TRENDS IN THE GROWTH OF OVINE OTHER LIVESTOCK AND POULTRY POPULATIONS OF INDIA

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1. INTRODUCTION

Working out projections of livestock and poultry populations is basic to any study on the development of livestock economy. The importance of investigating trends in the numbers of various papulations of livestock and poultry is evident in view of the fact that construction of life-tables for the respective populations, which provide alternative means of working out projections, is not possible due to lack of data on sex-wise age specific death rates. In an earlier paper Avadhani et al. (1968) presented the results pertaining to trends in the bovine population of the country obtained on the basis of the quinquennial livestock census data available since 1920 onwards. The present paper gives the results concerning trends in the populations of sheep, goats, horses and ponies, donkeys and mules, camels, and pigs as also of poultry separately. Utility of these trends for calculating projections of the respective populations in question has also been briefly examined.

2. THE BASIC DATA

As all particulars regarding coverage, etc., of the livestock censuses held almost quinquennially since 1920 onwards were given in detail in the earlier paper (Avadhani et al., 1968), only relevant information in respect of data available on sheep, goats, etc., is given briefly in what follows.

In the reports brought out on the six livestock censuses held before Independence throughout British India and some of the erstwhile native Indian States, only State-wise data were given. However, district-wise information regarding horses and ponies

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under the heads (*i*) horses, (*ii*) mares and (*iii*) youngstock (colts and fillies), and the total number of sheep, goats, mules, donkeys and camels was presented in Table V of Agricultural Statistics of India (1920-40) and Indian Agricultural Statistics (1945), Vols. 1 and 2, Government of India. But such data pertaining to pigs and poultry were not available in any of the reports/publications under reference even in respect of the total stock/fowls although these had been collected since the Fourth Livestock Census held in 1935. It was stated in these publications that livestock in cities and cantonments were included whenever it was possible to secure their enumeration. Obviously, this policy of collection of data is very arbitrary and adds to the multiplicity of factors which contribute to non-sampling errors.

In the publications entitled "Indian Livestock Census" Vols. I and II, which relate to 1951 and subsequent quinquennial censuses held after Indepedence, data were given for all-India with State-wise and district-wise details. Further, information was recorded under more detailed classifications than in the preceding six census reports/ publications as described in what follows.

In the 1951 census data on sheep and goats, horses and ponies, and donkeys were tabulated under the heads (*i*) upto 1 year, (*ii*) 1 to 3 years, and (*iii*) over 3 years, and the last two age categories were futher sub-classified according to sex. Information on mules, camels and also pigs was however recorded only in respect of total number of stock. Data were also collected on poultry and classified into (*a*) fowls and (*b*) ducks, fowls being further divided into (*i*) hens, (*ii*) cocks, and (*iii*) chickens, and ducks into (*i*) ducks, (*ii*) drakes, and (*iii*) ducklings.

In the censuses held in 1956 and the two subsequent quinquennia information on livestock and poultry was recorded separately for rural and urban areas. Besides, some modifications were introduced in the classification of stock also. Whereas sheep and goats were differentiated according to sex and divided into the groups (*i*) upto 1 year and (*ii*) over one year, donkeys were recorded only according to sex. In regard to horses and ponies, mules, camels, pigs and poultry the same classification as in 1951 was used in 1956 excepting that in the case of horses and ponies the age category 'upto 1 year' was further divided sex-wise. In the 1961 and 1966 censuses information on horses and ponies, pigs and poultry was tabulated under the same heads as in 1956, but mules were classified

into (*i*) upto 3 years and (*ii*) over 3 years, and camels into (*i*) 4 years and under and (*ii*) over 4 years with sex.

It is clear from the preceding description that although data were available on all livestock and poultry under somewhat detailed classification in the four censuses held after Independence, information only in respect of total number of stock/fowls can be used in a study on trends due to lack of such a classified data in the censuses carried out prior to 1951.

Requisite information on ovines, horses and ponies, donkeys and mules, and camels was collected separately for the chunk which lies in the region south of Vindhya and Satpura ranges, and the 108 selected districts in the region north of these ranges, which were considered in the earlier study on trends in the bovine population (Avadhani et al., 1968). This was done to ensure that the trend study was not affected by changes in the geographical content of areas for which figures were taken. Agricultural Statistics of India, Vols. 1 and 2, 1920-40, Indian Agricultural Statistics, Vol. 1 and 2, 1945 and Indian Livestock Census, Vols. 2, 1956 and 61 constituted the source of the data. But, it may be pointed out here that information from 1966 census could not be obtained separately for the South and the North as district-wise classified data are not yet published. Further, for all the districts in Bihar and West Bengal for the year 1935, Madhya Pradesh and the Punjab (undivided) for 1925, and Uttar Pradesh for 1940 for which census was not taken, substitutions by linear interpolation between the next later and previous counts had to be made. The data so assembled constitute the basis of the present investigation.

Since the methodological aspect of the problem has been discussed in detail by Avadhani et al. (1968), only the results pertaining to the trends in the numbers of sheep, goats, etc., are discussed in the following section.

3. Trends in Ovine, Other Livestock and Poultry Populations

As there were only 9 observations for each of the populations of sheep, goats, etc., no meaningful rigorous study could be made to examine the existence or otherwise of cyclical fluctuations in the series. A direct examination of the data on different stock did not indicate any cyclical movements. So to ensure minimum loss of

points on the graph, which is essential for the present study, the simple 3-period moving average technique was employed to get the approximations to the true trend components.

To choose suitable growth curves for determining the trends separately in the South and the North the respective moving averages were plotted on a graph for each type of stock. It is seen from these graphs that in most of the cases the depressions (or elevations) in the curves in one region are matched with elevations (or depressions) in the other region. So to eliminate the effects of migration the figures pertaining to the chunk in the South and the selected districts in the North for any given type of stock were scaled up to the levels of the respective regions on the basis of the 1961 census data and then were pooled to get the series from 1921 to 1961 which refers to the country as a whole. The imputed all-India series so obtained for each type of stock was then used together with the respective 1966 census count given in Agriculture in Brief (1968), Ninth Edition, for determining the corresponding trend curve.

The 3-period moving averages worked out for each type of stock with reference to the all-India series from 1921 to 1966 were first plotted on a graph and after close examination of these graphs appropriate curves were fitted to describe the trends. The results are presented in Table 1 and discussed separately for each type of stock in what follows.

3·1. Sheep

In this case even the fifth degree polynomial was found to explain only about 80 per cent of variation. A close scrutiny of the graph showed that the curve through the averages centred at 1946, 51,..., 61 was different in form from that passing through the points at 1926, 31,..., 41 as the curve in the former case has a quadratic curvature with concavity upwards and that in the latter has a curvature with concavity downwards. So attempts were made to fit two different curves to the two sets of four points each considered above. It was seen that whereas quadratic explained about 98 per cent of variation in the former case, it accounted only for about 50 per cent in the latter. The trend in the latest few quinquennia seems to be different from that of the earlier censuses. The latest four actual census counts of sheep available from 1951 onwards were used to describe the recent trend. With the help of the four census counts under reference the 3-period moving averages centred at 1956

and 61, say y_1 and y_2 respectively, were worked out and using these the following exponential curve was fitted.

$$y=y_2\,(1+r)^t$$

where $r=(y_2-y_1)/y_1$ and t runs over 5-year units with $t=0$ at 1961. The equation of the curve is given in Table 1. In the recent past the number of sheep increased at the 'compound rate' of 0·25 million per quinquennium.

3·2. *Goats and Camels*

Cubic and quadratic functions were respectively found to be suitable to describe the trends in the growth of goats and camels as these curves explained about 98 per cent of variation in the respective populations. The equations of the trend curves are presented in Table 1 and the corresponding graphs are depicted in Charts I and II. It is seen from these charts that the number of goats decreased during the quinquennium 1941-46 and camels declined to a minimum around 1940. The decrease in the numbers of these stock was attributed to the effects of Second World War (cf. Livestock Census of India, 1945 p. (ii).)

3·3. *Horses and Ponies, and Donkeys and Mules*

The curve passing through the 3-period moving averages of the data referring to horses and ponies was seen to have a quadratic curvature with a declining trend (see Chart III). Hence it is reasonable to expect that quadratic would fit well in this case explaining a very high precentage of variation. But fitting a quadratic to the trend in question amounts to imply that the stock under consideration would become extinct after sometime, which does not seem to be tenable in view of the fact that these stock will be very much needed for the country in the foreseeable future even though to a very negligible extent. Therefore a search was made for a suitable trend in the exponential family of growth curves. It was found that an exponential function with a quadratic exponent having negative cofficient to the second degree term accounted for more than 99 per cent of variation. Hence it is clear from the equation of this curve, which is presented in Table 1, that the population would tend to be negligible in the long run but certainly not become extinct. As a result, it is felt meaningful to describe the trend in the growth of horses and ponies by this curve.

In regard to donkeys and mules it may be noted at the outset that even though data are available separately for each type of stock no suitable curves could be found to describe the trends in individual stock and therefore the two sets of information were combined. The curve passing through the moving averages was found to have similar curvature as in the case of horses and ponies. Since the stock in question are also required even in the long run as pack animals specially in the mountainous terrain of the country, the same approach as for horses and ponies was adopted to find out a meaningful trend in the growth of these stock. The equation of the growth curve which accounted for about 92 per cent of variation is shown in Table 1 and the corresponding graphs in Chart IV. It is seen from the equation of the growth curve in question (or from Chart IV) that the long run behaviour of the population of donkeys and mules would be similar to that of horses and ponies.

3·4. *Pigs and Poultry*

As earlier mentioned data on pigs and poultry are available only from 1951 onwards. With the help of the available four observations on pigs and poultry a limited study on the linearity of the trend was first carried out. The growth curve appeared to be non-linear in the case of pigs but linear for poultry. An exponential curve of the type fitted to sheep which is dependent on the 3-period moving averages centred at 1956 and 1961 was taken to describe the growth of pig population and the straight line passing through the two 3-period moving averages was fitted to popultry population. It may be remarked that this procedure appears to be reasonable owing to the fact that, since the original observations are subject to erratic fluctuations the trend fitted to the four points, even if it explains a very high percentage of variation, is likely to be less stable than the one based on the 3-period moving averages. The equations of the respective growth curves are presented in Table 1. It is found from these equations that in the recent past the population of pigs increased at a 'compound rate' of 0·038 million per quinquennium and of poultry at the linear rate of 14 million per 5 years.

The utility of the trends in the growth of ovine, other livestock and poultry populations which are presented in Table 1 for the purpose of projecting the respective populations was also examined and the results are described in the following section.

4. APPLICATIONS

Assuming that the growth rates governing the trends in the numbers of sheep, horses and ponies, donkeys and mules, camels, pigs and poultry which are presented in Table 1 persist in future, the respective projections were worked out for 1966 and 1974 and are shown in Table 2 together with the corresponding 1966 census counts.

In the case of goats if the growth governing the trend curve given in Table 1 is taken to hold good in future, the population would work out to 674 million in 2011 which is too large to be meaningful specially in view of the fact that there does not exist any taboo against slaughter of these stocks. So attempts were made to fit a logistic curve for which cubic could provide a fairly good approximation. But logistic did not fit well. Also, since there exists competition between bovines and the goat population, an examination was made to see if any relationship exists between these populations first by working out the proportion of goats to bovines at 1921,..., 1966 and then fitting a trend. No reasonable conclusions could be drawn as a result of this study. Hence for the purpose of working out projections of the goat population the growth as observed in the last four censuses is assumed to hold in the next decade. Since the growth in goat numbers is found to be linear during this period, the line, *viz.*,

$$y = 48{\cdot}677 + 5{\cdot}798x', \text{ with } x' = 1 \text{ at } 1956,$$

which passes through the 3-period moving averages centred at 1956 and 1961, was used for working out the projections. The projections of goat population so obtained are shown in Table 2.

It is seen from Table 2 that the projected populations of sheep, goats, horses and ponies, donkeys and mules, camels and pigs for 1966 are almost in agreement with the respective 1966 census counts when considered to the nearest million. But in the case of poultry the projected figures for 1965 exceed the corresponding census count by about seven million. In 1974 total ovines and other livestock would be of the order of about 127 million and poultry about 144 million. The percentage increases in total ovines and other livestock, and poultry during the period of eight years from 1966 would be about 10 and 20 respectively.

5. SUMMARY

All the quinquennial census data available since 1920 onwards on ovines, other livestock and poultry were sifted and analysed.

Appropriate trends in the growth of these stock were determined. The utility of these growth curves for purpose of working out projections was examined.

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TABLE 1

Trends in the growth of Ovine, Other Livestock and Poultry Populations

Type of Stock/ Fowls	*Growth Curve*	*Variation explained (%)*
Ovines		
Sheep	$y=40.493\ (1+0.0249)^t$	—
Goats	$y=33.2786\ +12.6701x-3.0970x^2+0.2431x^2$	98.5
Other Livestock		
Horses and Ponies	$\log_{10} y=0.34851+0.00657x-0.00435x^2$	99.8
Donkey and Mules	$\log_{10} y=0.09551+0.01518x-0.00298x^2$	92
Camels	$y=0.7897-0.1431x+0.0195x^2$	99
Pigs	$y=5.027\ (1+0.0376)^t$	—
Total Poultry	$y=80.321+13.841x'$	—

Scale : y in millions, 1 unit for $t\equiv 5$ yrs. with $t=0$ at 1961, 1 unit for $x\equiv 5$ yrs. with $x=1$ at 1926 and 1 unit for $x'\equiv 5$ yrs. with $x'=1$ at 1956.

TABLE 2

Projections of Ovine, Other Livestock and Poultry Populations (in millions)

Type of Stock/Fowls	*1966**	*1966*	*1974*
Ovines			
Sheep	42.01	41.51	43.18
Goats	64.55	66.07	75.35
Other Livestock			
Horses and Ponies	1.15	1.14	0.85
Donkeys and Mules	1.13	0.98	0.83
Camels	1.03	1.08	0.46
Pigs	4.97	5.22	5.53
Total Ovines and Other Livestock	114.84	116.00	127.20
Total Poultry	115.07	121.84	143.99

*Actual census count.