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SEASONALITY OF FERTILITY IN MATLAB, BANGLADESH

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Summary. From matched birth and census records in the Matlab area of Bangladesh, monthly fertility rates for the period 1970–74 are studied for seasonal patterns by age and parity. Trigonometric regression techniques are used to summarize and compare the multiple series. Pronounced seasonal patterns are apparent for all age and parity groups. The general fertility rate peaks in December with a seasonal variation of 42% above and below the mean level. For younger women at low parities the peak is in late October, while for older women of higher parity it is in January. The shift progresses linearly with age and parity though the age effect is the more pronounced. A seasonal pattern of fecundability which varies by age group could explain the shift.

Introduction

A seasonal pattern of births has been found in virtually every population in which it has been sought (Cowgill, 1966). In the Indian subcontinent the seasonal pattern of births was documented in the last century (Hill, 1888) and recent work (Dyson & Cook, 1979; Bernard *et al.*, 1978) has shown the various patterns in different regions of India. In both East and West Bengal births are most numerous in the winter months (Dyson & Cook, 1979; Stoeckel & Chowdhury, 1972). The purpose of this paper is to extend the analysis of Stoeckel & Chowdhury in examining the seasonal patterns of fertility by age and parity in the Matlab area of Bangladesh during the period 1970–74.

Materials and methods

Study area

Matlab, in Comilla district of Bangladesh, is situated on the flat deltaic plain of the Meghna river. The climate is subtropical with three seasons: the monsoon (June–September), the cool–dry (October–February) and the hot–dry (March–May). During the monsoon a large portion of the area is inundated and country boats constitute the only means of transport between many villages. Rice cultivation is the major economic activity in the area with fishing the second in

importance. There are three rice harvests annually: *aman*, accounting for over half of the annual yield, is harvested in November and December; *boro* is harvested in March–April; and *aus* comes in June–July.

The population density of the area exceeds 2000 persons per square mile, with villages of approximately 1000 persons. Within the village there are distinct *baris* consisting of a number of patrilineally related households living in one compound. The average family lives in a hut with one or two rooms, mud floors, jute stick walls and thatched roof. Eighty-five per cent of the population are of the Muslim religion; 15% are Hindu. Muslim women are subject to the restrictions of purdah. Fewer than 3% of couples in the area used modern contraception during the period of this study.

Data collection

There has been vital registration in the area since 1966 under the aegis of the Cholera Research Laboratory (now the International Centre for Diarrhoeal Disease Research, Bangladesh), and censuses were conducted in 1966, 1968, 1970 and 1974. During the period covered by this study the registration system employed approximately 300 persons in four tiers. In the first tier female village workers visited each household daily (except during the monsoon) and inquired about vital events (births, deaths, and marriages) and migration. Male field assistants who visited each household monthly with the female worker and recorded the vital events on standard forms, constituted the second tier. Senior field assistants, the third tier, checked the work of the field assistants on their visits to each household three times a year. Finally, the field surveillance assistants carried out random checks of completeness and quality in the registration system.

Pregnancy outcomes are recorded as either miscarriage, stillbirth or live birth. A live birth is recorded if any signs of life are present.

Data for the period between the censuses of 1970 and 1974 form the basis of this study. By computer matching of these census and vital registration data, the populations of married females and their births were found for each 2-month interval from May 1970 to April 1974. (Two months was selected as the optimal interval in order to reduce the sampling variability of the rates and still retain the ability to discern seasonal patterns.) Simultaneously the age and parity of all women were updated at each 2-month interval. Table 1 shows the numbers of women in this study population on 1st May 1970 by age and parity. It can be seen that the population size is sufficiently large to provide quite stable estimates for a large array of age–parity specific fertility rates.

Analytic methods and results

Since there are 24 values of bimonthly rates for each of more than 35 age–parity combinations, some data reduction is needed. One starting point is to examine the rates by age (for all parities) and by parity (for all ages). The age-specific rates are shown in Fig. 1. The parity-specific rates are shown in Table 2. Seasonal patterns are very apparent. These appear to be unimodal and roughly sinusoidal, so a simple time series analysis is appropriate, by trigonometric regression.

Table 1. Number of married women in Matlab study population on 1st May 1970 by age and parity

Age	All parities	Parity 0	1	2	3	4	5	6	7	8+
All ages	14,165	702	1,309	1,753	1,793	1,873	1,741	1,697	1,389	1,908
15–19	1,075	505	401	152	17	—	—	—	—	—
20–24	2,618	134	644	907	561	260	72	29	8	3
25–29	3,357	26	182	484	784	811	559	308	130	73
30–34	2,819	10	44	115	258	461	524	568	458	381
35–39	2,509	9	22	68	116	222	368	497	462	745
40–44	1,787	18	16	27	57	119	218	295	331	706

Table 2. Parity-specific marital fertility rates* in Matlab, Bangladesh by 2-month periods, 1970–74

Year	Months	All	Parity 1	2	3	4	5	6	7	8+
1970	MJ	260	23	23	28	40	38	20	34	54
	JA	290	26	37	46	43	33	30	25	49
	SO	503	31	76	75	71	68	56	51	74
	ND	630	32	86	93	88	74	82	69	107
1971	JF	458	31	57	64	65	59	51	47	85
	MA	353	23	37	55	43	46	39	39	68
	MJ	245	21	26	32	30	32	32	32	39
	JA	252	24	26	42	33	30	30	25	42
	SO	496	53	44	71	78	66	54	55	74
	ND	701	48	68	110	119	88	84	67	117
1972	JF	464	32	44	72	70	63	47	51	83
	MA	335	32	25	42	46	45	32	44	68
	MJ	237	23	27	30	29	37	25	20	47
	JA	232	46	19	28	33	30	24	19	34
	SO	474	44	45	76	62	73	55	38	82
	ND	579	53	60	91	86	77	70	54	87
1973	JF	464	28	42	50	61	85	56	54	88
	MA	367	25	32	47	44	50	55	36	78
	MJ	351	41	33	40	53	45	40	28	70
	JA	395	46	35	44	65	53	40	37	75
	SO	595	68	48	80	91	77	57	47	126
	ND	586	61	53	76	89	73	51	61	123
1974	JF	465	45	29	53	60	67	63	53	94
	MA	315	29	27	31	45	50	45	30	60

* Rates are per 10,000 instead of the conventional 1000.

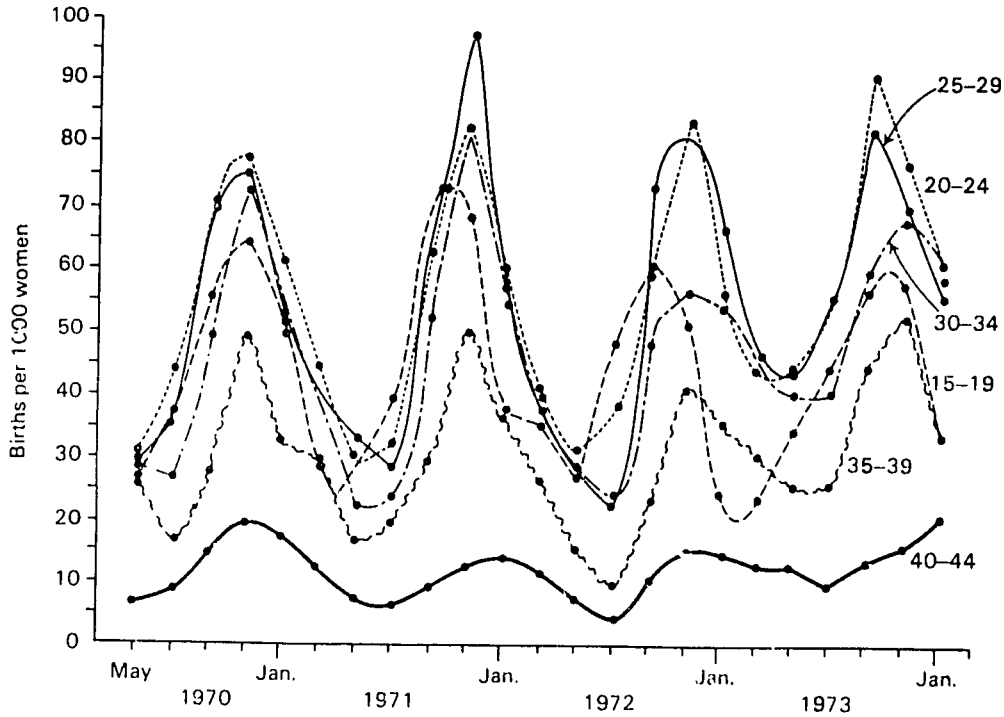

Fig. 1. Live births per 1000 married women in the study population of the demographic surveillance system for 2-month periods 1970–74 by age groups.

First the series of rates for each age–parity group was checked for a trend by simple linear regression. None showed a linear trend, indicating that fertility levels were relatively constant during this period. Each series was then standardized by calculating monthly percentage deviations from the mean value of the series, and to these deviations a trigonometric regression was applied, as described in the Appendix.

Table 3 shows the results of the trigonometric analyses for the series of age-order-specific rates (Age–parity groups which had an average fertility rate during the period of less than 0·001 were excluded from the analyses.) A significant seasonal pattern exists for virtually all age–parity groups. From the first panel of Table 3 it can be seen that the rate for all women (15–44) varies 42% above and below the mean level during the year, with the peak during the first days of December. The magnitude of the variability is virtually constant for all parities but the time of the peak shifts from late October for first births to early December for births of parities five and above.

Examining the results within age groups, the effect of parity disappears. Indeed the values of θ for all parities within each age group show that the shift of the peak with increasing age is more pronounced than the apparent parity effect seen in the first panel. This is further demonstrated by the results of simple linear regressions of the values of θ on age and parity separately (Table 4). Comparison of the relative

Table 3. Results of trigonometric regression analysis for age-order-specific fertility rates for married women 15–49 in Matlab, Bangladesh 1970–74

Age (years) and parity	F*	r^2	$\hat{\gamma}$	$\hat{\theta}$	Point estimate of peak
15–44					
All	58	0·85	42	2·10	1 Dec
1	9†	0·46	34	2·65	28 Oct
2	19	0·65	47	2·23	22 Nov
3	47†	0·82	50	2·22	23 Nov
4	32	0·75	46	2·20	24 Nov
5	44	0·81	40	1·98	7 Dec
6	29	0·73	43	1·95	8 Dec
7	44	0·81	42	1·86	14 Dec
8+	21†	0·67	38	1·93	9 Dec
15–19					
All	45	0·81	42	2·73	24 Oct
1	19†	0·64	39	2·81	19 Oct
2	10†	0·48	53	2·57	3 Nov
20–24					
All	55	0·84	42	2·25	21 Nov
1	2	NS	NS	NS	NS
2	19†	0·64	46	2·18	25 Nov
3	47	0·82	49	2·27	20 Nov
4	18	0·64	35	2·26	20 Nov
5	5	0·31	33	2·26	20 Nov
25–29					
All	33	0·76	45	2·17	26 Nov
2	8	0·43	57	1·93	9 Dec
3	32	0·75	58	2·18	25 Nov
4	19	0·64	48	2·25	21 Nov
5	18	0·63	37	2·15	27 Nov
6	13	0·55	42	2·18	25 Nov
7	4	0·28	37	2·01	5 Dec
8+	4	0·25	32	2·24	22 Nov
30–34					
All	49	0·82	45	1·90	11 Dec
3	8	0·44	47	1·64	26 Dec
4	18	0·63	60	1·96	8 Dec
5	36	0·77	52	1·84	15 Dec
6	24	0·69	43	1·83	15 Dec
7	22	0·67	39	1·84	15 Dec
8+	16†	0·60	43	2·07	2 Dec
35–39					
All	23	0·68	42	1·80	17 Dec
5	7	0·39	49	1·15	24 Jan
6	15	0·59	57	1·84	15 Dec
7	14	0·58	49	1·89	12 Dec
8+	13	0·55	37	1·88	12 Dec
40–44					
All	30†	0·74	40	1·49	5 Jan
6	6	0·36	57	1·24	19 Jan
7	5	0·30	56	1·46	6 Jan
8+	15†	0·60	36	1·54	2 Jan

* The significance of the $F_{2,21}$ distribution for $p = 0{\cdot}05$ and $0{\cdot}01$ are 3·47 and 5·78 respectively.

† For this series a significant or possibly significant (Durbin & Watson, 1951) serial correlation was present. However, referring to Table 2 of Vinod (1976) with this F-value, the trigonometric regression remains significant at the 0·05 level.

effects of age and parity using the standardized regression coefficients of multiple regression was not deemed suitable because of the high correlation between the age and parity variables. From the bivariate analyses, the correlation of θ and age is −0·88 while that of θ and parity is −0·42. The age pattern is shown graphically in Fig. 2.

Table 4. Results of linear regression of values of θ on age and parity

Variable	r	df	F	Significance
Age and parity	0·91	2,23	54·9	<0·001
Parity alone	−0·42	1,24	5·2	<0·05
Age alone	−0·88	1,24	88·9	<0·001

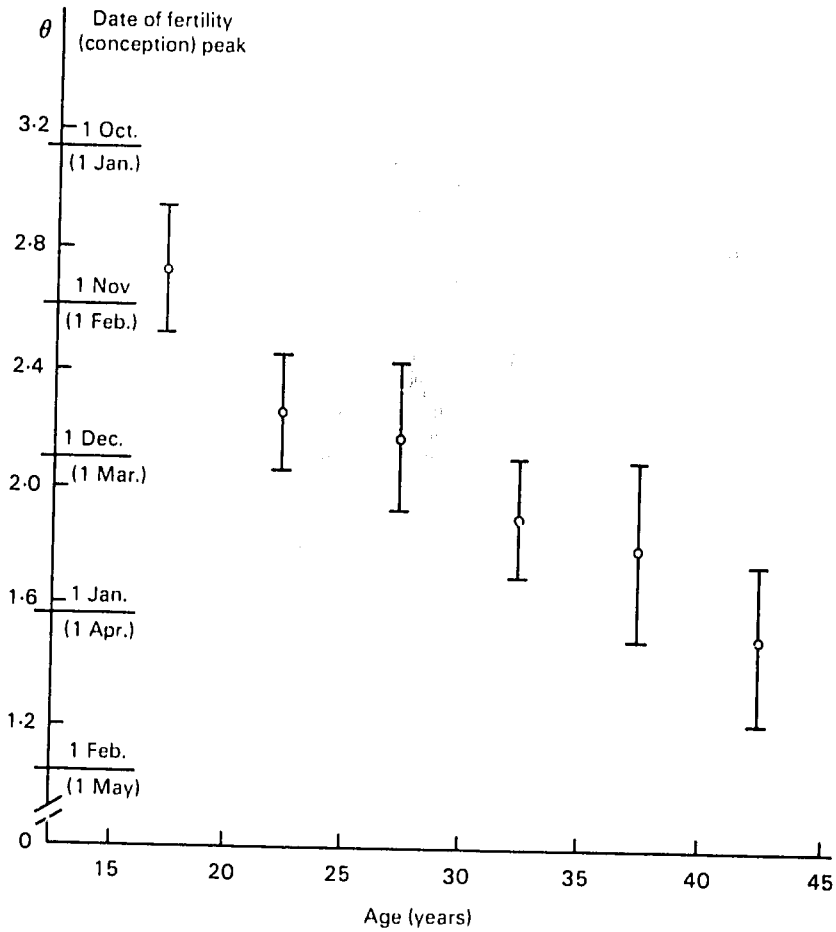

Fig. 2. Values of $\theta(\pm 2SE)$ and the corresponding seasonal peaks of fertility (and conception) in Matlab by 5-year age groups.

Discussion

There was marked seasonality of fertility in all age and parity groups in Matlab with the peak occurring between late October and January, depending on the age group of women. This places the peaks of conceptions in the late winter and early spring months. The seasonal variation is 40% above and below the mean level.

The seasonal differential in fertility is more pronounced than social, economic or geographic differentials that have been observed in the Bangladesh population, for example in the results of the Bangladesh Fertility Survey of 1975 (Ministry of Health and Population Control, 1978). Thus an understanding of this natural variability of fertility in the population could give important clues for the successful implementation of fertility control programmes.

The causes of the overall seasonal pattern of fertility in this population have been studied by several authors. Chen, Gesche & Mosley (1974), in a study of 200 women found that though there is seasonal absence of husbands, a seasonal pattern in fecundability (the monthly probability of conception) remained after this factor was controlled. Huffman *et al.* (1978) found a marked seasonality in the timing of resumption of menstruation postpartum with a peak in November. If fecundability varied between women, the increased proportion of menstruating women after November could lead to a higher conception rate in the early months of the year as women with high fecundability become pregnant (Chen *et al.*, 1974). Finally a seasonal pattern in the frequency of intercourse may exist. This is currently being studied in the Matlab population.

It is interesting to consider how these factors could explain the shift in the pattern with increasing age. Any explanation must also be consistent with the constant variability for all age groups. One possibility is that a seasonal pattern in the frequency of sexual intercourse exists for all age groups but has a later peak for older women. A second possibility is that, although women of all ages have a greater chance of resuming menstruation in November–December, the older women may have more anovulatory cycles during the first months. This would lead to a later conception peak for the older women. These provide hypotheses to be tested by further research.

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Appendix

If we let j represent the ordinal time interval ($j = 1$ corresponds to the interval May–June 1970) and y_j the deviation of the fertility rate (for interval j) from the mean value, then the trigonometric regression model is:

$$y_j = \gamma \cos(\omega_j + \theta) + \varepsilon_j \tag{1}$$

where γ gives the amplitude of the curve, θ locates the peak, ω is the period of the curve (here $\omega = 2\pi/6$) and ε_j is the error term. This model is easily transformed to the following linear regression model:

$$y_j = \beta_1 X_{1j} + \beta_2 X_{2j} + \varepsilon_j \tag{2}$$

where $\beta_1 = \gamma\cos\theta$, $\beta_2 = \gamma\sin\theta$, $X_{1j} = \cos(\omega j)$ and $X_{2j} = \sin(\omega j)$. The estimate of γ is $\hat{\gamma} = \sqrt{b_1^2 + b_2^2}$ where b_1 and b_2 are obtained from the usual normal equations. The estimate of θ is given by:

$$\hat{\theta} = \begin{cases} \pi + \arctan\left(\dfrac{-b_2}{b_1}\right) & b_1 < 0, b_2 < 0 \\ \arctan\left(\dfrac{-b_2}{b_1}\right) - \pi & b_1 < 0, b_2 > 0 \\ \arctan\left(\dfrac{-b_2}{b_2}\right) & b_1 > 0 \\ -\pi/2 & b_1 = 0, b_2 > 0 \\ \pi/2 & b_1 = 0, b_2 < 0 \end{cases}$$

(cf. Bloomfield, 1976).

The parameters in the model have the following interpretations. γ estimates the magnitude of seasonal variation as a percentage of the mean level. (For example, $\gamma = 0{\cdot}20$ signifies that the rate varies seasonally to a maximum of 20% above and below its mean value.)

θ locates the peak of the curve. Since $\gamma\cos(0)$ gives the maximum, by solving $\cos(\omega t + \theta) = 0$ [t is the continuous analogue of j in equation (1)] for t we obtain the time of the peak. This value is easily converted to months and days. Note that a value of $\theta = 0$ would correspond to a peak on 1 April.

Since the data represent series of measurements in the same population over time, the presence of serial correlation between the error terms in equation (1) must also be considered. In the presence of serial correlation the estimates of γ and θ remain unbiased but the significance tests are vitiated. Serial correlation was checked by examining the residuals from the trigonometric regression. The correlation of lag 1 was calculated (Kendall & Stuart, 1968) and its significance was tested with the Durbin–Watson statistic (Durbin & Watson, 1951). If the correlation was significant or possibly significant (the test is sometimes inconclusive) the regression F-value was compared with the bounds for significant F-values in the presence of serial correlation tabulated in Vinod (1976) to determine if the regression results were invalidated or not.