Supplementary Information

Conditional strategies as threshold traits

The environmental threshold model [1-3] is the most commonly used quantitative genetic model for understanding conditional strategies [4]. The model forms the basis of our expectation that the probability of double ovulation increases with age as an increasing cumulative normal function. The assumption of the model is that when the expression of dichotomous alternative phenotypes (single versus double ovulation in this case) are non-randomly influenced by one or more environmental cues, an individual's response to any of those cues can be quantified by the value of that environmental cue at which an individual switches phenotype (e.g. age at which an individual switches from single to double ovulation) (Fig. S1a). Variation at the population level in response to age is modelled as a normal distribution of switching ages, where in a cohort of individuals of the same age the normal distribution is split by a threshold between those individuals single ovulating (because their switching age is greater than the age of the cohort) and those double ovulating (because their switching age is less that the switching age of the cohort) (Fig. S1b). Increasing age increases the fraction of the population double ovulating by shifting the position of the threshold to the right. As age increases, the switching age of increasing numbers of individuals is exceed by the age of the cohort, the incidence of double ovulation increases as a cumulative normal function when plotted against age (Fig. S1c). According to the model, the sources of variation in switching age can include genetic variation and variation in other factors that non-randomly influence ovulation, such as parity, height, nutrition, and body mass index, as well as random environmental variation. Consequently, differences in ovulation state (single or double) between successive ovulations in the same individual. Differences in twinning rates between populations could reflect differences in any to these factors, as well as differences in prenatal survival [5]. However, if some fraction of variation in switching age is heritable, then past differences in selection on single versus double ovulation could theoretically be responsible for switch point differences among populations. We chose to model double ovulation in response to maternal age because changes in twinning rate in response to maternal age have been well documented in multiple human populations and maternal age has clear connections to fitness via age effects on live birth rate [6].

Statistical independence and the probability of live birth in double ovulations

The twinning rate formula ($T = F p / (1 + F (1-p))$), shows the relationship between twinning rate, live birth rate and double ovulation rate, where F_t is the double ovulation rate and p_t is the probability of survival from fertilization to birth. The derivation is as follows. If F and p are independent, then for a cohort of females,

$(1-F)\, p$ is the probability of singleton live births from single ovulation;

$F\, (2p\, (1-p))$ is the probability of singleton live births from double ovulation;

$F\, p^2$ is the probability of twin live births; and twinning rate, T, is,

$T = F\, p^2 / (F\, p^2 + F\, (2p\, (1-p)) + (1-F)\, p)$, which with rearrangement gives

$T = F\, p / (1 + F\, (1-p))$[7]. We also employed the assumption that the probabilities of live birth for each zygote are independent in our simulations and modeling in calculating the probabilities of two, one and zero zygotes surviving each developmental stage from conception to age 15.

Changes in probability of prenatal mortality with maternal age

We used a data set compiled from Danish Heath Registries[8], which include only pregnancy outcomes that required admission to a hospital. These outcomes were categorized by maternal age as spontaneous abortion, ectopic pregnancy, hydatidiform mole, stillbirth and livebirth. We included only spontaneous abortions, stillbirths and livebirths in our analysis.

Stillbirths were defined as a fetus lacking any sign of life at a gestational age of 28 weeks or more. The gestational age for spontaneous abortions was set at 9 weeks. For our analyses we relabeled stillbirths as late pregnancy losses. Because the Danish Registry data were compiled from hospital admissions, we assumed that early/cryptic pregnancy losses, for example due to implantation failure that did not require hospitalization were not included. By assuming that the probability of livebirth per conception on maternal age in the Danish Registry was the global average that we estimated from our analysis of twinning rates (Fig. 1, Table 1, Fig. S2d) we were able to estimate the incidence of these early losses from the ratios of abortion to live births and late losses to live birth for five maternal ages (Table S3). We used least squares regression to fit functions to these ages (Tables S1 and S2, Fig. S2) and used the predicted probabilities from the functions for early losses, abortions and late losses for different aged women as inputs in our simulations and probabilistic modeling (Table S1).

Modelling the fitness of single, double and conditional ovulation strategies

If the fitness of an individual at age x is the number of offspring conceived between age x and age M (age of menopause) that survive to age 15, then

$$\text{fitness at age } x = \sum_{k=x}^{M} C(k)$$

where $C(k)$ = number of children conceived when the woman is age k that survive to age 15.

We compare the expected values of these expressions for women utilizing a strategy of single ovulation with women utilizing a strategy of double ovulation and assume for both single and double ovulators that each egg ovulated is fertilized (i.e. conception occurs).

We estimate these expected values with the function

$$F(x) = \sum_{k=x}^{M} N(k)S(k \mid x)$$

where

$N(k)$ = average number of offspring conceived to women age k that survive to age 15

$S(k \mid x)$ = probability that a woman alive at age x has not died before age k.

Determining $N(k)$

Many variables introduced here are identical to or closely related to the variables listed in Table S1 where the variables used in the simulations are defined. If the reader is interested in the equivalences please refer to Table S3.

At age k, let $T = T(k)$ denote the expected time between ovulations (in months), and $V = V(k)$ denote the expected number of offspring per ovulation that survive to age 15. Then

$$N(k) = \frac{12V}{T}.$$

We first determine T for single and double ovulators, and will need the following variables:

$p = p(k)$ = probability zygote implants and survives to term

$\lambda_1 = \lambda_1(k)$ = probability zygote fails to implant or is lost in first month

$\lambda_2 = \lambda_2(k)$ = probability zygote implants but is aborted in early pregnancy

$\lambda_3 = \lambda_3(k)$ = probability zygote implants but is aborted in late pregnancy

$\lambda_4 = \lambda_4(k)$ = probability singleton that survived birth dies within first month

$\lambda_5 = \lambda_5(k)$ = probability singleton dies between first month and first year

$\lambda_6 = \lambda_6(k)$ = probability singleton dies between first year and weaning

$\lambda_7 = \lambda_7(k)$ = probability twin that survived birth dies within first month

$\lambda_8 = \lambda_8(k)$ = probability twin dies between first month and first year

$\lambda_9 = \lambda_9(k)$ = probability twin dies between first year and weaning

ssb = probability singleton fetus is not stillborn given that it reached term

tsb = probability twin fetuses are not stillborn given that they reached term

Δ_1 = average delay (in months) in next ovulation due to implant failure

Δ_2 = average delay (in months) in next ovulation due to early pregnancy loss

Δ_3 = average delay (in months) in next ovulation due to late pregnancy loss

Δ_4 = average delay (in months) in next ovulation due to still birth or loss of infant in first month

Δ_5 = average delay (in months) in next ovulation due to loss of infant between first month and first year

Δ_6 = average delay (in months) in next ovulation due to loss of infant between first year and weaning

Δ_7 = average delay (in months) in next ovulation due to infant surviving to weaning

Note that $p + \lambda_1 + \lambda_2 + \lambda_3 = 1$.

Then for single ovulators we have the following delays and probabilities:

Δ_1, failure to implant with probability λ_1

Δ_2, early pregnancy loss with probability λ_2

Δ_3, late pregnancy loss with probability λ_3

Δ_4, stillbirth or loss of infant in first month with probability

$$p \cdot ssb \cdot \Delta_4 + p \cdot (1 - ssb) \cdot \lambda_4$$

Δ_5, loss of infant between 1 and 12 months with probability $p \cdot (1-ssb) \cdot (1-\lambda_4) \cdot \lambda_5$

Δ_6, loss of infant between 1 and 2 years with probability

$$p \cdot (1-ssb) \cdot (1-\lambda_4) \cdot (1-\lambda_5) \cdot \lambda_6$$

Δ_7, infant survives to 2 years with probability $p \cdot (1-ssb) \cdot (1-\lambda_4) \cdot (1-\lambda_5) \cdot (1-\lambda_6)$

Summing the products of the delays and their respective probabilities gives us

$$\begin{aligned} T = {} & \lambda_1 \cdot \Delta_1 + \lambda_2 \cdot \Delta_2 + \lambda_3 \cdot \Delta_3 + p \cdot (1-ssb) \cdot \Delta_4 + \\ & p \cdot ssb \cdot (\lambda_4 \cdot \Delta_4 + (1-\lambda_4) \cdot (\lambda_5 \cdot \Delta_5 + (1-\lambda_5) \cdot (\lambda_6 \cdot \Delta_6 + (1-\lambda_6) \cdot \Delta_7))) \end{aligned}$$

where the first line results from delays due to prenatal loss and stillbirth, while the second line is from delays due to postnatal loss and weaning.

The situation for double ovulators is more complicated. We assume the survival to term of the two zygotes are independent events. We also assume that if twins survive to term then either both are stillborn or both experience live birth. After live birth, survival of twins going forth are independent events, but with different survival probabilities than singletons have.

To the seven delays $\Delta_1, \ldots, \Delta_7$ we assign probabilities $P_1, \ldots, P_7$ as follows.

Δ_1 occurs when both zygotes fail to implant. $P_1 = \lambda_1{}^2$.

Δ_2 occurs when both zygotes implant and early abort, or only one zygote implants and then early aborts. $P_2 = \lambda_2{}^2 + 2 \cdot \lambda_1 \cdot \lambda_2$.

Δ_3 occurs when both zygotes implant and late abort, or both zygotes implant and one early aborts while the other late aborts, or only one zygote implants and then late aborts.

$P_3 = \lambda_3{}^2 + 2 \cdot \lambda_2 \cdot \lambda_3 + 2 \cdot \lambda_1 \cdot \lambda_3$.

Without enumerating the separate events explicitly we note that there are eight events which contribute to a delay of Δ_4, and the sum of their probabilities is

$$P_4 = 2 \cdot (\lambda_1 + \lambda_2 + \lambda_3) \cdot p \cdot (1 - ssb) + p^2 \cdot (1 - tsb) +$$
$$2 \cdot (\lambda_1 + \lambda_2 + \lambda_3) \cdot p \cdot ssb \cdot \lambda_4 + p^2 \cdot tsb \cdot {\lambda_7}^2$$

where the first line is sums of probabilities associated with stillbirth, while the second line is sums of probabilities associated with loss of infant(s) in first month.

Five events contribute to Δ_5, with

$$P_5 = 2 \cdot (\lambda_1 + \lambda_2 + \lambda_3) \cdot p \cdot ssb \cdot (1 - \lambda_4) \cdot \lambda_5 +$$
$$p^2 \cdot tsb \cdot (2 \cdot \lambda_7 \cdot (1 - \lambda_7) \cdot \lambda_8 + (1 - \lambda_7)^2 \cdot {\lambda_8}^2)$$

where the first line are results from a singleton birth and the second line from a twin birth.

Six events contribute to Δ_6, with

$$P_6 = 2 \cdot (\lambda_1 + \lambda_2 + \lambda_3) \cdot p \cdot ssb \cdot (1 - \lambda_4) \cdot (1 - \lambda_5) \cdot \lambda_6 +$$
$$p^2 \cdot tsb \cdot (2 \cdot \lambda_7 \cdot (1 - \lambda_7) \cdot (1 - \lambda_8) \cdot \lambda_9 + (1 - \lambda_7)^2 \cdot (2 \cdot \lambda_8 \cdot (1 - \lambda_8) \cdot \lambda_9 + (1 - \lambda_8)^2 \cdot {\lambda_9}^2))$$

where again the first line are results from a singleton birth and the second line from a twin birth.

Seven events contribute to Δ_7, with

$$P_7 = 2 \cdot (\lambda_1 + \lambda_2 + \lambda_3) \cdot p \cdot ssb \cdot (1 - \lambda_4) \cdot (1 - \lambda_5) \cdot (1 - \lambda_6) +$$
$$p^2 \cdot tsb \cdot (2 \cdot \lambda_7 \cdot (1 - \lambda_7) \cdot (1 - \lambda_8) \cdot (1 - \lambda_9) + (1 - \lambda_7)^2 \cdot (2 \cdot \lambda_8 \cdot (1 - \lambda_8) \cdot (1 - \lambda_9) +$$
$$(1 - \lambda_8)^2 \cdot (2 \cdot \lambda_9 \cdot (1 - \lambda_9) + (1 - \lambda_9)^2)))$$

and again the first line are results from a singleton birth, the second and third lines from a twin birth.

We finally obtain our expected interovulation interval for double ovulators as

$$T = \sum_{j=1}^{7} P_j \cdot \Delta_j \ .$$

The second expectation we must determine is *V*, the number of offspring surviving to age 15 per ovulation. We need to introduce four more variables now, related to mothers surviving birth and offspring surviving to age 15. So we let *mss* = probability mother survives singleton birth

mst = probability mother survives twin birth

ss15 = probability singleton survives to age 15

ts15 = probability twin survives to age 15

Then for single ovulators we have

$$V = p \cdot ssb \cdot mss \cdot ss15$$

since it is assumed that if the mother does not survive the birth, the child will not survive either. For double ovulators we have

$$V = 2 \cdot p \cdot (1 - p) \cdot ssb \cdot mss \cdot ss15 + p^2 \cdot tsb \cdot mst \cdot (2 \cdot ts15^2 + 2 \cdot ts15 \cdot (1 - ts15))$$

and our calculation of $N(k)$ for both strategies is complete.

Determining $S(k \mid x)$

We continue to utilize the variables defined in the previous section. For comparison of the two strategies we assume that there is at most only one birth event at age *x*, and we first determine

$R(k)$ = probability a woman age *k* does not die in childbirth.

For a single ovulator we define

$B_S(k)$ = births per ovulation for a woman age *k*.

Since we know interovulation intervals $T(k)$ for $k \geq x$, we note that $\frac{12 \cdot B_S(k)}{T(k)}$ gives us births per year for a woman age *k*, and that this ratio serves as the probability a woman gives birth at age *k*. (Recall that the calculation of *T* differs for single and double ovulators.) For single ovulators we have $B_S(k) = p(k)$, so the probability a woman age k dies in childbirth is

$\frac{12 \cdot p(k) \cdot (1-mss)}{T(k)}$ and the probability a woman age k does not die in childbirth is

$$R(k) = 1 - \frac{12 \cdot p(k) \cdot (1-mss)}{T(k)}.$$

For double ovulators we consider the possibilities of twin and singleton births so we define

$B_T(k)$ = twin births per ovulation for a woman age k

$B_S(k)$ = singleton births per ovulation for a woman age k.

Then $\frac{12 \cdot B_T(k)}{T(k)}$ gives us twin births per year at age k and $\frac{12 \cdot B_S(k)}{T(k)}$ gives singleton births per year at age k. We know $B_T(k) = (p(k))^2$ and $B_S(k) = 2 \cdot p(k) \cdot (1-p(k))$, so the probability a woman age k dies in childbirth is $\frac{12 \cdot (p(k))^2 \cdot (1-mst)}{T(k)} + \frac{24 \cdot p(k) \cdot (1-p(k)) \cdot (1-mss)}{T(k)}$, and for double ovulators we obtain

$$R(k) = 1 - \frac{12 \cdot (p(k))^2 \cdot (1-mst)}{T(k)} - \frac{24 \cdot p(k) \cdot (1-p(k)) \cdot (1-mss)}{T(k)}.$$

The last variable we introduce is

asr = annual survival rate of the adult population.

So now we have, for both strategies (single and double ovulation)

$$S(x \mid x) = 1$$

$$S(x+1 \mid x) = R(x) \cdot asr$$

$$S(x+2 \mid x) = S(x+1, x) \cdot R(x+1) \cdot asr$$

.

.

.

$$S(k \mid x) = S(k-1, x) \cdot R(k-1) \cdot asr$$

and our calculation of $S(k \mid x)$ for both strategies is complete.

Numerical results

Parameter values coincide with those used in the simulations. Values are assigned to p, λ_2, and λ_3 as follows (recall that $p + \lambda_1 + \lambda_2 + \lambda_3 = 1$):

$$p(k) = 0.55 \cdot 0.89^{(k-18)}$$

$$\lambda_2(k) = 0.18555 - 0.010243 \cdot k + 0.000153 \cdot k^2$$

$$\lambda_3(k) = 11.849 \cdot k^{-2.916}$$

In the formula for *p* it is assumed that at age 18 a zygote has probability 0.55 of implanting and surviving to term, and that ova quality in the next year is 89% that of the current year based on our analysis of age- dependent twinning rates (Table S1). The formulas for λ_2 and λ_3 were obtained by least squares curve fitting of data in Table S2 (see Fig. S2).

In the simulation $\lambda_4, \ldots, \lambda_9$ are constants that do not change with age. The values of these and the remaining parameter values used in the simulation are as follows:

$$\lambda_4(k) = 0.07$$

$$\lambda_5(k) = 0.14$$

$$\lambda_6(k) = 0.122$$

$$\lambda_7(k) = 0.43$$

$$\lambda_8(k) = 0.302$$

$$\lambda_9(k) = 0.204$$

ssb = 0.962

tsb = 0.889

mss = 0.992

mst = 0.967

ss15 = 0.45975

ts15 = 0.17

asr = 0.993

$\Delta_1 = 1.5$

$\Delta_2 = 2.5$

$\Delta_3 = 7.5$

$\Delta_4 = 11.3$

$\Delta_5 = 15$

$\Delta_6 = 27$

$\Delta_7 = 35$

The result with these values is that the double ovulation strategy have greater fitness than the single ovulation strategy at every age (Fig. 3b).

Switch point analysis

The fitness functions constructed thus far assume that a female utilizes a strategy (single or double ovulation) for her entire reproductive life. Numerical results from the previous section showed that (for the parameter values listed) if a woman age *x* must choose a strategy which will be used for the remainder of her life, it is always better to be double ovulating. We now consider the possibility that a woman might utilize one strategy at the beginning of her reproductive life, then switch to the other strategy for the later part of her reproductive life. Does it make sense to do this, and if so is there an optimal age to switch from one strategy to the other? The following results utilize parameter values from the beginning of the previous section.

We first note that the function $N(k)$ (average number of offspring conceived to women age k that survive to age 15) is giving us the expected contribution to lifetime fitness made during age k (Fig. 3D). Note that initially in a female's reproductive life the function is larger for single ovulators, but that this changes around age 22.

This suggests it is better to single ovulate when early in one's reproductive life, then switch to double ovulating later in life. To investigate this define the variable sp = age at which the female stops single ovulating and begins double ovulating. So a female single ovulates from age 18 to age $sp - 1$, then double ovulates from age sp to age 40. Then the lifetime fitness of such a female is

$$F(sp) = \sum_{k=18}^{40} N(k) S(k \mid 18)$$

where $N(k)$ is constructed for a single ovulator for $k = 18, 19, \ldots, sp - 1$ and constructed for a double ovulator for $k = sp, sp + 1, \ldots, 40$. $S(k \mid 18)$ is constructed using $R(j)$ for single ovulators when $j = 18, 19, \ldots, sp - 1$ and then using $R(j)$ for double ovulators when $j = sp, sp + 1, \ldots, k - 1$.

We evaluated this function for values of sp from 18 to 40 (Fig.3A). This result suggests that that switching from single to double ovulation at age 25 yields the highest fitness return.

Limitations of available data

For the Gambia natural fertility population the sample size consisted of 99 twins and 2819 singletons[9]. For the Bangladesh population the sample size consisted of 494 subjects and 329 pregnancies[10]. For our analysis of the fitness of the different ovulatory strategies we assumed that the age-dependent prenatal survival rates for early losses, spontaneous abortions, and late losses that we derived from the Danish Hospital Registry[8] are representative of such losses in a natural fertility population.

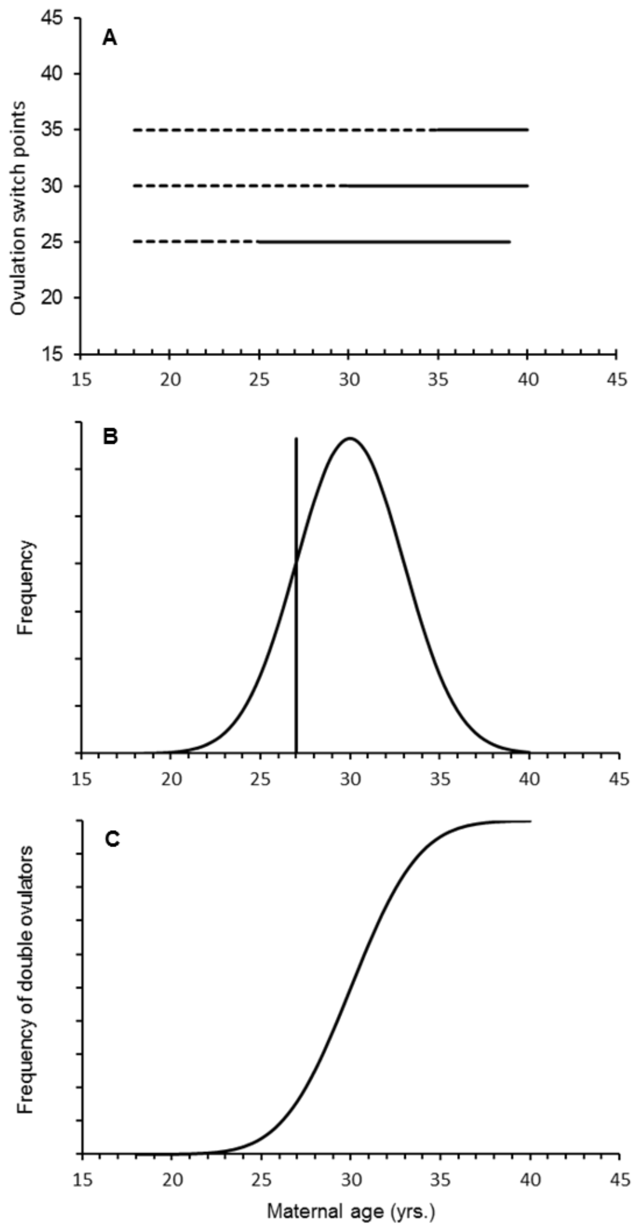

Fig. S1. Double ovulation as a threshold trait. **a,** Three conditional (age-dependent) ovulatory strategies that differ in age of switching from single (dashed line) to double ovulation (solid line). **b,** Threshold trait depiction of a population with normally distributed variation in age at switching (mean age at switching from single to double ovulation is 30 yrs., SD of 3 yrs.). At age 27, the threshold (vertical line positioned at age 27) divides the population into individuals that double ovulate (those with switching ages less than 27) and single ovulate (those with switching ages greater than 27). **C**, As age increases, the fraction of double ovulators increases as a cumulative normal distribution (mean of 30 yrs., SD of 3 yrs.) as the threshold shifts with age, increasing fraction of individuals whose switching age is less than the threshold.

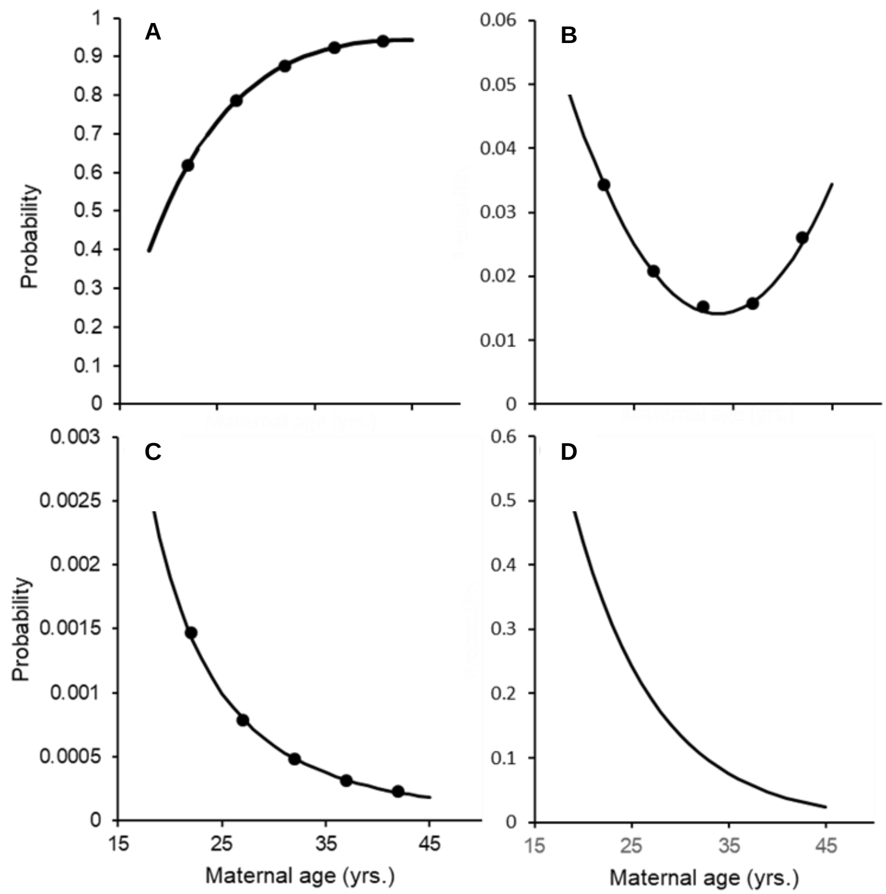

Fig. S2. Age-dependent probabilities of live birth and prenatal deaths from early losses, spontaneous abortion and miscarriage. **a-c**, points from Table S2; lines are best fitting curves from least squared regression. **a**, Early loss of pregnancy (variable r in Table S2); **b**. Spontaneous abortion (variable s in Table S2); **c**, Late loss of pregnancy (variable t in Table S2); **d**, Live birth (line from average of results in Fig. 1f; variable u in Table S2).

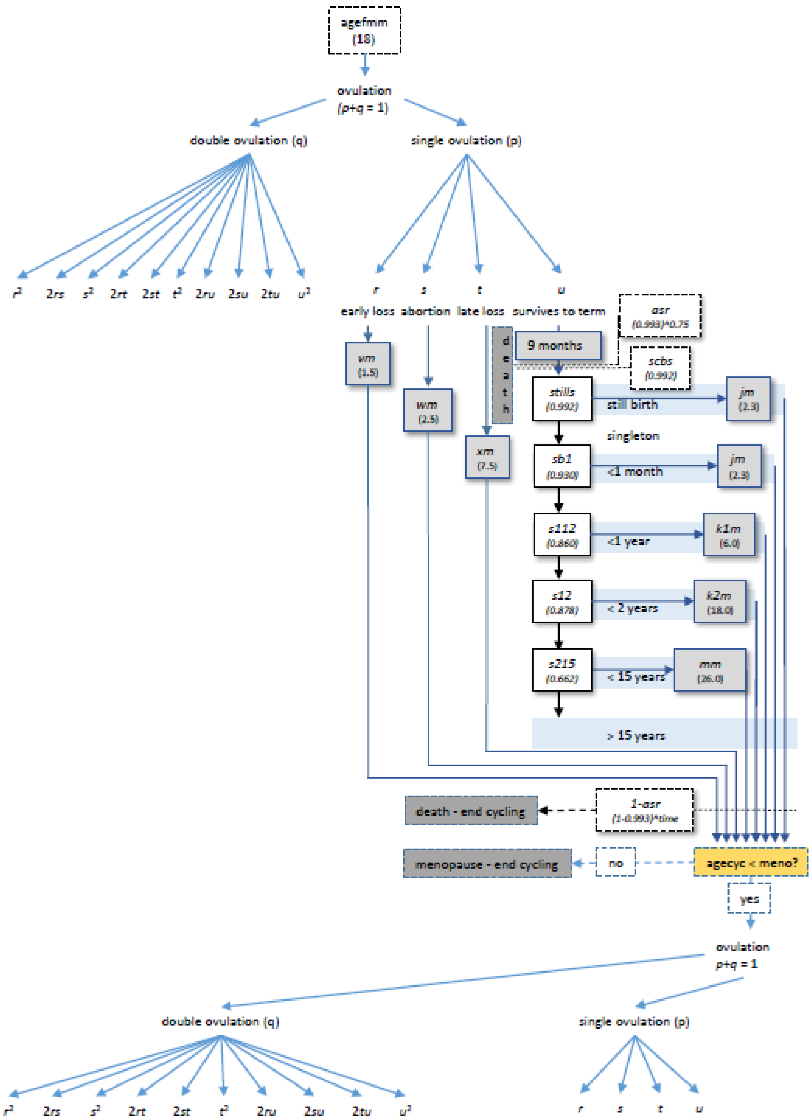

Fig. S3. Simulation of the outcomes for single ovulations. Solid lines represent outcomes for zygotes and offspring, and dashed lines outcomes and events for women. Women start ovulating at 18 years*. Parameters *r*, *s*, *t*, and *u* vary with maternal age. Grey boxes denote times (months) added following particular outcomes, and white boxes show the probabilities of certain outcomes. For example, when ovulation results in early loss, 1.5 months are added to female age. Offspring survive after term, only if their mother survives at the annual survival rate associated with the 9 months of pregnancy ($asr_{9\ months} = (0.993^{0.75})$), and the mother survives childbirth (*scbs*) and the child survives the possibility of being stillborn (*stills*). The child survives further time intervals subject to the probabilities in the white boxes. Continued offspring survival up to two years old accumulates time out of reproduction for the mother, before precipitating the resumption of ovulatory cycling. Women are subject to an annual survival rate (asr) during all time intervals (cycling and failed conceptions, and pregnancy), and therefore only females that survive for the time periods specified continue to cycle. When women die in childbirth (1-*scbs*), the child being born also dies; however, the death of mothers after successful childbirth (1-*asr*) does not affect the subsequent survival of the offspring, even those less than 2 years old. Before a new ovulation (single or double) occurs, the age of the female (*agecyc*; i.e. age at the beginning of ovulation plus accumulated time based on zygote/child survival) is checked against the specified age of menopause (*meno*) to ensure that $agecyc < meno$, in which case the female ovulates again, otherwise she ceases ovulatory cycling. The probability of single (*p*) or double (*q*) ovulation is dependent on age and the user defined switchpoint mean (*spm*) and standard deviation (*spSD*). The simulation allows standard deviations to be fitted around age and time intervals, but these were set as zero in this study.

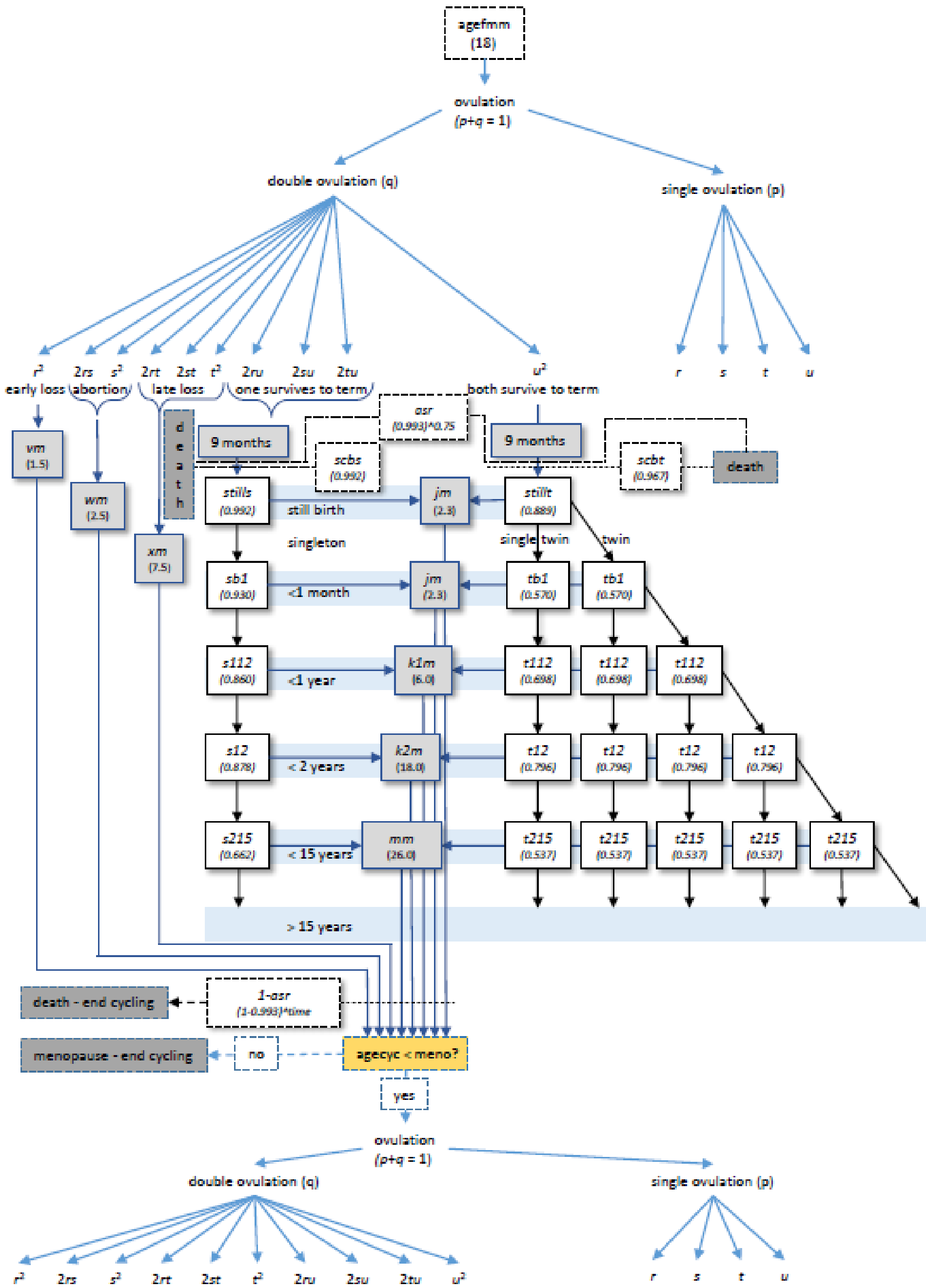

Fig. S4. Simulation of the outcomes for double ovulations**.** See Fig. S3 legend for description of the graphical representation of the model. The parameters *scbs* and *scbt* are the probabilities of maternal survival during single and twin childbirth respectively. For double ovulations, when ovulation results in early loss of both embryos, 1.5 months* is added to female age. However if one embryo is lost earlier and the other later (e.g. one early loss *r* and one late loss *t,* that occurs with the probability *2rt*), the time until ovulation is resumed is dependent on the survival of the longer surviving embryo (i.e. late loss = +7.5 months in the example of *rt*). Twin offspring that survive to term, survive childbirth each with a probability of *stillt* and survive further time intervals subject to the probabilities in the white boxes (illustrated in Fig. S3). As with the prenatal outcomes, continued survival of the longest living offspring up to 2 years at weaning accumulates increasing time before precipitating the resumption of ovulatory cycling. A woman's survival is applied according to asr_{time}. Only if $agecyc < meno$ do females ovulate again. The simulation allows standard deviations to be fitted around age and time intervals, but these were set as zero in this study.

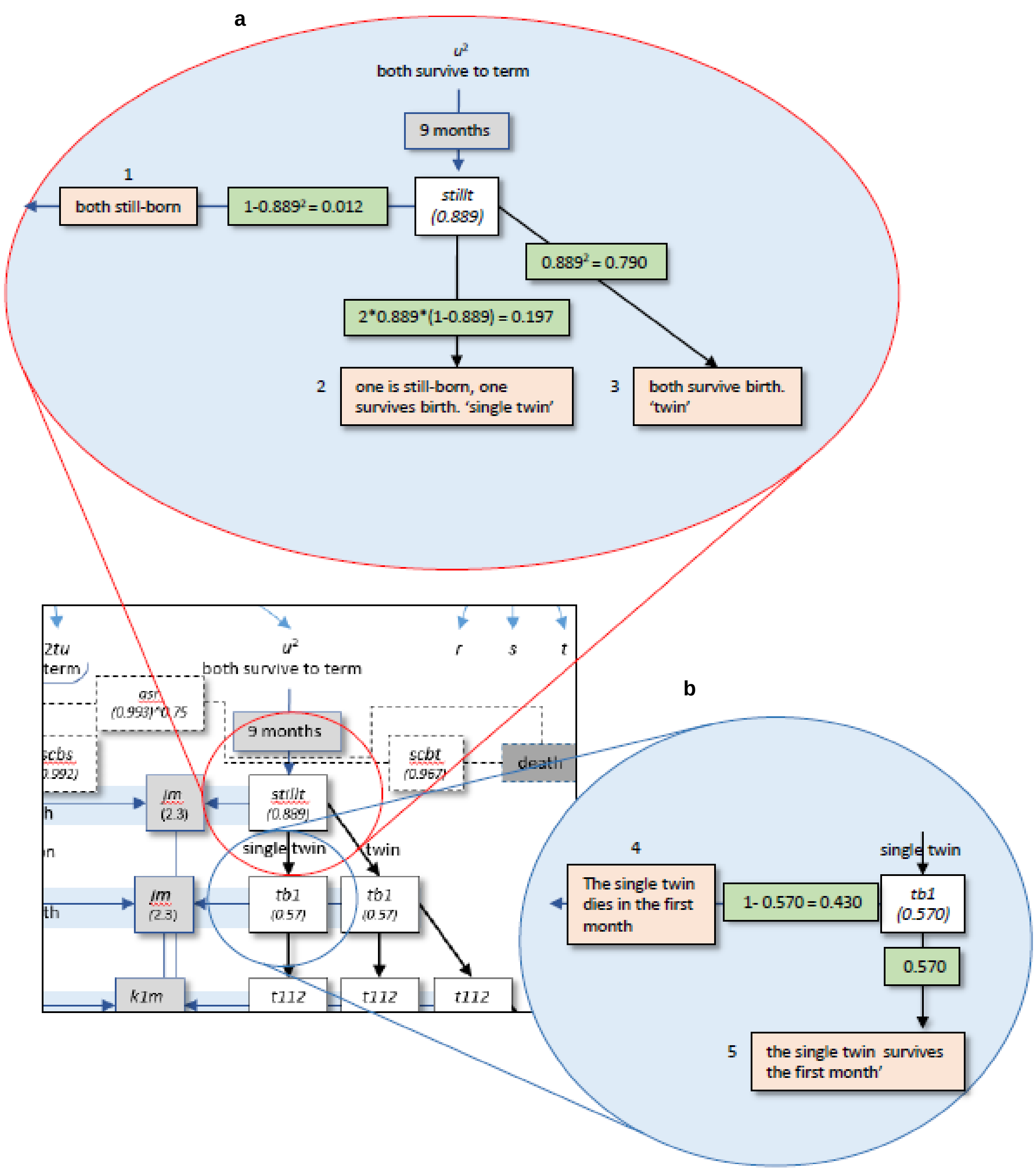

Fig. S5. Twin and singleton (and single twin) outcome details. **a,** Three outcomes when twins are present. The probability *stillt* is used to calculate the probabilities (green boxes) of 1) both twins dying during the period under consideration. 2) one twin dying and one surviving, or 3) both twins surviving. In the example shown the period under consideration is birth and shows the outcomes for *stillt*, but the pattern of 0, 1, or 2 surviving, applies to the right most cascade where white boxes joined by the horizontal, vertical and diagonal arrows. **B,** Two outcomes when singletons or single twins are present. The probability *tb1* is used to calculate the probabilities (green boxes) of 4) the single twin dying during the period under consideration or 5) the single twin surviving. In the example shown the period under consideration is from birth to one month.

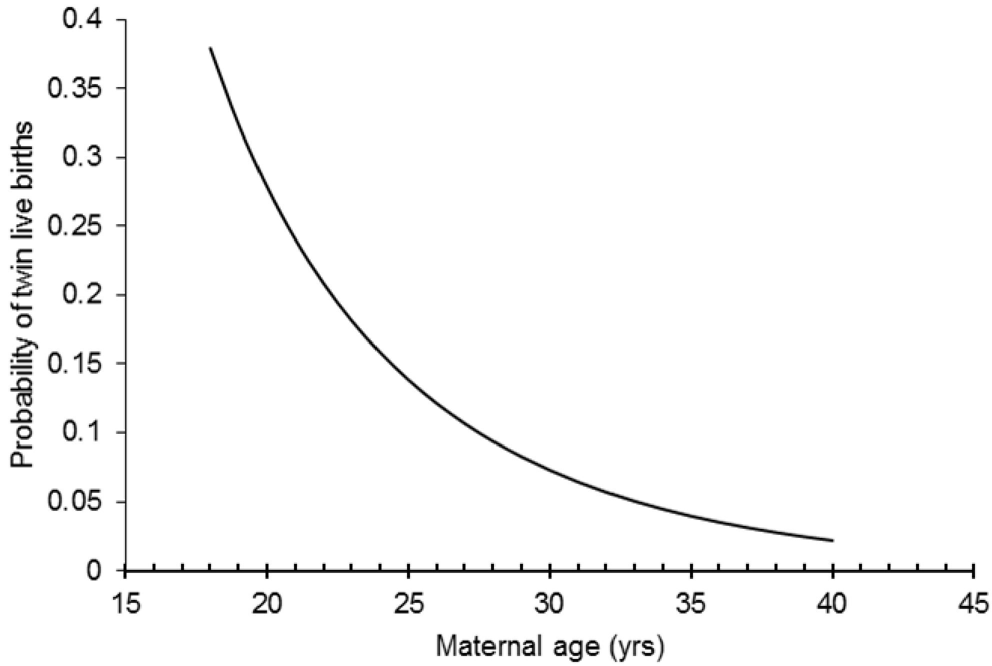

Fig. S6. Age-dependent probability of twin live births in double ovulators. Probability of twin births was calculated using formula 1 in supplementary material, assuming declining probability of live birth depicted in Fig. S2d.

Table S1.

Simulation and modeling variables

Variable	Value	Definition
agefmm	18	Age in years at first parous ovulation (*4*)
meno	40	Age at last reproductive cycle
q	Varies with age	Proportion of double ovulations. 0 or 1 depending on age at ovulation relative to *spm*. If age is greater than *spm*, women double ovulate, if less than *spm* they single ovulate
spm	Based on input	Age at which women switch from single to double ovulation. (If *spm* is less that *agefmm*, women always double ovulate. If *spm* is greater than *meno*, women always single ovulate.)
r	Varies with age	Probability of early (1-2 months) loss ($r = 1 - (u + s + t)$)
s	Varies with age	Probability of abortion (2-3 months) ($s = 0.185559 - 0.010243*age + 0.000153*age^2$)
t	Varies with age	Probability of late (6-9 months) loss ($t = 11.849*age^{-2.916}$)
u	Varies with age	Probability of live birth ($u = 0.55*0.89^{(age-18)}$).
vm	1.5	Mean months to next cycle after early pregnancy brood loss.
wm	2.5	Mean months to next cycle after brood loss from spontaneous abortion
xm	7.5	Mean months to next cycle after brood loss from late loss
asr	0.993	Annual adult survival rate (*4*)
scbs	0.992	Probability of surviving singleton childbirth (*4*)

scbt	0.967	Probability of surviving twin childbirth (*4*)
stills	0.962	Probability of not being still born: singleton (*4*)
stillt	0.889	Probability of not being still born: twins (*4*)
sb1	0.930	Singleton: survival rate birth to one month (*4*)
s112	0.860	Singleton: survival rate one month to 12 months (*4*)
s12	0.878	Singleton: survival rate one year to two years (weaning) (*4*)
s215	0.662	Singleton: survival rate two years to 15 years (*4*)
tb1	0.570	Twin: survival rate birth to one month (*4*)
t112	0.698	Twin: survival rate one month to 12 months (*4*)
t12	0.796	Twin: survival rate one year to two years (weaning) (*4*)
t215	0.537	Twin: survival rate two years to 15 years (*4*)
jm	2.3	Months added to 9 for brood loss before 1 month
k1m	6	Months added to 9 for brood loss after 1 month but before 1 year
k2m	18	Months added to 9 for brood loss after 1 year but before 2 year
mm	26	Months added to 9 for having offspring reaching 2 years (weaning)

Table S2.

Estimating the age-dependent probabilities of prenatal losses based on data from the Danish Hospital Registry (*26*)

Age (yrs)	Number of live births (L)	Number of abortions (A)	Number of late losses (S)	A/L	S/L	Live birth rate (u)	Abortion rate (s = Au/L)	Late loss rate (t = Su/L)	Early loss rate (r = 1-(u+ s+ t))
22	246038	24465	1046	0.099	0.004	0.345	0.034	0.001	0.619
27	312904	33728	1270	0.108	0.004	0.193	0.021	0.001	0.786
32	157457	22391	699	0.142	0.004	0.108	0.015	0.000	0.877
37	43471	11369	226	0.262	0.005	0.060	0.016	0.000	0.924
42	5101	3962	34	0.777	0.007	0.034	0.026	0.000	0.940

Table S3.

Equating variables used in mathematical model and simulations

Mathematical Model	**Simulation**
p	u
λ_1	r
λ_2	s
λ_3	t
λ_4	$1 - sb1$
λ_5	$1 - s112$
λ_6	$1 - s12$
λ_7	$1 - tb1$
λ_8	$1 - t112$
λ_9	$1 - t12$
ssb	*stills*
tsb	*stillt*
mss	*scbs*

mst	*scbt*
ss15	*sb1·s112·s12·s215*
ts15	*tb1·t112·t12·t215*
asr	*asr*
Δ_1	*vm*
Δ_2	*wm*
Δ_3	*xm*
Δ_4	*jm* + 9
Δ_5	*k1m* + 9
Δ_6	*k2m* + 9
Δ_7	*mm* + 9

References

1 Hazel, W., Smock, R. & Johnson, M. A polygenic model for the evolution and maintenance of conditional strategies. *Proceedings of the Royal Society B* **242**, 181-187 (1990).

2 Hazel, W., Smock, R. & Lively, C. M. The ecological genetics of conditional strategies. *American Naturalist* **163**, 888-900, doi:10.1086/386313 (2004).

3 Tomkins, J. L. & Hazel, W. The status of the conditional evolutionarily stable strategy. *Trends in Ecology & Evolution* **22**, 522-528 (2007).

4 Buzatto, B. A., Buoro, M., Hazel, W. N. & Tomkins, J. L. Investigating the genetic architecture of conditional strategies using the environmental threshold model. *Proceedings of the Royal Society B* **282**, doi:10.1098/rspb.2015.2075 (2015).
5 Catalano, R. A., Saxton, K., Bruckner, T., Goldman, S. & Anderson, E. A sex-specific test of selection in utero. *Journal of Theoretical Biology* **257**, 475-479, doi:10.1016/j.jtbi.2008.12.008 (2009).
6 McCoy, R. C. *et al.* Common variants spanning PLK4 are associated with mitotic-origin aneuploidy in human embryos. *Science* **348**, 235-238 (2015).
7 Atkinson, D. E. Frequency of dizygotic twinning. *Nature* **322**, 780-780 (1985).
8 Andersen, A.-M. N., Wohlfahrt, J., Christens, P., Olsen, J. & Melbye, M. Maternal age and fetal loss: population based register linkage study. *BMJ* **320**, 1708-1712, doi:10.1136/bmj.320.7251.1708 (2000).
9 Sear, R., Shanley, D., McGregor, I. A. & Mace, R. The fitness of twin mothers: evidence from rural Gambia. *Journal of Evolutionary Biology* **14**, 433-443, doi:10.1046/j.1420-9101.2001.00287.x (2001).
10 O'Connor, K. A., Holman, D. J. & Wood, J. W. Declining fecundity and ovarian ageing in natural fertility populations. *Maturitas* **30**, 127-136, doi:10.1016/s0378-5122(98)00068-1 (1998).