A

PERSISTENCY OF MILK YIELD IN PANDHARPURI BUFFALO

By

Miss. Sheela Damodar Mane

(Reg. No. 0152)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA, INDIA

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE AND DAIRY SCIENCE

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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APPROVED BY

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DEPARTMENT OF ANIMAL SCIENCE AND DAIRY SCIENCE

POST GRADUATE INSTITUTE
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RAHURI - 413 722
2003

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

Place : MPKV, Rahuri

(Miss. S.D. Mane)

Dated : 24/06/2003.

Dr. B.R. Ulmek
Head,
Department of Animal Science
and Dairy Science
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar
Maharashtra State (INDIA)

CERTIFICATE

This is to certify that the thesis entitled, **"Persistency of milk yield in Pandharpuri buffalo"**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **ANIMAL SCIENCE**, embodies the results of a piece of *bona fide* research work carried out by **Miss. Sheela Damodar Mane,** under my guidance and supervision and that no part of this thesis has been submitted for award of any other degree, diploma or publication.

The assistance and help received during the course of this investigation has been duly acknowledged.

Place : M.P.K.V.,Rahuri

Dated :24/ 06 /2003.

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Research Guide

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Associate Dean,
Post Graduate Institute,
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Maharashtra State (INDIA)

CERTIFICATE

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Place : M.P.K.V.,Rahuri

Dated :30 / 06 /2003.

(D.M. Sawant)

ACKNOWLEDGEMENTS

It is a fortunate and extremely honoured for the opportunity bestowed upon me to work under the versatile and intellectual guidance of my research guide Dr. B.R. Ulmek, Head, Department of Animal Science and Dairy Science, M.P.K.V., Rahuri who beside suggesting the research problem offered scholastic guidance and took keen interest throughout the course of this investigation.

I am also thankful to Dr. Y.G. Fulpagare, Associate Professor, Department of Animal Science and Dairy Science and Dr. U.Y. Bhoite, Assistant Professor, RCDP on cattle and my advisory committee members for their advice during my research work.

It is indeed a great pleasure for me to express my sincere thanks to Dr. D.P. Kaledhonkar, Assistant Professor, Department of Statistics, M.P.K.V., Rahuri and member of my advisory committee, for the valuable help during statistical analysis and scientific guidance for course of investigation.

I am highly obliged to Prof. B.G. Suryawanshi, Assistant Professor of Animal Science and Dairy Science, NARP and Prof. A.S. Jadhav for providing data and help rendered during this investigation.

I extend my thanks to Shri. Farande, Shri. Gut, Shri. lad, Shri. Zuge and all the staff members of Department of Animal Science and Dairy Science, M.P.K.V., Rahuri.

I am deeply thankful to Shri. R.L. Bhagat and Shri. Phadke, Bhartiya Agro-Industrial Foundation (BAIF), Urulikanchan, Pune for help rendered during statistical analysis.

I would like to express my sincere appreciation to my colleagues for their companionship during the study period and for their help during the course of this study.

No words are enough to express my heartiest feeling of love, gratitude and indebtedness to my dear friend Shashi for moral support, untiring continuous help, inspiration and bearing all sorts of

inconvenience caused during the entire period of bright and dark phases of my work.

My humble support towards the completion of studies entirely owes it's origin to the divine inspiration, I always derived from my family. I hardly find any word to express my heartiest gratitude and immense indebtedness to my parents Aai and Tatya for providing me to a learned post graduate citizen and build up my educational career. I will fail in my duty, if I do not express my deep sence of gratitude to my elder sister Tai, Jiju and Grandmother for their goodwill and constant inspiration throughout my educational carrier. The enthusiastic, cheerful and selfless encouragement of my dear sister Vaishu, Sheetal and brother Bablu has been invaluable to me. Last but not least all my own goes to them all.

While travelling on the path of life and education, many hands pushed me forth, learned hearts put me on the right path, enlighten by their knowledge and experience, I ever remain thankful to them all.

I am highly obliged to the authors past and present, whose literature has been cited.

Place : M.P.K.V., Rahuri (Sheela D. Mane)

Dated :24/06/2003.

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LIST OF ABBREVIATIONS

BFG	:	50 % Brown Swiss + 25 % Holstein Friesian + 25 % Gir
BS	:	100 % Brown Swiss
DAPMY	:	Days to attain peak milk yield
DP	:	Dry period
FG	:	50 % Holstein Friesian + 50 % Gir
FJG	:	50 % Holstein Friesian + 25 % Jersey + 25 % Gir
HF	:	100 % Holstein Friesian
J	:	100 % Jersey
JFG	:	50 % Jersey + 25 % Holstein Friesian + 25 % Gir
JG	:	50 % Jersey + 50 % Gir
LL	:	Lactation length
LMY	:	Lactation milk yield
M.S.	:	Maharashtra state
M.S.L.	:	Mean sea level
PMY	:	Peak milk yield
300 DMY	:	300- Days milk yield

ABSTRACT

PERSISTENCY OF MILK YIELD IN PANDHARPURI BUFFALO

By

Miss. Sheela Damodar Mane

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)
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2003

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The normal records pertaining to persistency of milk yield and milk production traits on 32 Pandharpuri buffaloes maintained at Zonal Agricultural Research Station, Shenda Park, Kolhapur over 11 years (1992-2002) were analysed to study the effect of period of calving, season of calving, lactation order and stage of lactation. The data were also analysed to form paritywise lactation curves.

Least squares means for persistency of milk yield estimated by Method-I (Mahadevan, 1951), Method-II (Ludwick and Peterson, 1943) and Method-III (McDowell *et al.*, 1961) were 9.89 $\pm$ 6.39, 0.88 $\pm$ 0.03 and 71.75 $\pm$ 3.59 per cent, respectively. Least squares means for milk production traits *viz.*, lactation milk yield, 300-days milk yield, peak milk yield, days to attain peak yield,

lactation length and dry period were 1315.36 ± 143.39 kg, 1219.55 ± 111.68 kg, 6.82 ± 0.40 kg, 53.82 ± 13.33 days, 296.79 ± 34.62 days and 120.73 ± 30.33 days, respectively.

Period of calving and season of calving significantly affect the persistency of milk yield (Method-III). The analysis of variance revealed that the period of calving had significant effect on peak milk yield and dry period. Season of calving had significant influence on days to attain peak yield.

The least squares mean for persistency of milk yield (Method-III) was 71.75 per cent. This indicates that Pandharpuri buffalo maintain relatively high level of production throughout the lactation period.

Critical study of the curve revealed that Gamma type function curve was more close to the observed lactation curve although R^2 value of inverse polynomial was higher than of gamma function. Gamma type function fitted best for Pandharpuri buffalo.

INTRODUCTION

1. INTRODUCTION

Cow and buffalo are the two main pillars that have contributed to the growth of the different nations by enriching the wealth of dairy sector. The cow and buffalo contribute 85.7 and 10.6 % to the total world milk production (557 million tons), respectively. Today, India's cattle and buffalo population is 214 million and 94 million, respectively [Patil, 2003].

In Maharashtra, buffalo contributes less than 25% of total bovine population (54.5 lakh). The increase in the buffalo population during last three decade (1961-1992) comes to the tune of 76.4%, which indicate it's utility for the rural masses in the state.

Pandharpuri buffalo is an important milch breed in scarcity and sub-mountain zone of M.S. Almost 3.5 lakh Pandharpuri buffaloes are present in the state. The information on Pandharpuri buffalo will be very useful for the future planning and genetic improvement of non-descript buffaloes in M.S. The breed of buffalo is named after the Pandharpur town of Solapur district.

Some buffaloes exhibited the tendency to maintain the rate of milk secretion for a longer time. Whereas, others tended to drop milk yield and dry off within a few weeks after parturition. The former are called persistent and the latter, non-persistent buffaloes. Thus, persistency of milk yield is the ability to maintain a relatively high level of production throughout the lactation period. This ability contributes a great deal towards the income from operating and producing herd.

As a matter of fact, persistency alone accounts for more than 60% of the variations in milk production and along with initial yield it accounts for more than 95% of the total variation (Saxena and Kumar, 1960). Naturally, persistent buffalo produce more milk yield than non-persistent one. The main practice then is to discard the non-persistent one and keep the persistent buffalo in a herd.

Persistency is closely related to some economic traits *viz*; lactation milk yield, 300-days milk yield, peak milk yield, days to attain peak milk yield, lactation period, dry period etc. These economic traits have been considered as criteria for selection of buffaloes.

Lactation curve refers to the graphical presentation of milk produced during a lactation period. Lactation curve is the daily or weekly change in the milk production. It consists of two phases *viz*; rising phase and declining phase. These phases are obtained as a consequence of initial increase in metabolic activities of animal. It starts with a certain level of milk production, known as initial milk yield. Initial milk yield though affected considerably by the physiological, nutritional and managemental factors, is a good indicator of genetic potential of the animal. Peak milk yield, which symbolizes the maximum level of physiological activity measures the inherent capability of an animal to raise it's milk production level in the prevailing (favorable or adverse) circumstances to the highest possible level.

Ascending phase also denotes the hereditary capacity of the individual in comparatively favorable conditions. Whereas, descending phase measures it's strength to antagonize the effect of adverse conditions.

Such type of studies on the lactation curves were scanty on buffaloes. The present study about lactation curve and accordingly fitness of suitable mathematical model will serve as a guideline prediction of lactation milk yield in Pandharpuri buffaloes. The investigation aims at studying the relative efficiency of some of the mathematical models, *viz*; linear, exponential, parabolic exponential, gamma and inverse polynomial function. The present study was undertaken with the following objectives:

1) To estimate the persistency of milk yield in Pandharpuri buffalo.
2) To study the production traits in Pandharpuri buffalo.
3) To predict lactation curve in Pandharpuri buffalo.

Pandharpuri buffalo

3B

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The available information on persistency of milk yield, milk production traits and lactation curve in buffalo and cattle have been reviewed in the following paragraphs:

2.1 PERSISTENCY OF MILK YIELD

A. Method-I (Mahadevan, 1951)

Rao et al. (1970) estimated persistency of milk yield as 1.74 to 1.99 and 1.88 to 2.10 in Murrah buffaloes at Mathura and Babugarh farm, respectively.

B. Method-II (Ludwick and Peterson, 1943)

The least squares mean reported for persistency of milk yield was 0.698±0.014 in Murrah buffalo (Gajbhiye and Tripathi, 1999).

C. Method-III (Mc Dowell et al., 1961)

Persistency of milk yield observed by Mahto et al. (1981) were 97.33±0.83, 95.83±0.84 and 96.52±0.79 % in Hariana crosses with HF, J and BS, respectively.

Least squares means observed in the literature for persistency of milk yield in different breeds of buffalo and cattle have been presented in Table 1.

Table 1. Average persistency of milk yield in different breeds of buffalo and cattle

Breed	Persistency	Author
Method-I		
Sahiwal	3.05 ±0.05	Sharma (1972)
Brown-Swiss	3.028 ±0.06	Sharma (1972)
Murrah	1.23 ±0.0076	Kumar et al. (1979)
Jersey x Hariana	4.439 ±0.08	Koley et al. (1979)
Indian buffalo	0.807 ±0.012	Garcha and Tiwana (1980)
Gir	3.92 ±0.00	Jain et al. (1981)
HF	2.72 ±0.61	Queiroz et al. (1991)
Iraqi buffalo	26.1 ±0.9	Juma et al. (1993)
Murrah	1.47 ±0.018	Gajbhiye and Tripathi (1999)
Method-II		
Brown-Swiss	0.874 ±0.01	Sharma (1972)
Sahiwal	0.803 ±0.01	Sharma (1972)
Red Sindhi	0.767 ±0.02	Sharma (1972)
Murrah	0.673 ±0.006 to 4.63 ±0.109	Bhat et al. (1982)
Murrah 1st lactation 2nd lactation 3rd lactation 4th lactation	 0.9745± 0.0017 0.9766 ±0.0018 0.9745 ±0.0017 0.9593 ±0.0036	Malhotra et al. (1984)
Jersey	0.938 ±0.010	Roy and Katpatal (1987)
Method-III (%)		
HF	66.0 ±13.0	Zamorano (1986)
HF	92.7	Caetano et al. (1982)
HF	74.58	Tocut and Pillo (1978)
Rathi	85.80 ±0.01	Qureshi et al. (1993)

2.1.1 Effect of period of calving

Period of calving had significant effect on persistency of milk yield in Murrah buffalo (Garcha and Tiwana, 1980) and Indian buffalo (Bhat and Kumar, 1979). Similar results were also reported by Dave et al. (1974), Malhotra et al. (1984), Gajbhiye and Tripathi (1999) and Kumar et al. (1979) in Murrah buffalo and Juma et al. (1993) in Iraqi buffalo.

2.1.2 Effect of season of calving

Season of calving had significant effect on persistency of milk yield in Murrah buffalo (Gajbhiye and Tripathi, 1999 and Malhotra et al., 1984). However, Khan et al. (1980), Koley et al. (1979), Dave et al. (1974) and Juma et al. (1993) found that season of calving did not influence the persistency of milk yield in Murrah buffalo, Jersey x Hariana, Murrah and Iraqi buffaloes, respectively.

2.1.3 Effect of lactation order

Persistency of milk yield was significantly affected by lactation order in Murrah buffalo (Garcha and Tiwana, 1980; Malhotra et al., 1984; Gajbhiye and Tripathi, 1999 and Kumar et al., 1979), Friesian crossbred cattle (Shah et al., 1983), Indian buffalo (Bhat and Kumar, 1979) and Iraqi buffalo (Juma et al., 1993).

2.2 Lactation milk yield

Average lactation milk yield (975.9 ± 23.9) was recorded by Sharma and Singh (1978) in Bhadawari buffalo during 1st lactation. However, Vij and Tiwana (1986) reported 2272.4 ± 22.42 kg lactation milk yield in Indian buffalo.

Lactation milk yield reported by several workers in different breeds of buffalo have been summarized in Table 2.

Table 2. Average LMY in different breeds of buffalo

Breed	LMY (kg)	Author
Murrah	1725.48 ±10.71	Sane et al. (1972)
Murrah	1728.24 ±8.03	Jawarkar and Johar (1975)
Indian buffalo 1st lactation	1709.45 ±16.41	Kanaujia and Balaine (1975)
Murrah	1921.31	Lall (1975)
Murrah	1476·26	Gurnani et al. (1976)
Murrah	1953·36	Boikovski (1977)
Murrah	1925·44	Polikhronov et al. (1977)
Bulgarian buffalo	1462·7.9	Polikhronov et al. (1977)
Murrah x bulgarian	1789·30	Polikhronov et al. (1977)
Murrah	1647.34 ±19.23	Basu and Ghai (1978)
Indian buffalo	1732.91 ±29.23	Garcha and Tiwana (1980)
Murrah	1717.93 ±61.16	Khan et al. (1980)
Indian buffalo	1732.91 ±29.34	Garcha and Tiwana (1981)
Murrah 1st lactation	1546.62	Jain and Taneja (1982)
Egyptian buffalo	2112 ±51.9	EL Kaschab et al. (1984)
Iraqi buffalo	1434.22 ±28.71	Juma and AL Samarai (1985)
Surti	1256.6 ±18.7	Govindhaiah and Rai (1986)
Murrah	1999.1 ±67.30	Sitorus et al. (1986)
Elite buffalo	3079.00	Tiwana et al. (1986)
Murrah	1342.2 ±28.3	Agarwal et al. (1987)
Medium sized buffalo	1267.2 ±88.4	Govindhaiah and Rai (1987)
Pakistani buffalo	1582 ±19.2	Gondal (1987)
Medium sized buffalo	1006.22 ±16.57	Tailor and Jain (1987)
Nili-Ravi buffalo	1929.10 ±91.05	Choudhary et al. (1988)
Nili-Ravi buffalo	1889.80 ±67	Dutt and Yadav (1988)
Murrah	2057.0 ±63.3	Prakash and Tripathi (1990)
Murrah (Coastal area)	1372.93 ±15.98	Sharma et al. (1990)
Murrah (Hilly area)	1350.67 ±18.14	Sharma et al. (1990)
Murrah1st lactation	2040.5 ±51.9	Singh and Rathi (1990)
Egyptian buffalo	1510 ±561	Mourad et al. (1991)
Murrah	2070.65± 31.13	Rohilla et al. (1992)
Mehsana buffalo	1711.6 ±29.1	Gajbhiye et al. (1994)
Murrah 1st lactation	1905.9 ±27.18	Dass and Sadana (1999)

2.2.1 Effect of period of calving

Significant variation in lactation milk yield due to period of calving were reported in Murrah buffalo (Garcha and Tiwana, 1980; Jain and Taneja, 1982; Lall, 1975; Jawarkar and Johar, 1975; Basu and Ghai, 1978; Vij and Tiwana, 1986; Prakash and Tripathi, 1990; Rohilla et al. 1992 and Dass and Sadana, 1999). Kanaujia and Balaine (1975) in Indian buffalo during 1st lactation, Dutt and Yadav (1988) in Nili-Ravi buffalo, Gajbhiye et al. (1994) in Mehsana buffalo and Mourad et al. (1991) in Egyptian buffalo, also found significant effect of period on lactation milk yield.

2.2.2 Effect of season of calving

Season of calving significantly influenced lactation milk yield in Murrah buffalo (Dani and Gaikwad, 1972; Sane et al., 1972; Gurnani *et al.*, 1976; Garcha and Tiwana, 1980; Sitorus et al., 1986; Vij and Tiwana, 1986; Agarwal et al., 1987; Prakash and Tripathi, 1990 and Dass and Sadana, 1999). Similar results were also reported in Pakistani buffalo (Gondal, 1987), Medium sized buffalo (Tailor and Jain, 1987), Indian buffalo (Patro and Bhat, 1979), Mehsana buffalo (Gajbhiye et al., 1994) and Egyptian buffalo (Mourad et al., 1991).

On the contrary, Jain and Taneja (1982) and Rohilla et al. (1992) observed non significant influence of season of calving lactation

milk yield in Murrah buffalo. Similar results were reported in Nili-Ravi buffalo (Dutt and Yadav, 1988) and Indian buffalo in 1st lactation (Kanaujia and Balaine, 1975).

2.2.3 Effect of lactation order

Significant effect of lactation order on lactation milk yield were observed in Murrah buffalo by Sane et al. (1972), Jawarkar and Johar (1975), Basu and Ghai (1978), Garcha and Tiwana (1980), Vij and Tiwana (1986), Agarwal et al. (1987), Sharma et al. (1990), Prakash and Tripathi (1990) and Rohilla et al. (1992). Similar results were also reported by Kanaujia and Balaine (1975) and Patro and Bhat (1979) in Indian buffalo, Gondal (1987) in Pakistani buffalo, Tailor and Jain (1987) in Medium sized buffalo and Mourad et al. (1991) in Egyptian buffalo.

However, contradictory result was obtained in Murrah buffalo (Gurnani et al. 1976).

2.3 300-days milk yield

Rohilla et al. (1992) and Bansode (1992) reported the average 300-days milk yield in Murrah buffalo as 2027.69 and 1625.19 kg, respectively.

The average 300-days milk yield reported by several investigators in different breeds of buffalo have been presented in Table 3.

Table 3. Average 300-DMY in different breeds of buffalo

Breed	300-DMY (kg)	Author
Indian buffalo		Patro and Bhat (1979)
1st lactation	1573.4± 22.21	
2nd lactation	1790.4± 27.74	
3rd lactation	1878.0 ±36.25	
4th lactation	1963.8 ±45.56	
5th lactation	1959.7 ±67.51	
6th lactation	1767.5 ±89.0	
Murrah(1st lactation)	1456.58	Jain and Taneja (1982)
Egyptian buffalo	2015.2± 46.8	EL Kaschab et al. (1984)
Murrah	1242.1 ±29.7	Agarwal et al. (1987)
Medium sized buffalo	1064.8 ±52.1	Govindhaiah and Rai (1987)
Nili-Ravi buffalo	1819.66 ±74.43	Choudhary et al. (1988)
Murrah	1962.1 ±49.2	Prakash and Tripathi (1990)
Murrah 1st lactation	1963.5 ±38.6	Singh and Rathi (1990)
Pakistani buffalo	2219.64 ±11.22	Khan et al. (1991)
Egyptian buffalo	1459 ±522	Mourad et al. (1991)
Mehsana	1623.4± 24.9	Gajbhiye et al. (1994)
Murrah(1st lactation)	1752.62 ±21.22	Dass and Sadana (1999)

2.3.1 Effect of period of calving

Jain and Taneja (1982), Rohilla et al. (1992) and Das and Sadana (1999) reported that variations in 300-days milk yield were attributed to the period of calving in Murrah buffalo. Same inferences were reported by Khan et al. (1991) in Pakistani buffalo and Mourad et al. (1991) in Nilli-Ravi buffalo, Gajbhiye et al. (1994) in Mehsana buffalo and Vij and Tiwana (1986) in Indian buffalo. However, Bansode (1992) found that the trait did not differ significantly due to period of calving in Murrah buffalo.

2.3.2 Effect of season of calving

Differences associated with the season of calving in 300-days milk yield were significant in Murrah buffalo (Agarwal et al., 1987 and Prakash and Tripathi, 1990). These results were in agreement with those reported by Gajbhiye et al. (1994) in Mehsana buffalo, Khan *et al.* (1991) in Pakistani buffalo and Mourad *et al.* (1991) in Egyptian buffalo.

Whereas, Jain and Taneja (1982), Bansode (1992), Rohilla et al. (1992) and Dass and Sadana (1999) reported that season did not affect the trait in Murrah buffalo. Similar result was also reported in Indian buffalo (Vij and Tiwana, 1986).

2.3.3 Effect of lactation order

Lactation order had significant effect on 300-days milk yield in Murrah buffalo (Agarwal et al., 1987; Prakash and Tripathi, 1990 and Rohilla et al., 1992). These results confirmed with that of Vij and Tiwana (1986) and Mourad et al. (1991) in Indian and Egyptian buffalo, respectively. They further reported that the 300-days milk yield during succeeding lactation was significantly higher than preceeding lactation upto fourth lactation which declined thereafter.

2.4 Peak milk yield

The average peak milk yield in Murrah buffalo were observed to be 8.23 ±0.06 and 12.88±0.12 kg by Sane et al. (1972) and Rohilla et al. (1992), respectively.

Peak milk yield observed by several authors in different breeds of buffalo have been presented in Table 4.

Table 4. Average PMY in different breeds of buffalo

Breed	PMY (kg)	Author
Indian buffalo	10.85± 0.13	Garcha and Tiwana (1980)
Mehsani and Surti	7.62 ±0.14	Choudhary and Choudhary (1981)
Indian buffalo	10.85 ±0.13	Garcha and Tiwana (1981)
Surti	6.6± 0.1	Govindhaiah and Rai (1986)
Elite buffalo	15.0± 0.00	Tiwana et al. (1986)
Indian buffalo	12.5 ±0.07	Vij and Tiwana (1986)
Medium sized buffalo	5.4 ±0.1	Govindhaiah and Rai (1987)
Murrah	11.21± 0.19	Prakash and Tripathi (1987)
Surti	6.50 ±0.15	Biradar (1990)
Murrah (1st lactation)	9.61 ±0.1	Singh and Rathi (1990)

2.4.1 Effect of period of calving

Period of calving significantly influenced the peak milk yield in Indian buffalo (Garcha and Tiwana, 1980 and Vij and Tiwana, 1986) and Murrah buffalo (Rohilla et al., 1992 and Dass and Sadana, 1999). Similar result was obtained by Biradar (1990) in Surti buffalo. Whereas, Choudhary and Choudhary (1981) and Prakash and Tripathi (1987) found non-significant effect of period of calving in Murrah and Mehsana and Surti buffalo, respectively.

2.4.2 Effect of season of calving

Sane et al. (1972), Agarwal et al. (1987) and Rohilla et al. (1992) observed significant variation in peak milk yield of Murrah buffalo due to season of calving. Similar inferences were drawn by Biradar (1990) in Surti buffalo. However, non-significant effect of season of calving on peak milk yield were observed by Choudhary and Choudhary (1981) in Mehsana and Surti buffalo and Vij and Tiwana (1986) in Indian buffalo. Prakash and Tripathi (1987) and Dass and Sadana (1999) also observed similar results in Murrah buffalo.

2.4.3 Effect of lactation order

Lactation order had significant effect on peak milk yield in Indian buffalo (Garcha and Tiwana, 1980 and Vij and Tiwana, 1986), Murrah buffalo (Sane et al., 1972; Agarwal et al., 1987; Prakash and Tripathi, 1987 and Rohilla et al., 1992) and in Surti buffalo (Biradar, 1990). On the contrary, Choudhary and Choudhary (1981) observed non-significant effect on trait in Mehsana and Surti buffalo.

2.5 Days to attain peak milk yield

Average days to attain peak milk yield reported by several authors in different breeds of buffalo have been summarized in Table 5.

Table 5. Average DAPMY in different breeds of buffalo

Breed	DAPMY (days)	Author
Indian buffalo	48.26±1.63	Garcha and Tiwana (1981)
Mehsana and Surti	48.32 ±3.03	Choudhary and Choudhary (1981)
Surti	33.0 ±1.00	Govindhaiah and Rai (1986)
Indian buffalo	50.4 ±0.97	Vij and Tiwana (1986)
Medium sized buffalo	52.6 ±5.1	Govindhaiah and Rai (1987)
Murrah	44.3 ±2.3	Prakash and Tripathi (1987)
Surti	36.04 ±1.75	Biradar (1990)
Murrah	52.88 ±1.62	Rohilla et al. (1992)

2.5.1 Effect of period of calving

Period of calving had significant effect on days to attain peak milk yield in Indian buffalo (Garcha and Tiwana, 1980 and Vij and Tiwana, 1986) and Murrah buffalo (Rohilla et al., 1992). On the contrary, non-significant influence of period of calving on days to attain peak milk yield were reported in Murrah buffalo (Prakash and Tripathi, 1987) and Mehsana and Surti buffalo (Choudhary and Choudhary, 1981).

2.5.2 Effect of season of calving

Season of calving had significant effect on days to attain peak milk yield in Indian buffalo (Garcha and Tiwana, 1980) and Murrah buffalo (Agarwal et al., 1987). Whereas, Prakash and Tripathi (1987) and Rohilla et al. (1992) reported non-significant effect of season of calving on peak milk yield in Murrah buffalo. Choudhary and Choudhary (1981) in Mehsana and Surti buffalo and Vij and Tiwana (1986) in Indian buffalo also reported similar results.

2.5.3 Effect of lactation order

Variations associated with the lactation order in number of days to attain peak milk yield were significant in Indian buffalo (Garcha and Tiwana, 1980 and Vij and Tiwana, 1986), Murrah buffalo (Agarwal et al., 1987 and Prakash and Tripathi, 1987) and Surti buffalo (Biradar, 1990). However, Rohilla et al. (1992) did not found significant effect of lactation order on the trait in Murrah buffalo. This result was confirmed by Choudhary and Choudhary (1981) in Mehsana and Surti buffalo.

2.6 Lactation length

The least squares means for lactation length reported in the literature were 315.0 ±0.00 (Lall, 1975), 291± 4.0 (Boikovski, 1977) and 375.10± 11.15 days (Khan et al., 1980) in Murrah buffalo. Lactation length reported by several authors in different breeds of buffalo have been summarized in Table 6.

Table 6. Average LL in different breeds of buffalo

Breed	LL (days)	Author
Indian buffalo	303.83 ±1.97	Kanaujia and Balaine (1975)
Murrah	267.4 ±3.4	Gurnani et al. (1976)
Murrah	285	Basu and Ghai (1978)
Indian buffalo	286.31 ±2.47	Kumar and Bhat (1978)
Indian buffalo	320.10 ±3.84	Garcha and Tiwana (1980)
Indian buffalo	320.10± 3.84	Garcha and Tiwana (1981)

Table 6 Contd...

Breed	LL (days)	Author
Murrah (1st lactation)	322.93 ±7.88	Jain and Taneja (1982)
Egyptian buffalo	309.2 ±8.1	EL Kaschab et al. (1984)
Iraqi buffalo	272.77 ±2.5	Juma and AL Samarai (1985)
Surti	342.2± 3.8	Govindhaiah and Rai (1986)
Murrah	264.0 ±7.5	Sitorus et al. (1986)
Elite buffalo	354.0	Tiwana et al. (1986)
Indian buffalo	329.7± 2.74	Vij and Tiwana (1986)
Medium sized buffalo	373.7 ±19.5	Govindhaiah and Rai (1987)
Medium sized buffalo	256.05 ±4.77	Tailor and Jain (1987)
Nili-Ravi buffalo	297.80 ±10.85	Choudhary et al. (1988)
Murrah	307.9 ±8	Prakash and Tripathi (1990)
Murrah (hilly area)	307.72 ±4.9	Sharma et al. (1990)
Murrah	291.83 ±4.41	Rohilla et al. (1992)
Surti	261.3	Tailor et al. (1992)
Mehsana	310.69 ±3.81	Gajbhiye et al. (1994)
Murrah	300.96 ±5.69	Chhikara et al. (1995)
Murrah (1st lactation)	324.99 ±3.36	Dass and Sadana (1999)

2.6.1 Effect of period of calving

Significant effect of period of calving on lactation length was reported in Murrah buffalo (Lall, 1975; Jain and Taneja, 1982; Rohilla et al., 1992; Chhikara et al., 1995 and Dass and Sadana, 1999) and in Indian buffalo (Kanaujia and Balaine, 1975; Patro and Bhat, 1979 and Garcha and Tiwana, 1980). Similar result was observed by Gajbhiye et al. (1994) in Mehsana buffalo. However, non-significant influence of period of calving on the trait was reported in Indian buffalo (Kumar and Bhat, 1978).

2.6.2 Effect of season of calving

Significant effect of season of calving on lactation length was reported in Murrah buffalo (Gurnani et al., 1976; Jain and Taneja, 1982; Sitorus et al., 1986 and Rohilla et al., 1992), Indian buffalo (Patro and Bhat, 1979 and Vij and Tiwana, 1986) and Italian buffalo (Roychoudhary *et al.*, 1971). Similar results were observed by Tailor and Jain (1987) and Tailor et al. (1992) in Medium sized and Surti buffalo, respectively. EL Kaschab et al. (1984) and Gajbhiye et al. (1994) also noticed the similar results in Egyptian and Mehsana buffalo, respectively. The contrary results were observed by Agarwal et al. (1987), Chhikara et al. (1995) and Dass and Sadana (1999) in Murrah buffalo and by Kanaujia and Balaine (1975) and Kumar and Bhat (1978) in Indian buffalo.

2.6.3 Effect of order of lactation

Kanaujia and Balaine (1975) and Kumar and Bhat (1978) found significant effect of lactation order on lactation length in Indian buffalo. Similar results were reported by Roychoudhary et al. (1971) in Italian buffalo, Sitorus et al. (1986) in Murrah buffalo and Tailor et al. (1992) in Surti buffalo. On the contrary, non-significant effect of parity on the trait were observed by Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo, Gurnani et al. (1976), Agarwal et al. (1987), Prakash and Tripathi (1990), Rohilla et al. (1992) and Chhikara et al. (1995) in Murrah buffalo and Tailor and Jain (1987) in Medium sized buffalo.

2.7 Dry period

The average dry periods were 176 (Gurnani et al., 1976) and 219.3 days (Kandasamy et al., 1993) in Murrah buffalo. Least squares means of dry period as observed in the literature in different breeds of buffalo have been presented in Table 7.

Tables 7. Average DP in different breeds of buffalo

Breed	DP (days)	Author
Indian buffalo 1st lactation	195.90 ±3.80	Kanaujia and Balaine (1975)
Murrah	148.1 ±6.6	Polikhronov et al. (1977)
Bulgarian	135.8 ±1.11	Polikhronov et al. (1977)
Murrah x Bulgarian	144.5 ±4.1	Polikhronov et al. (1977)
Murrah (1st lactation)	217.04 ±14.9	Jain and Taneja (1982)
Egyptian buffalo	116.9 ±4.3	EL Kaschab et al. (1984)
Iraqi buffalo	158.99 ±4.68	Juma and AL Samarai (1985)
Elite buffalo	151.7 ±0.00	Tiwana et al. (1986)
Murrah	139.4 ±12.2	Agarwal et al. (1987)
Medium sized buffalo	288.6 ±26.3	Govindhaiah and Rai (1987)
Nili-Ravi buffalo	113.7 ±1.5	Shah et al. (1987)
Medium sized buffalo	205.49± 9.66	Tailor and Jain (1987)
Nili-Ravi buffalo	139.06 ±4.47	Dutt and Yadav (1988)
Murrah	127.3 ±10.0	Prakash and Tripathi (1990)
Murrah	180.57 ±9.04	Rohilla et al. (1992)
Surti	205.4	Tailor et al. (1992)
Murrah (1st lactation)	186.23 ±6.30	Dass and Sadana (1999)

2.7.1 Effect of period of calving

Period of calving had significant effect on dry period in Nili-Ravi buffalo (Dutt and Yadav, 1988), Indian buffalo (Kanaujia and Balaine, 1975) and Murrah buffalo (Rohilla et al., 1992). However, Prakash and Tripathi (1990) and Dass and Sadana (1999) in Murrah buffalo found that the period of calving had non-significant effect on dry period.

2.7.2 Effect of season of calving

Dani and Gaikwad (1972), Agarwal et al. (1987), Kandasamy et al. (1993) and Dass and Sadana (1999) noticed significant effect of season of calving on dry period in Murrah buffalo. Similar results were also noticed by EL Kaschab et al. (1984), Tailor and Jain (1987) and Dutt and Yadav (1988) in Egyptian buffalo, Medium sized and Nili-Ravi buffalo, respectively. Gurnani et al. (1976), Jain and Taneja (1982), Prakash and Tripathi (1990) and Rohilla et al. (1992) in Murrah buffalo and Kanaujia and Balaine (1975) in Indian buffalo found non-significant effect of season of calving on dry period.

2.7.3 Effect of lactation order

Lactation order had significant effect on dry period in Murrah buffalo (Gurnani et al., 1976; Jain and Taneja, 1982; Rohilla et al., 1992 and Kandasamy et al., 1993) and Medium sized buffalo (Tailor and Jain, 1987). However, Kanaujia and Balaine (1975) in Indian buffalo and Agarwal et al. (1987) in Murrah buffalo reported contrary results.

2.8 Pattern of Lactation curve

Kumar and Bhat (1978) and Kumar and Bhat (1981) in Indian buffalo, Gahlot et al. (1988) in Rathi cow, Bagherwal and Khan (1990) in Murrah buffalo and Roy and Katpatal (1993) in Jersey cattle observed that inverse polynomial function was superior in describing the lactation curve.

However, Kumar and Bhat (1979) observed that parabolic exponential function was the best fit in describing the lactation curve in Indian buffalo. Gamma function was found to be the best fit for describing lactation curve in Indian buffalo (Bhat and Kumar, 1978) and Murrah buffalo (Basavaiah and Nagarcenkar, 1982; Cheema and Basu, 1983 and Gajbhiye and Tripathi, 1992).

2.8.1 Paritywise lactation curve

Rao (1977) in Sahiwal and Ulmek (1991) in Gir cattle observed that the values of goodness of fit for the different parities were consistently smaller for first lactation as compared to later lactations based on the average lactation curve. Singh and Bhat (1978) in Hariana cattle reported the variability of average lactation curves for the exponential function, which accounted for 74.49% at the lowest level (first lactation) and 98.38% at the highest level (sixth lactation).

MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1 Source of data

The data pertaining to the milk production efficiency traits of 32 Pandharpuri buffaloes for 111 lactations maintained at the National Agricultural Research Project, Zonal Agricultural Research Station, Shenda Park, Kolhapur (M.S.) were utilized for the present investigation.

3.1.1 Location and climate

The Zonal Agricultural Research Station, Shenda park is situated in Kolhapur corporation area to south of city on National highway No.4. It approximately lies between 16^0 43' North latitude and 74^0 14' East longitude at an elevation of 574 mts. above M.S.L.

Relative humidity for the period under study was 63%. Average annual rainfall recorded during the period was 1168.96 mm. Maximum and minimum temperature during the period ranged 30.19^{0}C to 17.19^{0}C.

3.1.2 History of herd

A research sub-project on Pandharpuri buffalo at Zonal Agricultural Research Station, Shenda park, Kolhapur (M.S.) was started on January, 1992.

The main objective of the project was to evaluate the performance of Pandharpuri buffalo in respect to important economical productive and reproductive traits under existing feeding and management condition.

3.1.3 General management practices

The animals were housed in conventional housing system. The separate barns were provided for young calves and breeding buffalo bulls. The green fodder fed to the animals throughout the year included Maize, Jawar, Cowpea, Grasses, Oat etc. The major source of dry fodder used for feeding was Jawar kadbi, Maiz, Paddy and Wheat straw. The concentrate mixture used for feeding of buffaloes as per their nutritional requirement. All prophylactic measures were followed as a routine, management practice.

3.2 Collection of data

The observations regarding persistency, production traits and lactation curves for 32 Pandharpuri buffaloes were collected from history cum pedigree sheets and daily milk recording sheets maintained over a period of 11 years (1992-2002).

The following traits were considered for the present investigation:

i. Lactation milk yield (LMY)
ii. 300-days milk yield (300-DMY)
iii. Peak milk yield (PMY)
iv. Days to attain peak milk yield (DAPMY)
v. Lactation length (LL)
vi. Dry period (DP)

3.3 Standardization of data

Records of abnormal cases like abortion and death were not included in the study.

3.4 Classification of data

The persistency of milk yield and milk production traits obtained were classified according to the period of calving, season of calving and lactation order.

3.4.1 Period of calving

The periods are formed assuming that year-to-year differences within a period due to different conditions of climatic cycles, fodder and feed availability and managemental skill available would be small. Hence the entire span of 11 years was divided into 3 periods as follows:

Sr. No.	Period of calving (yr)	Code
1.	1992-95	P1
2.	1996-98	P2
3.	1999-02	P3

3.4.2 Season of calving

The year was divided into three seasons based on climatic condition and coded as:

Sr. No.	Season of calving (month)	Code
1.	Rainy (June-September)	S1
2.	Winter (October-January)	S2
3.	Summer (Feb.-May)	S3

3.4.3 Lactation order

The lactation orders were considered upto first eight lactation and coded as:

Sr. No.	Lactation order	Code
1.	1st lactation	L1
2.	2nd lactation	L2
3.	3rd lactation	L3
4.	4th lactation	L4
5.	5th lactation	L5
6.	6th lactation	L6
7.	7th lactation	L7
8.	8th lactation	L8

3.5 Statistical methods

3.5.1 Estimation of persistency of milk yield

Persistency of milk yield was calculated by three methods.

3.5.1.1 Method-I (Mahadevan, 1951)

The method developed by Mahadevan (1951) and used by Saxena and Kumar (1960) was used for estimation of persistency of milk yield as follows:

$$P = (A-B) / B$$

Where,

P = Persistency of milk yield,

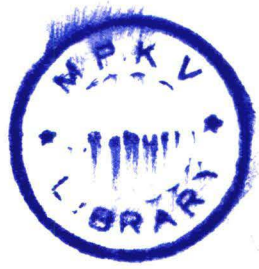
A = Total lactation milk yield,

B = Initial milk yield upto the attainment of peak yield.

3.5.1.2 **Method-II** (Ludwick and Peterson, 1943)

The method developed by Ludwick and Peterson (1943) and utilized by Asker and Bedeir (1961) and Bhat and Kumar (1978) was used for estimation of persistency of milk yield. In this case, persistency 'P' may be defined as summation of the consecutive ratios obtained by comparing production of each individual sub-division of the lactation period with the proceeding ones as follows:

$$\mathbf{P = R_1K_1 + R_2K_2 + R_3K_3}$$



$R_1 = X_2/X_1$, $R_2 = X_3/X_2$ and $R_3 = X_4/X_3$

$K_1 = R_1/R_1+R_2+R_3$, $K_2 = R_2/R_1+R_2+R_3$ and $K_3 = R_3/R_1+R_2+R_3$

Where,

P = Persistency of milk yield,

R = Ratios of two successive milk yield observations of lactation (R_1, R_2,R_3),

X_1 = Milk yield during the period of 2nd & 3rd month,

X_2 = Milk yield during the period of 4th & 5th month,

X_3 = Milk yield during the period of 6th & 7th month,

X_4 = Milk yield during the period of 8th & 9th month.

The constants K_1, K_2 and K_3 represents the weights of the three ratios i.e. X_2/X_1, X_3/X_2 and X_4/X_3.

3.5.1.3 **Method-III** (McDowell et al., 1961)

The method developed by McDowell et al. (1961) and utilized by Lahiri et al. (1981) was used for estimating the persistency of milk yield, which is as under:

$$\% P = 2 S (X > \bar{X}) - n \bar{X} / Sx \times 100$$

Where,

% P = Per cent persistency of milk yield,

S ($X > \bar{X}$) = Sum of yield for 30 days period greater than average 30 days yield for the lactation,

n = Number of periods when 30 days yield exceed to average for the lactation,

Sx = Sum of all 30 days yield,

$\bar{X}$ = Average yield for all 30 days period.

3.5.2 Least squares analysis

In order to overcome non-orthogonality of the data resulting from unequal number of observations and disproportionate sub-class frequencies and to study the various non-genetic factors, the least squares technique (Harvey, 1966) by fitting constants was used. For estimation of the effect of non-genetic factors, the following biometrical model was used:

Least squares analysis of variance for non-genetic factors

$$Y_{ijkm} = \mu + A_i + B_j + C_k + E_{ijkm}$$

Where,

Y_{ijkm} = Persistency of milk yield and production traits of m^{th} month of i^{th} period of calving, j^{th} season of calving and k^{th} lactation order

μ = Overall mean

A_i = Effect of i^{th} period of calving (i = 1, 2 and 3)

B_j = Effect of j^{th} season of calving (j = 1, 2 and 3)

C_k = Effect of k^{th} lactation order (k = 1, 2, ……,8)

E_{ijkm} = The random error, NID with mean and variance $(0, \delta^2 e)$, respectively.

3.5.3 Comparison method

The statistical significance of various fixed effects were tested by F-test. Whenever the effects were significant the differences between means were tested for significance by t-test.

3.5.4 Pattern of lactation curve

Five mathematical models viz., linear, exponential, parabolic exponential, inverse polynomial and gamma type were examined for fitting of lactation curve.

3.5.4.1 Linear function

$$Yt = a + bt$$

Where,

Yt = Average milk yield in t^{th} month of lactation

t = Number of month of lactation

b = Average slope of ascent (persistency measure)

a = Constant of intercept (theoretical value of Y at t = 0)

3.5.4.2 Exponential function

The mathematical model of this function is given below (Brody, 1923):

$$Yt = ae^{-bt}$$

Where,

Yt = Average milk yield in t^{th} month of lactation

t = Number of month of lactation

e = base of natural logarithm .

3.5.4.3 Exponential parabolic function

The function was first used by Sikka (1950). The model is,

$$Yt = ae^{(b1t + b2t2)}$$

Where,

Yt = Average milk yield in t^{th} month of lactation

t = Number of month of lactation

b_1 = Accounts for a linear decline

b_2 = Accounts for the parabolic terms

3.5.4.4 Inverse polynomial function

This function was first used by Nelder (1966). The mathematical model is as follows;

$$Yt = t\,(b_0+b_1t+b_2t^2)^{-1}$$

Where,

Yt = Average milk yield in t^{th} month of lactation

t = Number of month of lactation

b_1 and b_2 describe the ascending and descending phase, respectively and

b_0 = the theoretical value at the time of parturition.

3.5.4.5 Gamma type function

This function was given by Wood (1967).

$$Yt = at^be^{-ct}$$

Where,

Yt = Average milk yield in t^{th} month of lactation

t = Number of month of lactation

b and c describe the ascending and descending phase, respectively.

The efficiencies of the above functions were compared by coefficient of determination (R^2) and net and absolute deviation between observed and expected milk yield at monthly intervals.

The statistical analysis were carried out at Department of Statistics, MPKV, Rahuri.

3.6 Place of research work

Department of Animal Science and Dairy Science MPKV, Rahuri, Dist. Ahmednagar.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The results obtained in the present investigation, entitled "Persistency of milk yield in Pandharpuri buffalo," presented and have been discussed in this chapter.

4.1 Persistency of milk yield

The persistency of milk yield was calculated by three different methods *viz.*, Method-I (Mahadevan, 1951), Method-II (Ludwick and Peterson, 1943) and Method-III (McDowell *et al.*, 1961) in Pandharpuri buffalo.

A. Method-I (Mahadevan, 1951)

The least squares mean for persistency of milk yield estimated by this method was 9.89 $\pm$ 6.39 (Table 8). The lower values of persistency of milk yield than present value were reported by Rao *et al.* (1970) in Murrah buffalo, Sharma (1972) in Sahiwal and Brown Swiss cattle, Kumar *et al.* (1979) in Murrah buffalo, Koley *et al.* (1979) in Jersey x Hariana, Garcha and Tiwana (1980) in Indian buffalo, Jain *et al.* (1981) in Gir, Queiroz *et al.* (1991) in HF and Gajbhiye and Tripathi (1999) in Murrah buffalo (Table 1). While, higher value of persistency of milk yield (26.1 $\pm$ 0.9) was reported by Juma *et al.* (1993) in Iraqi buffalo. The higher persistency index might be due to earlier attainment of peak yield and it's continuation for a greater part of the lactation period.

B. Method-II (Ludwick and Peterson, 1943)

The persistency of milk yield estimated by this method was 0.88 $\pm$ 0.03 (Table 8).

Table 8. Least squares means and standard error for the factors affecting persistency of milk yield in Pandharpuri buffalo

Source of variation	Code	No.	Persistency of milk yield		
			Method-I	Method-II	Method-III
Overall	μ	112	9.89 ± 6.39	0.88 ± 0.03	71.75 ± 3.59
Period of calving					
1992-95	P_1	49	7.41 ± 3.78	0.89 ± 0.03	70.40 ± 3.60^b
1996-98	P_2	35	12.81 ± 4.05	0.86 ± 0.03	77.73 ± 3.85^a
1999-02	P_3	28	9.44 ± 3.48	0.89 ± 0.02	67.13 ± 3.31^c
Season of calving					
Rainy (June-Sept.)	S_1	24	9.65 ± 3.95	0.89 ± 0.03	78.79 ± 3.75^a
Winter (Oct-Jan)	S_2	76	12.61 ± 2.83	0.86 ± 0.02	67.51 ± 2.69^b
Summer (Feb-May)	S_3	12	7.41 ± 5.22	0.88 ± 0.04	68.96 ± 4.97^b
Lactation order					
1st lactation	L_1	32	6.94 ± 3.54	0.90 ± 0.02	74.08 ± 3.37
2nd lactation	L_2	26	6.12 ± 3.51	0.88 ± 0.02	72.41 ± 3.34
3rd lactation	L_3	19	17.08 ± 4.35	0.85 ± 0.03	76.16 ± 4.13
4th lactation	L_4	15	8.47 ± 4.74	0.89 ± 0.03	73.02 ± 4.50
5th lactation	L_5	9	12.63 ± 5.87	0.85 ± 0.04	73.92 ± 5.80
6th lactation	L_6	6	5.64 ± 7.07	0.89 ± 0.05	74.08 ± 6.73
7th lactation	L_7	3	16.00 ± 9.90	0.81 ± 0.07	70.32 ± 9.42
8th lactation	L_8	2	6.21 ± 12.14	0.91 ± 0.08	60.03 ± 11.55

Means under each class in the column with different superscript differed significantly.

The present value of persistency of milk yield was lower to those recorded by Sharma (1972) in Brown-Swiss, Sahiwal and Red Sindhi cattle and Bhat *et al.* (1982) and Gajbhiye and Tripathi (1999) in Murrah buffalo. However, higher values of persistency were observed by Malhotra *et al.* (1984) in Murrah buffalo and Roy and Katpatal (1987) in Jersey cattle (Table 1).

C. Method-III (McDowell *et al.*, 1961)

The overall estimate of persistency of milk yield was 71.75 ± 3.59 % in Pandharpuri buffalo (Table 8).

Almost similar result was reported by Tocut and Pillo (1978) in HF cattle. As compared to the present finding, the higher estimates for the trait were recorded by Mahto *et al.* (1981) in Hariana crosses with HF, J and BS; Caetano *et al.* (1982) in HF and Quereshi *et al.* (1993) in Rathi cattle. However, Zamorano (1986) noticed lower value of persistency of milk yield in HF cattle (Table 1).

4.1.1 Effect of period of calving

The least squares analysis of variance for persistency of milk yield revealed that period of calving had non-significant effect on persistency of milk yield by Method-I and Method-II (Table 9). While, significant effect in Method-III. The significant effect of period might be possibly due to variations in climatic, nutritional and managemental conditions in herd over the years.

Period of calving had significant effect on persistency of milk yield in Murrah buffalo (Garcha and Tiwana, 1980) and Indian buffalo (Bhat and Kumar, 1979). Similar results were reported by Dave *et al.* (1974),

Table 9. Least squares analysis of variance for persistency and milk production traits in Pandharpuri buffalo

Sr. No.	Traits	Source of variation							
		Period of calving		Season of calving		Lactation order		Error	
		d.f.	m.s.	d.f.	m.s.	d.f.	m.s.	d.f.	m.s.
1.	Persistency								
a.	Method-I	2	262.3980	2	158.7742	7	268.4922	100	267.3458
b.	Method-II	2	0.0146	2	0.0037	7	0.0089	100	0.0129
c.	Method-III	2	800.8829*	2	941.6076*	7	73.3250	100	241.9622
2.	LMY	2	279961.53	2	125557.89	7	196455.64	100	246716.23
3.	300-DMY	2	398476.44	2	14761.59	7	210873.54	100	157791.76
4.	PMY	2	7.7020*	2	0.8633	7	3.3731	100	1.9450
5.	DAPY	2	6122.1768	2	14580.7119*	7	3089.8945	100	2134.3186
6.	LL	2	1260.1200	2	3510.7974	7	9411.0904	100	11338.1598
7.	DP	2	47473.4453**	2	23874.6934	6	6763.5729	69	9434.7960

** = $P < 0.01$ * = $P < 0.05$

Malhotra *et al.* (1984), Gajbhiye and Tripathi (1999) and Kumar *et al.* (1979) in Murrah buffalo and Juma *et al.* (1993) in Iraqi buffalo.

The t-test revealed that buffaloes calved during P_3 had significantly lower persistency value calculated by Method-III (67.13 $\pm$ 3.31) than those calved during other periods (P_1 and P_2) and higher persistency of those calved during P_2 (77.73 $\pm$ 3.85 %).

4.1.2 Effect of season of calving

The effect of season of calving on persistency of milk yield were non-significant in the case of estimates obtained by Method-I and II. However, significant effect in Method-III (Table 9).

Persistency of milk yield by Method-I and II during all seasons did not differ from each other (Table 8). These results were in consonance with the findings of Dave *et al.* (1974), Koley *et al.* (1979), Khan *et al.* (1980) and Juma *et al.* (1993) in Murrah buffalo, Jersey x Hariana, Murrah and Iraqi buffalo, respectively. Whereas, significant results were reported in Murrah buffalo (Malhotra *et al.*, 1984 and Gajbhiye and Tripathi, 1999),

In the case of Method-III highest persistency value was observed during rainy season (78.79 $\pm$ 3.75 %) and lowest during the winter season (67.51 $\pm$ 2.69 %). Persistency of winter calver and summer calvers were at par with each other and both calvers significantly differed from rainy calver (Table 8). Season within year normally could have a significant effect on the persistency due to great variation in environmental conditions in the two seasons.

4.1.3 Effect of lactation order

Lactation order had non-significant effect on persistency of milk yield estimated by Method-I, II and III in Pandharpuri buffalo (Table 9).

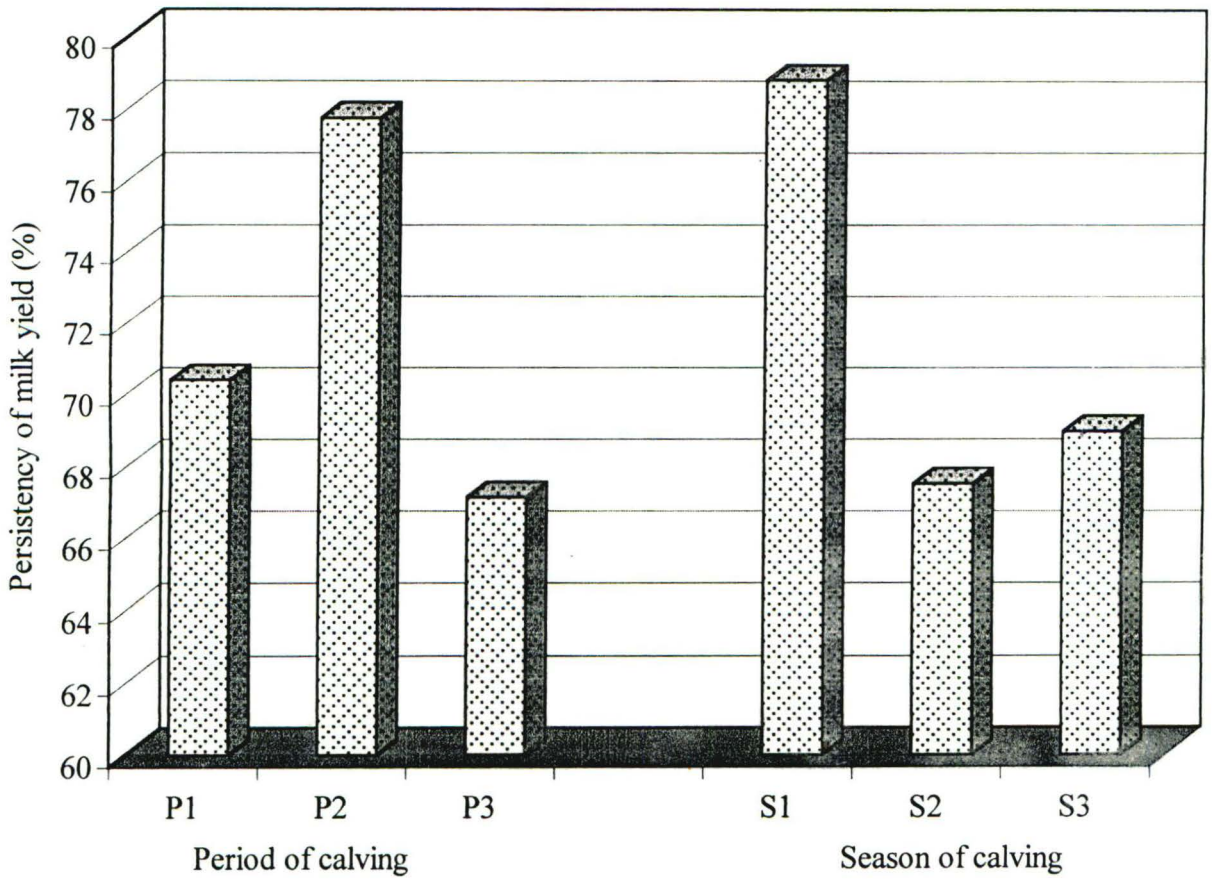


Fig. 1. Average persistency of milk yield (method III) in relation to period and season of calving

Whereas, significant effects of lactation order on the trait were reported by Kumar *et al.* (1979), Gracha and Tiwana (1980), Malhotra *et al.* (1984) and Gajbhiye and Tripathi (1999) in Murrah buffalo, Shah *et al.* (1983) in Friesian crossbred, Gill *et al.* (1970) in Hariana cattle, Bhat and Kumar (1979) in Indian buffalo and Juma *et al.* (1993) in Iraqi buffalo.

It was apparent from the persistency values estimated by Method-III that the highest persistency was in the third lactation (76.16 ± 4.13 %) and lowest in the eighth lactation (60.03 ± 11.55 %) (Table 8).

4.2 Lactation milk yield

The least squares means with standard error for lactation milk yield in Pandharpuri buffalo have been presented in Table 10.

The overall lactation milk yield in Pandharpuri buffalo was observed to be 1315.36 ± 143.39 kg. Almost similar results were reported in Murrah buffalo (Agarwal *et al.*, 1987 and Sharma *et al.*, 1990). However, the present value was higher than those reported by Sane *et al.* (1972), Jawarkar and Johar (1975), Lal (1975), Gurnani *et al.* (1976), Boikovski (1977), Polikhronov *et al.* (1977), Basu and Ghai (1978), Khan *et al.* (1980), Jain and Taneja (1982), Sitorus *et al.* (1986), Prakash and Tripathi (1990), Singh and Rathi (1990), Rohilla *et al.* (1992) and Dass and Sadana (1999) in Murrah buffalo, Kanaujia and Balaine (1975), Garcha and Tiwana (1980), Garcha and Tiwana (1981) and Vij and Tiwana (1986) in Indian buffalo, Polikhronov *et al.* (1977) in Bulgarian and Murrah x Bulgarian buffalo, EL Kaschab *et al.* (1984) in Egyptian buffalo, Juma and AL-Samarai (1985) in Iraqi buffalo, Tiwana *et al.* (1986) in Elite buffalo, Gondal (1987) in Pakistani buffalo, Choudhary *et al.* (1988) and Dutt and Yadav (1988) in Nili Ravi buffalo and Gajbhiye *et al.* (1994) in Mehsana buffalo. However, lower than those

observed by Sharma and Singh (1978) in Bhadawari buffalo during 1st lactation, Govindhaiah and Rai (1986) in Surti buffalo and Govindnaiah and Rai (1987) and Tailor and Jain (1987) in Medium sized buffalo (Table 2).

4.2.1 Effect of period of calving

The influence of period of calving on lactation milk yield was non-significant in Pandharpuri buffalo (Table 9).

However, contradictory results were reported in Murrah buffalo (Lall, 1975; Jawarkar and Johar, 1975; Basu and Ghai, 1978; Garcha and Tiwana, 1980; Jain and Taneja, 1982; Vij and Tiwana, 1986; Prakash and Tripathi, 1990; Rohilla *et al.*, 1992 and Dass and Sadana, 1999). Kanaujia and Balaine (1975) observed similar results in Indian buffalo during 1st lactation. Dutt and Yadav (1988) in Nili-Ravi buffalo, Mourad *et al.* (1991) in Egyptian buffalo and Gajbhiye *et al.* (1994) in Mehsana buffalo observed significant variations in lactation milk yield due to period of calving.

4.2.2 Effect of season of calving

The effect of season of calving on lactation milk yield was non-significant in Pandharpuri buffalo (Table 9).

Though, in lactation with yield the seasonal differences were non-significant, yet increasing trend was noticed in the buffaloes which calved during February-May.

These results were supported by the findings of Jain and Taneja (1982) and Rohilla *et al.* (1992) in Murrah buffalo, Kanaujia and Balaine (1975) in Indian buffalo and Dutt and Yadav (1988) in Nili-Ravi buffalo. On the contrary, the significant effects were reported by Dani and Gaikwad (1972), Sane *et al.* (1972), Garcha and Tiwana (1980), Gurnani *et al.* (1976), Sitorus *et al.* (1986), Vij and Tiwana (1986), Agarwal *et al.* (1987), Prakash

and Tripathi (1990) and Dass and Sadana (1999) in Murrah buffalo and Patro and Bhat (1979) in Indian buffalo, Gondal (1987) in Pakistani buffalo, Tailor and Jain (1987) in medium sized buffalo, Mourad *et al.* (1991) in Egyptian buffalo and Gajbhiye *et al.* (1994) in Mehsana buffalo.

4.2.3 Effect of lactation order

Lactation order had non-significant effect on lactation milk yield in Pandharpuri buffalo (Table 9). Similar result was reported by Gurnani *et al.* (1976) in Murrah buffalo. However, significant effect of lactation order on lactation milk yield were noticed in Murrah buffalo (Sane *et al.*, 1972; Jawarkar and Johar, 1975; Basu and Ghai, 1978; Garcha and Tiwana, 1980; Vij and Tiwana, 1986; Agarwal *et al.*, 1987; Sharma *et al.*, 1990; Prakash and Tripathi, 1990 and Rohilla *et al.*, 1992). Similar results were reported by Kanaujia and Balaine (1975) and Patro and Bhat (1979) in Indian buffalo, Gondal (1987) in Pakistani buffalo, Tailor and Jain (1987) in Medium sized buffalo, Mourad *et al.* (1991) in Egyptian buffalo and Yadav *et al.* (1994) in Tharparkar cattle.

4.3 300-Days milk yield

The overall least squares mean for 300 days milk yield was 1219.55 $\pm$ 111.68 kg in the present investigation (Table 10).

As compared to the present findings, the higher values for the trait were recorded by Patro and Bhat (1979) in Indian buffalo, Jain and Taneja (1982), Agarwal *et al.* (1987), Prakash and Tripathi (1990), Singh and Rathi (1990), Bansode (1992) and Rohilla *et al.* (1992) in Murrh buffalo, EL-Kaschab *et al.* (1984) and Mourad *et al.* (1991) in Eqyptian buffalo, Choudhary *et al.* (1988) in Nili-Ravi buffalo, Khan *et al.* (1991) in Pakistani buffalo, Gajbhiye *et al.* (1994) in Mehsana buffalo and Dass and Sadana

Table 10. Least squares means and standard error for the factors affecting LMY, 300-DMY and PMY in Pandharpuri buffalo

Source of variation	Code	No.	LMY (kg)	300 DMY (kg)	PMY (kg)
Overall mean	μ	112	1315.36 ± 143.39	1219.55 ± 111.68	6.82 ± 0.40
Period of calving					
1992-95	P_1	49	1426.50 ± 114.88	1352.01 ± 91.87	7.36 ± 0.32^{a}
1996-98	P_2	35	1274.06 ± 123.04	1202.10 ± 98.40	6.46 ± 0.35^{b}
1999-02	P_3	28	1245.53 ± 105.85	1104.55 ± 84.65	6.64 ± 0.30^{b}
Season of calving					
Rainy (June-Sept.)	S_1	24	1235.00 ± 119.89	1199.04 ± 95.88	7.00 ± 0.34
Winter (Oct-Jan)	S_2	76	1286.95 ± 85.98	1202.27 ± 68.76	6.93 ± 0.24
Summer (Feb-May)	S_3	12	1424.14 ± 158.59	1257.35 ± 126.83	6.53 ± 0.45
Lactation order					
1^{st} lactation	L_1	32	1236.66 ± 107.55	1063.38 ± 86.01	5.89 ± 0.30
2^{nd} lactation	L_2	26	1326.79 ± 106.75	1171.79 ± 85.37	6.79 ± 0.30
3^{rd} lactation	L_3	19	1309.58 ± 131.77	1192.91 ±105.38	6.41 ± 0.37
4^{th} lactation	L_4	15	1331.47 ± 143.88	1195.05 ± 115.06	6.15 ± 0.40
5^{th} lactation	L_5	9	1516.26 ± 178.33	1451.53 ± 142.61	7.32 ± 0.50
6^{th} lactation	L_6	6	1070.11 ± 215.02	1091.76 ± 171.96	6.81 ± 0.60
7^{th} lactation	L_7	3	1687.83 ± 300.75	1594.00 ± 240.52	7.18 ± 0.84
8^{th} lactation	L_8	2	1042.20 ± 368.77	996.02 ± 294.91	8.00 ± 1.04

Means under each class in the column with different superscript differed significantly.

(1999) in Murrah buffalo. However, lower value was obtained by Govindhaiah and Rai (1987) in medium sized buffalo (Table 3).

4.3.1 Effect of period of calving

The least square analysis of variance showed that the period of calving had non-significant effect on 300 days milk yield (Table 9).

Similar results were reported by Bansode (1992) in Murrah buffalo. However, significant differences in the trait due to period of calving were observed in Murrah buffalo (Jain and Taneja, 1982; Rohilla *et al.*, 1992 and Dass and Sadana, 1999), Pakistani buffalo (Khan *et al.*, 1991), Egyptian buffalo (Mourd *et al.*, 1991). Vij and Tiwana (1986) in Indian buffalo and Gajbhiye *et al.* (1994) in Mehsana buffalo.

4.3.2 Effect of season of calving

The effect of season of calving on 300 days milk yield was found to be non-significant in Pandharpuri buffalo (Table 9).

These results were in agreement with those reported by Jain and Taneja (1982), Rohilla *et al.* (1992), Bansode (1992) and Dass and Sadana (1999) in Murrah buffalo and Vij and Tiwana (1986) in Indian buffalo. However, contrardictory results were obtained by Prakash and Tripathi (1990), Agarwal *et al.* (1987) in Murrah buffalo, Khan *et al.* (1991) in Pakistani buffalo and Mourad *et al.* (1991) in Egyptian buffalo. Gajbhiye *et al.* (1994) also noticed similar results Mehsana buffalo.

The results obtained in the present study indicated adaptability of the animal showing non-appreciable gene environmental interactions.

4.3.3 Effect of lactation order

The effect of lactation order on 300 days milk yield in Pandharpuri buffalo was non-significant in the present investigation (Table 9).

However, significant results were reported by Agarwal *et al.* (1987), Prakash and Tripathi (1990) and Rohilla *et al.* (1992) in Murrah buffalo, Vij and Tiwana (1986) and Mourad *et al.* (1991) in Indian buffalo and Egyptian buffalo, respectively.

4.4 Peak milk yield

The overall least squares mean for peak milk yield was 6.82 ± 0.40 kg in the present investigation (Table 10). Almost similar values were reported by Biradar (1990) and Govindhaiah and Rai (1986) in Surti buffalo. The higher values for PMY were reported by Garcha and Tiwana (1980), Garcha and Tiwana (1981) and Vij and Tiwana (1986) in Indian buffalo, Choudhary and Choudhary (1981) in Mehsana and Surti buffalo, Tiwana *et al.* (1986) in Elite buffalo, Sane *et al.* (1972), Prakash and Tripathi (1987), Singh and Rathi (1990) and Rohilla *et al.* (1992) in Murrah buffalo, respectively. However, lower value was observed by Govindaiah and Rai (1987) in Medium sized buffalo (Table 4).

4.4.1 Effect of period of calving

Significant ($P < 0.05$) effect of period of calving on the peak milk yield was observed in Pandharpuri buffalo (Table 9).

These results corroborated with the findings of Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo, Rohilla *et al.*, (1992) and Dass and Sadana (1999) in Murrah buffalo, Biradar (1990) in Surti buffalo. Whereas, non-significant effect of period were observed by Choudhary and Choudhary (1981) and Prakash and Tripathi (1987) in Murrah and Mehsana and Surti buffalo, respectively.

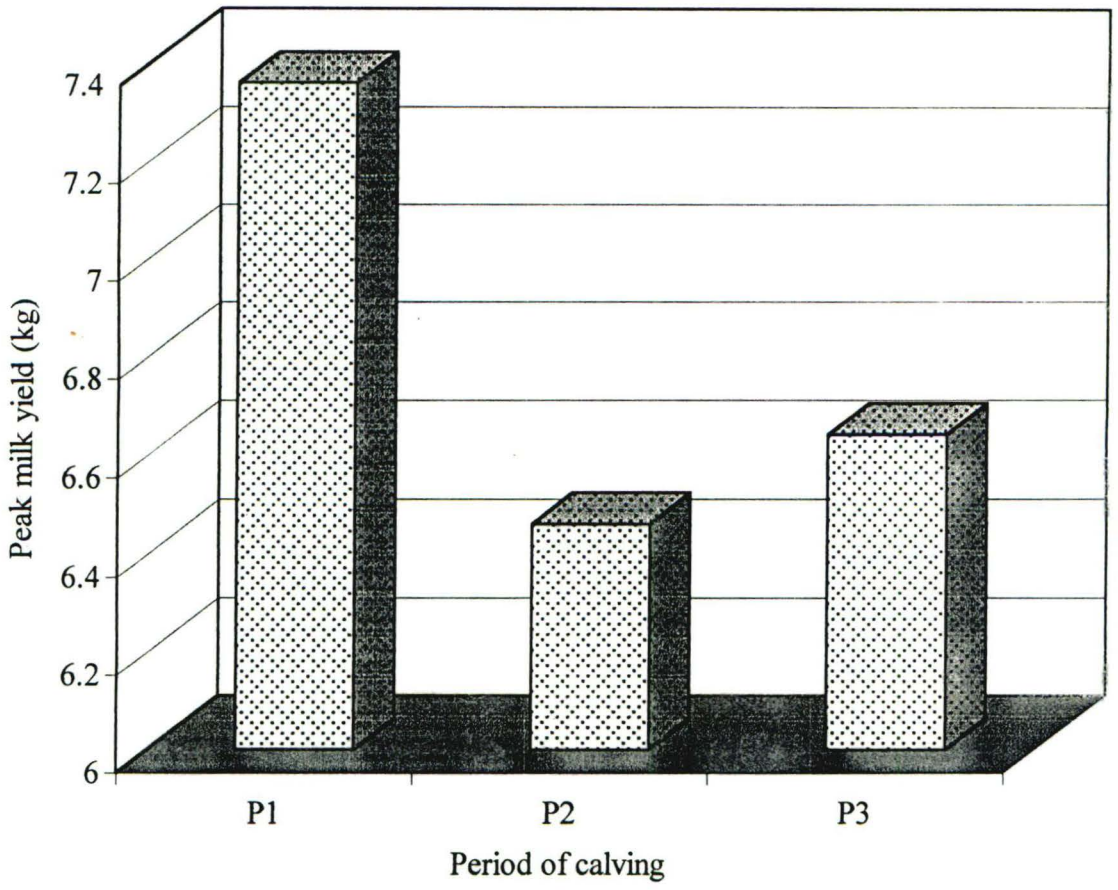


Fig. 2. Average peak milk yield in relation to period of calving

The t-test revealed that the peak milk yield during P_1 (7.36 $\pm$ 0.32 kg) was significantly higher than P_2 and P_3 which were at par with each other (Table 10).

However, it is possible to conclude that differences between periods, particularly in peak yield might be due to differential nutritional and managerial practices in herd over different times.

4.4.2 Effect of season of calving

The effect of season of calving was found to be non-significant on peak milk yield in the present investigation (Table 9).

These results were in agreement with the reports of Choudhary and Choudhary (1981) Mehsana and Surti buffalo in and Vij and Tiwana (1986) in buffalo Indian Prakash and Tripathi (1987) and Dass and Sadana (1999) also observed similar results in Murrah buffalo. However, significant effect of season of calving on the trait were observed by Sane *et al.* (1972), Agarwal *et al.* (1987) and Rohilla *et al.* (1992) in Murrah buffalo and Biradar (1990) in Surti buffalo.

Peak milk yield showed decreasing trend from S_1 (7.00 $\pm$ 0.34 kg) to S_3 (6.53 $\pm$ 0.45 kg). Peak milk yield was highest in the case of rainy calvers and lowest in summer calvers (Table 10). These results might be due to favourable climatic condition during S_1.

4.4.3 Effect of lactation order

The effect of lactation order on peak milk yield was non-significant in Pandharpuri buffalo (Table 9). Choudhary and Choudhary (1981) also obtained similar results in Mehsana and Surti buffalo. However, significant effect of lactation order on the trait were reported by Sane *et al.* (1972), Prakash and Tripathi (1987), Agarwal *et al.* (1987) and Rohilla *et al.*

Table 11. Least squares means and standard error for the factors affecting DAPY, LL and DP in Pandharpuri buffalo

Source of variation	Code	No.	DAPY (days)	LL (days)	No.	DP (days)
Overall	μ	112	53.82 ± 13.33	296.79 ± 34.62	80	120.73 ± 30.33
Period of calving						
1992-95	P_1	49	66.08 ± 10.68	295.22 ± 24.63	39	159.00 ± 26.16^a
1996-98	P_2	35	39.94 ± 11.44	304.29 ± 26.38	27	78.02 ± 26.84^b
1999-02	P_3	28	55.43 ± 9.84	290.87 ± 22.69	14	125.16 ± 29.07^a
Season of calving						
Rainy (June-Sept.)	S_1	24	24.16 ± 11.15^c	282.00 ± 25.70	16	72.62 ± 29.42
Winter (Oct-Jan)	S_2	76	48.10 ±8.00^b	294.53 ± 18.43	54	138.54 ± 18.97
Summer (Feb-May)	S_3	12	89.19 ± 14.75^a	313.85 ± 34.00	10	151.03 ± 32.68
Lactation order						
1st lactation	L_1	32	69.16 ± 10.00	333.96 ± 23.06	26	145.68 ± 25.56
2nd lactation	L_2	26	62.66 ± 9.93	329.32 ± 22.28	18	99.00 ± 26.74
3rd lactation	L_3	19	33.58 ± 12.26	317.63 ± 28.25	16	135.03 ± 28.76
4th lactation	L_4	15	40.04 ± 13.38	315.93 ± 30.84	9	157.75 ± 35.84
5th lactation	L_5	9	39.03 ± 16.59	297.47 ± 38.23	6	79.55 ± 44.36
6th lactation	L_6	6	63.65 ± 20.00	236.57 ± 46.09	3	104.62 ± 57.81
7th lactation	L_7	3	67.39 ± 27.97	339.25 ± 64.47	2	123.48 ± 73.85
8th lactation	L_8	2	55.05 ± 34.30	204.21 ± 79.05	-	-

Means under each class in the column with different superscript differed significantly.

(1992) in Murrah buffalo, Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo and Biradar (1990) in Surti buffalo.

The highest peak milk yield (8.00 ± 1.04 kg) was in the eight lactation and lowest (5.89 ± 0.30 kg) in the first lactation which might be attributed to reproductive status of the animal.

4.5 Days to attain peak milk yield

The average number of days required to attain peak milk yield was estimated as 53.82 ± 13.33 days in Pandharpuri buffalo (Table 11).

The present value was closer to those reported by Govindhaiah and Rai (1987) in Medium sized buffalo and Rohilla *et al.* (1992) in Murrah buffalo. However, lower values were obtained by Govindhaiah and Rai (1986) and Biradar (1990) in Surti buffalo, Garcha and Tiwana (1981) and Vij and Tiwana (1986) in Indian buffalo, Choudhary and Choudhary (1981) in Mehsana and Surti buffalo and Prakash and Tripathi (1987) in Murrab buffalo (Table 5).

4.5.1 Effect of period of calving

It was revealed from the least squares analysis of variance for days to attain peak milk yield (Table 9) that the period of calving had non-significant influence on days to attain peak milk yield in Pandharpuri buffalo.

These results were in consonance with investigation of Choudhary and Choudhary (1981) in Mehsana and Surti buffalo and Prakash and Tripathi (1987) in Murrah buffalo. However, significant effects of period of calving on the trait were observed by Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo and Rohilla *et al.* (1992) in Murrah buffalo.

4.5.2 Effect of season of calving

Season of calving significantly ($P < 0.01$) contributed to the variations in days to attain peak milk yield in Pandharpuri buffalo (Table 9).

These results were in agreement with the findings of Garcha and Tiwana (1980) and Agarwal *et al.* (1987) in Indian and Murrah buffalo, respectively. However, Choudhary and Choudhary (1981), Vij and Tiwana (1986) in Mehsana and Surti buffalo and Indian buffalo, Prakash and Tripathi (1987) and Rohilla *et al.* (1992) in Murrah buffalo did not agree with the present results. The summer calved buffaloes required significantly more days (89.19 $\pm$ 14.75) to reach peak milk yield than winter calvers (48.10 $\pm$ 8.00) and Rainy calvers (24.16 $\pm$ 11.15) (Table 11). The t-test revealed that DAPY differed significantly from each other due to season of calving.

Seasons within year normally could have a significant effect on days to attain peak yield. The rainy calvers could get sufficient green fodder during the season. The availability of adequate nutrients through green fodder might have resulted into reduction in days to attain peak milk yield in Pandharpuri buffaloes. Whereas, summer calves could not get sufficient quantity of naturally grown green fodders, which might prolonged the DAPY.

4.5.3 Effect of lactation order

Lactation order did not significantly influence the days to attain peak milk yield in the present investigation (Table 9). Similar results were reported by Choudhary and Choudhary (1981) in Mehsana and Surti buffalo and Rohilla *et al.* (1992) in Murrah buffalo. However, Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo, Prakash and Tripathi (1987) and Agarwal *et al.* (1987) in Murrah buffalo and Biradar (1990) in

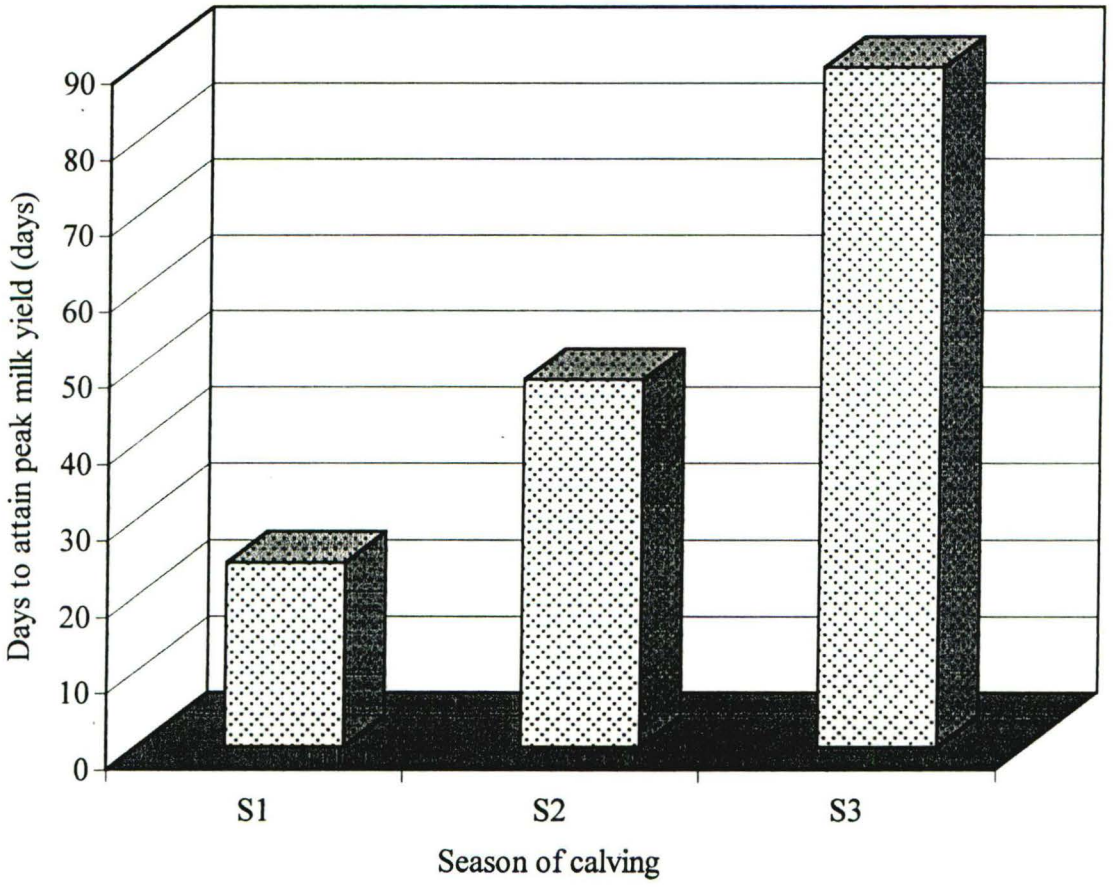


Fig. 3. Average days to attain peak milk yield in relation to season of calving

Surti buffalo observed significant influence of lactation order on days to attain peak yield.

The days to attain peak yield consistently decreased from first (69.16 ± 10.00) to third lactation (33.58 ± 12.26). The findings in the present study indicated that the stage of lactational maturity in the animal which may correspond with the development and increased functioning of active secretary tissues of the udder attained some where near the third lactation.

4.6 Lactation length

The overall least squares mean of lactation length was 296.79 ± 34.62 days in Pandharpuri buffalo (Table 11). The present lactation length was closer to the values reported by Basu and Ghai (1978) and Rohilla *et al.* (1992) in Murrah buffalo, Kumar and Bhat (1978) in Indian buffalo and Choudhary *et al.* (1988) in Nili-Ravi buffalo. The present lactation length was higher than the values reported by Gurnani *et al.* (1976) and Sitorus *et al.* (1986) in Murrah buffalo, Juma and AL-Samarai (1985) in Iraqi buffalo, Tailor and Jain (1987) in medium sized buffalo and Tailor *et al.* (1992) in Surti buffalo (Table 6). However, Kanaujia and Balaine (1975), Garcha and Tiwana (1980), Garcha and Tiwana (1981), Vij and Tiwana (1986) in Indian buffalo, Jain and Taneja (1982), Prakash and Tripathi (1990), Sharma *et al.* (1990), Chhikara *et al.* (1995) and Dass and Sadana (1999) in Murrah buffalo, EL-Kaschab *et al.* (1984) in Egyptian buffalo, Govindhaiah and Rai (1986) in Surti buffalo, Tiwana *et al.* (1986) in Elite buffalo, Govindhaiah and Rai (1987) in medium sized buffalo and Gajbhiye *et al.* (1994) in Meshana buffalo, reported higher values than the present study (Table 6).

4.6.1 Effect of period of calving

The effect of period of calving on lactation length was non-significant in the present investigation (Table 9).

These results were in agreement with those reported by Kumar and Bhat (1978) in Indian buffalo. However, significant effects of period of calving on lactation length were observed by Lall (1975), Jain and Taneja (1982), Rohilla *et al.* (1992), Chhikara *et al.* (1995) and Dass and Sadana (1999) in Murrah buffalo, Kanaujia and Balaine (1975), Patro and Bhat (1979) and Garcha and Tiwana (1980) in Indian buffalo. Similar result were also recorded in Mehsana buffalo (Gajbhiye *et al.*, 1994).

4.6.2 Effect of season of calving

Season of calving did not contribute to the variations in the lactation length in the present study (Table 9).

These results corroborated with the findings of Agarwal *et al.* (1987), Chhikara *et al.* (1995) and Dass and Sadana (1999) in Murrah buffalo and Kanaujia and Balaine (1975) and Kumar and Bhat (1978) in Indian buffalo. However, significant season as influence on lactation length were observed by Gurnani *et al.* (1976), Jain and Taneja (1982), Sitorus *et al.* (1986) and Rohilla *et al.* (1992) in Murrah buffalo, Roychoudhary *et al.* (1971) in Italian buffalo, Patro and Bhat (1979) and Vij and Tiwana (1986) in Indian buffalo, Tailor and Jain (1987) in Medium sized buffalo, EL Kaschab *et al.* (1984) in Egyptian buffalo, Tailor *et al.* (1992) in Surti buffalo and Gajbhiye *et al.* (1994) in Mehsana buffalo.

Apparently, lactation length showed increasing trend from S_1 to S_3 (Table 11). The lactation length was higher (313.85 $\pm$ 34.00 days) for buffaloes calved during summer and lower (282.00 $\pm$ 25.70 days) for rainy

season. The longer lactation length in summer calvers might be due to longer period required by them to attain peak milk yield.

4.6.3 Effect of lactation order

The variations in the lactation length were not affected by lactation order in Pandharpuri buffalo (Table 9).

These results were in agreement with those reported by Garcha and Tiwana (1980) and Vij and Tiwana (1986) in Indian buffalo, Gurnani *et al.* (1976), Agarwal *et al.* (1987), Prakash and Tripathi (1990), Rohilla *et al.* (1992) and Chhikara *et al.* (1995) in Murrah buffalo and Tailor and Jain (1987) in Medium sized buffalo. However, significant influences of lactation order were observed by Kanaujia and Balaine (1975) and Kumar and Bhat (1978) in Indian buffalo, Roychoudhary *et al.* (1971) in Italian buffalo. Similar results were noticed in Murrah buffalo and Surti buffalo by Sitorus *et al.* (1986) and Tailor *et al.* (1992), respectively.

4.7 Dry period

The least squares means and analysis of variance for the dry period have been presented in Table 11 and 9, respectively. The overall least squares mean for dry period in Pandharpuri buffalo was 120.73 $\pm$ 30.33 days (Table 11). Buffaloes having dry period upto 60 days were found to be most economical (Shah *et al.*, 1983). The longer dry period will increase the intercalving period, thereby reducing the number of calvings and lifetime milk production.

The present value was higher to those reported by EL Kaschab *et al.* (1984) and Shah *et al.* (1987) in Egyptian buffalo and Nili-Ravi buffalo, respectively and lower to those in Indian buffalo (Kanaujia and Balaine, 1975), Murrah buffalo (Gurnani *et al.*, 1976; Polikhronov *et al.*, 1977; Jain

and Taneja, 1982; Agarwal *et al.*, 1987; Prakash and Tripathi, 1990; Rohilla *et al.*, 1992, Kandaswamy *et al.*, 1993 and Dass and Sadana, 1999), Bulgarian and Murrah x Bulgarian buffalo (Polikhronov *et al.*, 1977), Iraqi buffalo (Juma and AL Samarai, 1985), Elite buffalo (Tiwana *et al.*, 1986), Medium sized buffalo (Tailor and Jain, 1987 and Govindaiah and Rai, 1987) and Surti buffalo (Tailor *et al.*, 1992) (Table 7).

4.7.1 Effect of period of calving

The influence of period of calving on dry period was highly significant ($P < 0.01$) in Pandharpuri buffalo (Table 9).

These results corroborated with the findings of Kanaujia and Balaine (1975), Dutt and Yadav (1988) and Rohilla *et al.* (1992) in Indian buffalo, Nili-Ravi buffalo and Murrah buffalo, respectively. However, non-significant effects of period of calving on the trait were observed by Prakash and Tripathi (1990) and Dass and Sadana (1999) in Murrah buffalo.

The t-test showed that the dry period of Pandharpuri buffaloes calved during P_2 were significantly lower than those calved in P_1 and P_3 periods. Where, P_1 and P_3 were on par with each other. The influence of periods can possibly be attributed to the variations in environmental conditions.

4.7.2 Effect of season of calving

The effect of season of calving on dry period was non-significant in Pandharpuri buffalo (Table 9).

These results were in line with the findings of Kanaujia and Balaine (1975) in Indian buffalo, Gurnani *et al.* (1976), Jain and Taneja (1982), Prakash and Tripathi (1990) and Rohilla *et al.* (1992) in Murrah buffalo. However, contradictory results were reported by Dani and Gaikwad

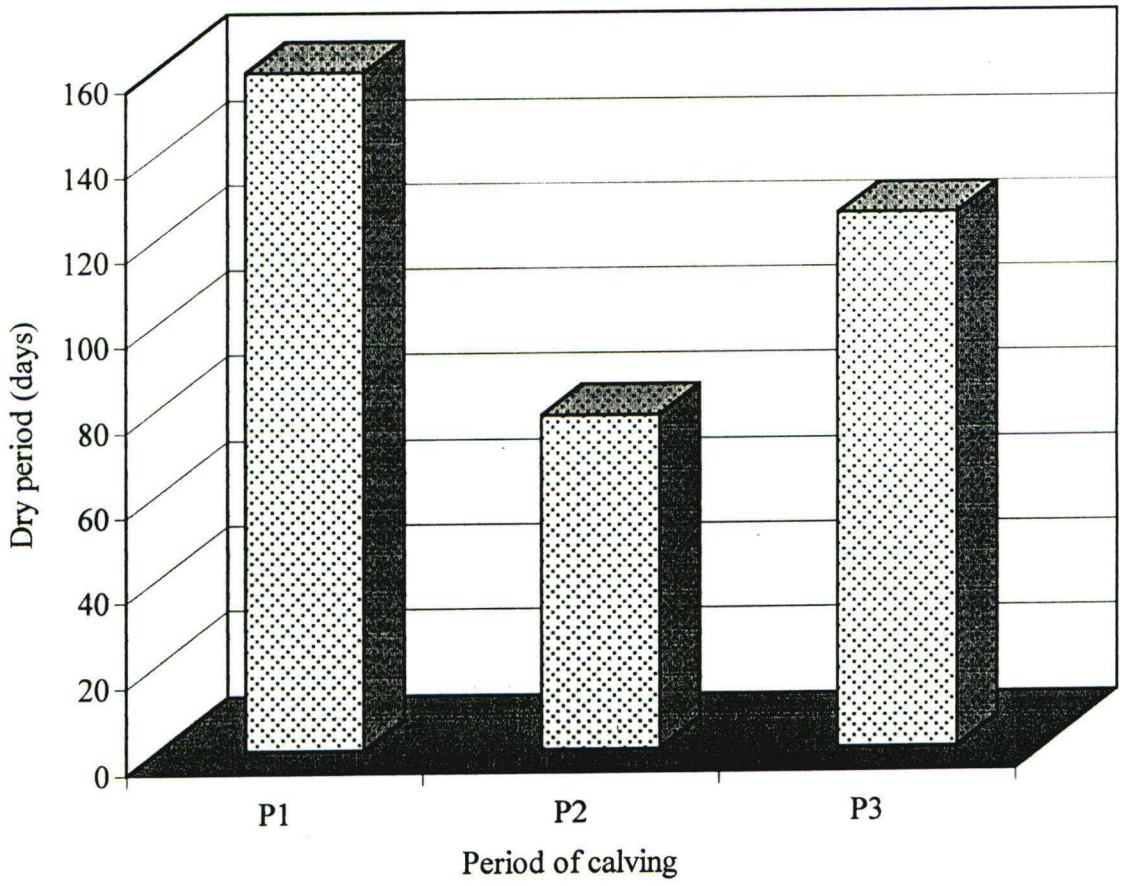


Fig. 4. Average dry period in relation to period of calving

(1972), Agarwal *et al.* (1987), Kandasamy *et al.* (1993) and Dass and Sadana (1999) in Murrah buffalo, EL Kaschab *et al.* (1984), Tailor and Jain (1987) and Dutt and Yadav (1988) in Egyptian buffalo, Medium sized buffalo and Nili Ravi buffalo, respectively.

Apparent longer dry period (151.02 $\pm$ 32.68 days) for summer might be probably due to the reason that most of the Pandharpuri buffaloes conceive during winter season prolonging lactation length and dry period.

4.7.3 Effect of lactation order

Lactation order had non-significant effect on dry period in Pandharpuri buffalo (Table 9). Similar results were reported by Kanaujia and Balaine (1975) and Agarwal *et al.* (1987) in Indian buffalo and Murrah buffalo, respectively. However, contradictory results were reported in Murrah buffalo (Gurnani *et al,* 1976; Jain and Taneja, 1982; Rohilla *et al.*, 1992 and Kdandasamy *et al.*, 1993) and Medium sized buffalo (Tailor and Jain, 1987).

The mean dry period in all lactations is considerably higher than what would be needed for economic efficiency of buffaloes. Dry period is mostly governed by environment and efficient management of the herd which could bring down the dry period in this breed of buffaloes.

4.8 Fitting of lactation curve

To study the trend of milk production during the lactation, the comparative efficiencies of linear, exponential, parabolic exponential, inverse polynomial and gamma type functions were tested on 111 individual lactations of Pandharpuri buffalo.

4.8.1 Paritywise lactation curve

The estimates of coefficient of determination (R^2) for different parities in Pandharpuri buffalo have been presented in Table 12. It was

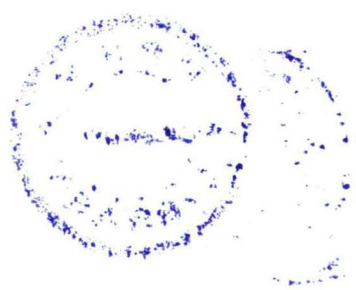


Table 12. R^2 for the different functions fitted to the lactation records of different lactation order

Lactation order	Linear function	Exponential function	Exponential parabolic function	Inverse polynomial function	Gamma type function
L_1	0.1974	0.2511	0.2660	0.6759	0.2683
L_2	0.4378	0.4793	0.4927	0.7405	0.5012
L_3	0.3298	0.3383	0.3386	0.6408	0.3383
L_4	0.2834	0.2670	0.3461	0.7325	0.3051
L_5	0.4300	0.4005	0.4287	0.7813	0.4296
L_6	0.2679	0.3001	0.3084	0.7564	0.3093
L_7	0.3585	0.3650	0.3714	0.8859	0.3654
L_8	0.8266	0.8057	0.9700	0.9726	0.9754

revealed from these results that the values of goodness of fit for different parities were smaller for first lactation compared to lat er lactations. These estimates were in agreement with Rao (1977) in Sahiwal and Ulmek (1991) in Gir cattle. The linear, exponential, parabolic exponential, inverse polynomial and gamma type functions accounted for 19.74, 25.11, 26.60, 67.59 and 26.83 per cent variability of average lactations (first lactation) and at best it accounted to 82.66, 80.57, 97.00, 97.26 and 97.54 per cent variability of average lactations during 8^{th} lactation. Based on the average lactation curves, Singh and Bhat (1978) in Hariana cattle reported the variability of average lactation curves for the exponential function, which accounted for 74.49 per cent at the lowest level during first lactation and 98.31 per cent at the highest level during sixth lactation.

Graphical comparison of lactation curve models showed that gamma type function was more close to the observed lactation curve for L_8 . Here also inverse polynomial function over estimated peak yield (Fig. 5). Considering higher R^2 values of gamma type tha n inverse polynomial function for L_8 gamma type function fitted best for Pandharpuri buffalo.

Suitability of inverse polynomial function in describing the lactation curve were reported by Kumar and Bhat (1978) and Kumar and Bhat (1981) in Indian buffalo, Gahlot *et al.* (1988), Bagherwal and Khan (1990) and Roy and Katpatal (1993) in Rathi cow, Murrah buffalo and Jersey cattle, respectively.

Inverse polynomial function had higher R^2 values for all lactations than the gamma function except L_8. Gamma function curve was more close to observed one than the curves of other functions. Here also inverse polynomial function over estimated peak yield (Fig. 6).

5/a

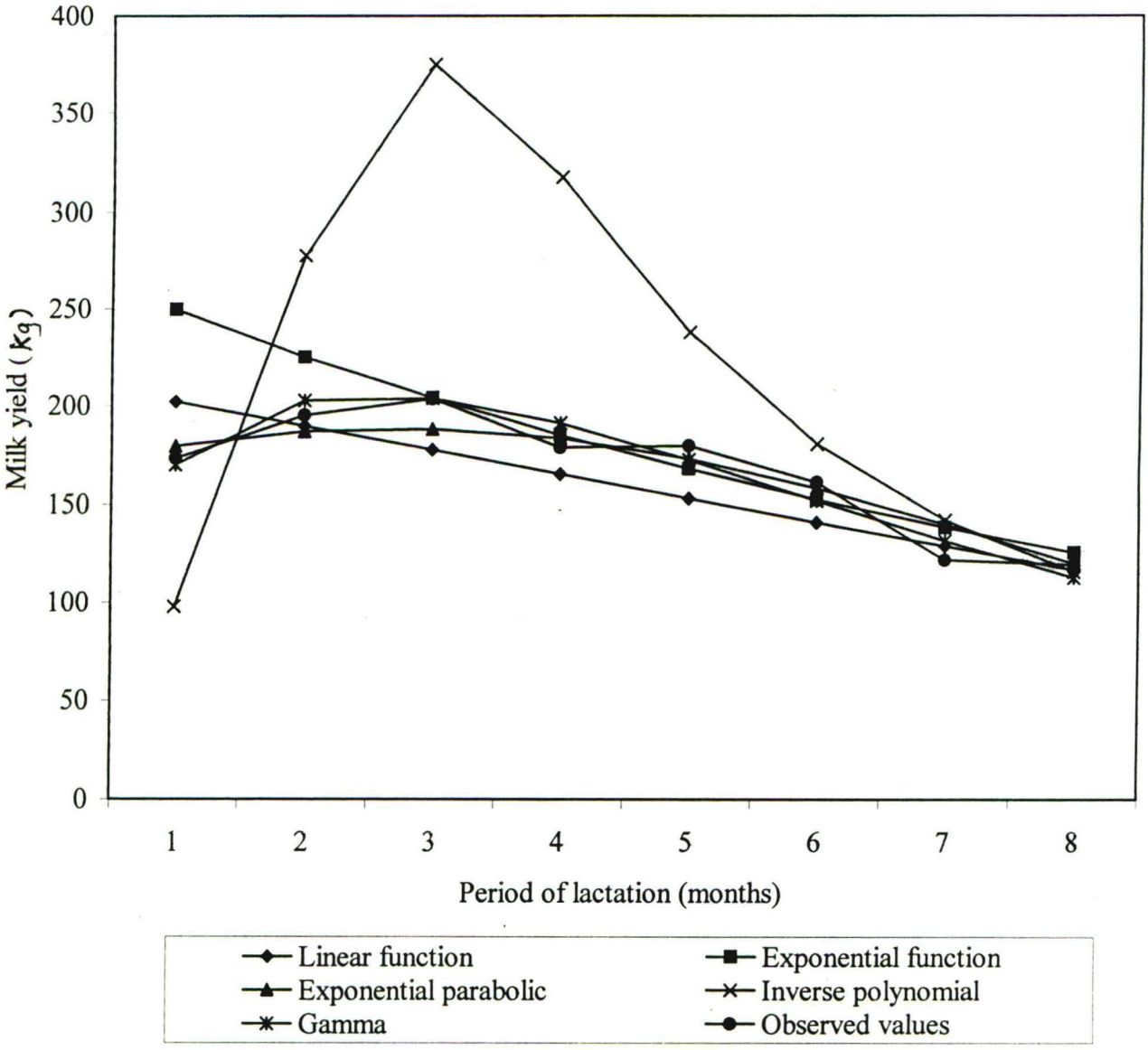


Fig. 5. Lactation curves for eightth lactation in Pandharpuri buffaloes

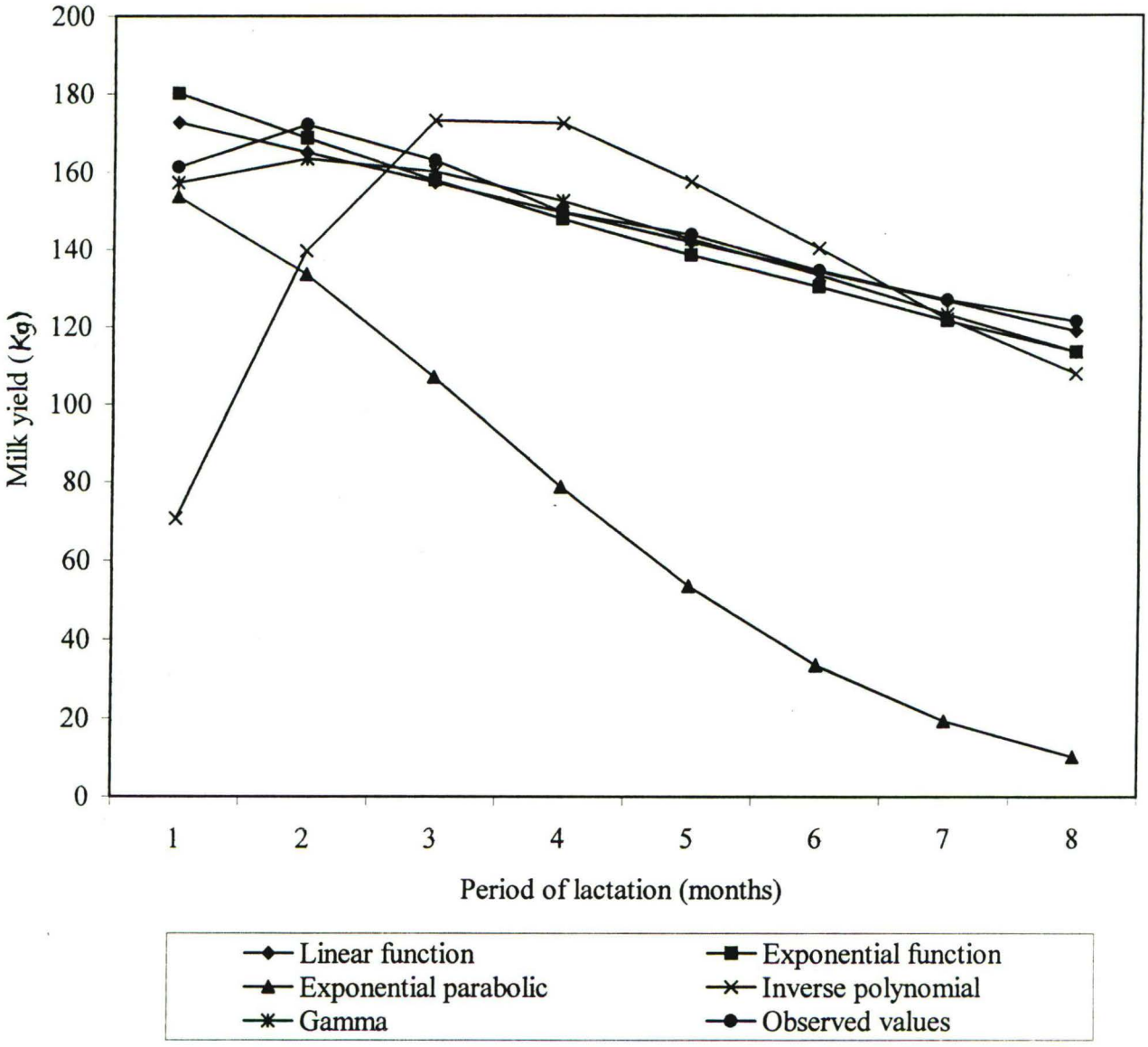


Fig. 6. **Lactation curves for overall lactations in Pandharpuri buffaloes**

Critical study of the curve revealed that deviation between the predicted and observed milk yield was the least in Gamma function as compared to the inverse polynomial although R^2 values of inverse polynomial were higher than Gamma function. Gamma function can be used for describing the lactation curve in Pandharpuri buffaloes. Similar results were reported by Bhat and Kumar (1978) in Indian buffalo and Cheema and Basu (1983), Basavaiah and Nagarcenkar (1982) and Gajbhiye and Tripathi (1992) in Murrah buffalo.

The linear and exponential curve (Fig. 6) showed that milk production are linearly but inversely related to the advancement of the period and did not describe the ascending phase of the lactation. Therefore, this function can be used to estimate milk yield only of declining phase of lactation. The R^2 value had lower estimates, indicating poorest fit of this function. The predicted values of monthly milk yield for parabolic exponential function were lower than observed values.

4.8.2 Parameters of lactation curve

The estimates of constants obtained by fitting linear, exponential, parabolic exponential, inverse polynomial and gamma type function to average lactation curve according to parity were presented in Table 13.

4.8.2.1 Linear function

The persual of Table 13 showed that 'a' constant (initial milk yield) was lowest (148.05) in 1st lactation and highest in 8th lactation. This trend of constant 'a' indicated that Phandharpuri buffaloes had inherent potential to hard persistent the initial milk yield in lactations ranging from 2nd to 8th.

The rate of decline i.e. 'b' constant was -5.21 in first lactation but it gradually decreased alongwith advancing age upto fifth lactation (-9.36). Kale (1999) in triple cross bred cattle reported that 'a' constant (initial milk yield) was lowest (383.23) in first lactation and increased upto third lactation and decreased to fifth lactation, the rate of decline i.e. 'b' constant was -18.57 in first lactation but it gradually decreased alongwith advancing age upto third lactation (-24.24).

4.8.2.2 Exponential function

It is evident from the Table 13 that constant 'a' (initial milk yield) was lowest (152.75) in L_1 which increased upto fifth lactation except L_3 (206.47). Rate of decline 'b' constant was 0.075 in second lactation (0.058) but it gradually decreased alongwith advancing age upto L_4 (0.062) and increased in fifth and eight lactation.

Kale (1999) in triple cross bred cattle observed that constant 'a' (initial milk yield) was lowest (5.99) in first lactation and increased upto third lactation (6.13), remained nearly steady in L_4 and decreased in fifth lactation (6.07). The rate of decline 'b' constant was low in first lactation (-0.0703) but it gradually increased alongwith advancing age upto fourth lactation (-0.0853) and decreased in fifth lactation.

4.8.2.3 Exponential parabolic function

It was observed from the Table 13 that the constant 'a' (initial milk yield) increased from 1st lactation (135.49) upto 3rd lactation (170.98). The linear constant 'b_1' (average slope) ranged from -0.05991 (L_3) to 0.0877 (L_8). The constant 'b_2' (rate of slope) was lower during L_8 (-0.01614) and higher during L_3 (-0.00042).

Table 13. Estimates of the constants obtained by fitting different functions to average lactation curve of different lactation order

Function	Const.	Lactation order							
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
Linear	a	148.05	177.09	168.87	172.48	194.28	176.81	191.23	214.19
	b	-5.21	-7.82	-7.29	-6.43	-9.36	-6.96	-6.38	-12.18
Exponential	a	152.75	189.58	173.30	179.30	206.47	183.24	191.44	273.80
	b	0.058	0.075	0.065	0.062	0.071	0.064	0.041	0.097
Exponential parabolic	a	135.49	169.49	170.98	133.84	175.26	167.98	183.02	167.11
	b_1	-0.01229	-0.03291	-0.05991	0.04749	0.003683	-0.03093	-0.02019	0.08775
	b_2	-0.00315	-0.0028	-0.00042	-0.00735	-0.00721	-0.00231	-0.00179	-0.01614
Inverse polynomial	b_0	0.014	0.014	0.011	0.055	0.006	0.0071	0.0072	0.017
	b_1	-0.0012	-0.0032	-0.0007	-0.020	0.000016	0.0013	0.0011	-0.0087
	b_2	0.0013	0.0014	0.0012	0.0026	0.0010	0.00096	0.00065	0.0019
Gamma type	a	139.43	171.15	172.94	154.45	193.13	172.20	190.54	215.43
	b	0.2076	0.2219	0.0054	0.3251	0.2401	0.1435	0.0180	0.5909
	c	0.096	0.115	0.066	0.121	0.130	0.091	0.045	0.234

4.8.2.4 Inverse polynomial function

The lowest value of 'b_0' constant (rising extreme) occurred in the fifth lactation (0.006) and highest in fourth lactation (0.055). The 'b_0' constant remained same for L_1 and L_2. The lowest value for 'b_1' constant (average slope) was -0.020 in L_4 and higher (0.0013) in L_6. The constant 'b_2' (declining extreme) was found to be lowest in L_7 (0.00065) and highest in L_4 (0.0026).

4.8.2.5 Gamma function

Table 13 indicated that the estimated constant 'a' (initial milk yield) was found to be gradually increased from L_1 (139.43) to L_3 (172.94) and thereafter increased from L_6 (172.20) to L_8 (215.43). Constant 'b' and 'c' showed higher values in L_8 (0.5909 and 0.234, respectively) and lowest in L_3 (0.0054) and in L_7 (0.045), respectively.

SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The present study was undertaken for the purpose of estimation of persistency of milk yield in Pandharpuri buffalo by three different methods *viz.*, Method-I (Mahadevan, 1951), Method-II (Ludwick and Peterson, 1943) and Method-III (McDowell *et al.*, 1961). To study the pattern of lactation curve and estimation of effect of non-genetic factors milk production traits *viz.*, lactation milk yield, 300-days milk yield, peak milk yield, days to attain peak yield, lactation length and dry period. The records pertaining to 111 lactations of 32 Pandharpuri buffaloes maintained at Zonal Agricultural Research Station, Shenda Park, Kolhapur, over a period of 11 years (1992-2002) were considered for the present investigation.

The models used variance analysis of production traits included effect of period and season of calving and lactation order. The data were subjected to the least squares analysis for unequal subclass numbers.

The overall least squares means for the persistency of milk yield were 9.89 $\pm$ 6.39, 0.88 $\pm$ 0.03 and 71.75 $\pm$ 3.59 per cent estimated by using formulae of Mahadevan (1951), Ludwick and Peterson (1943) and McDowell *et al.* (1961) respectively. However, milk production traits *viz.*, lactation milk yield, 300-days milk yield, peak milk yield, days to attain peak yield, lactation length and dry period were estimated as 1315.36 $\pm$ 143.39 kg, 1219.55 $\pm$ 111.68 kg, 6.82 $\pm$ 0.40 kg, 53.82 $\pm$ 13.33 days, 296.79 $\pm$ 34.62 days and 120.73 $\pm$ 30.33 days respectively in Pandharpuri buffalo.

Persistency of milk yield estimated by Method-III, peak milk yield and dry period were significantly influenced due to period of calving.

However, non-significant effect of period of calving on persistency of milk yield (Method I and II), lactation milk yield, 300-days milk yield, days to attain peak yield and lactation length were also observed.

The persistency of milk yield (Method-III) and days to attain peak yield were significantly affected due to season of calving. However, non-significant effect of season of calving on persistency values (Method I and II), lactation milk yield, 300-days milk yield, peak milk yield, lactation length and dry period were observed in Pandharpuri buffalo.

Critical study of the curve revealed that gamma type function was more close to the observed lactation curve although R^2 values of inverse polynomial was higher than that of gamma function. Gamma type function fitted best for prediction of milk yield in Pandharpuri buffalo.

5.2 Conclusions

1. The period of calving significantly contribute to the variations in persistency of milk yield, peak milk yield and dry period in Pandharpuri buffalo. Similarly the variations in persistency of milk yield and days to attain peak yield were attribute to the season of calving.
2. Based on this present study Pandharpuri buffalo appear to be having higher persistency of milk yield than Murrah buffalo.
3. Gamma function was the best fit for prediction of lactation curve in Pandharpuri buffaloes.

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6. LITERATURE CITED

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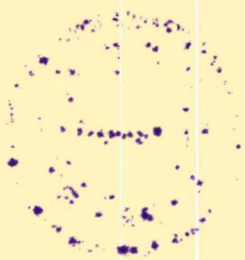
VITA



7. VITA

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