Indian Journal of Animal Sciences **92** (10): 1236–1240, October 2022/Short communication
https://doi.org/10.56093/ijans.v92i10.124993

Influence of breed, production system and fecundity on serum antioxidant profiles of goats reared in the tropical Island conditions

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Received: 21 June 2022; Accepted: 28 August 2022

Keywords: Andaman local goats, Antioxidants, Extensive and semi-intensive rearing system, Fecundity

Goats are considered as 'poor man's cow' and are ideal livestock for poor and marginal farmer's communities (Nair *et al.* 2021). They are better tolerant to different environmental conditions (Nair *et al.* 2021), drought (Stone *et al.* 2020), limited pastures (Sejian *et al.* 2021) and diseases (Pal and Chakravarty 2020) than other livestock species. Andaman and Nicobar Islands (ANI) has mainly two breeds of goat, viz. Andaman local goat (ALG) and Teressa goat, which are reared for meat purpose (Perumal *et al*. 2019). It is a unique island where goats are the primary livestock species and are considered as an insurance source during disaster periods similar to the mainland region (Regar *et al*. 2020).

Excessive production of pro-oxidants due to oxidative stresses causes an imbalance of antioxidant defense mechanism (Giorgio *et al.* 2020) and damages biological molecules (Juan *et al.* 2021). Oxidative stress causes multiple diseases in ruminants (Ayemele *et al*. 2021, Huang *et al.* 2021). Thus recognizing their importance, antioxidant profiles were studied in various conditions such as in pregnancy (Nawito *et al.* 2016), postpartum periods (Tanvi *et al.* 2017), different rearing systems (Karthik *et al.* 2021) and in various season stresses (Kumar *et al.* 2019, Perumal *et al.* 2019). The present study aimed to evaluate the influence of variations of the rearing system, breed and fecundity of indigenous goats of Andaman by estimating the level of antioxidant markers, viz. total antioxidant capacity (TAC), superoxide dismutase (SOD), total glutathione (TG) and catalase (CAT). To the best of our knowledge, studies on the antioxidant profiles of island-adapted goats are not available in the literature. Such studies will be helpful to understand the effect of these antioxidant markers on this tropical Island ecosystem.

The present study was conducted on goats reared at institutional goat breeding farm and farmer's fields in South Andaman district. On the Institutional farm, the goats were reared under a semi-intensive system. Animals were allowed to browse on natural vegetation in the morning (07:00 to 11:00 h), fed commercially available concentrate pellets @ 250-300 g/day/animal mixed with a mineral supplement, AGRIMIN® (Virbac, India). They were also provided with locally available jackfruit and breadfruit leaves. At farmers' flock, the goats were maintained under the extensive system where animals were allowed to graze loosely for 6-7 h and hand-fed with coconut, jackfruit and breadfruits leaves. Neither balanced concentrate feeding nor mineral mixture supplementation was practiced in farmers' flock. Twenty five healthy multiparous non-pregnant Andaman Local goat (ALG) (n=13) and crossbred (n=12) does reared under a semi-intensive (n=11) and extensive system (n=14), with high fecundity (n=18), and low fecundity (n=7) records were studied. Fecundity was estimated as the ratio of the number of kidding records with higher litter size (>1) to the total number of kidding records. Blood samples were collected and serum was separated by centrifugation. Antioxidants, viz. total glutathione (Cayman kit 703002), superoxide dismutase (Cayman kit 706002), catalase (Cayman kit 707002) and total antioxidant capacity (Cayman kit 709001) were estimated from serum samples as per the instruction of the manufacturer. All the procedures were followed after the ethical approval of the Institute Animal Ethics Committee (IAEC) as per the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) guidelines.

The antioxidant data was analyzed for outliers using the box-plot method and assessed for normality using the Kolmogorov-Smirnov normality test. All antioxidants test data were normally distributed. Homoscedasticity of variances, tested using Leven's test, were equal. The breed effects, effect of the production system (rearing system) and effect of fecundity were analyzed using the PROC GLM multivariate model of Statistical Analysis Software (SAS Institute Inc., USA, 2002).

The following model was used for analysis

$$Y_{ijk} = \mu + A_i + P_j + M_k + e_{ijk}$$

where Y_{ijk}, antioxidant parameter of the doe; μ, overall

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Table 1. Descriptive statistics of antioxidants (TG, CAT, SOD, TAC)

Variable	N	Range	Minimum	Maximum	Mean±SEM	Std. Deviation	CV
Total Glutathione (µM)	25	4.46	3.44	7.90	5.04±0.18	0.94	0.19
CAT acti (nmol/min/ml)	25	77.49	22.39	99.88	57.14±5.11	26.05	0.46
SoD activity in (U/ml)	25	0.13	0.03	0.15	0.08±0.01	0.03	0.38
TAC (mM)	25	1.89	2.49	4.38	3.36±0.10	0.50	0.15

Table 2. Effect of breed, rearing system and fecundity on antioxidant profiles*

Factor	Group	Total Glutathione (µM)	SoD activity (U/ml)	TAC (mM)	CAT activity (nmol/min/ml)	Wilks' lambda
Breed	ALG	5.13±0.29	0.078±0.01	3.37±0.14	50.65±7.54	p>0.05
	OTH	4.92±0.28	0.079±0.01	3.37±0.13	63.59±7.35	
Rearing system	FL	5.17±0.27	0.075±0.01	3.11±0.13[b]	66.27±7.01	p<0.05
	FR	4.87±0.30	0.082±0.01	3.63±0.14[a]	47.97±7.79	
Fecundity	High	4.98±0.24	0.073±0.01	3.46±0.11	54.82±6.14	p>0.05
	Low	5.07±0.35	0.084±0.01	3.29±0.16	59.42±9.022	

ALG, Andaman local goats; OTH, crossbred of ALG with Teressa and Malabari; FR, Semi-intensive Production system-Farm; FL, Extensive Production system-Field. *Values are expressed as least square means±SEM. Superscripts indicate significance at 5% level.

mean; A_i, fixed effect of i^{th} breed admixture group; P_j, effect of j^{th} fecundity group; M_k, k^{th} effect of production system group; e_{ijk}, error fraction. Correlation analyses of all dependent variables were performed using Pearson's correlation. Regression analyses of correlated dependent variables were performed, and the significance of regression was assessed using analysis of variance (ANOVA).

The study results are presented in Tables 1, 2 and 3. Breed, rearing system and fecundity were not significantly associated with the TG, SOD and CAT estimates. However, TAC level was highly associated with the rearing system, where significantly high TAC level was detected in the semi-intensive (Farm rearing) than extensive system (Field rearing) (Fig. 1). The high TAC value might be due to dietary supplementation of protein, lipids, etc., through concentrate feeding in farm animals. It is reported that proteins and lipids supplementation contribute to total antioxidant capacity (Edrees and Teama 2018, Nemec *et al*. 2000) by supplying essential amino acids and fatty acids (Wang *et al.* 2019). Similar to this study, pregnant and non-pregnant goats grazed on natural pasture had lower TAC values than concentrate-fed pregnant and non-pregnant Egyptian local goats (Nawito *et al.* 2016). TG decreased in control and starch diets but increased with high fat diet in ewes (Sgorlon *et al.* 2008) which contradicts the present study, as extensively reared goats had higher TG value. We observed that the extensive production system showed a higher CAT and SOD activity than the semi-intensive system which is supported by a study on WAD goats (Adenkola *et al.* 2018). These reports and the findings of this study indicate that, of all the four markers used, TAC is influenced by dietary supplementations and may be utilized as a reliable antioxidant marker for assessing the effect of nutritional manipulations. It also indicates that the diet needs to be considered while considering the TAC as an antioxidant marker.

Table 3. Pearson's correlations between different antioxidants

	CAT activity	SoD activity	TAC
Total Glutathione	0.237	-0.105	0.068
CAT activity		.420*	-.559**
SoD activity			-0.341

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.001 level (2-tailed).

The present study results indicate a lack of association of fecundity with any of the studied antioxidants. Similar to the present study, goats showed no variations for SOD, GSH, GSH-Px during different stages of pregnancy (Cetin *et al.* 2021). In contrast, TAC values were higher during the fourth to fifth months of pregnancy in multiple-bearing goats than singleton bearing goats (Abdel-Ghani *et al.* 2016). In comparison, low SOD, CAT and TAC levels were reported in multiple-bearing goats (Abd El Hameed *et al.* 2018). The inconsistent findings of these antioxidant statuses on pregnancy indicate the involvement of other factors such as the level of nutrition, stage of pregnancy etc. in the antioxidant profiles. The present study was conducted on non-pregnant does, compared to other reports. This may contribute to the findings of insignificant variation between high and low fecundity groups.

The lack of variation in the antioxidant profiles between breeds may indicate a similar adaptive mechanism. A study conducted at high altitude areas showed that crossbred goat develops an effective body adaptive mechanism against high-altitude-induced oxidative stress on prolonged exposure (Kumar *et al.* 2019). They reported high values of CAT, FRAP, DPPH%, GSH and β-carotene in crossbred goats and a higher body weight gain on prolonged exposure (Kumar *et al.* 2019). TAC value of the current study was lower than with the three different reported goat breeds Changthangi, Sirohi and Crossbred (Kumar *et al.* 2019). SOD concentration was slightly higher in goats reared under extensive than those in semi-intensive system in the present study; a similar result was obtained in WAD goats (Adenkola *et al.* 2018).

This study detected a positive correlation between CAT

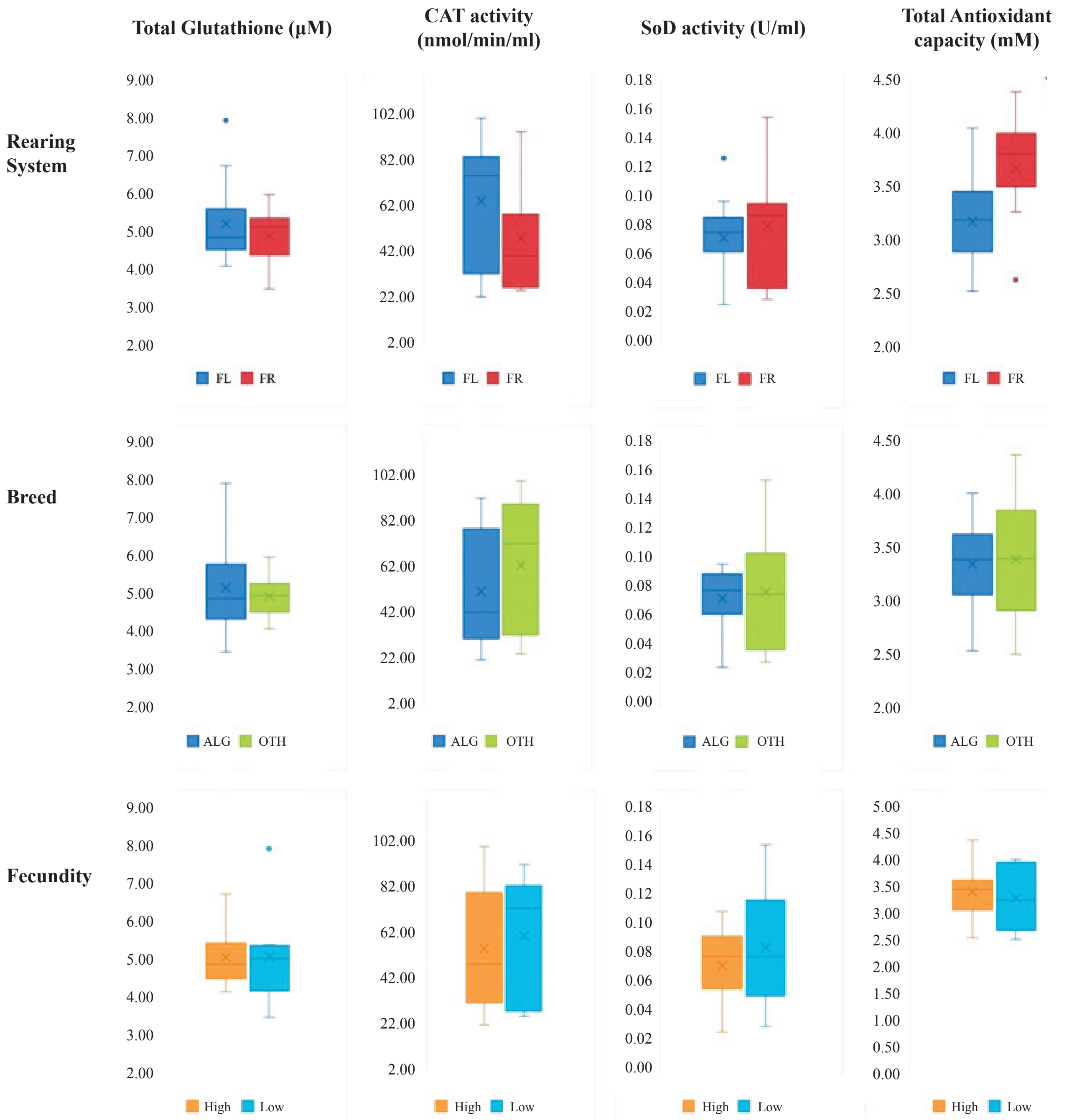

Fig. 1. Effect of production system, breed and fecundity on the serum antioxidants in Andaman Nicobar Islands. FR, Semi-intensive production system- Farm; FL, Extensive production system- Field; ALG, Andaman Local goats; OTH, Cross breds of ALG with Terassa and Malabari; High, High fecundity group; Low, Low fecundity group. Data were presented as box and whisker plot. Star mark indicate significance at 5% level.

and SOD but was not influential, as seen by the lack of a significant regression coefficient. It may indicate that CAT and SOD activities may be weakly associated or influenced by other factors that modulate redox homeostasis, as suggested by Lykkesfeldt and Svendsen (2007). The significant negative correlations and regression between CAT and TAC might indicate that the higher TAC activities negatively influence CAT activity. In bovine follicular fluid, it was shown that CAT activity is elevated in small bovine follicles, while TAC levels were lowest (Gupta *et al.* 2011). The TAC assay estimates multiple antioxidants such as albumin, uric acid, ascorbic acid, α-tocopherol, and bilirubin (Erel. 2004, Rubio *et al.* 2016). Hence levels of individual components of TAC need to be estimated and correlated with CAT which has not been taken up in this study. It is also plausible that these markers (CAT and TAC) do not work simultaneously or act on different target sites. Negative correlations between other antioxidants (GPx with SOD and Albumin) have been reported (Giorgio *et al.*2020).

SUMMARY

The present study assessed the physiological antioxidant status of goats reared under the humid tropical island ecosystem of the Andaman and Nicobar Islands (ANI). From 2019 to 2020, 25 multiparous non-pregnant does with three to six kidding records maintained in the organized farm of Central Island Agricultural Institute (CIARI) and farmer's field flocks from South Andaman district were selected for the study. Antioxidant markers such as total antioxidant capacity (TAC), superoxide dismutase (SOD), TG (Total glutathione) and catalase (CAT) were analyzed in blood serum with respect to rearing systems, breeds and level of fecundity. Correlation analyses of all dependent variables were performed using Pearson's correlation. The endogenous antioxidant systems, viz. CAT, TG and SOD was non-significant with respect to rearing systems, breeds and fecundity. Similarly, TAC was non-significant among the breeds and with fecundity; however, semi-intensively managed goats showed significantly higher values than goats under the extensive condition. Correlation analysis showed that CAT was positively correlated with SOD and negatively correlated with TAC. TG showed no correlation with any of the studied antioxidants. Regression analysis of CAT as dependent variable and SOD and TAC as independent variables showed significance. It is concluded that values of antioxidant in the study can be considered as a baseline data for the ALG and other goat breeds of Andaman and Nicobar Islands and other islands or topographies with similar ecosystems for further studies.

ACKNOWLEDGEMENT

We are thankful to the Director, ICAR-Central Island Agricultural Research Institute, Port Blair, for providing the necessary facilities to carry out the present research.

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