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Assessment of cold stress in crossbred cattle by wind chill temperature index

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Animals experience cold stress when environmental temperature drops below lower critical temperature. Exposure to cold stress can adversely affect milk production, feed intake (Hill and Wall 2017) and behaviour (Solianik *et al.* 2014) of animals. Conventionally, cold stress is described with Wind Chill Temperature (WCT) index (Angrecka and Herbut 2015) calculated by taking into account of both ambient temperature and wind velocity. Several studies have reported effect of WCT on physiological parameters, production and comfort of animals (Giri *et al.* 2017, Purwar *et al.* 2019), however, there is paucity of information on this for Jammu region of Jammu and Kashmir, where climatic condition during winter is severe with temperature dropping below 10°C. Therefore, the present study was undertaken to study the effect of WCT on physiological, hemato-biochemical, behavioural parameters and milk production in crossbred cattle of the region. The experiment spanned over November to March over 12 lactating crossbred cattle, aged between 4 to 5 years. Animals were kept indoor under standard management practices. WCT was calculated as per formula of Tucker *et al.* (2007). Physiological and behavioural parameters were recorded as per standard methods recorded at 6:00 h daily. Haemato-biochemical parameters were evaluated with automated blood analyser (Cell tech 30) or as per standard methods (Hafeman *et al.* 1974, Marklund and Marklund 1974) using commercial kits. The data were analysed as per the methods of Snedecor and Cochran (1994) using SPSS16 software.

The WCT recorded during experimental period was below the comfort zone (Yasothai 2014) described for crossbred cattle. The WCT decreased gradually from November reaching lowest point during January then increased up to March (Table 1). It was evident that WCT had a significant ($p<0.05$) effect on and high correlation ($P<0.01$; $r=0.943$) with milk production of animals (Fig. 1). For each point decrease in WCT the milk yield (MY) decreased by 0.730 kg per day. WCT had significant ($p<0.05$) effect on and strong positive correlation ($r=0.856$; $p<0.01$) with weekly mean rectal temperature (RT) and a decrease in RT by 0.094°C for each point decrease in WCT (Fig. 2A). We observed subnormal RT with decrease WCT, as reported by previous studies as well (Habeeb *et al.* 2018). WCT also had significant ($p<0.05$) effect on and positive correlation with respiration rate (RR) and pulse rate (PR) (Fig. 2B). These observation were in accordance to previous

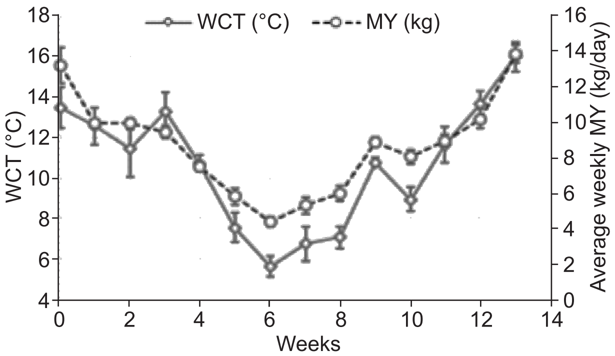

Fig. 1. Effect of WCT on milk yield.

Table 1. Microclimatic variables during the experimental period

Period	Week	Ambient temperature (°C)	Wind velocity (Km/hr)	WCT (°C)
Nov.	0	15.00±0.97	2.69±0.34	13.51±1.09
Dec.	1	14.00±0.82	2.42±0.37	12.60±0.92
	2	13.86±1.08	4.48±0.77	11.46±1.37
	3	15.14±0.74	3.48±0.58	13.28±0.97
	4	12.86±0.40	3.59±0.43	10.72±0.41
Jan.	5	9.57±0.65	2.84±0.48	7.58±0.73
	6	8.00±0.44	2.97±0.24	5.67±0.51
	7	8.86±0.86	2.92±0.58	6.77±0.88
	8	9.71±0.36	3.86±0.50	7.09±0.56
Feb.	9	12.57±0.30	2.76±0.21	10.80±0.20
	10	10.86±0.46	2.72±0.28	8.96±0.59
	11	13.57±0.89	3.52±0.65	11.66±0.89
	12	15.29±0.42	2.96±0.48	13.68±0.62
Mar.	13	16.57±0.72	1.44±0.20	16.01±0.72

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Table 2. Wind chill temperature (°C) and hemato-biochemical parameters of dairy cattle

Period	WCT (°C)	Hb (g/dl)	PCV (%)	ESR (mm/ 24 h)	AST(IU/L)	ALT(IU/L)	SOD (U/mg of protein)	GPx (unit/ml)	Glucose (mg/dl)
Nov.	13.51±1.01^{c}	10.60±0.18	32.37±0.89	2.80±0.15	89.08±1.90^{b}	27.16±0.59^{a}	17.55±3.06	4.77±0.33^{bc}	67.33±0.67
Dec.	12.67±0.62^{bc}	11.08±0.37	33.02±0.57	3.10±0.19	86.30±0.41^{ab}	28.65±0.56^{a}	15.36±2.74	3.52±0.63^{ab}	67.67±0.80
Jan.	7.56±0.45^{a}	11.25±0.10	33.25±0.63	3.31±0.16	84.97±0.78^{ab}	31.62±0.90^{b}	14.15±3.23	2.53±0.76^{a}	68.00±0.86
Feb.	10.43±0.40^{b}	11.38±0.27	33.55±0.71	2.89±0.32	82.86±0.77^{a}	33.10±0.99^{bc}	18.77±3.62	5.01±0.39^{bc}	68.83±0.60
Mar.	15.87±0.58^{d}	11.47±0.22	33.89±0.75	2.73±0.24	82.29±0.93^{a}	35.20±0.54^{c}	19.94±2.94	5.71±0.45^{c}	68.50±0.85

Values with different superscript within the row differ significantly (P<0.05).

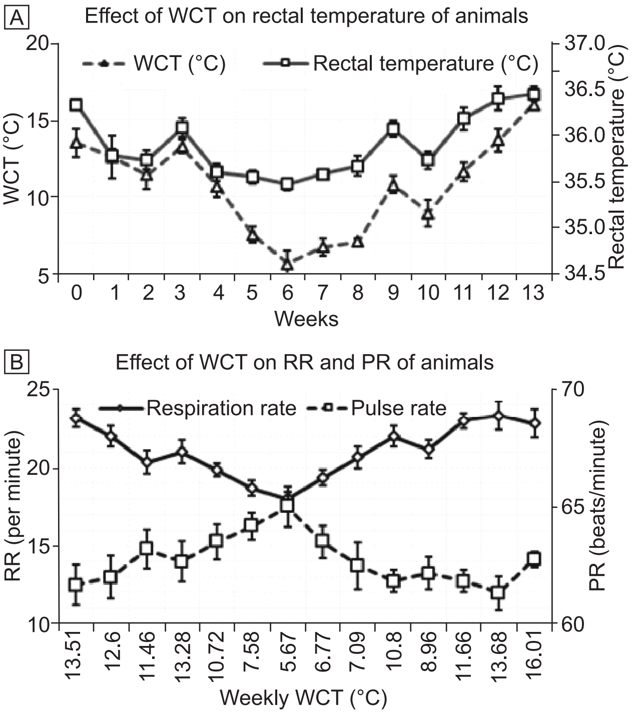

Fig. 2. Effect of WCT on RT (A) RR and PR(B).

studies (Ganaie *et al.* 2013, Angrecka and Herbut 2015, Habeeb *et al.* 2018) suggesting adaptive mechanisms initiated by animals to maintain homeostasis during cold stress. Regression analysis showed high dependence of RT and MY on WCT and medium dependence of RR and PR on WCT.

Table 3. Wind chill temperature (°C) and DMI, WI and R. No of dairy cattle

Period	WCT (°C)	Dry Matter intake (kg)	Water intake (litres)	Rumination number (R.No/5 min)
Nov	13.51±1.01^{c}	12.57±0.67	44.02±1.17	8.50±0.76
Dec	12.67±0.62^{bc}	12.70±1.21	44.81±1.48	8.83±0.48
Jan	7.56±0.45^{a}	13.16±0.83	43.42±1.18	9.00±0.63
Feb	10.43±0.40^{b}	13.34±0.78	43.27±1.07	8.50±0.72
Mar	15.87±0.58^{d}	12.22±0.52	42.98±1.18	8.00±0.63

Values with different superscript within the row differ significantly (P<0.05).

In the present study, we observed no significant effect of WCT on haematological parameters such as Hb, PCV and ESR (Table 2). However, WCT has significant (p<0.05) effect on biochemical parameters AST and ALT as reported in previous studies as well (Mazzullo *et al.* 2014). Oxidative stress parameters such as SOD and GPX followed the similar trend as WCT. It was evident that WCT had significant (p<0.05) effect on GPX and high positive correlation (r = 0.792) thus indicating that colder micro climatic condition had increased the GPx activity which is in accordance with Ohno *et al.* (1991). WCT had no significant (p>0.05) effect or correlation with blood glucose level. The behavioural parameters such as feed intake (DM basis), water intake and rumination number (R.No) showed no significant effect of WCT (Table 3). However, a high negative correlation (r=–0.892; p<0.05) between WCT and DM intake was observed in the study as previously reported (Bouraouri *et al.* 2002, Martel *et al.* 2021). The regression analysis indicated that for each point decrease in WCT, DMI increases by 128 g per animal per day.

Overall, the present study suggests that lactating crossbred cattle were adversely affected by cold stress at wind chill temperature ranging from 5.67±0.51 to 16.01±0.72°C as reflected by drop in milk production, subnormal rectal temperature and increased feed intake. The present study also indicated that mitigation strategies should be adopted to avoid adverse effect of cold stress on the animals.

SUMMARY

In the present experiment we studied the effect of cold stress as assessed by Wind Chill Temperature (WCT) on physiological, hemato-biochemical, behavioural parameters and milk production of crossbred cattle. The study spanned for a period of 14 weeks (November to March) with WCT range of 13.51±1.09 to 5.67±0.51. The rectal temperature (°C) and respiration rate (p<0.01, r=0.812) of the experimental animals showed positive correlation with WCT while pulse rate was negatively correlated (P<0.05; r= –0.639) with WCT. There was no effect of WCT on hematobiochemical parameters with exception of AST, ALT and GPx. Feed intake (DM basis), water intake and rumination number were negatively correlated with WCT. Milk yield (kg) showed positive correlation (p<0.01; r=0.943) with WCT and dropped by 66.59% at lowest WCT.

Regression analysis of data revealed high dependency of rectal temperature, respiration rate, milk yield and dry matter on WCT. The study concluded that cold stress is evident in crossbred at WCT range of 5.67±0.51 to 16.01±0.72°C.

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