India's falling sex ratios.

by Peter Mayer

A study was conducted to examine principal lines of explanation used to elucidate India's low sex ratios. Investigations of the increasing masculinization of the Indian population have been found to be used as proof to the relatively low position of women in society as compared to men. When used in these context, these studies are flawed for the social value of women can only be measured if the factors of education, employment, mortality and life expectancy are considered.

British India's first national census in 1871 confirmed for the whole of the subcontinent what had earlier been discovered for specific villages and districts in the north: that there were many fewer women than men:

[W]e find in British India 98 millions of males and 91 1/2 millions of females, or about 100 males to 94 females. . . . [T]here is in the whole of British India, so far as the [census] returns are to be credited, an excess of 5 1/2 millions of men over females, or nearly 6 per cent. (Natarajan 1972: 10)

Amartya Sen, writing over a century later, drew similar conclusions from world population figures of the 1980s. Taking the gender balance in industrialized countries as his point of reference, he estimated that parts of Asia and Africa evidenced a deficit in female numbers of about 11 percent. He concluded that in these regions "a great many more than 100 million women are 'missing'" (Sen 1990:61). Ansley Coale has offered a lower estimate of the global deficit, suggesting that the total number of missing females is about 60 million; nearly half of this deficit is in China (29.1 million); just under 40 percent in India (22.8 million) (Coale 1991: 522). Satish Agnihotri, taking complete equality as a base, has calculated that there were 31.85 million missing Indian females in 1991 (Agnihotri 1995: 2076).

Not only has the proportion of females in India remained low over the past 12 decades, but - to the mystification of Indian demographers - the sex ratio in India has fallen, almost without exception, by roughly 1 percent at each decennial enumeration in the twentieth century.(1) In this article I follow the convention of the literature on population in India and express the sex ratio in terms of the number of women per 1000 men. Figure 1 shows the trend of India's sex ratio over the past 90 years.

It has also been evident for well over a century that there are pronounced regional differences in India's masculine bias. The proportion of women in the population is lowest in northwestern India (especially in Punjab, Haryana, western Uttar Pradesh, Rajasthan, and northern Madhya Pradesh) and highest in south India (Kerala, Tamil Nadu).(2)

Agreement is broad in the scholarly literature that India's low sex ratios are a stark indicator of the inferior position women still occupy in Indian society. Pranab Bardhan, writing in the early 1970s, saw low sex ratios as a marker of the "general neglect of little girls," the origins of which are to be found in historical, cultural, ecological, and sociological causes (Bardhan 1974: 1303). The remarkable Report of the Committee on the Status of Women in India concluded that "an increase in the neglect of female lives as an expendable asset" is "the only reasonable explanation for the declining sex ratio observed to persist over several decades" (Committee on the Status of Women in India 1975: 373). Gail Omvedt referred to India's low sex ratios as "the most stark index of the oppression of women," the cause of whose higher death rates "is that girls are given less food and health care" (Omvedt 1978: 382). Maria Mies argued that India's declining sex ratios marked the differential impact of capitalist penetration of the economy upon poor rural and urban women (Mies 1980: 4). Asok Mitra, in a major study of changes in the sex ratio, drew attention to "the diminution of the value and status of women . . . [and] the cheapness of female lives and their expendable character" that are associated with the changes (Mitra 1979: 29).

In this article I review some of the principal lines of explanation advanced for India's low sex ratios and offer an alternative analysis that I believe is better able to address two central deficiencies in the existing literature.

Explanations for masculine bias

A century of concern with and study of India's anomalous sex ratios has produced a wide range of causal explanations. When, for instance, the 1991 census reported the lowest sex ratio in this century (929) it revived a brisk scholarly debate

about the reasons for the decline that had occurred in the 1980s. Outmigration from backward areas and the selective abortion of female fetuses whose gender had been determined by amniocentesis were suggested as possible causes (Kundu and Sahu 1991; Raju and Premi 1992). Other scholars suggested that double counting of migrating males had occurred - that is, counting at both their points of departure and destination (Rajan et al. 1991). More broadly, most explanations of the masculine bias in India's sex ratios have sought to demonstrate the impact of either discrimination against girls and women or the inferior economic position of women.

Traditional patterns of culture and women's autonomy

Tim Dyson and Mick Moore have explored the consequences of traditional regional kinship patterns in India for women's empowerment and demographic behavior. They identify a line of division between north and south India that runs roughly along the line of the Satpura Hills (Dyson and Moore 1983; see also Libbee 1980; Sopher 1980a). The region to the north of the line is characterized by greater masculine bias in the population, higher levels of fertility, lower ages at marriage, and higher levels of infant and child mortality than those to the south. Dyson and Moore attribute these contrasts to the different positions of women in regional patterns of culture, especially in kinship and forms of marriage alliance. The north Indian cultural system is characterized by the marriage of women into unrelated families outside their places of birth, political and economic solidarity among male relatives, and the exclusion of women from the inheritance of property. In the south, cross-cousin marriage, male alliance with other males with whom they are related by marriage, and the transmission of property to (or through) women all occur. Dyson and Moore conclude that these traditional cultural patterns produce greater female autonomy in the south and that this in turn is a major influence on most significant aspects of demographic behavior, including the survival of female children.

The payment of dowry and a purported transition in some parts of India from brideprice to dowry have also been cited as causes of differences and trends in sex ratios. The few case studies we have offer little support for the importance of dowry as a factor. Shalini Randeria and Leela Visaria, in their study of north Gujarat, find little difference in the value placed on women for whom brideprice is paid and those for whom dowry must be furnished (Randeria and Visaria 1984: 652). K. Mahadevan and R. Jayasree found factors such as parents' requirement for economic support in old age, physical support in family and village affairs, and the need to meet family obligations to be far more significant to those interviewed in Kerala, Andhra Pradesh, and Uttar Pradesh than issues of dowry payment (Mahadevan and Jayasree 1989: 126).

Discrimination in nutrition and health care

In his discussion of the high masculinity of India's population, Coale cites the disproportionately high rates of female mortality in regions with depressed sex ratios (Coale 1991: 520). The reasons for this excess mortality are far from clear. Two culturally related factors - discrimination in nutrition and in access to health care - have been proposed by a number of investigators. Those who have examined the significance of these factors as explanations for male bias in survival have relied heavily upon a relatively small number of case studies.(3) Sen, for example, has argued that the low Indian sex ratio appears to be the result of differential mortality arising from the neglect of female children. Drawing upon his study of two West Bengal villages, he shows that girls were even more undernourished than boys in both villages, with malnutrition being most severe where landlessness was greatest (Sen 1985: 84-93).

One apparent paradox that arises from explanations proposed in terms of nutrition is that food is relatively abundant - and poverty levels are lowest - in states such as Punjab and Haryana where the green revolution has been most successful; ironically, though, these are the same regions where women form the smallest proportion of the population (Bardhan 1974:1301; Bourne and Walker 1991: 208). A review by Richard Lipton and Richard Longhurst of the impact of modern seed varieties on the poor emphasizes that increased availability of food per se does not translate automatically into increased consumption by poor farm laborers (Lipton and Longhurst 1989:210-215). They also conclude that we know little about the factors that influence the distribution of food to children of either sex within poor families (pp. 235-243). This point is also made by Barbara Harriss and Elizabeth Watson in their summary of South Asian evidence of nutritional bias against females (Harriss and Watson 1987:91-93).

The evidence on the impact of unequal medical treatment appears to be inconclusive. Harriss and Watson found "little evidence of discrimination against females in access to health facilities" (p. 92). Monica Das Gupta, however, found in her study of Ludhiana District, Punjab that families spent more than twice as much on health care for boys as for girls in the

first two years of life. She found that excess mortality was not uniform for all girls; rather, it was concentrated among second and subsequent daughters. Das Gupta argues that this pattern reflects entrenched cultural patterns of preference for sons in Punjab (Das Gupta 1987; see also Vlassoff 1990; Dandekar 1975).

Plausible though these cultural factors are in explaining the broad regional pattern of sex ratios in India, the nature of the data to support them makes it doubly difficult to subject them to systematic examination. In the first place, we have seen that all-India data for these factors are rarely available. In the second, the cultural predispositions they identify are old if not ancient; Dyson and Moore note that they are widely believed to "predate the Muslim presence, reflecting instead basic differences between northern 'Aryan' and southern 'Dravidian' culture areas" (Dyson and Moore 1983: 47). Although they may help to explain the broad regional differences we observe, it is not evident that they can also explain the long-term trend of increasing masculinization of the Indian population.

The economic value of women

An alternative line of investigation has emerged from earlier studies of what one might call the "economics of female survival." The pioneering work of Ester Boserup (1970) showed that the nature of women's work in agriculture plays a major role in determining whether, at the time of marriage, women's families receive a brideprice or must give a dowry.

Writing in 1974, Bardhan proposed the fruitfully "wild conjecture" that the production of rice, unlike the cultivation of wheat, tends to be relatively intensive in its use of female labor. "Could it be," he asked, "that, in areas with paddy agriculture, the economic value of a woman is more than in other areas - so that the female child is regarded less of a liability than in, say, North and North-West India?" (Bardhan 1974:1304; see also Bardhan 1984).

Barbara Miller examined this question in her study of regional differences in sex ratios in India. Like Bardhan, she observed major differences in the demand for female labor in dry-field plough agriculture and intensive wet-rice cultivation; as well, there are differential demands for female labor between areas where rice is sown broadcast and areas in which it is cultivated by transplantation; finally, differences in regional culture are important in determining the gender division of labor even within similar modes of rice cultivation (Miller 1981: 109). Miller hypothesized that where, for economic or cultural reasons, the demand for female labor is high there will be correspondingly higher rates of survival of girls. Using district-level data from the 1961 census, Miller found a "moderately strong" correlation (r = .43) between female labor participation rates and juvenile sex ratios (Miller 1981:117).(4)

The factors determining the regional and historical patterns of female work participation in the Indian states were the subject of a number of studies in the 1970s and 1980s. In 1975 the government-appointed Committee on the Status of Women in India presented an extensive review of women's economic participation. It noted an "overall decline both in the percentage of [female] workers to total female population and their percentage to the total labor force after 1921," with pronounced declines in the industrial sector (Committee on the Status of Women in India 1975: 152).

Leela Gulati assessed the effect on female participation rates of income, cropping patterns, literacy, male work participation, and sex ratios. Using state-level data from the 1971 census, she found a statistically significant correlation between rural sex ratios and female work participation (r = .69) (Gulati 1975: 42).(5) She found, however, that this relationship disappeared when the data were stratified by level of sex ratio and by urban and rural workforces. Gulati concluded that neither cropping patterns nor any of the other variables she examined - female literacy, income levels, and scheduled caste/scheduled tribe population - helped to explain the observed differences in women's employment (p. 42).

D. Narasimha Reddy, commenting on Gulati's work, argued that differences in agricultural conditions largely explain variations in female work participation. He presented evidence that showed strong negative correlations between female work participation and irrigated area, rainfall, and agricultural productivity, although the relative contributions of these factors were not tested in a multiple regression model. Reddy argued that irrigation displaces female labor, which is more intensively used in areas of low rainfall.(6) He also found no difference in levels of association between female labor participation and the proportion of area devoted to dry rainfed crops like jowar and bajra and irrigated crops like rice (Reddy 1975).

The combined impact of female labor participation and broad cultural zones on sex ratios has been assessed by Satish Agnihotri, Richard Palmer-Jones, and Ashok Parikh (1998) using spatial analysis models of district-level data from the

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1981 census. Their study confirmed that districts where "Aryan" kinship patterns prevail have greater masculine bias. They also found that female labor participation significantly reduced the masculine bias in juvenile sex ratios in both north and south India, but to a greater extent in the north.

The most comprehensive investigation of the combined effects of labor, kinship, culture, stratification, and cropping patterns on mortality appears to be Sunita Kishor's 1993 study. Using data from the 1981 census, Kishor found that both cultural and economic factors were significant in explaining excess female mortality, with cultural factors explaining more of the observed differences than labor force participation (Kishor 1993:260-261).

Ram Pratap Gupta and Sara Attari examined female labor participation in five crop zones of the central Indian state of Madhya Pradesh between 1961 and 1991. Like earlier investigators, Gupta and Attari found that female work participation ratios and sex ratios are related. Where participation is highest - in the rice areas - sex ratios are highest; where participation is lowest - in the wheat zone - sex ratios are also lowest. Perhaps more importantly, they found that as female workforce participation has fallen, sex ratios have also declined (Gupta and Attari 1994: 89).

Others have argued that there is no evidence of a decline in women's work participation. Randeria and Visaria contend that while the census data appear to show a declining trend in workforce participation from 1911 onward, especially between 1961 and 1971, these results are not confirmed by National Sample Survey data. The authors found little change in female work participation in the 1960s and 1970s and concluded that "the situation has virtually remained unchanged in the last half a century!" (Randeria and Visaria 1984: 652).

From their review of the literature on the consequences of regional agricultural systems for the value of women's work, Harriss and Watson concluded that "the 'agricultural determinist' case does not stand up to the evidence," since the complexity and diversity of patterns make generalization problematical.(7) They also questioned attempts to link declining sex ratios to falling employment levels, largely because the aggregate figures conceal significant regional disparities in the impact of technology on the employment of women (Harriss and Watson 1987: 99-102).

Two fundamental issues

I now raise two major concerns, one of method, the other of fact, that in my view are inadequately addressed by the literature on India's sex ratios. I propose that, to be considered satisfactory, any explanation of India's masculine bias in sex ratios should address these two concerns, which I term the historical test and the mortality paradox.

The historical test

While there is evidence to support each of the several explanations for the masculine bias in India's population, few seem more adequate to explain the long-term pattern of decline experienced since 1901 than the proposals offered in the report on the 1872 census in the North-Western Provinces (Plowden 1873: xxviii-xxxix) - concerning climate, caste, religion, early marriage, concealment, and infanticide.(8) The lack of plausible explanations for these long-term changes is a significant lacuna in the literature. I propose therefore to adopt an historical test and to exclude from consideration factors, such as regional patterns of kinship, that appear to be largely unchanged over time. I also exclude "nonce explanations" - that is, explanations applying only to a single census or at most to a limited number of census years - such as the proposal by Kundu and Sahu (1991) that sex-selective abortions performed as the result of amniocentesis were the cause of lower sex ratios in 1991. Such explanations are prima facie incapable of explaining the overall pattern of historical decline. A necessary consequence of this historical test, then, is that only those explanatory factors can be examined for which there are satisfactory data series for the period 1911-91.(9)

The mortality paradox

The second concern has to do with what I term the "mortality paradox." As we have seen, differential and presumably intensifying patterns of female mortality are said to be the proximate cause of the growing masculine bias in the Indian population. Yet it is clear that over the past century mortality rates, especially infant mortality rates, have fallen sharply (Padmanabha 1982; Bhasin and Bhasin 1994). More broadly, although the evidence is not entirely consistent or free from challenge, the percentage of the Indian population living in poverty has fallen significantly, especially since Independence (Minhas et al. 1991). Increasing percentages of the population have access to safe drinking water, sanitation, and modern

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medicine (Census of India 1994; Centre for Monitoring the Indian Economy 1993). Above all, perhaps, the proportion of the population able to read and write has risen at every census.

The "mortality paradox" is perhaps most clearly illustrated by the historical trend of female life expectancy. As the horizontal axis of Figure 2 indicates, female life expectancy has increased significantly in the past nine decades. Yet with each extension of female lifespan, levels of female mortality, as apparently measured by the declining ratio of women to men in the population, have increased. Clearly something is seriously amiss. The second criterion I propose to adopt, then, is that an acceptable explanation of India's declining sex ratio must offer a sensible resolution of the mortality paradox.

Data

The data used in Figure 2 and in subsequent figures are for all-India. Two primary considerations make this restriction necessary: first, all-India figures are largely independent of the effects of migration; second, few relevant historical series are available for the entire period since 1911 for the post-States Reorganization boundaries in India. Reliance upon data aggregated at the all-India level makes it impossible to analyze regional and state differences.

With one exception, I have chosen to use previously published data series in the analysis that follows. One consequence of this otherwise parsimonious approach is that I have necessarily accepted the assumptions and validity of the work of earlier demographers. Finally, in most instances there are no figures for the 1941 census, which was severely truncated because it was conducted during World War II.

Historical trends in women's employment and literacy

I first explore a number of alternative historical explanations for the long-term decline in sex ratios in India, beginning with aspects of women's economic value. We have seen that evidence compiled by the Committee on the Status of Women in India suggested that long-term changes in the levels of female employment and their effect on increasing male-female differences in mortality may be a significant factor in the declining sex ratios in India in the twentieth century. Data are available from successive decennial Indian censuses from 1911 onward for the percentage of women classified as workers.(10) The data indicate that women's participation in the workforce has declined from a high of 34 percent in 1911 to a low of 20 percent in 1981. It is evident from Figure 3 that the declining trend in women's employment is closely correlated with the historical fall in sex ratios ($r = .90$). The coefficient of determination indicates that over 80 percent of the variation in sex ratios that has occurred since 1911 can be predicted from changes in the levels of women's employment.

Strong though this association is, it raises questions for which we require answers. Foremost among these is an explanation for the declining trend in women's employment. We can dispose of some explanations directly. Although Reddy's study (1975), discussed earlier, reported finding strong correlations between female work participation and rainfall, I have found no evidence of changes in rainfall patterns that might explain the long-term decline in female employment. What of the suggestions of a number of authors that women secure higher levels of employment where rice is grown? Have significant shifts occurred over time in the area devoted to rice that might explain the changes? I have found no series of consistent agricultural production figures for India in the twentieth century. Those we have, like Blyn's compilation (1966), either end at Independence or begin there. I have derived a proxy that expresses the ratio of area planted in wheat to area planted in rice.(11) The correlation, a negative one, between the wheat-to-rice ratio and the sex ratio is relatively strong ($r = -.78$). The negative correlation between changes in the wheat-to-rice ratio and female employment is also quite strong ($r = -.70$). These results are suggestive, since the cropping trend over the century has been for an increasing percentage of land to be planted in wheat. The negative relationship with female employment is certainly consistent with the hypothesis suggested by earlier scholars. The impact of changing cropping patterns on sex ratios is also consistent with that hypothesis, although I am not aware of any earlier study in which it has been examined. I will return to these relationships shortly.

These results for historical economic trends shed little light on the mortality paradox. One the other hand, the centrality of female literacy in human development and empowerment is well established (Bourne and Walker 1991; Franke and Chasin 1992; Kumar 1993; Rani and Rajaiah 1988; Dreze and Sen 1995). In the 1990s, for example, one finds a strong positive correlation in data for the Indian states between levels of female literacy and sex ratios ($r = .63$); states, such as

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Kerala, with high levels of female literacy also have high sex ratios. Given this association, it is puzzling that female literacy has not received greater attention in studies of Indian sex ratios.(12)

When the data on levels of female literacy are correlated with sex ratios, as shown in Figure 4, the result is quite unexpected. As female literacy has increased, the sex ratio has fallen; the correlation is very strong (r = .91). It seems highly probable that this result is a variant of the mortality paradox, whereby the sex ratio has fallen in tandem with increases in the female lifespan.

Resolving the mortality paradox

Before we seek to assess the comparative explanatory power of the available historical series, it is essential to attempt to resolve the mortality paradox. An avenue of investigation lies in examination of the comparative figures for male and female life expectancy in the twentieth century. Table 1 indicates that between 1921 and 1991, male life expectancy was greater than female life expectancy. In 1991 for the first time since the beginning of the century, female life expectancy exceeded that of males.(13)

We may also observe that while overall mortality rates have fallen substantially, those for men began to decline before those for women.(14) Data on infant mortality for example - which in 1976-77 accounted for 47 percent of all deaths - indicate that during the 1970s declining female death rates lagged behind those for males by six to eight years (Padmanabha 1982: 1288).

It is a commonplace that most of the rapid population increase that occurs during a demographic transition arises from sharp declines in death rates (Davis 1951: 37). This observation suggests an interpretation of the mortality paradox that is radically different from those we have assessed thus far. Since the natural growth rate of a population is simply the difference between the crude birth and death rates, we must ask whether slight lags in female mortality decline compared with those for males can explain India's declining sex ratios. In other words, if successive cohorts of children born in the intervals between decennial censuses experience higher rates of survival than those that have preceded them, then those cohorts will be correspondingly larger. If the boys in each of those new cohorts experience slightly greater improvement than the girls, then we might well find that while all children gain in survival, during the period of population transition the number of males would become larger than the number of females. This reasoning suggests that the declining sex ratios that have emerged in the twentieth century may be artifacts of the significant albeit sex-differentiated improvements in the life expectancy of the Indian population, which have resulted in rapid growth in population size.(15)

TABLE 1 Expectation of life at birth for males and females, India 1901-91

Year	Male	Female
1901-10	22.6	23.3
1911-20	19.4	20.9
1921-30	26.9	26.6
1931-40	32.1	31.4
1941-50	32.5	31.7
1951-60	41.9	40.6
1961-70	46.4	44.7
1971-80	50.9	50.0
1981-90	57.7	58.7

SOURCES: Padmanabha 1982: 1286; Tata Services Limited 1995: 31.

This hypothesis can be tested in a number of ways. For example, we can examine the association between the changing sex ratios and the rate of increase in the Indian population between censuses. As Figure 5 indicates, the two variables are strongly associated (r = .91), with higher rates of population growth being associated with more masculine sex ratios.

Since the principal factor contributing to population growth is falling mortality, an examination of the associations with female and male death rates would be an appropriate test. In the absence of available death rate series for men and women since 1911, crude death rates for the population as a whole must serve as a proxy. As Figure 6 indicates, we find

a strong correlation between trends in death rates and the sex ratio (r = .93).

Given that the sex ratio is, by definition, the ratio of the number of females to the number of males, our concern is to determine what factors most influence those population totals. An appropriate technique for integrating and evaluating the significance and connections between the different historical factors considered in this article is causal modeling, or path analysis.(16) I present such a model in the Appendix. Broadly speaking, the model suggests that most earlier studies of the Indian sex ratio question, by focusing on aspects of regional difference at a single point in time, have neglected factors, such as female education, that have a major impact on the dynamic structure of India's population.

Conclusion

Variations in the ratio of females to males among animals and humans have been one of the most intensively studied aspects of population dynamics (Godfray and Werren 1996). Perinatal differences, which are least subject to cultural influences, have received the greatest scrutiny in human populations (James 1987, 1995; Sieff et al. 1990). Too frequently, sex ratios are treated as being in some measure biologically or culturally fixed. Much rarer are approaches such as those that consider the implications of changes in sex ratios over time (e.g. Guttentag and Secord 1983).(17)

The study of the sex ratio question in India has been dominated by approaches that focus on specific aspects of household-level discrimination against girls and women, or on broader political-economic structures that seem to value women differently from men. Almost invariably these studies have looked at a single moment in time.

In this article I have approached the sex ratio question with a view to explaining the trend of increasing masculinization of the Indian population over the course of the twentieth century. The findings suggest that discrimination and the differing values placed on women's labor make a relatively minor direct contribution to the historical trend in India's sex ratio. Until recently, however, discrimination and unequal valuation have been significant causes of lags in improvement in women's life expectancy; they appear to have established patterns that have been greatly amplified by the demographic transition through which India is now passing. More broadly, if this conclusion is correct, it suggests that it is not appropriate to use sex ratios or trends in sex ratios as indicators of women's relative position in society; we should rely instead upon direct measures of education, employment, mortality, life expectancy, and so forth.

The logic of the argument I have developed here has an attribute that makes it unique among theories of India's declining sex ratios: it should, in principle, be possible for us to attempt short-term prediction as well. As a crude example of what might be done with greater refinement, consider the following exercise. The life expectancies of Indian women are projected to further surpass those of men over the coming decade. By 2001 women are projected to have a life expectancy at birth of 64.2 years and men 62.8 years; and for 2011 the corresponding figures are 68.3 and 67.1 (Tata Services Limited 1995: 36). I have no official projections for female literacy, but the regression equation for the 1961-91 censuses generates a predicted figure for 2001 of 38.3 percent and for 2011 of 44.8 percent. If those figures are entered into the multiple regression equation for the same years, the results are sobering. For 2001 the model predicts a population consisting of 490.9 million females and 538.3 million males, yielding an all-time low sex ratio of 912. These figures are quite sensitive to such things as the base years used and the regression models that are fitted, and hence can be no more than indicative of what is possible. Nevertheless, they may prepare us for a distinct possibility: until the demographic transition reaches its final phases, the trend toward increasing masculinity of India's sex ratios may well continue into the next century.

Appendix

In Figure A-1 I present a causal model for a number of significant variables that have affected the size of India's female population in the twentieth century. Only path coefficients ([Beta] weights) found to be statistically significant are reported. The explanatory power of the model for both the female and male populations is very high. Multiple regressions of the logs of both female and male populations on the proximate causal variables (percent of females literate, male and female life expectancies at birth) produce very high multiple coefficients of determination ([R.sup.2] = .996 for both).

The model presents some surprising results. First, the percentage of women in the workforce appears to make no significant independent contribution to the main determinants of the sex ratio. This is especially significant, given the degree of attention this factor has received from scholars.

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Second, cropping patterns appear to make their principal contribution through their impact on female literacy, rather than on female employment as has been suggested by other scholars. Since the increasing percentages of land planted in wheat are perhaps best seen as aspects of agricultural modernization, this positive correlation may be an artifact of the broader development process rather than an aspect of "agricultural determinism."

The impact of the increasing trend in female and male life expectancy on population size appears clearly in Figure A-1, although there is no ready interpretation of the negative sign for the impact of female life expectancy.

Perhaps most significantly, the model underscores the crucial mediating role that rising female literacy plays in increasing life expectancy and, both indirectly and directly, population growth. The greater impact of female literacy on female than on male life expectancy suggests that intensified efforts to eliminate female illiteracy will accelerate the rate at which India reverses the century-long trend in its sex ratios.

Notes

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1 Natarajan (1972) reproduces a century of analysis as it appeared in successive censuses of India. For a comprehensive survey of the literature on female mortality in India, see Harriss (1989).

2 See Dyson and Moore (1983) for a review of this topic. The geographical distribution of sex ratios is illustrated with great clarity in Oldenburg (1992).

3 For a survey of case studies available in the 1980s, see Harriss and Watson (1987); Das Gupta (1987); Harriss (1995).

4 Clark has suggested that it is fruitful to consider excess female mortality in socioeconomic terms. Excess mortality among landless laborers is likely to reflect the influence of poverty, while among the owners of the means of production high dowry costs may promote outright neglect (Clark 1987:WS14-WS15).

5 Gulati's causal explanation, though, reverses that proposed by Miller; Gulati argues that where female numbers exceed those of males, their responsibility for family livelihood is increased, hence so is their workforce participation (Gulati 1975: 42).

6 Rosenzweig and Schultz, by contrast, find a significant positive correlation between average district rainfall and the probability that a woman is employed (Rosenzweig and Schultz 1982: 808).

7 See also Agarwal (1984); Mencher and Saradamoni (1982).

8 Plowden noted that men outnumbered women in southern Europe and wondered whether similar geographic forces might be at work in north India. He also considered, and rejected, the possibility that climatic influences could be at work. He found that masculine bias was more common in upper-caste Hindu communities than among either Muslims or members of lower castes. He found insufficient differences in the ages at which marriages were contracted to explain the differences in sex ratios. Plowden acknowledged that the "dreadful practice" of female infanticide was a significant contributing factor, as was the tendency of people to conceal the existence of young girls from census enumerators.

9 The first census for which data on female labor participation are available is 1911.

10 It is evident that the data series has been constructed on the basis of India's post-Partition boundaries, though the Report does not explicitly address questions of method. To ensure comparability with earlier censuses I have used figures for both main and marginal workers for 1971-91. In line with the practice of other scholars, I have used adjusted figures derived on the basis of survey data for 1971 labor participation (Mitra et al. 1980; Omvedt 1978; Randeria and Visaria 1984).

11 The figures for 1901-41 are derived from Blyn (1966: 253, 258, 262, 316); those for 1951-81 are given by Chopra

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(1988: 14); and those for 1991 appear in Tata Services Limited (1995: 50). The series must be interpreted with caution as it was not possible to reconstruct the pre-1947 data on the basis of post-Partition borders. Because they are based on all-India data, significant regional changes, such as the post-green revolution production of rice in Punjab, cannot be analyzed separately.

12 One of the few studies to examine the temporal trend of male and female literacy, though not in connection with changing sex ratios, is Sopher (1980b), especially pp. 175-182.

13 Dyson argued on the basis of earlier census data that female life expectancy began to exceed that of males between 1971 and 1981 (Dyson 1987: 19).

14 Dyson noted the phenomenon in these terms: "One might hypothesize that the emergence of higher male life expectation occurred because males obtained more than their 'fair share' of benefits as circumstances slowly improved" (Dyson 1987: 3).

15 Anantharam and Premi have suggested, on the basis of a cross-national study of population changes in 81 countries between 1974 and 1983, that sex ratios became more masculine during the demographic transition (1989: 41). In the conclusion to her study of changes in mortality between 1881 and 1931 in the United Provinces and the Bombay and Madras Presidencies, Clark suggests that changes in mortality may explain the increasing masculinization of the population: "as mortality began to decline, it simply declined less fast for females than for males, as patterns of discrimination between the value of male and female life continued. With increased overall opportunity to survive, these patterns of discrimination could become even more refined, more selective" (Clark 1989: 144). See also Dandekar (1975: 1656).

16 The underlying logic of causal modeling is presented by Blalock (1964). Kim and Kohout (1975) present a clear account of the techniques involved. A recent example of the use of the technique in the sociological literature can be found in Kick et al. (1990).

17 South and Trent evaluated Guttentag's hypotheses in a cross-national study of 117 countries. They report mixed but general support; nevertheless, the effects of sex ratios were generally smaller than those for socioeconomic development (1988:1111).

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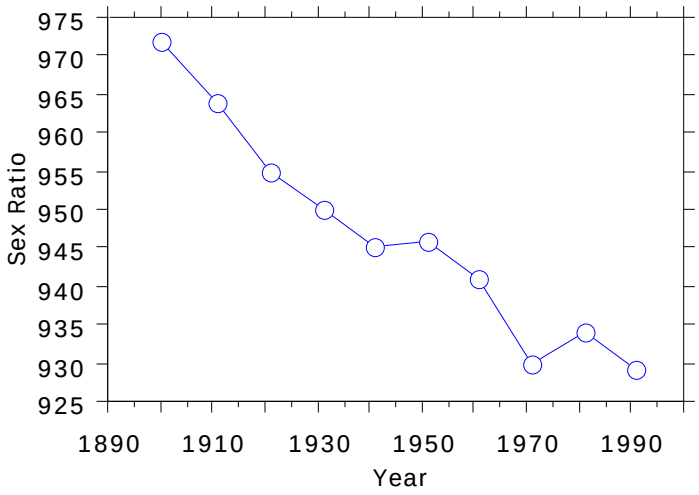
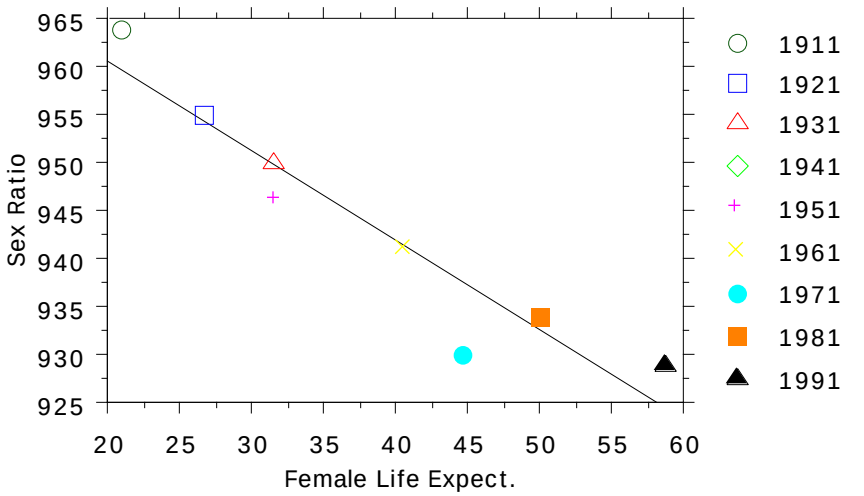
Figure 1: Trend of Sex Ratio in India 1901-1991



Source:(Census of India, 1995: 51)

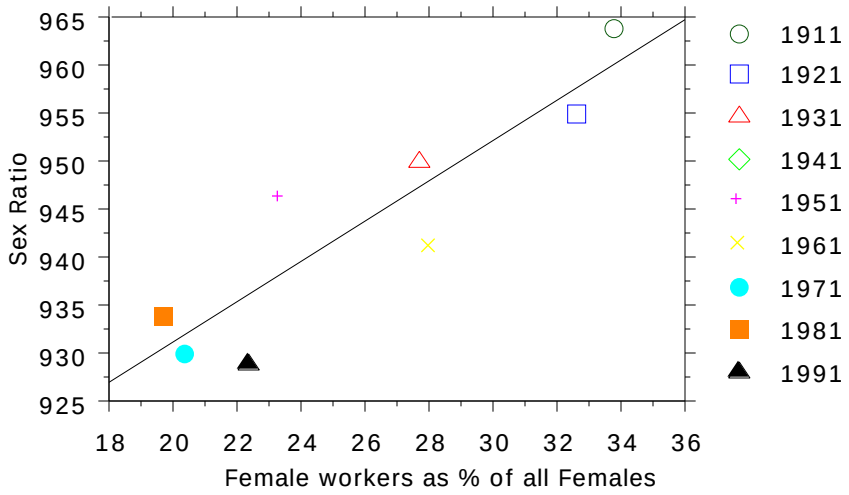
Figure 2: Sex Ratio vs. Female Life Expectancy 1911-1991



Sex Ratio = 979.063 - .931 * Female Life Expect.; R^2 = .898

Sources: (Padmanabha, 1982: 1286; Tata Services Limited, 1995: 31)

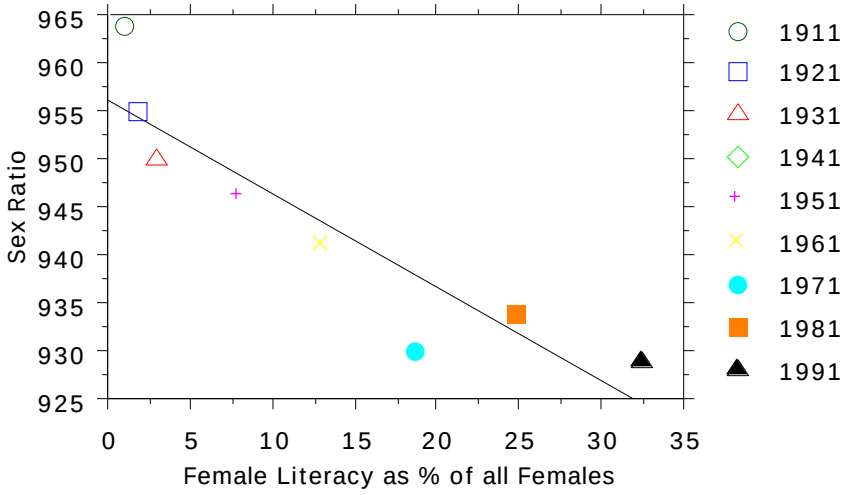
Figure 3 Female Workers as a per cent of all Females vs. Sex Ratio, India 1911-1991



Sex Ratio = 889.343 + 2.092 * Female workers % ∑ Females; R^2 = .812

Sources: (Committee on the Status of Women in India, 1975: p. 153; Padmanabha, 1981: p. 3; Mitra, et al., 1980; Tata Services Limited, 1995: p. 40)

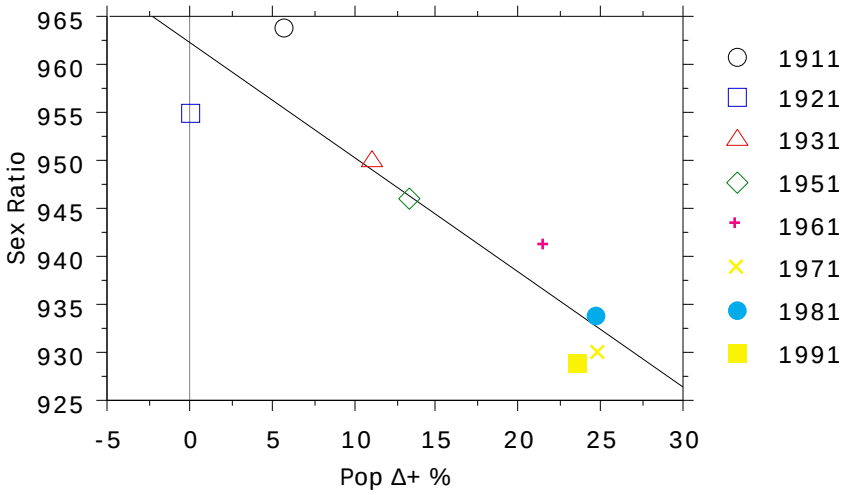
Figure 4: Sex Ratio vs. Per cent female literacy, 1911-1991



Sex Ratio = 956.157 - .977 * Female Literate % ∑ Females; R^2 = .827

Sources: (Committee on the Status of Women in India, 1975: 265; Tata Services Limited, 1995: 31).

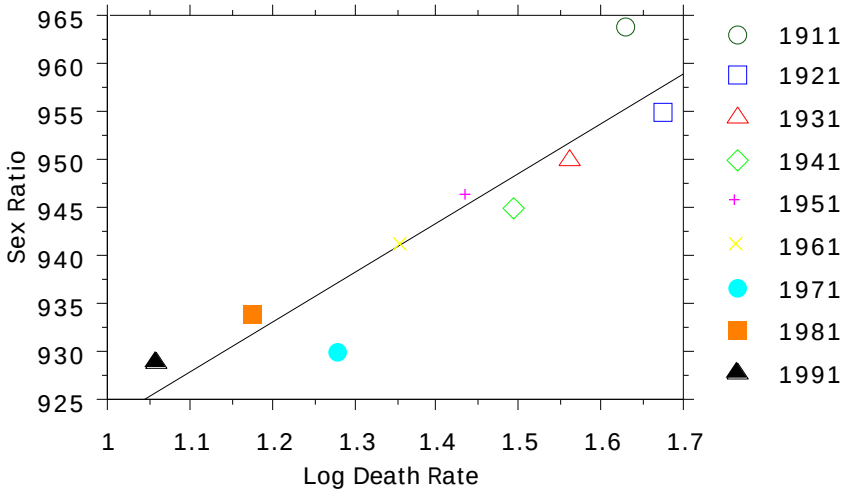
Figure 5: Sex ratio vs. rate of population increase, 1911-1991



Sex Ratio = 962.268 - 1.198 * Pop Δ+ %; R^2 = .832

Sources: (Committee on the Status of Women in India, 1975: 10; Tata Services Limited, 1995: 32)

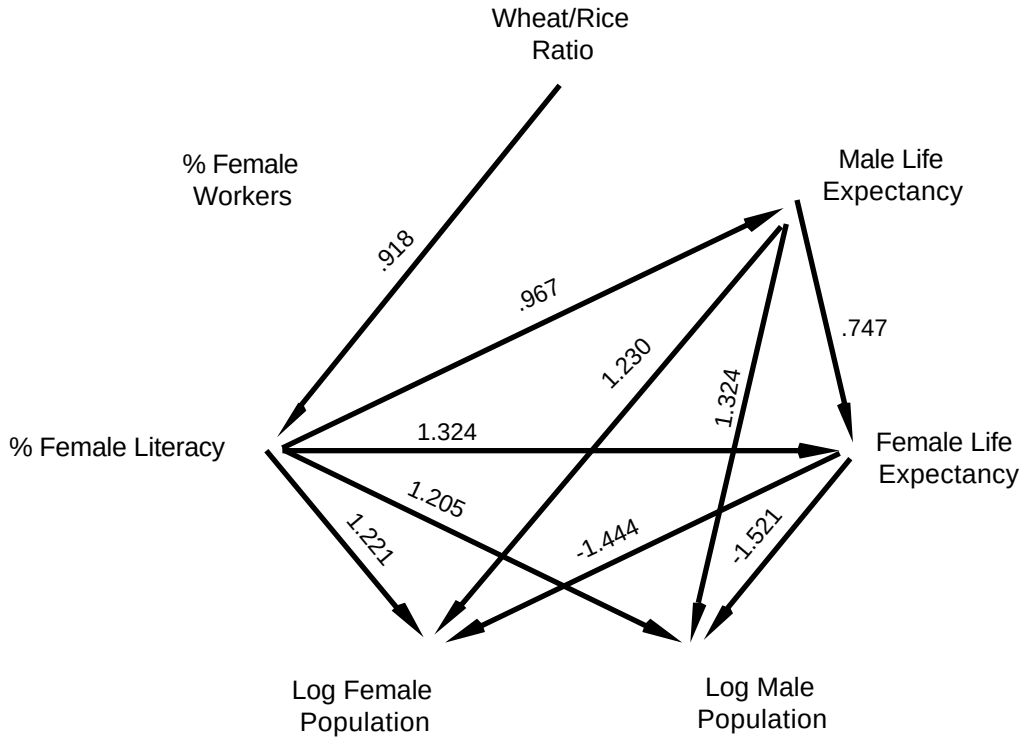
Figure 6: Sex ratio vs. death rate, 1911-1991



Sex Ratio = 871.048 + 51.684 * Log Death rate; R^2 = .85

Sources: (Davis, 1951: 36; Bhasin and Bhasin, 1994: 17; Tata Services Limited, 1995: 31)

Figure 7: Causal Model of Changes in Female and Male Population of India, 1911-1991*



* Paths are deleted where probability of F > .07