CHAPTER 2

Bovine Sex Ratios in India: Theories and Empirical Findings

2.1 Introduction

Analysis of the variations in the sex ratios of human and animal populations across regions has been a subject of interesting debate among social scientists in India (Miller 1981, Bardhan 1974, Wadley and Derr 1987, Harris 1965, Crotty 1980, Vaidyanathan, Harris and Nair 1982). Demographers who worked on human sex ratios by age groups have shown a North-South divide in the preference for the male child, as reflected in the sex ratio of child mortality and the index of son preference (The index of son-preference is defined as $100 \times E/c$, were ‘$E$’ is the excess number of sons over daughters considered ideal and ‘$c$’ is the ideal family size. The index varies from -100 to 100). It is revealed from the analysis of Population Censuses and other sources of data on child mortality by sex, that the sex ratio (defined as male/female) of children below one year tends to be significantly higher in the North Indian states of Punjab, Haryana, Uttar Pradesh, Rajasthan, and Madhya Pradesh than in the South Indian States of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. (see for details Basu 1995). The index of son preference reveals that it is significantly higher in the North than in the South. A variety of explanations are offered for such variations in the preference for the male over the female, in terms of economic and cultural factors. According to Miller (1981) it is the higher demand for female labour in South Indian agriculture than in the North and the higher widespread practice of dowry in the North than in the South, that have contributed to the observed variations in son-preference. Recent research shows variations in the preference for male children over female children across districts in Tamil Nadu. The ‘unwanted’ female children are gotten rid of by deliberate starvation and infanticide (Rajan et al. 1991, Chunkath et al.1997, Sudha and Rajan 1999).

Somewhat in parallel to the above discussion, research by economists and social anthropologists has pointed out the prevalence of significant variations in the cattle and the buffalo sex ratios across states in India. It was Harris (1966) who showed first that the sex ratio of adult cattle was higher in the South, followed by the East and that the lowest was in the North Indian states. He attributed such variations to the relatively higher demand for draught animals in the rice-growing regions of the South and the East than in the North. He also noted the significantly higher preference for she-buffaloes over he-buffaloes in the North than in the East and the South and
attributed it to variations in requirement of milk in the human diet: people in the North who are exposed to cold climate require a higher source of fat and protein from milk than those living in the other regions. Harris’s cultural materialistic explanations were subjected to scrutiny by a number of researchers in India and abroad (see Dandeker 1967, 1969, Shah 1967, Heston 1971). In the midst of such debates, there took place attempts to quantify the existence of 'surplus cows'. The advocates of the 'surplus cows' hypothesis argued that given the reproductive efficiency of cows, it would be possible to meet the requirement of male cattle for traction in agriculture, by maintaining a smaller stock of cows that are better fed than the existing stock, that the existence of surplus is due to the Hindu religion's sentiments against consumption of beef and slaughter of cattle (see Dandekar: 1969 & 1970, Mishra 1978) and that a deliberate policy of cattle slaughter would increase the economic welfare of the people.

Raj (1969) took the discussion on surplus cattle into new heights through his highly influential paper on the “Investment in Livestock in Agrarian Economy”. With the help of an analytical model that captured the growth in demand for milk, draught power and other goods and services obtained from cattle on the one hand, and the factors operating from the supply side like the size distribution of land, ecological factors like irrigation, the use of land for crops and for the cultivation of fodder, on the other, he predicted that the size and composition of cattle maintained in the country is the stock that is needed to meet the demand. To illustrate his arguments, he also compared the Indian situation with that of the United States and found that his model correctly predicted the stock size that prevailed in that country. In the empirical part of his paper he looked at the systematic variations in the sex and species composition of bovine stock and accounted for the variations in terms of demographic, economic, ecological, technological and institutional factors. The line of analysis advocated by Raj was extended by Vaidyanathan (1978, 1988) through systematic empirical research. Since in-depth reviews of earlier studies are already available (Nair 1981a, Dhas 1986, Vaidyanathan 1989 and George 1996) we refrain from undertaking a repeated exercise on this aspect.

However, in order to sharpen the focus of the present exercise, we will attempt a limited survey of studies on India's bovine economy. The review is organized in the following sequence. In the light of the arguments that the primary function of cows is to produce male calves to be raised as draught animals and that the requirement of draught power in agriculture has been undergoing significant changes overtime, we shall first present a review of studies on the work-animal stock.
This is followed by a review of studies on the milch animal stock, including trends in milk production, its sources of growth, changes in consumption and demand for milk. At the end of the review, we will present our main findings with a view to highlighting the focus of the present study.

### 2.2 Work Animal Population

The Royal Commission on Agriculture (1928) had observed that the number of bullocks per unit of cultivated area in a region is related to the number of cultivators, the average size of landholdings, the soil character, availability of irrigation, cropping pattern, time available for ploughing before sowing and the species composition of the work-animal population. Fahimuddin (1963) who examined the question with reference to Bihar found that work-animal density was intimately related to cropping pattern, size of holdings and quality of the soil.

Sharma (1981) in his analysis of the inter-district variations in the density of draught animals in Haryana explained the observed variations in terms of area cultivated, farm size and the degree of agricultural mechanisation, especially tractorisation. His analysis revealed that tractorisation has only a weak effect on the draught-animal stock.

Vaidyanathan (1978) and Vaidyanathan, Nair and Harris (1982) examined the changes in work-animal density across states in India by formulating the following hypothesis that explained not only the density of work animals, but also the way the sex ratio of bovines is decided.

"As human population density rises, land is cultivated more intensively, and, since private property prevails, there is a progressive decline in the average size of holdings. Because of the seasonality of rainfall, plow animals function as a "energy gate". Hence, the decline in size of holding does not lead to a proportional decline in the number of plow animals per holding. Land has to be prepared for sowing in a short time during which it is too risky to depend on hiring someone else's animals. It is only by owning his own plow animals that the farmer can ensure timeliness of initial operations. As a result, the total number of plow animals may rise faster than the requirements of draft power. This leads to a lower rate of utilization and/or selection for smaller breeds. Beyond a certain point, however, increases in the cost of maintaining animals relative to the needs of human subsistence force farmers to give up the ownership of draft animals. The extent to which this occurs depends on the effectiveness of exchange and/or lease arrangements and the feasibility of substituting human for animal labour in cultivation" (Vaidyanathan 1982, p.366).
The above hypothesis has two sets of relationships which may be written as follows: (i) with rise in human density, work animal density would tend to increase more rapidly than draught requirements up to a point, beyond which it would decline, and (ii) with increase in human density the proportion of adults in the bovine population would tend to increase up to a point, beyond which it would diminish. The above hypothesis did not take into account the influence of other factors, especially the role of technological, economic and ecological factors in shaping the variations in density and sex ratios. Vaidyanathan (1989) further tested this inference by means of a regression model with work-animal densities as the dependent variable and rainfall, percentage of area under irrigation, average size of landholding and the average horse power from mechanical power on the other as independent variables. His model found all the variables to have significant influence on the density of work-animals. He further extended his analysis by bringing in factors like feed supply and those influencing the demand for milk to test the relationship between work-animal density and bovine sex ratios. His analysis revealed that demand for milk and the availability of feed supply exert a negative effect on the sex ratio of bovines.

There were also attempts to test this hypothesis by other researchers. Nair (1981a) analysed the density-dependent hypothesis using historical data (1920s to 1970s) for Kerala and all-India. He observed that while the country as a whole was still in the ascending phase of the relation between human density and bovine density, Kerala had already entered the declining phase. In Kerala, the density of adult male cattle had been declining and that of adult female cattle increasing. Among the young stock in the state, the density of the female stock was increasing. The decline in adult male density and increase in young female cattle density indicated that in the State, farmers had begun substituting milch animals for draught animals. Dolberg (1982) and Jabar and Green (1984) tested the density-dependent hypothesis with the data collected from Bangladesh and found that very small farms preferred to have small animals and that, while the size of the holding declined, the sex ratio changed in favour of milch animals. Dhas (1986) who examined the decline in the work-animal density in Tamil Nadu during 1951 to 1982, found patterns of change closely similar to those of Kerala.

Apart from population pressure on land and consequent reduction in the size of holding, mechanisation of agriculture has also been found to influence draught-animal holding. In the case of Punjab, Hanumantha Rao (1975) observed that mechanisation triggered by steeply rising wage
rate of field labourers and increasing bullock prices, had led to reduction of the use of animal power in agriculture. Grewal and Kahlon (1973) had observed that tractorization also led to a significant change in the sex composition of cattle: a drastic decline in total animal population associated with rise in the proportion of milch animals.

Introduction of mechanical power does not necessarily lead to decline in draught animal population if it is associated with intensification of cultivation. For example, Sharma (1981) found that in Haryana there existed a positive relation between growth in mechanical power and work-animal density. He attributed this to (i) the introduction of pumpsets which led to more intensive land preparation which in turn involved a net increase in the requirement of animal power and (ii) the confinement of tractorization to only portions of the farms. Jarvis (1982) argued that an increase in the demand for milk and beef was also a factor that is likely to reduce the supply of draught power services in India, particularly in the context of mechanisation of agriculture.

Odend'hal (1988a) observed that the demand for bullocks in the Daltaic West Bengal during the period between 1977 and 1987 declined consequent on the increasing use of hand-operated tractors for ploughing even though the male cattle population had increased significantly in the upland regions of the state (Odend'hal: 1988b).

Nair and Dhas (1989, 1990) analysed, using data from the National Sample Survey (26th and 37th rounds), the factors shaping the density of draught animals per cultivated holding and their utilisation pattern across size groups of land holdings. Their study showed that in most parts of India, agricultural mechanisation had not resulted in any reduction in draught animal stock. Dhas (1989) observed that the draught animal population in Tamil Nadu had been declining from the mid-sixties and that the rate of decline had become higher from the mid-'seventies. These changes were analysed in relation to factors such as availability of mechanical power, size of land holdings, cropping pattern, feed supply and increasing requirements of milch animals. The study revealed that while the intensity of agricultural mechanisation had not contributed to a decline in the draught animal population, all the other factors had.

Sharma (1989) observed reduction in the draught animals in a village in west Uttar Pradesh during the period 1964 to 1984 and consequent very low rate of replacement of animals by tractors. But he argued that the introduction of tractors had resulted in a considerable shift in the
ownership of draught power among different size groups of farms, which enabled farmers either to discard, or to maintain fewer, animals. Mishra and Sharma (1990) examined the changes in size, composition and regional variations in the draught animal population in India during 1951 to 1982. The study revealed that there had taken place a virtual stagnation in the draught animal population between 1961 and 1977 and that it was followed by a marginal reduction during 1977-1982. The steep reduction in draught animal population in Kerala and Tamil Nadu is attributed also to decline in the area under rice cultivation and large shifts of area to tree crops, particularly plantation crops. The shift was marginal till the end of the 1970s. Prabaharan (1991) examined the size, composition and utilisation of draught animals in Tamil Nadu across agro-climatic zones, based on a survey conducted during 1989-90. He observed the practice of hiring out draught animals for crop production activities as a method of their intensive utilisation.

Saxena (1995) observed that though a gradual decline in the draught animal population in Gujarat had begun as early as in 1966, inter-regional and inter-district disparities in the density of draught animals were pronounced, due primarily to differences in the level of tractorisation, size of operational holdings and availability of irrigation facilities. It was found that the rental markets for both animal and tractor power were becoming increasingly popular. Shah (1997) found that the structure of draught power in Maharashtra was undergoing a significant change during the period between 1956 and 1987. Mechanisation of irrigation and tractorisation was taking place at a much higher rate than increase in draught animal population. Similar trends were observed in Karnataka also (Brithal and Ravishankar, 1999).

The foregoing survey has brought out the factors that influenced the density of draught animals across regions in the country. It indicates the influence of agro-climatic factors, crop pattern, size of holding and degrees of mechanisation in determining work-animal density. It also establishes the linkage between the requirement of draught power in agriculture and the holding of milch animals. The review presented in the section that follows will further highlight these linkages.

2.3 Milch Animal Population

Traditionally, adult female cattle were maintained for the purpose of producing male calves to be raised as bullocks, the production of milk being considered a by-product. However, with the decline in the requirement of draught power in agriculture and the growth in the demand for milk, the stock of cows as milch animals has been increasing over time. Also, she-buffaloes, which are
rated superior to cows for milk production, have gained more importance over time. There exist a large number of studies that attempted to examine the changing role of milch animals across regions and size of landholdings in the country. These studies have highlighted two important aspects of the bovine stock: (a) the size of the cow population in the economy is largely a function of the bullock population required; and (b) reduction of the required bullock population is difficult without significant changes in the techno-economic and institutional set up in agriculture. Such studies highlight a growing trend in milch animal population and a shift in the bovine sex ratio in favour of milch animals.

Sharma et al. (1987) estimated that the annual growth rates of breedable cattle and buffalo population in India were 1.01 and 1.49 per cent respectively during 1945-1972. The growth rates in milch animal population were found to have been different across states. Birthal and Ravishankar (1999) observed a declining growth rate of milch stock in Karnataka since 1976. (also see Singh and Sharma 1979, Sharma et.al. 1987, Arya and Rawat 1989, Singh et al. 1990, Dhas 2001, Sharma, R.K 2001). Species composition and breed composition of milch animal stock have also been topics of research since the early 1960s. Significant variations in the relative importance of she-buffaloes and cows for milk production are observed across regions in the country. The relative importance of she-buffaloes tends to increase in regions in which demand for milk is high and the supply of feed abundant. The productivity of she-buffalo is higher than that of cow. (Telang and Chavan 1965, Ram and Singh 1974, Reddy et al. 1980, Raut and Amble 1969, Acharya et al. 1973; Srivastava and Singh 1975, Sardiwal and Kalla 1975, Sharma et al. 1975, Lavania et al.1975, Phukan and Gohain 1975, Pichholiya 1975, Sivakumar 1978 a, Patel et al. 1982, Tripathi et al. 1986, Ramesh Chand 1995 Shiyani 1996 and Saxena 2000).

Studies have shown that the cost of production of buffalo milk is lower than that of cow milk. (Reddy et al. 1980, Raut and Amble 1969, Acharya et al. 1973, Srivastava and Singh 1975, Gangwar and Bhatia 1980, Acharya and Pawar 1980, Kalyankar 1980, Sharma and Singh 1994c Saxena 2000 and Pandey et al.2002). The lactation period of she-buffalo is longer too than that of cows (Telang and Chavan 1965, and GOI 1984). An important advantage of she-buffalo over cow is the efficiency of buffaloes to convert feed into milk with higher fat content. The estimated fat content of buffalo milk is about 7.5 per cent and that of cow milk is roughly about 3.7 per cent (Aggarwala and Sharma 1961, Vaidyanathan 1982, Singh and Rai 1998). She-buffaloes have certain disadvantages over she-cattle. Their maintenance cost is higher (Srivatsava and Singh

The relative advantage of she-buffalo over she-cattle has been undergoing some changes due to the upgradation of cattle breeds through cross-breeding. Cross-breeding of cattle and upgrading of buffaloes are the main thrusts of the breeding technology used for increasing milk production in India. The underlying rationale for this strategy is the higher productivity and lower unit cost of milk production of crosbred animals (Acharya et al. 1973, Reddy and Mathur 1980, Yedev and Singh 1982, Ganpule and Desai 1983, Kalamani 1984, Patel et al. 1984, Pandey and Mishra 1985, Saxena 2000). Several scholars who have advocated a selective approach in this matter have called the claim of the superiority of crossbreds over the indigenous breeds of cattle into question. According to Surender Singh (1979), the increase in the number of cross-bred cows will result in increase in the severity of the shortage of feeds and fodder in India. Vaidyanathan (1989) argued that the diffusion of cross-bred cows is greater in areas where the bullock population has stabilised or is declining and where buffaloes do not have a clear advantage over cows in terms of milk-yields and feed productivity. He attributed the success of the cross-breeding programme in Kerala to the decline in bullock population and the dominant role of cows as the source of milk.

In general, the studies on the breed composition of milch animals indicate that there has taken place a change in the composition in favour of cross-bred and upgraded milch animals, though their intensity varies across regions. Nair (1982) highlighted the steady increase in the cross-bred population in the 'seventies and the early 'eighties in Kerala. According to him, it is the sharp decline in the requirement of draught animals in agriculture and increase in the demand for milk
that contributed to the rapid diffusion of cross-breeding in Kerala. Studies conducted in other regions of the country indicate that the requirement of draught animals in agriculture as an important factor contributing to the diffusion of cross-breeding technology.

Studies on the distribution of milch animal population across size groups of landholding have provided certain interesting insights. Ram and Singh (1974) noted that the larger holdings had maintained larger number of milch animals and vice versa, but that the proportion of cows tended to increase with increase in the size of holding only up to a point. Beyond the 5-10 acres size group it was the proportion of buffaloes that increased with increase in the holding size. Sivakumar (1978a, 1978b) who examined the distribution of cows and buffaloes across big, medium, small and landless households in two villages of Tamil Nadu found a positive relation with size of landholding. According to Desai and Verma (1978) the pattern in certain parts of Gujarat was different; it was the beneficiary marginal farmers and agricultural labourers who possessed more milch animals than the non-beneficiary farmers. In Karnal, close correspondence was observed between the number of milch animals and the size of holding. Singh and Singh (1981) and, Birthal and Ravishankar (1999) reached similar findings from their study in Karnataka. The same researchers had found that the distribution of milch animals was less skewed than that of landholdings. Several studies have found that only the relatively well-off sections of farmers maintain she-buffaloes, since buffaloes were costlier and their inter-calving period was longer than those of cows. (Singh 1975, Reddy et al. 1980, Chopra and Katyal 1980, Acharya and Pawar 1980). Evidence from Farm Management Studies and National Sample Surveys on Landholdings, have corroborated with this conclusion that the distribution of she-buffaloes was more skewed than that of cows. (Reddy et al., 1980, Gangwar and Bhatia 1980, Chopra and Katyal 1980, Srivastava and Singh 1975, and, Birthal and Ravishankar 1999)

A number of micro level studies conducted by individual researchers in different parts of the country have also provided data on the ownership of milch animals by households belonging to different landholding and social groups. Some of these studies have also looked into the specific role played by different poverty alleviation programmes in creating ownership of milch animals among poor households and the factors influencing the sustainability of this asset.
Prasad (1978) analysed the dairy scheme introduced in the tribal areas of Seethampeta and Salur blocks of Andhra Pradesh by the Girijan Development Agency. He observed that the animals distributed were of low quality and therefore their yield was lower than that had been estimated in the project. The tribals reported non-availability of concentrates in nearby local markets and lack of resources for purchasing them as reasons for poor feeding of concentrates to milch animals. The beneficiaries sold only 50 per cent of the milk production to the Dairy Development Corporation, the rest being sold in the local market for meeting daily expenses. Desai and Verma (1978) who carried out a study in Baroda and Padna taluks of Gujarat found that beneficiary marginal farmers and agricultural labourers possessed more milch animals than non-beneficiaries, and that about one-fourth of the former groups had disposed of the milch animals for the purchase of which they had received loan assistance. Apte (1982) who evaluated the Integrated Dairy Development project at Warmanagar in Kolhapur District, Maharashtra state also found the same predicament for small farmers and agricultural labourers, due, reportedly, to the poor quality of milch animals. Also, since animals purchased under this scheme were from within the region itself the scheme did not add to its net cattle population. Nor was the scheme administrated in accordance with the stipulated guidelines. The National Bank for Agriculture and Rural Development (NABARD, 1987) evaluated the dairy development scheme in Quilon district of Kerala, implemented by the Kerala Co-operative Central Mortgage Bank. Financial assistance had been given to farmers for purchase of cross-bred cows and for construction of cattle sheds. Non-availability of green fodder in adequate quantity and the consequent heavy dependence on concentrate feeds raised costs of maintenance of the cows. Except for a few high-yielding animals, dairying became a losing proposition. This scheme also therefore failed to improve the economic conditions of the beneficiaries. Seabright (1989) examined the livestock investments made under IRDP in Tamil Nadu based on the evidence from two villages from Trichirapally district during 1985. He observed that the benefits to households, which invested in livestock through IRDP, were significantly lower than those to households, which purchased livestock on their own. Between a-third and more than half of IRDP beneficiaries had become in fact, worse off as a result of their availing of IRDP loans. It was also observed that the IRDP participants paid higher prices for their livestock and spent more on purchased feed and labour. Seabright (1991,1992) based on the same source of data, argued that investment in livestock under IRDP had been extremely unprofitable for many a participant household.
Singh and Das (1984) who evaluated the milch animal scheme of IRDP in Subarkantha district, Gujarat found that the average number of animals per household, the average milk production per animal per lactation, the average use of concentrate feed and veterinary medicine, the average quantities of milk sold and milk retained for consumption, the average price realised and the gross revenue from sale of milk, were all higher for the beneficiary households. The study highlighted the role played by the village milk producers' co-operative societies to realise such an impact from the scheme. Though the cost per litre of milk was higher for the beneficiaries than for the non-beneficiaries, a situation which they attribute to the better feeding of the animals by the beneficiaries, the cost difference was offset by the higher milk production per milch animal kept by the beneficiaries. The study also revealed that differences in natural and human resource endowments and basic infrastructural facilities across regions had a significant bearing on the performance of the programme.

Bowonder et al. (1987) attempted to examine the impact of the dairy development programme of the IRDP in three major States, viz. Karnataka, Andhra Pradesh and Maharashtra. The programme was found to have resulted in higher levels of income and consumption of milk and milk products as well as in higher food consumption among beneficiary households. It had resulted in higher milk yield, higher quantities of milk to be retained for own consumption and higher levels of income through sale of milk per household in all the four land-holding classes. The study also highlighted, however, the fodder shortage problem. Cattle distribution was not linked up with the fodder generation programme and the problem of fodder shortage was severe among landless labourers and marginal farmers in several dairy villages. Sharma and Singh (1994a) observed the existence of cross-bred cows and graded buffaloes, of higher number of dairy animals per household and higher milk production, and of higher consumption and marketed surplus in areas in which the cattle development projects were implemented, than in non-project areas.

In sum, the studies surveyed in this section indicate the influence of the draught power requirement in agriculture on the size of milch animal holdings, the superiority of she-buffaloes over she-cattle as milch animals, the influence of draught power in the diffusion of cross-breeding technology and the distributional bias of milch animals towards larger holdings. The review also reveals that the distribution of milch animals under anti-poverty programmes did not contribute to increase in the ownership of milch animals by poor households. We examine in the next section the trends and the determinants of milk production.
2.4 Milk Production and Consumption

Bhote and Jayaraman (1967) who studied the trends in milk production during 1951-61 based on data from Central Statistical Organisation for 18 states observed that milk production of both cow and buffalo had steadily increased. Singh and Sharma (1979) who analysed data published by F.A.O in its Production Year books, found that during 1965 to 1973 the milk production in India had increased at a much higher rate than in the world as a whole and that buffalo milk production had increased at a higher rate than cow milk production. Nair (1985) observed that the estimated milk production, which had been about 20 million tonnes during the 'sixties, had increased to 23 million tonnes by 1974 and further to 33 million tonnes by 1982. He also found that the proportion of buffalo milk to total milk production had been increasing; while the growth in milk production during the 'sixties was due mostly to increase in the population of milch animals, during the 'seventies, it was due largely to increase in the productivity of the stock. Increase in productivity was facilitated by the increase in the supply of feed made possible by the higher rates of agricultural growth from the mid-'sixties onwards. George (1985) attempted to decompose the aggregate state level milk production estimates into contributions by cows and buffaloes separately. His analysis of the sources of growth (George 1988) in milk production between 1961-72 and 1972-82 showed that growth in the production of cow milk was accomplished by improvements in breeding efficiency and average yield of animals in-milk, whereas the growth in buffalo milk production was due to a large extent, to increase in the milch animal population and only partly to improvements in breeding efficiency and productivity per milch animal. Based on official milk production figures, the growth pattern and compositional change in milk production between 1964 and 1983 were analysed by Singh, et al. (1986). They observed that she-buffaloes contributed a major share of milk production: that milk production was growing at a more rapid rate in the later decades, and that significant disparities existed in the production of milk across states.

The factors of growth of milk production varied from state to state. Mergos and Slade (1987), in their study with reference to Madhya Pradesh, observed that the increase in milk production was caused by improvements in yield without any substantial adoption of the cross-bred technology. The increase in yield was due to higher input use and greater technical efficiency. In Karnataka the growth was found to be due to changes in the composition of local and crossbred cows rather than yield developments (Alderman 1989). Birthal and Ravishankar (1999) observed that milk
production in Karnataka more than doubled during a period of less than two decades from the mid-1970s and that the proportion of cow milk in total production remained unchanged at about 55 per cent; but the share of cross-bred cattle milk to the total cattle milk was increasing during the period. In Himachal Pradesh, the increase during 1951 to 1986 was accounted for more by increase in buffalo milk than by increase in cow milk (Sharma and Varsisht 1992). In Bihar, rapid increase was noted till the early years of the 1990s; since then the state has been experiencing relative stagnation.

The relationship between increase in feed availability and growth in milk production is best understood from a review of studies on feed availability and requirement as well as of response of milk yield to feed input. Estimates of feeds and fodder show that a wide gap existed between availability and requirement. The Nutrition sub-Committee of ICMR and ICAR (1964) estimated that the total supply of animal feeds was deficient by 30 per cent in respect of TDN and 70 per cent in respect of DCP. Based on the 1961 Livestock Census and crop-cutting experiments, Whyte and Mathur (1968) estimated a shortfall in the supply of green fodder, dry fodder and concentrates to the tune of 470.4 million tonnes, 727.9 million tonnes and 85.6 million tonnes respectively. Amble et al. (1965) estimated the deficiency of DCP at 30 per cent for animals in milk, 50 per cent for dry animals, 60 per cent for adult males and between 80 to 90 per cent for the young stock. The Committee on Livestock Feeds and Fodder estimated the quantity of straw and Kadbi estimated it in 1973 at 207 million tonnes (GOI 1974). According to the National Commission on Agriculture (1976), the total availability of green fodder, dry fodder and concentrates in India during 1976 was 219.55 million tonnes, 309.00 million tonnes and 11.50 million tonnes respectively. Studies carried out at the regional level also highlight the gap between the requirement and the availability of feed. Rajpurohit (1975) observed that during 1971-72, the availability- requirement ratios of both dry and green fodder in Karnataka were lower than one for all the districts. Nirman et al. (1982) estimated that the total production of dry fodder contributed by rice, wheat, jowar and bajra was 235 million tonnes in India for the year 1977-78; the production of fodder crops in Meerut and Karnal for the years 1972-73 to 1975-75, was estimated at about 1.8 million tonnes in Meerut and 2.1 million tonnes in Karnal (Prakash and Bokil 1983).

Some attempts have gone also into the relationship between feed input and milk yield. Mellor and Pontives (1964) in their study on demand for milk and concentrate feeds in India showed that as
the input of concentrate feed per animal increased, its milk yield also showed an increasing trend thereby indicating the positive response of milk yield to feed input. Vaidyanathan (1989) analysed the trends in feed supply in terms of nutrients (viz., TDN and DCP,) for the Livestock Census Years 1951-1972, but he was not able to relate feed supply to productivity due to paucity of comparable data on milk yield. However, his analysis of cross-sectional data on feed input and milk yield of cows and she-buffaloes, (based on the data available from the IARS milk production surveys) indicated that as one moves from regions with low availability of feed per animal to regions with higher availability, the milk yield of animals also showed a rising trend. States with higher availability of feed per animal also seem to have had a larger proportion of animals in milk thereby indicating the positive effect of feed supply on the productivity of milch animals. It may be noted that the role of feed in milk production is very much determined by the relative price of feed and milk, the price of the latter being influenced by the level of its demand.

The demand for milk is expected to be influenced by size and composition of human population, per capita income, consumption pattern, price of milk, the relative prices of its close substitutes and the availability of supplies. The size of the population, which represents the size of the consumers’ market in total, is expected to have a positive association with the demand for milk. The pattern and levels of milk consumption also vary across age, sex, religion, region and socio-economic and employment groups. When income increases, people consume more nutritious food (Gopalappa: 1996). The relationship between income and demand for milk is usually expressed through the concept of income elasticity of demand for milk. As it is easier to obtain more reliable data on expenditure than on income, expenditure elasticities are used as proxy for income elasticities. Several studies show that the value of the elasticity is greater than one and that its value is higher in rural areas than in urban areas. Using the data available from the National Sample Survey organisation, Bose 1960, Ganguly 1960, Roy and Laha 1960, Iyenger and Jain 1969, and Sinha and Giri 1989 estimated the expenditure and income elasticities of broad categories of food items, including milk and milk products. Jonas (1971) analysed the inter-temporal and inter-city variations in expenditure on milk and milk products and observed that the lowest level of expenditure elasticity was 1.08 and that the per capita expenditure on milk and milk products was the highest in Delhi. The National Council of Applied Economic Research (1972) observed that the expenditure on milk and milk products among middle class families was more sensitive to income changes as revealed by the high income elasticity coefficient.
Several other studies on expenditure elasticity of demand for milk and milk products conducted in different regions of India have shown significant variations among income and expenditure classes and locations (Singh 1981, Sharma and Ram 1991, Gandhi and Mani 1995, Birthal 1996, NCAER 1967, NCAER 1972, Patel et al. 1974, Kesavan 1982, Singh and Singh 1986, Parisot, 1990, Sardana et al. 1995). The sex-disparity in consumption of milk was studied by Jatrana and Sangwan (1996). They found higher levels of consumption among boys in all income groups than among girls. In general, children particularly below five years of age consumed more milk than others.

The per capita expenditure on milk and milk products was higher in farming, business and service categories than in the labouring groups. Various other state-level studies have also reinforced these general findings (Ram and Singh 1974, Prabhakaran and Sivaselvam 1986, Sharma and Kuber Ram 1991, Kumar et al. 1995, Singh et al. 1996 and Keshari and Malik 1998). Longitudinal and cross section studies across regions and districts have also drawn similar conclusions (Jain and Kalla 1981, Jain and Patell 1987). Rural-urban differences in expenditure on milk and milk products were also observed to be high; in rural areas, the expenditure was in some cases almost double of that in urban areas (Lata and Ram 1986). Occupational status was found to be a major factor too.

The demand for milk is also influenced by the cost and availability of substitutes for milk. Raj (1969) identified edible oils and meat, fish and egg as close substitutes for milk fat and milk protein respectively. Vegetable oil is considered a close substitute for milk fat because it can be used for almost all the purposes for which butter is used. Meat, fish and egg are also considered close substitutes for milk protein (Vaidyanathan 1983 and Nair 1987). Using inter-state cross-section data for 1961-62, Nair and Vaidyanathan (1979) attempted to examine the extent to which these commodities are close substitutes for milk fat and milk protein. Their analysis did not conclusively show that these commodities are close substitutes for milk. Apart from the limitations of the data, Vaidyanathan (1982) underscored certain factors that limit the substitutability of these items for milk.

"........by estimating the separate relations for milk protein and milk fat, we are in effect ignoring the important fact that proteins and fat are joint products of milk and that their relative proportions in milk were highly variable across states. Moreover, the model ignores the effect of supply factors on consumption and relative prices, and views observed variations in intake wholly as adjustments of demand to given relative prices assumed,
implicitly, to be governed by long-term supply conditions" (p.110). Vegetarians do not consume meat, fish or eggs under any circumstances. It could also be that the substitution is limited to a certain part of the consumption, only milk fat taken in the form of ghee might be substituting for edible oil....” (Pp.109 and 110).

The consumption of milk is also determined by its availability. During the past three decades the centre and the state governments have made large scale attempts to link the rural milkshed areas with the urban milk markets through investment in milk procurement, processing and marketing as part of their dairy development strategies. The efforts under the Operation Flood to expand co-operative dairying in the country have played a vital role in this process. There exists a vast literature that examines the impact of this intervention on the production and consumption of milk (see for instance, Research Team 1982, Singh and Katar 1984, Alderman 1987, Mascarenhas 1988, Doornbos and Nair 1990, Doornbos et al. 1990, Franco and Chand 1991, George 1985 and 1994). In general, these studies argue that (1) the commercialization of milk production through co-operatives has led to decline in milk consumption in rural areas; (2) since the price of milk in rural areas has gone up, milk consumption of rural producing households has declined, and (3) as the milk price has not increased in proportion to the prices of other commodities and feed inputs the price advantage has gone mainly to the urban population.

2.5 Conclusion

In the preceding sections, we have made an attempt to review the theoretical and empirical findings regarding the factors and the processes shaping bovine sex ratios in India. The principal insights emerging from this review are summarized as follows:

1. Apart from agro-climatic conditions, the density of work animals is determined by cropping pattern, size distribution of land holding and degree of technological change (agro-technology) in agriculture. The higher the density of work animals the higher will be the bovine sex ratio.

2. The bovine sex ratio would shift in favour of females with decline in the requirement of draught power in agriculture.

3. The shift in sex ratio in favour of females will be determined also by the demand for milk. The reduction in draught animal stock and the consequent release of feed thus raising the number of milch animals would result in shifts in size and composition of bovines in favour of females.
4. The species composition of milch animals is determined by the demand for milk and availability of feed supply. When demand for milk tends to increase and feed supply becomes larger, the species composition of milch animals would become weighted increasingly in favour of she-buffaloes because of their comparatives advantage over milch cows.

5. The diffusion and adoption of cross-breeding technology will be faster with reduction in draught power requirements in agriculture.

6. The number of milch animals per holding tends to increase with increase in the size of land holdings. This relationship might not have undergone change due to the distribution of milch animals under various anti-poverty programmes.

7. The growth in milk production in recent years has been largely due to increase in the productivity of milch animals. The increase in the milk yield for reasons other than breed improvement appears to be due to increase in feed input per animal.

8. Milk has become an essential item of consumption and not at all a luxury as is reflected in the decline in expenditure elasticities. The level of milk consumption is determined, apart from income and other household characteristics, by cost and availability of substitutes for milk fat and milk protein.

9. The expansion of the commercialization of milk production appears to be resulting in increase in the disparity of milk consumption between rural and urban areas.

These propositions arising out of our survey of research will be explored in detail in the chapters that follow. As a prelude, we analyse in the ensuing chapter the inter-relationship between agricultural change and bovine holdings in Tamil Nadu for a major part of the 20th century.