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ASPECTS OF INDIA'S BOVINE ECONOMY: SOME PRELIMINARY RESULTS

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Past studies on India's livestock economy[1] have more or less exclusively centred on whether or not there is surplus cattle in India. Those who assert that the existing stock is far in excess of what is needed, with prevalent technology, to meet current demand for livestock products and services, base their conclusion on essentially the following arguments: (*a*) The current replacement and growth requirements of adult stock can be met with substantially fewer adult females than the number presently maintained in the country by reducing the mortality rates among young stock. (*b*) At the same time, a reduction in animal population will increase the feed availability per animal and that better feeding alone, without any other change in technology of the livestock industry, can increase the productivity of milk, work and also calving rates *at least in proportion*. While the first argument is indisputable, the empirical evidence for the second is not clearly established. More importantly, one has to recognize that, as in the case of human labour, the removal of redundant animals and the effective utilization of the reduced stock for meeting the existing demand for work, milk and calves, would require major changes in organizational arrangements in the agricultural sector.

Preoccupation with the question of 'surplus cattle', important as it is, has unfortunately deflected attention from a study of the reasons why the size and composition of livestock in India are what they are. It has been of course, recognized that the present pattern of livestock holding and management may be the result of rational decisions in response to economic forces operating within the constraints of the existing socio-economic institutions, rather than of irrational religious prejudice. Marvin Harris(7)† has made a forceful statement of this viewpoint. Raj(13) has pointed to the existence of wide variations in the composition of cattle herds between regions which are apparently unrelated to the religious composition of their respective human populations. Mishra (10) has suggested that the secular trends towards a deceleration in the growth of cattle population, and towards increasing specialisation in the use of cattle for work and buffaloes for milk, reflect adaptations in response to economic forces. However, these observations have not been followed by a systematic study of the variations in the composition of bovine herds or their productivity across regions, and over time, much less to explore the factors which might explain these phenomena. This paper is a preliminary attempt in that direction.

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1. A select bibliography of earlier work is given in the Annex.

† Figures in parentheses denote references cited in the Annex.

We begin with a review of some salient facts regarding the size and composition of bovine population as well as its behaviour over time. This is followed by a discussion, mostly of an exploratory nature, of the reasons for observed variations, over space and time, of selected dimensions of the bovine population. In particular, we shall discuss mortality patterns, the use of bovines as draught animals, relative roles of the cattle and the buffalo, and the pattern of variation in the composition of the bovine herd across States and land holding classes.

I

BOVINE POPULATION

Size and Composition

The overall picture: India's bovine population in 1972, the year of the latest Livestock Census for which data are available, was a little over 235 million. There are thus some 40 bovines for every 100 human beings and about 150 bovines for every 100 hectares of cultivated area. By either index, the density of bovine population in India is among the highest in the world. About 29 per cent of the total consists of young stock, *i.e.*, animals aged 3 years and less. Among the adult animals, the females slightly outnumber the males. More than three-fourths of the bovine population are cattle; buffaloes constitute a little under a fourth. There are significant differences in the age-sex composition of these two categories of bovines (Table I).

TABLE I—COMPOSITION OF BOVINE POPULATION: INDIA, 1972

(*million*)

	Cattle		Buffaloes		Total	
	Number	Per cent	Number	Per cent	Number	Per cent
Adult males	74.5	41.8	8.1	14.1	82.6	35.0
Adult females	56.4	31.6	29.2	50.9	85.6	36.3
Young stock	47.5	26.6	20.1	35.0	67.6	28.7
Total	178.4	100.0	57.4	100.0	235.8	100.0

Source: Government of India: Eleventh Livestock Census, 1972 based on final figures of 18 January, 1976, Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, (mimeo.).

In the first place, while there are 140 males for every 100 females among adult cattle, there is an overwhelming predominance of females among adult buffaloes, with less than 30 males per 100 females. Second, cattle account for about 90 per cent of all adult male bovines while their share in adult females is only 66 per cent. These point to (*a*) the dominance of cattle as a source of draught power; and (*b*) the relatively high degree of dependence

TABLE II—HUMAN (RURAL) AND BOVINE POPULATION RELATIVE TO CROPPED AREA: STATES, 1972

States	Rural population 10^6	Bovine population 10^6				Cropped area 10^6 hectare	Density per hectare of cropped area				
		Adult males	Adult females	Young stock	Total		Rural population	Bovine population			
								Adult males	Adult females	Young stock	Total
Andhra Pradesh	34.99	6.83	7.73	5.00	19.56	12.24	2.859	.558	.632	.408	1.598
Assam	13.70	2.46	1.97	1.86	6.29	3.04	4.51	.809	.648	.612	2.069
Bihar	50.67	8.01	6.09	4.49	18.59	11.00	4.61	.728	.554	.408	1.690
Gujarat	19.18	3.09	3.86	2.96	9.92	9.91	1.935	.312	.390	.299	1.001
Karnataka	22.15	4.10	5.54	3.59	13.23	9.93	2.231	.413	.558	.361	1.332
Kerala	17.82	0.62	1.46	1.25	3.33	3.01	5.92	.206	.485	.415	1.106
Madhya Pradesh	34.88	10.75	10.17	10.84	32.26	20.55	1.70	.523	.569	.527	1.570
Maharashtra	34.63	6.51	6.46	5.04	18.01	17.29	2.00	.377	.374	.292	1.042
Orissa	20.13	5.29	4.48	3.12	12.81	7.94	2.54	.666	.564	.393	1.623
Punjab/Haryana	18.46	2.69	4.88	4.58	12.15	10.68(H)	1.73	.252	.457	.429	1.138
Rajasthan	21.19	4.09	7.10	5.87	17.06	17.28	1.23	.237	.411	.340	0.988
Tamil Nadu	28.65	5.04	5.14	3.24	13.42	7.55	3.79	.668	.681	.318	1.777
Uttar Pradesh	76.00	15.34	13.34	10.16	38.84	23.02	3.29	.665	.578	.440	1.684
West Bengal	33.51	5.26	4.01	3.43	12.70	7.08	4.73	.743	.566	.488	1.798

Source: Rural population: Census 1971. Bovine population: Livestock Census 1972. Cropped area: Three-year average for 1970-71, 1971-72, and 1972-73.

on buffaloes as a source of milk. They also suggest that, unlike in the case of cattle, farmers maintain buffaloes primarily for milk production. Third, the proportion of young stock is considerably higher among buffaloes than among cattle.

Inter-State Variations

As may be expected, the density of bovine population, as well as its composition, varies widely among the States. The extent of these variations can be seen from Table II.

The overall density of the bovine population relative to cropped area ranges from less than 100 per hundred hectares of gross area sown in Rajasthan to over 200 in Assam. In general, and relative to cropped area, States with a relatively high density of human population (rural) also tend to have a high density of bovine population. Significantly, however, the bovine density does not increase in the same proportion as human density. In fact, the rate of increase in the former tends to decline as the latter rises, and eventually levels off. The density of adult males and of adult females also shows a similar relation with human density. But there is hardly any correlation between human density and the number of young stock per hectare (Table III).

TABLE III—RELATION BETWEEN HUMAN AND BOVINE DENSITIES

Adult males/hectare	0.5619	+0.6796*X (0.1242)	−0.0897* X^2 (.0177)	0.7521 R^2
Adult females/hectare	0.0151	+0.2583*X (0.0756)	−0.0332* X^2 (0.0108)	0.5656 R^2
Young stock/hectare	0.3083	+0.0438*X (0.0989)	−0.0030 X^2 (0.0141)	0.1399 R^2
Total bovines/hectare	−0.2149	+0.0317*X (0.2358)	−0.1323* X^2 (0.0337)	0.6825 R^2

X=Rural population/hectare. * Significant at 5 per cent.

A comparison of the regression coefficients for adult males and adult females suggests that, as population density increases, the number of adult males per hectare tends to rise faster than that of adult females initially, and that, while both of them decelarate, the degree of deceleration is greater among females. In other words, as one moves from areas of low to high human densities, not only does the bovine density rise, but the proportion of adult males in the herd seems to rise and that of adult female to fall.

As regards the relative importance of cattle and buffaloes, cattle are seen to outnumber buffaloes in all States except Punjab and Haryana. The degree of their dominance in the bovine population, however, varies a great deal (Table IV). The ratio of cattle to buffaloes is well below the national average in Andhra Pradesh, Gujarat, Rajasthan and Tamil Nadu, while in Assam, West, Bengal and Orissa the ratio is much higher than the average.

TABLE IV—COMPOSITION OF BOVINE POPULATION: STATES, 1972

States	Cattle				Buffaloes				Ratio of cattle to buffaloes			Lactating efficiency	
	AM	AF	YS	Total	AM	AF	YS	Total	AM	AF	Total	Cattle	Buffaloes
Andhra Pradesh	43.9	33.8	22.3	100	19.0	49.6	31.4	100	4.09	1.21	1.77	42.4	59.8
Assam	45.0	31.1	23.9	100	49.1	39.9	11.0	100	11.25	11.06	14.17	60.4	53.1
Bihar	48.9	28.1	23.0	100	19.5	51.7	28.8	100	10.16	2.20	4.05	32.8	43.1
Gujarat	47.5	28.1	24.4	100	1.2	58.8	40.0	100	71.28	0.89	1.86	54.8	58.4
Haryana	38.7	29.6	21.7	100	2.4	50.9	46.7	100	15.29	0.57	0.97	58.4	66.9
Himachal Pradesh	41.5	31.0	27.5	100	2.6	66.6	30.8	100	64.43	1.66	4.00	47.0	15.1
Jammu & Kashmir	33.5	37.2	29.7	100	10.1	58.0	31.9	100	13.78	2.68	4.77	53.1	57.5
Karnataka	37.9	37.3	25.8	100	9.5	56.0	34.5	100	12.44	2.07	3.12	46.1	59.5
Kerala	13.7	45.5	40.8	100	47.9	33.1	19.0	100	1.73	8.33	6.05	51.1	60.5
Madhya Pradesh	36.3	30.7	33.0	100	19.8	45.1	35.1	100	8.37	3.19	4.57	39.3	47.4
Maharashtra	42.2	31.1	26.7	100	9.3	56.4	34.3	100	20.15	2.45	4.45	41.9	58.4
Orissa	40.7	35.2	24.3	100	45.0	31.5	23.5	100	7.40	9.16	8.22	39.9	47.0
Punjab	41.7	27.2	31.1	100	7.2	51.3	41.5	100	5.44	0.54	0.89	64.0	66.6
Rajasthan	31.6	37.0	31.4	100	3.2	54.3	42.5	100	26.81	1.85	2.72	48.6	54.2
Tamil Nadu	43.9	34.6	21.5	100	13.9	52.1	34.0	100	11.40	2.46	3.71	52.2	64.1
Uttar Pradesh	52.3	25.7	22.0	100	12.9	52.3	34.8	100	8.43	1.02	2.08	47.6	57.0
West Bengal	39.9	32.0	28.1	100	63.3	24.9	11.8	100	9.08	18.57	14.42	50.9	63.0

Source: Livestock Census, 1972.

AM = Adult males.
AF = Adult females.
YS = Young stock.

Lactating efficiency = Ratio of number of females in milk to total adult females.

The dominance of cattle is generally more marked among adult males than adult females. In general, the cattle-to-buffalo ratio among the former is higher and is indicative of the overwhelming role of cattle as a source of draught power in most parts of the country. Kerala, and, to a much smaller degree, Assam, Orissa and West Bengal, are exceptions to this general pattern. In Kerala, for instance, though the cattle population is about six times that of buffaloes, there are only 170 adult male cattle for 100 adult male buffaloes. This reflects an unusally higher mortality rate among adult male cattle, as well as the considerably more widespread use of buffaloes for draught purposes.

The proportion of adult females to adult males is much higher for buffaloes than for cattle in a large majority of the States. However, in Assam, Kerala, Orissa and West Bengal, the proportion of adult males among buffaloes is considerably greater than that of adult females. In these areas the use of buffaloes for draught purposes is at least as important as for milk. Ecological factors might be responsible for this. All these States happen to be areas of relatively high rainfall with rice as the dominant crop; and buffaloes are particularly well suited for ploughing and land preparation for paddy cultivation under these conditions. It is also possible that the buffaloes in these regions are of inferior breeds with relatively low milk yields, and consequently their attraction as milch animals is not as great as in other parts of the country.

The ratio of young stock to total population is generally higher among buffaloes. This is true in all States except again, Assam, Orissa, Kerala and West Bengal. Apart from the differences between the two groups of States mentioned above, there are considerable inter-State variations in the proportion of young stock both among cattle and buffaloes. Since the number of calves born is a function of the number of adult females, States with a relatively high proportion of adult females may be expected to have a larger proportion of young stock. The correlation coefficient between these two variables is in fact positive and significant for cattle (0.4769, significant at 5 per cent) and even more so, for buffaloes (+0.7255, significant at 1 per cent). Nevertheless, this leaves a substantial part of the observed variations to be explained. The other relevant factors would be the mortality rates among young stock, the breeding efficiency of female animals, and the rate of growth of adult stock. The first two factors, one expects, will be negatively associated with the proportion of young stock, while the last should show a positive association.

Variations by Size of Holdings

The relation between human and bovine densities can also be seen from the variations in the pattern of bovine stock in relation to size of land holdings. Such data are available from the National Sample Survey (NSS) for the country as a whole relating to 1960-61, and by States for 1972. The all-India data for 1960-61 are set out in Table V.

TABLE V—COMPOSITION OF CATTLE AND BUFFALOES BY SIZE CLASS OF OPERATIONAL HOLDINGS: ALL-INDIA, 1960-61

Size class (acres)	Bovines per 100 acres	Cattle				Buffaloes				Adult male/female		Cattle/bovines		
		Adult males	Adult females	Young stock	Total	Adult males	Adult females	Young stock	Total	Cattle	Bovines	Adult males	Adult females	Total
Below 0.49	270	19.4	43.8	36.8	100	12.6	58.5	28.9	100	0.44	.21	.83	.71	.77
0.5—0.99	181	37.7	31.8	30.5	100	17.5	52.8	29.7	100	1.99	.33	.89	.67	.78
1.0—2.49	138	46.8	28.3	25.9	100	26.6	45.0	28.4	100	1.69	.59	.87	.69	.78
2.5—4.99	105	47.4	28.7	23.9	100	21.0	48.4	30.6	100	1.65	.44	.90	.72	.81
5.0—7.49	75	45.8	29.4	24.8	100	21.7	46.5	31.8	100	1.56	.47	.88	.69	.78
7.5—9.99	70	45.9	29.1	25.0	100	21.6	46.8	31.6	100	1.58	.46	.89	.70	.79
10.0—12.49	66	47.7	29.3	23.0	100	19.3	47.5	33.2	100	1.62	.41	.89	.66	.76
12.5—14.99	64	44.8	29.8	25.4	100	17.7	49.0	33.3	100	1.50	.36	.89	.67	.77
15.0—19.99	56	47.0	29.3	23.7	100	12.4	52.3	35.3	100	1.61	.24	.92	.64	.76
20.0—24.99	42	45.1	30.6	24.3	100	12.8	52.8	34.4	100	1.47	.24	.92	.66	.77
25.0—29.99	39	45.1	30.8	24.1	100	13.6	51.0	35.4	100	1.47	.27	.91	.65	.76
30.0—49.99	32	44.2	30.5	25.2	100	11.4	51.8	36.8	100	1.46	.22	.93	.65	.76
Over—50.00	28	42.2	31.2	23.3	100	12.7	53.3	34.0	100	1.35	.24	.92	.65	78

Source: Government of India: National Sample Survey: Number 113—Sixteenth Round: July 1960-June 1961—Tables with Notes on Agricultural Holdings in Rural India, Cabinet Secretariat, New Delhi, 1967, pp. 79 and 97.

The average number of bovine stock per unit of cultivated area declines sharply as the size of holding increases. Thus holdings with less than one acre carry over six times as many bovines per unit area as holdings of 30 acres and more. Since the land-man ratio is positively related to size of holdings, these data also corroborate the positive association between human and bovine densities shown by the across-State comparisons.

The composition of bovine stock held by holdings below one acre is quite different from the rest. The proportion of adult males in the bovines owned by them is considerably smaller than the average, and that of adult females and of young stock correspondingly larger. This pattern holds for cattle and buffaloes. The preponderance of adult females in the very small holdings would seem to suggest that they concentrate more on producing milk. Beyond the one acre limit, the pattern changes: both among cattle and buffaloes the ratio of adult males shows a mildly falling trend, and that of adult females a rise, as one moves up the scale of land holding. There is some indication that larger holdings have a somewhat larger proportion of buffaloes as young stock; there is no clear trend in the proportion of young stock among cattle.

The relative importance of buffales does not seem to vary much between different land holdings. However, it would appear that larger holdings tend to have a higher proportion of adult males as cattle, while the ratio of cattle to buffaloes among adult females seems negatively correlated to the size of holding. Larger holdings apparently depend to a greater extent on buffaloes as a source of milk. The ratio of cattle young stock to total young stock also seems to be the lower in larger holdings; the relationship is less pronounced, and more erratic, in the adult female category. But since the cattle-buffalo ratio is highly variable between regions, one should be cautious in drawing conclusions from all-India data.

Trends in Total Population

The total bovine population has risen by about 19 per cent over the last two decades (Table VI). Most of this increase however took place during the fifties, especially between 1956 and 1961. (The reasons for the exceptionally larger increase in the latter period need to be examined.) Since 1961, the bovine population has risen by barely 4 per cent, most of it between 1966 and 1972. The adult male and young stock population seems to have grown considerably faster than the adult females during the fifties. In the sixties, while there was hardly any rise in the former two categories, the number of adult females continued to grow.

Throughout the period, the population of buffaloes has consistently grown faster than that of cattle, the difference being most marked in the adult female and the young stock categories. Significantly, and in sharp contrast with buffaloes, cattle young stock population has been declining in absolute terms during the last decade in spite of the reduction in mortality rates. The decline is especially marked among male young stock and presages a reduction in the number of adult cattle in the coming years. The behaviour of the adult

TABLE VI—TRENDS IN BOVINE POPULATION: ALL-INDIA, 1951-1972

(Numbers in million)

	1951	1956	1961	1966	1972	Percentage change			
						1956/1951	1961/1956	1966/1961	1972/1966
Adult males									
Cattle	61.87	64.87	72.53	73.32	74.49	4.85	11.2	1.1	1.6
Buffaloes	6.78	6.51	7.68	8.20	8.07	—4.00	18.0	6.8	—1.6
Total	68.65	71.38	80.21	81.52	82.56	4.00	12.4	1.6	1.3
Adult females									
Cattle	49.87	49.93	54.20	54.68	56.40	0.1	8.6	0.9	3.1
Buffaloes	21.86	22.35	25.02	26.16	29.24	2.2	11.9	4.6	11.8
Total	71.73	72.28	79.22	80.84	85.64	0.8	9.6	2.0	5.9
Young stock									
Cattle	43.58	43.81	48.83	48.05	47.49	0.5	11.5	—1.6	—1.2
Buffaloes	14.76	16.09	18.50	18.59	20.12	9.0	15.0	0.5	8.2
Total	58.34	59.90	67.33	66.64	67.61	2.7	12.4	—1.0	1.5
Total									
Cattle	155.26	158.67	175.62	176.06	178.38	2.2	10.6	0.3	1.3
Buffaloes	43.40	44.95	51.20	52.92	57.43	3.6	13.9	3.3	8.5
Total	198.66	203.62	226.82	228.98	235.81	2.5	11.4	0.95	2.98

Source: Livestock Censuses.

male buffalo population is rather erratic. After declining some 5 per cent between 1951 and 1956, it rose sharply in the subsequent decade, but fell again during 1966-1972.

The steady rise in the ratio of buffaloes to cattle among adult female shows that farmers have been progressively shifting to buffaloes as a source of milk. In 1951, there were 44 adult female buffaloes for every 100 adult cows; by 1972, the ratio had risen to 52. The lactating efficiency of cattle seems to have remained remarkably stable; that of buffaloes rose sharply between 1951 and 1956, fell in the subsequent decade and despite a recovery in 1972, still remains well below the 1956 level (Table VII).

TABLE VII—TRENDS IN ADULT FEMALE BOVINE POPULATION: ALL-INDIA, 1951-1972

	1951	1956	1961	1966	1972
Breeding cattle					
Total	46.38	47.26	51.00	51.76	54.42
In milk	18.97	20.10	20.67	20.97	22.04
Per cent	40.90	42.50	40.50	40.50	40.50
Breeding buffaloes					
Total	21.01	21.69	24.24	25.52	28.51
In milk	10.22	11.82	12.46	15.92	15.07
Per cent	48.60	54.40	51.40	50.60	52.90
Ratio of breeding cattle to buffaloes ..	2.28	2.18	2.10	2.02	1.92

TABLE VIII—SIZE AND COMPOSITION OF BOVINE STOCK PER 100 HOUSEHOLDS BY SIZE CLASS OF OPERATIONAL HOLDINGS IN RURAL AREAS, 1961-62 AND 1971-72

Size class (acres)	Total bovines		Adult males		Adult females		Young stock		Ratio of cattle to buffaloes	
	1961-62	1971-72	1961-62	1971-72	1961-62	1971-72	1961-62	1971-72	1961-62	1971-72
0.01—0.49	66.30	73.80	12.72	21.58	29.94	29.35	23.64	22.87	2.79	4.66
0.50—0.99	159.83	153.00	58.36	58.04	60.40	58.19	41.07	36.77	3.53	4.27
1.00—1.24	247.63	189.74	108.80	78.71	81.92	69.56	56.91	41.47	3.81	3.74
1.25—2.49		252.02		118.67		79.28		54.09		4.30
2.50—4.99	364.81	365.70	161.89	164.70	117.74	111.37	85.18	81.71	4.21	3.59
5.00—7.49	500.69	475.10	208.08	200.91	173.19	158.20	119.42	115.99	3.91	3.79
7.50—9.99	580.17	540.93	235.46	230.76	191.10	186.06	153.61	123.41	3.57	3.37
10.00—12.49	627.22	621.82	255.13	246.46	217.29	225.47	154.30	149.89	3.35	3.18
12.50—14.99	724.06	677.65	276.28	262.07	255.01	253.07	192.72	162.51	3.45	3.18
15.00—19.99	787.16	721.55	304.80	282.96	276.09	267.09	206.27	171.50	3.20	3.26
20.00—24.99	841.72	777.46	317.74	294.80	305.97	288.77	218.01	203.89	3.41	2.99
25.00—29.99	931.21	907.85	340.28	342.15	345.23	329.66	245.70	236.04	3.07	3.42
30.00—49.99	1131.71	1003.15	462.46	376.83	385.26	372.20	283.09	254.06	2.45	3.26
Over 50.00	1636.19	1401.42	603.21	528.04	603.00	529.61	429.98	343.77	2.92	3.35
All sizes	307.64	278.22	121.61	111.94	107.62	98.86	78.41	67.43	3.51	3.47

Source: For 1961-62—Government of India: National Sample Survey: Number 144—Seventeenth Round: September 1961-July 1962—Tables with Notes on Some Aspects of Land Holdings in Rural Areas, Cabinet Secretariat, New Delhi, 1961.

For 1971-72—Government of India: National Sample Survey: Number 215—Twentysixth Round: July 1971-September 1972—Tables on Land Holdings—All-India, National Sample Survey Organisation, Department of Statistics, Ministry of Planning, New Delhi, 1976.

Changes in Land Holding Classes

Some idea of the behaviour of bovine stock, overall and by major categories, by size class of holding is available from the NSS for 1961 and 1972. The data are summarised in Table VIII. Changes in total bovine population and its major components obtained from the NSS data are broadly in accord with the Livestock Census data. Between 1961 and 1972, there has been a marginal increase in both adult males and adult females, but hardly any change in young stock population. The increase in adult female population is, however, less than in the Livestock Census.

The data show that total bovine population per household and that of adult males, adult females and young stock have declined in practically all land holding classes. In the very small holdings (with less than 0.2 hectare) there has been a rise in the total bovines and adult males. There was also an exceptionally large change in the 0.4 to 1.00 hectare group in all categories. (This is so much at odds with the general pattern and the numbers for 1972 are so implausibly large as to raise doubts on the accuracy of this estimate.) In the remaining groups, it seems that the decline in total bovine stock and of adult females per household has been somewhat greater than the average in the larger holding households, and lower than the average among the smaller holdings. But the extent of decline in adult females and young stock bears no relationship at all to the size of holding.[2]

The overall decline in cattle to buffalo ratio is largely concentrated in the middle size holdings (from 1.00 to 10 hectares); holdings below one hectare, and those above 10 hectares, appear to have substantially increased the share of cattle in their bovine stock. There is also a pattern to the improvement in breeding efficiency. There has been hardly any improvement in the small holdings; the extent of improvement seems to increase with the size of holdings till about 10-12 hectares, before tapering off in the largest 2-3 land holding class. A more disaggregated Statewise analysis of the change in the pattern of bovine stock by different classes of holdings would help understand whether the patterns revealed by the all-India data are widespread or whether they reflect shifts in the spatial distribution of bovine stock.

II

THE PATTERN OF MORTALITY

A closer examination of the sex composition of young stock (see Table V) reveals some rather puzzling features. Since the rearing of bovines from birth to adulthood involves substantial costs, one would expect the marked plurality of male cattle at the adult stage, and of females among buffaloes, to be reflected in the sex ratios of young stock as well. This is indeed the case for buffaloes whose sex ratio (males per hundred females) is below 100 in all the three age groups for which data are available and declines steadily from 0-1

2. In so far as averages for particular land holding classes are subject to larger margins of error than the average for the sample as a whole, all these conclusions should be treated cautiously.

to the 3+ age group (Table IX). The latter suggests that the sex ratios are progressively adjusted from birth to adulthood to achieve the desired sex distribution of adult stock. The behaviour of sex ratios among cattle across age groups is very different and seems to be erratic. The sex ratio is close to 100 in 0-1 age group, declines substantially in the 1-3 age group, before shooting up to over 130 among the adult animals. *Prima facie*, it is difficult to see why the sex ratio among young cattle should be so far out of line, not just in magnitude but directionally as well, with the ratio among adult stock.

TABLE IX—SEX COMPOSITION OF CATTLE AND BUFFALOES IN DIFFERENT AGE GROUPS: ALL-INDIA, 1966

	Cattle			Buffaloes		
	0-1	1-3	3+	0-1	1-3	3+
Males (millions)	11.2	12.1	73.3	4.0	2.4	8.2
Females (millions)	11.1	13.6	54.7	5.9	6.3	24.1
Males/100 females	100.7	89.6	136.2	67.0	39.0	32.0

Source: Government of India: Indian Livestock Census, 1966, Vol. II—Detailed Tables, Part I, Ministry of Agriculture, Directorate of Economics and Statistics, New Delhi, 1972 (mimeo.).

This pattern seems to prevail in most parts of India. It will be seen from Table X that in most States, as in all-India, survival rates of buffalo calves

TABLE X—SURVIVAL RATES OF YOUNG BOVINE STOCK: STATES, 1966

States	Cattle				Buffaloes			
	0-1		1-3		0-1		1-3	
	Male	Female	Male	Female	Male	Female	Male	Female
Andhra Pradesh ..	0.976	1.000	0.472	0.530	0.681	0.869	0.227	0.369
Assam	1.000	0.931	0.388	0.437	0.985	0.932	0.409	0.451
Bihar	0.943	1.000	0.612	0.752	0.821	0.997	0.292	0.594
Gujarat	1.000	0.837	0.581	0.553	0.300	0.963	0.073	0.580
Haryana	1.000	0.906	0.375	0.504	0.673	1.000	0.101	0.572
Jammu & Kashmir ..	0.967	1.000	0.630	0.629	0.385	0.860	0.135	0.461
Kerala	0.692	1.000	0.245	0.594	0.514	0.616	0.372	0.303
Madhya Pradesh ..	0.982	0.996	0.783	0.962	0.689	0.873	0.400	0.796
Maharashtra	0.984	0.988	0.600	0.633	0.437	0.750	0.150	0.386
Mysore	1.000	0.986	0.446	0.494	0.520	0.805	0.148	0.322
Orissa	1.000	0.987	0.490	0.514	1.000	0.944	0.443	0.492
Punjab	1.000	0.998	0.567	0.533	0.579	0.865	0.130	0.565
Rajasthan	0.993	0.948	0.497	0.717	0.708	0.999	0.214	0.799
Tamil Nadu	0.999	1.000	0.455	0.461	0.695	0.840	0.209	0.297
Uttar Pradesh	1.000	0.990	0.461	0.424	0.629	0.987	0.143	0.372
West Bengal	0.936	1.000	0.570	0.508	0.712	0.737	0.292	0.345

Note:—Computed from Livestock Census data for 1966 using the same assumption as for all-India (see Table III). In the case of cattle, the number of calves in 0-1 group exceeds the number of cows in milk in most States. Therefore, the calculations are based on the number of males or females in 0-1 group, whichever is higher.

In the case of buffaloes, the number of calves born is, in all States except Orissa, taken as equal to the number of females in milk. In Orissa since the population below 1 year is greater than the buffaloes in milk, the number of males below 1 year is taken as the starting point.

from birth to age 1 and then on to adulthood are considerably less than those of cattle. Most States also conform to the all-India pattern in that the survival rates for cattle calves through the first year of birth are roughly the same for both males and females, the major exception being Gujarat and Kerala. Again, in most States, as in all-India, more females aged one year survive to adulthood than males of the same age even though males are predominant in the adult population. The significant exceptions to this pattern are Gujarat, Punjab and Uttar Pradesh. In all these cases, fewer female calves survive to adulthood compared to males and this pattern is consistent with the observed sex ratios among adults. In Kerala, again, the relative survival rates of male and female cattle through the young age is consistent with the sex ratio of adult stock. The deviations from the all-India pattern are fewer in the case of buffaloes. In most cases the relative survival rates in the young ages are consistent with the observed sex ratios of adult stock which generally show a marked plurality of females.

Relative mortality rates, and therefore sex ratios, follow this general pattern throughout the last two decades, with indications of some secular trends (Table XI). Among cattle there has been a steady decline in the number of male to female calves below 1 year suggesting that the mortality rate of females has fallen relatively to that of males. The mortality rates in the 1-3 age group seems to have fallen for both sexes, but the fall is considerably greater and more sustained among females. While the number of males per female in the 0-3 group has steadily fallen between 1951 and 1966 (the data for 1972 are not yet available), the ratio has moved in the opposite direction among adult cattle. The apparently odd pattern of mortality as between sexes of cattle at different ages has been intensified over time.

TABLE XI—TRENDS IN SEX RATIO OF CATTLE AND BUFFALOES BY AGE GROUP: ALL-INDIA, 1951-1972

			1951	1956	1961	1966	1972
Cattle							
Sex ratio	0-1		104.8	103.2	101.2	100.7	N.A.
	1-3		97.8	95.9	90.3	89.6	N.A.
	3+		124.0	131.8	135.6	136.2	132.1
Mortality rate							
	1-3	Male	N.A.	.547	.441	.443	N.A.
		Female	N.A.	.423	.381	.378	N.A.
Buffaloes							
Sex ratio	0-1		68.6	68.6	69.7	67.5	N.A.
	1-3		45.2	37.9	41.1	38.7	N.A.
	3+		31.0	29.9	31.5	32.3	27.6
Mortality rate							
	1-3	Male	N.A.	.820	.790	.802	N.A.
		Female	N.A.	.524	.489	.488	N.A.

Source: Livestock Censuses.
Sex ratio is defined as the number of males per 100 females.
N.A. = Not available.

Among buffaloes, there has been some decline in the number of males per female in the 0-1 age group suggesting a rise in male mortality in the first year of birth relative to female mortality. Female mortality has definitely fallen in the 1-3 age group; the decline of mortality among adult males is less pronounced and apparently not sustained. As a result, the sex ratio in this group moves rather erratically from census to census. In the adult age group, there was a slight rise in the number of males per female between 1956 and 1966, but the ratio has since fallen rather sharply.

Assuming that at birth there is an approximate parity between males and females, changes in sex ratios across age groups are essentially a reflection of differential mortality (whether due to natural causes or to slaughter). We have made rough calculations of the average mortality rates in 0-1 and 1-3 age group on the basis of data from the 1966 Livestock Census (Table XII). They show that in both the age groups, the overall mortality rate is much higher for buffaloes than for cattle. It seems unlikely that this is due to greater natural susceptibility of young buffaloes to fatal infection and disease than cattle; more likely, it is a reflection of deliberately greater neglect of buffalo young stock by farmers. Of greater significance from the viewpoint of the sex ratio is the differential mortality of males and females. In the case of buffaloes, the rate of male mortality is higher than that for females in both the age groups, the difference being particularly pronounced in the first year of birth. In the case of cattle, there seems to be little difference between the mortality rates of the two sexes in the first year of their life. But between 1 and 3 years of age, the mortality rate among males is significantly higher than among females. It seems highly implausible that this change in the mortality pattern between 0-1 and 1-3 age groups could be the result of any natural factors. If, on the other hand, it is the result of deliberate deci-

TABLE XII—ROUGH ESTIMATES OF SURVIVAL RATES OF CATTLE AND BUFFALOES IN DIFFERENT AGE GROUPS: ALL-INDIA, 1966

		Cattle	Buffaloes
0-1	Male	1.0	0.615
	Female	0.994	0.912
1-3	Male	0.557	0.198
	Female	0.622	0.512

Assumptions:

1. The number of calves born in any census year is equal to twice the number of male and of female calves in the 0-1 age group or the number of breeding females in milk whichever is higher.
2. Number of calves born in the inter-censal years estimated by linear interpolation.
3. Mortality rate in the 0-1 age group does not change over time.
4. Surviving calves of 1-3 years age in year t [$P_{t\ (1-3)}$] should have born in $t-1$ and $t-2$.

$$\text{Survival rate} = \frac{[P_{t\ (1-3)}]}{b^{o}_{t-1} + b^{o}_{t-2}}$$

where, b^{o}_{t} refers to the number of calves born in year t.

Notes: — (*a*) Since the number of calves in 0-1 exceeds the number of breeding cattle in milk, we have taken the number of male calves in this age group as the basis for survival rate calculation.

(*b*) In the case of buffaloes, since the number of calves in 0-1 is very much lower than the number of breeding females in milk, the number of calves born is assumed to be equal to the atter, and divided evenly between the male and female. Note that these are only crude pproximations of the number of calves born.

sion on the part of farmers, it seems rather odd that they should let fewer males survive to adulthood relative to females, when at the adult stage they have to carry a lot more males than females.

It is possible that the observed sex ratio at the adult stage does not reflect the farmer's perference so much as the differential mortality rates of the sexes at different stages of adulthood. There is indeed some indication that the mortality rates of adult males and females follow divergent patterns. Dandekar has estimated (see Table XIII) on the basis of data collected in 1950-51 that, among adult cattle, females have a consistently higher mortality rate than males and that the difference increases sharply within age. Thus between 3 and 6 years, the average mortality rate for females is some 40 per cent higher than for males; in the 6-9 age group, it is over 230 per cent. After age 9 the mortality rates of the two sexes seem to converge rapidly. By contrast, the mortality rate among adult buffaloes is consistently higher for males, the difference reaching a maximum in the 5-6 age group, falling off quite rapidly thereafter.

TABLE XIII—ANNUAL DEATH RATE OF CATTLE AND BUFFALOES AT DIFFERENT AGE GROUPS: ALL-INDIA, 1950-51

(Average death rate per thousand animals)

Age group	Cattle			Buffaloes		
	Bullocks	Cows	Calves	He-buffaloes	She-buffaloes	Calves
Below 1 ..			263.2			386.5
1-2 ..			84.5			194.7
2-3 ..			55.2			154.8
3-4 ..	60.9	85.9		149.3	83.2	
4-5 ..	60.9	85.9		149.3	83.2	
5-6 ..	60.9	85.9		198.7	74.9	
6-7 ..	41.0	94.1		151.8	88.6	
7-8 ..	26.6	94.1		151.8	88.6	
8-9 ..	26.6	126.0		151.8	88.6	
Over 9 ..	128.6	174.0		164.4	136.4	

Source: V. M. Dandekar: Second Report on the Poona Schedule of the National Sample Survey, 1950-51, Gokhale Institute of Politics and Economics, Poona, 1954, p. 67.

Note:—1. The basis for these estimates are explained thus:

"Data on distribution by age of different animals as well as on deaths and slaughter in four weeks prior to the interview were collected. The latter related to the former gives four weekly death rates in different age groups. In order to derive annual death rates from the above data, the following procedure was adopted for the age groups 0-1 and 1-2: For the age group 0-1, the weekly death rates for successive 13 periods were obtained from the four weekly death rates for 0-1 and 1-2 (namely, 35.7 and 8.6 for cattle) by taking weighted averages, the weights being 13, 0; 1, 72; 2, 11;..... 12, 1. These death rates were then successively applied to survivals at the end of each to get annual death rates of the 0-1. This measures the proportion of calves below 1 year age which will die in the course of the year. (This is rather different from infant mortality rate as usually measured, namely, the number of live-born calves which live to year 1.) The death rate for 1-2 is derived on the basis of four weekly death rates from this age group successively 13 times to the survivals at the end of each four weekly period" (p. 63).

2. The above estimates of mortality are based on sample data on age distribution which seem defective, especially in the young age groups; the ratio of young stock aged less than one year to those of 1-3 years age derived from the Gokhale Institute data is much less than obtained from Livestock Census and subsequent NSS Reports. Also on the basis of data on birth rates given on pp. 75-76 of the report, and the data on the population in the 0-1 age group, the infant mortality rates would seem to be very much higher than shown in the above table.

Since there is no strong reason to believe that the adult female cattle are inherently more prone to disease and death than the buffalo or the male cattle, the differential mortality pattern can only be explained in terms of differential care and attention given to different categories of animals. Dandekar's estimates suggest that the mortality rate among females cattle is not very different from that for female buffaloes in the 3-6 age group; but, thereafter the former rises sharply while the latter shows but a marginal rise till about 9 years. Neglect of the cow, which usually takes the form of indifferent or inadequate feeding and makes it difficult for the animal to withstand the stresses of successive pregnancies, seems to become pronounced after the second lactation. Clearly, at this stage the bullock is given much greater care and attention. One has to probe deeper into the reasons for this apparent difference in the care of cows and bullocks. Perhaps the milk yields of cow drops off sharply after the second/third lactation; perhaps the calving interval and/or the dry period increases with the age of the animal; perhaps the lack of specialisation across land holding classes intensifies the competition for limited feed resources in the smaller farms thus forcing them to choose the bullock in preference to the cow. As between the cow and the she-buffalo, it is possible that the latter receives greater care partly because it is more valuable as a milch animal and also because its biological character demands more careful attention. All this is, however, speculative and, even if true, still does not explain why the farmer should not take better care of the young male cattle. For by reducing the male mortality rate in the 1-3 age group, the farmer in fact can make do, as far as reproductive function is concerned, with fewer cows than at present. This whole question needs to be studied in greater depth using more recent data.

III

DRAUGHT ANIMALS

At the time of the Livestock Census of 1972, there were about 83 million working bovines in the country: 75 million of them were cattle, the remaining being buffaloes. Almost all (97 per cent) of working animals in both the categories were males.[3] The number of adult male bovines therefore provides a close approximation to the size of the draught animal population.

The number of draught animals per hectare of cropped area varies a great deal across States as well as between land holdings of different sizes. In general, States with relatively high density of rural population relative to cropped area also tend to have more draught animals per unit area; but the rate of increase in the latter falls off as one moves up the scale of human density. The relation is much the same when we view the distribution of human and draught animal population by size of holdings. These are summarised by the following regression equation.

3. There were 2.1 million working cows and 0.4 million working she-buffaloes. The use of female cattle for work seems to be pronounced in the three Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. They accounted for over half of the total number of working cows in the country. In all these States the ratio of working cows to working cattle was considerably higher than the national average and reaches a high 12 per cent in Tamil Nadu.

1. State cross-section[a]: 1972
$$Y_1 = 0.5619 + 0.6796\ X_1^* - 0.0897\ X_1^2 \quad (R^2 = 0.75)$$
2. Land holding[b] cross-section: 1972
$$Y_2 = .292201 + .157352^*X_2 - .002299^*X_2^2 \quad (R^2 = .95)$$
$$(.013825) \qquad (.000266)$$

a. State regressions based on Population and Livestock Census data.
b. Based on NSS Twentysixth Round data.

Notes:—Y_1=Adult male bovines per hectare of cropped area; Y_2=Adult male bovines per hectare of operated area; X_1=Population per hectare of cropped area; X_2 = Number of persons per hectare of operated area in different size classes. * Significant at 5 per cent.

The more densely populated regions, like the relatively small holdings, are generally also areas where natural factors like soil and climate, and or the availability of man-made irrigation facilities permit intensive cropping involving higher inputs of both human and animal power. Over most of India, the soil is so hardened by prolonged dry spell and high temperatures of the summer that the preparation of land for sowing cannot be done by human labour alone. The use of animals or machines is indispensable. Animals are also used in other agricultural operations (like weeding and interculture) as well as in transportation of inputs and outputs. Clearly, more intensive cultivation is associated with larger input of human labour; but it is not obvious that there is any strong or immutable technological reason compelling a higher level of animal power input along with higher human labour input. Animal power can be substituted by machines over practically the whole range of operations; and there is scope for using human labour at least in some of the operations currently being done by animals. In parts of Kerala where adequate pre-sowing rainfall is available, even land preparation is done wholly by human labour.[4] Thus one has to look for a complex of factors to explain the observed variations in the extent of draught animal power in relation to the cropped area.

The fact that more intensive cultivation generally associated, in India, with relatively high population densities and small holdings may require a relatively high input of animal power, does not explain why small farms and farms in densely settled areas should carry relatively large stock of draught animals per unit area. The usual explanation in terms of the indivisibility of animal units is not wholly convincing because this limitation can be, in principle, overcome by a system of leasing of animal services. In fact, if, as seems to be the case, the available stock of animals is in excess of the requirements during the critical periods, or periods of peak demand,[5] a leasing system should lead to greater efficiency in the sense of meeting all the demand for animal labour with a smaller stock of animals. The potential gain

4. This is one of the interesting findings of a survey conducted by K. Narayanan Nair He also found a well developed bullock leasing system.

5. The Farm Management Survey data show that bullocks are unemployed for upwards of 40 per cent of available time even during the peak season. For instance, in Orissa bullocks were employed only 57 per cent of the time in June-July (the peak season for that State); 60 per cent of the time in Gujarat (May) and 50-60 per cent in Uttar Pradesh (April-May and October). These data are all from surveys conducted in the mid-fifties.

from leasing or sharing is likely to be the greater because smaller farms tend to use the draught animals less intensively.

As a matter of fact, however, the extent of leasing seems quite limited. The ratio of hired to total bullock labour was less than 5 per cent in the Punjab and Orissa, 18 per cent in Madhya Pradesh, and 10 per cent in Madras.[6] This is more surprising because some recent surveys report that a sizeable proportion of farmers, especially those with very small holdings, do not have any working bovines. Thus, the NSS reports that in 1971-72, about a third of the rural households operating land did not have any working bovines; and 65 per cent of farms with less than 0.40 hectare did not have any working bovines.[7]

The absence of well developed lease market could be an indication that the critical period when animal power is imperative may be much shorter than a month and the average utilization rate over a month or two does not give a correct picture of the conditions during the critical season. If this were so, and the penalty in terms of loss of output of not getting the animals at the right time is large, the willingness of farmers to carry an apparently excessive stock of draught animals, operated for only a fraction of the time may be more explainable.

Since, *prima facie*, animals and machines are substitutable, one would expect that as the intensity of machine input per unit area increases that of animal power per unit will fall. We tested this hypothesis as well as the relation between the holding size and draught animal stock per hectare[8] on the data from the Livestock Census (in respect of a cross-section of States in 1961 and 1971) as well as on the NSS data (in respect of a cross-section of holdings of different sizes for all-India and for a few States). The only significant variable explaining the variations in draught animals per hectare, and that too not consistently, was the average size of holding. The coefficients for mechanical power had mostly the expected negative sign but were statistically insignificant in the inter-State cross-section as well as across land holding classes for all-India and in three out of the five States for which the latter were tried (Table XIV).

Over time also, the relation between mechanical and animal power in agriculture remains clouded. At the all-India level, the stock of the adult male bovines has grown considerably slower than the cropped area. Consequently, except during 1951-56, the number of adult male bovines per hectare of cropped area has been consistently falling. Over the same period, there was a sharp rise in the quantum of mechanical power per hectare (Table XV).

6. Figures relate to mid-fifties.

7. The proportion of households operating land but not owning any working bullocks or buffaloes varies widely. It is around 16 per cent in Punjab, 40-50 per cent in Andhra Pradesh, Karnataka and Tamil Nadu and close to 90 per cent in Kerala.

8. This is meant as a rough test of the indivisibility hypothesis. If, for whatever reason, farmers wish to hold some draught animals irrespective of the holding size and given that these animals are indivisible units, the number of animals per hectare should increase as the holding size decreases. In this regression, the number of animals in each size class of holdings was averaged over *all* holdings in that class (including those without any work animals). Since the proportion not owning any work animals is inversely related to the holding size, this introduces a systematic bias in the estimated relations.

TABLE XIV—RELATION BETWEEN DRAUGHT ANIMALS PER HECTARE (Y), AVERAGE HOLDING SIZE (X_1) AND MECHANICAL POWER PER HECTARE (X_2)

All-India

State cross-section $Y = 139.07 - \underset{(4.64)}{26.8X_1^*} - \underset{(.321)}{.066X_2}$ ($R^2 = .777$)

Land holding classes: States

Punjab	$\text{Log } Y = 4.95 - \underset{(.013)}{.089X_1^*} - \underset{(.405)}{.883X_2^*}$	($R^2 = .90$)
Kerala	$Y = 42.357 - \underset{(0.954)}{1.288X_1} + \underset{(10.897)}{3.971X_2}$	($R^2 = .258$)
Karnataka	$Y = 111.569 - \underset{(1.27)}{4.299X_1^*} - \underset{(152.82)}{297.302X_2^{**}}$	($R^2 = .561$)
Andhra Pradesh ..	$\text{Log } Y = 4.434 - \underset{(.016)}{0.056X_1^*} + \underset{(3.904)}{.832X_2}$	($R^2 = .548$)
Tamil Nadu ..	$Y = 231.26 - \underset{(2.486)}{2.527X_1} - \underset{(115.691)}{334.26X_2^*}$	($R^2 = .623$)

Sources: The data underlying these regressions are all from the National Sample Survey: Number 215—Twentysixth Round, *op. cit.*

Note:—We tried three functional forms in all cases, namely, linear, semi-log and log linear. In general the R^2 is lowest in the linear form and largest in the log linear form. But as a rule, the change in the functional form seems to increase the value of the coefficient for land holding size, but not that of the mechanical power which remains insignificant except in a few cases. In the case of Punjab neither coefficient for the linear form is significant, but both are significant in the semi-log form. In the case of Andhra Pradesh both coefficients are insignificant in the linear form, but one of the coefficients is significant in the semi-log form.

* Significant at 5 per cent.

** Significant at 10 per cent.

TABLE XV—TRENDS IN ANIMAL AND MECHANICAL POWER USED IN AGRICULTURE: ALL-INDIA, 1951-1972.

	1951	1956	1961	1966	1972
Number of working animals[1] (million)	67.3	70.7	80.4	81.4	82
Gross sown area[2] (10^6 ha.) ..	127.9	145.7	155.2	158	164
Number of tractors ('000) ..	8.64	17.73	27.3	54	148
Number of pumpsets ('000) ..	108.6	169.2	390.1	886	3176
Number of cane crushers ('000)	21.3	23.3	33.3	45	87
Total horse power[3] ('000) ..	782	1227	2527	5465	18535
Working animals/ha.	.526	.485	.518	.515	.500
Mechanical power (HP/ha.) ..	.006	.008	.016	.035	.113

Source: Livestock Censuses.

1. Including working adult females, and, hence not strictly equal to adult males.
2. Three-year average centred around each year at the head of the column.
3. Assuming that a tractor has an average power of 15 HP and all other equipment 5 HP each.

At first sight, this would seem consistent with the hypothesis that animal power per hectare is being substituted with mechanical power mostly for irrigation and to a lesser degree for land preparation and, perhaps transport.,

But this neat picture vanishes when we look at the State level data. Of the five selected States, all show a rapid and sustained rise in mechanical power per hectare, but only three recorded a decrease in the number of draught animals per unit area (Table XVI). The latter index behaves quite erratically in Andhra Pradesh while in Karnataka it has shown a sustained rise from 1956 to 1972. And there is obviously no consistent relation between the rate of increase in mechanical power per hectare and the rate of change of draught animals per hectare.

TABLE XVI—TRENDS IN DRAUGHT ANIMALS AND MECHANICAL POWER IN HP PER HECTARE OF CROPPED AREA: SELECTED STATES, 1956-1972

States	1956	1961	1966	1972
Andhra Pradesh				
Draught animals	.469	.552	.548	.586
Mechanical power	.023	.025	.047	.116
Karnataka				
Draught animals	.369	.387	.391	.411
Mechanical power	.007	.013	.032	.113
Kerala				
Draught animals	.383	.355	.297	.206
Mechanical power	.009	.015	.027	.054
Tamil Nadu				
Draught animals	.679	.817	.788	.708
Mechanical power	.042	.102	.254	.602
Punjab				
Draught animals	.276	.282	.266	.245
Mechanical power	.013	.022	.048	.291

Note:—Computed from Livestock Census data. Draught animals include working male and female animals; in computing the mechanical power, we have taken the number of pumpsets, power operated cane crushers and tractors and assumed the average horse power per unit of equipment at 5 HP per pumpset and crusher and 15HP per tractor. The per hectare calculations are based on the three-year averages of gross sown area in each State centred around each year indicated at the head of the column.

IV

MILCH ANIMALS

As noted earlier, the total number of adult female bovines relative to crop area is positively associated with the human population density; small holdings, which on the average have less land per capita than larger holdings, tend to carry on a larger number of adult female bovines per unit area; and, during the last decade, the adult female population seems to have grown rather faster than the total. It is, however, difficult to interpret and, even more so to explain the significance of the variations in numbers and density unless we also take into account the variations in the productivity of female animals in their dual role as producers of milk and of calves.

The reproductive efficiency of bovines, measured by the number of adult female stock required to meet a given demand for calves, depends on the age at first calving and the interval between successive calvings. The lower the age at first calving and the smaller the inter-calving interval, the greater the reproductive efficiency. The productivity of milk, on the other hand, is a function of the inter-calving interval, the length of lactation and the average daily yield per animal in milk. Nation-wide data on inter-calving intervals are not readily available. But we do have considerable data on the proportion of adult females which are in milk[9] as well as on the average milk yields. These, set out in Table XVII, show that (*a*) both in terms of

TABLE XVII—PRODUCTIVE EFFICIENCY OF COWS AND BUFFALOES: ALL-INDIA AND STATES

States	Year	Cows		Buffaloes		Density of human population*
		Proportion in milk	Average daily yield (kg.)	Proportion in milk	Average daily yield (kg.)	
Andhra Pradesh	1966-67	33	0.79	52	1.40	2.86
Bihar	1965-66	43	1.23	51	3.19	4.61
Gujarat	1963-64	46	1.67	61	3.08	1.94
Kerala	1964-65	45	1.11	59	2.01	5.92
Madhya Pradesh	1966-67	35	0.51	40	1.77	1.70
Tamil Nadu	1965-66	43	1.22	53	1.96	3.79
Maharashtra	1964-65	32	0.61	53	2.26	2.00
Mysore	1965-66	46	0.72	51	1.32	2.23
Orissa	1960-61	42	0.50	N.A.	N.A.	2.54
Punjab	1966-67	54	2.28	62	3.99	1.73
Rajasthan	1962-63	34	2.12	52	3.02	1.23
East Uttar Pradesh ..	1962-63	33	0.62	46	1.91	3.29**

Source: Daroga Singh, *et al.*: Monograph on Estimates of Milk Production, Indian Council of Agriculture Research, New Delhi (undated), pp. 16 and 21. Average milk yield relates to yield per animal in milk.

* Rural population per hectare of cropped area, 1972.

** Relates to Uttar Pradesh.

9. This index, which we have called Lactating efficiency, approximates the ratio of lactation length to calving interval. Differences in reproductive efficiency are thus partially reflected in this index.

lactating efficiency and of milk yields, the buffalo is consistently superior to the cow, though the degree of superiority is by no means uniform; and (*b*) both indices of productivity for cows and buffaloes taken separately vary a great deal across States.

Livestock Census data also show that the buffalo is more efficient in terms of the proportion of breeding females which are in milk in practically all States. This difference between cows and buffaloes has persisted throughout the last two decades and in fact seems to be somewhat greater now compared to 1951. Excluding 1956 (which shows an abnormal change from 1951), there would appear to be hardly any change in the proportion of cows which are lactating while there is some rise in the ratio for buffaloes. The pattern shows much variation between States. Again excluding 1956, the lactating efficiency of the cow seems, in contrast to the all-India pattern, to have increased appreciably at any rate in the southern States and the Punjab. The index for buffaloes shows, as in all-India, a rise though of varying degrees. It is also apparent that the sustained reduction in the ratio of cows to she-buffaloes observed at the all-India level has not occurred in all parts of the country. While the reduction is marked in the Punjab, the ratio shows hardly any change in Andhra Pradesh, and has actually increased in Kerala and Tamil Nadu (Table XVIII).

TABLE XVIII—TRENDS IN THE RATIO OF BREEDING CATTLE TO BREEDING BUFFALOES: INDIA AND SELECTED STATES, 1951 TO 1972

States		1951	1956	1961	1966	1972
Andhra Pradesh	A	1.29	1.26	1.20	1.23	1.21
	B	30.6	40.8	30.8	33.7	35.8
	C	47.2	57.2	50.0	49.6	53.3
Karnataka	A	2.70	2.94	1.89	1.87	2.07
	B	36.6	40.7	36.6	39.1	40.8
	C	48.0	54.2	47.4	50.1	54.7
Kerala	A	7.92	7.78	9.03	9.38	8.33
	B	35.6	40.7	37.6	39.9	47.1
	C	46.7	48.8	46.8	51.9	56.1
Tamil Nadu	A	1.85	1.92	2.42	2.32	2.46
	B	38.7	42.7	42.3	41.9	46.0
	C	51.2	56.1	54.3	55.9	58.4
Punjab	A	0.91	0.84	0.74	0.57	0.55
	B	58.9	59.7	58.0	58.8	61.3
	C	55.4	62.0	55.4	57.9	64.7
All-India	A	2.28	2.18	2.10	2.02	1.92
	B	40.9	42.5	40.5	40.5	40.5
	C	48.6	54.4	51.5	50.6	52.9

Source: Livestock Census Reports for various years.
A = Number of breeding cows per breeding buffalo.
B = Proportion of breeding cows in milk.
C = Proportion of breeding buffaloes in milk.

In an attempt to explain the inter-State variations in the indices of efficiency of milch animals, we examined the relation between them and the extent of human population pressure on land. One might expect that the less densely populated areas can afford to feed the animals better and, to the extent better feeding reduces the inter-calving interval and, or increases lactation period, this would imply that the ratio of animals in milk to total breeding females as well as average milk yields should be higher in such areas. As a matter of fact, however, there is no systematic relation between productive efficiency (defined as above) of either cattle or buffaloes, on the one hand, and population density, on the other. Nor is there a significant relation between population density and average milk yields.[10] This could well be a reflection of the defects in the data and, in particular, the inadequacy of cropped area per capita as a measure of relative pressure of population on land. Since land quality across States does vary a great deal on account of differences in soil, rainfall and irrigation, a proper measure of relative population pressure on land should make allowances for these differences.

The limitations of using per capita land area may be less severe when we compare holdings of different sizes. For, while larger holdings have, on the average, poorer quality land, they also generally tend to have larger incomes both per family and per capita. One might therefore expect that larger holdings, by virtue of their superior command over resources relative to the human population they support, will be able to hold superior quality animals. If this were so, the calving efficiency, the lactation length as well as milk yields of large holdings should be well above the average small holdings. In point of fact, there seems to be no systematic relation between the size of holding and the ratio of lactating to total breeding females.[11] Scattered data from the Farm Management Surveys also do not show any marked or consistent trend for milk yield to rise with the holding size.[12]

The greater and increasing prominence of buffaloes among adult females than among adult males is usually to be explained in terms of the superior efficiency of the buffalo as a milch animal. It should be noted however that the differences in efficiencies are not uniform as between regions: In Tamil Nadu, for instance, the ratio of milk yield per cow in milk and that per buffalo in milk is around 1.6 while in Maharashtra it is nearly 3.7. Similarly, the lactating efficiency of the buffalo is only 10-15 per cent better than that of the cow in Madhya Pradesh compared to 65-70 per cent in Maharashtra. Eco-

10. It might be noted that W. Burns in his famous report (1) claimed that the average animal milk yield per cow tended to be higher in areas with lower rainfall. The milk capacity per animal in regions of 30 inches or less rainfall being more than twice that of animals in areas with over 70 inches rain. Since there is a positive association between rainfall and population density, this could also imply an inverse relation between population density and milk yields. However, a more disaggregate analysis of more recent data on milk yield does not support the hypothesis. [See Ashok V. Desai (5)]. The lack of such a relationship can also be seen from Table XIV.

11. It would, however, seem from the NSS data that, while the overall breeding efficiency of both cows and buffaloes increased between 1961 and 1972, the increase was apparently more in larger holdings. If true, this is a significant fact which needs to be explored further.

12. We looked at the Farm Management Survey data from the mid-fifties for Maharashtra, Madras, Uttar Pradesh and Punjab. There is no systematic relation between the holding size and milk yield per animal in three of the States. The Punjab data however show a strong positive relation between the two variables.

logical conditions suitable for the rearing of buffaloes and their use as work animals are not present in all parts of the country. Moreover, higher milk yields of buffaloes also involve larger cost because they require higher feed inputs (especially concentrates) and buffaloes need greater care and attention. And finally, the extent of reliance on buffaloes for milk is constrained by the limited demand for the species as a source of draught power.

A satisfactory explanation of the factors determining the size composition and productivity of adult female bovines clearly calls for a more complex model. Such a model will have to take cognizance of the fact that, on the supply side, efficiency is partly determined by inherent genetic characteristics of the animals, and partly by the quality of management (as reflected in the amount and type of feed, care for animal health, etc.). The former as it were sets the limiting values of various parameters (such as calving interval, age at first calving, lactation length, and efficiency in converting feed into milk), while the latter determines their actual values. The quality of management again cannot be viewed independently of the demand and price conditions facing producers. And any model has to recognize that the demand for milk and for calves are determined by quite different sets of factors: the former by population and real incomes; the latter by the requirement for replacement of animals lost by death or slaughter, and for growth of the herd.

V

COMPOSITION OF THE BOVINE HERD

Another important aspect of the bovine population relates to its age and sex composition. The review of available data in section I revealed large variations across States in the ratio of adult males, adult females and young stock to bovine population. The data seem to suggest a systematic relation between age-sex composition of bovines and human density. More specifically, the proportion of adult male stock tends to increase, and that of adult females to fall, as one moves up the scale of human density. It is tempting to rationalise this by saying that as the pressure of population on land increases, and the competition between human and bovines intensifies, farmers tend to restrain the number of adult females in order to accommodate the requiste number of draught animals. But such an explanation could be an over-simplification because there are large differences in land quality, cropping patterns and the availability of alternate sources of power, and also because the proportion of different categories of animals reflect the net result of adjustments of herd composition to condition of demand for different animal products and services, costs of feed and maintenance, and productive efficiencies.

Interestingly, when one views the composition of bovine stock across land holding classes, it is found that, for the country as a whole, the differences are nowhere near as striking. Of course, the very small land holdings do have a distinctly different pattern from the rest of the population. The bovine stock held by them consists of a smaller proportion of adult males and a notice-

ably larger proportion of adult females than the average. Except for this, the percentage distribution of total bovine stock as between adult males, adult females and young stock, is surprisingly stable in different size classes of holdings.

It is possible that the all-India data, aggregating as they do regions with very different agro-climatic and institutional conditions, give a distorted picture. In order to check possible distortions on this account, we have compared the size and composition of bovine population by size of holdings in four selected States, *viz.*, Maharashtra, Punjab, Tamil Nadu and Uttar Pradesh (Table XIX). There are of course significant differences in the average composition of bovine stock as well as in the behaviour of the total bovine population per hectare and its composition relative to the land holding size as between these States. Thus, Tamil Nadu has 280 bovines per hectare of operated area, compared to 107 in Maharashtra; buffaloes comprise less than 15 per cent of bovine stock in Tamil Nadu and Maharashtra, compared to 53 per cent in Punjab; and, while differences in the proportion of adult females to the total are not marked, there is a great deal of variation in the shares of adult males and young stock with Punjab having an exceptionally low proportion of adult males and large proportion of young stock. [13]

The share of adult males in total stock is generally much lower than the average, and that of adult females much higher, in the very small land holding class (Tamil Nadu being an exception). The tendency for the proportion of adult males to fall as land holding increases is evident in Maharashtra, Punjab and Tamil Nadu but no clear trend is visible in Uttar Pradesh. The proportion of adult females shows a tendency to rise with holding size in Tamil Nadu and to a lesser extent in Punjab. But in the other two States, the relation is erratic even if we exclude the smallest farms. The proportion of young stock seems to be positively associated with holding size in Tamil Nadu, Uttar Pradesh and Punjab, but no clear trends are visible in Maharashtra. In none of the four States do we find any systematic relation between breeding efficiency of either cattle or buffaloes with the holding size. These diverse patterns of relation between holding size and composition of bovine stock in different States clearly argue for a disaggregated analysis, by regions, in order to satisfactorily explain the variations. Even so, the State level data do seem to broadly reinforce the conclusion based on all-India data that, except for very small holdings, there seems to be no *striking* difference across land holding classes in terms of either the nature or the degree of specialisation.

This is *prima facie* rather surprising in a situation where the availability of, and access to, resources needed for the maintenance of animals is unequal as between different classes of farmers. A farmer with one acre has obviously much less home grown forage and feed compared to one with ten acres. The latter being on the average much better off in terms of per capita income and

13. It is also noteworthy that while in all States, the overall bovine density per hectare of operated area falls as land holding increases, the strength of the relation is by no means uniform: the fall is very sharp and sustained in Punjab and Uttar Pradesh, somewhat less pronounced in Maharashtra, and least pronounced and rather erratic in Tamil Nadu.

TABLE XIX—SIZE AND COMPOSITION OF BOVINE STOCK IN DIFFERENT CLASSES OF LAND HOLDINGS IN FOUR STATES, 1972

Size of holding (acres)	Number of bovines/100 hectares				Proportion of adult males				Proportion of adult females			
	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0.01-0.49 ..	464.35	1335.48	635.42	954.44	9.0	11.0	59.7	33.6	59.5	47.6	28.0	36.2
0.50-0·99 ..	633.57	446.68	496.81	570.10	36.0	—	53.8	47.5	29.9	51.1	30.1	34.1
1.00-1.24 ..	323.21	1069.18	293.19	590.35	43.6	8.3	65.6	47.4	30.4	69.9	24.7	38.7
1.25-2.49 ..	259.89	488.24	232.70	393.37	43.4	36.4	60.2	50.4	34.5	36.2	24.9	31.5
2.50-4.99 ..	200.41	295.88	241.61	263.68	43.7	37.5	52.6	48.1	32.7	38.8	29.6	34.0
5.00-7.49 ..	139.64	224.57	228.39	198.53	44.1	32.7	50.6	45.6	33.4	37.9	33.3	33.7
7.50-9.99 ..	89.30	163.76	225.43	165.64	48.6	39.4	39.2	44.5	38.8	37.9	40.5	37.4
10.00-12.49 ..	97.02	158.10	241.03	140.72	44.3	37.2	39.3	44.6	32.3	39.3	38.7	35.6
12.50-14.99 ..	92.28	132.90	132.50	120.20	41.0	32.9	46.1	48.1	35.1	35.5	38.4	34.8
15.00-19.99 ..	88.28	103.13	154.41	123.60	38.5	30.3	39.8	44.8	31.9	39.9	36.0	34.9
20.00-24.99 ..	68.16	94.19	194.79	117.78	39.3	33.6	32.0	38.8	33.8	38.6	44.8	34.8
25.00-29.99 ..	74.56	88.33	—	119.95	40.4	34.9	—	40.1	36.8	34.7	—	27.7
30.00-49.99 ..	65.67	65.72	112.99	70.76	39.6	26.4	31.1	43.4	36.1	40.4	49.8	33.9
Over 50.00 ..	119.73	41.88	28.82	21.90	30.8	—	45.8	66.2	35.8	—	42.0	11.9
All classes ..	106.79	203.60	282.18	243.49	40.6	25.6	50.4	44.5	35.3	35.9	31.7	35.5

(*Contd.*)

TABLE XIX—(*Concld.*)

Size of holdings (areas)	Proportion of young stock				Lactating efficiency: Cattle				Lactating efficiency: Buffaloes			
	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh	Maha-rashtra	Punjab	Tamil Nadu	Uttar Pradesh
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
0.01-0.49 ..	31.5	42.4	12.3	30.2	.29	.50	.54	.47	.64	—	1.00	.57
0.50-0.99 ..	34.1	46.2	16.1	18.5	.77	1.00	.18	.45	.62	—	.88	.57
1.00-1.24 ..	26.0	21.8	9.8	13.8	.89	.74	—	.34	.85	.14	—	.61
1.25-2.49 ..	22.1	27.5	15.0	18.1	.54	.32	.64	.50	.90	.78	.79	.59
2.50-4.99 ..	23.6	24.2	17.8	17.8	.63	.56	.42	.53	.82	.64	.55	.57
5.00-7.49 ..	22.6	29.4	16.1	20.8	.64	.53	.34	.51	.78	.57	.81	.63
7.50-9.99 ..	12.5	24.0	20.3	18.2	.61	.57	.29	.52	.72	.73	.47	.57
10.00-12.49 ..	23.4	23.5	22.1	19.9	.57	.49	.25	.48	.90	.57	.57	.62
12.50-14.99 ..	23.9	31.7	15.5	17.1	.53	.53	.18	.32	.74	.62	.36	.63
15.00-19.99 ..	20.5	29.9	24.2	20.3	.53	.59	.32	.49	.58	.68	.69	.58
20.00-24.99 ..	26.8	27.8	23.1	26.5	.59	.57	.29	.70	.73	.68	.18	.80
25.00-29.99 ..	22.7	—	—	25.4	.58	.83	—	.52	.55	.83	—	.32
30.00-49.99 ..	24.2	33.2	19.1	22.7	.52	.66	.76	.51	.63	.67	.67	.76
Over 50.00 ..	11.9	33.2	—	12.1	.48	.18	—	1.00	.97	.53	—	.77
All classes ..	24.2	38.5	17.9	20.0	.57	.54	.39	.50	.72	.61	.68	.59

Source: Government of India: National Sample Survey: Number 215—Twentysixth Round: July 1971-September 1972—Tables on Land Holdings (State Volumes II), National Sample Survey Organisation, Department of Statistics, Ministry of Planning, New Delhi, 1975.

wealth is likely to have access to much larger resources (by way of own savings or borrowings) for livestock rearing. Under these conditions, it would seem rational (in the sense of securing maximum returns per unit of resources spent on livestock husbandry) for the small farmer to maintain as high a proportion of his bovine stock in the productive categories (like draught animals or animals in milk) and keep the proportion of unproductive animals (calves, dry cows or dry buffalos) to a minimum. Indeed, since many of them are not likely to have sufficient work for draught animals, it would seem more economical for them to have as few of this category as possible. On the other hand, a large farmer by virtue of his superior command over resources (in terms of quantum and of terms) as well as high level of his own requirements for animal products and services, might be able to afford a larger number of bovine stock, of better quality and of a more diversified composition. But in actual fact there seems to be no such specialisation; on the contrary, the remarkable similarity in the composition of bovine stock across land holdings seems to suggest that the farmers seek to be self-reliant in meeting their requirements of all major categories of bovines.

The farmers could of course find it advantageous, or even necessary, to aim at such self-reliance if there were no well developed markets for animals. But this is evidently not the case in India. There is in fact a widespread, and well organized, trade in bovines throughout the country. As early as 1950, Dandekar reported that the majority of adult male bovines owned by farmers (60 per cent of cattle and 72 per cent of buffaloes), over a fifth of cows and close to 40 per cent of she-buffaloes were purchased. On the other hand, the survey showed that most (95 per cent) of the young stock were home-bred.[14]

Perhaps the data, which, by necessity are aggregated, conceal considerable degree of specialisation within different classes of farmers. That this may be happening is suggested by the extra-ordinarily high proportion of farmers, especially with small holdings, who do not own any draught animals. Another indication of this is given by the sample verification of the 1966 Livestock Census[15] which suggests that a little over half of the sample households had no cattle whatsoever, 65 per cent had no working bullocks, and as many as 83 per cent had no cows in milk.

Another possible explanation could be that the availability of draught animals at the right time is so critical to the farming operations (which could be the case if the preparation and sowing operations have to be completed within a very short time during which animals can either not be leased at all or only at high cost), that even small farms find it worthwhile to maintain draught animals along with others. The possibility of getting some supplementary income from milk and of rearing calves for sale at maturity with little or no real cost (on account of the availability of surplus family labour, combined with the possibility of finding free grazing on public lands) may

14. V. M. Dandekar, *op. cit.*, p. 66.
15. Government of India: National Sample Survey: Number 183—Tables with Notes on Post-Census Survey of Livestock Numbers 1966 (Rural Sector), Delhi, 1971, pp. 56, 59 and 62.

also contribute to a more diversified pattern of bovine stock in small holdings. Again without more detailed data and further careful analysis, no definitive conclusions can be hazarded.

VI

CONCLUSION

The purpose of this paper, as mentioned at the outset, is rather modest: It has sought to marshall some of the available information on the structure of India's bovine population, and its behaviour across regions and over time. In the process, certain interesting patterns have been noticed and some of these are at odds with expectation. The pattern of mortality by age and sex among cattle, the lack of any strong substitution relation between animal and mechanical power, the seeming lack of pronounced specialisation in the bovine economy of small and large farms and the existence of a systematic relation between human density, on the one hand, and the level and composition of the bovine stock, on the other, are some interesting findings of this review. Our attempts to explain these apparent puzzles are far too crude and simplified to provide definitive answers. But they do raise several questions which deserve to be pursued in greater depth in order to better understand the factors determining the size and productivity of a resource which, next to land and irrigation, is the largest resource of India's rural economy.

ANNEX

The following are some of the principal contributors to the discussion, the main highlights of which are well summarised in S. N. Mishra (11).

(1) W. Burns: Technological Possibilities of Agricultural Development in India, Superintendent, Government Press, Lahore, 1944.

(2) V. M. Dandekar, "Problem of Numbers in Cattle Development", *The Economic Weekly*, Vol. XVI, Nos 5, 6 and 7, Annual Number, February 1964.

(3) V. M. Dandekar, "India's Sacred Cattle and Cultural Ecology", *Economic and Political Weekly*, Vol. IV, No. 39, September 27, 1969.

(4) V. M. Dandekar, "Sacred Cattle and More Sacred Production Functions", *Economic and Political Weekly*, Vol. V, No. 12, March 21, 1970.

(5) Ashok V. Desai, "The Livestock Situation", *The Economic Weekly*, Vol. XVII, Nos. 5, 6 and 7, Annual Number, February 1965.

(6) C. H. Hanumantha Rao, "India's 'Surplus' Cattle: Some Empirical Results", *Economic and Political Weekly*, Vol. IV, No. 52, December 27, 1969.

(7) Marvin Harris, "The Cultural Ecology of India's Sacred Cattle", *Current Anthropology*, Vol. VII, No. 1, 1966.

(8) Alan Heston, "An Approach to the Sacred Cow in India", *Current Anthropology*, Vol. XII, April 1971.

(9) S. N. Mishra, "Cattle Meat and Economic Welfare", *Kyklos*, Vol. XIX, Fasc. 1, 1966.

(10) S. N. Mishra, "Some Inferences from Compositional Changes in India's Livestock Population (1920-1966)", Vol. XXV, No. 4, October-December 1970.

(11) S. N., Mishra, "Surplus Cattle in India: A Critical Survey", *Sociological Bulletin*, Vol. 22, No. 2, 1973.

(12) K. N. Raj, "Investment in Livestock in Agrarian Economies", *Indian Economic Review*, Vol. IV (New Series), No. 1, April 1969.

(13) K. N. Raj, "India's Sacred Cattle: Theories and Empirical Findings", *Economic and Political Weekly*, Vol. VI, No. 13, March 27, 1971.