

Physiological Responses, Performance, Behaviour, and Welfare of Garut Sheep Raised in Semi-Intensive System in Indonesia

Maulana YP*, Ramdani D, Indrijani H, Yunasaf U, Mayasari N

Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang, Indonesia.

*E-mail: yasin15001@mail.unpad.ac.id

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ABSTRAK

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Peternakan domba di Indonesia terutama bergantung pada sistem intensif, yang sangat padat karya, dengan ruang gerak dan jumlah ternak yang terbatas. Negara-negara maju, di sisi lain telah mengembangkan peternakan sistem semi-intensif yang dapat meminimalkan jumlah pekerja dan dapat memberikan kesejahteraan hewan kepada dombanya. Penelitian ini bertujuan untuk membandingkan performans, respon fisiologis, perilaku, dan kesejahteraan domba Garut yang dipelihara menggunakan manajemen semi-intensif dengan penyediaan umbaran dan hanya kandang, rancangan percobaan uji-T menggunakan sepuluh ulangan ($n=10$). Percobaan menggunakan domba betina sebanyak 20 ekor (umur satu tahun) dengan bobot rata-rata (\pm SD) ($18,74 \pm 2,53$ kg). Hasil penelitian menunjukkan bahwa tidak ada perbedaan ($P>0,05$) antara domba dengan akses ke umbaran dan tanpa akses terhadap konsumsi bahan kering (gram/ekor/hari) dan pertambahan bobot harian (gram/ekor/hari). Domba dengan akses ke umbaran memiliki status fisiologis yang lebih baik, terutama denyut jantung dan frekuensi pernapasan pada pagi dan sore hari ($P<0,05$) dibandingkan dengan domba dipelihara di kandang. Rasio N/L darah domba betina dengan pemberian umbaran menunjukkan hasil yang lebih baik ($P<0,05$), dan lingkungan pemeliharaan tidak menunjukkan perbedaan atau menimbulkan efek stres pada ternak dengan akses ke umbaran ($P>0,05$). Kesejahteraan domba lebih terpenuhi dengan menyediakan umbaran di peternakan domba, dan perilaku ternak juga lebih aktif ketika diberikan akses umbaran. Kesimpulannya bahwa sistem semi intensif dengan akses umbaran meningkatkan performa domba Garut sekaligus meningkatkan pemenuhan indeks kesejahteraan dan kesehatan fisiologisnya. Pendekatan ini harus dipromosikan ke seluruh Indonesia untuk pengelolaan peternakan yang lebih baik.

Kata Kunci: Sistem Peternakan, Domba Garut, Kesejahteraan Ternak, Kandang, Fisiologi

ABSTRACT

Maulana YP, Ramdani D, Indrijani H, Yunasaf U, Mayasari N. 2022. Physiological responses, performance, behaviour, and welfare of garut sheep raised in semi-intensive system in Indonesia. *JITV* 27(3):130-141. DOI:<http://dx.doi.org/10.14334/jitv.v27i3.3068>.

Sheep farming in Indonesia mainly relies on an intensive, labor-intensive system, with limited wiggle room and the number of livestock. On the other hand, developed countries have developed a semi-intensive system that can minimize the number of workers and provide animal welfare to their sheep. This study aimed to compare performance, physiological responses, behavior, and animal welfare of reared Garut sheep in semi-intensive management with an outdoor and full indoor pen, employing a T-test experimental design using ten replicates ($n=10$). This experiment used 20 ewes sheep (one year old) with an average body weight of 18.74 ± 2.53 kg. This experiment found no difference in dry matter intake (gram/head/day) or average daily gain (gram/head/day) between both treatments ($P>0.05$). Ewes with access to an outdoor pen had better physiological status, especially heart rate and respiratory rate, particularly in the morning and afternoon ($P<0.05$) compared to ewes with the full indoor pen. The ratio of blood N/L for ewes with an outdoor barn showed better results ($P<0.05$), and the rearing environment did not show any difference nor induce stress on livestock with access to an outdoor pen ($P>0.05$). Ewes' welfare increases, and they become more active after being provided access to an outdoor pen. A semi-intensive system with an outside enclosure enhances Garut ewes' performance, blood parameters, and welfare index.

Key Words: Farming System, Garut Sheep, Livestock Welfare, Pen, Physiology

INTRODUCTION

Previous studies showed housing system might affect sheep performance and welfare, especially in the

tropical region (Sejian et al. 2021). Many farms, especially in less developed countries, continue to neglect animal welfare; this is related to poverty and social problems (Pinnillos et al. 2016) and other reasons

such as land limits, practical reasons, or to be safe from predator attacks. However, in terms of business benefits, scientific literature identifies employment benefits. It was discovered that improved animal welfare makes the animals safer and easier to handle, which results in a need for fewer workers, who are more satisfied, likely to have substantially less time off, and have fewer medical expenses (Sinclair et al. 2019). Farmers with low animal welfare awareness could affect their performance and decrease quality. Many livestock enterprises developed in Indonesia, such as sheep, mainly Garut sheep, have a significant potential to be developed, especially in West Java, Indonesia. In 2018, the largest sheep population was in West Java Province, with a total of 12.229.250 heads out of 17.833.732 sheep (Ditjen PKH 2021). Indonesia has a high opportunity for sheep husbandry development business to fulfill animal protein.

Sheep development in West Java and other provinces in Indonesia still depend on small-scale traditional farmers with a very labor-intensive environment. It limits animal freedom also the number of sheep population owned. Intensive livestock production is also one of the main reasons for biodiversity loss. Habitat change, such as natural to improved pastures and grassland to feed crops as one of the intensification consequences, could result in higher impacts. It also negatively affects water withdrawal, pesticides, or inorganic fertilizers. The farm that relies on grazing has the potential to defy this declining trend. Tälle et al. (2016) found that grazing generally had a more positive effect on the conservation value of semi-natural grasslands. Pasture-raised sheep products fill a premium niche. The production of pasture-raised sheep can fill a premium niche, have a minor negative environmental impact, and better animal welfare, including wildlife. The livestock rearing system significantly affects the welfare and comforting livestock during maintenance. Sheep farmers in Indonesia generally use an intensive rearing system with complete indoor maintenance. It could stress and emergence abnormal behavior affecting sheep production performance. Therefore some farmers practice a semi-intensive rearing system by providing access to an outdoor pen is a good choice for raising ewes. This system gives low stress and a better environment that increase productivity.

At this time, consumers also pay more attention to how the process of raising livestock they will consume. Many consumers, especially in developed countries, prefer to consume free-range raised livestock products. Consumer perceptions toward pasture-raised livestock are influenced mainly by their impact on the environment, and their health also depends substantially on the context of a purchase decision. Numerous consumer groups are prepared to pay more for pasture-raised attributes and the premium price of organic

products (Stampa et al. 2020). Another reason is that consumers consider this rearing system better meet animal welfare. The provision of an outdoor pen in the rearing system has been regulated by institutions such as the USDA (United States Department of Agriculture) and Humane Farm Animal Care (HFAC). In certain countries such as America, The United Kingdom, and other European countries, where generally livestock products have their grades and with a certificate of recognition of free-range system by these institutions, livestock products could be sold at better prices without limiting livestock rearing welfare.

Access to open land (outdoor pen) in sheep farming increases lymphocyte proliferation in the body (Colditz & Hine 2016). The outdoor pen also supports the implementation and maintenance of livestock welfare during rearing (Colditz & Hine 2016). In addition to a semi-intensive rearing system of sheep while also paying attention to nutritional needs and health maintenance, a semi-intensive rearing system with access to an outdoor pen can provide good production results for livestock production (De Brito et al. 2017).

A semi-intensive rearing system providing access to an outdoor pen is suitable for sheep breeding. Open land increases interaction between rams and ewes, leading to a higher chance of conception. An open land provides a place for the animal to do more activities. It helps to manage ewes weight, which affects the giving birth process. A rearing system that provides access to an outdoor pen for sheep with some concentrate feed could increase the level of low nesfatin-1. It is good for reproductive and reproductive organ metabolism. Another result from this study was an increase in feed consumption in sheep with a good Body Condition Score (BCS) and an increase in milk production without affecting the ewe's weight (Barbato et al. 2021).

Use of free-range in sheep farming (Osoro et al. 2013; Gracindo et al. 2014) and welfare (Llonch et al. 2015; Grandin 2018; Munoz et al. 2019) have been studied a lot by other academics, but none of those previous studies have looked at the influence of provision of outdoor pen on sheep behavior affected by more fulfilled welfare, especially for Garut sheep. Thus, this study aims to evaluate and compare the physiological status, body weight, growth, conception rate, temperature humidity index, welfare index, and behavior of Garut sheep reared using a semi-intensive system where half subjects are provided with access to an outdoor pen, and other half was reared in indoor pens fulltime.

MATERIALS AND METHODS

Location and farming systems

This study was carried out at the Experimental Farm of Universitas Padjadjaran (UNPAD; 6.93°S, 107.8°E,

and 750 m above sea level), Sumedang Regency, West Java Province, Indonesia, between January 2021 to July 2021. The average temperature during the experimental period was 23.2°C with a relative humidity of 82%. The outdoor pen used in this experiment was sized approximately 50 m² with a short (length 1-5 cm) field grass covering it and surrounded by an iron fence produced by NV Bekaert SA, Indonesia. Total 20 individual indoor pen-sized (1 m long × 0.7 m wide × 0.9 m high) parted by wood panels. The individual indoor pen is equipt with eyes and part-physical contacts.

Animals

The research ethics committee has approved animal care and experimental condition for sheep in this study of Universitas Padjadjaran (protocol No. 305/UN 6.KEP/EC/2021). Twenty ewes of 12±2 months old (Garut breed, Decree of Indonesian Agricultural Minister No. 2914/Kpts/OT.140/6/2011) were used in this experiment. Their initial average body weight was 19.5±2.5 kg (13.57% coefficient of variation, CV). The average body weight was 18.7±2.46 kg (12.82% CV) on day 10 of adaptation, and then the experiment was started here. Each ewe was randomly placed in an individual indoor pen with free access to feed and ad libitum clean water. Ten ewes had access to an external pen every day from 09.00 to 11.00 am (except during rain) (Outdoor Pen Treatment or OP). Another ten ewes were entirely confined in the indoor pen until day 70 of the experiment (Indoor Pen Treatment or IP). From day 71 to 138, each treatment modified the indoor pen into a communal pen-sized (2.5 m long × 4.2 m wide × 0.9 m high). Each indoor communal pen provided one ram for mating to measure ewes' conception rate. The exact time scheduled treatment was applied.

Animals feeding

All ewes were fed three times daily: 1 kg forage at 07:00 am, whole concentrate (500 grams) at 12:00 am, and 2 kg forage at 4:00 pm. The diet was mixed forage and designed concentrate. Concentrate consisted of 14.5 percent crude protein and 67 percent TDN (Total Digestible Nutrients). Feed ingredient composition and chemical content of concentrate can be seen in Table 1. Leftover forage and concentrate were collected and weighed before the next feeding time.

Data collection and measurements

Microclimate parameters

Characteristics studied were indoor pen temperature (Tip, °C), outdoor pen temperature (Top, °C), and

relative humidity of both indoor and outdoor pen (RH, %) to compare microclimate in different farming methods. Tip, Top, and RH variables were measured and recorded manually every day at 07:00 am, 12:00 am, and 4:00 pm for 70 days using a digital room thermometer (HTC-2, Eagletech, China). The thermometer -50 to 70°C (±1°C accuracy) was used. RH measurement ranges between 20 and 99 % (±5 % accuracy). The thermometer was placed 1.5 m above the ground. It is not exposed to solar radiation and is shielded from the weather and radiation.

Physiology responses

Physiology responses affected by thermoregulatory variables such as respiratory rate (RR, breaths min⁻¹), heart rate (HR, beats min⁻¹), and rectal temperature (RT, °C) of each ewe were collected every Wednesday for 70 days of the experiment. Ewes were restrained in their indoor pen and controlled by holding the chin with both hands, then pressed by knees to prevent movement. The containment procedure took about 3 min per ewe. All ewes were adapted to the procedure and did not resist immobilization. RR was determined by monitoring flank movements and counting exhale of ewes for over 60 seconds with three repetitions assisted by a flexible stethoscope. HR was determined by positioning the same flexible stethoscope on the left thoracic region over the aortic arch and counting the heartbeat for 60 seconds with three repetitions. RT was measured by inserting a flexible tip digital clinical thermometer (MC-343F, Omron, China), with a measurement range of 32.0–42.0°C, maximum indication error of ±0.1°C, in the ewes rectum for 30 seconds. Thermoregulatory variables readings were carried out three times at 07:00 am, 12:00 am, and 4:00 pm. In addition, blood collection was also carried out on day 70 to test the neutrophil-lymphocyte ratio of blood as an additional stress test parameter. Additional parameters like red blood cells, white blood cells, and other hematological and blood chemical parameters were also done.

Animal performance

The performance of ewes was measured by collecting feed intake data daily. It counted the difference between offered and leftover in a gram of DMI (g/head/day). Bodyweight and growth of some specific body parts are being monitored and measured bi-weekly (Wednesday) until day 70.

Thermal comfort indices

Thermal comfort and environmental indices were calculated based on meteorological data recorded in an

Table 1. Ingredient composition and chemical content of the concentrate

Feed Ingredients	DM	CP	TDN	CF	Ca	P	Usage
	------(%)-----						
Corn ¹	92.01	8.00	80.00	11.00	0.25	0.58	5
Dried cassava ¹	84.71	1.84	78.30	0	0.29	0.38	10
Chocolate skin ¹	80.00	14.50	47.00	33.00	-	-	15
Coconut Meal ¹	88.50	19.00	78.00	0	0.08	0.52	15
Palm Meal ¹	90.80	14.69	75.50	0	0.26	0.19	15
DDGS ²	89.30	30.60	88.00	10.0	0.09	0.67	5
Wafer Crust ¹	90.00	13.60	70.00	5.00	0.50	0.30	15
Pollard ¹	89.57	16.41	74.83	5.86	0.13	1.29	19
Salt ¹	90.00	-	-	-	0.33	0.07	0.4
Lime ¹	100.00	-	-	-	39.00	-	0.4
Premix ¹	98.00	-	-	-	4.00	2.00	0.2

¹Nurfitriani & Muhamad (2021); ²USGC (2018)

DDGS= distillers dried grains with solubles, DM= Dry matter, CP= Crude protein, TDN= total digestible nutrient, CF= crude fiber, Ca= calcium, P= phosphorus

Table 2. Ethogram, description, and definition of observed behaviors

Behavior Explanation	Ethogram Classification		
	Behavior	Activity	Body Position
Animals are grazing with their heads down, and they can be stationary or moving	Grazing	Feeding / Grazing	Upright - Bow
Animals eat with their heads down on the available feed	Eat at the Feed Tray	Feeding / Grazing	Upright - Bow
Animals travel by taking progressive steps forward. The head position can be up or down.	Walk	Active	Upright
Animals are still and stand up straight. Behaviors are recorded only when the head is moving or chewing with the head held high.	Remastication - Standing	Active	Upright – Mouth movement
Animals lie down and are inactive with small head movements	Lying	Inactive	Kneel
Animals are still and stand up straight. Behaviors were recorded only when the head was held upright without movement.	Stand up	Inactive	Upright

Source Barwick et al. (2018)

Indoor and outdoor pen. The temperature and humidity index (THI) of the indoor and outdoor pens was determined, as described in the following equation by Thompson & Dahl (2012):

$$THI = (1.8 \times T + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)]$$

where T is air temperature (°C), RH is relative humidity (%), and THI is comfort index.

70. Ewes were observed in four sessions from 09:30 to 09:45 am; then from 10:15 to 10:30 am; next from 2:30 to 2:45 pm; and last from 3:15 to 3:30 pm (±15 min each session). Data collected were the duration and frequency of behavior shown during each session. Details of behavior classification can be seen in Table 2.

Behavior activities

Behavior activities were collected using a CCTV (closed-circuit television) placed in the outdoor and indoor pen. It was done to collect behavior data on day

Welfare index

Ewes' welfare index during rearing was assessed on day 70 of the study through a questionnaire based on the Welfare assessment from (EFSA 2014; Indonesia 2012). The answer was based on the farming system

and the condition of ewes from each treatment until the day of the assessment. A higher value denotes better satisfaction with livestock welfare. Six stable keepers completed the assessment, tallied, and compared the two treatments.

Conception rate

The conception rate of ewes was collected and measured using a conception test kit (Pregnaprop) by taking a sample of ewes urine on days 104 and 138. If the ewes' urine mixed and reacted with pregnadrop substance and became clear, that stated the ewes were pregnant; if not reacted, then ewes were not pregnant.

Statistical analysis

This study used a complete randomized design, with a t-test design for treatment structure. Three statistical measurements were used in this experiment for body weight, growth, dry matter consumption, conception rate; hematology parameters; and temperature humidity Index data were analyzed using an independent T-test. The variables for Independent T-test were computed as follows:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \text{ with } s_p = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}}$$

where \bar{x}_1 is the mean of the first sample; \bar{x}_2 is the mean of the second sample; n_1 is the sample size (i.e., number of observations) of the first sample; n_2 is the sample size (i.e., number of observations) of the second sample; s_1 is the standard deviation of the first sample; s_2 is the standard deviation of the second sample; s_p is pooled standard deviation.

While welfare index data were analyzed using the Mann-Whitney test, the behavior parameter was analyzed using time management analysis. Data were analyzed in SPSS 26 statistical software. Statistical significance was assumed at $P < 0.05$.

RESULTS AND DISCUSSION

Results

Microclimate parameters and thermal comfort index

This study did not find any interaction between indoor and outdoor pen farming systems for air temperature and relative humidity. However, the isolated effect of indoor pen farming systems was found. The air relative humidity was higher in IP than in OP ($P = 0.001$). It was also revealed that the RH value was higher than the typical reference for sheep due to the relatively humid area of the cage and the

significant amount of rain that fell at the time of the study. A ventilator cage or an exhaust fan could be added to lower RH. A heating device could be added to lessen weather effects during heavy rainfall. As expected, IP showed 6% higher relative humidity compared with OP. Moreover, we did not find any differences between both systems regarding the air temperature ($P = 0.630$).

This study also did not find interaction in Temperature-Humidity Index (THI) between indoor and outdoor pen farming systems ($P = 0.614$). However, both treatments have a positive THI outcome, indicating that the environment in which the experiment was conducted is at a safe stage and suitable for use as a livestock development area, and can be used as a guide for farmers looking for a suitable spot to start a farm.

Thermoregulatory variables

Based on the interaction observed between the time of day and the farming system ($P < 0.05$), the respiratory rate of ewes showed higher in IP compared to OP (Table 4). At noon, the difference between systems was not too high. It was only one breath per minute for every period of data collection. Increased respiratory rate was sufficient to keep ewes' rectal temperature in the physiological interval (Tables 4 and 5). For both IP and OP treatments, animals did not have any differences and were still normal ($P > 0.05$). Heart rate for ewes in outdoor pen treatment (OP) was lower (Table 4) than for ewes in indoor pen treatment (IP) and showed a significant difference. These physiological parameters were associated with microclimate parameters (air temperature and relative humidity) (Table 3) that are much higher in indoor pen treatment (IP). It could cause disturbance and induce ewes to be more inclined to be stressed and increase heart rate and respiratory rate.

Hematology parameters

A significant difference ($P < 0.05$) was found in Red Blood cells (RBC), Hemoglobin (Hb), hematocrit, Ratio of N/L (Neutrophil/Lymphocyte), and lymphocyte from both treatments. IP treatment has a higher RBC, Hb, and hematocrit, while OP treatment has a higher N/L ratio and lymphocyte. The lowest stress marker (e.g., ratio of N/L) indicated that an animal in a comfort zone or situation is 0.19 in a pregnant goat (Nareswari et al., 2021). This lower average N/L ratio compared to unpregnant ewes because progesterone hormone, active during pregnancy, stimulates the central nervous system to produce anti-stress. Logical markers-stress markers could be correlated with a physio, such as lower heart rate and respiratory rate of ewes with OP treatment. In this study, high THI in IP treatment has a higher

Table 3. Mean values (mean±SEM) of microclimate and thermal comfort index between treatments

Variables	Treatment		Normal reference range
	Indoor Pen	Outdoor Pen	
Air Temperature (°C)	23.27±0.16a	23.16±0.16a	20–30°C ¹
Air Relative Humidity (%)	85.19±0.79a	78.99±1.14b	≈60 % ¹
THI	65.22±0.13a	65.13±0.13a	Until 74 ¹

¹ Santos et al. (2021)

Means with different letters (lowercase for rows) differ among themselves (T-test; P<0.05)

Table 4. Mean values (mean±SEM) of Respiratory rate (breaths min⁻¹) and heart rate between treatments throughout the day

Periods of the day	Respiratory rate (breaths min ⁻¹)		Heart rate (beats min ⁻¹)	
	Indoor Pen	Outdoor Pen	Indoor Pen	Outdoor Pen
07.00	24.40±0.31a	23.30±0.15b	101.30±2.49a	90.50±0.96b
12.00	25.40±0.31a	24.20±0.20b	115.10±2.05a	104.90±2.56b
16.00	25.20±0.29a	24.20±0.25b	111.30±1.87a	103.90±1.51b
Normal reference range	24 to 50 ¹		84-135 ²	

¹ Singh et al. (2016) ² Scott (2015)

Means with different letters (lowercase for rows) within farming systems differ among themselves (T-test; P<0.05).

Table 5. Mean values (mean±SEM) of rectal temperature (°C), between treatments throughout the day

Periods of the day	Temperature (°C)	
	Indoor Pen	Outdoor Pen
07.00	38.55±0.06a	38.54± 0.04a
12.00	38.78±0.05a	38.74±0.16a
16.00	38.86±0.06a	38.85±0.04a
Normal reference range	39.5-39.9°C ¹ ; 38.3–39.9°C ²	

¹ Reece (2015), ² Wojtas et al. (2014)

Means with different letters (lowercase for rows), within farming systems differ among themselves (T-test; P < 0.05).

risk of inducing stress. It showed that ewes in IP treatment have higher RBC, HB, and hematocrit, can cope with high oxygen needs and are more susceptible to pathogen microorganisms in the body. The immune system will be more responsive to guard against pathogen microorganisms in the body. Higher lymphocyte values in ewes after OP treatment demonstrated that they could be more disease resistant than the one with lower lymphocyte values. Increasing stress levels impact higher catecholamine secretion in ewe's body, and Catecholamines cause the hypothalamus to produce Corticotropin-Releasing Hormone (CRH), which causes the anterior pituitary to produce adrenocorticotropin (ACTH). Cortisol production is stimulated by adrenocorticotropin hormone leading to lymphopenia (low lymphocytes) and neutrophilia (high neutrophilia) in ewes (Satyaningtijas et al. 2014). This result also proves that

ewes with access to outdoor pen (OP) treatment had a lower stress level than those from IP treatment.

Performance variable

From all performance parameters collected, only chest size from OP treatment shows a higher and more significant result (P<0.05). This study revealed that sheep receiving OP treatment had other behaviors that did not reduce their ability to grow; otherwise, they were nearly identical to ewes with IP treatment or had a greater ADG (Average Daily Gain) than ewes that confined fully in an indoor pen (IP). This big difference in the ewes can be seen in chest size, which was attributable to the dynamic behavior of ewes in the outdoor pen, which allowed more muscle to accumulate in the chest, resulting in a larger chest circumference.

Table 6. Mean values (mean±SEM) of various hematology parameters of ewes between treatment

Parameter	Treatment		Normal reference range
	Indoor pen	Outdoor pen	
RBC (10 ¹² /l)	15.04±0.17a	14.02±0.37b	9-15 10 ¹² /l ¹
Hb (g/dL)	13.96±0.26a	12.16±0.32b	9-13 g/dL ²
Hematocrit (%)	38.87±0.81a	34.66±0.82b	27-30% ³
MCV (fL)	25.40±0.62a	24.80±0.59a	-
MCH (pg)	8.34±0.94a	7.88±0.89a	-
MCHC (g/dL)	32.25±3.59a	35.38±0.41a	-
WBC (10 ⁹ /l)	15.51±1.21a	18.31±1.33a	-
N/L Ratio	0.77±0.05a	0.56±0.06b	≤1.5 ⁴
Neutrophil (10 ⁹ /l)	6.70±0.70a	6.71±0.79a	-
Lymphocyte (10 ⁹ /l)	8.73±0.61a	11.51±0.99b	-

¹Scott (2015), ²Gogaev et al. (2020), ³Wojtas et al. (2014), ⁴Oramari et al. (2014)

Means with different letters lowercase for rows), within farming systems differ among themselves (T-test; P<0.05). RBC= red blood cell, Hb= hemoglobin, MCV= mean corpuscular volume, MCH= Mean corpuscular hemoglobin, MCHC= mean corpuscular hemoglobin concentration, WBC= white blood cell, N/L Ratio= neutrophil/lymphocyte ratio

Table 7. Mean values (mean±SEM) of various performance parameters of ewes between treatment

Parameter	Treatment		P-value
	Indoor pen	Outdoor pen	
BW Day 0 (Kg)	18.04±0.73a	19.94±0.57a	0.057
BW Day 70 (Kg)	23.66±0.94a	25.69±0.83a	0.120
ADG (gram/day)	80.24±7.93a	82.28±8.31a	0.861
DMI (gram/head/day)	602.59±15.19a	617.25± 8.23a	0.407
FCR	8.49±1.19a	8.18±0.81a	0.827
Chest size Day 70 (cm)	67.03±1.16a	70.11±0.73b	0.037
Height Day 70 (cm)	62.20±1.89a	62.92±2.69a	0.498
Hip Width Day 70 (cm)	17.50±0.24a	17.59±0.31a	0.819

Means with different letters (lowercase for rows) within farming systems differ among themselves (T-test; P< 0.05). BW= body weight, ADG = average daily gain, DMI= dry matter intake, FCR= feed conversion ratio

Table 8. Mean rank (mean±SOR) of welfare index observation of ewes between treatment

	Treatment		P-value
	Indoor pen	Outdoor pen	
Welfare Index	83.36±7585.50a	99.64±9067.50b	0.026

Means with different letters (lowercase for rows), within farming systems differ among themselves (Mann-Whitney test; P<0.05)

Table 9. Mean values (mean±SEM) of conception rate of ewes between treatment

Day	Treatment		P-value
	Indoor pen	Outdoor pen	
104 (%)	70±0.15a	60±0.16a	0.660
138 (%)	80±0.13a	90±0.09a	0.556

Means with different letters (lowercase for rows) within farming systems differ among themselves (T-test; P<0.05)

Table 10. Observation result of ewes behaviors

Behavior	Treatment															
	Indoor pen								Outdoor pen							
	Duration (s)				Frequency				Duration (s)				Frequency			
Session	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Active	23.8	1.8	42.4	208	1.2	0	1.4	3.2	315.6	454.4	168.6	455.8	10	6.8	1.4	5.4
Inactive	869	898.2	822.6	629	2.6	0.2	2.2	2.4	187.6	143.4	717.6	325.6	7	4.4	1.2	2.6
Feeding	7.2	0	35	63	0.8	1.2	0.8	1.8	396.8	302.2	13.8	118.6	6	4.4	1	3

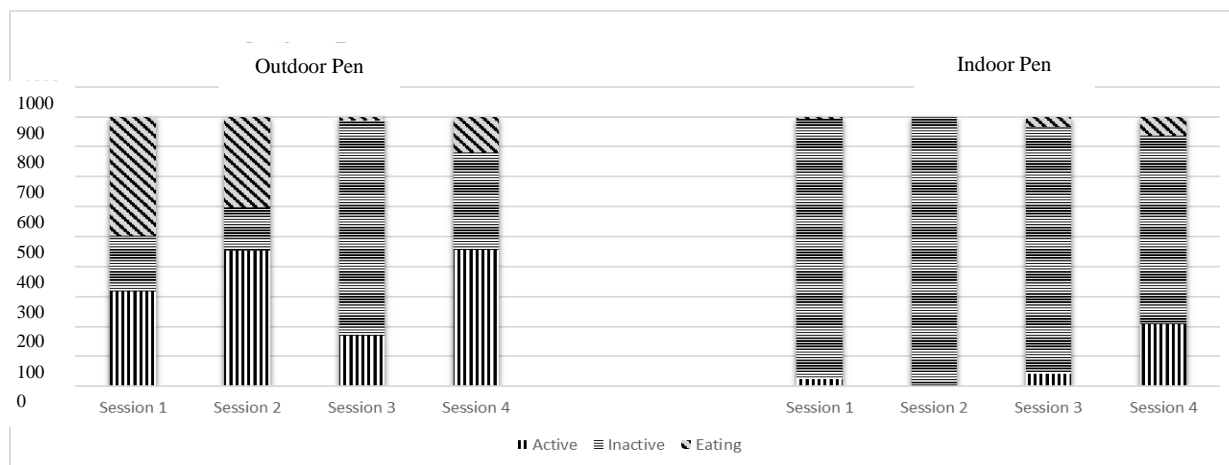


Figure 1. The behavior of ewes by duration

Welfare index observation

OP treatment showed higher results ($P < 0.05$) in animal welfare. A higher index score of ewes in OP treatment demonstrates that providing an outdoor pen could better meet the needs and well-being of ewes without compromising livestock growth.

Pregnancy rate

There is no significant difference shown in the treatment for pregnancy rate ($P > 0.05$) between indoor (IP) and outdoor pen (OP) farming systems. However, if we look at the progression from one measurement to the next, this study could be observed that IP treatment had 70% of the pregnant population in the first measurement, while OP therapy had 60%. Even so, in the second measurement, ewes with OP treatment had a 30% greater pregnancy rate than those with IP treatment, resulting in an overall pregnancy rate of 80% in IP treatment and 90% in OP treatment.

Behavior of ewes

There was an increase in inactive behavior and eating behavior of ewes in outdoor pen treatment. This

phenomenon shows that indoor pens did not fulfill ewes need and welfare and have higher stress risk.

In this experiment, ewes behavior was observed in four distinct sessions to acquire a complete picture of the influence of being in an indoor and outdoor pen on ewes behavior. The first session was compelled from 09:30 until 09:45 am; then from 10:15 until 10:30 am; next from 2:30 until 2:45 pm; and last from 3:15 until 3:30 pm (± 15 minutes each session). The observation of ewes behavior can be seen more clearly in Diagram 1. Indoor pen treatment was dominated by passive behavior, and the outdoor treatment had a higher result in active and feeding behavior. This observation demonstrates that providing an outdoor pen for ewes can increase their activity level, which increases as the area expands, allowing ewes to roam freely and partake in behavioral patterns as their instincts urge.

Discussion

Table 3 shows the value of indoor and outdoor pens in the Temperature Humidity Index (THI). THI was not significantly different ($P > 0.05$), with an average value of 65.22 and 65.12 for indoor pens, respectively. Rana et al. (2014) calculated the THI value from temperature and relative humidity to determine the heat stress. THI table presents five animal comfort zones: $72 <$ no stress,

72–78 mild stress, 78–89 severe stress, 89–98 very severe stress, and 98> dead animals. It could be concluded that the outdoor and indoor pen environment will not cause stress for ewes. THI results also support the ewes' body temperature, which is not significant despite the expenditure on the outdoor pen because the THI value is not much different and does not cause heat stress in ewes.

Table 4 shows data from observations of ewes' physiological status. It could be seen that ewes given access to an outdoor pen had lower respiratory rate per minute and heart rate or pulse rate per minute. It was also significantly different ($P < 0.05$) in the morning, noon, and evening examinations (Table 4). This observation indicates that ewes tend to be more comfortable during rearing. Singh et al. (2016) stated that tropical sheep have a respiratory rate frequency ranging from 24 to 50 breaths per minute, varying from many breeds, and a heart rate ranging from 84 to 135 per minute (Scott 2015). Complete rearing treatment in an indoor pen showed that ewes were more stressed than in outdoor pens. This increase in respiration rate and heart/pulse rate is caused by an increase in oxygen demand by the body, so the supply of blood needs to be increased; this increase directly affects heart rate and respiration rate and is also due to the effect of decreasing blood pressure from peripheral vasodilation (Pachen et al. 2021).

Meanwhile, the rectal temperature of the two treatments in Table 5 shows that values ($P > 0.05$) were not much different but still within the average level. Wojtas et al. (2014) said that ordinary sheep's body temperature under thermoneutral conditions ranges from 38.3–39.9°C. This body temperature results from heat balance received and released by ewe's body.

Table 6 also shows significant differences in parameters ($P < 0.05$). The number of red blood cells (RBC), amount of hemoglobin (Hb), and the number of ewes blood hematocrit. This difference itself is still within the average level, where the standard red blood cell value for sheep ranges from 9–15 $10^{12}/l$ (Scott 2015; Gogaev et al. 2020), for blood hemoglobin values ($P < 0.05$) range from 9–13 g/dL (Gogaev et al. 2020), and a hematocrit of 27–30% (Wojtas et al. 2014). The ewes' situation in an indoor pen, which is usually static, and lack of air movement may indeed cause stress in ewes, resulting in increased cell metabolism throughout the body and an increase in energy demand causing oxygen demand and accelerated erythropoiesis on the bone marrow. There was also an increase in the red blood cell. Hematocrit is the proportion of blood cells compared to plasma, so the increase in hematocrit is in line with the increase in erythrocytes. When the erythrocytes increase, hematocrit value will also increase, and vice versa. High hematocrit in the ewes' body is caused by erythropoiesis, indicating an increase

in energy requirements in the body. The environment could affect stress, in this case, the restricted movement of Ewes. Providing access to an outdoor pen is one way to solve this issue. Another step that could be taken is to lessen the impact of other stress factors, such as inadequate feed, poorly ventilated cages, and many other factors.

According to Mills et al. (2012), when animals are frightened or stressed, spleen constriction is increased by epinephrine so that the movement of red blood cells in the blood becomes very vigorous, finally increasing the hematocrit value. This study showed that indoor pens had higher hematocrit values than outdoor pens. It was estimated due to heat stress, lack of freedom of movement, and not being accustomed to contact with humans. Pinto-Santini & Ungerfeld (2019) stated that the potential effect of a ewe's in-estrous phase could also increase the hormone cortisol, which raises stress in animals, and the effect of stress during blood collection can increase since ewes are frightened during the injection. These findings provide another explanation for this abnormal hematocrit value for both treatments. The number of blood erythrocytes causes the difference in hemoglobin in ewes' blood. This increase is in line with an increase in energy requirements resulting in amino acids forming Hb prioritized for energy synthesis so that Hb decreases. Breeding ewes are most likely to be exposed to heat stress. Narayan & Parisella (2017) stated that stress caused an increase in glucocorticoid production, primarily cortisol, which stimulates gluconeogenesis. Increased gluconeogenesis rate for energy fulfillment resulting Hb-forming amino acids (especially glycine and methionine) preferred to enter the Krebs cycle pathway for energy synthesis, which causes the rate of Hb formation to decrease (Duehlmeier et al. 2013).

Table 6 shows physiology from the blood test physiology results of ewes. N/L ratio showed significant differences ($P < 0.05$). Maheshwari et al. (2013) said that changes in the ratio of neutrophils/lymphocytes (N/L) are indicators of assessing individual responses to environmental changes. In addition, Gjerstad et al. (2018) stated that the hypothalamic–pituitary–adrenal (HPA) axis regulates circulating levels of glucocorticoid hormones. When stress engages the HPA axis, a spike in glucocorticoid hormones helps the body get ready to deal with the stressor and recover from it. Metabolic processes modulation, immune system, reproduction, behavior, and cognitive functioning are a few of glucocorticoids' many consequences. One of the body's responses to stressors is known to increase glucocorticoid hormones for gluconeogenesis.

As a result, variations in the number of neutrophils and lymphocytes in the blood are one of the physiological measures used to assess livestock stress

levels, including sheep. Oramari et al. (2014) stated that the normal value of the N/L ratio in sheep is ≤ 1.5 . The results of both treatments showed that the ewes were not classified as stressed. However, the value of the N/L ratio of ewes given access to an outdoor pen had a lower ratio value and showed a higher lymphocyte value. The lower value of lymphocytes in ewes' blood in the full indoor pen was due to environmental stress. It caused body ewes to activate the hypothalamic-pituitary-adrenal cortical system causing the hypothalamus to produce corticotrophin-releasing factor (CRF). CRF stimulates the pituitary to release the hormone ACTH (adrenocorticotropin hormone) then adrenal cortex tissue produces corticosteroid hormones. Corticosteroid hormones cause a decrease in lymphocyte levels. This decrease in lymphocytes causes a decrease in the immune system. Pascual-Alonso et al. (2017) stated that stress could cause the body's N/L ratio, cause an increase in hormones secreted by adrenal glands and increase the N/L ratio.

Table 7 shows ewes' growth and weight gain from the two treatments. There was no significant difference in parameters ($P > 0.05$) except the chest circumference of ewes reared in an outdoor pen which showed a higher value between indoor and outdoor pens. This big difference in the ewes' chest circumference was attributable to active activity in an outdoor pen allowing more chest muscle accumulation. It resulted in a larger chest circumference. This claim is supported by research from Zhang et al. (2022), who found that exercising sheep could increase muscle metabolism. These findings are consistent with the findings of this study, which found that exercise in an outdoor pen led to more significant muscle development than indoor treatment. An increase in chest circumference indicated it. Both body weight, ADG (Daily Weight Gain), and other body measurements did not show significant differences.

Table 7 also shows data on livestock dry matter consumption and feed conversion ratio where there is no significant difference in parameters ($P > 0.05$). These results indicate that the availability of outdoor pens for ewes does not affect dry matter consumption. This study also showed that sheep placement in outdoor pens does not affect livestock production but still pays attention to livestock welfare during rearing. Galindo et al. (2016) stated that until now, farming systems have focused on animal nutrition, basically comparing monoculture systems with systems combining grasses and legumes without regard for livestock welfare.

Table 10 shows the results of observing the behavior of ewes due to the provision of access to the outdoor pen. The results show that ewes with access to outdoor pens have higher active feeding behavior than ewes entirely reared in indoor pens. This higher dynamic behavior proves that ewes are more prosperous

because they can behave according to their instincts, channel their desire to move and move, and interact without a hitch. In Figure 1, it can be seen that ewes that are entirely reared in indoor pens without having access to their outdoor environment behavior are dominated by inactive behavior wherein a total of four observations, the value is consistently above 70%; this passive behavior also proves that ewes tend to be more stressed due to not being able to move. The result is confirmed by observations of ewes physiological status, where the value is greater than the treatment in outdoor treatment.

Regarding self-breeding in an open environment, it has been shown that no relationship exists between dominance and mating behavior (Ungerfeld et al., 2019). Although it rarely happens, in the mating process with only one ram, there is a possibility that there is a dominating ewe, especially those with a larger and more aggressive body, which causes rivalry among ewes for a ram and can result in a lower pregnancy rate (González-Tavizón et al. 2022). Nevertheless, with the high active behavior of ewes in outdoor pen treatment and the continuous presence of a ram, there is a significant level of social interaction between ewes and rams. It is recommended that further investigations be conducted into the quality of newborn lambs, the miscarriage rate of ewes, and also the death rate of newborn lambs reared using this outdoor pen system, including the study of the ideal outdoor pen based on the area of observation or farm that can more boost livestock growth without compromising livestock welfare.

CONCLUSION

In a tropical country like Indonesia, providing access to an outdoor pen better influences handling stress in livestock. Also, it benefits their welfare, particularly in terms of freedom of mobility, interaction with one another, and an increase in dynamic behavior and feeding. Providing access to the outdoor pen has a positive effect on blood parameters.

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