INTRODUCTION

Punjab is the leading agrarian state of the country. It not only contributes a large chunk in the pool of grain stock but its contribution towards milk production in the country is also very significant. Dairying in the recent decades has been considered as a vital component in the diversification of agriculture and it has progressively been receiving increased emphasis in the recent years. There is growing realization that promotion of dairying not only contributes towards national health building, but also creates substantial employment opportunities. As a matter of fact, growth in employment in dairy has compensated for the fall in labour employment in the crop sector (Sidhu and Bhullar, 2004). Various factors like per capita incomes of the people, development of processing facilities as well as expansion in the milk collecting facilities at the door steps of the farmers through village level milk cooperative societies and increase in the milk prices due to increased demand which provided incentives to the farmers to adopt dairy for enhancing incomes significantly influenced the increase in milk production. There has been a substantial increase in milch cattle population in the state from 8,87,500 in 1977 to 10,28,476 in 2010 and in milch buffaloes from 20,48,800 to 30,06,629 during the period from 1977 to 2010. It is encouraging to learn that milk production in the state has increased from 3.32 million tones in 1980-81 to 9.38 million tones in 2009-10 with just three percent of India’s milch animals. Such a big leap in the milk production may be attributed through increase in the number of animals or through effective improvement in the productivity and better utilization of stock. So the contribution of these components viz. number of milch animals and productivity of these animals has been studied with a view to analyze the relative importance of these two determinants of milk production. Therefore, the present study is an attempt to examine (a) compositional changes in bovine population, (b) the trends in the growth of milk output and the sources of milk output growth.

MATERIALS AND METHODS

The study is based upon secondary data collected from various published sources such as Statistical Abstracts of Punjab and Livestock Censuses of Punjab. Besides tabular analysis, per annum growth rates were computed to indicate an increase or decrease in bovine population during inter-census periods as follows.
\[
\frac{P_t}{P_0} = \left(1 + \frac{r}{100}\right)^t
\]

where

\(P_t\) is bovine population in the \(t^{th}\) period.
\(P_0\) is the bovine population in the base year
\(r\) is the compound growth rate and,
\(t\) is the time in years.

In case of milk production, the compound growth rates have been computed by fitting exponential function of the form as the time series data without any gaps was available.

\[Y = AB^t\]

Where \(Y\) is the variable for which the growth rate is to be worked out
\(t\) is the time
\(B = 1+r\), where \(r\) is the compound growth rate and, \(A\) is constant.

To analyze the relative contribution of bovine population and increase in milk yield to growth in milk production, 'The 'Additive Decomposition Model' developed by Minhas and Vaidyanathan (1965) was used.

The model is as under:

\[M_t - M_{t-1} = (P_t - P_{t-1}) Y_{t-1} + (Y_t - Y_{t-1}) P_{t-1} + (P_t - P_{t-1}) (Y_t - Y_{t-1})\]

Where

'M' refers to total milk production by species.
'\(P\)' refers to population of in-milk animals
'\(Y\)' refers to yield per in milk animal
't' and 't-1' refers to the terminal and base years respectively.

To examine the productivity of milch bovines, lactation efficiency was worked out as under:

\[
\text{Lactation efficiency} = \frac{\text{Adult female bovine numbers in milk}}{\text{Total adult female bovines}}
\]

RESULTS AND DISCUSSION

**Bovine Population : Composition and Growth**

This section examines the growth and compositional changes in total bovine population. Total bovine population in Punjab during different inter census period is presented in Table 1.

Bovine population in Punjab increased from 7421.80 thousands in 1977 to 8810.5 thousands in 1997 and then declined to 8033 thousands during 2003 and 6796.55 thousands in the year 2007 showing annual compound growth rate of 0.86 per cent between the years 1977 and 1997 but decline in the population at the rate of 2.56 percent per annum during 1997 to 2007. Total bovine population declined at the rate of 0.29 percent per annum during 1977-2007. Buffalo population in Punjab recorded 0.68 per cent annual growth rate during 1977-2007 while the stock of cattle declined at the rate of 2.08 per cent during the same period. The sharpest decline was witnessed in the population of indigenous cattle i.e. at the compound growth rate of 6.09 per cent per annum. The composition of bovine population has also changed over the last three decades. The composition based on breed shows that due to fast growth of buffaloes and negative growth of cattle, their respective shares in 2007 turned out to be 74.09 per cent and 25.91 per cent in the total bovine population. The trends in the size and composition of the bovine stock in the state shows that a shift has taken place in favour of more productive milch animals. The population of less productive bovines (indigenous cattle) has declined whereas that of productive animals like crossbred cows and buffaloes has increased.

**Compositional Changes and Growth Rate of Adult Bovine**

Bovine population which comprises buffaloes and cattle was further classified on the basis of sex, age and the purpose for which these animals are reared. Growth and composition of adult bovine in Punjab during inter census periods is presented in Table 2.

Stock of adult male bovine, referred as work animals declined by almost four times between 1977 and 2007 which means a negative annual compound growth rate of 5.05 per cent. The rate of decline was slightly higher for buffaloes as compared to cattle. In 2007, the work animals constituted 77.82 per cent of cattle and 22.18 per cent of buffaloes. The reason for sharp decline in the stock of adult male bovine was the large scale mechanization of agriculture in the state making this section of bovine population redundant. Stock of adult female, which are reared mainly for milch purpose and to some extent for breeding purposes, increased from 3110.7 thousands in 1977 to 5049.9 thousands.
in 1997 and then declined to 4217 thousands in 2003 and 3870.34 thousands in 2007 witnessing annual growth rate of 0.73 per cent. The population of in milk bovine increased at the rate of 1.11 per cent per year during the same period. The total number of cows increased during intervening period but again declined later on. It is interesting to note that the number of indigenous cows declined very sharply while the number of crossbred cows increased at the annual compound growth rate of 0.06 per cent between 1990-2007 indicating a replacement of indigenous cows by crossbred cows.

Stock of other bovines consisting of permanently dry and infertile cows and buffaloes declined from 66.7 thousand to 43.63 thousand with the negative annual growth of 1.40 per cent during 1977 to 2007. However, the stock of adult bovine which had not calved even after attaining the age of calving increased up to 2003 but found declined in 2007.

Classification of adult female bovine based on species indicates that stock of buffaloes increased at the rate of 1.06 per cent per annum whereas the stock of indigenous cows experienced negative growth exceeding 5.00 per cent per annum. The growth rate comes to be -0.17 per cent when crossbred cows are also included. These...
differences in growth rates raised the share of buffaloes, in adult female bovine maintained for milk and breeding purpose from 69.63 per cent in 1977 to 76.82 per cent in 2007.

About 18.43 per cent bovine reared for milk purpose during 2007 were crossbred cows. Another silver lining is that the proportion of in milk cows and buffaloes has increased from 62.26 per cent to 69.83 per cent during this period indicating a qualitative increase in the total bovine stock.

**Growth in milk production**

Milk production and per capita availability of milk in Punjab is presented in Table 3. Over the last decades, the state has progressed leaps and bound in its milk production. The state currently occupies a much higher position in milk production owing to sustained and concerted efforts towards total dairy development in the state. A significant growth in total milk production in the state was observed during the last decades. The total milk production in 1980-81 was 3.22 million tonnes which increased to 9.38 million tonnes during 2009-10. Punjab produces about 8.64 per cent of the country's total milk production. The growth is on account of both improvements in productivity and shift in priorities towards buffalo and crossbred cattle.

It is remarkable to note that the per capita per day availability showed a substantial increase from 541 gms to 944 gms during the said period which is much higher as compared to the national average of 258 gms per day. Further increases in per capita income and changing consumption pattern would lead to acceleration in demand for milk and milk products in the state and thus would give a boost to this sector (Radha Krishan and Ravi, 1994; Gandhi and Mani, 1995; Kumar, 1998 and Dastagiri, 2001).

The growth in milk production in different phases of Operation Flood (OF) Programme in the state is presented in Table 4. During OF-I (1970-71 to 1980-81), the milk production in the state increased significantly at the rate of 4.49 per cent per annum.

The rate of growth in milk production during OF-II slowed down but in the third phase, it jumped at the rate of 4.86 per cent. The overall rate of growth of milk production during the period 1980-81 to 2009-10 was observed to be 3.96 per cent in the state, slightly less than the national level growth rate of 4.27 per cent.

The production of milk depends upon the

| Table 3 : Milk production and per capita availability of milk in Punjab |
|---|---|---|---|
| Year | Punjab | India |
| | Milk production (million tonnes) | Per capita availability (gms/day) | Milk production (million tonnes) | Per capita availability (gms/day) |
| 1980-81 | 3.22 (10.18) | 541 | 31.6 | 128 |
| 1985-86 | 4.03 (9.16) | 597 | 44.0 | 160 |
| 1990-91 | 5.14 (9.53) | 682 | 53.9 | 176 |
| 1995-96 | 6.42 (9.69) | 798 | 66.2 | 197 |
| 2000-01 | 7.77 (9.64) | 870 | 80.6 | 220 |
| 2005-06 | 8.90 (9.16) | 930 | 97.1 | 241 |
| 2009-10 | 9.38 (8.64) | 944 | 108.46 | 258 |

Figures in parentheses are percentages to all India milk production.

| Table 4: Growth in production of milk during Operation Flood Programme in Punjab and India (%) |
|---|---|---|---|
| Operation : Flood Programme Period | Punjab | India |
| Phase I : 1970-71 to 1980-81 | 4.49* | 4.51* |
| Phase II : 1980-81 to 1984-85 | 4.46* | 6.91* |
| Phase III : 1985-86 to 1995-96 | 4.86* | 4.23* |
| Post OF : 1996-97 to 2005-06 | 2.80* | 3.65* |
| After OF I: 1980-81 to 2009-10 | 3.96* | 4.27* |

Source: Statistical Abstract, Punjab, various issues
Note: * Compound growth rates significant at one per cent level.
productivity of milch animals and the total breedable population. Productivity of milch animals was considered on the basis of two factors (a) average milk yield per milch animal (b) ratio of adult females in milk to total adult females known as lactation efficiency. As the average milk yield per indigenous cow, crossbred cow and buffalo in milk was 5.64 kgs, 10.54 kgs and 8.51 kgs respectively during 2009-10 in the state which was found to be more than the national average of 2.14 kgs per indigenous cow, 6.87 kgs per crossbred cow, and 4.57 kgs per buffalo (GOI, AH Statistics, 2010). It can be inferred that the average productivity went up substantially in case of cows. There is an increase in the yield of buffaloes also but it is less sharp than that of crossbred cows. Buffaloes have higher yields than indigenous cows but crossbred cows are more productive than either indigenous cows or buffaloes. The lactation efficiency of dairy animals has also improved overtime in state. Among these milch animals, buffaloes and crossbred cows had the highest lactation efficiency as compared to indigenous cows. Lactating efficiency in crossbred cows was 62.46 percent in 1990 which increased to 65.13 percent, 71.49 and 75.29 percent in 1997, 2005 and 2010 respectively while in case of buffaloes it increased from 63.48 percent to 65.49, 72.32 and 73.71 percent respectively during the said period indicating qualitative improvement in the breeds of milch animals.

**Sources of Growth in Milk Production**

Increase in the population and the productivity of milch animal are the two sources of growth in milk production. About 109.72 per cent of the growth in bovine milk production between 1990-2010 was due to yield effect, the effect of population (-5.05 %) and interaction effect(-4.67%) were found to be negative (Table 5). The contribution of yield effect increased from 70.66 per cent during 1990-97 to 99.44 and 383.07 per cent during 1997-2005 and 2005-10 respectively. The contribution of population effect showed a declining trend i.e. from 23.28 per cent in 1990-97 to 0.45 per cent during 1997-2005 and then became negative i.e. -235.20 per cent during 2005-10. The same trend was observed in case of interaction effect. It declined from 6.06 per cent during 1990-97 to 0.11 per cent and became negative i.e. -4.67 per cent during 1997-2005 and 2005-10, respectively. The dominance of the yield effect was true in the growth of milk production from cows as well as buffaloes.

A comparison of the relative contribution of the sources of growth in the production of cow and buffalo milk revealed (Table 5) that from 1990-97 the contribution of population effect in case of cow milk was found to be negative during the period of 1990-97 and 1997-2005 (-20.16% and -41.10% respectively) but became positive (27.12%) during 2005-10. Yield effect emerged as a very strong factor in the growth of cow milk production. The contribution of yield was 132.30 per cent during 1990-97 and it jumped to 149.61 per cent during 1997-2005, showing a very significant increase in the yield levels of cow milk. The contribution of yield effect was found to be 67.06 percent during the period of 2005-10. The contribution of yield effect for the total period i.e. from 1990-2010 was 115.71 per cent. The contribution of interaction effect came out to be negative i.e. -12.14% and -8.51 % respectively during the periods 1990-97 and 1997-2005 but became positive (5.22%) during 2005-2010. It can be inferred that in case of cow

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Table 5 : Percentage contribution of in-milk bovine population, productivity growth and the interaction between productivity and population to growth in milk production
milk production, the contribution of yield factor consolidated over time and the effect of population weakened.

In case of buffalo milk, both population and yield were major contributing factors during 1990-97 but its contribution declined in subsequent periods. During 1990-97 the contribution of population effect was 46.03 per cent, it then declined to 7.08 per cent during 1997-2005 and became negative (-631.07%) during 2005-10. The per cent contribution of yield effect in case of buffalo milk during 1990-97 was 45.38 per cent and it increased to 91.03 percent and 657.44 percent during 1997-2005 and 2005-2010 respectively. Overall, the contribution of yield effect was 106.73 per cent during 1990-2010 and that of population effect was negative i.e.-3.78 per cent during the same period. The contribution of interaction effect was observed to be negative (-2.95%) for buffalo milk production during 1990-2010.

CONCLUSION
The Punjab state possesses a very high milk production potential in the country due to its many favourable endowments. The trends in the size and composition of the bovine stock in the state indicate that a shift has taken place in favour of more productive milch animals. The proportion of female bovines in the total bovine population has increased steadily. The proportion of crossbred cattle in the total cattle was found to be about 80 percent during 2007. Lactation efficiency in crossbred cows was 75.29 percent in 2010 while in case of buffaloes it was 73.71 percent, indicating qualitative improvement in the breeds of milch animals. The population of less productive bovines (indigenous cattle) has declined whereas the productive animals like crossbred cows and buffaloes has increased i.e. distribution of animals have shifted from low to high milk yield animals. The state currently occupies a much higher position in milk production owing to sustained and concerted efforts towards dairy development in the state. Milk production grew at the compound growth rate of 3.96 percent per annum during 1980-81 and 2009-10. A structural shift in the composition of milk production has also taken place in the state. The contribution of yield effect was found most pronounced in the growth of milk production from cows as well as buffaloes. The productivity of milch animals, as measured by their yields, indicated a steady increase, reflecting the positive contribution of technological change in breeding and feeding.

REFERENCES
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