

Effect Of Pen Enrichment On Performance And Behavior Of Isolated West African Dwarf Rams

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Abstract

Sheep are highly social animals that love being in the comfort of their flock, and anything that separates or isolates them from their flock subjects them to stress. 12 West African Dwarf weaned rams were allotted into 6 different pens each in isolation. The pens were enriched with coloured walls and mirror. T1- control with no enrichment; T2- enriched with mirror only; T3- enriched with mirror and red coloured wall; T4- enriched with mirror and green coloured wall; T5- enriched with mirror and red coloured wall; T6- enriched with mirror and yellow coloured wall. Each treatment got replicated twice with one ram. The experiment lasted 6 weeks during which data were collected on feeding pattern, water consumption, vocalization frequency, time spent on specific behaviors such as eating, drinking, walking, self image watching, resting and frequency of head-butt towards the self-image in the mirror. The behaviors were captured with the use of 6 television cameras installed in the experimental pens. Blood samples were also taken at the last day for haematological studies. Data generated were analyzed statistically. The enrichment had no effect on feed intake, final body weight and weight gained. However, the behavioral responses to the different enrichment varied. The results of this work suggest that mirror and colored background can be used to alleviate stress among isolated rams in the short run only.

Keywords: Enrichment; Sheep; Conspecifics; Isolation; Stress; Welfare

INTRODUCTION

Environmental enrichment plays a crucial role in improving animal welfare by enhancing the living conditions of farm animals, particularly those housed in confinement [1]. For ruminants such as rams, social isolation can be a significant stressor, leading to behavioral changes, reduced performance, and compromised welfare [2]. In commercial livestock systems, animals are often housed in barren environments that fail to stimulate natural behaviors, thereby increasing stress and anxiety levels [3]. Providing environmental enrichment, such as mirrors and color stimuli, has been suggested as a strategy to mitigate these negative effects by offering psychological and physiological benefits [4].

Color perception in animals varies across species, and it influences their behavior, feed intake, and emotional state [5]. Studies on livestock species indicate that colors can serve as important environmental cues that impact their welfare and performance [6]. For instance, research on poultry has shown that different colored lighting affects growth rate, stress levels, and overall behavior [7]. However, limited research has been conducted on the effect of colored walls in ruminant housing systems, particularly for isolated rams. Understanding how different colors influence ram behavior and performance can help optimize housing designs for improved welfare.

Mirrors have been widely used as an environmental enrichment tool for social species, particularly in the absence of conspecifics [8]. Studies on cattle and sheep suggest that mirrors can reduce stress and improve overall well-being in isolated individuals [9].

For example, sheep exposed to mirrors exhibited reduced signs of distress and engaged in behaviors indicative of improved psychological welfare [10]. The mirror provides an illusion of social companionship, which may alleviate loneliness and promote natural behaviors in isolated rams.

Despite the growing interest in environmental enrichment strategies, there is limited information on the combined effect of colored walls and mirror exposure on the performance and behavior of rams in isolated housing conditions. Therefore, this study aims to investigate the effect of pen enrichment with

different colored walls and mirrors on the performance and behavior of isolated rams.

MATERIALS AND METHOD

The research was conducted at the small ruminant unit of Agriculture Programme situated in Bowen University, Iwo campus, Osun State. Iwo is a Local Government Area located between Latitudes 7°38'N and 7°40' north of the Equator and Longitudes 4°09' 4°13' east of Greenwich Meridian.

The experimental animals for this study were twelve (12) weaned West African Dwarf rams allotted in a completely randomized design (CRD) into six treatments (T1- T6) each with replicates. The pens were enriched with coloured walls and mirror. T1- control with no enrichment; T2- enriched with mirror only; T3- enriched with mirror and red coloured wall; T4- enriched with mirror and green coloured wall; T5- enriched with mirror and blue coloured wall; T6-enriched with mirror and yellow coloured wall. The experiment lasted six weeks during which data were collected in respect of the daily feed intake (DFI), weekly body weight (WBW), weekly body weight gained (WBWG) and mortality rate while the feed conversion ratio (FCR) and feed conversion efficiency (FCE) were calculated.

Furthermore, six television cameras were used with one camera serving the two replicates within each treatment. The pens were illuminated with electric bulbs at night throughout the experiment. The following behaviors were monitored in response to the different types of pen enrichment; time spent walking (seconds), total number of bleats (counts), time spent eating (seconds), head-butt towards self-image in the mirror (counts), fixation time on self-image in the mirror (seconds), time spent resting (seconds), time spent ruminating (seconds).

Blood samples were collected from the rams at day 0, week 3 and week 6 of the experiment from the jugular veins as described by [11], for the haematology and serum biochemical analysis.

The rams were fed daily ad libitum with grasses (Brachiaria), cowpea hay, cowpea pod, soybean bran, wheat offal mixed with palm kernel cake (PKC), sorghum and cassava peels.

The data generated were analyzed with the SPSS package version 20 and Microsoft Excel, version 2019 (for data visualization). The means were separated using Duncan Multiple Range Test (DMRT). Tests were carried out at 5% level of significance.

The ethical approval for this research was obtained from the Research Ethics Committee of the College of Agriculture, Engineering and Science, Bowen University, Iwo, Nigeria.

RESULTS AND DISCUSSION

Performance Characteristics of Isolated Rams Under Different Pen Enrichment Treatments

The impact of different pen enrichment treatments on the performance characteristics of isolated rams is presented in Table 1. The results indicate significant variations in feed intake, water intake, body weight changes, feed conversion ratio (FCR), feed conversion efficiency (FCE), and mortality rates across the treatments.

Table 1: The performance characteristics of isolated rams across the treatments over six weeks

Parameters	T1	T2	T3	T4	T5	T6
Average Feed Intake (kg)	2.86±0.23b	2.16±1.05a	2.31±0.40a	2.93±0.29b	2.12±0.38a	2.03±0.44a
Average water intake (L)	4.02±1.45ab	5.02±1.92b	4.42±0.93ab	4.34±1.54ab	3.52±1.11a	3.65±0.68a
Initial Body weight (kg)	10.70±0.54a	11.71±0.00b	9.62±0.36a	11.54±1.20b	11.29±1.04ab	10.75±0.00ab
Final Body weight	10.67±0.59a	11.18±0.00a	10.10±0.14a	11.64±2.79a	9.23±1.27a	10.31±0.00a
BWG (kg)	-0.03±0.06b	-0.53±0.00ab	0.49±0.22b	0.10±1.60b	-2.06±0.23a	-0.44±0.00ab
FCR	95.47	4.07	4.76	29.28	1.03	4.61
FCE (%)	1.05	24.55	21.02	3.35	96.71	21.70
Mortality (%)	0	50	0	0	0	50

T1- Non-enrichment (control); T2- Mirror only; T3- Blue + Mirror; T4- Green + Mirror; T5- Red + Mirror; T6- Yellow + Mirror; FCR: Feed Conversion Ratio; FCE: Feed Conversion Efficiency

BWG: Body Weight Gain= Final body weight (kg) – Initial body weight (kg)

Feed and Water Intake

Average feed intake varied significantly ($P < 0.05$) among the treatments. Rams in T1 (non-enriched control) and T4 (Green + Mirror) recorded the highest feed intake (2.86 ± 0.23 kg and 2.93 ± 0.29 kg, respectively), whereas rams in T2 (Mirror only), T5 (Red + Mirror), and T6 (Yellow + Mirror) had the lowest feed intake (2.16 ± 1.05 kg, 2.12 ± 0.38 kg, and 2.03 ± 0.44 kg, respectively). This suggests that green-colored walls with mirrors may have a stimulating effect on feed intake, possibly due to the calming influence of green, as suggested by previous studies [12].

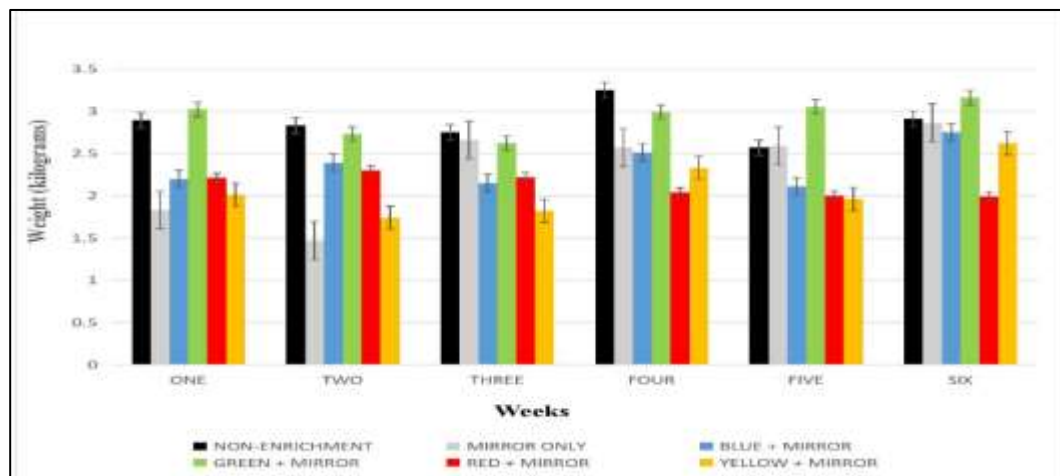


Figure 1: Comparison of the weekly feed intake between treatments over six weeks

Water intake followed a slightly different trend, with the highest intake observed in T2 (Mirror only) at 5.02 ± 1.92 L. Rams in T5 (Red + Mirror) and T6 (Yellow + Mirror) consumed the least water (3.52 ± 1.11 L and 3.65 ± 0.68 L, respectively), suggesting a potential impact of color on drinking behavior. Similar findings have been reported by [13], who noted that color stimuli influence feeding and drinking behavior in ruminants.

Body Weight Changes

Initial body weights were similar across treatments, with slight variations. However, final body weights did not show significant improvement across the treatments, with some groups experiencing weight loss. Rams in T5 (Red + Mirror) recorded the most significant weight loss (-2.06 ± 0.23 kg), while T3 (Blue + Mirror) showed a slight weight gain (0.49 ± 0.22 kg). This indicates that red-colored walls may induce stress, leading to reduced performance, whereas blue-colored walls may have a calming effect, enhancing feed utilization [14].

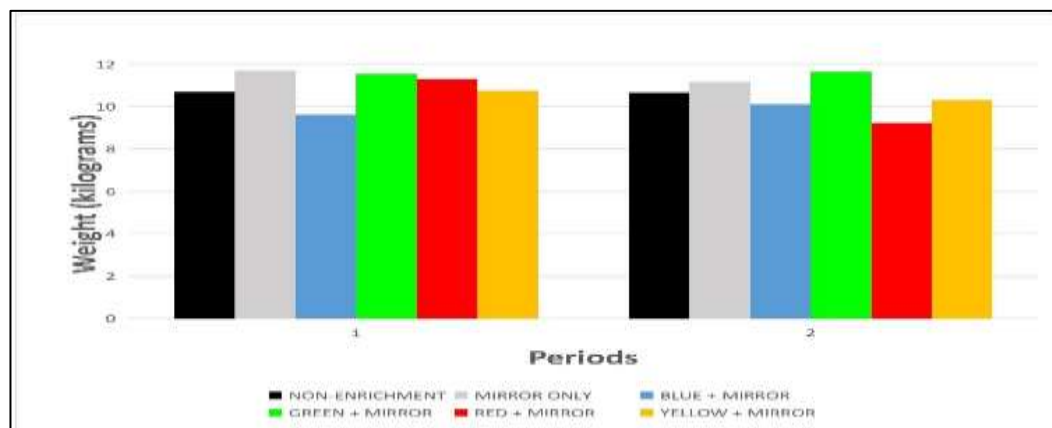


Figure 2: Comparison of initial (1- before experiment) and final (2- sixth week) body weights between treatments

Feed Conversion Ratio (FCR) and Feed Conversion Efficiency (FCE)

The FCR and FCE values were highly variable, with negative FCR values observed in T1 (-95.47), T2 (-

4.07), T5 (-1.03), and T6 (-4.61), indicating poor feed efficiency.

Rams in T3 (Blue + Mirror) had the best FCR (4.76), suggesting that the blue color may optimize feed utilization. The negative FCE values in most treatments indicate inefficient weight gain, which may be attributed to the stress of isolation [15].

Mortality Rate

Mortality was recorded in T2 (Mirror only) and T6 (Yellow + Mirror), with 50% mortality in both groups. The high mortality rate in these treatments suggests that mirrors alone or in combination with yellow-colored walls may induce stress or confusion in isolated rams. This aligns with findings by [16], who reported that unfamiliar visual stimuli could heighten stress responses in social animals.

Behavioral Characteristics Vocalization and Locomotion

In Table 2, the frequency of vocalization varied widely across treatments, with T3 (Blue + Mirror) exhibiting the highest number of vocalizations (15.57 ± 17.34 counts), followed by T1 (Non-enrichment, 14.63 ± 26.95 counts). The lowest vocalization counts were observed in T4 (Green + Mirror, 2.13 ± 4.16 counts) and T2 (Mirror only, 2.25 ± 3.99 counts), suggesting that mirrors or green-colored environments may have had a calming effect on the rams [1, 17]. High vocalization rates are often associated with stress, anxiety, or social isolation [18], indicating that rams in T1 (No enrichment) and T3 (Blue + Mirror) experienced higher distress.

The time spent walking was longest in T3 (Blue + Mirror, 121.25 ± 120.62 seconds), followed by T2 (Mirror only, 99.25 ± 77.37 seconds), while the shortest was recorded in T5 (Red + Mirror, 68.38 ± 49.48 seconds). The increased walking in T3 and T2 suggests that rams were more active and exploratory, potentially engaging with their mirror image. In contrast, rams in T5 (Red + Mirror) moved the least, possibly due to stress associated with red coloration, as observed in previous studies where red was linked to agitation and avoidance behaviors in livestock [19].

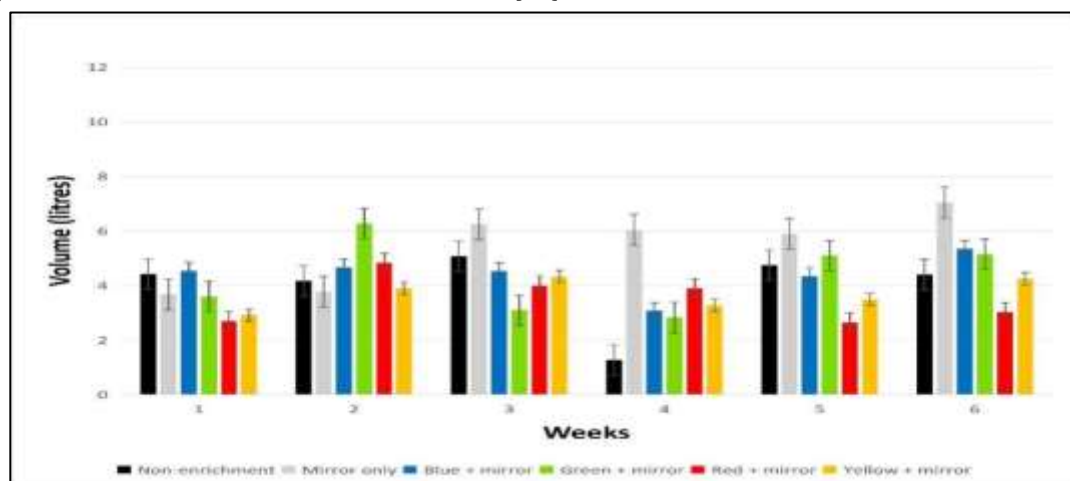


Figure 3: Comparison of the weekly water intake between treatments over six weeks

Mirror Interaction and Resting Behavior

Rams in T2 (Mirror only) spent the longest time looking at their self-image (770.13 ± 817.53 seconds), whereas T4 (Green + Mirror) recorded the shortest mirror interaction time (218.63 ± 280.17 seconds). This suggests that the mirror alone was more engaging, but when combined with colored backgrounds, its effect varied.

Studies have shown that mirrors can serve as a social substitute in isolated animals, reducing stress [9], but their effectiveness depends on individual perception and the surrounding environment.

The time spent resting was highest in T1 (Non-enrichment, 2006.50 ± 909.10 seconds), suggesting that rams without enrichment were more inactive. Interestingly, T6 (Yellow + Mirror) had the lowest resting time (1116.00 ± 746.52 seconds), which aligns with findings that yellow hues can have stimulating effects, reducing restfulness in animals [5].

Feeding and Rumination

No significant differences were observed in time spent eating ($P > 0.05$), although T2 (Mirror only, 1508.00 ± 1293.83 seconds) and T3 (Blue + Mirror, 1503.25 ± 701.66 seconds) had the highest values. These results suggest that mirrors, particularly when paired with blue, may encourage feeding behaviors. Rumination time varied across treatments, with T4 (Green + Mirror) recording the highest duration (1229.88 ± 748.88 seconds), while T2 (Mirror only, 663.88 ± 635.23 seconds) and T5 (Red + Mirror, 663.88 ± 635.23 seconds) had the lowest.

646.88±462.15 seconds) had the lowest. The longer rumination in T4 (Green + Mirror) suggests that green-colored environments may enhance relaxation and digestion, aligning with studies reporting the calming effects of green hues in farm animals [20].

The number of head-butts towards the mirror was recorded in T4 (Green + Mirror, 3.75±10.61 counts) and T5 (Red + Mirror, 4.63±8.67 counts), while other treatments had zero interactions. This suggests that certain colors might trigger more aggressive or investigative behaviors towards their reflection.

Correlation Between Resting and Rumination

Table 4 shows a positive correlation ($r = 0.34$, $P = 0.02$) between time spent resting and time spent ruminating, indicating that rams that rested longer also engaged in more rumination. This aligns with previous findings that relaxed animals exhibit improved digestive activity and welfare [21].

Table 3: The behavioral characteristics of isolated rams across the treatments over four weeks

Parameters	T1	T2	T3	T4	T5	T6
Number Vocalization (counts)	14.63±26.9 5a	2.25±3.99a	15.57±17.34a	2.13±4.16a	7.88±12.67a	9.50±15.69a
Time spent walking (seconds)	73.13±108. 99a	99.25±77.37 a	121.25±120.6 2a	87.38±154.5 6a	68.38±49.48 a	97.63±100.6 5a
Time spent looking at self-image (seconds)	NO MIRROR	770.13±817. 53b	252.75±310.2 6ab	218.63±280. 1 7a	385.63±393. 3 6ab	671.63±431. 1 3ab
Time spent resting (seconds)	2006.50±9 09.10a	1639.13±222 0.00a	1389.63±812. 57 a	1866.63±738 . 70a	1648.13±708 . 42a	1116.00±746 . 52a
Time spent eating (seconds)	1186.75±5 12.91a	1508.00±129 3.83a	1503.25±701. 66 a	1074.50±580 . 15a	1440.50±702 . 31a	942.88±507. 5 5a
Time spent ruminating (seconds)	1121.50±5 31.26a	663.88±635. 23a	823.13±497.2 3a	1229.88±748 . 88a	646.88±462. 1 5a	714.25±351. 7 7a
Number of Head-butt towards self-image (counts)	NO MIRROR	0.00±0.00a	0.00±0.00a	3.75±10.61a	4.63±8.67a	0.00±0.00a

T1- Non-enrichment; T2- Mirror only; T3- Blue + Mirror; T4- Green + Mirror; T5- Red + Mirror; T6- Yellow + Mirror

Haematological Response of Rams to Isolation and Environmental Enrichment

Haematological parameters as shown in Table 5 provide insight into an animal's physiological and immune status, especially in response to stress and environmental conditions[22]. The results presented in Tables 4 and 5 highlight the effects of isolation and different environmental enrichment on the blood profiles of rams.

Table 4: The haematological parameters of the first blood samples from the rams before isolating them in their respective rooms

Parameters	T1	T2	T3	T4	T5	T6
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PCV (%)	18.50±17.68 a	9.50±3.54a	17.50±7.78a	9.50±0.71a	18.00±12.73 a	7.50±3.54a
RBC (×10 ¹² /L)	1.17±0.00a	1.83±0.78a	4.77±3.47a	2.01±0.24a	5.60±5.44a	5.60±5.44a
WBCT (×10 ⁹ /L)	13.15±1.63a	21.80±11.88 a	28.90±17.39 a	29.35±23.97 a	20.00±9.90a	18.80±7.07a
Neutrophil (%)	21.00±21.21 a	29.50±3.54a	28.50±21.92 a	18.50±12.02 a	13.50±2.12a	6.00±8.49a
Lymphocyte (%)	69.00±26.87 a	53.00±1.41a	61.50±21.16 a	73.50±13.44 a	78.50±2.12a	74.50±10.61 a
Monocyte (%)	9.50±4.95a	13.50±2.12a	10.00±4.24a	8.00±1.41a	7.50±0.71a	19.00±18.39 a
Eosinophil (%)	0.00±0.00a	4.00±0.00b	0.00±0.00a	0.00±0.00a	0.50±0.71a	0.50±0.71a
Basophil (%)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
MCV (fL)	40.75±14.78 a	50.05±1.63a	40.85±13.51 a	49.35±2.76a	39.85±16.19 a	41.90±19.09 a
MCH (pg)	20.55±15.63 a	27.55±1.77a	18.00±12.73 a	26.80±2.83a	19.35±14.07 a	17.25±11.10 a
MCHC (g/L)	466.50±241.2 5a	550.00±169.7 0a	412.00±175.3 6a	543.00±268.7 0a	451.00±169.7 2a	391.50±855.6 9a
Hb (g/dL)	6.75±4.31a	5.15±2.05a	6.35±0.21a	5.35±0.07a	7.00±2.69a	7.00±3.54a
MPV (fL)	11.80±7.21a	16.40±0.42a	11.45±7.43a	16.30±0.98a	11.90±7.21a	12.75±8.42a

T1- Non-enrichment; T2- Mirror only; T3- Blue + Mirror; T4- Green + Mirror; T5- Red + Mirror; T6- Yellow + Mirror; MCV-Mean Corpuscular Volume; PCV- Packed Cell Volume; RBC- Red Blood Cell Count; WBCT- White Blood Cell Total; MCH- Mean Corpuscular Haemoglobin; MCHC- Mean Corpuscular Haemoglobin Concentration; Hb- Haemoglobin

Packed Cell Volume (PCV), Red Blood Cell (RBC), and Haemoglobin (Hb)

The PCV values before isolation ranged from 7.50% (T6) to 18.50% (T1), and after isolation, they ranged from 7.00% (T2) to 22.00% (T1). Notably, PCV increased slightly in T1 (Non-enrichment) and T5 (Red + Mirror) after isolation, suggesting a possible adaptive response to stress (Table 6). However, the low PCV in T2 (Mirror only, 7.00%) and T4 (Green + Mirror, 7.50%) indicates potential stress-induced anaemia [23]. The haemoglobin (Hb) values followed a similar pattern, with the lowest recorded in T2 (3.80 g/dL) and the highest in T1 and T5 (7.95 g/dL and 7.05 g/dL, respectively).

Red Blood Cell (RBC) counts varied widely, with T5 (Red + Mirror) recording the highest value ($7.69 \times 10^{12}/L$) after isolation, which may indicate a stress-induced erythropoietic response [17]. In contrast, T2 (Mirror only, $1.40 \times 10^{12}/L$) and T4 (Green + Mirror, $1.48 \times 10^{12}/L$) recorded the lowest RBC counts, suggesting that these treatments may not have effectively mitigated stress-related physiological changes.

White Blood Cell Count (WBCT) and Immune Response

White blood cell count (WBCT) is an indicator of immune function and physiological stress [24]. After isolation, WBCT significantly increased in T1 (Non-enrichment, $35.90 \times 10^9/L$), suggesting heightened stress and immune activation. A similar trend was observed in T4 (Green + Mirror, $22.95 \times 10^9/L$) and T6 (Yellow + Mirror, $25.75 \times 10^9/L$), though these were lower than in T1.

Conversely, T2 (Mirror only, $10.90 \times 10^9/L$) had the lowest WBCT after isolation, suggesting that mirrors alone may have helped reduce stress-related immune responses. However, previous studies have shown that low WBCT can indicate immunosuppression caused by prolonged stress exposure [25]. Table 5: The haematological parameters of the second blood samples from the rams after isolating them in their respective rooms

Parameters	T1	T2	T3	T4	T5	T6
PCV (%)	22.00±14.14 a	7.00±0.00a	16.00±9.89a	7.50±2.12a	21.50±3.54a	14.50±13.44 a
RBC (×10 ¹² /L)	2.32±0.00a	1.40±0.00a	4.24±3.59a	1.48±0.43a	7.69±1.79a	4.95±5.61a
WBCT (×10 ⁹ /L)	35.90±20.72 a	10.90±0.0 0a	20.80±8.77a	22.95±15.2 0a	19.45±8.84a	25.75±14.35 a
Neutrophil (%)	23.00±2.83a	52.00±0.0 0a	31.50±10.61 a	50.50±31.8 2a	41.00±1.41a	23.00±4.24a
Lymphocyte (%)	66.50±6.36a	31.00±0.0 0a	55.00±14.85 a	37.00±29.6 9a	44.00±8.49a	69.00±4.24a
Monocyte (%)	10.50±3.54a	15.00±0.0 0a	12.00±2.83a	11.50±0.71a	13.00±7.07a	8.00±0.00a
Eosinophil (%)	0.00±0.00a	2.00±0.00a	1.00±1.41a	1.00±1.41a	2.00±2.83a	0.00±0.00a
Basophil (%)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
MCV (fL)	40.20±14.00 a	52.30±0.0 0a	43.15±14.21 a	52.60±0.98a	28.50±1.84a	38.65±17.04 a
MCH (pg)	17.75±11.81 a	27.20±0.0 0a	17.95±12.52 a	28.85±1.20a	9.25±0.07a	19.90±15.98 a
MCHC (g/L)	416.00±148. 49a	520.00±0. 00a	389.50±160. 51a	548.00±12. 73a	322.00±19. 79a	469.50±205. 77a
Hb (g/dL)	7.95±2.76a	3.80±0.00a	5.40±1.13a	4.25±1.06a	7.05±1.63a	5.40±3.25a
MPV (fL)	11.50±6.65a	17.20±0.0 0a	12.00±7.92a	19.70±3.68a	6.50±0.14a	12.00±6.22a

T1- Non-enrichment; T2- Mirror only; T3- Blue + Mirror; T4- Green + Mirror; T5- Red + Mirror; T6- Yellow + Mirror; MCV-Mean Corpuscular Volume; PCV- Packed Cell Volume; RBC- Red Blood Cell Count; WBCT- White Blood Cell Total; MCH- Mean Corpuscular Haemoglobin; MCHC- Mean Corpuscular Haemoglobin Concentration; Hb- Haemoglobin

Neutrophil and Lymphocyte Dynamics

Neutrophil percentage increased significantly in T2 (Mirror only, 52.00%) and T4 (Green + Mirror, 50.50%) after isolation, indicating a stress response, as neutrophilia is often associated with acute stress and inflammation. The highest lymphocyte percentage was recorded in T6 (Yellow + Mirror, 69.00%), suggesting a potential stress-buffering effect of yellow-colored environments.

Monocyte, Eosinophil, and Basophil Response

Monocyte values remained relatively stable across treatments, with slight increases in T2 (Mirror only, 15.00%) and T5 (Red + Mirror, 13.00%) after isolation. Interestingly, eosinophils were detected in T2, T4, and T5 post-isolation, which may indicate allergic or stress-related immune responses [11]. Basophils were absent in all treatments, aligning with typical haematological profiles of ruminants under controlled conditions.

Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular

Haemoglobin Concentration (MCHC)

MCV values remained within the normal physiological range (28.50–52.60 fL), but T4 (Green + Mirror) showed an increase (52.60 fL), suggesting potential cellular swelling due to hydration or stress. MCH and MCHC values were highest in T4 and T2, indicating a compensatory response to stress-induced oxygen demand [26].

Comparison of Haematological Parameters in T1 (Non-Enrichment) Before and After Isolation

Tables 3 and 4 highlight the haematological changes in rams without enrichment (T1) before and after isolation. The most notable changes include:

- Increase in WBCT (from $13.15 \times 10^9/L$ to $35.90 \times 10^9/L$, $P = 0.34$), indicating heightened immune activation.
- Slight increase in PCV (from 18.50% to 22.00%) and Hb (from 6.75 g/dL to 7.95 g/dL), suggesting a mild adaptive response.
- Minimal changes in lymphocytes, monocytes, and neutrophils, suggesting the rams maintained some immune stability despite isolation stress.

These findings indicate that while isolation induced stress responses, the absence of enrichment may have prolonged the physiological impact on immune parameters.

CONCLUSION AND RECOMMENDATION

The study highlights that pen enrichment with different colored walls and mirrors influences the performance of isolated rams. Blue-colored walls with mirrors (T3) demonstrated the most positive effects on feed intake and body weight gain, whereas red and yellow walls contributed to higher stress levels and poorer performance.

These findings suggest that color and visual enrichment should be carefully considered in housing designs to optimize welfare and productivity in rams.

Also, pen enrichment with different colored walls and mirrors significantly influences behavior, restfulness, and feeding patterns in isolated rams. While mirror-only treatments increased visual engagement, their effect on stress reduction was limited. Blue and green color enrichment (T3 and T4) showed the most favorable behavioral responses, promoting activity, feeding, and rumination. In contrast, red and yellow environments (T5 and T6) were associated with reduced rest and possible stress-related behaviors. These findings emphasize the importance of choosing appropriate environmental enrichment to enhance welfare and reduce isolation stress in rams.

The haematological results suggest that isolation stress affected the physiological and immune responses of rams, with variations across different enrichment treatments.

These findings highlight the importance of appropriate environmental enrichment in mitigating isolation-induced stress in rams. Mirrors alone may not be sufficient, and color-based enrichment (especially green and yellow) could help maintain better physiological stability.

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