Seasonality of sex ratio in Germany

A.Lerchl
Institute of Reproductive Medicine of the University, Domagkstr. 11, D-48129 Münster, Germany

It was investigated whether there is a seasonal variation in sex ratio at birth in Germany. The analysis was based on records from the German Bureau for Statistics, covering the period from 1946 to 1995. A highly significant ($P \leq 0.001$), albeit low-amplitude rhythm was found with two peaks in May and December, and two nadirs in March and October. No correlations were found between sex ratios and seasonal birth rates during this period.

Key words: human/seasonality/sex ratio

Introduction

A number of physiological and endocrine parameters are influenced by environmental factors, e.g. diurnal rhythms of temperature and activity, and annual fertility rhythms (seasonal reproduction). Even humans, who are often referred to as being representatives of non-seasonal mammals, show distinct annual rhythms in reproduction (Roenneberg and Aschoff, 1990a,b). Likewise, some psychological disorders have a pronounced annual rhythm, e.g. the seasonal affective disorder (SAD; Madgen et al., 1996).

In humans, the sex ratio at birth (SSR; secondary sex ratio) is not 1:1 as one could expect from the equal numbers of Y- and X-bearing spermatozoa (Wyrobek et al., 1994), but is slightly shifted towards boys. Usually, some 5–7% more boys than girls are born. It is not yet clear why such a difference occurs (James, 1996; Mittwoch, 1996). It is possible that endocrine (James, 1989) and immunological factors (Ober, 1992) cause this discrepancy. Another hypothesis is that the sex ratio depends on the time of conception within the ovulatory cycle (James, 1987). According to the theory, early and late conceptions result in more boys, while conceptions around the time of ovulation result in comparatively more girls. Since the amplitude of births shows a clear annual rhythm it was interesting to investigate whether there is any annual rhythm of SSR in Germany.

Materials and methods

Recordings of births were provided by the Federal Bureau for Statistics, Wiesbaden, Germany. The period from 1946 to 1995 was covered, with the number of boys and girls born in each month. Data were available for both parts of Germany which were formerly separated.

Sex ratios were calculated by division and grouped for each month (a total of 600 months were analysed). To prevent artificial effects, the fall of SSRs after the end of World War II (Gilbert and Danker, 1981; Lerchl, 1997) was compensated by a linearizing procedure, based on the annual means of the sex ratios (Figure 1). The function of the equation is

$$y = (a-d)/(1 + (x/c)^b) + d$$

with $y =$ sex ratio, $a = 1.1056$, $b = 263.941$, $c = 1945.306$, and $d = 1.0556$. The correlation of the calculated values and the original data per year was high ($R^2 = 0.877$). After checking for homogeneity of variances, data were analysed by analysis of variance (ANOVA). Table I shows the total number of births and the sex ratios per month.

To investigate further the periodicity of the data, serial ANOVAs were performed with different period lengths from 2 to 20 months. The seasonality of birth rates was calculated as described elsewhere (Roenneberg and Aschoff, 1990b) and correlated with the monthly SSR data.

Results

A highly significant ($P \leq 0.001$) bimodal seasonal rhythm of SSR is evident although its amplitude is low (Figure 2). Peaks around SSR = 1.058 are located in May and December while nadirs occur during March (SSR = 1.054) and October (SSR = 1.052). The difference between the highest and the lowest average values is thus $<1\%$ of the total SSR. The period analysis shows two significant period lengths of 6 months ($P \leq 0.01$) and 12 months ($P = 0.001$), respectively (Figure 3).

There were no significant correlations between SSR values and birth rates for either individual data ($n = 600$) or for the mean data ($n = 12$), respectively, for up to $-12$ months lag between the two parameters.

Discussion

The data presented here provide clear evidence that the human SSR shows a weak but highly significant bimodal seasonal component. The low amplitude of the rhythm is in accordance with the only other positive studies in this respect showing a seasonal rhythm for the SSR in the USA with maxima being located in early summer (Slatis, 1953; Lyster, 1972). However, the data for the USA show the second peak observed in December/January only up to the mid-40s; thereafter, it is no longer present.

It was a surprising observation that no significant correlation whatsoever was seen when comparing SSR with birth rates since such a relation was apparently evident for the USA, at least between 1964 and 1968, with a lag of 2 months (Lyster, 1971).

The data presented here are in contrast to another study for Germany where no significant seasonal rhythm in SSR was found (Gilbert and Danker, 1981). However, there are important differences: first, the observation period (1946–1967 versus 1946–1995); second, the observation area (former West...
A.Lerchl

Figure 1. Decline of sex ratio in Germany after World War II. Shown are the individual data points and the calculated trend (line). Because of this trend, the raw monthly data were adjusted by subtraction.

Table 1. Total number of births analysed. Shown are the detrended data

<table>
<thead>
<tr>
<th>Months</th>
<th>Boys</th>
<th>Girls</th>
<th>Sex ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2 144 258</td>
<td>2 031 085</td>
<td>1.055720</td>
</tr>
<tr>
<td>February</td>
<td>2 231 388</td>
<td>2 116 085</td>
<td>1.054489</td>
</tr>
<tr>
<td>March</td>
<td>2 250 044</td>
<td>2 134 702</td>
<td>1.057735</td>
</tr>
<tr>
<td>April</td>
<td>2 209 176</td>
<td>2 088 591</td>
<td>1.058044</td>
</tr>
<tr>
<td>May</td>
<td>2 206 100</td>
<td>2 085 074</td>
<td>1.058044</td>
</tr>
<tr>
<td>June</td>
<td>2 174 077</td>
<td>2 055 390</td>
<td>1.057744</td>
</tr>
<tr>
<td>July</td>
<td>2 168 442</td>
<td>2 054 593</td>
<td>1.055412</td>
</tr>
<tr>
<td>August</td>
<td>2 115 981</td>
<td>2 003 562</td>
<td>1.056110</td>
</tr>
<tr>
<td>September</td>
<td>2 204 918</td>
<td>2 091 307</td>
<td>1.054325</td>
</tr>
<tr>
<td>October</td>
<td>2 031 415</td>
<td>1 931 599</td>
<td>1.051675</td>
</tr>
<tr>
<td>November</td>
<td>2 014 843</td>
<td>1 906 017</td>
<td>1.057096</td>
</tr>
<tr>
<td>December</td>
<td>2 021 887</td>
<td>1 912 102</td>
<td>1.057416</td>
</tr>
</tbody>
</table>

Figure 2. Seasonality of sex ratios at birth in Germany. Data from 1946 to 1995 are included. Values are the means ± SEM. *P < 0.001* (ANOVA). For comparison, the non-detrended curve is also shown.

Germany versus whole Germany); and third, consequently, the total number of births analysed was different (approximately $2 \times 10^6$ versus $50 \times 10^6$). In addition, there were no compensations for linear trends in the earlier work, resulting in artificial changes in seasonal rhythms.

The low amplitude of the seasonal rhythm as reported here is without any consequence for the individual couple who desire their child(ren) to be of a specific sex. The interesting feature is, though, that in humans the sex of their offspring seems to be subject to changes as observed more clearly in a number of other animals (Trivers and Willard, 1973). Although the reason for this fascinating aspect of sexual reproduction is still unexplained it may be an important hint for understanding basic principles in human fertility regulation.

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References


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