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SEASONAL VARIATION OF BIRTHS IN RURAL WEST BENGAL: MAGNITUDE, DIRECTION AND CORRELATES

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Summary. This paper examines seasonal variation of births in a rural community of West Bengal, India, by exploring data from the 1992–93 National Family Health Survey. Suitable time series analyses were used to determine the seasonal pattern of births and to estimate peaks. The trigonometric regression technique was used to carry out this objective. The study attempted to link the results of the regression analysis to the atmospheric temperature of the region during 1987–91, the distribution of respondents' husbands' occupations and the marriage pattern of the community. It was found that, in the study population, conceptions were numerous in the first quarter of a calendar year and the distribution of conceptions over calendar months was negatively associated with the average monthly temperature. In addition, the marriage pattern of the community and the occupational distribution of the fathers also had a significant effect on the distribution of births over calendar months. It is hoped that the findings will boost the development of needs-based maternal and child health (MCH) and family planning programmes in the community.

Introduction

The seasonal variation of births is a commonly observed natural phenomenon that is present in virtually all plant and animal populations, including human beings. In human populations, seasonality of births is observed in diverse geographical, ecological, environmental, social and cultural settings, but its pattern seems to be specific to the local environment.

In the study of Lam & Miron (1987), from the estimates of more than 25 countries two main seasonal patterns emerge. The first pattern, referred to as the US pattern, consists of a September peak and an April/May trough. The second pattern, referred to as the North European pattern, consists of a global spring peak, a global November trough and a local September peak. Populations located at warm latitudes display the US pattern, while those at cooler latitudes show the North European pattern. The same late summer/early autumn peak has been described for continental United States by several researchers (Huntington, 1938; Mills, 1939; Pasamanick, Dinitz & Knobloch, 1959, 1960; Chang *et al.*, 1963; Cowgill, 1966a; Erhardt, Nelson & Parker, 1971; Lyster, 1971; Kevan, 1979; Shimura, Richter & Miura, 1981). Europe, Canada and Japan, in contrast, exhibit a mid-winter to mid-spring peak (Cowgill, 1966a, b; Kevan, 1979; Shimura *et al.*, 1981). However, in East Pakistan, the highest proportion of births occur in the last 3 months of a year and the lowest proportion between May and July (Stoeckel & Choudhury, 1972; Becker, 1981). Among the rural Tamangs of Nepal, the seasonal pattern of birth shows two peaks in May and July and two troughs in January/February and August (Panter Brick, 1996). In the Indian subcontinent, the seasonal pattern of births was documented by Hill way back in 1888. More recent studies have shown that births are most numerous in cooler months in this region (Dyson & Cook, 1979; Stoeckel & Choudhury, 1972; Bernard & Bhatt, 1978).

A large quantity of literature indicates that seasonality is affected by various factors: environmental temperature, rainfall and socioeconomic, ecological and behavioural patterns. Temperature has been found to be negatively correlated with number of monthly conceptions (Chang *et al.*, 1963; Clark & Thompson, 1987; Parkes, 1968; Stoeckel & Choudhury, 1972). Warm temperatures are presumed to affect birth rates either through reduced semen quality (Levine *et al.*, 1988), reduced coital frequency or reduced fetal viability (Chang *et al.*, 1963; Clark & Thompson, 1987; Dyson & Crook, 1981; McDonald, 1966; Pasamanick, Dinitz & Knobloch, 1959, 1960; Stoeckel & Choudhury, 1972). Bernard & Bhatt (1978) also found that conception correlated inversely with environmental temperature in their study area, Baroda and Udupi in Gujarat, India. They also found that abortions and stillbirths were greater in hotter weather. However, according to Lam & Miron (1996) although the extreme summer temperature reduces conceptions in the southern United States, there is no evidence that extreme cold temperature affects conceptions.

Recent studies have found a strong correlation between marriage timings and seasonal variation of births (Demoliates & Katsouyiannopoulos, 1995). Matsuda & Kahyo (1994) showed that the modernization of Japanese society after the Second World War might have been responsible for the drastic changes in the marriage pattern and degree of seasonality of births there. Some authors have also described marriage pattern as a partial rather than a prime factor in the regulation of seasonality of births (Trovato & Odynak, 1993). Stoeckel & Choudhury (1972), in their study of Bangladeshi women, observed that in the absence of month-wise data on marriage patterns, the births to first-order pregnancies were generally events which occurred to newly married couples and possibly reflected the seasonal pattern of marriage.

Besides marriage patterns, cultural factors such as religious festivals (Cowgill, 1966; Johnson, Ann & Palan, 1975; Takashashi, 1964), business cycles (Kirk, 1960) and the existence of occupations requiring the temporary absence of the husband (Stoeckel & Choudhury, 1972) have also been cited as important determinants of birth seasonality. Bailey *et al.* (1992) presented a model relating temperature and rainfall and their effect on agricultural cycles (including workload, migration for occupation, food production), marriage, rituals affecting coital frequency and ovarian function and their ultimate effects on fertility.

However, although there has been abundant research on seasonality of births in many countries, so far very little literature is available on the Indian population. One reason may be the lack of large-scale reliable data on births. A few factual reports, based on census and sample registration systems and some very localized studies, are all that are available. The present study attempts to explore the phenomenon of birth seasonality: its magnitude, direction and correlates in rural societies of West Bengal, India. Specifically, it attempts to examine the distribution of births over calendar months, test for any existing seasonal pattern and locate peaks for different age parity groups in three 5-year periods in the aforesaid population. It also tries to link the causes of concentration of births in some months of a calendar year (if any) to environmental, economic and social perspectives of the study community.

Data and methods

West Bengal, an eastern province of the Indian Republic, extends from 21°25′ to 27°13′ north latitudes and from 85°50′ to 89°50′ east longitudes. Since a large portion of West Bengal forms a part of the Ganga River delta, the state's topography is flat and featureless, dominated by alluvial plain. Divided into seventeen districts, the state's only mountainous area lies in the lap of the Himalayas and contains one district, Darjeeling. The districts of Jalpaiguri, Koch Bihar, West Dinajpur and Malda form the sub-Himalayan region. In the west, Purulia, Bankura and Birbhum constitute the dry plateau area. The rest of the districts come under the Gangetic Plain. West Bengal has a sub-tropical hot and humid climate, very much affected by the annual monsoon. The state is inhabited by various ethnic and religious groups and has thus developed a distinguished Bengali culture, rich in educational achievements, intellectual thoughts and philosophy. The economy of West Bengal, though highly agriculture based, occupies a leading position in the country in the industrial sector. The state has advanced demographic features, particularly in urban areas. West Bengal, from the very day it was created in 1947, has been greatly affected by illegal international migration from neighbouring Bangladesh, which has badly affected its development. The overall development of the state has therefore been moderate.

Data for the present study were compiled from different sources. Information on monthly maximum and minimum temperatures during 1987–91 were collected for each district from the statistical abstract published annually by the Bureau of Applied Economics and Statistics, Government of West Bengal, India. Other information, such as number of births, husband's occupation, pregnancy order etc., were extracted from the National Family Health Survey (NFHS), India, standard rectangular record tape. The survey was conducted in the State of West Bengal (as part of a nation-wide survey) during April to July 1992, on a representative sample of 4322 ever-married women aged 13–49 by the International Institute for Population Sciences, Mumbai, India (National Family Health Survey Reports, West Bengal (IIPS), 1995).

Several time series analysis techniques were used. It was assumed that there is a multiplicative relationship between the four components, i.e.:

Times Series = Secular Trend × Seasonal Variation × Cyclical Variation × Irregular Variation.

To deduce the seasonal part of a time series the trend, cyclical and irregular components must be removed from the data. The method of 'Ratio to Centred 12-month Moving Average' was used here for this purpose.

Ratio to moving average method

Periodic fluctuations in a series are eliminated by taking a moving average of the period equal to the period of fluctuation. So, from the monthly data, seasonal fluctuation can be removed by taking a 12-month moving average, which again can be centred by taking a further two-point moving average. These moving averages will also remove any cyclical variation. The moving average value may therefore be supposed to give estimates of the combined effects of trend and cyclical variation. The percentages of the original data values to the moving averages are therefore expected to represent seasonal variation with some irregular fluctuations (Gupta, 1985).

If there were no seasonal variation, these percentages would be expected to be quite close to 100. So, a deviation of these percentages from 100 would represent seasonal fluctuation of the data and would act as the dependent variable in further analysis. To determine the extent and peak of seasonal variation the simple and yet elegant method of Fourier analysis was used.

The trigonometric regression

The essence of Fourier analysis is the representation of a set of data in terms of sinusoidal functions. The most basic property of the sinusoid that makes it suitable for the present study is its simple behaviour under a change of time scale. A sinusoid of frequency (in radian per unit time) or period $=2\pi/\omega$ may be written as

$$y_t=\gamma \cos(\omega t+\theta), \tag{1}$$

where γ is the amplitude, θ is the phase and y_t denotes the t^{th} data value. Using this simple sinusoidal function a trigonometric regression model is fitted to the data (Bloomfield, 1976):

$$Y_j = \gamma \cos(\omega j+\theta) + \varepsilon_j, \tag{2}$$

where j represents the ordinal time interval; Y_j = the deviation of the ratio to moving average from 100 for the interval j; $\omega=2\pi/12$; and ε_j is an error term.

Putting $\beta_1=\gamma\cos\theta$, $\beta_2=-\gamma\sin\theta$, $X_{1j}=\cos\omega j$ and $X_{2j}=\sin\omega j$, the above model is easily transformed to a linear regression model:

$$Y_j = \beta_1 X_{1j} + \beta_2 X_{2j} + \varepsilon_j. \tag{3}$$

To keep the model simple, no constant term is added to the model. The least square estimates of the parameters of model (3) are as below:

$$g=\sqrt{b_1^2+b_2^2}$$

and

$$m=\pi+\arctan(-b_2/b_1) \qquad ;b_1<0,\ b_2<0$$

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$$\begin{array}{ll} \arctan(-b_2/b_1) - \pi & ; b_1<0,\ b_2>0 \\ \arctan(-b_2/b_1) & ; b_1>0 \\ -\pi/2 & ; b_1=0,\ b_2>0 \\ \pi/2 & ; b_1=0,\ b_2<0 \end{array}$$

where b_1, b_2, g and m are estimated values of β_1, β_2, γ and θ.

The parameters of the model have specific interpretations. The amplitude of the fitted curve γ gives the magnitude of seasonal variation as a deviation from 100, i.e. $\gamma=0{\cdot}4$ implies that the percentages of births vary seasonally to a maximum of 40 above and below 100 (note that if there is no seasonal variation γ will be 0). The phase θ locates the exact point of the peak of the seasonal variation in terms of months and days. Since $\gamma\cos(0)$ gives the maximum amplitude, by solving $(\omega t+\theta)=0$ (where t is the continuous analogue of j in eqn (2)) or by calculating

$$t=\frac{|m|}{\omega}$$

the peak can be located, where t is the continuous analogue of 'j' in eqn (3).

However, the study suffers from some limitations due to lack of data. As mentioned in the literature, seasonal variation in marriage has a particular effect on the season of first conception. To study the effect of marriage pattern on birth seasonality, data on the exact month of marriage would have been helpful. However, such data were not collected in the NFHS. Month of first birth was therefore used as a proxy for the marriage variable. It should be noted here that season of first birth is expected to have a strong relationship with marriage season. Furthermore, most biological and environmental factors affect the time of conception rather than the time of birth, and intra-uterine mortality is also affected by season. So conception rather birth would be a better unit of study. Since specific dates of abortions and stillbirths experienced by the sample women were not available, it was impossible to study the number of conceptions and this therefore reduced the accuracy of the present study. A record of the length of gestation period for each birth observed would have reduced the error, as this could have been used to calculate the month of conception of live births. However, most of the studies conducted so far have faced similar restrictions. Lastly, as data on some environmental variables such as photoperiod, humidity and rainfall were not available the effect of these on birth seasonality could not be studied, although it seems from earlier studies that they could have some influence on birth seasonality.

Results

Testing for seasonality of births: results of trigonometric regressions

Tables 1, 2 and 3 give the results of trigonometric regressions for the years 1987–91, 1982–1986 and 1977–1981 respectively. Regression analysis was applied to different parity and age groups, as well as the all-women group for each 5-year period. As age and parity of women are two very important demographic variables, they were primarily taken into the analysis at this stage.

Table 1. Results of the trigonometric regression analysis, rural West Bengal, 1987–91

Variables	β_1	β_2	γ	θ	Sig F	Point estimate of peaks
Parities						
All	− 19·65	10·86	22·45	− 2·63	0·0000	Dec. 1
1	− 22·81	12·94	26·23	− 2·62	0·0004	Dec. 1
2	− 19·59	13·51	23·80	− 2·54	0·0040	Nov. 26
3	− 20·94	7·31	22·18	2·80	0·0290	Dec. 11
4	− 9·89	6·34	11·80	− 2·56	0·5338	Nov. 27
Age of mother						
13–19	− 23·90	20·46	31·46	− 2·43	0·0000	Nov. 19
20–24	− 13·12	− 1·66	13·23	3·01	0·0982	Dec. 23
25 +	− 9·71	17·15	19·71	− 2·08	0·0079	Oct. 30

A first look at Table 1 reveals a marked seasonal pattern of births among women that is indicated by the amplitudes of the fitted curves. For all age and parity groups except women of parity 4, regression lines fit significantly to the observed data at least at the 10% level. For all women, seasonality of births varies to a maximum of 22 points above and below the 100 level. The curve shows a peak at December 1st. For parities 1, 2 and 3, the amplitudes of the curves vary from 22 to 26 points and the peaks lie between November 26th and December 11th. There is no uniform shifting of the seasonal peaks over the parity cohorts. Seasonality seems to be the highest for teenage mothers, who show a variation to a maximum of more than 30 points above and below the 100 level. Though for women aged 20–24 the variation is rather low, for the 25+ age group it increases to around 20 points. In this case also there is no uniform shifting of peaks over the age groups. Thus, Table 1 clearly shows a remarkable seasonal pattern of births during the period 1987–91 with late autumn to mid-winter peaks (late October to late December). Possible reasons for this pattern will be discussed in a later section.

Table 2 reveals a significant seasonal pattern of births among women of different age and parity groups for the period 1982–1986. Here, for all parity groups except parity 2 and 4, regression lines fit significantly to the observed data at least at the 10% level. For all women seasonality of births varies to a maximum of 16 points above and below the 100 level. The curve shows a peak at November 14th. For parities 1 and 3 the amplitudes of the curves vary from 16 and 23 points above and below the 100 level, whereas the corresponding peaks lie at November 13th and November 4th. There is no significant shifting of seasonal peaks over the parity cohort. Again, for teenage mothers seasonality seems to be comparatively higher than for higher age groups. Here the variation is 21 points above and below the 100 level. The peak of the curve is at November 2nd. Although for women in the age group 20–24 no striking seasonal pattern was observed, women in the age group 25+ had a rather moderate seasonal variation of 12 points. As for the above parity groups, there is no significant

Table 2. Results of the trigonometric regression analysis, rural West Bengal, 1982–86

Variables	β_1	β_2	γ	θ	Sig F	Point estimate of peaks
Parities						
All	− 11·05	11·24	15·76	− 2·34	0·0013	Nov. 14
1	− 11·28	12·05	16·50	− 2·32	0·0736	Nov. 13
2	− 9·85	8·78	13·20	− 2·24	0·1859	Nov. 8
3	− 13·00	19·43	23·38	− 2·16	0·0113	Nov. 4
4	− 12·70	3·90	13·29	− 2·84	0·3987	Dec. 13
Age of mother						
13–19	− 11·66	18·22	21·36	− 2·13	0·0031	Nov. 2
20–24	− 9·21	− 0·58	9·23	3·08	0·2567	Nov. 27
25 +	− 11·92	0·44	11·93	− 3·10	0·0655	Dec. 29

shifting of peaks over the age groups. Thus Table 2 shows a moderate seasonal pattern of births during the period 1982–86, with late autumn to mid-winter peaks (early November to late December) very similar to those observed earlier. The regression lines for parity 2 and 4 fall short of statistical significance.

In Table 3, except for all-parity women and those of parity 1, the regression lines fail to fit significantly to the observed data. For all women seasonality of birth varies to a maximum of 14 points above and below the 100 level and the curve shows a peak at December 12th. For parity 1 the amplitude of the curve is 17 and the peak lies at November 28th. Although there is no secular shifting of peaks over parity groups, all the curves show peaks between late November and late December. On the other hand, for seasonal patterns among age groups regression lines fit significantly to the observed data at least at the 10% level. For three age groups, the amplitude of the curve varies from 15 to 20 and the peaks lie between October 25th and December 19th. Thus, from Table 3, no clear picture emerges about seasonal patterns among different parity groups, particularly for parities greater than one. However, age-wise seasonal patterns of births were found to range from late autumn to mid-winter.

It was expected that a secular trend would be observed in the peaks over the calendar year, but Tables 1–3 do not show any such consistent shifting of peaks, either among parity or age groups, or for all women combined. However, most of the peaks are observed in the last 2 months of a calendar year. For 1982–86 and 1977–81 it was found that the regressions, though they fitted, were not significant in many age and parity groups. In the NFHS, though the interviewers were instructed to probe suitably the stated months of births, respondent recall lapse errors may have possibly undermined the accuracy of reported births occurring prior to 1986. For 1977–81 in particular, as women aged 34 and above are not represented at all in the sample, for these years the estimation could not be done on representative age groups and hence the estimates are obviously not accurate. Sampling fluctuation caused by the small

Table 3. Results of the trigonometric regression analysis, rural West Bengal, 1977–81

Variables	β_1	β_2	γ	θ	Sig F	Point estimate of peaks
Parities						
All	− 13·57	4·60	14·33	− 2·81	0·0005	Dec. 11
1	− 14·38	8·82	16·87	− 2·59	0·0171	Nov. 28
2	− 9·73	4·25	10·62	− 2·73	0·4194	Dec. 7
3	− 18·17	1·85	18·27	− 3·04	0·1788	Dec. 25
4	− 13·98	1·45	14·06	− 3·04	0·3294	Dec. 25
Age of mother						
13–19	− 8·19	18·05	19·82	− 1·99	0·0014	Oct. 25
20–24	− 14·53	− 2·90	14·82	2·94	0·0812	Dec. 19
25 +	− 12·90	− 15·22	19·95	2·27	0·0065	Nov. 10

number of samples is probably the highest for these years. However, the results pertaining to 1987–91 are encouraging, so all explanations regarding the seasonal peaks of births are given for these years only.

Effect of temperature on seasonality of conceptions

The evidence for a relationship between temperature and seasonal pattern of conceptions is contradictory. However, based on the available literature, the following relationships can be expected: (1) that temperature affects marriage timing, the economic activities of couples and living patterns etc. which have an effect on birth seasonality; (2) that an increase in environmental temperature reduces the frequency of intercourse and sperm mobility and increases fetal wastage by increasing fetal infection, thereby affecting birth seasonality (Chang *et al*., 1963; Clark & Thompson, 1987; Parkes, 1968; Stoeckel & Choudhury, 1972; Levine *et al*., 1988; Bernard & Bhatt, 1978).

Although three 5-year periods were considered earlier, in relating temperature to the distribution of conceptions over calendar months only the first 5-year period before the survey was considered because average monthly maxima and minima were not available for earlier years. For each calendar month average maximum and minimum temperatures were calculated by taking arithmetic means over 5 years.

Over the districts of West Bengal there is considerable variation in maximum and minimum temperatures from north to south to west. To reduce the effect of heterogeneity of temperature between the districts they were grouped into three different regions within which maximum and minimum temperatures are more or less homogeneous. The regions were the sub-Himalayan, Gangetic Plain and the Plateau regions. The district of Darjeeling was dropped from the analysis because of its significantly lower minimum and maximum temperatures than any other district.

Figures 1 and 2 give graphical representations of the relationship between temperature and number of conceptions in the sub-Himalayan region. It is clear from

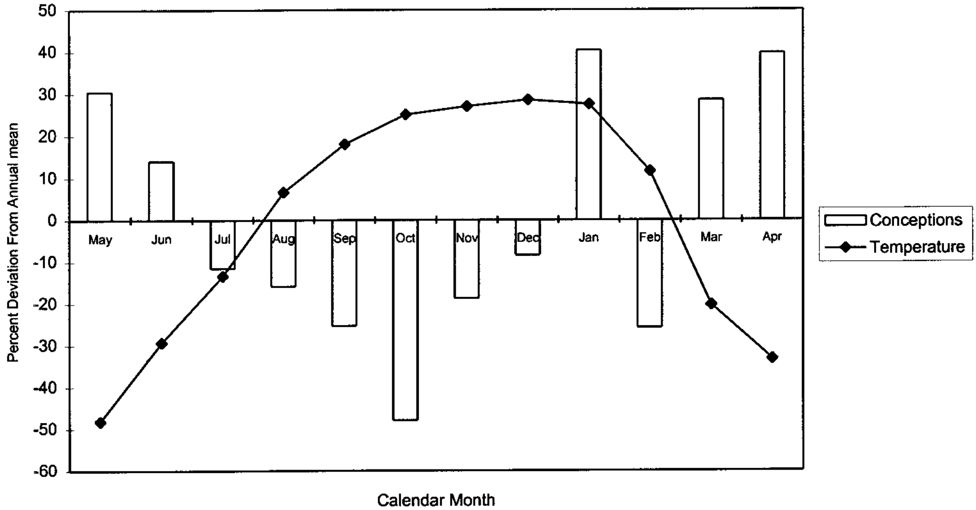

Fig. 1. Percentage deviation from annual mean: minimum monthly temperature and percentage of conceptions, West Bengal, sub-Himalayan Region, 1987–91, by calendar months.

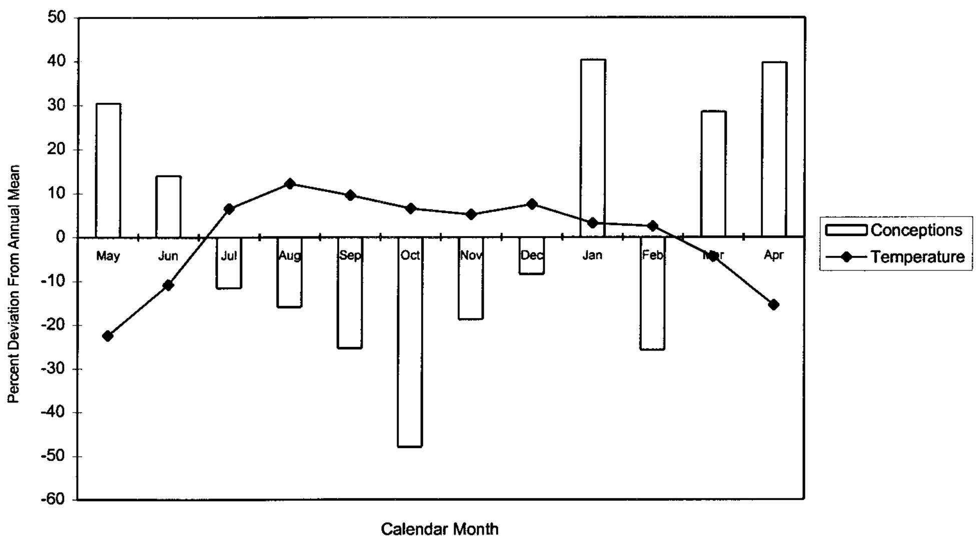

Fig. 2. Percentage deviation from annual mean: maximum monthly temperature and percentage of conceptions, West Bengal, sub-Himalayan Region, 1987–91, by calendar months.

the figures that in sub-Himalayan West Bengal conceptions occur mostly during the spring, i.e. January to April, and hence births occur in late autumn, i.e. during late October to late January (assuming an average 9-month gestation period).

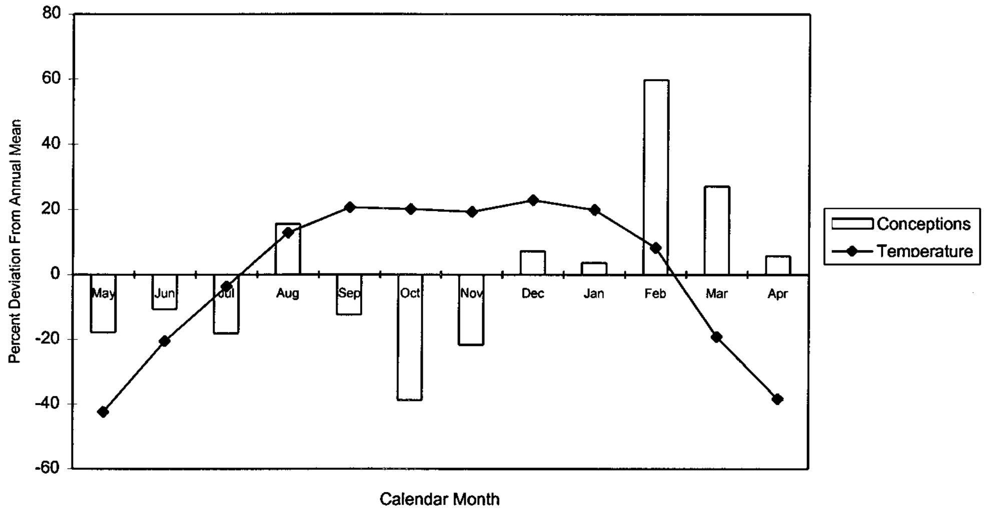

Fig. 3. Percentage deviation from annual mean: minimum monthly temperature and percentage of conceptions, West Bengal, Gangetic Plain, 1987–91, by calendar months.

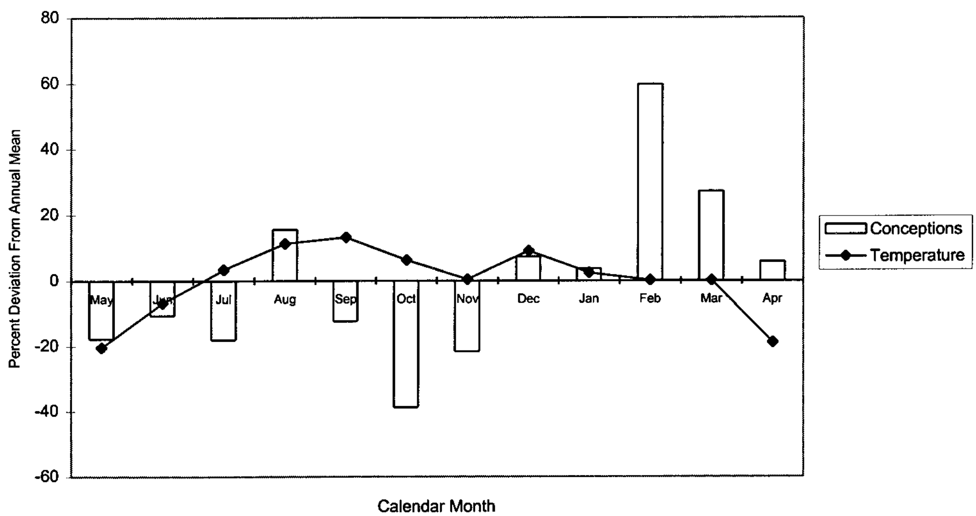

Fig. 4. Percentage deviation from annual mean: maximum monthly temperature and percentage of conceptions, West Bengal, Gangetic Plain, 1987–91, by calendar months.

Figures 3 and 4 show the graphical representation of temperature-wise variation of percentage of conceptions in the Gangetic Plain. The conceptions are found to heap in spring with troughs in May to July. It is clear from the figures that, at least in Gangetic West Bengal, maximum and minimum monthly temperatures do not

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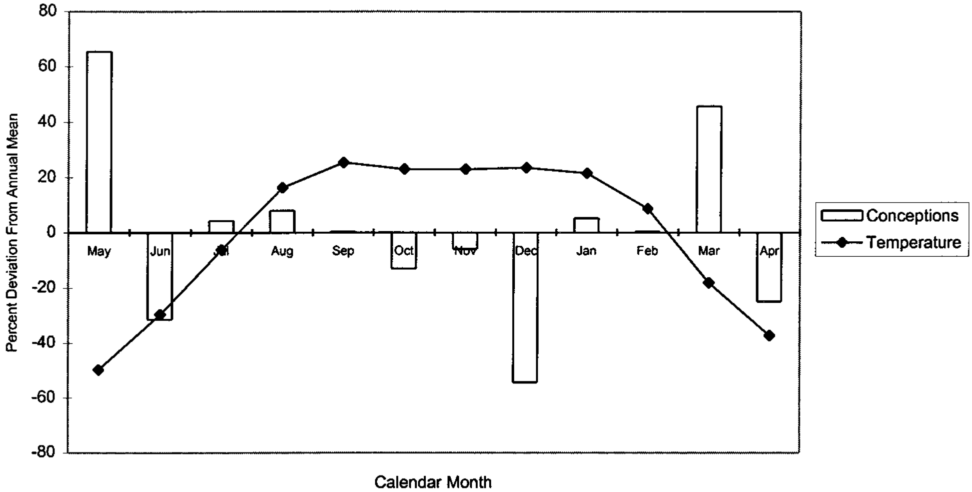

Fig. 5. Percentage deviation from annual mean: minimum monthly temperature and percentage of conceptions, West Bengal, Plateau Region, 1987–91, by calendar months.

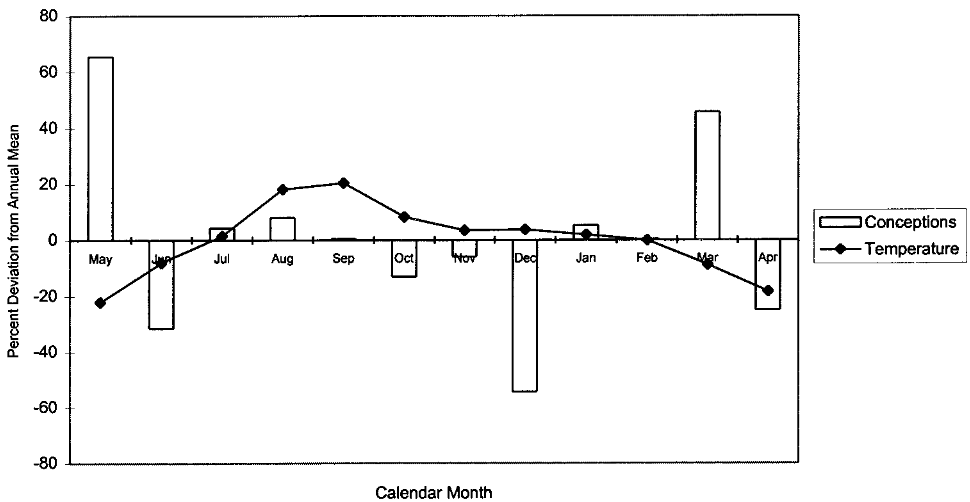

Fig. 6. Percentage deviation from annual mean: maximum monthly temperature and percentage of conceptions, West Bengal, Plateau Region, 1987–91, by calendar months.

correlate with the percentage of conceptions. One explanation for this finding may be that there is less variation in temperature in this region over the calendar months. However, one encouraging finding, which corroborates many earlier findings, is that conceptions occur mostly in the spring season when both minimum and maximum temperatures are below the annual mean.

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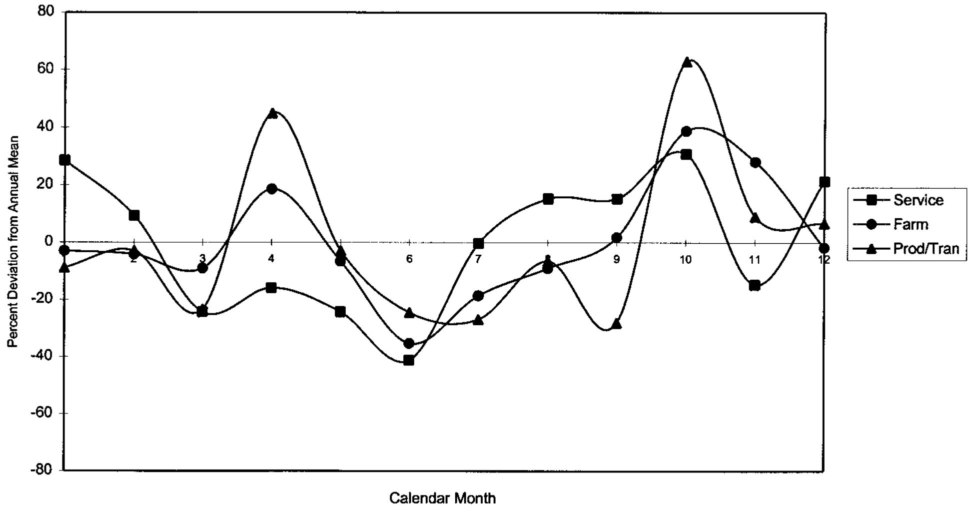

Fig. 7. Percentage deviation from annual mean: percentage of births, West Bengal, 1987–91, by occupational category.

Figures 5 and 6 show the relation between minimum and maximum temperatures and percentage of conceptions over calendar months in the plateau region of West Bengal. Low variation in maximum temperature but high variation in minimum temperature characterizes this region. Conceptions are found to peak in March and May, when both maximum and minimum temperatures are below the annual mean. It is clear from these figures that whenever the temperature is above the annual average, there are fewer conceptions.

Thus, Figs 1–6 suggest that conceptions are greater when the temperature is low (either maximum or minimum) or, in other words, they occur mostly in the spring when both maximum and minimum temperatures are close to average or below. For all three regions the relationship is clearer in the case of minimum temperature, which is understandable since minimum temperature generally occurs at night when the chance of sexual intercourse is highest. The above findings therefore suggest that environmental temperature can be identified as one of the main factors in the seasonality of births in rural West Bengal, as estimated by the trigonometric regression described earlier.

Effect of husband's occupation on seasonality of births

The existing literature suggests that the seasonal variation of births is indirectly related to occupational category through the workload, availability of food and migratory job of the husband. In some occupations such as agriculture, hunting, fishing etc. the workload is not equally distributed throughout the year. It can be assumed that the variation of workload may affect the time of conception. On the other hand, jobs that are service, clerical, administrative etc. are characterized by a balanced workload throughout the year. Again, occupations like production and transportation are related to seasonal demand for labour and require frequent long absences of the husband from home. For peasants, there is a season when sufficient food is available to the household; this is during late winter-spring in West Bengal (Stoeckel & Choudhury, 1972; Bailey *et al.*, 1992).

In Fig. 7, husband's occupation is related to the seasonal variation of their wives' births. Three main categories are taken, viz. 'service sector', 'production and transportation' and 'agriculture, hunting, fishing etc'. For women whose husbands work in the service sector no global peak of birth is observed. There are some inconsistencies regarding the distribution of births among these women. It appears from the figure that no seasonal pattern exists in this category. For women whose husbands are either in agricultural activities or in fishing or hunting there is a much more consistent seasonal pattern of births with a global peak during mid-October. Among these women, births are concentrated during October to November, which implies a peak in the proportion of conceptions during January and February, when the workload is at minimum and food availability is at maximum. This really shows a definite relation between agricultural occupation and seasonality of births. Women whose husbands are in production and transportation jobs show two peaks of births: a global peak in October and a local peak in April. This implies two peaks in conception: one in January and a second in July–August. The local peak of conceptions in July–August is readily understandable, because during this period the demand for production and transportation labour is low, so husbands stay at home for longer periods leading to more conceptions. However, the global peak of conceptions in January may be related to other factors such as temperature. In any case, no particular factor can be said to have sole effect, as other important factors may have an influence.

Marriage pattern and seasonal variation of births

Anderton & Barrett (1990) demonstrated a relationship between marriage timing and that of first births in a non-contracepting population. They found that each had a regular cycle at yearly intervals, and that these were strongly associated with each other. The lag between the two cycles composes the mean time of conception after marriage and the mean gestation interval. Stoeckel & Choudhury (1972), in their study of Bangladesh, also found a relationship between marriage pattern and first birth order, taking a time lag of 10 to 12 months between them, which consisted of a 2- to 3-month waiting time to conception after marriage and 9-month gestation period. In West Bengal, marriages take place both in the winter months (i.e. from November to mid-December and from mid-January to the beginning of March) and in the summer (from mid-April to mid-August), according to Gupta (1997–98). The cooler months are usually preferred as the summer is characterized by scorching heat and the rainy season can cause damage to roads limiting access in rural areas. If it is assumed that more marriages occur during the cooler months, and that there is a 10- to 12-month waiting time for conception and gestation (as assumed by Stoeckel & Choudhury, 1972), the heaping of first-parity births from late October to late December, as estimated by trigonometric regression, is found to be strongly correlated with the existing marriage pattern of West Bengal.

Discussion

This study attempted to identify seasonal variation in the number of births in rural West Bengal and possible causes for it. The seasonality of births was examined in three 5-year periods using the technique of trigonometric regression. This was done for three broad age and parity groups, as well as for the whole cohort of women. Peaks or heapings of births were evident for different age and parity groups. In addition, environmental, social and economical factors were related to the observed seasonality of births among Bengali women. It was found that environmental temperature, husband's occupation and marriage timing affect the seasonal variation of births, either directly or indirectly.

It is interesting to note that if seasonality of births does exist in a population there will be a seasonal demand for maternal and child health care and family planning. Hence the provision of good quality services throughout the year requires an understanding of the phenomenon of birth seasonality. The present findings thus generate a set of issues for formulating and modifying future maternal and child health care, in particular delivery-related issues.

The study is narrow, as it could not encompass the entire gamete of birth seasonality because of limitations of the data. However, it does provide a baseline for future research and formulation of needs-based programmes to give thrust and dynamism to the existing health care system of West Bengal.

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References

Anderton, D. L. & Barrett, R. E. (1990) Demographic seasonality and development: the effect of agricultural colonialism in Taiwan, 1906–1942. *Demography* **27**, 397–411.

Bailey, R. C., Jenike, M. R., Ellison, P. T., Bentley, G. R., Harrigan, A. M. & Peacock, N. R. (1992) The ecology of birth seasonality among agriculturists in Central Africa. *J. biosoc. Sci.* **24**(3), 393–412.

Becker, S. (1981) Seasonality of fertility in Matlab, Bangladesh. *J. biosoc. Sci.* **13**(1), 97–105.

Bernard, R. P. & Bhatt, R. V. (1978) Seasonality of birth in India. *J. biosoc. Sci.* **10**(4), 409–421.

Bloomfield, P. (1976) *Fourier Analysis of Time Series: An Introduction.* Wiley, New York.

Chang, K. S. F., Chan, S. T., Low, W. D. & Ng, C. K. (1963) Climate and conception rates in Hong Kong. *Hum. Biol.* **35**, 366–376.

Clark, S. J. & Thompson, R.W. (1987) Seasonal distribution of live births in a rural community in the southern United States. *Hum. Ecol.* **15**(3), 289–300.

Cowgill, U. (1966a) Season of birth in man. *Man* **1**, 232–240.

Cowgill, U. (1966b) Season of birth in man. Contemporary situation with special reference to Europe and to southern hemisphere. *Ecology* **47**, 614–623.

Demoliates, Y. D. & Katsouyiannopoulos, V. C. (1995) Seasonality of births: changing pattern correlated with the seasonality of marriage. *J. Epidemiol. Comm. Hlth* **49**(1), 110–111.

Dyson, T. & Crook, N. (1979) Season of births and deaths in developing countries. In: *Proceedings of Conference on Seasonal Dimensions to Rural Poverty*. University of Sussex, Brighton, UK.

Dyson, T. & Crook, N. (1981) Seasonal patterns in births and deaths. In: *Seasonal Dimensions to Rural Poverty*, pp.135–162. Edited by R. Chambers, R. Longhurst & A. Pacey. Pinter, London.

Erhardt, C. L., Nelson, F. G. & Pakter, J. (1971) Seasonal patterns of conception in New York City. *Am. J. publ. Hlth* **61**, 2246–2258.

Gupta, B. M. (1997–98) *Pangika*. Gupta Press, Calcutta, West Bengal.

Gupta, S. C. (1985) *Fundamentals of Statistics*. Himalaya Publishing House, Bombay.

Hill, S. A. (1888) The life statistics of an Indian province. *Nature* (*London*) **38**, 245.

Huntington, E. (1938) *Season of Birth*. John Wiley and Sons, New York.

James, W. H. (1971) Social class and season of birth. *J. biosoc. Sci.* **3**, 309–320.

Johnson, J. T., Ann, T. B. & Palan, V. T. (1975) Seasonality of births for West Malaysia's two main racial groups. *Hum. Biol.* **47**, 295–307.

Kevan, S. M. (1979) Season of life – Season of death. *Social Sci. Med.* **13D**, 227–232.

Kirk, D. (1960) The influence of business cycles on marriage and birth rates. In: *Demographic and Economic Change in Developed Countries*, pp. 241–260. Proceedings presented at the National Bureau Committee for Economic Research, Special Conference Series, No. 11. Princeton University Press.

Lam, D. A. & Miron, J. A. (1987) Seasonality of births in human populations. *Social Biol.* **38**(1–2), 51–78.

Lam, D. A. & Miron, J. A. (1996) The effect of temperature on human fertility. *Demography* **33**(3), 291–305.

Levine, R. J., Bordson, B. L., Brown, R. M., Stanley, J. M. & Starr, T. B. (1988) Deterioration of semen quality during summer in New Orleans. *Fert. Steril.* **49**, 900.

Lyster, W. R. (1971) Three patterns of seasonality in American births. *Am. J. of Obstet. Gynec.* **110**(70), 1025–1028.

McDonald, R. L. (1966) Lunar and seasonal variations in obstetric factors. *J. genet. Psychol.* **108**, 81–87.

Matsuda, S. & Kahyo, H. (1994) Geographical difference and time trends in the seasonality of birth in Japan. *Int. J. Epidemiol.* **23**(1), 107–118.

Mills, J. N. (1939) *Biological Aspects of Circadian Rhythms*. Plenum Press, New York.

Nath, D. C. (1994) Effect of seasonality on waiting time to conception: An Indian experience. *J. Fam. Welfare* **40**(2), 40–46.

Panter-Brick, C. (1996) Proximate determinants of birth seasonality and conception failure in Nepal. *Popul. Stud.* **50**(2), 203–220.

Parkes, A. A. (1968) Seasonal variation in Human sexual activity. In: *Genetic and Environmental Influence on Behaviour*. Edited by J. M. Thoday & A. S. Parkes. Oliver and Boyd, Edinburgh.

Pasamanick, B., Dinitz, S. & Knobloch, H. (1959) Geographic and seasonal variations in births. *Publ. Hlth Rep.* **74**, 285–288.

Pasamanick, B., Dinitz, S. & Knobloch, H. (1960) Socioeconomic and seasonal variations in birth rates. *Milbank meml Fund q. Bull.* **38**, 248–254.

Shimura, M., Richter, J. & Miura, T. (1981) Geographical and secular changes in the seasonal distribution of births. *Social Sci. Med.* **15D**, 103–109.

Stoeckel, J. & Choudhury, A. A. K. M. (1972) Seasonal variation of births in rural East Pakistan. *J. biosoc. Sci.* **4**, 107–116.

Takahashi, E. (1964) Seasonal variation of conception and suicide. *Tohoku J. exp. Med.* **84**, 215–227.

Trovato, F. & Odynak, D. (1993) The seasonality of births in Canada and the provinces, 1881–1989: theory and analysis. *Can. Stud. Popul.* **20**(1), 1–41.