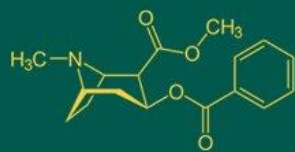


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Seasonal variation in haemato-biochemical profile during growth phase in indigenous Red Kandhari (RK) calves

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Abstract

The present research was conducted on Red Kandhari (RK) calves from July to December 2023 to observe haematological and biochemical variations during their growth phase (0-12 m). For the study, 32 healthy RK calves were divided into four treatments; RK1 (0-3 m), RK2 (3-6 m), RK3 (6-9 m), and RK4 (9-12 m), respectively. The animals were reared under semi-intensive housing management. Blood samples were collected in the mid of each treatment period (45th day/treatment), and analysed for hematological and biochemical parameters. A significant increase was observed for total erythrocytes at RK2 as compared to, RK4 ($p < 0.05$). While, for the other hematological components, no significant variation was noted, at RK3 and RK4, as compared to RK1 and RK2. Serum glucose levels were highest at RK1 ($p < 0.05$) and then decreased linearly with age at RK2-RK4. For other parameters like protein, albumin, uric acid, creatinine, triglyceride, alkaline phosphatases, calcium, and phosphorus, we recorded a strong declining trend at RK3 and RK4, as compared to RK1 and RK2, respectively. The values obtained in this work fall within the normal range for the RK species, and hence can also be used as reference values and for disease diagnostic and evaluation. Results from the study indicate that, in RK calves there is a major metabolic shift from 6 m onwards and that the breed is highly resistant, robust, resilient and very well adapted to the local climatic conditions and environmental stress.

Keywords: Red Kandhari, hemato-biochemical, growth, resilience, environmental stress

1. Introduction

Indigenous livestock species have always been an important contributor to the rural economy, and especially, form the backbone of the small and marginal agri-livestock-ecosystems (Singh and Rao, 2021) [43]. These animals are well adapted to the regional environmental conditions and can sustainably produce, as compared to exotic or crossbreeds (Naseer *et al.*, 2020) [35]. In the last 2 decades as the earth's temperature are rising, and the impact of heat stress and decrease in production is more evident in the colder regions, with the tropics (IPCC, 2018) [14]. When the animals are not able to dissipate the excess heat, effectively, the heat load increases and immediately various physio-metabolic mechanisms are activated to preserve homeothermy (Collier *et al.*, 2019; Wankar *et al.*, 2019) [5, 51]. In dairy cattle THI values over, 68, resulted a decline in milk production and its components, while for the beef cattle the THI threshold is marginally higher, but nevertheless, the production is compromised (Bunning and Wall, 2020; WANKAR *et al.*, 2024) [4, 49]. With the changing climate, rapid urbanization and increased demand for animal products, the preservation of native cattle becomes even more pertinent, for sustained food supply to humans (Wankar *et al.*, 2024; Gokirmakli and Bayram, 2017; Wankar *et al.*, 2021; World Consumption of Meat, 2023) [49, 11, 50, 52].

The Indian subcontinent is bestowed with rich livestock bio-diversity. According to the National Bureau of Animal Genetic Resources (NBAGR), there are 53 registered Indigenous cattle breeds (NBAGR, 2022) [36], while the State of World's Animal Genetic Resources (SoW-AnGR), has recorded 60 Indian cattle breeds (Sharma *et al.*, 2015) [42]. The Red Kandhari [RK] cattle breed is one of the oldest recognised [Red Kandhari, Maharashtra, NDIA_CATTLE_1100_REDKANDHARI_03024] from Maharashtra. The animals are of medium build and dark reddish to brownish in color (Ingle *et al.*, 2016) [13].

Bulls are used for farming operations, while the cows are mainly reared for their milk, which is marginal, 500-600 l of milk/lactation/cow (Ingle *et al.*, 2016; Kauthale *et al.*, 2019) [13, 21]. As a drought breed, it possesses extraordinary resilience and adaptation to extreme climatic events, droughts, and thrives optimally under hydric and nutritional stress (Dzavo *et al.*, 2020; Jadhav *et al.*, 2025) [9, 16]. Also, many workers have reported that native cow's milk is more nutritious, more palatable, easily digestible, with better proteins, casein, lacto-globulin and fats as compared to exotic breeds, which make it an important dietary nutrient for humans (Kauthale *et al.*, 2019) [21].

However, in the past decades, the farmers, dairy owners, and breeders have incorporated high yielding dairy cross breeds for higher production and profits (Livestock Census, 2012) [28]. Also, there is cross-breeding with the exotic cattle, which led to depletion of indigenous germplasm (Sarang *et al.*, 2024) [40]. The 20th livestock census has reported just 11% of this breed as pure graded, which forms a meagre proportion in comparison to that of native Khillar cattle breed, accounting for 50% in Maharashtra (Livestock Census, 2019) [29] [Fig. 1]. Hence, proper planning, awareness and favourable government policies are essential for the breed conservation.

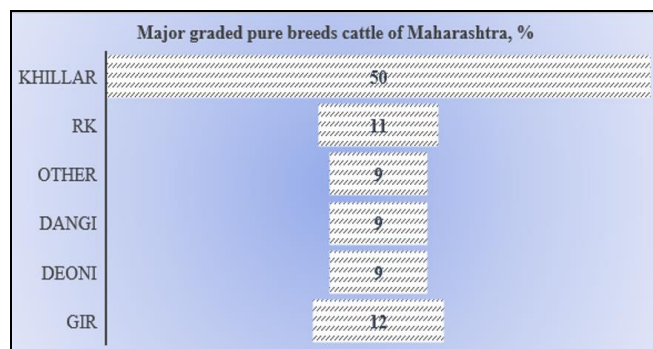


Fig 1: Major graded pure breed cattle in Maharashtra

Data is sourced from: Breedwise Report of Livestock & Poultry Based on 20th Livestock Census-2019, Maharashtra

1.1 Origin, history, and characteristics of the Red Kandhari breed: The Asian continent, and in particular the Indian sub-continent, has been the origin for many *Bos indicus* cattle breeds, which are well known for their thermotolerance, adaptability, resilience, and production potential under extreme environmental conditions. Most of the cattle breeds exported globally came from the Indian sub-continent and then further developed into high producing dairy cattle, like the Brazilian Nellore and the Girolando (Dani *et al.*, 2008) [6]. A recent phylogenetic research work on 13 indigenous breeds, using single-nucleotide polymorphism (SNP), confirmed minimum genetic variation and a common ancestry for the *Bos indicus* cattle as compared to *Bos taurus* breeds (Strucken *et al.*, 2021) [46], indicating minimum divergence and higher regional and climatic adaptability (Decker *et al.*, 2014) [7].

The Red Kandhari is an ancient cattle breed, regionally called “Lakhalbunda”. The breed is distributed across Nanded, Latur, Parbhani, Ahmadnagar, and Hingoli districts of the Marathwada region in Maharashtra (Yadav *et al.*, 2018) [53]. The region-wise distribution for adult RK males and females is presented in Fig. 2. This region exhibits extremes of climatic conditions, and the summer

temperatures range from 44-46°C, while the rainfall here is scanty (1150 mm/yr), and droughts are very common (dcmsme.gov.in). The animals are dark red to brownish colored and medium-sized. This breed is mainly reared as draught animals, and the bullocks are used for farming (Ingle *et al.*, 2016) [13], while the cows yield 500-600 L/lactation (Kauthale *et al.*, 2019; Yadav *et al.*, 2018) [21, 53]. The Red Kandhari are maintained extensively, in small herds, by small and marginal farmers, thriving mainly, either on community pastures and agricultural waste (Kauthale *et al.*, 2019) [21]. This ancient breed of cattle is threatened, as a result of the adoption of cross-breed cows for milk, dilution of the indigenous germplasm, and mechanization of the farming operations (Jadhav *et al.*, 2025) [16]. In response to the conservation of native animals, recently in 2024, the government of Maharashtra has passed a resolution to “Establishment of cattle breeding farm for conservation and multiplication of Red Kandhari and Deoni cattle at Beed District of Maharashtra” (archive.org/details/in.gov.maharashtra).

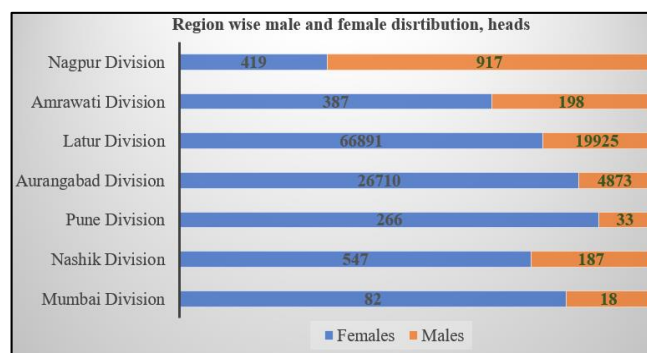


Fig 2: Region wise distribution of adult RK male (> 2yrs) and females (> 3 yrs) in Maharashtra

Data is sourced from: Breedwise Report of Livestock & Poultry Based on 20th Livestock Census-2019, Maharashtra

1.2 Previous research and findings: College of Veterinary and Animal Sciences, Parbhani, established in 1972, has been actively involved in research, development, and conservation of the native livestock breed. The college also a recognised government of Maharashtra Red Kandhari breeding and conservation centre. Till date, the College of Veterinary and Animal Sciences, Parbhani and Vasantrao Naik Marathwada Krushi Vidyapeeth [VNMKV], Parbhani, has conducted 51 and 120, post-graduate and doctoral research projects on the RK breed, respectively. The research data is assessable on the krishikosh.egranth.ac.in website (krishikosh.egranth.ac.in, 2025). The breed has shown resiliency over a wide spectrum of challenging environmental conditions and different stressors (thermal, drought, nutritional, etc.). Although the milk yield/day is marginal, it is consistently produced, and the milk constituents also do not vary, despite the seasonal changes. Scaling on this background, the present research explores the growth phase of the RK calves from a hematological and biochemical perspective. Growth is of one of the most important phases of life, and paves the pathway for future breeding and production potential of any species, and it's also the phase when animals are most susceptible to stressors, pathogens, and parasites. Evaluation of the blood cells, components, and the biochemical constituents gives an accurate status of the animal's health and growth profiles

(Verma *et al.*, 2020) [48]. Similarly, study of hematological and biochemical components also gives animals nutritional, metabolic, and disease status, essential for early treatment of culling (Radostits *et al.*, 2006) [38].

2. Material and Methods

2.1 Experimental animals

Present work was conducted at the Red Kandhari Unit, located at, Instructional Livestock Farm Complex, College of Veterinary and Animal Sciences, Parbhani, from July-December, 2023. A total of 32 animals were selected for the study and equally divided into 4 groups, based on their age. Each group consisted of a total of 8 calves, four male and four female, respectively. RK1 consisted of calves between 0-3 m, similarly, RK2, RK3, and RK4 had calves aged 3-6 m, 6-9 m, and 9-12 m, respectively. All the experimental procedures were approved by Scientific Research and Animal Ethics Board of the institute (PHY/34th BOS/02, 14/06/2023).

2.2 Animal management and housing

All the treatment groups were reared under a semi-extensive rearing system and went to grazing from 0900-300 hrs. Only the RK1 animals were completely stall-fed. After grazing the animals from RK2-RK4, treatments were also stall-fed as per their nutritional requirements, as per the ICAR standards (Udeybir and Mandal, 2014) [47]. The calves had free access to drinking water in the calf shed throughout the experimental period.

2.3 Sampling

For all treatments, blood was collected from all the animals, in the morning hours in the mid of the treatment period (on 45th days), before the grazing. 10 ml of blood was drawn by jugular venipuncture, and immediately, 2-3 ml was poured into sterile tubes coated with anticoagulants. This portion was used for haematological estimations, and, analysed within 2 hrs of blood collection. Remaining, 7 ml of blood was poured into glass tubes, kept at a 45°, angle and allowed to clot naturally for 30 min. After that, this clot was centrifuged at 3000 RPM for 10 min for harvesting serum, and stored at -20°C for biochemical estimations. The weather data for the experimental duration was collected from World-Weather.info website (World-Weather.info) and minimum, maximum, average temperatures, relative humidity, average precipitation, cloud cover, sunny days were recorded. While, the temperature humidity index [THI], was calculated by formula given by Mader *et al.* (2006) [30],

$$\text{THI} = (0.8 \times \text{Tdb}) + [(RH/100) \times (\text{Tdb} - 14.4)] + 46.4$$

Where,

Tdb = dry bulb temperature and RH = relative humidity

2.4 Sample analysis

In all the blood samples, haematological parameters like, haemoglobin (Hb), total erythrocyte count (TEC), total leukocyte count (TLC), differential leukocyte count (DLC), packed cell volume (PCV), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC), were estimated on a fully automatic haematology analyser. Similarly, total protein, albumin, globulin, A:G ratio,

triglycerides, Alkaline phosphatase, glucose, uric acid, creatinine, calcium, and phosphorus, were estimated by using commercial kits, on a fully automatic biochemical analyser (UNICORN 120).

2.5 Statistical analysis

Statistical analysis was done by using one-way ANOVA, IBM SPSS Statistics software (SPSS 26.0). Level of significance was fixed at $P < 0.05$, and differences were indicated by Tukey's test (^{a,b,c,d}).

3. Results

3.1 Haematology variables

The variation for the haematological components in the different RK groups is presented in Table 1. There was no significant difference in hemoglobin concentration within groups, but RK2 had the lowest levels. For RBC concentrations, there was no variation at RK1 and RK3, but RBC was significantly highest at RK2 as compared to RK4 ($p \leq 0.05$), group, respectively. The white blood cell concentration didn't vary within groups ($p \geq 0.05$), but RK4 had the lowest levels within groups. The haematocrit values didn't differ significantly from RK1-RK4, but RK2 had the lowest levels of PCV. Likewise, the mean corpuscular volume (MCV) was also lowest for the RK2 groups as compared to other treatments ($p \geq 0.05$). Similarly, the mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration didn't vary significantly, amongst groups but, lower MCH and MCHC were recorded for RK2 and RK1 than the other groups. There was no significant variation for the white blood cells ($p \geq 0.05$), like lymphocytes, monocytes, neutrophils, and eosinophils (Table 2). However, the RK3 group had concurrently higher levels of monocytes and eosinophils and lower levels of neutrophils and lymphocytes than all other groups.

3.2 Biochemical variables

The biochemical components at different growth periods are shown in Table 3. There was no significant variation ($p \geq 0.05$) for serum total protein, albumin, and globulin, within different groups, but numerically, the highest values were found in the RK3, than other groups. Similar to the serum proteins, the A/G ratio also did not differ significantly within groups. Glucose levels decreased linearly from RK1 to RK4 ($p \leq 0.05$). The highest levels for serum glucose were noted at RK1 (115.39 ± 4.43 mg/dl), which decreased gradually in RK2-RK3, and the lowest levels were noted at RK4 (51.29 ± 3.12 mg/dl). For serum creatinine and uric acid, we noted no significant variation, but notably higher levels were at RK3 and RK4 as compared to that at RK2 and RK1, respectively.

In Table 4, the lipid, enzyme, and mineral variation for RK calves is presented. Serum concentration of triglycerides was non significantly higher in the RK1 and RK2 groups as compared to RK3 and RK4, respectively. A similar trend was also noted for alkaline phosphatase enzyme, which was higher initially in RK1 and RK2, and then decreased at RK3 and RK4 ($p \geq 0.05$). Serum phosphorus also increased non significantly with age in the treatment groups, while for calcium, no peculiar trend was observed within treatments.

3.3 Weather parameters

The variation in the meteorological variables and THI during experimental period is presented in Table 5, Higher

temperatures were recorded from July-November, October being the hottest month. While lower temperatures were seen in November and December. The average humidity was higher from July-September, as compared to October-December period. Similarly, highest THI was noted for August, followed by, July and September, while, during October to December THI was low. The average rainfall and cloudy days, were maximum from July-September, while clear sunny days, were highest from October to December.

4. Discussion

For most of the hematological variables, the RK calves showed no significant age wise variations. The slightly higher values for the hemoglobin in the RK1 group might be due to elevated hemoglobin synthesis during the initial 3 months after birth. Present findings are corroborated by Dzavo *et al.* (2020) [9] who reported no notable impact of age or seasons on the hemoglobin content in Mashona cattle. Variation in the blood-biochemical components in accordance with age is one of the most notable signs of adaptability to the environment and growth, and many researchers consider the indigenous breeds, to be more prolific than the cross breeds or the exotic cattle (Mazzullo *et al.*, 2014) [32]. Similarly, Kalyani *et al.* (2018) [19], who studied seven native cattle breeds, viz, Gir, Sahiwal, Deoni (Milch); Kangayam (Draught), Ongole, Rath, and Tharparkar (Dual purpose), reported optimum hemoglobin concentration in these breeds, according to sex and climatic conditions, indicating the adaptability and resilience (Kalyani *et al.*, 2018) [19]. The hemoglobin range of the RK calves in this study was comparable to Gir and Hanwoo calves (Jacob *et al.*, 2019; Kim *et al.*, 2021) [15, 23] and Holstein Friesian and crossbred calves, respectively (Jezek *et al.*, 2011; Bouda and Jagos, 2014) [17, 3].

In the RK1 calves, the RBC levels were higher than the RK4 group (9-12 m), which indicate higher erythropoiesis during early life, which gradually decreases with puberty. Also, Bouda and Jagos, (2014) [3] in crossbred calves (0-6 m); Karumalaisamy *et al.* (2022) [20] in indigenous Kangayam calves, and Kumar *et al.* (2019) [26] in Harijana cattle, respectively have observed an age-related decline in RBC levels, which confirms the present findings. This adaptability of the erythrocytic indices also reflects the breed resilience and robustness, environmental adaptation and hemopoietic homeostasis with age, in the RK cattle. (Dutta and Bora, 2020) [8].

Marginally higher leukocytes till the 6 months of age (RK2) in our study, indicate higher susceptibility environmental stressors or growth-related increase during this phase, which later decreased (Karumalaisamy *et al.*, 2022) [20]. Similarly, a higher trend for leukocyte concentrations has been reported by Dzavo *et al.* (2020) [9] and Sripath *et al.* (2018) [45] in drought and Malnadgidda cattle breeds. The white blood cells, neutrophils, lymphocytes, monocytes, and eosinophils, all mediate the immune response against different pathogens, infections, and parasites. In this study, there was no notable variation or trend, which indicates a lack of infections and immune response, and our results are corroborated by other workers, reporting non-significant variation for leukocytes, with respect to age in different cattle breeds (Kumar *et al.*, 2019; Kumar *et al.*, 2017) [26, 27]. However, other studies show a significant age wise variation in the leukocytic concentration in growing calves (Kumar *et al.*, 2019; Dzavo *et al.*, 2020; Park *et al.*, 2019) [26, 9, 37].

The erythrocytic indices like PCV, MCV, MCH, and MCHC didn't vary significantly, but a peculiar trend was noted for all the indices. All the indices were lower at age 3-6 m (RK2), and then increased marginally till 12 m of age (RK3-RK4), which indicates a transition period for the haemopoietic system, with approaching puberty. Contrastingly, Karumalaisamy *et al.* (2022) [20] have reported higher values for PCV, MCV, MCH, and MCHC in indigenous Kangayam calves, with age. Similarly, others have reported higher values for these erythrocytic indices in the calves during growth phase (Jacob *et al.*, 2019; Kim *et al.*, 2021) [15, 23].

The protein metabolism also showed an interesting trend; lower at 3-6 m of age (RK2), and thereafter increased non statistically at RK3 and RK4 ($p \geq 0.05$). Serum protein carries many important functions, and gradually the levels stabilize, indicating a balance between protein anabolism and catabolism with the growth phase. Protein levels are also known to fluctuate with an animal's health status, reproductive stage, and environmental conditions. These protein stores (serum total protein, protein ratios, albumins, and globulins) and their metabolites also reflect the critical nitrogen balance in an animal (Sejian *et al.*, 2012) [41]. The marginally higher levels of protein, albumin, globulin, creatinine, and uric acid RK3 and RK4, calves clearly indicate higher hepatic production and anabolism, common during the growth phase (Mamun *et al.*, 2013) [31]. Also, the animal's nutritional status doesn't entirely affect the creatine levels, and it mainly depends on the anabolic muscle metabolism (Klinkon and Jezek, 2012) [24].

The calves are primarily monogastric and dependant entirely on cow's milk during the 1st 3-4 m after birth. The highest levels for serum glucose ($p \leq 0.05$), in RK1, indicate monogastric digestive function and dependency on glucose for energy. Further decline in glucose levels in RK2 and RK3, indicates a transition from monogastric to ruminant digestion, which coincides at weaning, evident by higher consumption of roughages or starter feed (Khan *et al.*, 2007; Rashid *et al.*, 2013) [22, 39]. Similar decreasing levels for glucose in growing calves have been earlier reported by many workers, which corroborate the present findings (Kumar *et al.*, 2019; Kumar *et al.*, 2017; Yu *et al.*, 2019) [26, 27, 54].

Triglyceride levels started declining at RK2 and thereafter declined, which might be due to higher utilization or lipid storage with age, in RK calves. This corresponds with the decrease in glucose levels, indicating a metabolic shift from glucose to lipids or VFA's in the calves (Bagade *et al.*, 2024) [1]. Similar decrease in serum triglyceride and lipids have been reported in neonatal calves (Knowles *et al.*, 2000) [25], in Sahiwal cattle (Kumar *et al.*, 2017) [27], and in unweaned calves and piglets (Yu *et al.*, 2019) [54], which validate present findings. While others have reported an increase in triglyceride levels with age in beef and Bonsmara calves, respectively (Jill *et al.*, 2022) [18].

Alkaline phosphatase is a tissue nonspecific enzyme, extensively produced in the liver, kidneys, and bones and is indispensable for bone metabolism, its mineralization, and phosphorus metabolism. Its primary functions are bone metabolism, mineralization, and calcium and phosphorus turnover, and the levels are quite high in growing animals and decrease by puberty (Narisawa *et al.*, 2013; Gaikwad *et al.*, 2007) [34, 10]. The low levels of the enzyme in our study, correspond to higher concentrations of calcium and

phosphorus (RK3-RK4), which is indicative of maximum growth during the phase. Similarly, Knowles *et al.* (2000)^[25] and Mohri *et al.* (2007)^[33], have reported low enzyme levels in growing calves, while higher calcium and phosphorus levels were observed by Mamun *et al.* (2013)^[31] and Sreedhar *et al.* (2013)^[44], which confirms the present findings and the interrelationship for ALP, calcium, and phosphorus turnover in growing calves.

In the present study, the RK calves were reared on a semi-extensive system, exposing them to all the environmental variables, like, fluctuations of temperature, humidity, rainfall, solar intensity and THI etc. The temperatures ranges, of 86-89°F, humidity between 79-82% and its

combination i.e., THI's of 78-85, are considered severe enough to subject the animals to moderate-severe thermal stress (Bohmanova *et al.*, 2007)^[2]. Despite these challenging environmental conditions, the RK calves didn't showed any adverse hemato-biochemical alterations, during their growth period, which is indicative of superior acclimatization and adaptation of the indigenous cattle, as compared to exotic breeds (Hansen, 2004)^[12]. Also, we recorded a solid, transition trend for most of the biochemical components, after 6 m till 12 m, in the RK calves, which strongly imply, optimized growth, in accordance to the environmental conditions.

Table 1. Hematological parameters of Red Kandhari calves during different seasons

Treatment	Hemoglobin (gm%)	p value	RBC (10 ⁶ /mm ³)	p value	WBC (10 ³ /mm ³)	p value	PCV (%)	p value	MCV (fl)	p value	MCH (pg)	p value	MCHC (g/dl)	p value
RK1	11.67 ± 0.26	0.39	5.22 ± 0.21	0.09	10.13 ± 1.15	0.30	34.31 ± 0.90	0.08	66.96 ± 3.96	0.58	25.62 ± 0.48	0.18	32.00 ± 1.00	0.09
RK2	10.73 ± 0.30	0.42	5.92 ^a ± 0.20	0.70	12.51 ± 0.86	0.16	30.73 ± 0.95	0.41	57.57 ± 4.29	0.73	22.98 ± 1.63	0.89	32.06 ± 2.09	0.84
RK3	10.95 ± 0.39	0.31	5.40 ± 0.33	0.08	9.46 ± 1.37	0.82	31.63 ± 1.37	0.46	59.87 ± 5.90	0.76	23.85 ± 1.11	0.12	35.20 ± 0.96	0.10
RK4	10.90 ± 0.44	0.84	4.81 ^b ± 0.25	0.03	8.33 ± 1.55	0.47	32.00 ± 1.04	0.68	74.90 ± 7.96	0.08	25.98 ± 2.18	0.16	33.75 ± 0.54	0.15

All values are presented as Means ± SEM; Different superscripts ^{a,b,c,d} within a column indicate difference at $p \leq 0.05$

RBC: Red blood cells; WBC: White blood cells; PCV: Packed cell volume; MCV: Mean corpuscular volume; MCH: Mean hemoglobin concentration; MCHC: Mean corpuscular haemoglobin

Table 2. White blood cell% of Red Kandhari calves during different seasons

Treatment	Neutrophils%	p value	Lymphocytes%	p value	Monocyte%	p value	Eosinophils%	p value
RK1	32.37 ± 1.45	0.06	61.87 ± 1.55	0.13	3.25 ± 0.41	1.00	2.50 ± 0.18	0.20
RK2	32.37 ± 0.80	0.67	62.12 ± 1.10	0.47	3.12 ± 0.51	0.25	2.37 ± 0.18	0.53
RK3	31.50 ± 0.65	0.73	61.50 ± 1.08	0.68	4.37 ± 0.41	0.41	2.87 ± 0.12	0.35
RK4	32.65 ± 0.70	0.87	61.50 ± 1.11	0.41	3.37 ± 0.46	0.19	2.50 ± 0.18	0.20

All values are presented as Means ± SEM; Different superscripts ^{a,b,c,d} within a column indicate difference at $p \leq 0.05$

Table 3. Biochemical components of Red Kandhari calves during different seasons

Treatment	Total protein (g/dl)	p value	Albumin (g/dl)	p value	Globulin (g/dl)	p value	A/G ration	p value	Glucose (mg/dl)	p value	Creatinine (mg/dl)	p value	Uric Acid (mg/dl)	p value
RK1	6.22 ± 0.44	0.60	2.96 ± 0.16	0.99	3.26 ± 0.32	0.47	0.93 ± 0.10	0.35	115.39 ^a ± 4.43	0.28	1.48 ± 0.15	0.19	1.37 ± 0.16	0.49
RK2	5.41 ± 0.47	0.84	2.49 ± 0.14	0.07	2.92 ± 0.36	0.71	0.92 ± 0.09	0.10	64.55 ^b ± 4.44	0.03	1.36 ± 0.13	0.29	1.73 ± 0.14	0.59
RK3	7.02 ± 0.52	0.82	2.98 ± 0.15	0.77	4.04 ± 0.41	0.85	0.77 ± 0.07	0.64	61.76 ^b ± 5.28	0.18	1.56 ± 0.11	0.90	1.80 ± 0.31	0.80
RK4	6.22 ± 0.64	0.82	2.70 ± 0.26	0.84	3.51 ± 0.39	0.61	0.77 ± 0.02	0.06	51.29 ^b ± 3.12	0.89	1.56 ± 0.19	0.71	1.90 ± 0.21	0.61

All values are presented as Means ± SEM; Different superscripts ^{a,b,c,d} within a column indicate difference at $p \leq 0.05$

A/G: Albumin to Globulin ratio

Table 4. Lipid, Enzyme and mineral profile of Red Kandhari calves during different seasons

Treatment	Triglycerides (mg/dl)	p value	Alkaline Phosphatase (U/L)	p value	Calcium (mg/dl)	p value	Phosphorus (mg/dl)	p value
RK1	34.14 ± 3.56	0.50	302.39 ± 27.56	0.21	9.61 ± 0.37	0.63	1.37 ± 0.16	0.49
RK2	33.82 ± 3.11	0.64	311.99 ± 30.33	0.36	9.20 ± 0.22	0.14	1.73 ± 0.14	0.59
RK3	32.59 ± 2.19	0.32	275.81 ± 42.86	0.19	9.59 ± 0.35	0.53	1.80 ± 0.31	0.80
RK4	23.36 ± 3.62	0.65	245.31 ± 31.42	0.20	9.37 ± 0.32	0.38	1.90 ± 0.21	0.61

All values are presented as Means ± SEM; Different superscripts ^{a,b,c,d} within a column indicate difference at $p \leq 0.05$

Table 5. Meteorological variation during the experimental period

Month	Avg. high temperature, day, °F	Avg. low temperature, night, °F	Avg. high temperature, month, °F	Avg. low temperature, month, °F	Relative humidity, month, %	Avg. THI, month	Avg. precipitation, month, mm	Cloudy cover days, month	Sunny days, month
July	84	77	86	76	79	83.42	29	2	0
August	86	76	86	74	82	84.83	11	15	5
September	84	76	86	74	81	84.36	20	9	1
October	88	71	89	70	64	78.77	1	8	22
November	85	68	87	68	57	73.83	1	9	20
December	78	63	82	56	43	63.75	0	10	21

* THI: temperature humidity index

5. Conclusion

The results of the present study indicate that the RK calves are acclimatized to the environmental conditions under the semi-extensive management. The breed shows natural genetic adaptation to the climatic conditions, like, high temperatures, humidity and THI, with minimum or no impact on the metabolism during the growth phase. Our observations for the hematological and biochemical components confirms that, for this breed, the major transition period starts beyond the 3-6 m period and continues till the 9-12 m. The red kandhari is an important native, robust, cattle breed of Maharashtra, well adapted to local climatic stressors and heat stress. Comprehensive future research and rigorous conservation is pertinent, to preserve indigenous germplasm, in the climate-changing scenario.

6. Ethics approval

All the experimental procedures were approved by the Animal ethics committee and were followed. We declare that no animals were harmed during the present research.

7. Disclaimer (Artificial Intelligence)

Authors declare that, no generative AI tools were used for preparation or editing this manuscript.

8. Declaration of competing interest

The author declares no conflict of interest.

9. Acknowledgement

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