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Original article

Production and oxidative stress responses in a cage designed for creep-feeding lambs

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ABSTRACT

This research aims to assess the production and oxidative stress reactions of lambs fed in a specially designed cage for creep feeding. For this purpose, the Akkaraman lambs (n = 60) were separated into four groups (15 individuals by two sexes and two groups), and all were fed the same ration. On the days that all the data was collected, the lambs were precisely 20, 34, 48, and 62 days old. The study included collecting data on body weights, body measures, and saliva samples from lambs. When the change in body weight was investigated, the results indicated that the differences between caged creep and control feeding groups (P = 0.343) and among the groupings concerning gender (P = 0.735) were insignificant. The importance levels of change differences in body measurements based on feeding methods and gender are withers height: P = 0.003, P = 0.198; body length: P < 0.001, P = 0.394; pectoral chest width: P = 0.030, P = 0.906; chest depth: P < 0.001, P = 0.741; chest circumference: P = 0.093, P = 0.529; back length: P = 0.221, P = 0.935; head length: P = 0.004, P = 0.072 and head width: P = 0.112, P = 0.617 calculated. The study's saliva samples, the effects were examined, and significant differences in Malondialdehyde (P = 0.014), superoxide dismutase (P = 0.029), catalase (P < 0.001), and glutathione s-transferase (P = 0.001) were discovered between control feeding and caged creep feeding methods. In ischemia-modified albumin (P > 0.05), the difference between the groups was insignificant. According to these findings, caged creep feeding systems are preferable for achieving faster growth rates in Akkaraman lambs; however, caged creep feeding techniques in bigger areas with longer periods are considered better for welfare conditions.

1. Introduction

One of the most important parts of sheep breeding activities is lamb-raising. Natural and artificial breastfeeding methods can be used to raise lambs. The amount of milk consumed by the lamb, the length of the suckling period, and the milk yield capacity of the dam are of great importance in choosing the rearing method (Şahin and Olfaz, 2019).

The enhancement of lamb growth and performance through creep feeding is widely acknowledged, mainly when there is a reduction in the supply of sheep's milk for various reasons, both before and after weaning. It is also worth mentioning that in sheep farming ensuring uniform growth within the lamb flock is important. Studies on creep feeding in lambs conducted under optimal conditions indicate superior development compared to those solely fed on milk (Şenyüz, 2020).

The practice of "creep feeding" involves supplementing the diet of nursing lambs alongside their milk intake. Lambs undergoing suckling from their mothers exhibit accelerated and enhanced development when augmented with a creep diet. Improving the size of lambs at a particular stage of development results in increased levels of sheep milk production and enhanced consumption of creep feed (Ely and Fink, 2014).

Several factors, including the quantity and composition of the additive, as well as the animals' genetic traits, significantly impact the response of a lamb's diet to creep feeding (Poli et al., 2020). Creep feeding facilitates enhanced energy and protein consumption by lambs,

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improving overall performance (Wilson et al., 1971; Matthews and Madsen, 1960). As a pivotal management strategy for performance improvement, creep feeding becomes particularly crucial when it amplifies nutrient intake by the lambs (Fernandes et al., 2014). However, the efficacy of this intensified response is contingent upon an accompanying enhancement in the quality of pastures (Farinatti et al., 2006); otherwise, the supplementation may prove superfluous (Poli et al., 2008).

The incorporation of creep feeding into a production system offers numerous potential advantages, including accelerated rumen development and heightened feed utilization (De Villiers, 1997), potentially resulting in an elevated weaning weight (Coetzee, 2011). In cases when pasture availability for ewes is limited and lamb supply is limited, providing creep feed to lambs may increase profitability (Brand et al., 1999).

The change from a monogastric digestive system to a ruminant one is a crucial stage in increasing lamb weight. Additionally, the decline in growth rate commonly occurs when the milk output of dams declines, further complicating the transition. Creep feeding emerges as a valuable intervention in navigating this transition, preventing or mitigating the consequences of this decline (Bernardi et al., 2005).

Although oxidative stress research in ruminants is still in its infancy, numerous studies are being conducted to examine the effects of oxidative stress on the growth, energy balance, metabolism, diet, production qualities, and health status of newborn ruminants (Gökçe et al., 2022). It is known that alterations in the metabolism of oxidants and antioxidants play a significant role in lamb life and development (Soriano et al., 2015).

We prefer cages for creep feeding because it allows the lambs to feed whenever they want, in an area that their mothers or larger lambs in the herd cannot reach. From another perspective, it is to achieve uniformity among the lambs in the flock. Does this cage demage the growth of the lambs and some body size and stress them in an environment they are not accustomed to, or does it create a favourable situation because it allows them to stay with their mothers all the time? These topics formed the outline of this research.

This research focuses on using cages during the creep feeding process and its potential effects on oxidative stress and growth in lambs. It aims to fill a specific gap. For this purpose, we evaluated the effects of oxidative stress and growth measures of AKK lambs housed in the cage we developed.

2. Method

This study examined the production response of lambs to the caged creep feeding technique on a farm in the city of Erzurum in Turkey's eastern Anatolian area.

2.1. Ethical notes

There were no practices requiring ethics committee permission carried out on lambs. For this reason, it did not include an ethics committee in the study.

2.2. Lambs and the study's design

The lambs were chosen based on their body weight and size during the selection process, ensuring their characteristics were relatively similar. Furthermore, each lamb in the research was precisely 20 days old, and the measurements were collected at regular two-week intervals. The age of the lambs on the days when all the data gathered was precisely 20, 34, 48, and 62 days old. At the beginning of this research, lambs were selected from a single flock in a barn exposed to the same environmental conditions. Thus, genetic variation is minimized as much as possible.

In this research, both feeding techniques (control and caged creep feeding) and gender (female and male) were taken into consideration when creating the groups. The control group for lambs, which breeders employ in the area; the second is the study group, which uses caged creep feeding, and for which we plan to carry out the primary research and explain the findings. The study used 30 AKK lambs, 15 males, and 15 females for each feeding technique, for a total of 60 lambs.

The lamb were raised separately from their dams by breeders in the control group. They were allowed twice a day to suckle their dams. For the remainder of the time, the lambs and the dams were separated, lodged with others and housed in the same shelter but in independent compartments.

Fig. 1 shows the cage used for the caged creep feeding method in the study. In this cage, the lambs had the opportunity to eat and also feed with their dams at any time. In other words, unlike the control group, the caged creep-feeding group lambs were not completely separated from their dams but always close to them.

The feeding methods and nutritional amounts employed on the lambs in both feedings are shown in Table 1.

2.3. Measurements and methods

The lambs' body weight, body measurements, and saliva samples were collected once every two weeks during the experiment. It was attempted to measure the body weights of the lambs in the study at the same hours during the day.

The body sizes of the animals in the study were taken from eight different regions. The regions and measurement equipment, respectively, are back length (BAL), head length (HL), chest circumference (CC), and body length (BL): measuring strips; chest depth (CD) and withers height (WH): measuring sticks; and head width (HW) and pectoral chest width (PCW): measurement gauge (Yildirim and Yildiz, 2013).

Swap sticks were used to collect saliva samples from all the lamb's mouths in the study. Three hundred (60x5) total lambs at ages 20, 34, 48, and 62 days old had saliva samples taken. Malondialdehyde (MDA) level, ischemia-modified albumin (IMA), superoxide dismutase (SOD) activities, glutathione s-transferase (GSH-ST), and catalase (CAT) values in lamb saliva samples were studied. MDA (Yoshioka et al., 1979), IMA (Bar-Or et al., 2000), SOD (Sun et al., 1988), GSH-ST (Tietze, 1969), and CAT (Goth, 1991) the levels of saliva samples were quantified with Biotech ELISA Reader (Bio Tek Quant MQX200 Elisa reader/USA).

2.4. Statistical analysis

The results obtained from this study were evaluated as average, and the differences found were declared using the general linear model ($P < 0.05$). Levene's test of equality of error variances in the body weight, body measurement, and saliva data groups was performed, and the homogeneity test difference significance levels in the groups were determined as $P > 0.05$. The percentages were utilized to create comparisons between the research groups. This measure was taken to minimize the impact of sex and genetic dates. Although the animals in the groups were selected to be equal in size at the start of the trial, it was revealed that some lambs developed faster or stayed smaller than others, even within the same group, throughout the study. The data percentages for each animal were calculated and compared to mitigate this unfavorable influence on the results. These percentage comparisons were analyzed in the first and final days' body weight and body measurement data, and a growth ranking was generated among the findings. IBM SPSS Statistics for Windows was used to analyze the data. (Version 25, IBM Corp., Armonk, NY, USA).

In this research, the effects of gender and feeding methods on body weight and some body measurements of lambs were investigated, and the following model was created.

$Yijk = \mu + ai + bj + eijk$

In the model, Yijk = Shows the value of each parameter considered,

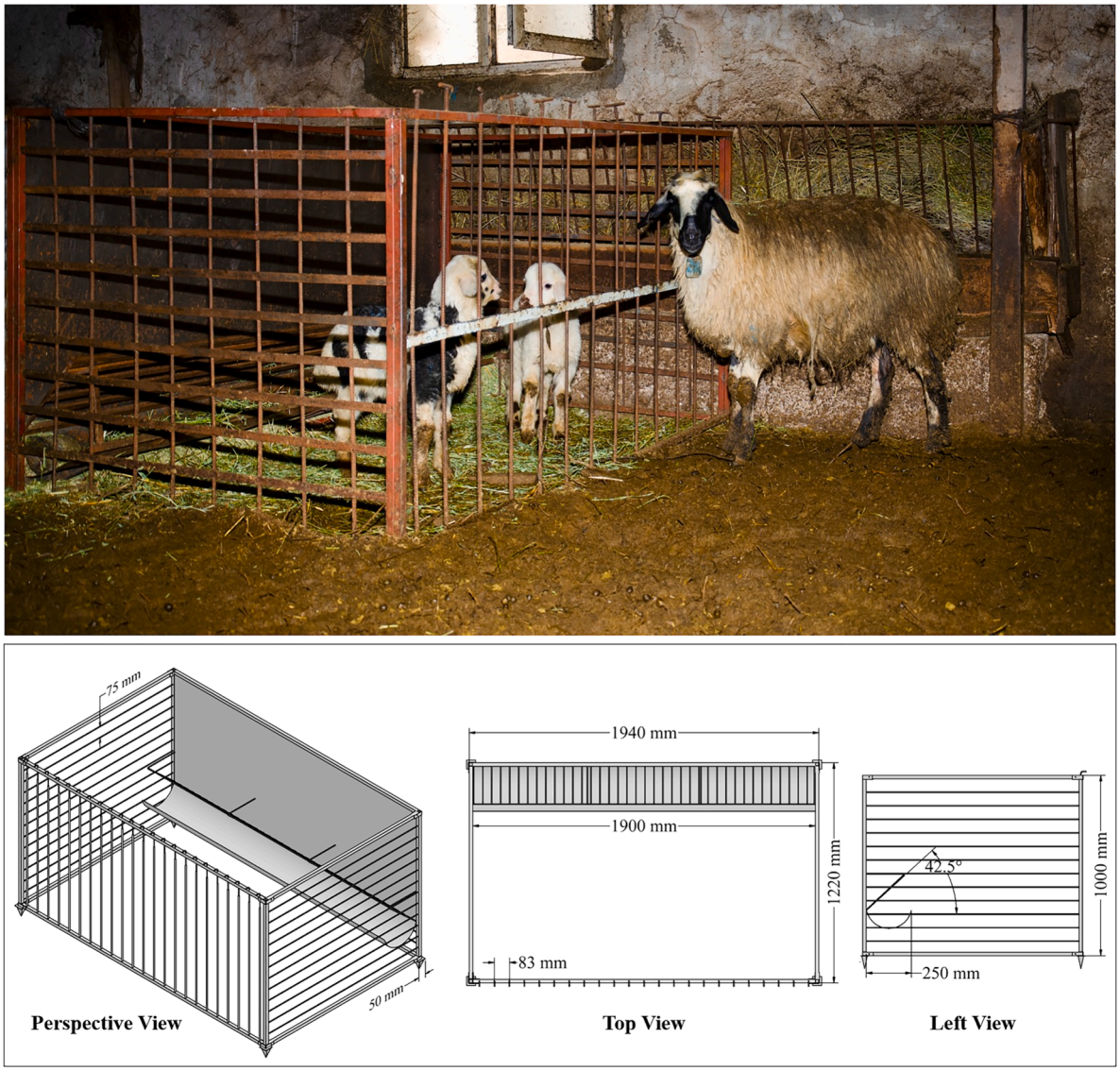

Fig. 1. The caged creep feeding cage used in the study.

Table 1
Nutritional methods and nutrient contents applied to lambs throughout the study.

Days	Roughage (eatage, oat, straw, etc.) (g/lamb/day)	Concentrate feed (barley meal) (g/lamb/day)	Breastfeeding Conventional	Creep
0–20	–	–	Adlibitum	Adlibitum
21–34	100	100	Twice/day	Adlibitum
35–48	200	200	Twice/day	Adlibitum
49–62	400	400	Twice/day	Adlibitum

μ = Population average of this parameter, ai = The effect of feeding method (control − caged creep), bj = Effect of gender (male–female), eijk = Error due to chance.

The following model was used to investigate the effect of cage type on some saliva analysis (SOD – MDA – CAT – GSH-ST – IMA) values used to examine animal welfare parameters in the study.

$Yij = \mu + ai + eij$

In the model, Yij = Shows the value of each parameter considered, μ = Population average of this parameter, ai = The effect of feeding method (control − caged creep), eij = Error due to chance.

3. Results

3.1. Body weights and measurements

The results indicated that female lambs in the caged creep-feeding groups had higher body weight gain in comparison to the other groups. Among the caged creep-fed groups, it was observed that the male subjects who were provided with creep-feeding exhibited the largest chest depth (CD), pectoral chest width (PCW), body length (BL), and chest circumference (CC) sizes. The males fed with the control group displayed the largest back length (BAL) body size, while the females fed with the caged creep-feeding group had the highest withers height (WH), head length (HL), and head width (HW) sizes. Caged creep-fed males showed greater growth than other feeding groups, according to the overall body size improvement analysis.

The body weights and measures of the lambs taken throughout the experiment are shown in Tables 2 and 3.

When the rate of percentage change in body weight was investigated between the 20th and 62nd day, the differences between caged creep and control feeding groups ($P = 0.343$) and among the groupings concerning gender ($P = 0.735$) were insignificant.

Table 2 shows that the change in body weight data of lambs between

Table 2
Body weights of the lambs on the measurement days (Means).

	Body weight (kg)			
	CCR-F	CCR-M	CO-F	CO-M
Lamb's age (day)				
20	5.85	6.77	6.03	6.55
34	7.20	8.52	7.28	7.99
48	9.39	10.77	9.47	10.77
62	12.01	13.48	11.73	13.29
% [a]	105.22	99.26	94.63	102.93
[b]	1	3	4	2

[a] The rate of change between the 20th and 62nd day of the lamb's age.
[b] Sorting by percentages.

the 20th and 62nd day of age is CCR-F > CO-M > CCR-M > CO-F. Also, it was determined that there is a 10.59 % difference between CCR-F and CO-F. It indicates that the caged creep feeding technique is more beneficial for females than males in terms of body weight.

The importance levels of percentage change rate differences (between the 20th and 62nd day) in body measurements based on feeding methods and gender are WH: $P = 0.003$, $P = 0.198$; BL: $P < 0.001$, $P = 0.394$; PCW: $P = 0.030$, $P = 0.906$; CD: $P < 0.001$, $P = 0.741$; CC: $P = 0.093$, $P = 0.529$; BAL: $P = 0.221$, $P = 0.935$; HL: $P = 0.004$, $P = 0.072$ and HW: $P = 0.112$, $P = 0.617$ calculated.

Table 3 shows the variations in body measures (%) of the lambs in the study from the 20th to the 62nd day. When the discrepancies in the data from these findings are reviewed, the males in the control feeding group had the greatest BAL values, whereas the males in the cage-creep group had the highest PCW, CD, CC, and BL values. Furthermore, females in the cage-creep group had the highest WH, HL, and HW values. Body size was bigger in many cage-creep males than in other groups when body data was evaluated in general. The cage creep feeding strategy, in particular, was shown to enhance chest measurements in males and head measurements in females.

3.2. Saliva parameters

Except for superoxide dismutase (SOD), the levels of oxidative stress indicators, namely Malondialdehyde (MDA), catalase (CAT), glutathione s-transferase (GSH-ST), and ischemia-modified albumin (IMA), were found to be greater in the control group compared to the creep groups.

Table 4 shows the results of the study's saliva samples taken from lambs. When the effects were examined, significant differences in MDA ($P = 0.014$), SOD ($P = 0.029$), CAT ($P < 0.001$), and GSH-ST ($P = 0.001$) were discovered between control feeding and caged creep feeding methods. In IMA, however, the difference between the groups was insignificant ($P > 0.05$). When the saliva analysis data were reviewed regarding overall animal wellbeing, it was discovered that the lambs in the control feeding group were more tranquil than those in the cage-creep feeding group. In other words, the animal welfare values obtained demonstrate that the caged creep feeding technique is not very suitable.

Table 4
Saliva parameters examined in lambs.

	Parameters (Mean ± SD)				
Feeding methods	MDA (nmol/mL)	SOD (U/mL)	CAT (IU/mL)	IMA (ΔABSU)	GSH-ST (IU/mL)
Control	2.45 ± 0.64	13.43 ± 5.68	12.82 ± 1.66	0.35 ± 0.11	0.16 ± 0.03
Creep	2.64 ± 0.59	11.87 ± 5.33	14.10 ± 2.42	0.38 ± 0.16	0.17 ± 0.03
Total	2.55 ± 0.62	12.65 ± 5.55	13.46 ± 1.17	0.36 ± 0.14	0.17 ± 0.03
P	0.014	0.029	< 0.001	0.186	0.001

Table 3
Changes in lamb body size as a result of feeding methods (Means, cm).

	CCR-F	CCR-M	CO-F	CO-M	CCR-F	CCR-M	CO-F	CO-M
	Withers height				Body length			
Lamb's age (day)								
20	40.33	42.40	40.73	43.00	34.80	35.40	34.53	35.40
34	43.13	46.53	44.87	45.73	37.33	38.33	36.27	37.33
48	47.80	50.80	48.33	49.67	39.87	41.60	39.07	40.07
62	51.73	53.60	50.27	51.80	44.13	46.13	42.47	43.13
Increment (%) [a]	28.26	26.42	23.40	20.47	26.82	20.32	22.97	21.85
[b]	1	2	3	4	4	1	3	2
	Pectoral chest width				Chest depth			
20	10.40	10.80	10.33	10.97	16.93	17.27	17.53	18.60
34	10.93	11.47	10.77	11.20	18.47	19.00	18.13	18.73
48	11.17	11.93	11.23	11.63	20.13	21.00	19.53	19.87
62	12.00	12.60	11.70	12.30	21.93	23.07	20.80	21.73
Increment (%) [a]	15.38	16.67	13.23	12.16	29.53	33.59	18.63	16.85
[b]	2	1	3	4	2	1	4	3
	Chest circumference				Back length			
20	44.87	46.53	45.07	46.00	21.13	22.20	19.80	20.47
34	47.20	49.93	47.27	47.40	23.67	24.47	22.53	23.27
48	52.13	53.07	52.13	53.00	26.20	27.07	25.00	25.80
62	54.93	57.00	53.80	55.53	30.67	31.93	28.93	30.20
Increment (%) [a]	22.44	22.49	19.38	20.72	45.11	43.84	46.13	47.56
[b]	2	1	4	3	3	4	2	1
	Head length				Head width			
20	10.60	12.07	11.60	12.20	7.90	8.20	7.83	8.27
34	11.53	13.27	11.87	12.33	8.87	9.13	9.03	9.23
48	14.00	14.53	13.97	13.93	9.10	9.33	9.20	9.37
62	14.67	15.63	14.63	15.07	9.53	9.87	9.23	9.60
Increment (%) [a]	38.36	29.56	26.15	23.50	20.68	20.33	17.87	16.13
[b]	1	2	3	4	1	2	3	4

[a] The rate of change between the 20th and 62nd day of the lamb's age.
[b] Sorting by percentages.

4. Discussion

Numerous inquiries into the creep feeding technique in animals have been conducted, with the prevailing emphasis on augmenting body weight in kilograms, as evidenced by studies such as those by Brand et al. (Brand et al., 1999), De Villiers et al. (2002), Brundyn (2002), Terblanche (Terblanche et al., 2012), and Yildirim et al. (2023). This investigation, in contrast, centred on the rate of increase and whether such increments exhibited proportional changes. Consequently, both proportional enhancements in body weight and related body measures were subjected to evaluation. Despite the proximity of initial weights, inherent variables such as sex and individual genetic factors may introduce variability in the data when scrutinizing animal growth. However, focusing on proportional disparities in the data during the analysis stage was deemed more conducive to obtaining precise outcomes. Consequently, this study adopted a data evaluation approach based on percentage values.

In this research, body weights, body measurements, and oxidative stress parameters of AKK sheep were evaluated in the creep-feeding cage system, the dimensions of which were designed by the researcher, and the cage's measurements were shared in detail. Many creep-feeding techniques are applied to feed lambs. However, literature data was found when the properties of a cage are given or examined in detail, and oxidative stress parameters are taken from saliva and evaluated. Therefore, this research was unique in its features.

According to some researchers (Brand et al., 1999), creep feeding could be more economically suitable during the quality and quantity decline of pasture, especially when milk and natural feed also fail to meet lamb development potential. Furthermore, it is well-recognized that early exposure to starchy foods like grain has certain advantages (Martínez et al., 2015). There were no difficulties or failures in the dimensions of the creep-feeding cage system that was designed. However, it has been observed that the cage wires in the system should be mounted securely to the system since the animals tend to remove them. Furthermore, it's advisable to fix the cage to the ground or in a corner to prevent sheep and lambs from moving it.

According to SIDP (SIDP (Sheep industry development program, inc, 1990) and Martínez et al. (2015), lambs can start creep-feeding at ten days old. However, just like the researchers (Banchero et al., 2006), who reported that lambs did not start consuming significant amounts of extra food until 3–4 weeks old. In the place where the experiment was conducted, a breeder advised that the switch to creep feeding to be done on the 20th day and supplementary foods could only be given then. Furthermore, that is why, in this research, measurements started to be taken on the 20th day.

4.1. Creep and control feeding groups

The creep-feeding method has been reported to affect lambs' body weight by some researchers positively (Brand et al., 1999; De Villiers et al., 2002; Brundyn, 2002; Terblanche et al., 2012; Martínez et al., 2015; Puspawati, 2021; Yildirim et al., 2023), but in this study, the difference between the control and creep feeding groups was not statistically significant ($P > 0.05$).

It was determined that the 62-day body weight values obtained in this research were close to the 62-day body weight (kg) values (CCR-F = 11.75, CCR-M = 13.47, CO-F = 11.71, CO-M = 13.54) found in the studies of some researchers (Yildirim et al., 2023) on AKK lambs. In a research conducted by Brand and Brundyn (2015), it was found that the weaning weight of animals that were provided with creep-feed was 36.5 kg, whereas the control group had a weaning weight of 30.6 kg. The research aimed to investigate the impact of creep-feeding on the performance of dairy lambs. Similar to the study (Brand and Brundyn, 2015), the analysis revealed that lambs subjected to a creep feeding strategy had a higher rate of body weight increase.

The animals' body weights, regardless of gender, at 62 days were 12.75 kg and 12.51 kg in the caged creep and control feeding groups, respectively. In a research conducted by Martínez et al. (2015), it was observed that the body weight of lambs on the 48th day differed depending on the feeding method. Lambs provided with creep feeding between the ages of 10 to 48 days had a body weight of 11.87 ± 0.249, while the control group, which did not get creep feeding, had an average body weight of 10.24 ± 0.375. The research aimed to investigate the impact of creep feeding at various stages of development on Chilola lambs. In the research conducted by Agwa et al. (2016), the researchers measured the body weight of lambs in both the creep and control groups on the 60th day. The creep group's average body weight was 16.70 ± 0.54, whereas the control group had an average body weight of 15.67 ± 0.54. Creep feeding benefits every study procedure, although the observation methods used in the aforementioned investigations vary. On the other hand, this study showed more favorable outcomes, particularly in females.

When we look at the creep-feeding studies done with the AKK breed lambs used in the study; Ceyhan et al. (2018) reported a weaning weight of 20.23 ± 0.805 in the creep-fed lambs and 18.52 ± 0.146 in the control group in their research to determine the effects of creep feeding on growth and survival rate in lambs. They discovered that creep feeding improves both production and survivability. In another research, Şenyüz and Erat (2018) discovered that lambs which were fed using the creep feeding method had significantly higher weaning body weights than those fed milk. Creep feeding is beneficial in studies with Akkaraman breed lambs, similar to this study.

In this study, when the percentage change in the body weight of the lambs between 20 and 62 days was examined, it was observed that the growth rate was the highest (105.22 %) in female lambs fed with caged creep feeding. In previous studies (Yildirim et al., 2023), it was determined that the most change (73.87 %) in the body weight of lambs between 20 and 76 days was in male lambs fed with the creep feeding method. In this regard, it shows that the creep feeding method has a positive effect on the growth of lambs, but differences in feeding time may make a difference in the growth of the genders.

When the body measurements of this research are evaluated; Males of the caged creep-feeding group had the largest PCW, BL, CC, and CD values; males of the control feeding group had the highest BAL values; and females of the caged creep-feeding group had the largest WH, HL, and HW values. When body measurement values were examined in a study conducted by some researchers (Yildirim et al., 2023) in creep feeding areas, the largest BAL was found in females using the traditional feeding method; the greatest WD was found in men using the traditional diet; and the largest PCW, BL, CC, CD, HW, and HL were found in creep-fed males. As a result, this study concluded that, when the improvement in body size is considered, the body size difference in many males who were creep-fed increased more than in other groups, similar to Yildirim's results.

In the investigation of thin-tailed lambs conducted by Puspawati (2021), it was observed that lambs provided with creep-feed exhibited significantly ($P < 0.05$) greater measurements for chest circumference, body length, chest depth, and withers height compared to lambs without access to creep-feed. However, no significant differences ($P > 0.05$) were noted in chest width, hip width gain, or hip height. These outcomes align with our research findings, affirming the efficacy of creep-feeding in influencing specific body measurements.

4.2. Gender

In the study, the evaluation of the impact of gender on the body weight of AKK lambs revealed that females, when provided with caged creep feed, exhibited a more favorable percentage growth rate than males. Conversely, Noyan and Ceyhan (2021) asserted that, in their examination of the influence of sex on AKK lambs, males displayed greater body weight gains than females, thus differing from the findings of the current investigation. In a separate study (Yildirim et al., 2023),

researchers established that using the creep feeding method improved body weight for both sexes, encompassing both male and female lambs when contrasted with the traditional feeding method. Furthermore, in the present study, it was discerned that the females within the control group exhibited the least favorable growth percentage regarding body weight, in correspondence with the outcomes reported by Yildirim et al. (2023).

4.3. Animal welfare

The current body of literature lacks investigations about oxidative stress parameters (SOD, IMA, MDA, CAT, and GSH-ST) in lambs subjected to a creep-feeding method employing the caging technique, with specific emphasis on AKK lambs. This study introduces the initial dataset in the literature addressing this particular caged creep-feeding technique. Upon meticulous examination of the research outcomes, disparities were evident when compared with the findings of a previous investigation conducted by Yildirim et al. (2023), which examined the repercussions of a 20–72-day creep feeding technique on AKK lambs. The present study disclosed that, excluding SOD, all oxidative stress parameters (MDA, CAT, GSH-ST, and IMA) exhibited higher values than those observed in the control groups subjected to the caged creep feeding method. Conversely, in the data presented by Yildirim et al. (2023), MDA and IMA values were low, while all other parameters (SOD, CAT, and GSH-ST) were elevated. A comprehensive evaluation showed that the caged creep feeding technique implemented in this study resulted in less favorable welfare conditions than the creep feeding method employed by Yildirim et al. (2023).

5. Conclusions

As a result, females in the creep-feeding groups showed faster growth than all groups regarding body weight. Additionally, the growth rate in most body measurements of creep-fed lambs of both sexes was higher than in the control group. However, no significant ($P > 0.05$) difference was found between the creep and control groups regarding both body weight and gender.

In the findings of body measures across the research groups, the CCR-M group had the highest CC, PCW, CD, and BL values; the CCR-F group had the highest WH, HL, and HW values; and the CO-M group had the highest BAL values. Most creep-feeding males performed better than other groups in terms of body size. Except for SOD, all MDA, CAT, IMA, and GSH-ST values of oxidative stress markers were higher in the control group than in the creep groups. Given these findings, the caged creep feeding system may be favoured for achieving a faster growth rate in AKK lambs; however, this caged should use the creep feeding technique in greater areas to enhance welfare conditions more effectively.

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CRediT authorship contribution statement

Fatih Yildirim: Formal analysis, Methodology, Resources, Software, Writing – original draft, Writing – review & editing. **Ahmet Yildiz:** Data curation, Formal analysis, Methodology. **Burak Hülagü:** Data curation, Formal analysis, Visualization. **Ali Osman Kesen:** Data curation, Methodology, Writing – review & editing. **Alperen Varalan:** Conceptualization, Data curation, Methodology. **Tuba Doğan:** Conceptualization, Data curation, Methodology.

Declaration of Competing Interest

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