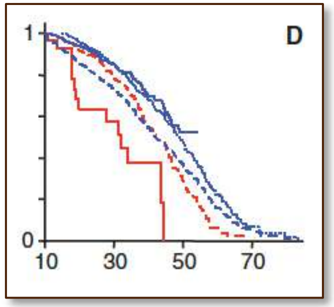

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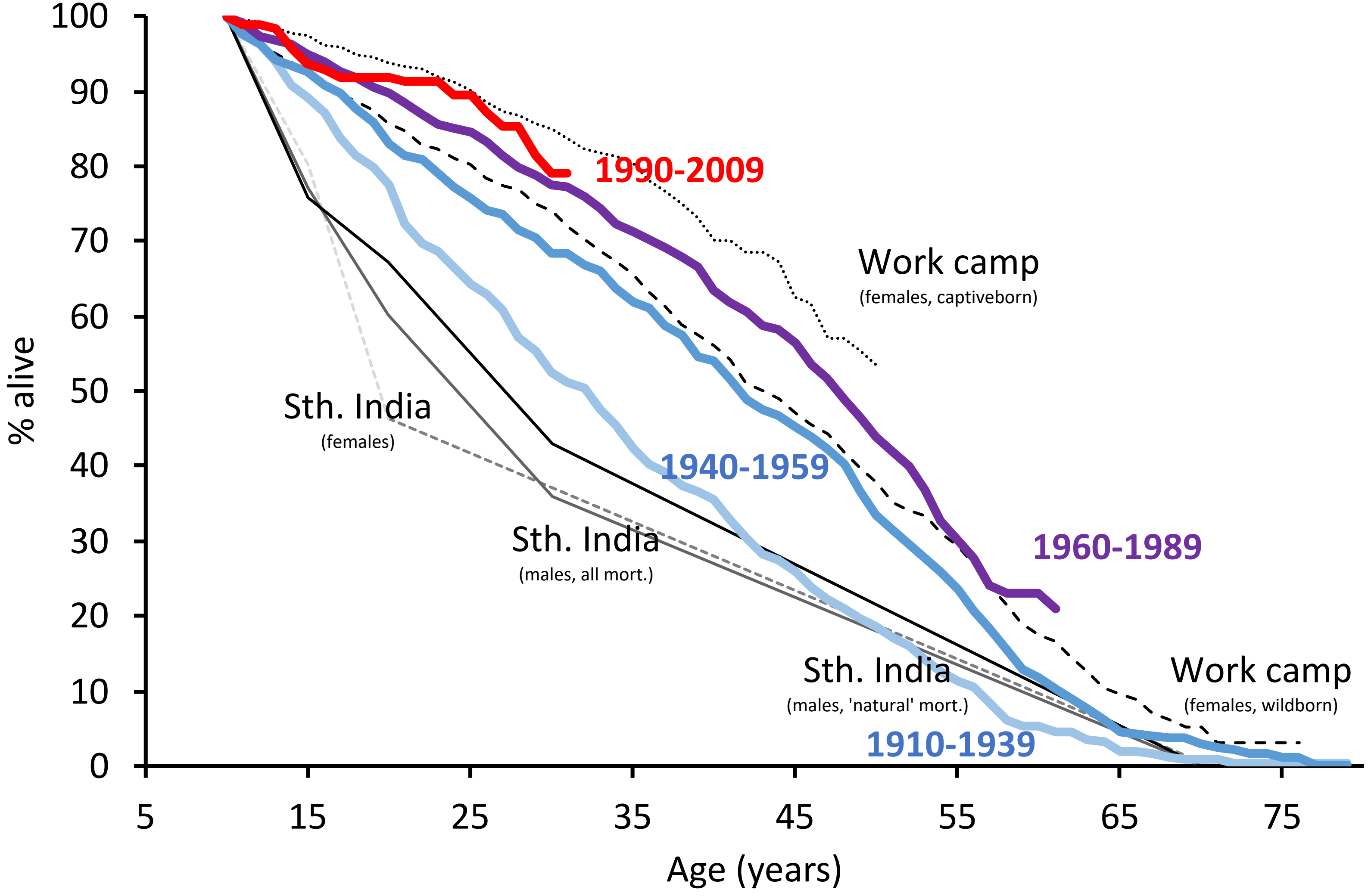

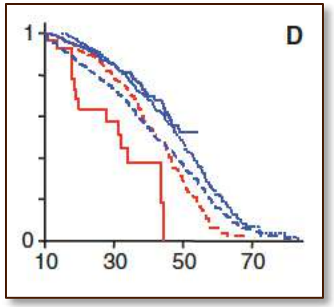

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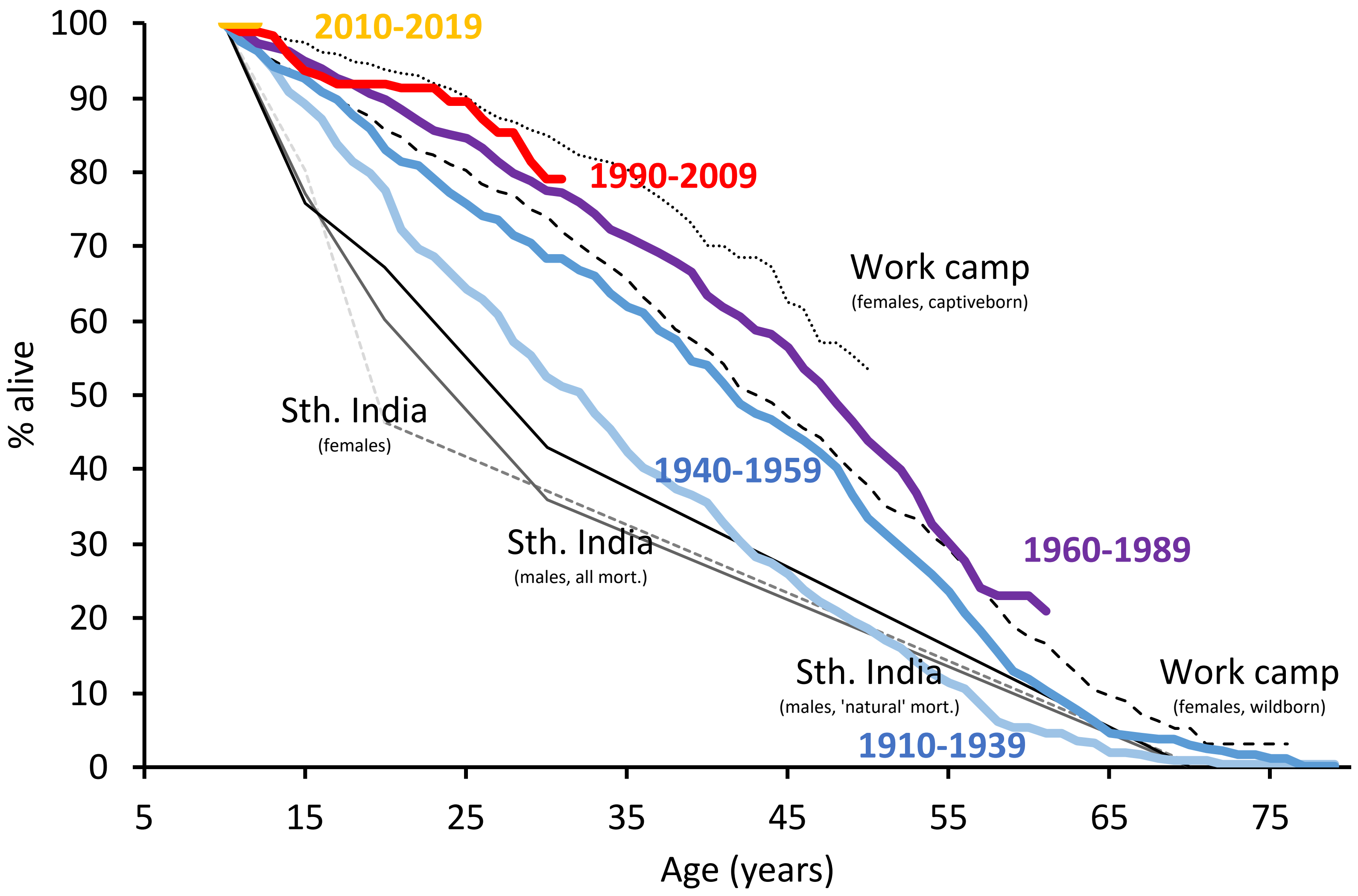

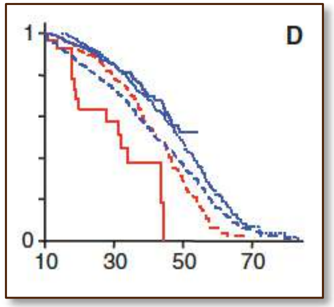

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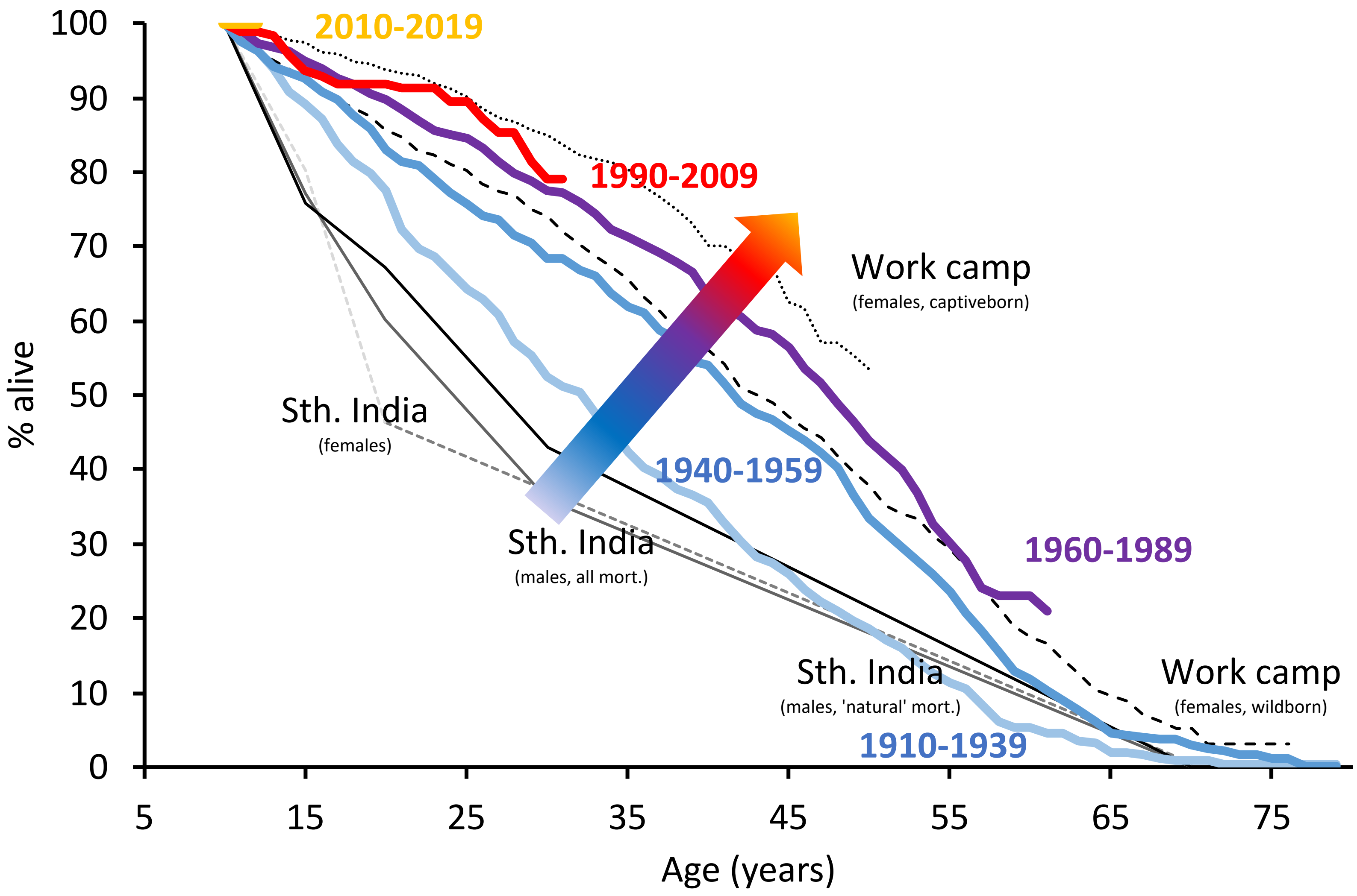

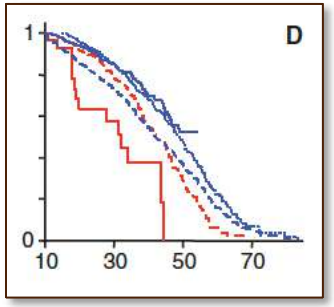

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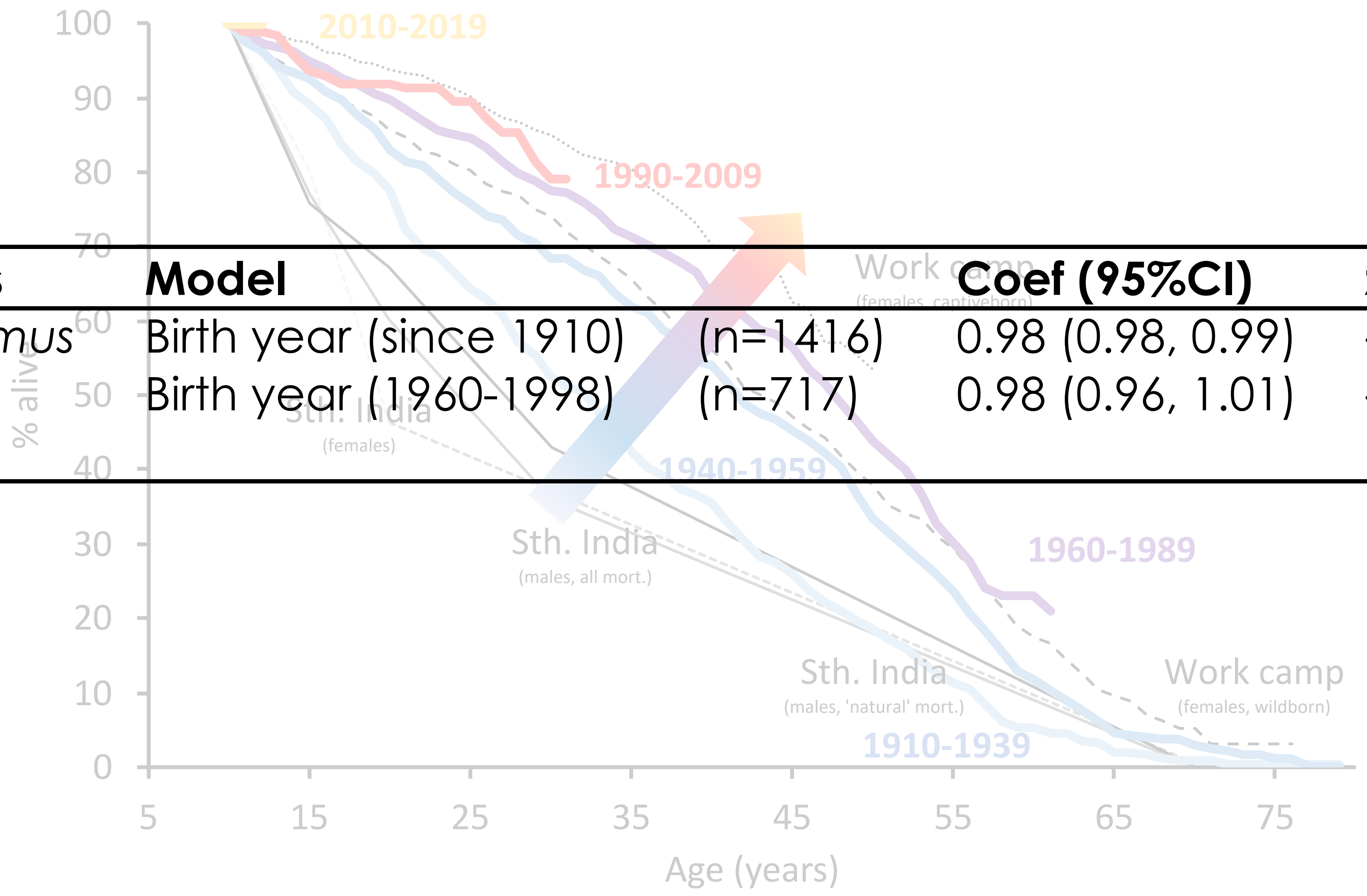

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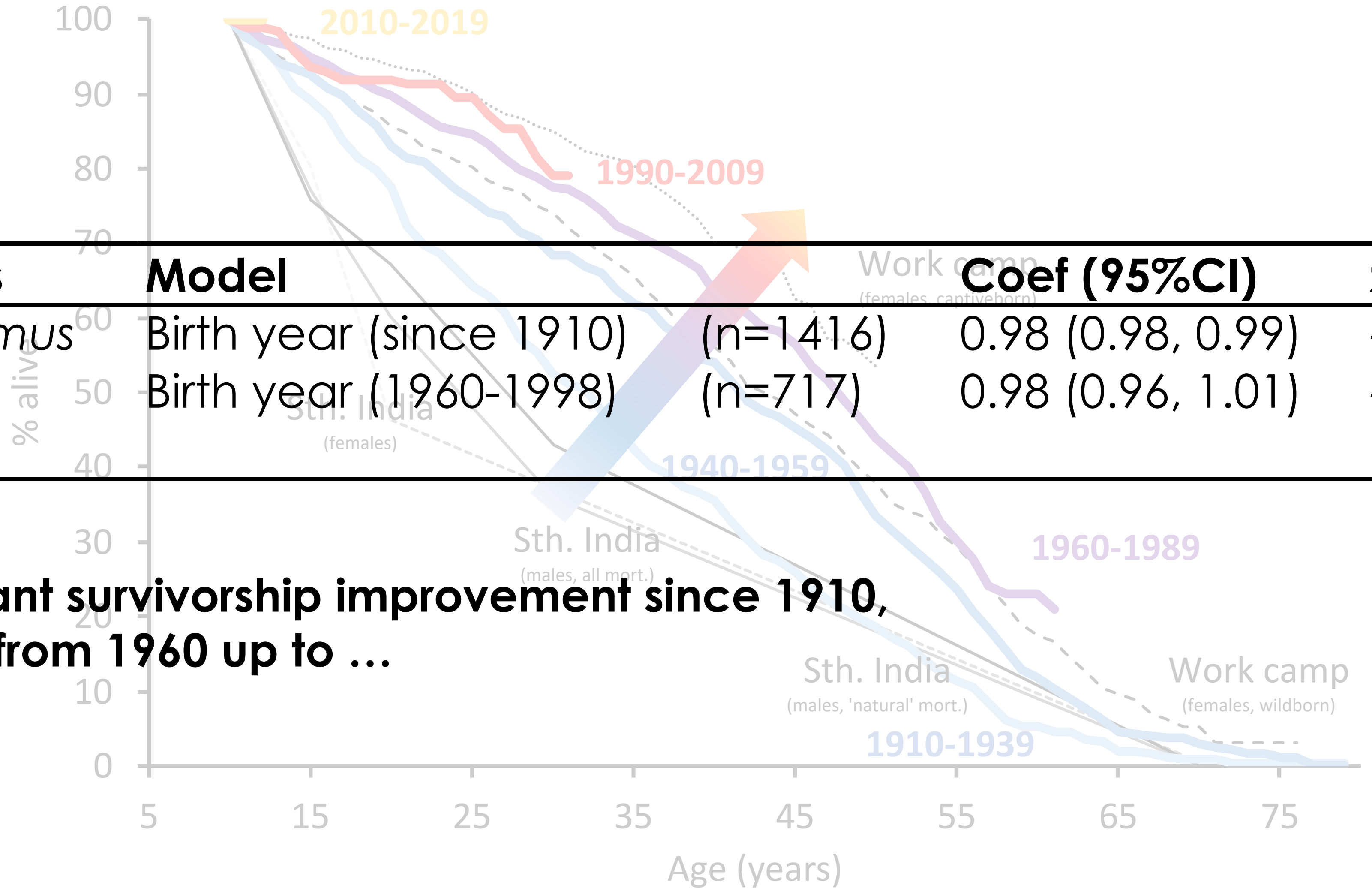

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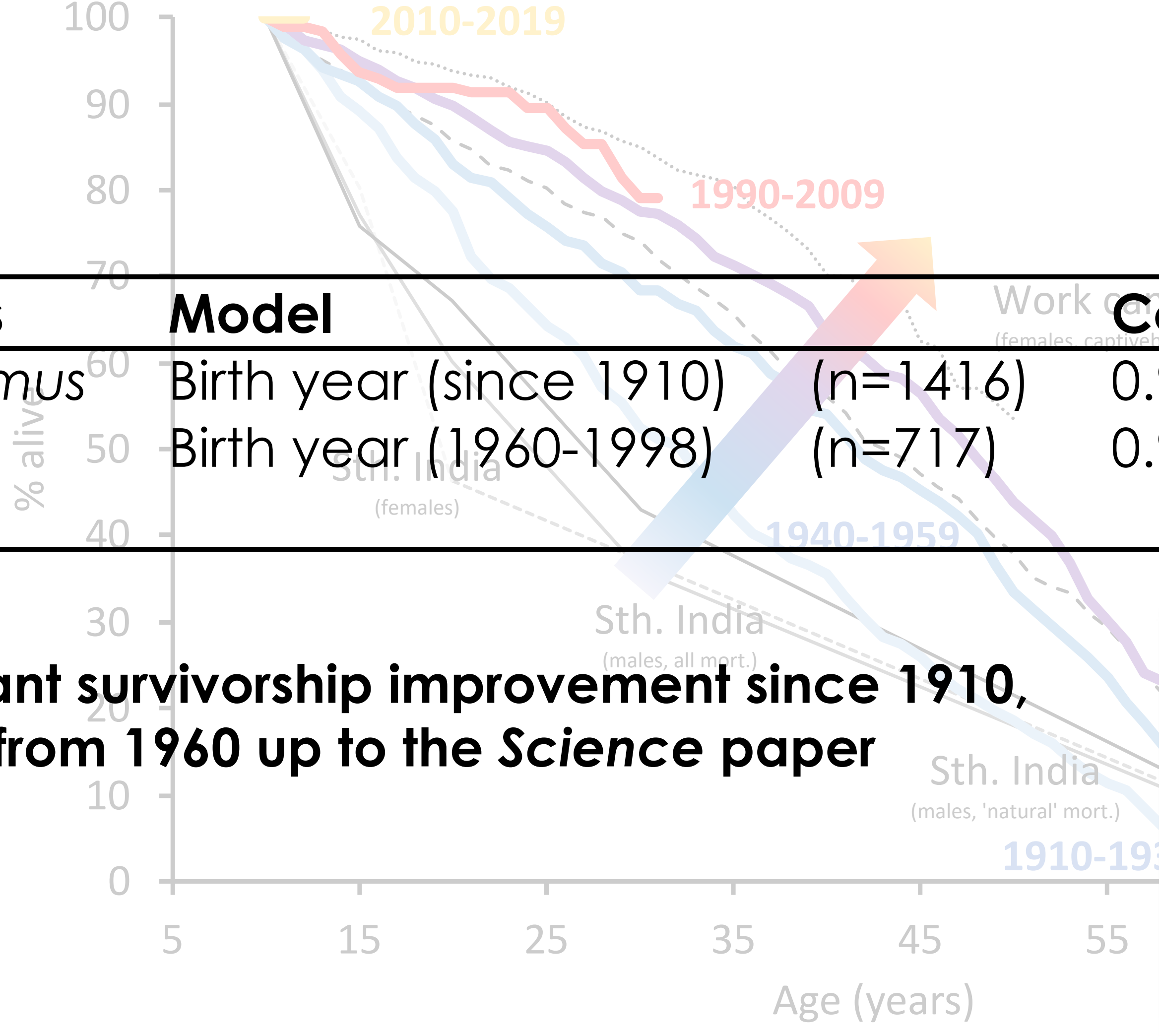

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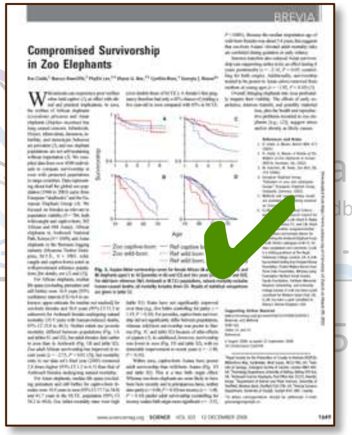

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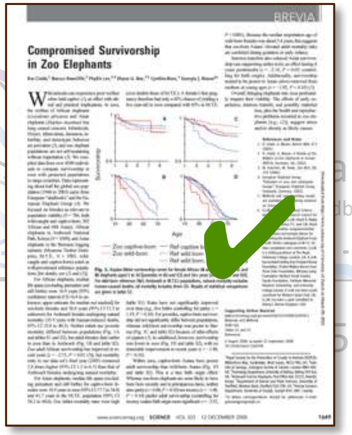

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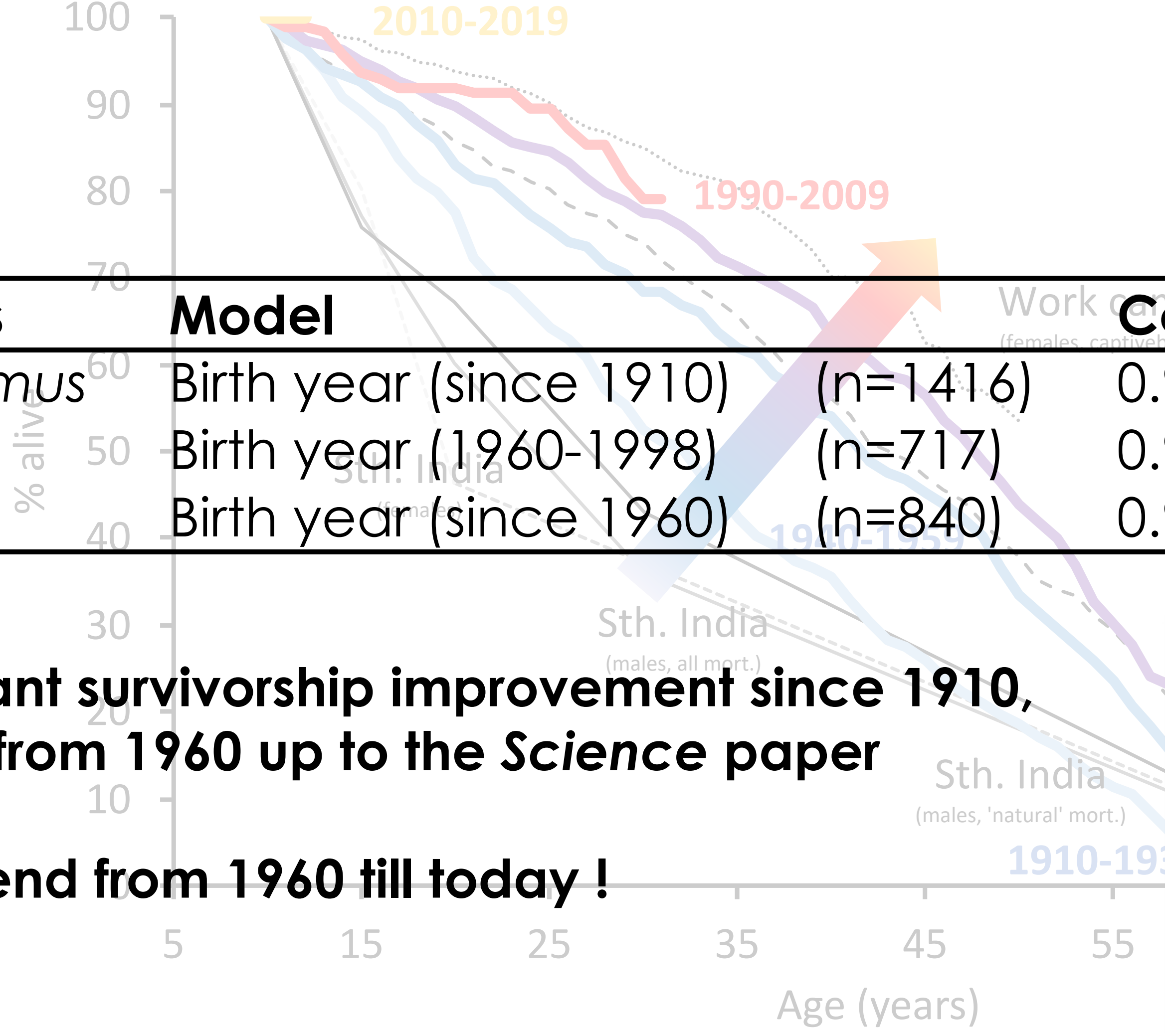

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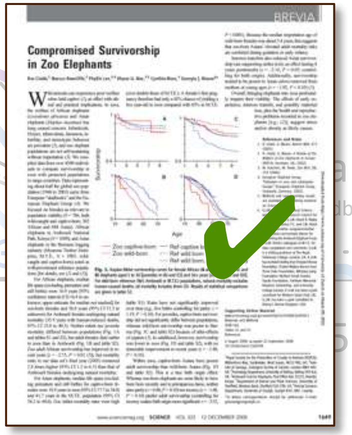

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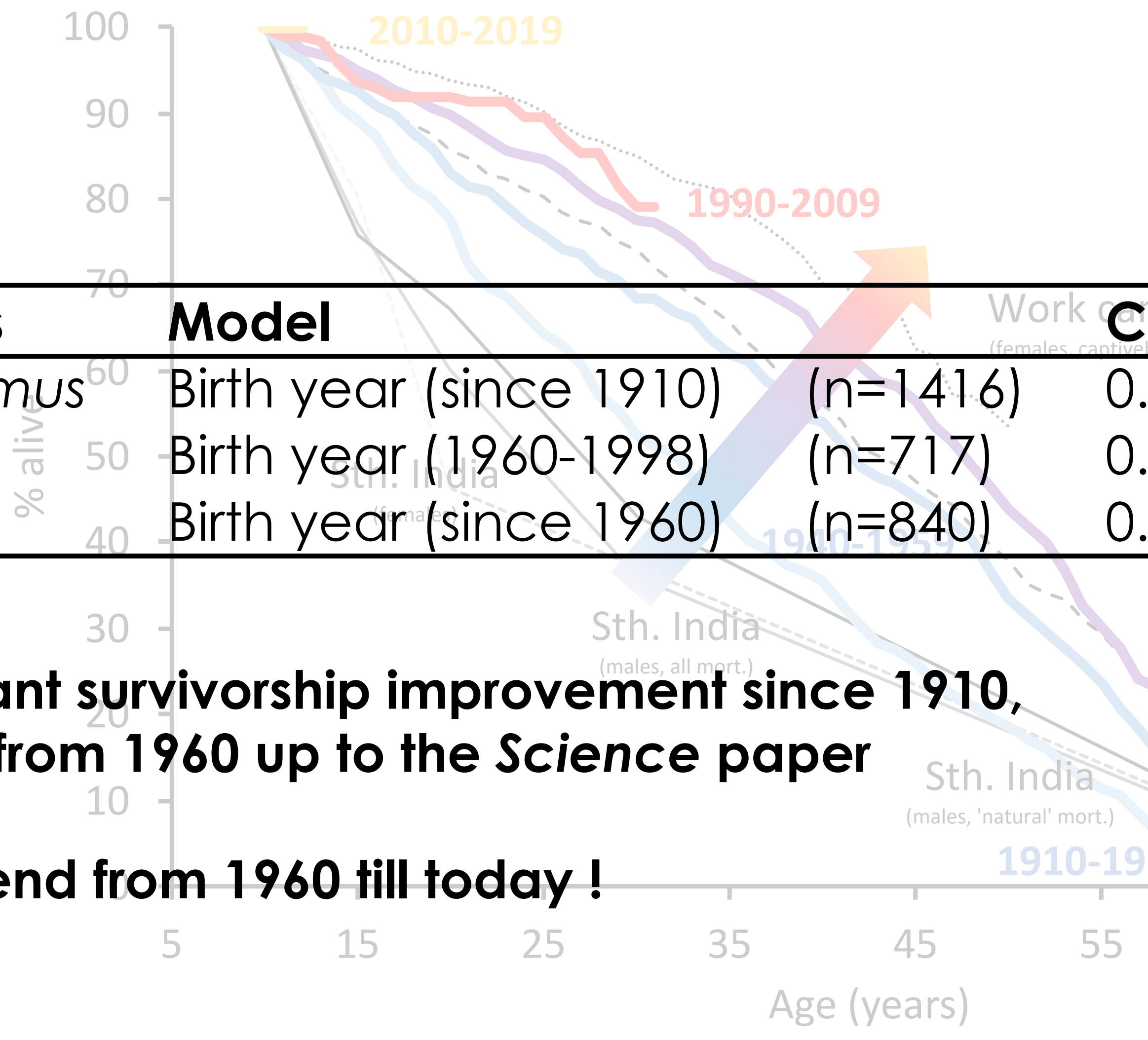

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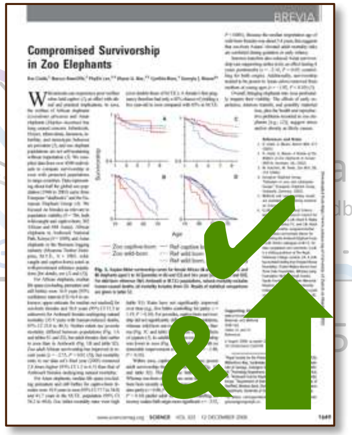

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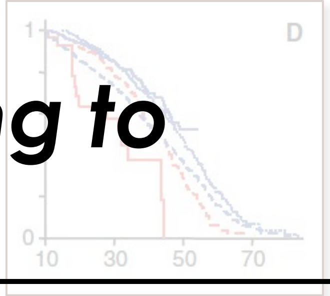

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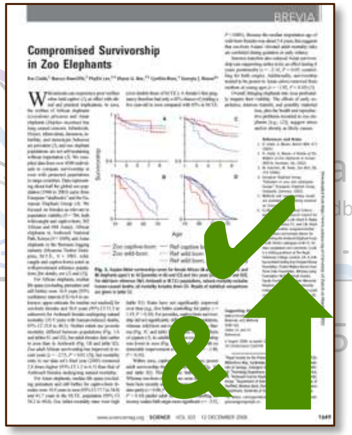
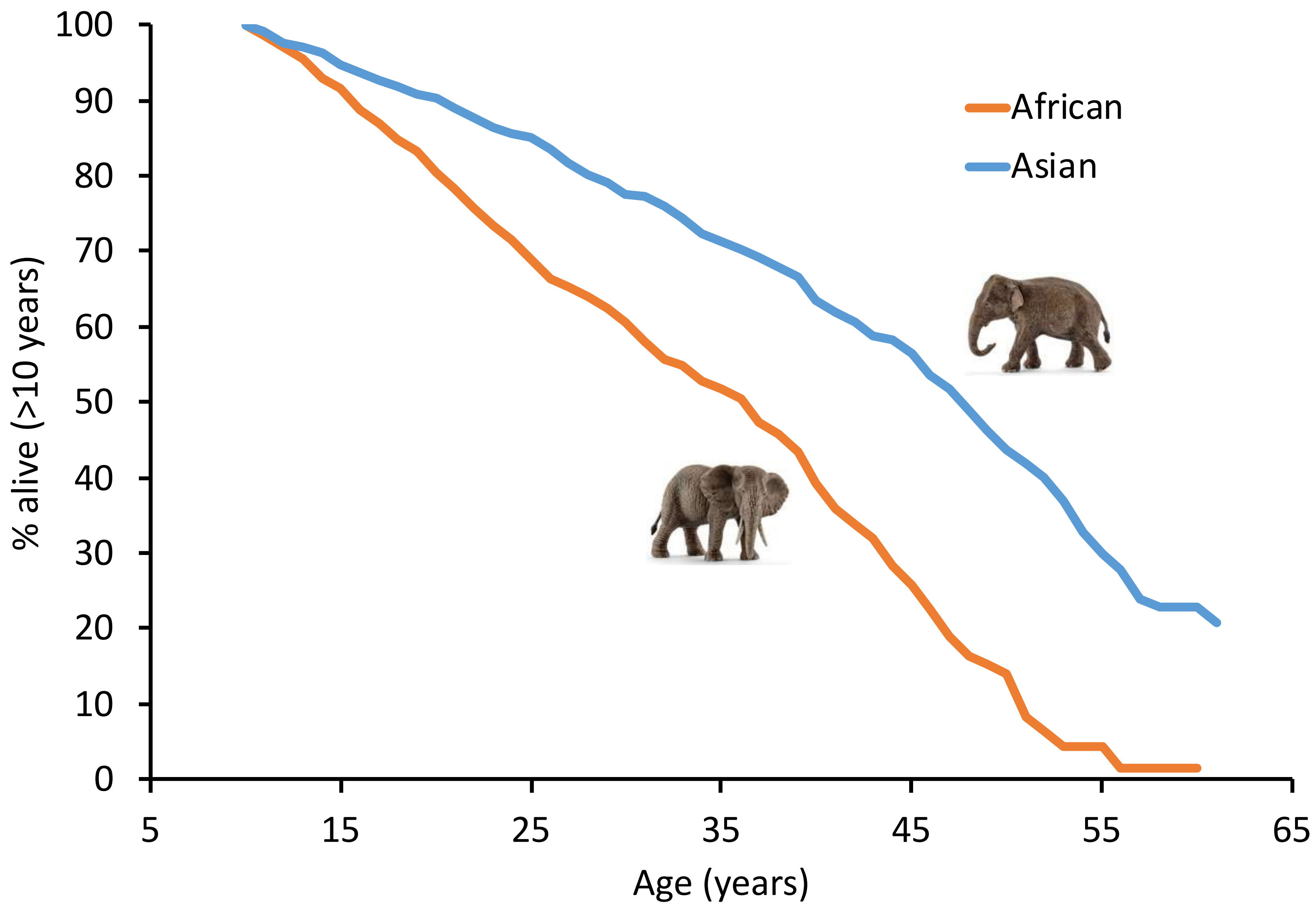


Adult survivorship – species comparison (N.Am. & EU, since 1960)



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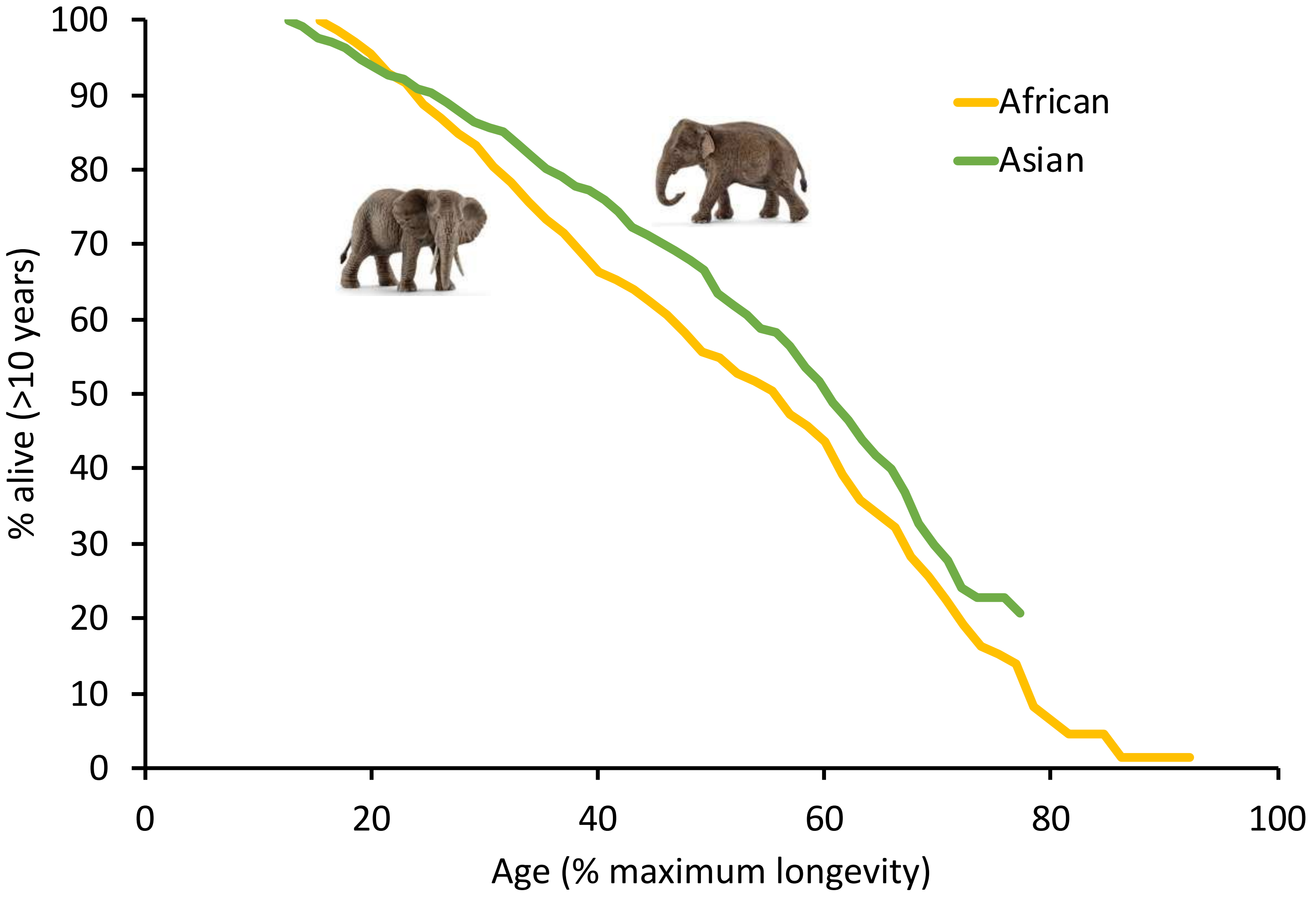

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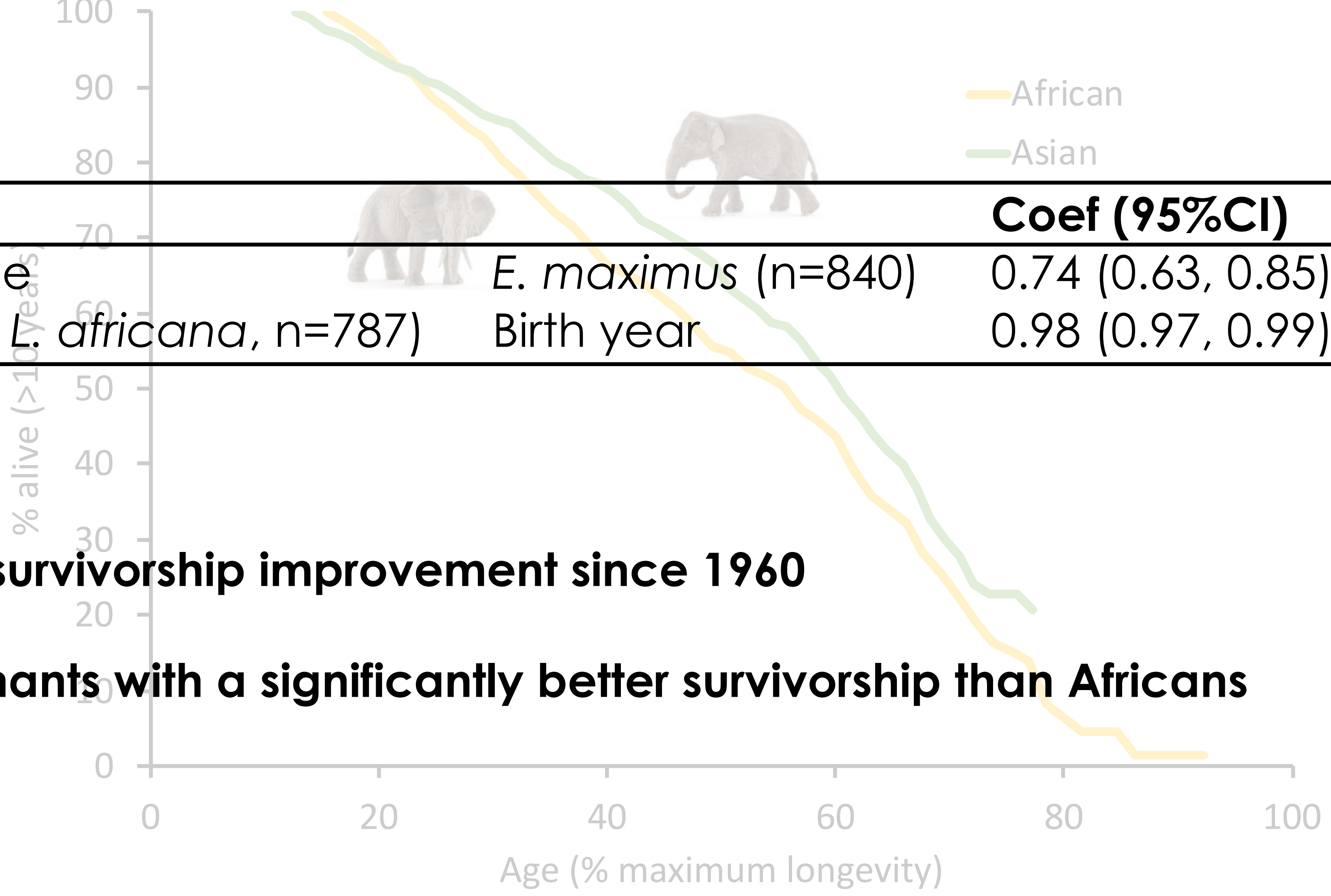

Model		Coef (95%CI)	z	P
Relative age	*E. maximus* (n=840)	0.74 (0.63, 0.85)	-4.05	<0.001
(reference: *L. africana*, n=787)	Birth year	0.98 (0.97, 0.99)	-5.02	<0.001

Significant survivorship improvement since 1960

Asian elephants with a significantly better survivorship than Africans

Summary and Recommendations

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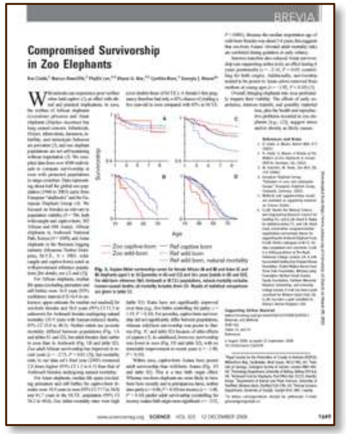
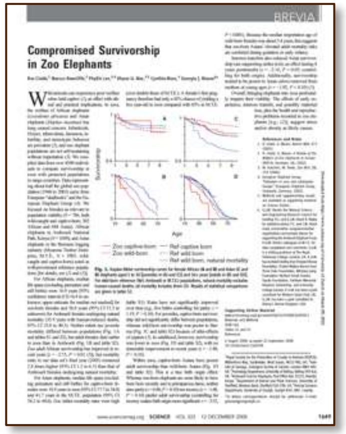


Don’t question the data …

Summary and Recommendations



Don’t question the data …

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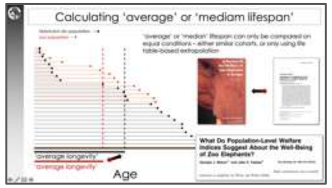

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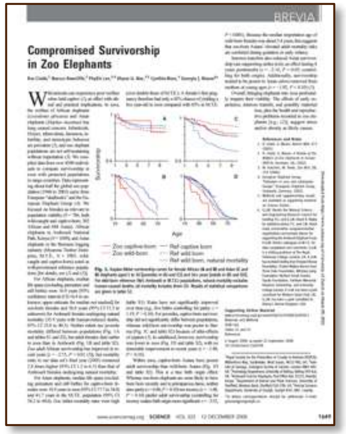
BREVIA

Compromised Survivorship in Zoo Elephants

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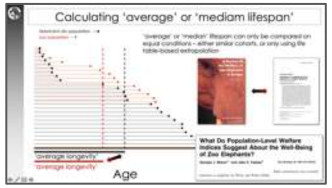

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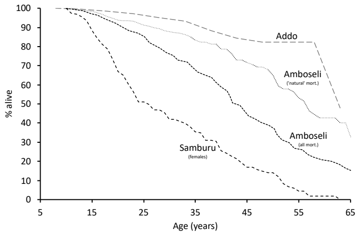

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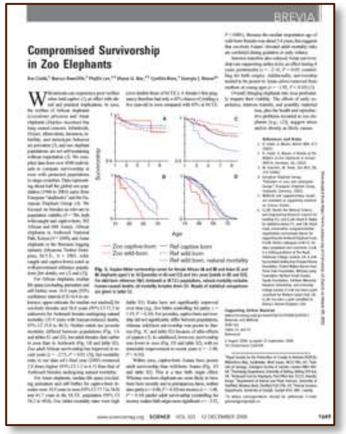
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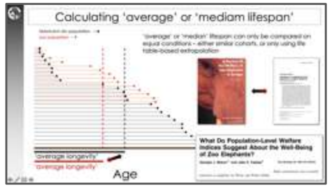

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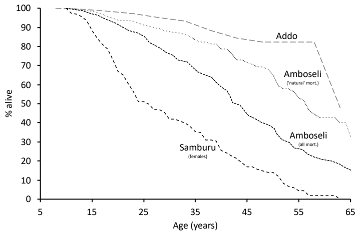

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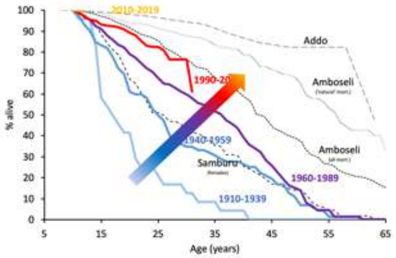

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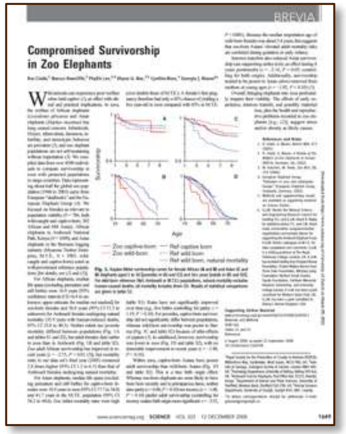

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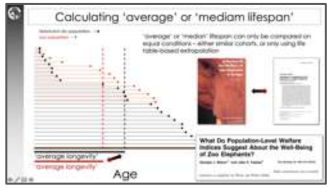

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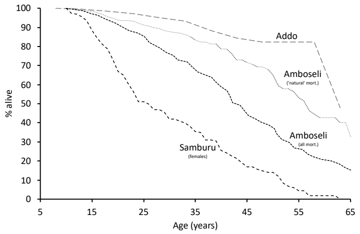

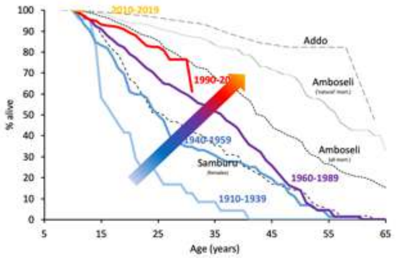

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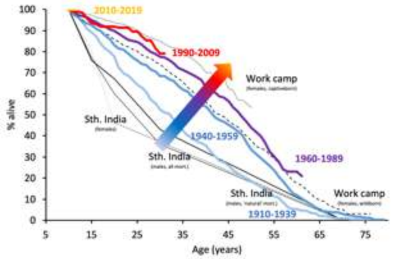

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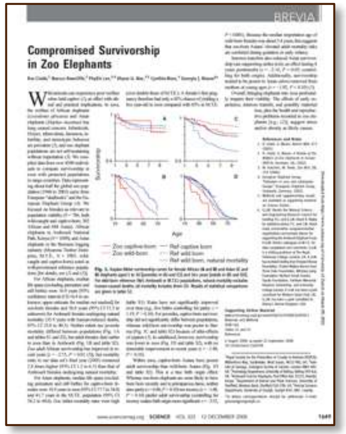

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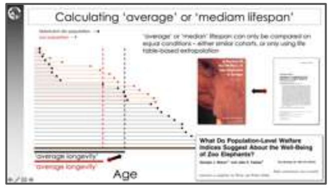

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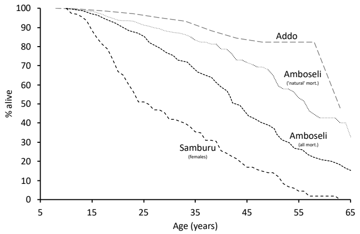

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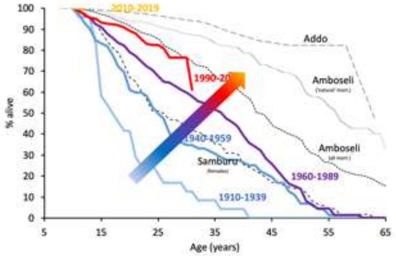

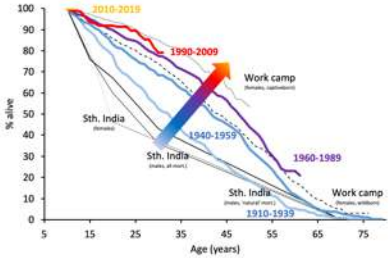

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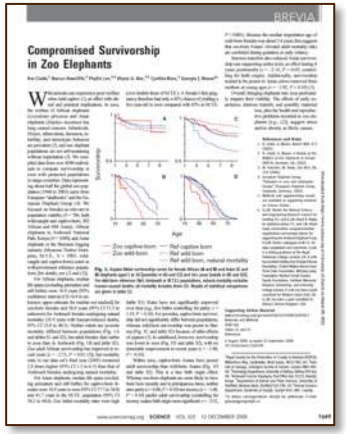

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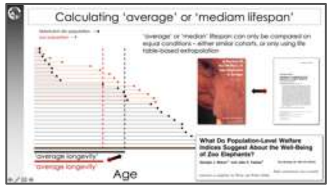

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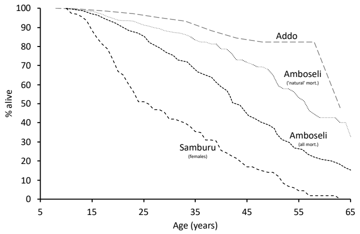

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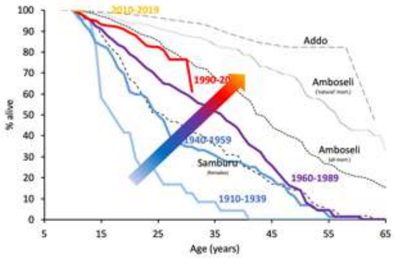

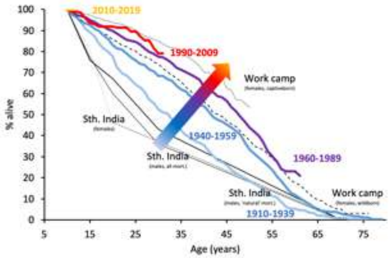

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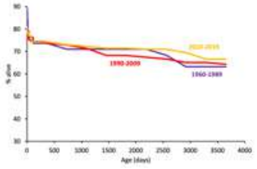

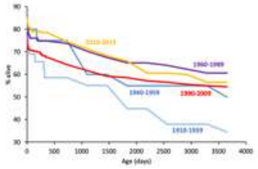

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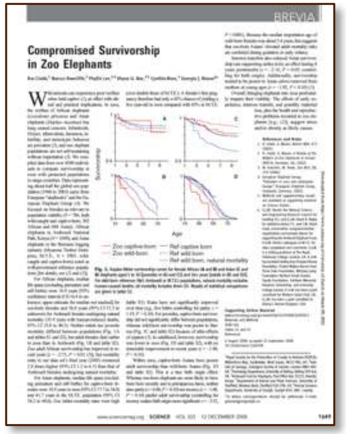

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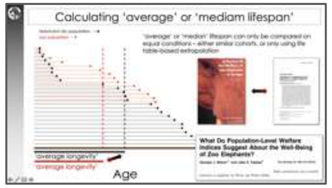

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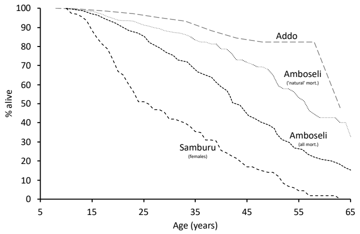

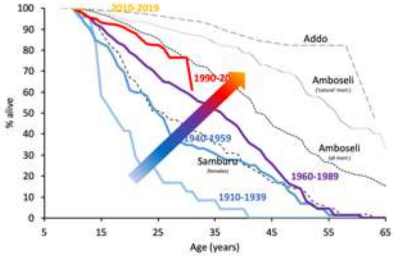

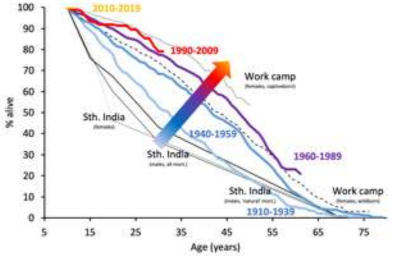

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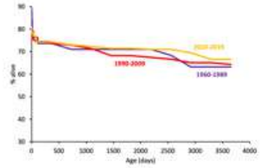
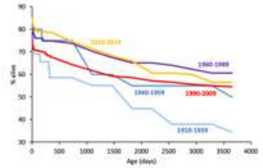
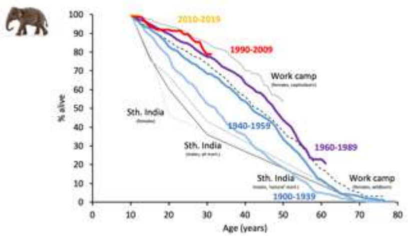


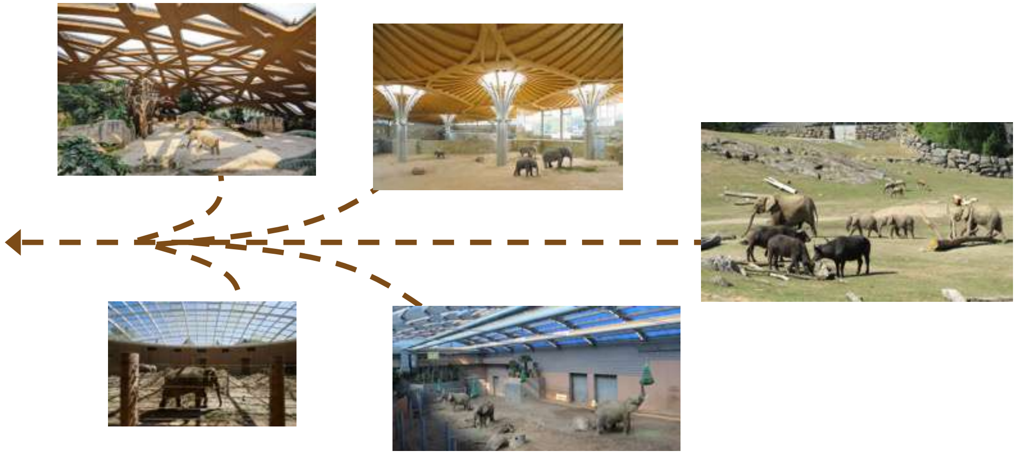


Survivorship monitoring must continue, and there should be no regression.

Outlook

Demographic data are the result of many individual actions but cannot recommend individual actions – only inform large-scale decisions.





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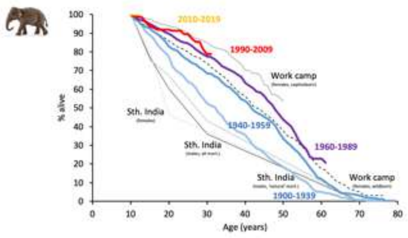

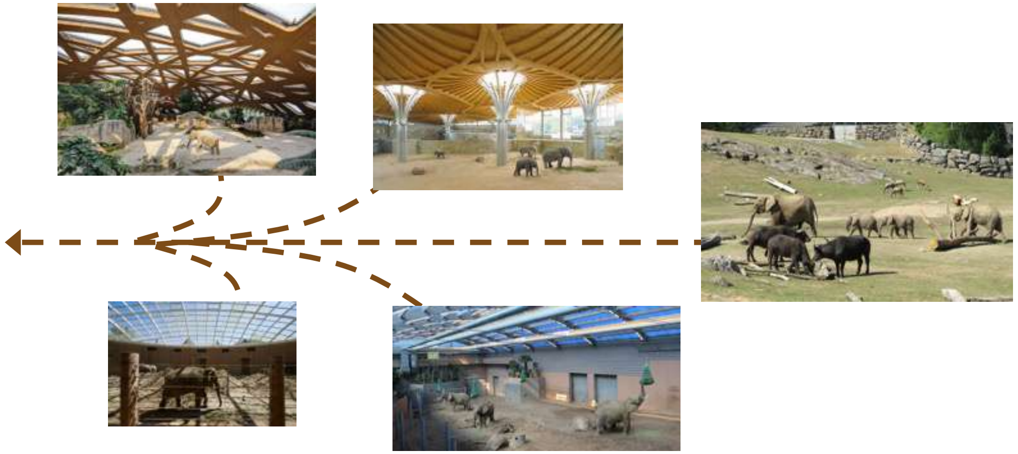

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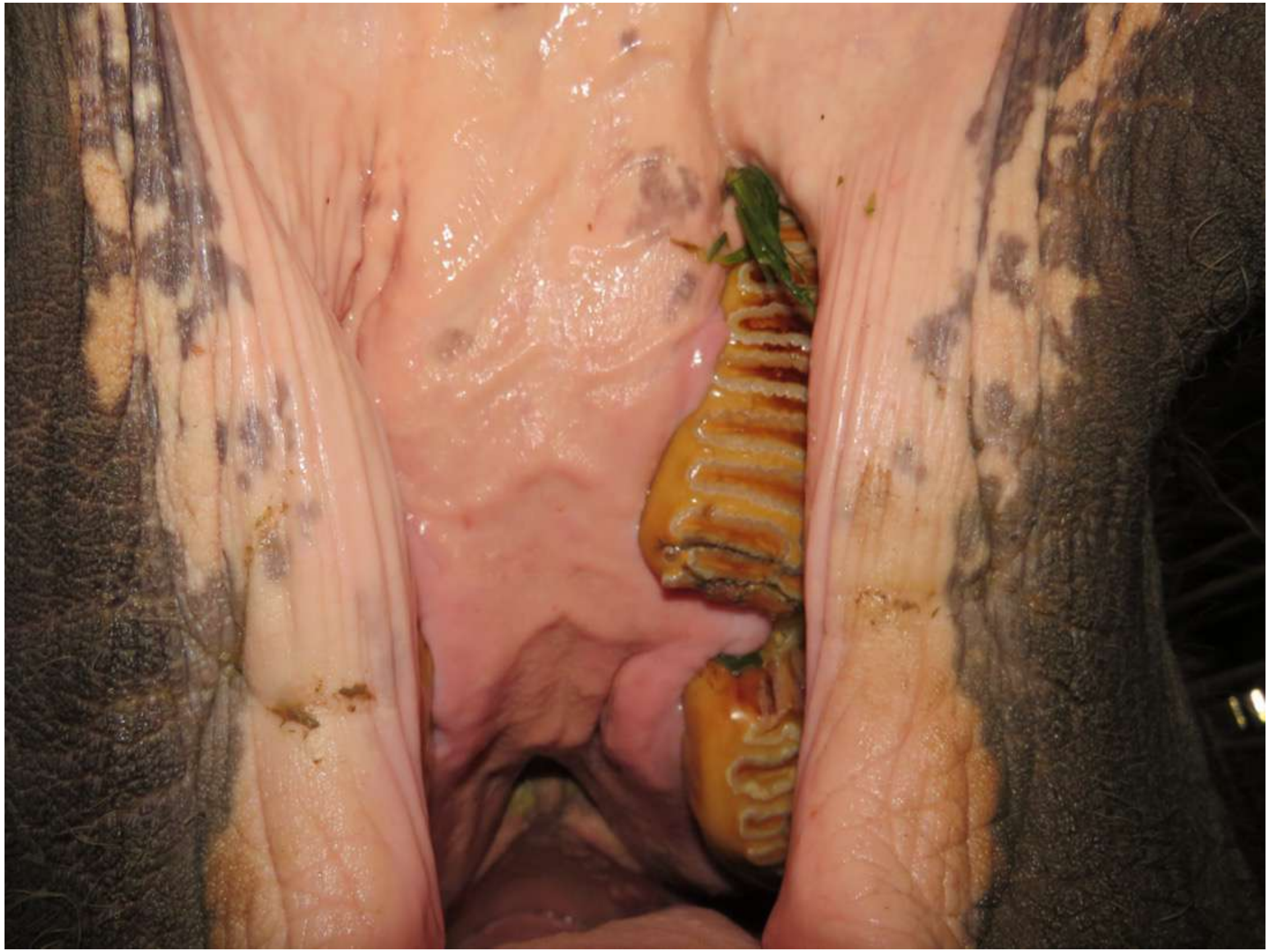

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"This development is positive, yet something to be expected, not celebrated."

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"This development is positive, yet something to be expected, not celebrated."

And this development needs to be continued to ensure a further improvement in our management & care of elephants.

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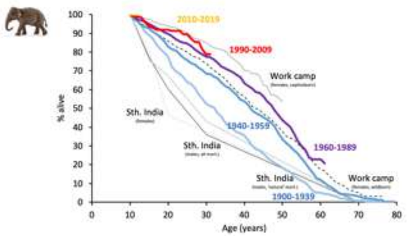
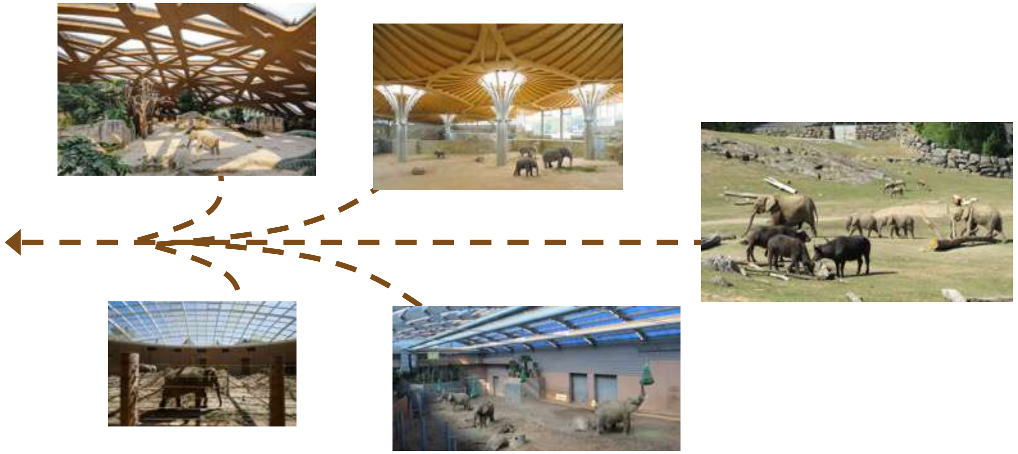
To understand demographic changes, we need to know what is happening in the total of facilities …





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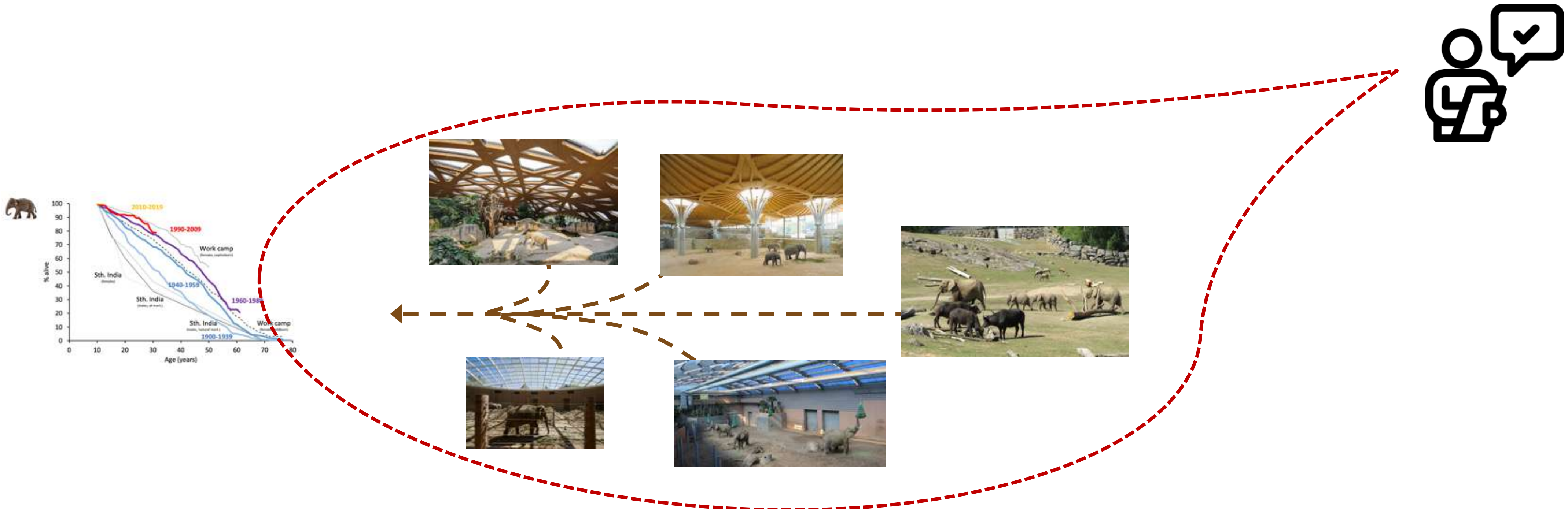

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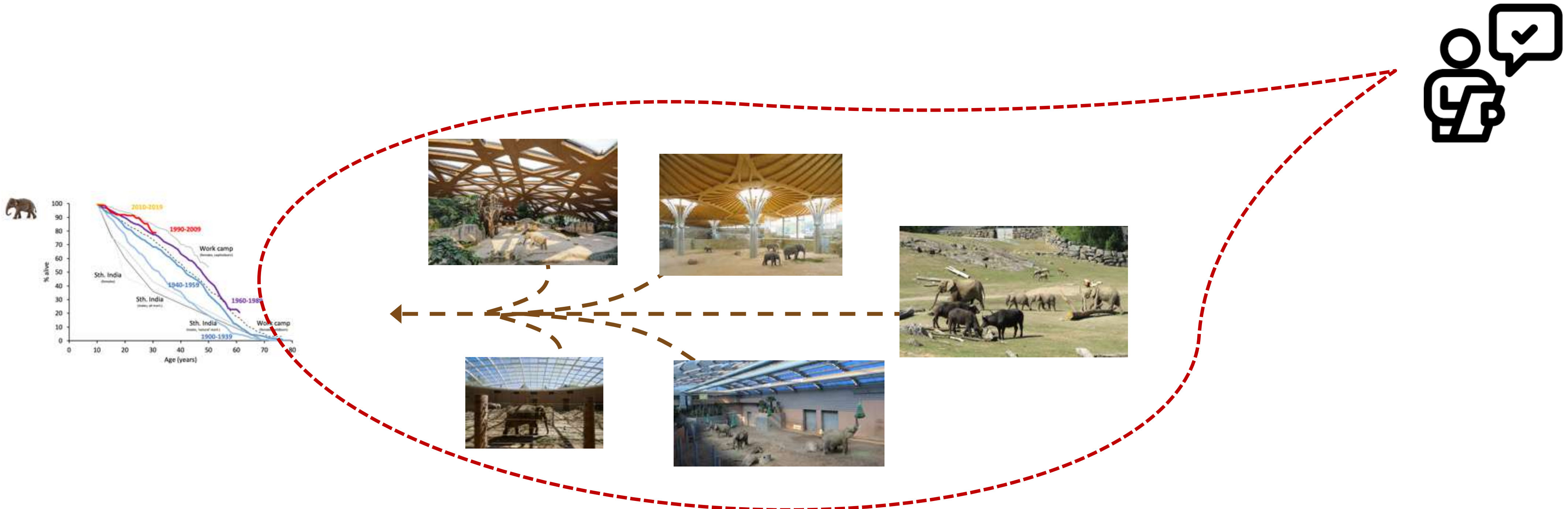
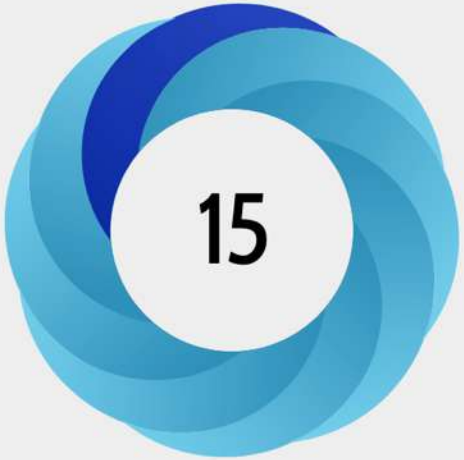
To understand demographic changes, we need to know what is happening in the total of facilities … by surveying the facilities. Ideally, on a regular basis (5-10 years). ***Doing 'just another husbandry and health survey' is a good idea!***





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Published in	Zoo Biology, September 2022
DOI	10.1002/zoo.21733
Pubmed ID	36074074
Authors	Lara Scherer, Laurie Bingaman Lackey, Marcus Clauss, Katrin Gries, David Hagan, Arne Lawrenz... [show]

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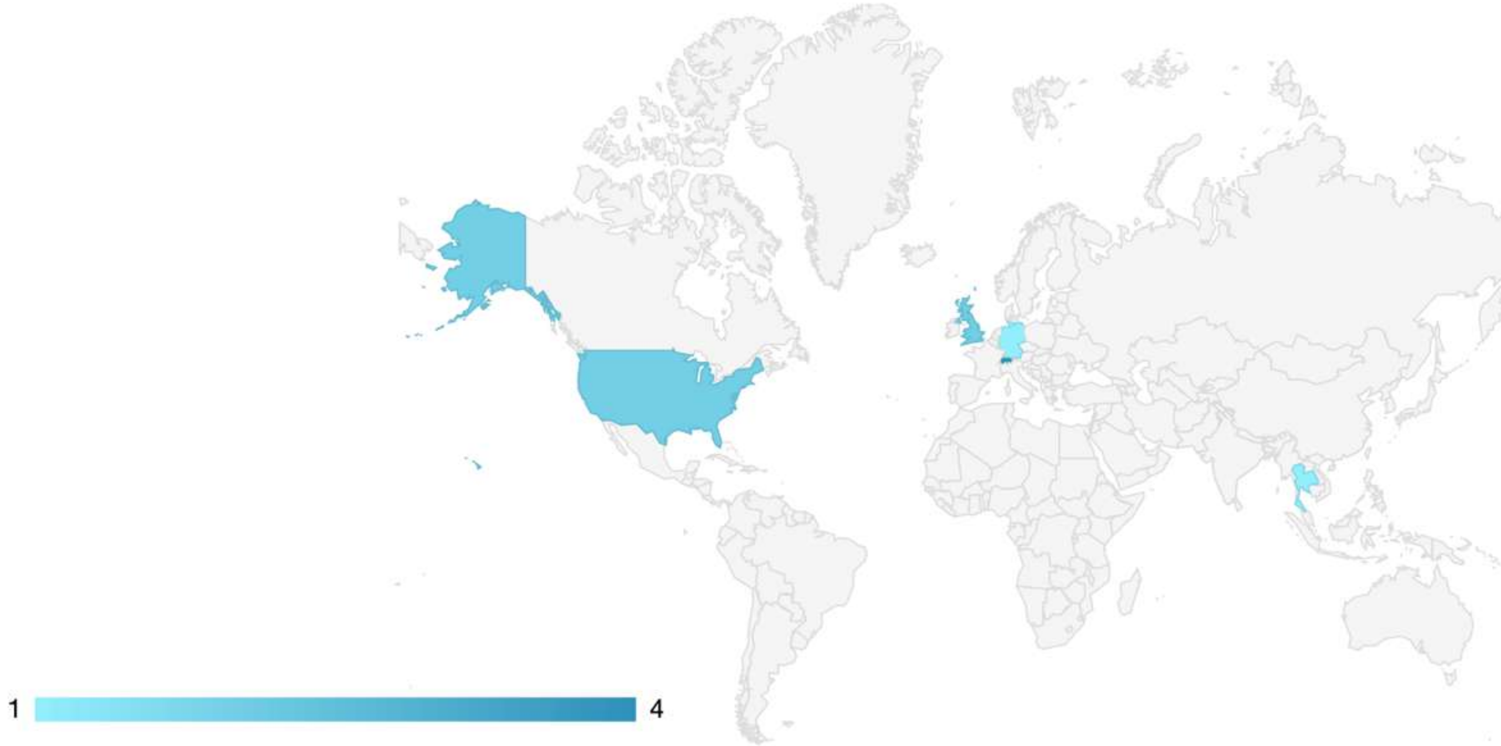


Received: 31 May 2022 | Revised: 25 August 2022 | Accepted: 26 August 2022

DOI: 10.1002/zoo.21733

TECHNICAL REPORT

ZOOBIOLOGY WILEY

The historical development of zoo elephant survivorship

Lara Scherer[1] | Laurie Bingaman Lackey[2] | Marcus Clauss[1] | Katrin Gries[3] | David Hagan[4] | Arne Lawrenz[3] | Dennis W. H. Müller[5] | Marco Roller[6] | Christian Schiffmann[7] | Ann-Kathrin Oerke[8]

[1]Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

[2]Hendersonville, North Carolina, USA

[3]Zoological Garden Wuppertal, Wuppertal, Germany

[4]Indianapolis Zoo, Indianapolis, Indiana, USA

[5]Zoological Garden Halle (Saale), Halle (Saale), Germany

[6]Zoological Garden Karlsruhe, Karlsruhe, Germany

[7]Tier-Erlebnispark Bell, Bell, Germany

[8]European Elephant Service, Endocrinology Laboratory, German Primate Center, Goettingen, Germany

Correspondence

Marcus Clauss, Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Winterthurerstr 260, Zurich 8057, Switzerland.

Email: mclauss@vetclinics.uzh.ch

Abstract

In the discussion about zoo elephant husbandry, the report of Clubb et al. (2008, Science 322: 1649) that zoo elephants had a "compromised survivorship" compared to certain non-zoo populations is a grave argument, and was possibly one of the triggers of a large variety of investigations into zoo elephant welfare, and changes in zoo elephant management. A side observation of that report was that whereas survivorship in African elephants (*Loxodonta africana*) improved since 1960, this was not the case in Asian elephants (*Elephas maximus*). We used historical data (based on the Species360 database) to revisit this aspect, including recent developments since 2008. Assessing the North American and European populations from 1910 until today, there were significant improvements of adult (≥10 years) survivorship in both species. For the period from 1960 until today, survivorship improvement was significant for African elephants and close to a significant improvement in Asian elephants; Asian elephants generally had a higher survivorship than Africans. Juvenile (<10 years) survivorship did not change significantly since 1960 and was higher in African elephants, most likely due to the effect of elephant herpes virus on Asian elephants. Current zoo elephant survivorship is higher than some, and lower than some other non-zoo populations. We discuss that in our view, the shape of the survivorship curve, and its change over time, are more relevant than comparisons with specific populations. Zoo elephant survivorship should be monitored continuously, and the expectation of a continuous trend towards improvement should be met.

KEYWORDS

husbandry, mortality, Proboscidea, progress, survival

Geographical breakdown

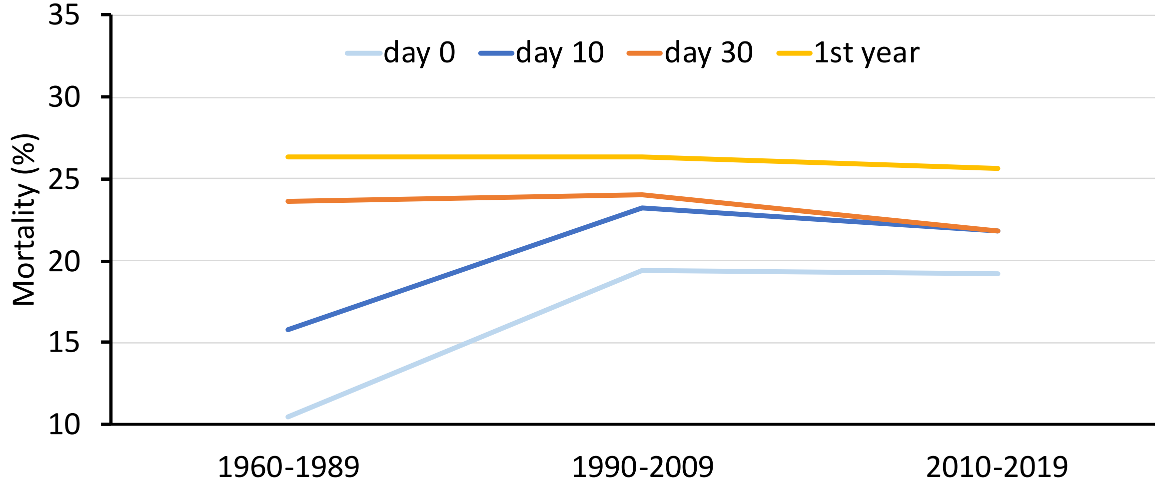
Demographic breakdown

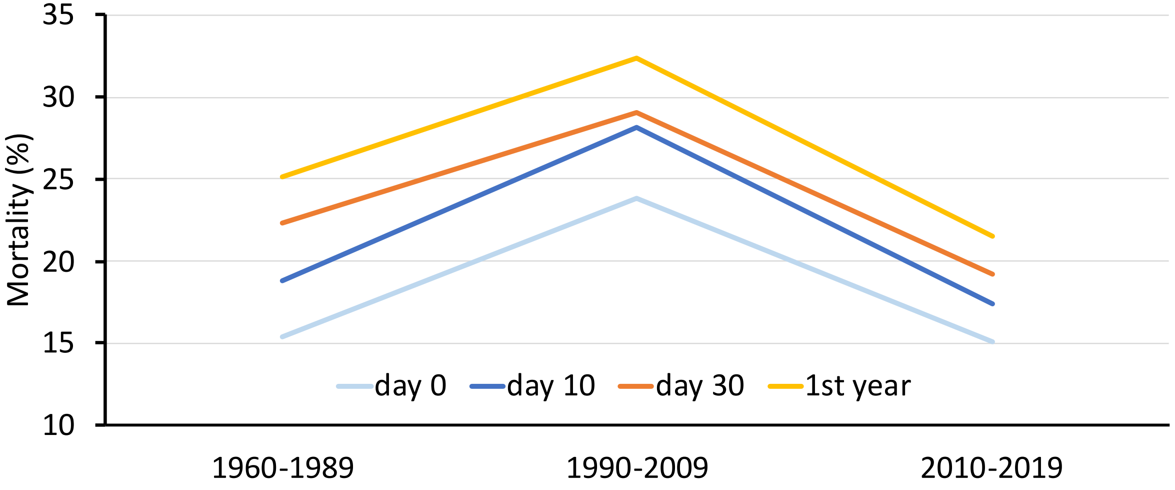
thank you for your attention

Species360 Research Data Agreement # 2019-Q3-RR3
there is no funding to report

conflict of interest: all co-authors work for zoological gardens, or are linked to the zoo community

Juvenile mortality (zooborn only)





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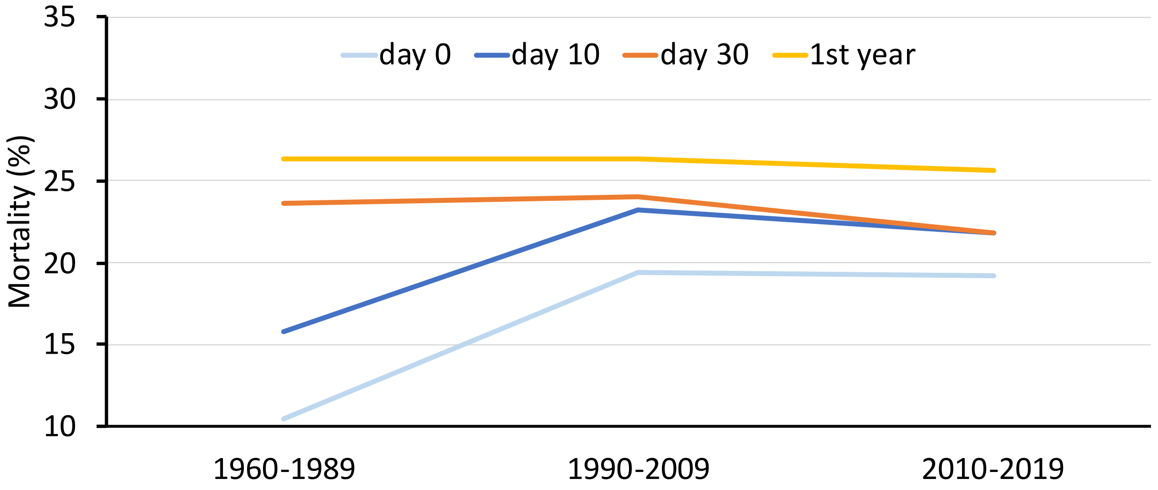

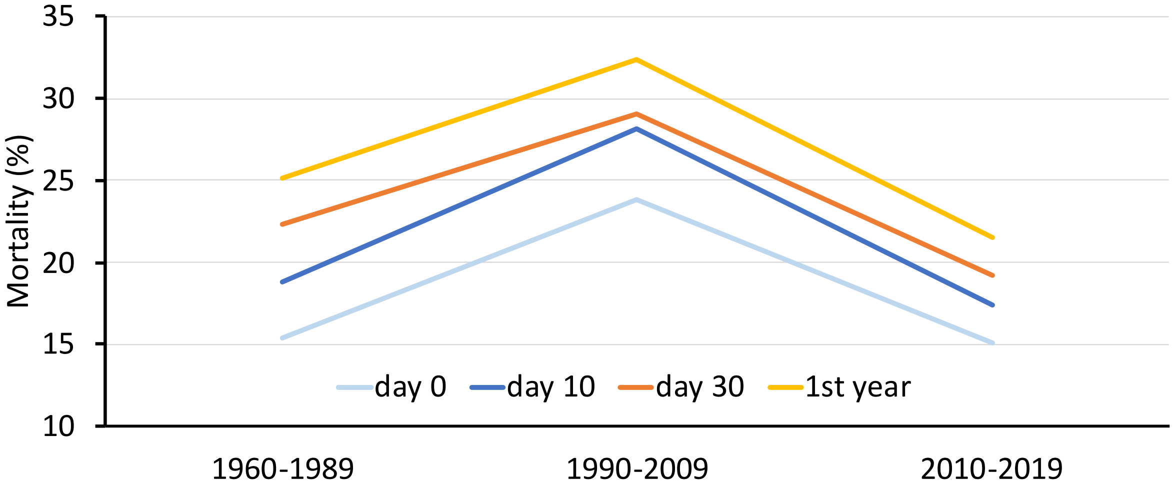

Are comparisons with *in situ* reliable – in terms of day0 mortality reporting ?

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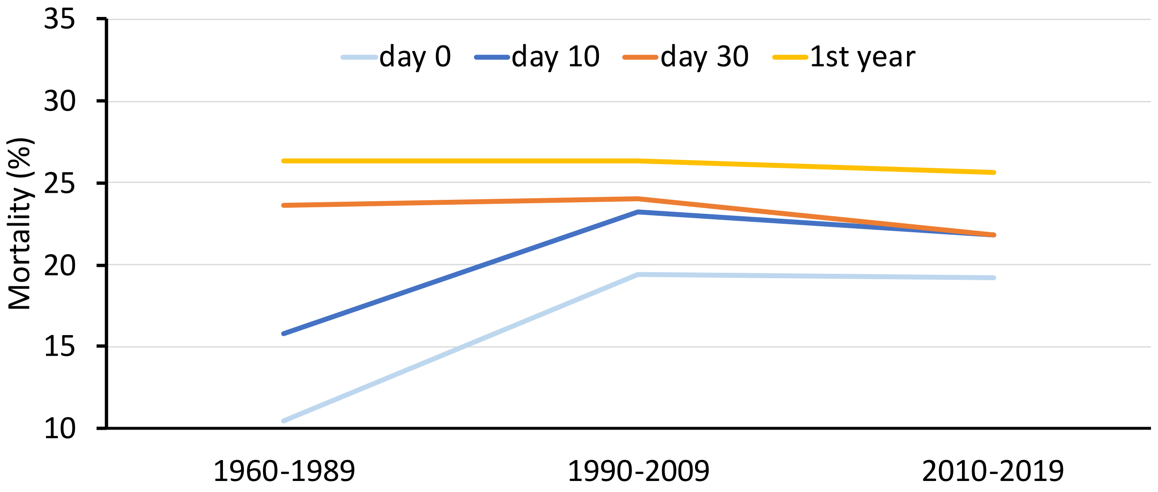

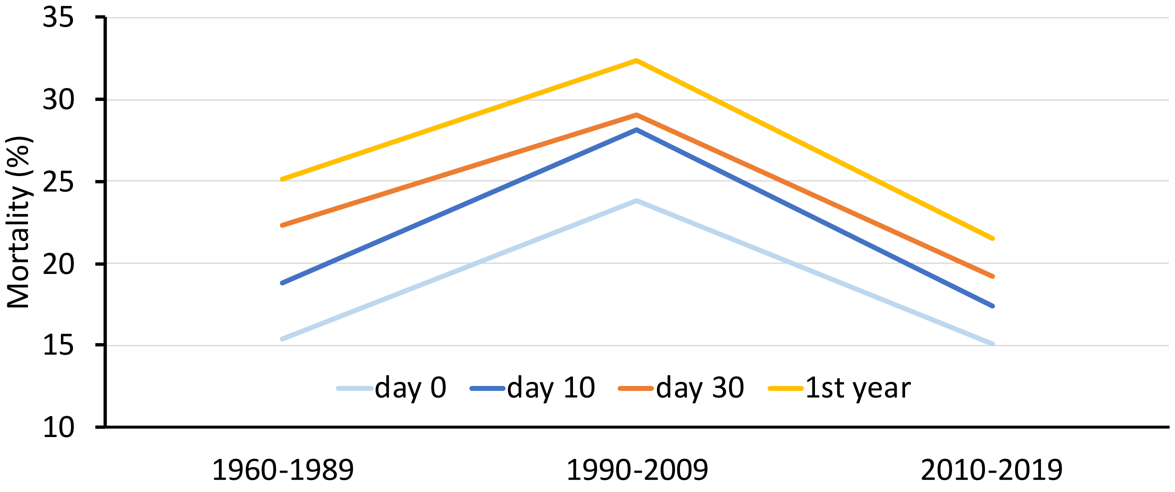

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'Natural' births in zoos – establishment of experienced matrilines.