

Can the sex of the second child be predicted by the birth-weight of the first child?

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Summary The reproduction costs to a human mother are different if she has a son as opposed to a daughter. According to the Trivers–Willard hypothesis, evolution should promote those females who, having the ability to invest in the more expensive sex, are also able to adjust the sex of their offspring accordingly. It is therefore possible that a mother's biological condition (which is also connected with her reproductive potential), as measured by the neonatal weight of her first child, can be a good predictor of the second child's sex. From data for 227 healthy mothers from Wrocław (Poland) we show that the probability of giving birth to a boy in the second pregnancy is higher after a relatively heavier first-born child (ANOVA, $F(1,225) = 3.79$, $P < 0.053$). This relationship, however, is only significant after a first-born daughter ($F(1,117) = 9.66$, $P < 0.002$) and not after a first-born boy. Some possible explanations of the fact that only the birth-weight of a first-born daughter – and not a son – can be a good predictor of the secondary sex ratio are also discussed. © 2002 Harcourt Publishers Ltd

INTRODUCTION

Evolutionary theory predicts that a female in good health and condition would maximise her reproductive success in the long run if she gave birth to a son. Conversely, a female in poor condition who gave birth to a weak or unhealthy male offspring could expect a poorer reproductive return than if she gave birth to a daughter. Here we hope to demonstrate that the weight at birth of a first child is a good indicator of a mother's physical condition and also, therefore, of her ability to invest in the more expensive sex during her next pregnancy, as well as the likelihood that she in fact does so.

According to the Trivers–Willard hypothesis (1) evolution should favour parents who are able to adjust their

parental investment relative to their own condition and their offspring's expected reproductive success. Male offspring have a faster rate of growth and also a higher demand for nutrients and because of that and other factors they are also more liable to be affected by harmful influences (2). Therefore, a female in poor condition would gain better reproductive success by giving birth to the less expensive (female) sex and a female in good condition to the more expensive (male) one. It has been shown in certain mammals that better-fed (3,4), or dominant or heavier (5,6) females gave birth to significantly more sons than daughters. At the present time such data for humans are overall somewhat ambiguous (7). Some studies have shown that a mother's socioeconomic status (SES) (8) and her higher scores in tests for dominance (9) are positively correlated with a higher secondary sex ratio, i.e. more boys than girls were born to such mothers. However, a mother's condition is not only her SES but also her health, physiology and other factors which are intimately connected with her genotype. It is thus entirely feasible that such an indicator of a female's physical condition as the birth-weight of her first-born child, can

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be a good measure of a female's ability to invest in the second pregnancy and also a good predictor of the sex of her next child.

METHODS AND RESULTS

Data were collected on the basis of a questionnaire completed by mothers in 11 outpatients' surgeries for healthy children and in five GP surgeries in Wrocław. Only mothers resident in the Wrocław conurbation were chosen, whose last-born child at the time of the study was between approximately 10 months and 16 months old. From this broad sample, 227 mothers out of 799 met the criteria of the research design, i.e. they had more than one child, did not give birth to twins, had not been on any kind of hormonal treatment and were healthy. For this sub-sample, the sex of the second born child appeared to be dependent on the neonatal weight of the first-born child (ANOVA, $F(1,225) = 3.79$, $P < 0.053$). However, after dividing this sub-sample into same-sex samples in relation to the first-born child, this dependence was revealed to be statistically significant only in relation to the first-born having been a girl ($F(1,117) = 9.66$, $P < 0.002$). As Figure 1 shows, the mean neonatal weight of girls after which a boy was born was 3.32 kg (SD = 0.40) and of those after which a girl was born was only 3.05 kg (SD = 0.52).

To determine how far removed from a 1 : 1 ratio the sex ratio at birth of the second-born children was, in relation to the neonatal weight range of the first-born daughters, we divided the sample of 119 girls into two subgroups: girls with neonatal weight lower than the mean (< 3.20 kg) and those weighing at least 3.20 kg. It was determined that after an earlier-born lighter girl, the proportion of the second-born boys to girls was 36.0 : 64.0%. In contrast, after an earlier-born heavier girl (3.20 kg and above) the ratio was almost the reverse, namely 66.7 : 33.3%.

There was no effect of mother's age at first child's birth on the sex of the first child ($F(1,206) = 0.35$, $P < 0.55$)

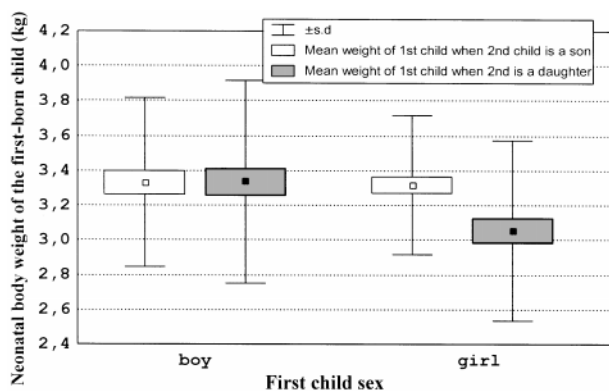


Fig. 1 The mean neonatal weights of the first-born child in relation to the sex of the second-born child after the first-born son and daughter.

(8.3% of mothers did not reveal their age) and no difference in the mean interbirth intervals in dependence on the first-born child's sex ($F(1,223) = 0.62$, $P < 0.43$). There was no effect of mother's weight before the last pregnancy on the sex of the first and the second child ($F(1,212) = 0.22$, $P < 0.64$ and $F(1,212) = 0.02$, $P < 0.89$) (5.7% of mothers did not reveal their weight).

Why is it that only the birth-weight of a first-born girl can be a predictor of the mother's ability to invest in the next child? Since male foetuses are more sensitive to a wider range of disturbing factors in utero (2) their birth-weight does not need to be a good indicator of a mother's ability to invest in the more expensive male offspring, but only of the condition of a given pregnancy. Thus, lower female birth-weight may better reflect the mother's biological condition (e.g. factors related to her genetic quality) and her ability to invest in any offspring. What is more, mothers in poor physical condition have a higher probability of miscarrying each male foetus and therefore might be more likely to give birth to a low-weight daughter.

An additional factor that tends towards the lowering of the sex ratio (trend $F > M$) in the second pregnancy is the active and natural anti-H-Y maternal immunisation which is released in the mother's bloodstream after giving birth to a boy (10,11). The exposure to the H-Y antigen during the course of pregnancy in mice is essential to bring about demonstrable immunoregulatory changes, which cause the lowering of the sex ratio of later litters in mice (10). In 11 out of 12 univariate studies collected by Chahnazarin (7), it was found that in humans birth order affects sex ratio at birth negatively. What is more, having antecedent sons decreases the probability of subsequent male births for particular mothers (12). It could then be postulated that some mothers who gave birth to a heavier boy and are in good condition to invest in this sex in the next pregnancy are immunised against male foetuses and are able to give next live birth only to a female. This could be a likely explanation of no predictability of the second child's sex on the basis of the first boy's birth-weight, but this hypothesis would only be supported if it could be shown that the extent of this immunisation was positively correlated with the neonatal weight of the first-born boy.

CONCLUSION

To sum up, our results on the secondary sex ratio of the second-born children in relation to the neonatal weight variance of first-born children, seem to be in accord with the biological model of adjusting the sex of the next offspring to reproductive potentiality which is the key feature of the Trivers-Willard hypothesis of sex-ratio variation.

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