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Seasonal variation of livebirths, stillbirths, extramarital births and twin maternities in Switzerland

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A study was made of the seasonal variation in all births, and births according to marital status, multiplicity and birth status (live and still) in Switzerland recorded between 1876 and 1990. To obtain seasonal variation in as pure as possible form, our analyses are based on rates. When comparing the seasonality in data sets showing markedly different levels, standardised indices were used. Assuming the length of pregnancies with twins to be about one month shorter than for pregnancies with singletons, lagged twinning rates were calculated but, in comparison with actual twinning rates, the general seasonal variation remained. Therefore, this study was based on actual twinning rates. A monotonic increase in the amplitude of the seasonal variation in general births was noted for the period 1876–1930, with strong seasonal variation holding for 1921–1980. After that, a marked decline in the amplitude can be observed. Seasonality of both all births and twin maternities showed very similar pattern for the periods 1876–1930 and 1969–1990, with maxima in the spring (March–May) and troughs in late autumn (October–December). Twin maternities showed a strong seasonality for the period 1876–1930, being about 20% higher in March than in October. The twinning rate in the period 1876–1930 was about 2.6 per thousand units higher than in the period 1969–90. For twin maternities there was also a stronger seasonal variation during the earlier period than during the later one. The pattern of the seasonal variation for extramarital births, showing a maximum in February (conceptions in May–June) and a minimum in August (conceptions in November–December) with a difference of no less than 24% was more marked than for the marital births. It seems likely that this seasonality of extra-marital maternities was due mainly to seasonal variation of coital rates and multiple ovulation in the early summer months coinciding with optima of light, temperature and food supply. A strong reduction in the rate of stillbirths (gestational age more than 29 weeks) was observed during the twentieth century. The stillbirth rate declined from about 40 per 1000 in the 1870s to fewer than 5 per 1000 in the 1980s. Irrespective of this strong decline in the stillbirth rate, the same seasonal rhythm was noticed throughout the period with high stillbirth rates among births around March and low rates during the summer and autumn. Twin Research (2000) 3, 189–201.

Keywords: seasonality, marital status, twinning rate, secular trends, lagged twinning rate, stillbirth rate

Introduction

Three main seasonal factors can influence fertility in a number of mammalian species, including man; they are photoperiod, temperature and humidity. However, human beings differ from most other species in that they are socialised and are not real seasonal breeders, and it has been questioned whether these seasonal factors influence fertility in humans.[1] There are few studies of the seasonal variation in births, stillbirths and twinning, examining the effects of environmental, biological, and social factors. This is particularly so in respect of data from the nineteenth century, and results are often conflicting. Seasonal patterns of fertility may reflect variation in the frequency of sexual intercourse, female fecundity, male fertility, and embryonal and fetal death rates (spontaneous abortions). Today moreover, seasonal trends indicate that the pattern may also depend on cultural factors, for example, couples may prefer to have their children in spring. Secular trends in the seasonality of births etc. can elucidate the changing socio-economic environment and therefore of great interest.

The seasonal pattern of births shows marked differences even when we study neighbouring populations or the same population during different periods. For Iceland, there was a remarkable secular change in the pattern during the period 1856–1990.[2] At the beginning of this period the number of births was maximal in August to October. At the end of the period the peak had shifted to somewhat earlier in

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the year (July–September). If we compare the findings for Iceland with the findings for the other Nordic countries during the same period, there are striking differences. In Sweden, in the 1850s the maximum is in January–March. After that, the maximum moves forward continuously during the year, occurring in March–May in the 1980s. In Norway, the maximum is in March–May for almost the whole period 1871–1996. Hence, starting from quite different patterns, all the Nordic countries seem to show a convergence towards a common pattern with a maximum of births in the spring and early summer. The strength in the seasonality shows notable differences. In Sweden and Norway, the seasonal variation was lowest in the first decades of the twentieth century, being higher before and after that period. For Iceland, the seasonal variation was very strong in the nineteenth century and since then has continuously decreased. Despite this decrease, the seasonal fluctuations in the birth rate were more marked in Iceland than in Sweden or Norway.[2]

Seasonality statistics for twin and multifetal maternities are limited and conflicting. Knox and Morley[3] found that in Yoruba women in West Nigeria the monthly frequencies of twin maternities were significantly higher from May to October than from November to April. In Finland (1961–64) the peak of multifetal maternities occurred in spring or early summer.[4] For Hungary (1951–60 and 1968–70) Czeizel[5] noted a peak of twin maternities about February, March and April. Elwood[6] noted that dizygotic twinning rates in Canadian cities (1952) showed a seasonal variation with an October maximum. Kamimura[7] reported for Japan that the birth rate of twins rose to a maximum in the late autumn or early winter, and Imaizumi et al[8] reported for Japan a high prevalence of conceptions of twins in April. James[9] identified a winter peak in triplet maternities that was about 5% higher in December than in June in England and Wales (1952–59 and 1963–75). This seasonal pattern was similar to that for twin pairs of unlike sex but about double the amplitude. Kendler and Robinette[10] studied twins of war veterans in USA (born 1917–1927) for whom zygosity was determined by individual assessment of each twin pair. The results did not support a significant seasonality for all twin maternities or a specific seasonality for either MZ or DZ twins. Richter et al,[11] using historical parish records, found variable seasonal trends in the twinning rate in Gorlitz, Germany. Philippe[12] in an isolated population in Canada (Quebec) noted that twin maternities occurred more often in winter and early spring, while singletons peaked in the autumn. Little and Elwood[13] concluded that the available evidence does not support the existence of seasonal variation in total, DZ or MZ twinning rates in either North-east Scotland or Northern Ireland in the years 1975–79. Elster and Bleyl[14] noted a large peak in triplet maternities in the USA in the spring (April–May) and a smaller peak in the late summer (August–September). Dionne et al[15] studied the seasonal variation in twin maternities in Washington State (1984–90) and concluded that there was a tendency for twins, and particularly discordant-sex twin pairs, to have been conceived during the period of high sunlight. In the State of São Paulo, Brazil, Krieger et al[16] found no evidence of seasonality either for the twin maternity rate considered as a whole or for the DZ twinning rate. For Denmark in 1855–69, the peak of twinning was discernible in the late winter or early spring. The peak incidence of twin maternities in Denmark was particularly strong for the extramarital maternities. However, in such a limited series the seasonal fluctuations of the illegitimate twin maternities were not significant.[2,17]

In this study we set out to investigate trends in the seasonality of twin maternities and births of other types, using data for the period 1876–1990 in Switzerland. Secular seasonality statistics of twinning rates from the nineteenth century are of particular interest, because they reflect the natural fertility before the onset of the demographic transition with lower infant mortality and more effective family planning around the beginning of the twentieth century.

Material and methods

Rates and indices

If one studies the specific seasonal pattern of twin maternities, for instance, 'the population at risk' is the monthly number of maternities. If the population at risk is ignored, then the specific seasonal variation in twin maternities is masked by the seasonal variation in general maternities. Therefore, one has to analyse the twinning rate. For births, deaths, etc., the seasonal variation is disturbed by the different lengths of the months, including the effect of leap years and one has to consider the rates per day. Comparisons of the seasonality in data sets showing markedly different levels (e.g. twin maternities vs general maternities, legitimate births versus illegitimate births) must be based on standardised indices.

Monthly indices and their standard errors

Let the number of births in the month number i during a given period be n_i and the total number of births be $n = \Sigma n_i$. Let k_i be the length of month

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number i and $k = \Sigma k_i$ be the length of the year. We introduce the monthly rates per day $r_i = n_i/k_i$ and define the monthly indices

$$I_i = 100 \frac{\frac{n_i}{k_i}}{\frac{\sum n_i}{\sum k_i}} = 100 \frac{k}{k_i}\frac{n_i}{n} \quad (i=1,...,12). \qquad (1)$$

We prefer this definition instead of the more straightforward

$$I_i' = 100 \frac{\frac{n_i}{k_i}}{\frac{1}{12}\sum \frac{n_i}{k_i}} \quad (i=1,...,12). \qquad (1)'$$

The indices i_i' ($i = 1,\ldots,12$) in (1)'have the property that their sum is exactly 1200. For the indices I_i ($i = 1,\ldots,12$) in (1) the sum differs slightly from 1200 but in our data the difference is in decimals. Assuming that the numbers n_i ($i = 1,\ldots,12$) are random and that the total number of births, n, is fixed and non-random, it is easier to obtain accurate formulae for $E(I_i)$ and $Var(I_i)$ than for $E(I_i')$ and $Var(I_i')$. This follows from the fact that denominator of the index I_i contains the non-random sums n and k but the index I_i' contains the sum $\Sigma n_i/k_i$.

Let us denote the frequency of births f(t), where t is time and, consequently, the number of births per time unit is nf(t). If we analyse monthly data, then $E(n_i) = n\pi_i$ where $\pi_i = \int_{M_i} f(t)dt$, M_i being month number i, is the probability that a birth occurs in month number i. Now,

$$E(I_i) = 100 \frac{k}{k_i n} E(n_i) = 100 \frac{k}{k_i}\pi_i = 100 \frac{\pi_i}{k_i/k} \quad (i=1,...,12). \qquad (2)$$

In this formula the ratio k_i/k is month number i as a proportion of the whole year. Therefore, formula (2) gives a theoretical index which is greater than 100 if the proportion of births in this month exceeds the relative length of the month, otherwise the index is less than 100. Under the null hypothesis that there are no seasonal variation, $\pi_i = k_i/k$ and

$$E(I_i) = 100 \quad (i=1,...,12). \qquad (2)'$$

If we use the obvious estimate $\hat{\pi}_i = n_i/n$, we obtain

$$Var(I_i) = 10000 \left(\frac{k}{k_i}\right)^2 Var\left(\frac{n_i}{n}\right) = 10000 \left(\frac{k}{k_i}\right)^2 \frac{\pi_i(1-\pi_i)}{n} \qquad (3)$$

$$\approx 10000 \left(\frac{k}{k_i}\right)^2 \frac{n_i(n-n_i)}{n^3}.$$

and

$$SE(I_i) \approx 100 \left(\frac{k}{k_i}\right)\sqrt{\frac{n_i(n-n_i)}{n^3}}. \qquad (4)$$

If the k_is are defined as the monthly figures for numbers of general maternities and if, in addition, one assumes that they are so large (in comparison, for instance, with the number of twin maternities) that they can be considered non-random, the formulae obtained hold also for twinning rates.[18]

In this study the statistical model building is based on multiple trigonometric regression models since they are flexible to data that differ from the simple sine curve.[19] Concerning the multiple trigonometric regression models and the Walter-Elwood method used in this study, we also refer to our recent papers.[2,17,18,20,21] In an early paper, Stutvoet[22] considered that the months had different lengths and defined the monthly birth rates as corrected monthly percentages. However, when he introduced the trigonometric regression models he assumed, in contrast to us, that the months have equal lengths. Furthermore, he considered only models with two sine functions, that is, his model corresponds to ours with M = 2.

Material

Our study is based on the official demographic data for Switzerland, 1876–1990. The data are collected from the official statistics of Switzerland. Recently Statistics Switzerland has published a monograph of the vital statistics of Switzerland with the tables on a CD diskette.[23] In our series the data for some periods are missing. For the years 1921–25 and 1931–68 no seasonal data on twin maternities are available, and for the period 1921–1968 the monthly number of stillbirths is missing. Under these circumstances, different statistical analyses have to be based on the different data sets.

Results

Seasonality of general births

According to Jenny[24] and Stutvoet,[22] the strength of the seasonal variation in births in Switzerland (1871–1940) increases markedly. We have the opportunity to extend Stutvoet's study by considering the period 1876–1990. Due to missing data, our temporal analysis of the seasonal variation is based on all births for the period 1876–1920 and 1969–1990 and on livebirths for the period 1921–1968. In the latter period the rate of stillbirths was about 10–30 per 1000 (Figure 4). Hence, the effect of the missing stillbirths is minute. In Figure 1 we observe a monotonically increased strength of the seasonal variation for the period 1876–1940. This result is in

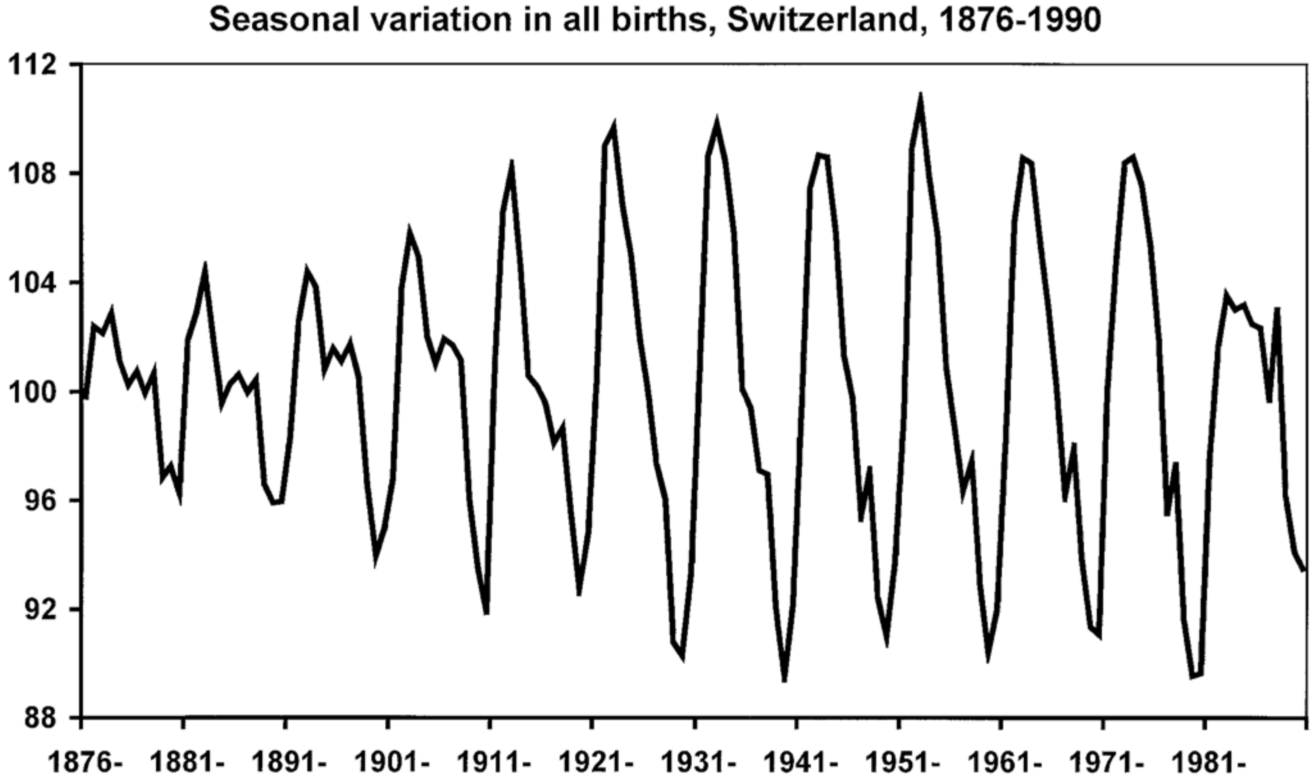

Figure 1 Secular trends in the seasonal variation in the general births in Switzerland, 1876–1990. We observe a monotonically increased strength of the seasonal variation for the period 1876–1940, a constant strong seasonal variation for 1921–1980 and a marked decline in strength during 1981–90.

good agreement with Stutvoet's results. However, we observe in Figure 1 that the strong seasonal variation holds for 1921–1980, after which date a marked decline in the strength can be observed.

Lagged twin rates

If we assume that the length of gestation for twins is about one month shorter than for singletons the monthly twinning rates should be defined as the number of twin maternities in a given month divided by the total number of maternities in the next month. In order to eliminate the effect of the different lengths of the consecutive months, the calculation must be based on the rates per day for twin maternities during one month and for all maternities during the next month. This attempt results in lagged monthly twinning rates.[18] Calculations of the lagged monthly twinning rates show that the general seasonal pattern of the twinning rates persists.[18] As a consequence of this the traditional monthly twinning rates satisfactorily describe the general seasonality of the twinning rate and we have used the traditional definition of monthly twinning rates for the statistical analyses below. Furthermore, often only the actual monthly rates are available. Obviously, the statistical models chosen are equally applicable, irrespective of how the monthly twinning rates are defined.

Seasonality of twin maternities

The indices of general births and of twin maternities in Switzerland show very similar seasonal pattern for the periods 1876–1920 and 1926–30 (for short 1876–1930) and for the period 1969–1990 (Table 1). The missing number of stillbirths for the period 1826–30 causes slightly overestimated twinning rates for the period 1876–1930. Furthermore, we stress that the maternities for the years 1921–25 are not included in the calculations of the twinning rates. In Figure 2 we observe that for the twinning rates in the period 1876–1930, there was a discernible peak in the spring (March–April) and a trough in late autumn (October–December). For the period 1969–1990, the peak was somewhat later, in March to May, and the troughs are still in October–December, ie the spring peak is not confined to a single month. Furthermore, in the twin maternities the seasonal variation was somewhat larger in the period 1876–1930 than in the period 1969–90 (the

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Table 1 Seasonal indices for all births and twin maternities and their standard errors in Switzerland, 1876–1930 and 1969–1990

	General maternities				Twin maternities			
	1876–1930		1969–1990		1876–1930		1969–1990	
Month	Index	SE	Index	SE	Index	SE	Index	SE
Jan	99.51	0.16	99.08	0.25	97.91	1.39	101.13	2.48
Feb	104.16	0.17	103.61	0.26	105.87	1.52	102.36	2.62
Mar	105.57	0.16	106.31	0.25	110.53	1.47	106.91	2.54
Apr	103.95	0.16	106.20	0.26	108.56	1.48	105.25	2.57
May	101.07	0.16	105.55	0.25	105.47	1.43	107.91	2.55
Jun	100.79	0.16	104.05	0.26	105.04	1.46	105.12	2.57
Jul	100.72	0.16	102.02	0.25	98.66	1.39	100.00	2.47
Aug	100.14	0.16	97.24	0.24	98.28	1.39	92.21	2.38
Sep	99.96	0.16	99.71	0.25	94.06	1.39	97.83	2.49
Oct	95.77	0.16	93.36	0.24	90.79	1.34	90.68	2.36
Nov	94.11	0.16	91.50	0.24	91.78	1.37	94.46	2.45
Dec	94.57	0.15	91.37	0.24	93.55	1.36	96.14	2.42
Mean	100.03		100.00		100.04		100.00	

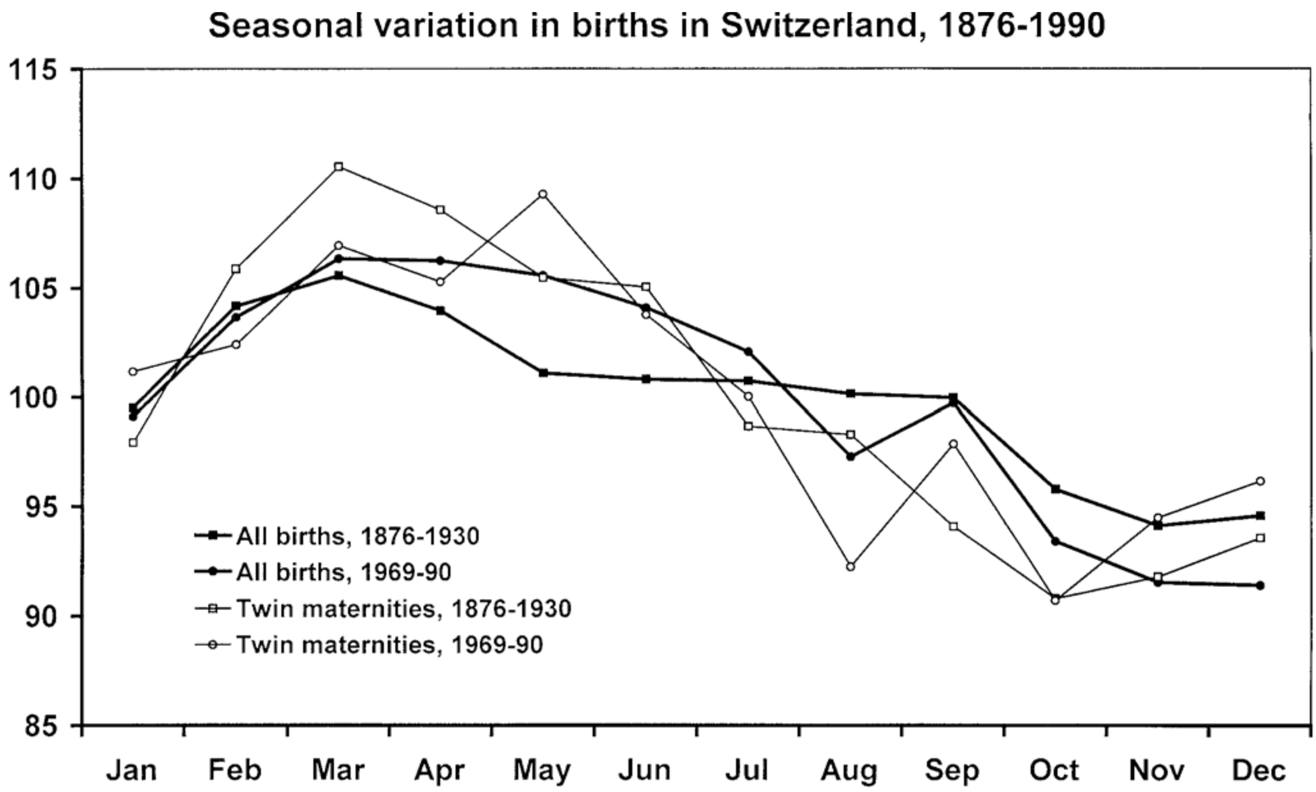

Figure 2 The monthly indices of all births and twin maternities in Switzerland, 1876–1920 and 1926–30 (in short 1876–1930) and 1969–90.

coefficients of variation are 0.068 and 0.058, respectively). As a consequence of the strong secular trend in the strength of the seasonal variation in the general births, a detailed comparison between the periods 1876–1930 and 1969–90 is not feasible.

The monthly twinning rates in Switzerland during the periods 1876–1930 and 1969–90 are given in Table 2. The observed data for the period 1876–1930 show only one peak with high monthly twinning rates discernible throughout the period March to June and one trough with a minimum in September. During the period 1969–90, no clear seasonal pattern is discernible for the twinning rate. For neither period can the seasonal pattern be considered sinusoidal, and a multiple trigonometric regression model (M = 2) gives a better fit than a simple trigonometric regression. The level of the twinning rate was markedly higher for the period 1876–1930 than for the period 1969–90, the corresponding total twinning rates being 12.7/1000 and 10.0/1000,

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Table 2 Seasonal twinning rates and their standard errors in Switzerland, 1876–1930 and 1969–1990

	1876–1930		1969–1990	
Month	Monthly twinning rate	SE	Monthly twinning rate	SE
Jan	12.46	0.18	10.22	0.26
Feb	12.87	0.19	9.90	0.26
Mar	13.26	0.18	10.07	0.25
Apr	13.22	0.19	9.93	0.25
May	13.21	0.19	10.37	0.26
Jun	13.20	0.19	9.99	0.26
Jul	12.40	0.18	9.82	0.25
Aug	12.43	0.18	9.50	0.25
Sep	11.92	0.18	9.83	0.26
Oct	12.00	0.18	9.73	0.26
Nov	12.35	0.19	10.34	0.28
Dec	12.53	0.19	10.54	0.28
Total	12.66	0.054	10.02	0.075

respectively. Furthermore, we observe in Table 2, and in Figure 3, that the seasonal variation in the twinning rate was stronger during the first period than during the second. The corresponding coefficients of variation were 0.038 and 0.030, respectively. It is to be noted that, in comparison with Figure 2, the variation in the general maternities is eliminated in Table 2 and Figure 3.

If we apply the Walter and Elwood method[25] we obtain for the period 1876–1930 the value $\theta = 102.8°$ ($\chi^2 = 64.8$ with 2 degrees of freedom), indicating a peak in April, and for the period 1969–90 $\theta = 30.0°$ ($\chi^2 = 4.23$ with 2 degrees of freedom), indicating a peak in late January. The last χ^2 value is not statistically significant. These results confirm the observations that, during the second period, the seasonal variation is very slight, and, in addition, that the empirical curves differ markedly from a simple sine curve. Therefore, the Walter-Elwood method is not applicable.

Seasonality of births and marital status

Figure 4 shows the monthly birth indices according to marital status of the mother in Switzerland, 1876–90. The expected values are estimated according to the simple trigonometric regression and the optimal trigonometric regression.[2] For the legitimate series the optimal model contains two pairs of trigonometric terms but for the illegitimate series the simple regression model is optimal. This indicates differences in the seasonal pattern. September shows an isolated peak for the illegitimate births (conceptions around Christmas and New Year).

According to Figure 4, the seasonal variation is stronger among the illegitimate than among the legitimate births. The observed ranges, measured as maximum minus minimum, are 24.5 and 7.5, respectively. However, one has to take into consideration that there are stronger random fluctuations in the illegitimate series than in the legitimate series. For the legitimate birth indices the SE, estimated according to the formulae given above, is between 1.12 and 1.21 and for the illegitimate birth indices the SE is between 4.78 and 5.62. If we compare the ranges with the SEs, we find that the range for the illegitimate births is around 5 times the SEs. The corresponding figure for the legitimate births is over 6. Hence, the stronger seasonal variations in the illegitimate than in the legitimate births may at least partly be explained by stronger random fluctuations. Also for Denmark (1855–64) a strong but insignificant spring maximum was noted for illegitimate twin maternities.[19]

Fellman and Eriksson[2,17] discussed how to test the strength of the variation by considering the estimated amplitudes. The estimated amplitudes measure the maximum deviation from the average level. For the legitimate series, the optimal model contains two pairs of trigonometric terms but, for the illegitimate series, the simple regression model is optimal. We obtain for the amplitude the estimate $R_1 = 10.44$ with (the approximate) $SE_{\tilde{R}_1} = 1.25$ ($t = 8.4$) for the illegitimate births and $R_1 = 2.37$ with $SE_{\tilde{R}_1} = 0.29$ ($t = 8.2$) and $R_2 = 2.09$ with $SE_{\tilde{R}_2} = 0.29$ ($t = 7.2$) for the legitimate births. These test results indicate also that the stronger seasonal variations in the illegitimate than in the legitimate births can mainly be explained by stronger random fluctuations.

For the sub-periods 1876–1920 and 1969–90, data concerning the seasonal variation in both live and stillbirths were available to us. In Figure 5 we observe that the stillbirth rate decreases markedly. The stillbirth rate declined from about 40 per 1000 in the 1870s to less than 5 per 1000 in the 1980s. In Figure 5 we have included stillbirth data for males and females given by Bickel[26] for the period 1881–1947. Up to the 1930s there is good agreement between the series but after 1930 Bickel's data indicate a slightly stronger decline than our interpolated data. According to Bickel the Catholic areas showed lower numbers of stillbirths than the Reformed areas. This may be a consequence of different criteria for the diagnosis of stillbirths during the perinatal period and stillbirths. Our opinion is that, in spite of Bickel's criticism, our data for the whole of Switzerland are reliable.

Both livebirths and stillbirths show seasonal variation (Table 3). The seasonal variation is slightly more marked in the stillbirths than in the livebirths but stronger random fluctuations among the stillbirths contribute to this difference. In addition, the stillbirths show marked contrasts between constantly high levels during winter and spring (January to May) and low levels during summer and autumn (July to November). Despite the marked decline in the total number of stillbirths, the stillbirth rate

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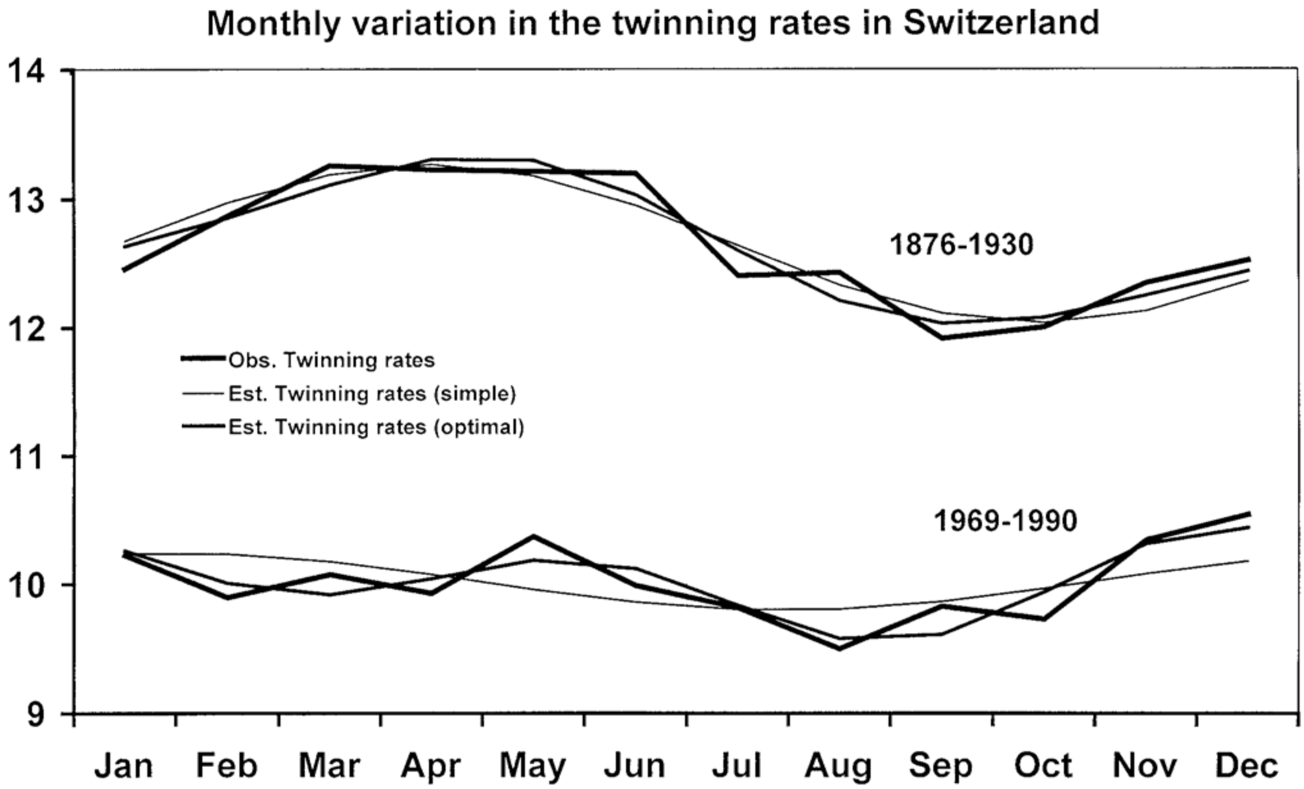

Figure 3 Seasonal variation of observed and expected monthly twinning rates in Switzerland, 1876–1930 and 1969–90. The expected values are estimated according to simple trigonometric regression and optimal trigonometric regression.[2] For both periods the optimal regression model contains two pairs of trigonometric terms.

shows a similar seasonal pattern in the period 1969–1990 and in the period 1876–1920. The livebirth indices for 1969–90 show a higher seasonality in March to June than for 1876–1920. This is in good agreement with the temporal trend in the seasonality of all births (see Figure 1). In comparison with stillbirths livebirths also show months with intermediate levels, particularly for the period 1876–1920.

Discussion

Human twinning depends mainly on four biological parameters:

(1) coital rate,

(2) the probability of fertilisation of an ovum, given that coitus has occurred in the fertile period,

(3) the probability of double ovulation,

(4) the spontaneous abortion rate.[9]

In Switzerland, the major seasonal peak in the general birth rate occurs mainly in March–April. The fact that this coincides with the seasonal peak in twinning suggests that one or more of the four parameters mentioned above influence the twinning rate in the same ways that they influence the birth rate, but that their influence is accentuated.

Coital rate

It seems reasonable to infer that coital rates are higher in the summer, even though to the best of our knowledge, there are no convincing direct numerical data on the seasonality of coital rates. At least in the UK there is evidence of greater volume of sales of contraceptive materials in the summer and the seasonal variation in sexual offences also argues that this seasonality is not wholly dependent on opportunity.[27,28] Data from the USA suggest that loss of virginity is particularly likely during the summer.[29] In the USA seasonal fluctuations in coital rates have been noted; however, shifting the birth rates back 40 weeks to the approximate conception dates revealed no association with the observed coital rates.[30]

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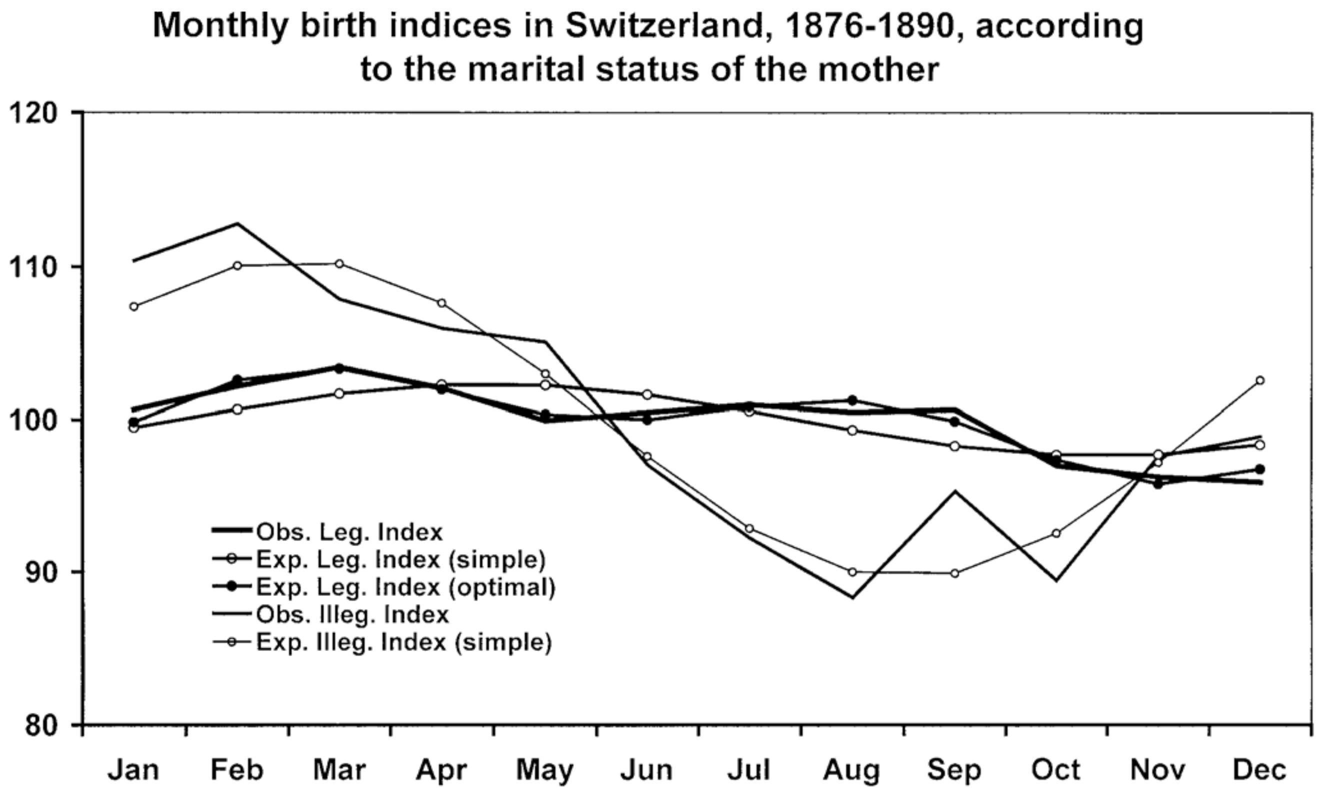

Figure 4 Monthly birth indices according to the marital status of the mother in Switzerland, 1876–1890. The expected values are estimated according to simple trigonometric regression and optimal trigonometric regression.[2] For the legitimate series, the optimal model contains two pairs of trigonometric terms. Although September shows an isolated peak for the illegitimate births, the simple regression model is optimal for this series. This indicates differences in the seasonal pattern. The stronger seasonal variations in the illegitimate than in the legitimate births can mainly be explained by stronger random fluctuations.

The probability of fertilisation, given that coitus has occurred at the optimum time

James[9,28] suggested that this parameter is as high as 0.9 but nothing is directly known of it in human beings and we know of no evidence of any seasonal variation in it. Because the seasonality of twinning in Switzerland is contemporaneous with the seasonality of birth rates, fertilisation is a parameter that has to be seriously considered. The strong seasonal peaks of twinning and of illegitimate births indicate that in these mothers the possibility of fertilisation is high. Extra-marital mothers have a significantly higher twinning rate than married ones, particularly in the ages 25–39 and it has been proposed that mothers with multifetal maternities conceive easily and are an élite class from the point of view of reproduction.[31–36]

The spontaneous abortion rate

During recent decades there has been increasing evidence that prenatal elimination may perhaps be the rule rather than the exception. More than three-quarters of all human conceptions may be absorbed or aborted at an early stage, most of them by way of failure of implantation or early spontaneous abortion because they are abnormal.[37,38] Recent studies indicate that the risk of preterm delivery (< 37 weeks of gestation) is approximately nine times higher in women with multifetal pregnancies than in women with singleton pregnancies.[39] One would expect that the likelihood of the presence of lethal genes with prenatal selection would be greater in two zygotes (dizygotic twins) than in one.[31] In humans only a fraction of conceptions of both singletons and twins result in livebirths.[40] There is evidence that the incidence of recognised spontaneous abortions (fetal deaths), for example in India, New York, Montreal, Belgium and Sweden, is higher in the spring and early summer.[41–43] The reason for this is not known, although a significant increase in the frequency of conceptions for the Down syndrome has been noted during the first 4 months of the year.[44] Paraskevaides et al[45] found that conceptions resulting from artificial inseminations had a peak lasting from early winter until early spring. James[9] argued that a trough in twinning would follow 4 to 7 months after a seasonal peak in spontaneous abortions, thus in

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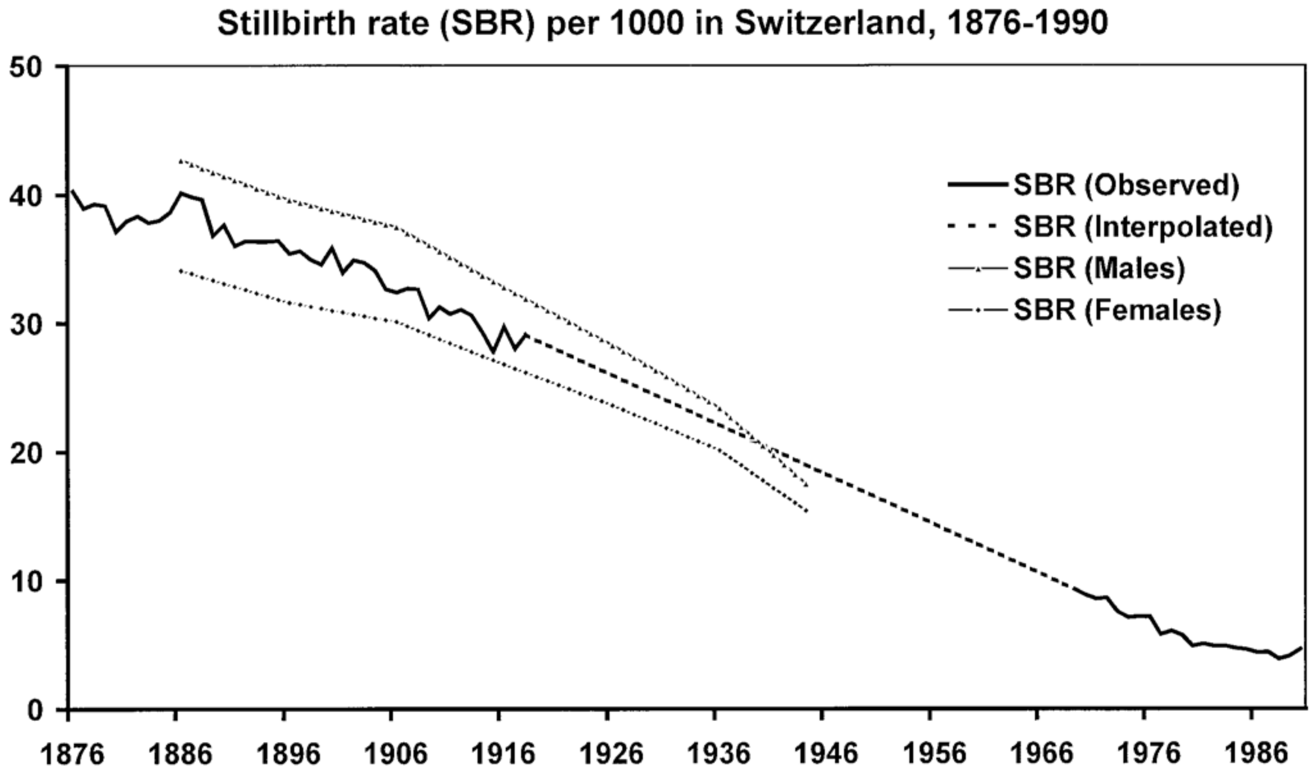

Figure 5 The stillbirth rate per thousand births in Switzerland, 1876–1990. For the period 1921–1968 stillbirth data are missing. The stillbirth rate decreases from about 40 per 1000 in the 1870s to less than 5 per 1000 in the 1980s. The stillbirth data for males and females are given by Bickel[26] for the period 1881–1947.

Switzerland in October–December, which is in fact the case. However, at Creighton, USA, Kovar and Taylor[46] observed no statistical difference between the average number of 1141 spontaneous abortions occurring during the various seasons of the years 1954–58. Yet the study tended to support the clinical impression that spontaneous abortions appear in groups, and there was a substantial direct relationship between significant daily temperature changes and the number of abortions.

Pathological examination and autopsy data suggest that double ovulation is considerably more frequent than the incidence of dizygotic twinning among maternities.[47,48] According to Boklage,[49] most human pregnancies never reach term, as they fail before clinical recognition. Data indicate term survival of no more than 1 in 4 natural conceptions and no more than 1 in 50 natural twin pairs. More than one pregnancy in eight begins as twins, and, for every live-born twin pair, 10–12 twin pregnancies result in single births; thus 12–15% of all livebirths are products of twin embryogenesis.

Because twin gestation ends with a single birth more often than with twins, the terms blighted twin,

Table 3 Live and stillbirth indices for Switzerland, 1876–1920 and 1969–1990

	1876–1920				1969–1990			
Month	Live births	SE	Still births	SE	Live births	SE	Still births	SE
Jan	99.27	0.17	105.56	0.90	99.08	0.25	107.16	3.23
Feb	103.70	0.18	106.04	0.94	103.63	0.26	102.71	3.34
Mar	105.22	0.17	108.45	0.91	106.34	0.25	108.67	3.25
Apr	103.71	0.17	106.03	0.91	106.25	0.26	103.19	3.24
May	100.84	0.17	100.28	0.87	105.58	0.25	108.99	3.26
Jun	100.79	0.17	99.42	0.89	104.09	0.26	103.41	3.24
Jul	101.00	0.17	92.56	0.84	102.08	0.25	94.39	3.05
Aug	100.47	0.17	95.67	0.86	97.22	0.24	98.47	3.11
Sep	100.37	0.17	95.79	0.87	99.76	0.25	92.32	3.08
Oct	96.24	0.17	94.44	0.85	93.36	0.24	93.85	3.05
Nov	94.30	0.16	96.78	0.88	91.56	0.24	91.10	3.06
Dec	94.40	0.16	99.45	0.87	91.42	0.24	95.67	3.07

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foetus papyraceus and vanishing twin have attracted considerable attention.[50,51] There have been several studies on the seasonality of spontaneous abortions which, however, did not show any correlation between the frequency of spontaneous abortions and the seasonality of births or twin maternities.[5,42,46,52] This failure may have been due to the great number of unrecognised abortions at a very early stage of pregnancy. Nakamura et al[53] noted that most cases diagnosed or suspected as vanishing twins were observed in one period between October and December. However, their series was small and needs confirmation.

For twin gestations the rate of spontaneous abortions seems to be very high and the majority of these are unrecognised. However, the rate of unrecognised embryonic or fetal deaths (so-called chemical pregnancy, miscarriage and stillbirth) of twin gestations does not seem to vary greatly with the season, for if this were the case, then presumably the twinning rate would not show a seasonal variation which more or less parallels that of all births.

Seasonality of nutritional status

In the past, with limited technology for storage and preservation of food, human societies were more dependent upon fluctuations in the food availability. The term 'seasonal hunger' has been used to indicate recurrent periods when a society recognised symptoms of hunger due to shortage of food. Often this occurred in spring and early summer when extra physical effort was needed to get the new crop into the ground, the time when food supplies were in shortest supply. Substantial seasonal changes in light and temperature are correlated with such rhythmic biological phenomena as reproduction. Annual reproductive rhythms in animals are typically linked with the time of year that provides the optimum opportunity for the birth and rearing of the young. Seasonal rhythms also occur in humans and are evident in such phenomena as birth and twinning rates.[20] However, as a consequence of years with famines and similar privation in the past, the seasonality may have been strongly disturbed as a result of inadequate food intake and/or the increased energy expenditure required to obtain food. This may have suppressed the frequency of ovulation in non-lactating women and prolonged lactational amenorrhoea.[21]

Relationship between latitude and seasonal reproductive patterns

Stumpf and Denny[54] have stressed the importance of vitamin D production during the light season. Vitamin D is recognised as a transducer and hormonal messenger of sunlight, acting as a somatotropic activator and modulator of vital processes for the seasonal and estival adaptation of growth, development and procreation. Until recent times, before vitamin D prophylaxis was introduced, rickets was a relatively common disorder, particularly in the higher latitudes. As a consequence of rickets, many women may have had a narrow pelvis and labour difficulties. In such women the selective disadvantage is obvious.[55] In populations with insufficient dietary intake of vitamin D, rickets due to the ultraviolet deprivation may have been an important selective factor. Particularly for a girl and her reproductive potential, it may have been an advantage to have been born in the late winter and early spring, which in fact seems to be the case with the majority of populations.[56–59]

Studies on birth seasonality carried out at higher latitudes have shown that fertility is indirectly affected by temperature and light. This operates through agricultural seasonality, which is dependent on rainfall, with its consequences for availability of food, for physical work load and for exposure to infectious diseases. If one excludes the Americas, there is a tendency, at the higher latitudes, for the annual peak in births to occur in winter–spring (summer conceptions). The relationship between latitude and the amplitude of the annual rhythm of births is variable, but the greatest amplitude of changes tends to be seen in the populations at latitudes of 30° or 40°, and Switzerland lies around latitude 47°N.[58,59] In general, Switzerland shows strong seasonal variation but this variation has shown marked secular changes (Figure 1).

It is interesting that the illegitimate births (Figure 4) show a secondary peak around September (corresponding to Christmas and New Year conceptions). According to James,[6] this indicates an increment due to the revelry at those times. Since the middle of the nineteenth century there has been a seasonality in the USA with a major peak in the autumn and a minor peak in the spring. In contrast, in Canada and Europe, there has been a major peak in spring and a minor one in the autumn.[56,57] James has noted that, more recently, the pattern in Europe has been slowly changing so that in many European countries there is now a major peak in the autumn and a minor one in the spring, and he suggested that this change is due to increasing numbers of couples being randomly apart (for business and other purposes) during the rest of the year but reunited around Christmas.[60]

The seasonal patterns of human births are presumed to reflect seasonal variation in conceptions, the specific cause being variation in the frequency of intercourse or ovulation, or variation in semen quality, but mortality of the embryo, particularly during the early stages of pregnancy, cannot be discounted.[61] Significant seasonal variation has been recorded in the occurrence of spontaneous abortions and even in the success rate of artificial insemination.[45,62] Evidence that human ovulation can be regulated seasonally is indirect, but it does exist, as has been shown in this study for Switzerland. North European populations at latitudes of 55–71°N, where the seasonal variation in luminosity is still stronger, show a still more marked peak in births in the spring.[2,17,20,63,64] In Finnish Lapland (65–70°N) hormonal changes compatible with greater activity of the reproductive axis 9 months earlier during the summer have also been recognised.[65] However, evidence gathered by some neuroendocrinologists tends to argue against reproductive photoresponsiveness in humans.[61]

Legitimacy and twinning

In the Scandinavian countries we noted a significantly higher twinning rate among extra-marital maternities than among marital ones, especially among mothers aged 25–39 years.[32,33] This phenomenon has been confirmed in many other populations, for example in Poland and in the USA.[66,67] For Polish data (1946–1967), Piasecki and Wrona[66] noted a higher seasonality of general births and twin maternities in the first calendar months of the year (conceptions in spring). The extra-marital births in Poland also showed a higher frequency of twin maternities than in marital births. James[28] has proposed that this 'curious feature' may be attributed to hormones. The suggestion is that, in general, illicit sexual intercourse is the occasion of erotic arousal and a high female gonadotrophin level (and hence an increased risk of dizygotic twins). In contrast, the suggestion is that in young women, illicit sexual intercourse is (or used to be) an occasion of emotional turmoil but (perhaps because of anxiety) erotic deficit and low gonadotrophin levels. There is also a possibility of a behavioural explanation here; coital rates (and hence the probability of superfecundation) may generally be expected to be higher in liaisons outside marriage, but not in the youngest age category. Bellis and Baker[68] have offered evidence that licit and illicit sexual liaisons are associated with rather different reproductive behaviour.

In England and Wales (1951–66) illegitimate and legitimate conception rates closely follow the same seasonal pattern, with the maximum conception rate around the summer solstice and this also applies in the USA and in most other countries.[69,70] However, for the extra-marital births, Switzerland has a considerably stronger total variation (24%) than England (8%) for instance.[69]

In the series of Lam and Miron[71] the illegitimate births in Finland (1926–38) showed a more pronounced seasonality than the legitimate ones. For the period 1921–38, the illegitimate births in Sweden showed a much stronger seasonal variation than for the period 1948–64, but in the legitimate births the trend was quite the reverse. For England (1948–83), the differences in the patterns of legitimate and illegitimate births were small. For the USA, Rosenberg[70] noted that legitimate and illegitimate births displayed similar seasonal patterns, judging from data for the single year 1963.

In our earlier studies we have drawn attention to the fact that unmarried mothers, particularly in the age group 25–39, have a significantly higher twinning rate than married mothers. There is also increasing evidence that mothers of twins and higher multifetal maternities have a high fertility – an élite from the reproductive point of view. This fact may at least partly explain why the seasonality seems to have been considerably higher among twin maternities than among singleton births.[31–36]

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