Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2019; 7(4): 116-120

Received: 28-05-2019
Accepted: 30-06-2019

Prakash G
PG Scholar, Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Kerala, India

Anilkumar K
Professor, Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Kerala, India

V Jamuna
Assistant Professor, Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Kerala, India

Corresponding Author:
Prakash G
PG Scholar, Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Kerala, India

Comparison of five different lactation curve models for prediction of monthly test day milk yields and first lacatation milk yield in crossbred cattle of Kerala

Prakash G, Anilkumar K and V Jamuna

Abstract
A study was undertaken for modeling of best fit lactation curve in crossbred cattle of Kerala by using monthly test day milk yields (MTDMYs). For developing lactation curve models, data of 936 crossbred cattle sired by 188 bulls spread over a period of 16 years (2002-2017) in seven different field centers of ICAR-Field Progeny Testing Scheme, Kerala were used. Lactation curves using different MTDMY were modeled with Inverse Polynomial Function (IPF), Mixed Log Function (MLF), Parabolic Exponential Function (PEF), Wilmink function (WIF) and Woods function (WOF). Among these, Wilmink Function showed best fitness of good criteria. WIF had maximum R^2 (86.45%), low RMSE (0.009949 kg), minimum AIC (-58059.79) and minimum BIC (-9656.57) values. Stepwise backward multiple regression method was used to predict FLMY using different combination of MTDMYs. Wilmink function is adjudged as the most effective function in predicting MTDMYs and FLMY of crossbred cattle of Kerala. The lactation curve based on Wilmink function had 82.67% desired type showing that the management systems adopted for crossbred cattle of Kerala is good.

Keywords: Lactation curve, milk yield, crossbred cattle

Introduction
India has 190.90 million cattle and crossbred cattle account for 39.73 million. Number of crossbred cattle has increased during 2012 as compared to 2007 from 33.06 million to 39.73 million [2]. Even though crossbreds are 20.81% of total cattle ofthe country they contribute 54.49% of milk production from cattle [1]. In contrast to other parts of the country, major milk producer in Kerala is crossbreds [1]. The crossbred cattle population of the state is 1.25 million and indigenous cattle is only 0.077 million [1]. Milk production of Kerala is estimated to be 2520.04 thousand tones of which 2358.00 thousand tones are from crossbreds and 23.46 thousand tones are from indigenous cattle [1]. Lactation curve is the graphical representation of milk yield against time.Lactation curve has three different phases, namely, ascending phase, persistent phase and declining phase [3]. The ascending phase is the period of sudden rise in the milk yield. The persistent phase indicates the inherent capacity of the animal for sustaining the level of milk production which is the longest phase of the lactation. The last phase is declining phase, indicating drying off of the animal, which is comparatively short. Hence, the shape of lactation curve (LC) gives indications about the various changes in different stage of lactation. The main aim of modeling of the lactation curve is to predict the lactation milk yield with a minimum error for evaluation of animals for selection and breeding [5, 6, 7, 8].

Materials and Methods
The milk yield and pedigree information of progenies of test bulls were collected from the history sheets and milk record registers of ICAR-Field Progeny Testing Scheme, Kerala Veterinary and Animal Sciences University. The data from records on monthly test day milk yields and first lactation milk yield of 936 crossbred cattle sired by 188 bulls spread over a period of 16 years (2002-2017) were collected. The records of cross bred cattle of known pedigree and with normal lactation were included in the present study. Records of animals with minimum lactation length of 100 days and 500 kg lactation milk yield were only considered in the present investigation. The calving should be under normal physiological conditions.

Crossbred cattle having history of abortion, still birth, infertility and other reproductive problems were not included in the present study. Milk yield traits were normalized with mean ± 3 standard deviation. From different field centers of ICAR-Field Progeny Testing Scheme, Kerala test day milk yields of animals were recorded at 30 days interval starting from 20 days of calving. Ten monthly test-day milk yield records (20thday, 50th day,…, 290th day) were taken at an interval of 30 days. Total of 8020 first lactation MTDMYs records of crossbred cattle of Kerala was used to model different lactation curve models parameters (Table 1.)

Table 1: Different Lactation curve models used for crossbred cattle of Kerala

S. No	lactation curve	Model
1	Inverse polynomial function [4]	$Y_t = t / (a + bt + ct^2)$
2	Mixed log function [5]	$Y_t = a + bt^{0.5} + c \log t$
3	Parabolic exponential function [6]	$Y_t = a \exp (bt\text{-}ct^2)$
4	Wilmink function [7]	$Y_t = a + be^{-kt} + ct$
5	Woods Gamma function [8]	$Y_t = at^b e^{-ct}$

In this model, Yt = Average daily milk yield in the tth test day, a = Approximate initial milk yield just after calving, b = Inclining slope parameter up to peak yield, c = Declining slope parameter, t = monthly test days in milk at tth test day and k = 0.05.

The above-mentioned models were fitted to first lactation milk yield. The most suitable model for first parities was identified on the basis of Co-efficient of determination (R^2) value, Root Mean Square Error (RMSE) values, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).Residuals were plotted graphically which gives an accuracy of the model to fit the lactation curve.

Grouping desirable and non-desirable type of lactation curve based Wilnimk function parameters was done (Table 2).

Table 2: Types of lactation curve based on Wilmink function parameters

Sr. No	Type	Parameters	
		b	C
1	Desirable	-ve	-ve
		-ve	+ve
2	Non desirable	+ve	+ve
		+ve	-ve

Results and Discussion

Table 3: Estimates of lactation curve parameters of different models in crossbred cattle.

Sr. No	Functions	Lactation curve parameters		
		A	b	C
1	Inverse polynomial function	-0.00147	1.982628	0.00077
2	Mixed log function	2.462999	-1.32643	10.34256
3	Parabolic exponential function	10.2036	0.00088	-0.000011347429
4	Wilmink function	12.41631	-5.21446	-0.02536
5	Woods function	6.71009	0.239335	-0.00465

Table 4: Goodness of fit criteria for different lactation curve functions.

Sr. No	Functions	R^2 (%)	RMSE (Kg)	AIC	BIC
1	Inverse polynomial function	79.76	0.026076	-89424.06	-14883.95
2	Mixed log function	85.07	0.008542	-69905.84	-11630.91
3	Parabolic exponential function	86.30	0.007698	-82834.35	-13785.66
4	Wilmink function	86.45	0.009949	-58059.79	-9656.57
5	Woods function	85.16	0.008302	-82727.54	-13767.86

(AIC - Akaike information criterion, R^2 -Co-efficient of determination, BIC - Bayesian information criterion and RMSE - Root mean square error)

Table 5: Predicted MTDMYs and per cent deviation from observed value of different lactation curve functions in crossbred cattle.

MTD	O.V	IPF		MLF		PEF		WIF		WOF	
		P.V	% D	P.V	% D	P.V	% D	P.V	% D	P.V	% D
1 (20th)	10.08	9.61	4.66	9.99	0.99	10.26	1.79	9.99	0.89	9.93	1.49
2 (50th)	10.52	12.12	15.21	10.64	1.14	10.24	2.76	10.72	1.90	10.70	1.62
3 (80th)	10.15	10.93	7.59	10.27	1.18	10.05	1.08	10.29	1.38	10.42	2.56
4 (110th)	9.69	9.52	1.75	9.66	0.31	9.68	0.10	9.61	0.83	9.77	0.93
5 (140th)	9.02	8.63	4.21	8.96	0.67	9.14	1.33	8.86	1.66	9.01	0.11
6 (170th)	8.39	7.70	8.22	8.24	1.79	8.44	0.60	8.14	2.98	8.19	2.38
7 (200th)	7.73	7.00	9.44	7.53	2.59	7.67	0.78	7.44	3.75	7.43	3.88
8 (230th)	6.96	6.43	7.61	6.82	2.01	6.86	1.44	6.76	2.87	6.71	3.45
9 (260th)	6.09	5.95	2.30	6.13	0.66	6.04	0.82	6.10	0.16	6.06	0.49
10 (290th)	5.30	5.64	6.60	5.48	3.58	5.29	0.19	5.49	3.77	5.49	3.77

(IPF - Inverse Polynomial Function, MLF - Mixed Log Function, PEF - Parabolic Exponential Function, WIF - Wilmink function, WOF - Woods function, MTD – Monthly test day, O.V – Observed value, P.V - Predicted Value and D – deviation)

Table 6: Actual and predicted average first lactation milk yield of different functions with average and per cent deviation.

Sr. No	Lactation curve models	Actual (kg)	Predicted (kg)	Average deviation	Percent deviation
1	Inverse polynomial function	2507.87	2505.84	333.35	13.29
2	Mixed log function	2507.87	2511.56	333.53	13.30
3	Parabolic exponential function	2507.87	2509.87	333.47	13.30
4	Wilmink function	2507.87	2529.43	334.76	13.35
5	Woods function	2507.87	2511.23	333.51	13.30

Table 7: Frequency and types of lactation curve based on Wilmink function parameters in crossbred cattle of Kerala.

Sr. No	Type	Observation	Frequency (%)
1	Desirable	663	82.67
2	Non desirable	139	17.33

Average MTDMY start from 10.08 kg in first test day and its reached peak yield 10.52 kg at second test day then its start declining and reached minimum of 5.30 kg by last test day (Table 5). In Holstein Friesian cattle and Karan Fries cattle also reported that highest MTDMY was observed in TD-2 and lowest in last test day [9, 10].

As per Table 3 and 4, average first lactation MTDMYs predicted with maximum accuracy (R^2= 86.45%) was obtained with Wilmink function, and the minimum accuracy was obtained with Inverse polynomial function (R^2= 79.76%). R^2 values of Mixed log function (R^2= 85.07%), Parabolic exponential function (R^2= 86.30%) and Woods function (R^2= 85.16%) were not much different from Wilmink function. In Holstein Friesian cattle, Italian water buffaloes, Murrah buffaloes and Simmental cattle reported that among various lactation curve models Wilmink function had more than 90% of R^2 [11, 12, 13, 14, 15, 16]. Linear, exponential, hyperbolic, inverse quadratic, exponential with constant term, quadratic, Wilmink and Wilmink extended to model the lactation curve in dairy cattle and found that Winmink Models were better than the others [17].

Average first lactation monthly test day milk yields predicted with minimum RMSE (0.007698 kg) was obtained with Parabolic exponential function, and the maximum RMSE (0.026076 kg) was obtained with Inverse polynomial function. Mixed log function (RMSE = 0.008542 kg), Wilmink function (RMSE = 0.009949 kg) and woods function (RMSE = 0.008302 kg) were almost having equal RMSE to parabolic exponential function (Table 4.) Based on RMSE it can be concluded that parabolic exponential function, Mixed log function, Wilmink function and Woods function are better than inverse polynomial function in predicting MTDMY. In Karan Fries cattle, Sahiwal cattle and Murrah buffaloes also reported minimum root mean square error 0.0236 kg, 0.08 kg and 0.02 kg, respectively[3, 18, 19].

The average Akaike information criterion (AIC) with Inverse polynomial function, Mixed log function, Parabolic exponential function, Wilmink function, and Wood function were -89424.06, -69905.84, -82834.35,-58059.79 and -82727.54, respectively. Average first lactation monthly test day milk yield predicted with minimum AIC (-58059.79) was obtained with Wilmink function, and the maximum AIC (-89424.06) was obtained with inverse polynomial function (Table 4.). Based on AIC the best fitting model to predict first lactation MTDMYs in crossbred cattle of Kerala was Wilmink function. In Iranian primiparous Holsteins and Sahiwal cattle adjudged AIC as goodness of fit criteria for selection of best fit lactation curve, respectively [20, 21].

The average Bayesian information criterion (BIC) with inverse polynomial function, mixed log function, parabolic exponential function, Wilmink function, and gamma type function were-14883.95, -11630.91, -13785.66, -9656.57 and -13767.86, respectively. Average first lactation monthly test day milk yield predicted with minimum BIC (-9656.57) was obtained with Wilminks function, and the maximum BIC (-14883.95) was obtained with Inverse polynomial function (Table 4.) Thus, the best fitting model to predict first lactation MTDMYs in crossbred cattle of Kerala was Wilmink function when BIC values are considered. In crossbred cattle, Chiapas sheep and Sahiwal cattle also found that AIC and BIC as better goodness of fit criteria for selection of best fit lactation curve [21, 22, 23].

The graphs (Figure 1-5) depicts the observed and predicted MTDMYs, using the five models namely Polynomial Function, Mixed Log Function, Parabolic Exponential Function, Wilmink function and Woods function. The predicted MTDMYs using five LC models and its deviation from observed values shows that deviation in prediction of first lactation MTDMYs from actual yield using parabolic exponential function was minimum and ranged from 0.10% in second test day (50th day) to 2.76% in fourth test day (110th day) whereas inverse polynomial function had maximum deviation ranging from 1.75% in fourth test day (110th day) to 15.21% in second test day (50th day) in crossbred cattle of Kerala. InKaran Fries cows reported minimum error -0.15 kg in 5th test day to 0.18 kg in 7th test day in prediction of MTDMY using Polynomial function (Table 5.) [3].

Average first lactation milk yield was 2507.87 kg. Average FLMY predicted by multiplying each test milk yield predicted from five different lactation curve function with 30 and adding that value. Predicted FLMY by using Inverse Polynomial Function, Mixed Log Function, Parabolic Exponential Function, Wilmink function and Woods function were 2505.84 kg, 2511.56 kg, 2509.87 kg, 2529.43 kg and 2511.23 kg, respectively (Table 6.). All the functions were having similar average and per cent deviation. In Sahiwal cattle reported that similar range of error in prediction of FLMY in five different lactation curve functions [18].

In the present study, 82.67 per cent cattle had desirable type of lactation curve and 17.33 per cent had non-desirable lactation curve (Table 7.). This indicates that effects of environmental factors are not sufficient to change the production of crossbred cattle of Kerala. In Karan Fries cattle and Murrah buffaloes reported that 81.34 per cent and 88.96 per cent of desirable and 18.66 per cent and 11.04 per cent of non-desirable lactation curve based on Wilmink lactation curve parameters [16, 24].

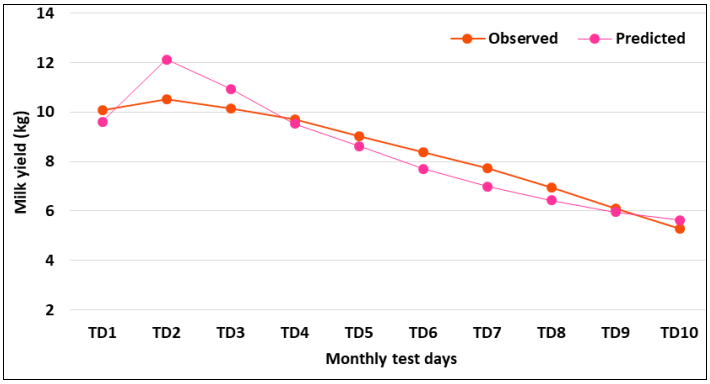

Fig 1: Observed and predicted MTDMYs for Inverse polynomial function in crossbred cattle.

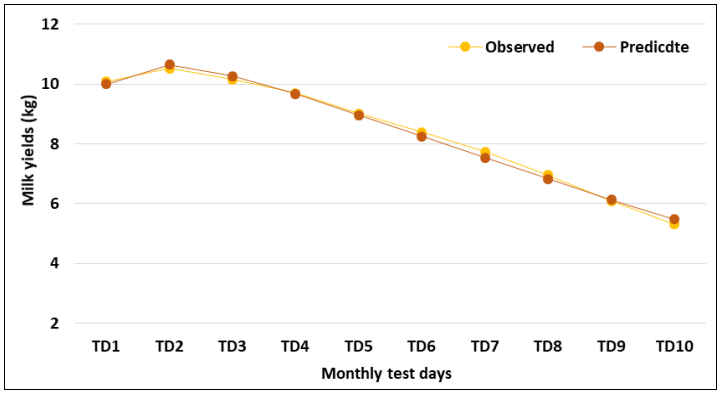

Fig 2: Observed and predicted MTDMYs for Mixed log function in crossbred cattle.

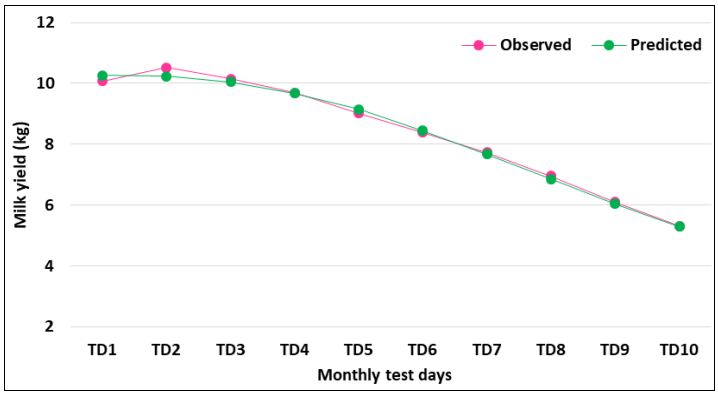

Fig 3: Observed and predicted MTDMYs for Parabolic exponential function in crossbred cattle.

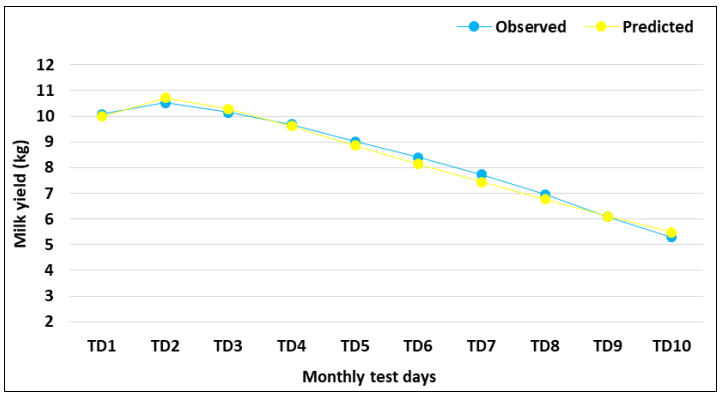

Fig 4: Observed and predicted MTDMYs for Wilmink function in crossbred cattle.

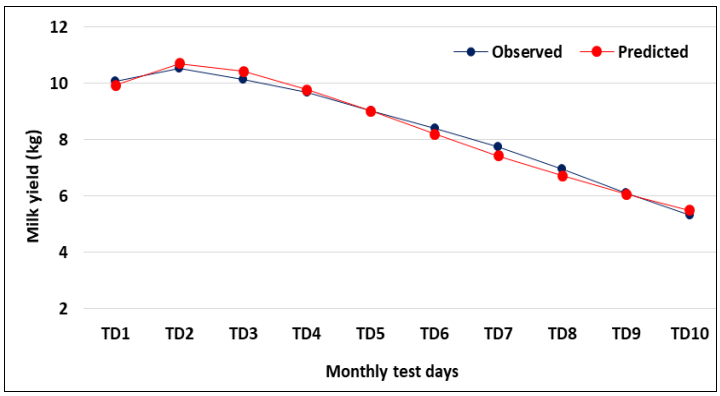

Fig 5: Observed and predicted MTDMYs for Woods function in crossbred cattle.

Conclusion

Lactation curve, at any stage of lactation, it is possible to predict milk yield. This property can be used in case of incomplete records as there are more chances for missing data in small holder systems. Modelling of lactation curve is an important tool in designing appropriate breeding and management strategies to achieve genetic improvement.

Acknowledgments
The author gratefully acknowledges The Director, Centre for Advanced Studies in Animal
Genetics and Breeding for permitting to publish this article and for the facilities extended for conduct of this study.

References

1. Dairying in Kerala. A statistical profile. National dairy development board, 2016, 1-135.
2. BAHS [Basic Animal Husbandry and Fishery Statistics]. Government of India. Department of Animal Husbandry, Dairying and Fisheries. Ministry of Agriculture and Farmers welfare, 2017. Available: https://www.dahd.nic.in [30 june.17].
3. Banu N.R. Genetic evaluation of the lactation curve in Karan Fries cattle. Ph. D. Thesis, National Dairy Research Institute, Karnal, 2010, 1-198.
4. Nelder JA. Inverse polynomials, a useful group of multi-factor response functions. Biometrics. 1966; 22:128-141.
5. Guo Z, Swalve H. Modelling of lactation curve as a sub-model in the evaluation of test day records. In Proceedings of Interbull open meeting, Prague, Czech Republic, 1995, 11.
6. Sikka L. A study of lactation as affected by heredity and environment. Jounal Dairy Science. 1950; 17:231-252.
7. Wilmink JB, Syndicate RD. Adjustment of test-day milk, fat and protein yield for age, season and stage of lactation. Livestock. Production Science. 1987; 16:335-348.
8. Wood PDP. Algebraic model of the lactation curve in cattle. *Nature*. 1967; 216:164-165.
9. Rekaya R, Carabano MJ, Toro MA. Use of test day milk yield records for genetic evaluation of production traits in Holstein Friesian cattle. Livestock Production Science. 1999; 57:203-217.
10. Sambhaji KL. Genetic evaluation of Karan Fries sires based on test-day milk yield records. M.V.Sc Thesis, National Dairy Research Institute, Karnal, 2009, 1-136.
11. Olori VE, Brotherstone S, Hill WG, McGuirk BJ. Fit of standard models of the lactation curve to weekly records of milk production of cows in a single herd. Livestock Production Science. 1999; 58(1):55-63.
12. Dimauro C, Catillo G, Bacciu N, Macciotta NP. Fit of different linear models to the lactation curve of Italian water buffalo. Italian Journal of Animal Science. 2005; 4:22-24.
13. Kumar S. A comparative study of lactation curve models for prediction of lactation milk yield in Murrah buffaloes. M.V.Sc Thesis, National Dairy Research Institute, Karnal, 2007, 1-105.
14. Cilek S, Keskin I. Comparison of six different mathematical models to the lactation curve of Simmental cows reared in Kazova state farm. Jounal of Veterinary Animal Adv. 2008; 7:1316-1319.
15. Seyed-Sharifi R, Seyedsharifi R, Kheir AR. Selection for lactation curve and determination of the lactation curve function in Iranian Holstein cows by empirical mathematical models. Journal of Food, Agriculture & Environment. 2009; 7(2):453-455.
16. Valsalan J. Genetic and phenotypic profiling of lactation curve in Murrah buffaloes. Ph. D Thesis, National Dairy Research Institute, Karnal, 2015, 1-128.
17. Martínez López I, Ortiz Rodríguez IM, Rodríguez Torreblanca C. A study of lactation curves in dairy cattle using the optimal design of experiments methodology. Italian Journal of Animal Science. 2019; 18(1):594-600.
18. Bhagwanrao DV. Modelling lactation curve for sire evaluation in Sahiwal cattle. Ph. D. Thesis, National Dairy Research Institute, Karnal, 2012, 1-134.
19. Sahoo SK, Singh A, Shivahre PR, Singh M, Dash S, Dash SK *et al.* Prediction of fortnightly test-day milk yields using four different lactation curve models in Indian Murrah Buffalo. Adv. Anim. Vet. Sci. 2014; 2(12):647-51.
20. Torshizi ME, Aslamenejad AA, Nassiri MR, Farhangfar H. Comparison and evaluation of mathematical lactation curve functions of Iranian primiparous Holsteins. South African Journal of Animal Science. 2011; 41(2):104-15.
21. Prakash V, Gupta AK, Gupta A, Gandhi RS. Lactation curve modelling using Legendre Polynomial in Sahiwal cattle. Indian Journal of Animal Sciences. 2016; 86:485-488.
22. Prasad SH, Singh RK, Singh RA. An extension of Wood's model to describe the lactation performance of dairy animals. Indian Journal of Animal Sciences. 2004; 74:428-431.
23. Pelaez VCG, Muniz GJEG, Villalobos, L.N. Empirical models used for lactation curve analysis in the Chiapas sheep breed using random regression models. International Journal of Livestock Production. 2014; 5(3):55-64.
24. Vohra, V. Studies on genetic variability of lactation curve traits for Karan Fries cows. Ph. D Thesis, National Dairy Research Institute, Karnal, 2010, 1-120.