Sibling competition lengthens while hazardous environments shorten optimal human birth spacing

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Overview

Maternal birth intervals increase with age[1] across human societies and throughout the Primates order.

After giving birth, a mother must usually wean her youngest child before she can reproduce again.

Birth intervals in natural fertility populations are typically 3-5 years[2].

Newborns divert maternal attention from existing children. Young children with many dependent siblings may experience higher mortality rates than if they are the sole recipient of their mother's provisioning.

In addition, **children competing for investment can reduce maternal fertility**[3].

Spacing births allows a woman to recover somatic and extra-somatic resources in preparation for a new birth. Closely-spaced births increase the risk of child mortality.

Here, we examine the question:

How do birth intervals adapt to ecology and sibling competition?

To answer this question, we developed a **state-dependent optimality model**[4].

The model calculates optimal birth spacing over a female's lifespan.

Optimising birth intervals

At every age, a female makes a **decision** whether to reproduce or not. Decisions depend on her **state:** her age and the structure of her existing family.

The model evolves the optimal birth spacing strategies in **high and low mortality environments** with **differing intensities of sibling competition** for maternal resources.

Environmental mortality

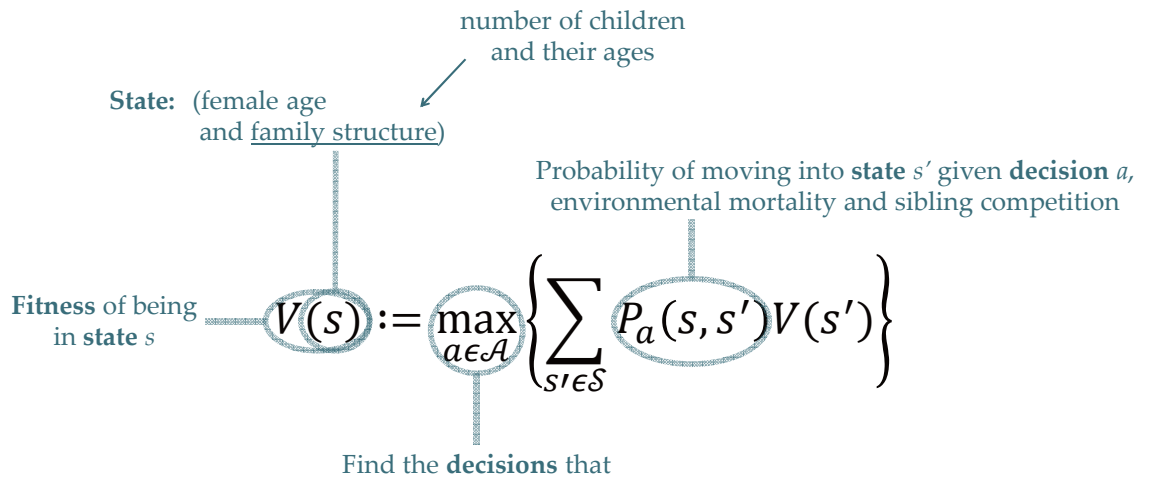
- Individual mortality curve includes decreasing infant, extrinsic and increasing senescent mortality components (Siler model)
- High mortality curve fitted from Tsimane data; low mortality curve fitted from 1960s Swedish data.

Sibling competition

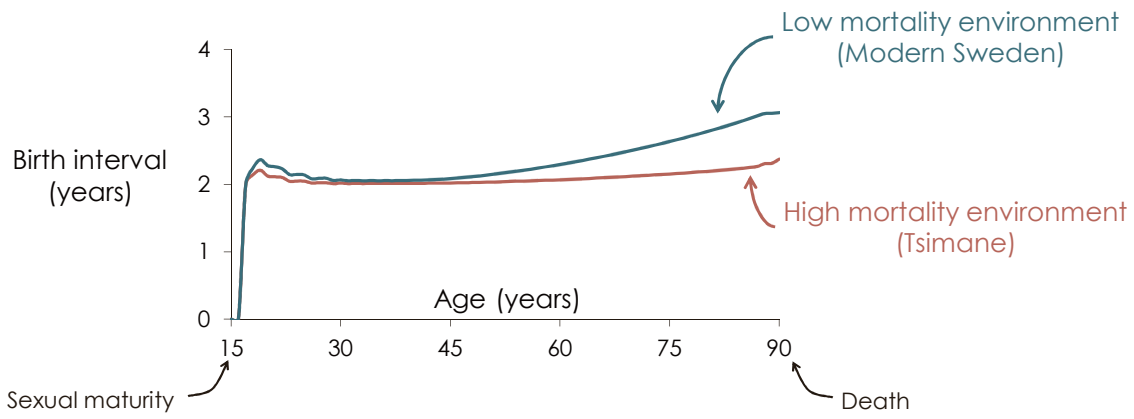
- Each child in a family negatively impacts its siblings' survival.
- These hazards are summed and increase the mortality hazard of other children in the family.

By accounting for the fitness consequences of all decisions in all states, the model produces a strategy that maximises reproductive success.

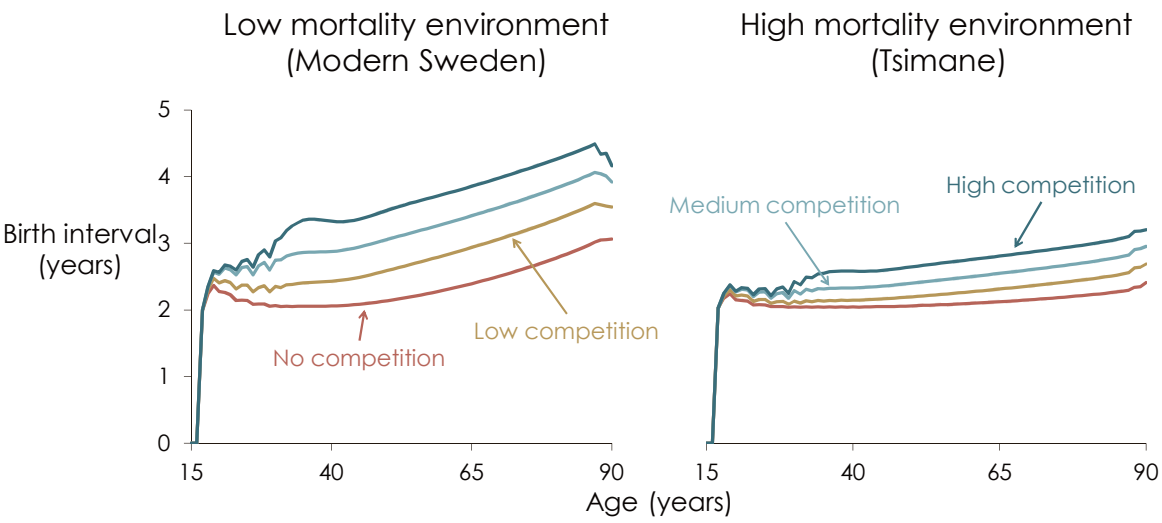
A State-Dependent Optimality Model[5]



High-risk environments shorten birth spacing



Sibling competition lengthens birth intervals



Discussion

In high-mortality environments, life history theory predicts a faster reproductive rate, partly from shorter birth intervals. Our model shows how this pattern can emerge. Birth intervals increase with age, as observed in human populations.

As predicted[3], intensified sibling competition reduces maternal fertility by lengthening her birth intervals. Competition in a high-risk environment extends birth intervals by over 2 years in the case of high-intensity competition.

Here, there is no menopause. Other results (not shown) find menopause can evolve when accounting for an exponentially increased risk of dying during childbirth with age.

References

1 – Caro, TM *et al.* (1995). Termination of reproduction in nonhuman and human female primates. *Int J Primatol*, 16, 205–220.
2 – Sear R & Mace R (2008) Who keeps children alive? A review of the effects of kin on child survival. *Evol Hum Behav* 29: 1–18.
3 – Lawson, DW, Alvergne, A & Gibson, MA (2012). The life-history trade-off between fertility and child survival. *Proc Roy Soc B*, 279, 4755–4764.
4 – Houston, AI & McNamara, JM (1999). *Models of Adaptive Behaviour: An Approach Based on State*; **5** – Also known as Stochastic Dynamic Programming or Markov Decision Processes