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Research Paper

Seasonal Haematological Profile of Cattle in Four Agro-Climatic Regions of Tamil Nadu Under Different Housing Systems

Environmental Science

KEYWORDS : Cattle, haematology, housing system

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ABSTRACT

The environment in which the dairy cattle is reared affects its ability to maintain health and production which is in turn related to physiological mechanisms. A study was conducted in the four agro-climatic regions of Tamil Nadu viz. North Eastern zone, North Western zone, Western zone, and Hilly zone with the objective to determine the reference values for the haematological parameters of crossbred cattle in milk during the four seasons kept under five housing systems. Initially a survey was conducted in the four selected agro-climatic regions with a pre-structured interview schedule for identifying the existing dairy cattle housing patterns, production and management measures. Based on the survey animals from five housing systems with thatch, tile, cement sheet, metal sheets and open housing systems were selected for haematologic examination. During the South West monsoon season WBC, HB, PCV, MCHC, PLT, MPV and PCT were found to differ significantly ($p<0.01$) between animals kept in different housing systems in all the agro-climatic zones. During the North East monsoon season WBC, RBC, HB, PCV, MCHC and RDW were found to differ significantly ($p<0.01$) between animals kept in different housing systems in all the agro-climatic zones. During cold season WBC and MCHC were showing highly significant difference ($p<0.01$), whereas RDW, PLT and PCT were showing significant difference ($p<0.05$) between animals kept in different housing systems in all the agro-climatic zones. Highly significant difference ($p<0.01$) was found in WBC, HB and MCHC between animals kept in different housing during summer season, whereas PCV was showing significant difference ($p<0.05$). There was no significant difference ($p<0.05$) in the other haematological parameters during any of the seasons.

INTRODUCTION

Animal comfort and welfare are considered as the important points in dairy herd management. Though India is having the world's highest cattle population, the average milk production of the cattle is very low. Improving the health and comfort of the animals is one of the ways to improve the farm economics. Blood profile has been used widely for the assessment of health status of animals and to find out the reasons for low production or disease (Lee et al. 1978). Regional agro-climatic conditions and seasonal variations affect the comfort level of the animals directly. This effect can be modified through providing better management conditions like better feeding and housing. Studies using climatic chamber for determining the haematological and biochemical responses of animals showed that erythrocytes, haemoglobin, and PCV were higher during summer than during winter conditions (Ferreira et al., 2009). There is a need to establish agro-climatic based season specific reference range for blood parameters in crossbred cattle. The management measure, especially the housing plays an important role in alleviating the stress of animals. The present study was undertaken at the seven agro-climatic regions of Tamil Nadu with the objective to determine the reference values for the haematological parameters of crossbred cattle during the four seasons kept under five housing systems.

MATERIALS AND METHODS

The study was conducted in the four agro-climatic regions of Tamil Nadu viz. North Eastern zone, North Western zone, Western zone and Hilly zone. Out of this, the first three agro-climatic regions have the highest cattle population and the Hilly zone has the cattle with high productivity. The research was carried out in two phases. The first one involved the base line survey to identify the existing dairy cattle housing system and the second one involved the seasonal assessment of the haematological parameters of the cattle in selected farms. Based on the survey, the major housing patterns existing in the region were identified and categorized for further detailed investigation. Farmers with at least five cows were selected from each agro-climatic zone with the major types of housing pattern identified for conducting the field investigation. For each season a total of thirty blood samples were collected from milking crossbred cattle (five housing types with six replicates) for haematological studies. A total of 120 samples were collected for each season with a grand total of 480 samples during the whole experimental period. The study was conducted for one year duration and the period was divided into four seasons as per Shanmugasundaram et al. (1973) as South West monsoon (June – August), North East monsoon (September-November), cold season (December-February) and summer season (April-May). In each sampling season the number of animals sampled in each group was always greater than five recommended by Whitaker (2000).

Whole blood was collected between 12.00 noon to 2.00 pm from each cow through jugular venipuncture into tubes containing EDTA for haematological analyses, as described by Grunwaldt, *et al,* (2005). Total White Blood Cells - (TWBC), Total Red Blood Cells - (TRBC), Haemoglobin - (HB), Haematocrit Value - (HCT/PCV), Mean Corpuscular Volume - (MCV), Mean Corpuscular Haemoglobin - (MCH) and Mean Corpuscular Haemoglobin Concentration - (MCHC) were studied by standard methods described by Coles (1986) and Perumal (2010) by using autohaematology analyzer (Mindray, BC- 2800 Vet, LabResource, Inc., USA). The collected data were statistically analyzed by one way analysis of variances (ANOVA) for finding the difference between the groups by using statistical package SPSS 17. Multiple correlations were worked out for identifying the most suitable housing system in each agro-climatic zone.

RESULTS AND DISCUSSION

From the survey was observed that mostly the farmers were using thatch, tile, cement sheet (CC), metal sheets and open housing systems for rearing the animals. Hence these five types of housing systems were selected for the study. The mean±S.E of haematological parameters of animals under various housing types in all the agro-climatic zones under the studyduring South West monsoon, North East monsoon, cold season and summer are presented in Table1, 2, 3 and 4 respectively.

Sl No	Agro-climatic region	North Eastern Zone Housing Types					North Western Zone Housing Types				
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open
1	WBC (10^3/µl)	9.01 ±1.98	7.45 ±2.06	10.45 ±2.69	11.56 ±1.96	10.43 ±1.99	11.76 ±2.35	10.86 ±3.76	8.05 ±0.09	7.96 ±2.10	7.60 ±2.50
2	RBC (10^6/µl)	5.12 ± 0.24	5.53 ±0.26	5.72 ±.044	5.56 ±0.26	5.09 ±0.32	5.83 ±0.03	4.87 ±0.12	5.25 ±0.02	5.05 ±0.22	5.16 ±0.21
3	HGB (g/dl)	8.80 ±0.41	9.91 ±0.72	8.15 ±0.04	8.73 ±0.57	8.41 ±0.46	9.80 ±0.06	8.21 ±0.23	8.38 ±0.04	8.20 ±0.38	8.53 ±0.34
4	HCT (per cent)	25.18 ±1.17	27.86 ±1.46	23.93 ±1.11	25.20 ±1.63	24.65 ±1.42	28.66 ±1.67	24.25 ±0.56	25.11 ±1.33	24.78 ±1.11	25.25 ±1.04
5	MCV (fl)	49.33 ±1.62	50.53 ±1.17	50.61 ±1.36	46.41 ±2.61	48.71 ±1.16	50.28 ±1.12	49.93 ±1.14	47.93 ±1.51	49.40 ±2.30	49.01 ±0.71
6	MCH (pg)	17.21 ±0.90	17.81 ±0.60	17.11 ±0.05	18.81 ±2.50	16.55 ±0.26	17.06 ±0.36	16.81 ±0.48	15.93 ±0.05	16.26 ±0.87	16.51 ±0.41
7	MCHC (g/dl)	34.95 ±0.93	35.36 ±0.80	33.95 ±0.03	34.60 ±0.25	34.13 ±0.42	34.08 ±0.28	33.80 ±0.33	33.31 ±0.01	33.01 ±0.35	33.78 ±0.59
8	RDW (per cent)	17.18 ±0.58	16.58 ±0.07	16.43 ±0.03	17.25 ±0.34	16.73 ±0.51	16.60 ±0.44	16.30 ±0.27	16.86 ±0.03	16.66 ±0.43	17.96 ±0.91
9	PLT (10^3/µl)	322.66 ±19.34	324.50 ±98.75	249.16 ±43.94	170.83 ±41.06	247.83 ±35.53	403.66 ±44.85	410.00 ±72.28	298.66 ±26.14	404.50 ±31.03	393.83 ±92.29
10	MPV (fl)	7.41 ±0.15	7.15 ±0.40	7.30 ±0.00	6.91 ±0.25	7.21 ±0.14	70.90 ±0.22	8.01 ±0.24	7.31 ±0.18	7.13 ±0.16	7.18 ±0.26
11	PDW (per cent)	15.98 ±0.16	15.75 ±0.14	15.90 ±0.01	15.50 ±0.30	15.90 ±.15	16.21 ±0.21	16.13 ±0.18	15.71 ±0.25	15.91 ±0.20	15.63 ±0.38
12	PCT (per cent)	0.23 ±0.01	0.22 ±0.07	0.18 ±0.00	0.12 ±0.03	0.18 ±0.02	0.32 ±0.04	0.30 ±0.04	0.22 ±0.01	0.28 ±0.02	0.28 ±0.06

Table 1. Mean ± SE of haematological parameters during South West monsoon

Sl No	Agro-climatic region	Western Zone Housing Types					Hilly Zone Housing Types					Over all	F value	P Value
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open			
1	WBC (10^3/µl)	10.31 ±3.61	11.43 ±4.13	12.65 ±0.68	13.06 ±1.86	12.80 ±2.82	11.81 ±3.24	10.20 ±7.53	13.50 ±2.48	7.66 ±1.75	9.36 ±4.01	10.39 ±0.31	2.418	0.003
2	RBC (10^6/µl)	5.66 ±0.34	5.60 ±0.44	5.32 ±.031	5.44 ±0.29	5.75 ±0.24	5.70 ±0.37	6.65 ±0.90	6.16 ±0.34	6.75 ±0.71	6.61 ±0.98	5.64 ±0.10	1.495	0.103
3	HGB (g/dl)	9.05 ±0.55	8.38 ±0.77	8.86 ±.045	9.03 ±0.43	9.11 ±0.52	9.53 ±0.51	11.40 ±0.68	11.01 ±0.07	12.38 ±0.31	10.85 ±0.90	9.33 ±0.15	4.770	0.000
4	HCT (per cent)	25.38 ±1.61	24.25 ±2.01	25.33 ±1.17	25.98 ±1.26	26.01 ±1.69	26.11 ±1.09	30.06 ±1.49	30.11 ±2.09	33.40 ±0.57	29.58 ±2.32	26.55 ±0.37	3.018	0.000
5	MCV (fl)	45.05 ±1.66	43.50 ±2.56	48.00 ±1.52	48.31 ±3.11	45.13 ±1.30	53.75 ±0.85	47.43 ±3.36	49.25 ±2.98	51.40 ±3.55	47.36 ±3.85	48.56 ±0.49	1.177	0.292
6	MCH (pg)	16.00 ±0.57	14.90 ±0.87	16.66 ±.046	19.51 ±2.40	15.78 ±0.45	19.51 ±0.64	17.75 ±1.06	17.96 ±0.94	18.91 ±1.17	17.06 ±1.11	17.21 ±0.24	1.454	0.120
7	MCHC (g/dl)	35.63 ±0.32	34.35 ±0.50	34.91 ±0.60	34.73 ±0.26	35.06 ±0.53	36.38 ±0.79	37.83 ±0.61	36.58 ±0.44	37.06 ±0.48	36.63 ±0.96	35.01 ±0.16	5.703	0.000
8	RDW (per cent)	17.85 ±0.64	16.61 ±0.27	17.70 ±0.77	16.70 ±0.33	17.53 ±0.21	16.43 ±0.25	14.33 ±2.41	16.95 ±0.04	17.01 ±0.82	17.18 ±0.73	16.84 ±0.16	1.078	0.385
9	PLT (10^3/µl)	275.83 ±67.42	156.33 ±67.21	152.50 ±23.58	170.33 ±28.50	184.33 ±39.79	367.33 ±27.87	301.16 ±48.59	444.33 ±63.91	455.50 ±24.06	426.66 ±141.98	308.00 ±15.40	2.954	0.000
10	MPV (fl)	6.65 ±0.15	6.68 ±0.19	6.80 ±.020	7.20 ±0.31	6.83 ±0.15	7.41 ±0.12	6.58 ±0.20	6.61 ±0.19	7.01 ±0.37	6.81 ±0.35	7.10 0.06	2.807	0.000
11	PDW (per cent)	15.31 ±0.21	15.36 ±0.29	15.35 ±.019	15.63 ±0.34	15.13 ±0.09	16.31 ±0.07	15.48 ±0.34	15.58 ±0.33	15.83 ±0.32	15.73 ±0.46	15.72 ±0.06	1.427	0.132
12	PCT (per cent)	0.18 ±0.04	0.10 ±0.04	0.10 ±0.01	0.12 ±0.02	0.12 ±0.02	0.27 ±0.02	0.18 ±0.04	0.29 ±0.05	0.32 ±0.03	0.19 ±0.02	0.21 ±0.01	3.910	0.000

Table 2. Mean ± SE of haematological parameters during North East monsoon

Sl No	Agro-climatic region	North Eastern Zone Housing Types					North Western Zone Housing Types				
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open
1	WBC (10^3/µl)	13.75 ±2.53	12.00 ±1.39	13.45 ±3.84	9.12 ±1.28	14.85 ±1.89	11.68 ±1.70	14.30 ±3.64	15.48 ±1.68	11.75 ±1.71	14.80 ±2.16
2	RBC (10^6/µl)	7.03 ±0.22	6.68 ±0.75	6.18 ±0.54	7.62 ±0.58	7.25 ±0.49	6.83 ±0.86	6.68 ±0.07	7.27 ±0.49	7.82 ±0.75	6.65 ±0.75
3	HGB (g/dl)	10.65 ±0.61	9.88 ±0.52	9.02 ±0.55	9.70 ±0.37	11.22 ±0.48	9.55 ±0.47	9.80 ±0.31	11.47 ±0.41	10.87 ±0.73	10.13 ±0.64
4	HCT (per cent)	30.48 ±1.74	28.17 ±1.47	25.42 ±1.43	28.05 ±1.11	31.93 ±1.40	27.40 ±1.49	27.50 ±1.16	32.38 ±1.26	30.93 ±1.98	28.72 ±1.85
5	MCV (fl)	44.83 ±3.14	45.08 ±3.28	44.12 ±4.56	38.48 ±1.92	45.92 ±2.75	43.50 ±3.73	42.40 ±2.20	46.50 ±2.70	41.58 ±3.19	46.17 ±3.50
6	MCH (pg)	15.67 ±1.13	15.80 ±1.16	15.52 ±1.36	13.30 ±0.72	16.13 ±0.91	15.18 ±1.39	15.08 ±0.64	16.47 ±0.88	14.58 ±1.12	16.27 ±1.23
7	MCHC (g/dl)	35.05 ±0.22	35.18 ±0.28	35.58 ±0.70	34.63 ±0.30	35.32 ±0.24	34.93 ±0.33	35.87 ±0.58	35.62 ±0.23	35.18 ±0.26	35.40 ±0.24
8	RDW (per cent)	18.57 ±0.43	18.05 ±0.45	18.45 ±0.63	19.42 ±0.61	18.77 ±0.29	19.02 ±0.67	18.48 ±0.61	18.80 ±0.29	18.65 ±0.46	18.40 ±0.44
9	PLT (10^3/µl)	184.67 ±31.92	288.67 ±109.30	437.17 ±228.94	239.67 ±41.88	164.33 ±17.97	334.33 ±102.22	409.00 ±233.84	157.83 ±15.19	182.00 ±36.37	276.00 ±109.94
10	MPV (fl)	6.35 ±0.21	6.73 ±0.26	6.58 ±0.42	6.07 ±0.13	6.47 ±0.21	6.50 ±0.28	6.53 ±0.20	6.52 ±0.23	6.45 ±0.20	6.60 ±0.29
11	PDW (per cent)	14.97 ±0.14	15.17 ±0.28	15.08 ±0.42	14.60 ±0.11	15.00 ±0.13	14.97 ±0.31	14.92 ±0.22	14.97 ±0.14	14.77 ±0.20	15.15 ±0.27
12	PCT (per cent)	0.12 ±0.02	0.21 ±0.09	0.13 ±0.02	0.14 ±0.02	0.11 ±0.01	0.23 ±0.08	0.12 ±0.02	0.10 ±0.01	0.11 ±0.02	0.20 ±0.09

Table 2. Continued

S l No	Agro-climatic region	Western Zone Housing Types					Hilly Zone Housing Types					Over all	F value	P Value
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open			
1	WBC (10^3/µl)	7.73 ±0.58	9.77 ±1.47	7.57 ±0.87	8.53 ±0.92	15.45 ±2.57	12.80 ±0.82	9.82 ±0.54	8.82 ±1.55	10.00 ±0.23	18.77 ±3.22	12.02 ±0.49	2.377	**0.003**
2	RBC (10^6/µl)	5.32 ±0.32	5.18 ±0.66	5.43 ±0.41	4.62 ±0.36	5.38 ±0.09	6.72 ±0.15	5.30 ±0.28	7.50 ±0.59	6.83 ±0.81	6.77 ±0.78	6.45 ±0.14	2.823	**0.000**
3	HGB (g/dl)	8.47 ±0.43	8.17 ±0.96	7.55 ±0.83	7.85 ±0.70	8.87 ±0.32	10.30 ±0.37	8.67 ±0.48	9.77 ±0.54	9.62 ±0.63	10.48 ±0.89	9.60 ±0.16	3.448	0.000
4	HCT (per cent)	24.38 ±0.95	23.12 ±2.17	18.17 ±2.89	22.08 ±1.44	25.60 ±0.60	29.43 ±1.12	25.23 ±1.07	28.17 ±1.49	27.62 ±1.54	29.30 ±2.71	27.20 ±0.46	4.518	**0.000**
5	MCV (fl)	47.35 ±1.90	46.83 ±1.63	40.47 ±2.66	49.57 ±1.17	48.97 ±1.40	45.05 ±0.91	49.17 ±1.31	39.07 ±2.31	43.98 ±4.25	45.10 ±4.67	44.71 ±0.65	1.185	0.285
6	MCH (pg)	16.33 ±0.48	16.27 ±0.25	17.78 ±1.42	17.48 ±0.58	16.92 ±0.80	15.77 ±0.28	16.75 ±0.51	13.53 ±0.89	15.20 ±1.29	16.10 ±1.54	15.81 ±0.23	1.280	**0.214**
7	MCHC (g/dl)	34.72 ±0.78	35.02 ±0.89	46.00 ±6.46	35.40 ±0.99	34.63 ±0.79	35.13 ±0.31	34.27 ±0.55	34.68 ±0.33	34.87 ±0.39	35.97 ±0.48	35.67 ±0.38	2.595	**0.001**
8	RDW (per cent)	17.50 ±0.51	18.02 ±0.46	17.82 ±0.50	17.27 ±0.42	17.27 ±0.52	17.95 ±0.17	16.82 ±0.55	19.67 ±0.45	18.05 ±0.44	19.13 ±0.59	18.30 ±0.12	2.336	**0.004**

9	PLT (10^3/µl)	372.50 ±35.41	289.00 ±37.02	525.21 ±322.76	347.67 ±44.58	326.50 ±40.01	207.50 ±20.22	302.83 ±44.94	224.33 ±44.81	203.50 ±34.16	497.50 ±241.71	298.51 ±27.71	0.734	0.775
10	MPV (fl)	6.22 ±0.19	6.35 ±0.28	6.07 ±0.38	7.05 ±0.16	6.77 ±0.24	6.75 ±0.08	7.23 ±0.39	6.12 ±0.22	6.67 ±0.39	6.45 ±0.28	6.52 ±0.06	1.270	0.221
11	PDW (per cent)	15.23 ±0.15	15.22 ±0.28	14.90 ±0.20	15.63 ±0.17	15.57 ±0.23	15.10 ±0.07	15.75 ±0.32	14.60 ±0.09	15.10 ±0.38	14.88 ±0.37	15.08 ±0.06	1.547	0.086
12	PCT (per cent)	0.23 ±0.02	0.18 ±0.02	0.19 ±0.03	0.24 ±0.03	0.22 ±0.02	0.14 ±0.01	0.22 ±0.04	0.13 ±0.02	0.14 ±0.02	0.18 ±0.09	0.17 ±0.01	1.157	0.309

Table 3. Mean ± SE of haematological parameters during cold season

Sl No	Agro-climatic region	North Eastern Zone Housing Types					North Western Zone Housing Types				
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open
1	WBC (10^3/µl)	12.05 ±0.74	9.43 ±1.48	11.18 ±0.85	11.75 ±0.67	11.65 ±0.98	9.90 ±1.69	10.25 ±2.59	9.28 ±1.38	8.52 ±0.63	15.58 ±2.81
2	RBC (10^6/µl)	5.78 ±0.52	5.82 ±.39	5.78 ±0.48	5.95 ±0.22	5.33 ±0.21	4.93 ±0.25	6.00 ±0.30	5.85 ±0.34	5.35 ±0.25	5.97 ±0.56
3	HGB (g/dl)	8.93 ±0.68	9.25 ±.66	8.67 ±0.45	9.23 ±0.24	8.27 ±0.35	7.38 ±0.19	9.13 ±0.51	8.78 ±0.51	8.67 ±0.52	8.93 ±0.76
4	HCT (per cent)	26.43 ±1.68	26.90 ±1.73	25.90 ±0.92	26.70 ±0.61	24.47 ±0.91	22.27 ±0.60	27.10 ±1.44	24.98 ±1.33	23.95 ±1.46	27.83 ±1.99
5	MCV (fl)	46.77 ±1.87	46.88 ±1.07	46.43 ±2.56	45.57 ±1.08	46.43 ±1.19	46.05 ±1.74	45.93 ±1.52	43.50 ±2.00	45.32 ±1.91	46.50 ±1.91
6	MCH (pg)	15.52 ±0.36	15.83 ±.38	15.22 ±0.56	15.55 ±0.39	15.52 ±0.38	15.07 ±0.57	15.32 ±0.44	14.53 ±0.78	15.22 ±0.67	15.10 ±0.73
7	MCHC (g/dl)	33.42 ±0.58	33.87 ±.19	33.13 ±0.62	34.27 ±0.16	33.53 ±0.22	32.92 ±0.50	33.48 ±0.23	33.50 ±0.32	33.70 ±0.30	32.57 ±0.32
8	RDW (per cent)	19.68 ±0.71	17.73 ±.85	19.17 ±0.64	16.67 ±0.21	18.27 ±0.67	18.48 ±0.64	17.52 ±0.23	18.52 ±0.64	17.28 ±0.22	17.92 ±0.42
9	PLT (10^3/µl)	178.50 ±17.22	261.83 ±38.77	231.33 ±46.70	282.67 ±52.05	203.83 ±25.95	307.00 ±49.63	361.50 ±57.69	275.83 ±55.54	298.00 ±45.01	393.00 ±54.99
10	MPV (fl)	6.53 ±0.11	6.87 ±0.14	6.42 ±0.15	6.60 ±0.17	6.62 ±0.15	6.55 ±0.17	6.67 ±0.23	6.25 ±0.07	6.67 ±0.07	6.67 ±0.20
11	PDW (per cent)	14.87 ±0.14	15.57 ±.14	15.00 ±.17	15.40 ±0.18	15.20 ±0.23	15.17 ±0.22	15.17 ±0.18	14.85 ±0.26	15.37 ±0.20	15.28 ±0.20
12	PCT (per cent)	0.12 ±0.01	0.17 ±0.03	0.14 ±0.03	0.17 ±0.05	0.13 ±0.02	0.20 ±0.03	0.24 ±0.03	0.17 ±0.03	0.23 ±0.04	0.23 ±0.05

Table 3. Continued

Sl No	Agro-climatic region	Western Zone Housing Types					Hilly Zone Housing Types					Over all	F value	P Value
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open			
1	WBC (10^3/µl)	11.28 ±1.24	9.17 ±1.41	10.37 ±.55	9.32 ±1.18	10.60 ±1.70	13.42 ±0.94	8.43 ±1.28	8.12 ±0.66	8.00 ±0.99	13.37 ±0.74	10.58 ±0.33	2.126	0.009
2	RBC (10^6/µl)	5.45 ±0.31	5.72 ±0.24	5.67 ±.95	6.35 ±0.36	5.65 ±0.33	5.87 ±0.27	5.72 ±0.60	5.58 ±0.35	5.75 ±0.36	5.57 ±0.65	5.70 ±0.09	0.465	0.971
3	HGB (g/dl)	8.07 ±0.39	8.25 ±0.24	9.13 ±.48	8.68 ±0.71	8.60 ±0.67	9.68 ±0.55	8.78 ±0.38	9.22 ±0.55	9.02 ±0.28	8.00 ±0.59	8.73 ±0.12	1.088	0.375
4	HCT (per cent)	24.68 ±1.18	23.93 ±0.71	25.33 ±1.71	26.43 ±1.66	26.30 ±1.41	27.25 ±1.53	25.15 ±0.95	26.48 ±1.56	26.08 ±0.83	23.50 ±1.31	25.58 ±0.30	1.166	0.302
5	MCV (fl)	45.95 ±1.13	46.20 ±1.38	44.68 ±4.15	44.25 ±1.95	45.35 ±1.79	47.33 ±2.16	46.05 ±3.04	48.20 ±0.42	46.68 ±2.22	46.87 ±3.04	46.05 ±0.44	0.269	0.999

6	MCH (pg)	15.60 ±0.50	15.77 ±0.45	15.08 ±1.32	14.77 ±0.66	15.22 ±0.70	16.65 ±0.84	15.83 ±0.92	16.20 ±0.40	15.95 ±0.73	15.63 ±0.81	15.48 ±0.14	0.536	0.939
7	MCHC (g/dl)	34.10 ±0.30	34.30 ±0.29	33.95 ±0.19	33.45 ±0.50	33.65 ±0.34	35.22 ±0.27	34.67 ±0.43	33.70 ±0.61	34.33 ±0.16	33.60 ±0.74	33.77 ±0.10	2.268	0.005
8	RDW (per cent)	17.73 ±0.39	17.13 ±0.35	17.43 ±0.73	18.23 ±0.71	18.08 ±0.54	16.83 ±0.23	17.70 ±0.59	17.15 ±0.33	17.15 ±0.34	17.20 ±0.64	17.79 ±0.13	2.016	0.014
9	PLT (10^3/µl)	409.67 ±81.26	277.67 ±28.78	327.33 ±17.54	303.17 ±22.90	363.33 ±78.36	416.33 ±52.42	422.00 ±62.13	243.67 ±59.05	423.00 ±78.10	305.67 ±61.62	314.27 ±12.67	1.957	0.017
10	MPV (fl)	6.90 ±0.12	6.87 ±0.15	6.83 ±0.34	6.62 ±0.32	6.77 ±0.25	6.65 ±0.08	6.52 ±0.31	6.67 ±0.13	6.83 ±0.22	6.83 ±0.32	6.67 ±0.04	0.679	0.831
11	PDW (per cent)	15.53 ±0.18	15.40 ±0.15	15.35 ±0.36	15.12 ±0.25	15.55 ±0.36	15.53 ±0.17	15.33 ±0.33	15.57 ±0.16	15.48 ±0.26	15.68 ±0.36	15.32 ±0.05	1.001	0.467
12	PCT (per cent)	0.29 ±0.06	0.19 ±0.02	0.22 ±0.01	0.19 ±0.03	0.25 ±0.05	0.31 ±0.04	0.28 ±0.05	0.16 ±0.04	0.29 ±0.06	0.21 ±0.05	0.21 ±0.01	1.943	0.018

Table 4. Mean ± SE of haematological parameters during summer season

Sl No	Agro-climatic region	North Eastern Zone Housing Types					North Western Zone Housing Types				
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open
1	WBC (10^3/µl)	9.27 ±1.31	8.58 ±0.96	9.53 ±0.54	11.32 ±1.08	11.70 ±2.08	5.58 ±0.67	7.88 ±0.68	9.02 ±1.15	5.92 ±0.67	6.05 ±0.79
2	RBC (10^6/µl)	5.68 ±0.27	5.80 ±0.31	5.75 ±0.14	5.01 ±0.31	5.10 ±0.42	5.06 ±0.30	6.16 ±0.11	5.18 ±0.33	5.09 ±0.39	4.58 ±0.13
3	HGB (g/dl)	8.18 ±0.34	9.22 ±0.53	8.33 ±0.28	7.65 ±0.57	7.58 ±0.31	6.92 ±0.46	9.08 ±0.18	7.25 ±0.35	7.98 ±0.66	6.70 ±0.33
4	HCT (per cent)	24.35 ±1.18	27.55 ±1.49	25.10 ±0.59	22.42 ±1.48	22.78 ±0.78	21.57 ±1.56	26.58 ±0.37	21.50 ±0.98	23.98 ±2.17	20.78 ±1.05
5	MCV (fl)	43.07 ±1.46	47.67 ±1.12	43.80 ±0.67	44.85 ±1.04	45.97 ±2.73	42.57 ±0.90	43.18 ±1.08	42.00 ±1.73	47.20 ±2.03	45.75 ±2.89
6	MCH (pg)	14.38 ±0.37	15.85 ±0.38	14.45 ±0.34	15.20 ±0.42	15.15 ±0.85	13.95 ±0.34	14.75 ±0.41	14.08 ±0.59	15.67 ±0.56	14.70 ±0.96
7	MCHC (g/dl)	330.65 ±0.50	33.38 ±0.20	33.12 ±0.41	33.98 ±0.34	33.37 ±0.22	32.93 ±0.32	34.12 ±0.30	33.68 ±0.11	33.35 ±0.48	32.23 ±0.48
8	RDW (per cent)	17.75 ±0.56	17.58 ±0.86	17.50 ±0.27	17.60 ±0.67	17.62 ±0.79	18.15 ±0.61	17.93 ±0.44	17.55 ±0.30	17.03 ±0.33	17.57 ±0.25
9	PLT (10^3/µl)	199.00 ±20.41	223.83 ±22.45	183.33 ±27.17	294.67 ±52.58	272.00 ±69.90	308.33 ±34.82	314.50 ±55.37	275.50 ±58.12	371.67 ±49.22	315.83 ±47.78
10	MPV (fl)	6.53 ±0.10	6.72 ±0.12	6.40 ±0.15	6.63 ±0.07	6.68 ±0.20	6.03 ±0.14	6.33 ±0.12	6.52 ±0.09	6.75 ±0.29	6.58 ±0.30
11	PDW (per cent)	15.12 ±0.16	15.48 ±0.18	15.08 ±0.09	15.32 ±0.10	15.40 ±0.25	14.95 ±0.14	14.88 ±0.11	15.27 ±0.15	15.50 ±0.25	15.37 ±0.30
12	PCT (per cent)	.13 ±.01	0.15 ±0.01	0.12 ±0.02	0.20 ±0.04	0.15 ±0.05	0.19 ±0.02	0.20 ±0.04	0.17 ±0.04	0.26 ±0.04	0.21 ±0.04

Table 4. Continued

Sl No	Agro-climatic region	Western Zone Housing Types					Hilly Zone Housing Types					Over all	F value	P Value
	Parameter (n=6)	Thatched	Tile	Metal	CC	Open	Thatched	Tile	Metal	CC	Open			
1	WBC (10^3/µl)	9.43 ±1.18	7.33 ±0.77	9.70 ±1.35	8.67 ±0.68	8.47 ±0.87	10.47 ±1.16	8.23 ±1.08	7.25 ±1.19	11.65 ±1.44	8.68 ±1.22	8.74 ±0.28	2.589	0.001
2	RBC (10^6/µl)	5.34 ±.38	5.04 ±0.32	5.47 ±0.21	5.98 ±0.16	5.33 ±0.25	5.85 ±0.51	5.51 ±0.50	5.65 ±0.65	5.78 ±0.62	5.08 ±0.44	5.42 ±0.08	1.197	0.276
3	HGB (g/dl)	8.02 ±0.54	8.47 ±0.33	8.47 ±0.23	8.67 ±0.28	8.02 ±0.42	8.98 ±0.61	8.25 ±0.26	8.47 ±0.59	8.57 ±0.67	7.98 ±0.50	8.14 ±0.11	2.258	0.005
4	HCT (per cent)	23.65 ±1.54	22.77 ±1.21	23.83 ±0.80	25.17 ±0.81	23.93 ±1.09	27.82 ±2.02	24.65 ±0.79	25.40 ±1.81	25.12 ±1.67	23.57 ±1.17	24.13 ±0.32	2.078	0.011
5	MCV (fl)	46.37 ±1.93	45.48 ±0.67	43.93 ±1.81	42.18 ±0.60	45.28 ±2.09	49.42 ±1.94	46.20 ±3.13	46.67 ±3.23	44.70 ±2.56	47.43 ±2.29	45.19 ±0.44	1.044	0.420
6	MCH (pg)	15.05 ±0.54	15.02 ±0.14	14.90 ±0.62	14.43 ±0.23	15.07 ±0.74	17.20 ±0.80	15.42 ±1.14	15.47 ±1.08	15.05 ±0.72	15.88 ±0.55	15.08 ±0.15	1.287	0.209

7	MCHC (g/dl)	33.82 ±0.34	33.13 ±0.20	34.10 ±0.46	34.42 ±0.38	33.40 ±0.33	35.78 ±0.73	33.43 ±0.49	33.30 ±0.63	33.95 ±0.70	33.73 ±0.57	33.64 ±0.11	2.521	0.002
8	RDW (per cent)	17.32 ±0.26	17.30 ±0.32	17.92 ±0.83	17.30 ±.22	18.33 ±0.75	17.50 ±0.36	17.33 ±0.40	17.45 ±0.64	17.73 ±0.52	17.32 ±0.42	17.59 ±0.11	0.350	0.994
9	PLT (10^3/ µl)	299.17 ±35.88	288.83 ±39.21	275.50 ±24.74	310.83 ±37.70	319.50 ±30.75	274.33 ±25.17	365.00 ±47.47	378.50 ±36.41	344.67 ±38.51	344.00 ±61.72	297.95 ±9.99	1.503	0.101
10	MPV (fl)	6.42 ±0.13	6.75 ±0.15	6.67 ±0.27	6.45 ±0.14	6.62 ±0.32	6.92 ±0.31	6.65 ±0.31	6.68 ±0.23	6.70 ±0.38	6.80 ±0.24	6.59 ±0.05	0.779	0.727
11	PDW (per cent)	15.18 ±0.20	15.38 ±0.21	15.23 ±0.13	14.93 ±0.12	15.37 ±0.34	15.65 ±0.34	15.58 ±0.31	15.55 ±0.32	15.22 ±0.29	15.50 ±0.27	15.30 ±0.05	0.945	0.531
12	PCT (per cent)	0.20 ±0.03	0.19 ±0.03	0.18 ±0.01	0.17 ±0.03	0.21 ±0.02	0.18 ±0.04	0.24 ±0.04	0.25 ±0.03	0.23 ±0.03	0.23 ±0.04	0.19 ±0.01	1.371	0.159

During the South West monsoon season WBC, HB, PCV, MCHC, PLT, MPV and PCT were found to differ significantly ($p<0.01$) between different housing systems in all the agro-climatic zones under study. During the North East monsoon season WBC, RBC, HB, PCV, MCHC and RDW were found to differ significantly ($p<0.01$) between different housing systems in all the agro-climatic zones under study.

During cold season WBC and MCHC were showing highly significant difference ($p<0.01$), whereas RDW, PLT and PCT were showing significant difference ($p<0.05$) between different housing systems in all the agro-climatic zones under study.

Highly significant difference ($p<0.01$) was found in WBC, HB and MCHC between different housing during summer season, whereas PCV was showing significant difference ($p<0.05$). There was no significant difference ($p<0.05$) in the other haematological parameters during any of the seasons.

The total leukocyte count (x103/µl) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 7.45 – 13.50 (10.39±0.31), 7.56-18.76 (12.02±0.49), 8.00- 15.58 (10.58±0.33) and 5.58-11.70 (8.74±0.28) respectively. The higher values mostly exceeded the limit given by Benjamin (2007).

The total erythrocyte count (x106/µl) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 4.87-6.75 (5.64±0.10), 4.61-7.81 (6.45±0.14), 4.93-6.35 (5.70±0.09) and 4.58-6.15 (5.42±0.08) respectively. The lower values were found to be slightly less than the range given by Coles (1986). However, similar values were reported by Sharma et al. (2009).

The haemoglobin (g/dl) during South West monsoon, North East monsoon, cold and summer season were showing the range (overall mean ± SE) of 8.15-12.38 (9.33±0.15), 7.55-11.46 (9.60±0.16), 7.38-9.68 (8.73±0.12) and 6.7-9.21 (8.14±0.11) respectively. The values were found to be slightly less than the range given by Coles (1986).

The packed cell volume (per cent) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 23.93-33.40 (26.55±0.37), 18.16-32.38 (27.20±0.46), 22.26-27.83 (25.58±0.30) and 20.78-27.81 (24.13±0.32) respectively. The values were found to be less than the range given by Coles (1986). However, similar values were reported by Das et al. (2009) and seasonal variation in PCV was reported by Mirzadesh et al. (2010).

The MCV (fl) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 43.50-53.75 (48.56±0.49), 38.48-49.56 (44.71±0.65), 43.50-48.20 (46.05±0.44) and 42.00-49.41 (45.19±0.44) respectively. The values were found to be within the normal range given by Coles (1986). However, it was contrary to the finding of Randhawa et al. (2009), there was no reduction in MCV during rainy and summer seasons.

The MCH (pg) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 14.90–19.51 (17.21±0.24), 13.30-17.78 (15.81±0.23), 14.53-16.65 (15.48±0.14) and 13.95-17.20 (15.08±0.15) respectively. The values were found to be with in the normal range given by Coles (1986). However, it was contrary to the finding of Randhawa et al. (2009), there was no reduction in MCH during rainy season.

The MCHC (g per dl) during South West monsoon, North East monsoon, cold and summer seasons were showing the range (overall mean ± SE) of 33.01-37.83 (35.01±0.16), 34.26-46.00 (35.67±0.38), 32.56-35.21 (33.77±0.10) and 32.23-35.78 (33.64±0.11) respectively. The values were found to be slightly higher than the range given by Coles (1986) but the mean got reduced during summer contrary to the findings of Mirzadesh et al. (2010).

Haematological parameters which are showing significant correlation ($p<0.05$) were selected (RBC, HB, PCV, MCH, PLT, PDW and PCT) for identifying the most suitable housing system in each agro-climatic zone.

In North Eastern zone animals reared in tile roofed housing was found to be healthier and comfortable with respect to the haematological parameters. The mean ± SE values of RBC (5.96±0.24 x 106/µl), HB (9.57±0.29 g/dl), PCV (27.62±0.73 per cent), MCH (16.33±0.38 pg), PLT (274.71±36.70 x 103/µl), PDW (15.49±0.10 per cent) and PCT (0.19 ±0.03 per cent) were recorded under tile housing.

In North Western zone animals reared in tile roofed housing was found to be healthier and comfortable with respect to the haematological parameters. The mean ± SE values of RBC (5.92±0.16 x 106/µl), HB (9.06±0.19 g/dl), PCV (26.35±0.53 per cent), MCH (15.49±0.29 pg), PLT (373.75±60.59 x 103/µl), PDW (15.28±0.13 per cent) and PCT (0.22 ±0.02 per cent) were recorded under tile housing.

In Western zone there was no single housing system showing a marked difference from others on the basis of the selected haematological parameters. However, the cement sheet roofed housing system has shown a slight advantage over others. The mean ± SE values of RBC (5.59±0.20 x 106/µl), HB (8.55±0.28 g/dl), PCV (24.92±0.71 per cent), MCH (16.55±0.74 pg), PLT (283.00±21.31 x 103/µl), PDW (15.32±0.14 per cent) and PCT (0.18 ±0.02 per cent) were recorded under cement sheet roofed housing.

In Hilly zone cement sheet roofed housing was found to be more comfortable with respect to the haematological parameters. The mean ± SE values of RBC (6.27±0.32 x 106/µl), HB (9.90±0.39 g/dl), PCV (28.05±0.89 per cent), MCH (16.28±0.57 pg), PLT

(356.67±30.29 x 103/µl), PDW (15.41±0.16 per cent) and PCT (0.25 ±0.02 per cent) were recorded under cement sheet roofed housing.

CONCLUSION

Based on the present study the reference intervals were established for the haematological parameters on agro-climatic basis. It was concluded that the climatic condition and the management in each agro-climatic condition is affecting the haematologic parameters of crossbred cattle.

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