

A Model For Sex Ratio Decline in India

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ABSTRACT The sex ratio in India has declined from 972 females per 1000 males in 1901 to 929 females per 1000 males in 1991. A model had been proposed for the quantitative analysis of the problem in the form, $\ln(x_t/y_t) = \ln(x_0/y_0) - 2st$, where x_t/y_t represents the number of females per male at time t , x_0/y_0 is the initial sex ratio and s is the differential growth rate component which discriminates the growth of the female population from that of the male. The study reveals that there has been a sex discriminated population growth in India in the twentieth century, although the rate of decline of the female has decreased. If the current trend of population growth continues, there will be a further decline in the female population.

INTRODUCTION

There has been a perpetual decline of sex ratio in India from 972 females per 1000 males in 1901 to 929 females per 1000 males in 1991 (Table 1). This is indicative of the sex discriminated population growth, i.e., The growth rate of the female population is less than that of the male population. Some of the factors which have contributed to this unbalanced sex growth are : female foeticide (Thukral, 1993), female infanticide, preferential choice for the male child, early marriage, physiological stresses on the female due to over reproduction and other socio-economic factors. This sharp declining trend in the sex ratio in India is a matter of great concern and needs explanation (Research and Reference Division, 1992). The present report proposes a model for the quantification of sex discrimination during population growth in India.

THE MODEL

The growth of human population is by and

Table 1 : Sex ratio data from 1901 to 1991

Census year	Sex ratio (females / 1000 males)	
	India	Kerala
1901	972	1004
1911	964	1008
1921	955	1011
1931	950	1022
1941	945	1027
1951	946	1028
1961	941	1022
1971	930	1016
1981	934	1032
1991	929	1041

large exponential and may be described by the equation

$$dN/dt = rN$$

$$\text{or } N_t = N_0 e^{rt} \quad \dots (1)$$

where r is the specific growth rate, N_t is the number of individuals at time t and N_0 is the initial number of individuals. If there are x females and y males in the population and the specific growth rate is the same for either sex, equation (1) may be written as

$$dx/dt = rx$$

$$\text{and } dy/dt = ry \quad \dots (2)$$

However, if the specific growth rates for the two sexes are different, say r_1 and r_2 , then

$$dx/dt = r_1 x$$

$$\text{and } dy/dt = r_2 y \quad \dots (3)$$

The values of r_1 and r_2 may be supposed to be made up of two components each : a uniform growth rate component, r , which is equal for the two sexes; and a differential growth rate component, s , which discriminates the growth rate of the female from that of the male. Thus, we have,

$$dx/dt = (r-s)x$$

$$\text{or } x_t = x_0 e^{(r-s)t} \quad \dots (4)$$

$$\text{and } dy/dt = (r+s)y$$

$$\text{or } y_t = y_0 e^{(r+s)t} \quad \dots (5)$$

By definition, if $s > 0$, the female population will grow slower than the male population; if $s=0$, both the populations will grow at the same rate, and if $s < 0$, the male population will grow slower than the female population. The sex ratio (defined herein as the number of females per male) is then given by

$$x_t/y_t = (x_0/y_0)e^{-2st} \quad \text{or } \ln(x_t/y_t) = \ln(x_0/y_0) - 2st \quad \dots(6)$$

The value of s may be estimated from the straight line equation obtained by regressing $\ln(x_t/y_t)$ on t , i.e.,

$$s = -\text{slope}/2$$

Rewriting equation (6) we get the value of s between two instants of time

$$s = \ln[(x_t/y_t)/(x_0/y_0)]/2t \quad \dots(7)$$

From equations (4) and (5) we get

$$r = [(\ln x_t - \ln x_0)/t] + s \\ = [(\ln y_t - \ln y_0)/t] - s \quad \dots(8)$$

The sex dependent population growth is then given by

$$N_t = e^r (x_0 e^{-st} + y_0 e^{st}) \quad \dots(9)$$

DISCUSSION

The Census of India data on sex ratio for the period 1901-91 is given in table 1. A regression of $\ln(x_t/y_t)$ on time as per equation (6) (Fig.1) yields

$$\ln(x_t/y_t) = -4.9715 \times 10^{-4} t - 0.0326 \\ (r = 0.9690, p < 0.001) \quad \dots(10)$$

Table 2 : Variation in the value of s

Decade years	Value of s ($\times 10^{-4}$)			
	India		Kerala	
	Decadal	wrt 1901	Decadal	wrt 1901
1901-11 10	4.132	4.132	-1.988	-1.988
1911-21 20	4.690	4.411	-1.148	-1.737
1921-31 30	2.625	3.816	-5.411	-1.158
1931-41 40	2.638	3.521	2.440	-2.961
1941-51 50	-0.529	2.711	-0.488	-2.362
1951-61 60	2.650	2.701	-2.927	-1.481
1961-71 70	5.896	3.155	2.944	-0.849
1971-81 80	-2.146	2.490	-7.813	-1.719
1981-91 90	2.684	2.514	-4.342	-2.010

wherefrom the value of s comes out to be 2.4858×10^{-4} per year. The value of s was also computed as per equation (7) (Table 2). It is evident that the decadal value of s has been positive except for the decades 1971-81 and 1941-51. The decade 1961-71 was the worst for the female sex. The values of s as computed for the time intervals following the base year, 1901 to the end of different decades showed a decreasing trend indicating a decline in the rate of sex ratio in India. The best fit was obtained on plotting s against $\ln t$, (Fig. 2) giving the regression equation

$$s = -8.9797 \times 10^{-5} \ln t + 6.6173 \times 10^{-4} \\ (r = -0.8878, p < 0.001) \quad \dots(11)$$

Putting the values of s computed from equation (10) into equation (6), we obtain a sex ratio curve for India which is in good agreement with the observed values (Fig. 3). An extrapolation of data reveals that the sex ratio in India will further decline to 925 in 2001 and to 912 in 2051. However, since the values of s are dependent on changing socio-economic environments, sex ratio predictions for the future can not be made with accuracy.

Whereas the sex ratio has been in favour of the male in the country as such, the State of Kerala has registered a reverse trend (Table 1). A plot of $\ln(x_t/y_t)$ against time (Fig. 1) yields a positive correlation with the regression equation

$$\ln(x_t/y_t) = 3.10358 \times 10^{-4} t + 6.855 \times 10^{-3} \\ (r = 0.8410, p < 0.01) \quad \dots(12)$$

This provides the value of s equal to -1.5518×10^{-4} per year. The decadal values of s for the State of Kerala have been negative throughout except for the decade 1961-71. The values of s with respect to 1901 as the base year also reveal the sex ratio in favour of the male. However, no specific trend could be identified for change of s with respect to time for the State of Kerala. An extrapolation of data on the basis of regression line (Fig. 1) reveals that the sex ratio in this State may slightly decline by

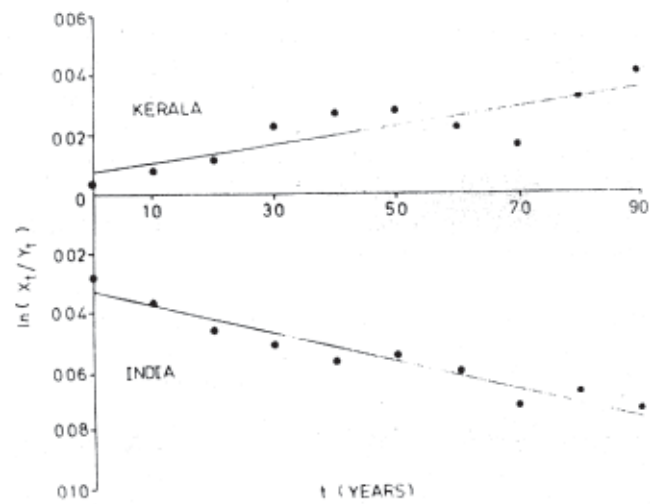


Fig. 1. Sex ratio regression line for India and for the State of Kerala (1901-1991)

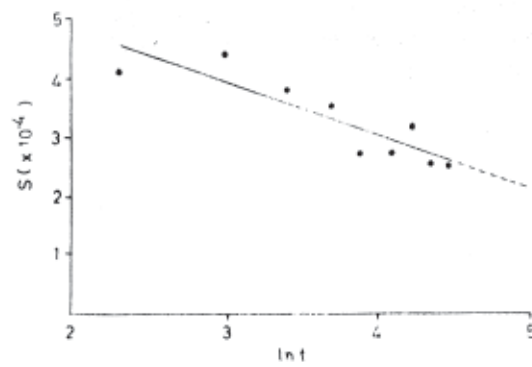


Fig. 2. Regression of differential growth rate component (s) on time elapsed wrt 1901 for India

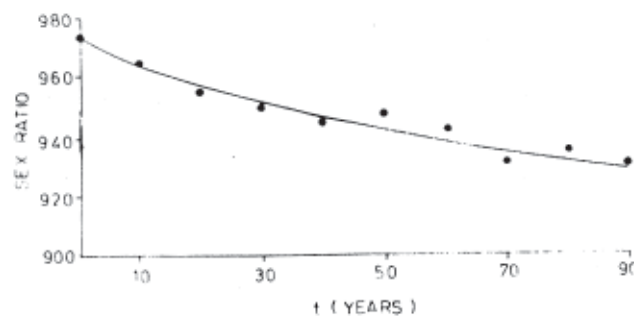


Fig. 3. Sex ratio values for India as computed from the model (curve) and as observed (points) (1901 - 1991)

the turn of century to 1039 and may increase to 1055 by the year 2051. However, the sex ratio variations in a larger population as that of the country are more consistent than that of a smaller population. It would be of course pertinent to believe that the sex ratio will stabilize as the population approaches stable age distribution and the value of s will approach zero with time.

It may be mentioned that on account being by and large an orthodox population, the evil practice of female foeticide is widely prevalent in the society in India. Sex determination tests are frequently undertaken and the embryo is illegally aborted if it is a female. Besides, female infanticide is still being practised in a few villages in different parts of the country. The per capita expenditure on the bringing up of a female is far less than that on a male. Decline in the sex ratio of infants and children in the age group of 0 to 4 years (Department of Social Wel-

fare, 1978) from 1078 females per 1000 males in 1901 to 958 females per 1000 males in 1981 in India can not be accounted by chance variation. All these factors have contributed to the sex ratio decline in India.

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REFERENCES

- Department of Social Welfare : *Women in India - A Statistical Profile*. Ministry of Education and Social Welfare, New Delhi (1978).
- Research and Reference Division. : *India (1991)*. Department of Publications (1991), Government of India, New Delhi (1992).
- Thukral, A.K. : Female foeticide and sex ratio. *J. Hum. Ecol.*, 4:51-54 (1993).