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FACTORS AFFECTING THE REPRODUCTIVE PERFORMANCE EFFICIENCY OF BEEF CATTLE IN THE SOUTH SULAWESI PROVINCE

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Abstract
The application of artificial insemination (AI) technology continues to improve, especially in South Sulawesi, one of Indonesia's beef cattle population centers. This study aims to determine the factors influencing AI implementation in South Sulawesi. Secondary data on reproduction performance from iSIKHNAS were tabulated by district, inseminator, cattle breed, and reproductive variables (S/C value and pregnancy percentage). Data were analyzed using descriptive, variance, and correlation analyses. Bali, Limousin, and Simmental cattle had S/C of 2.24, 2.44, and 2.61, respectively. Different district locations have better S/C (P<0.05), such as Palopo, Barru, Sidenreng Rappang, Jeneponto, North Luwu, Sinjai, Bantaeng, and Tana Toraja. The performance of inseminators had a significant effect (P<0.05). Although with a low number of inseminators, Tana Toraja had the best reproductive efficiency, compared to Soppeng, which has many inseminators but low livestock reproductive efficiency (P<0.05). In conclusion, reproductive efficiency performance is influenced by location (district topography) and inseminator performance, whereas the breed of cattle does not affect S/C values and pregnancy percentage. The results of the correlation analysis showed that S/C has a positive correlation with inseminator performance of 44.3%.
Keywords: artificial insemination, beef cattle reproduction, service per conception, South Sulawesi

FAKTOR-FAKTOR YANG MEMPENGARUHI EFISIENSI KINERJA REPRODUKSI SAPI POTONG DI PROVINSI SULAWESI SELATAN

Abstrak
Penerapan teknologi inseminasi buatan (IB) terus ditingkatkan terutama di Provinsi Sulawesi Selatan sebagai salah satu daerah sentra populasi sapi pedaging di Indonesia. Penelitian ini bertujuan menentukan faktor-faktor yang mempengaruhi pelaksanaan IB di Provinsi Sulawesi Selatan. Data sekunder berupa kinerja repoduksi dari iSIKHNAS ditabulasi berdasarkan lokasi (kabupaten), inseminator, bangsa sapi, dan pebuah reproduksi yaitu nilai S/C dan persentase (%) kebuntingan. Data dinalasisi secara deskriptif, analisis ragam dan korelasi. Hasil penelitian menunjukkan bahwa sapi bali, limosin dan semental masing-masing memiliki angka S/C yaitu sebesar 2,24, 2,44, 2,61. Perbedaan lokasi (kabupaten) memiliki performa efisiensi reproduksi S/C yang lebih baik (P<0,05) seperti di kabupaten Palopo, Barru, Sidenreng Rappang, Jeneponto, Luwu Utara, Sinjai, Bantaeng, dan Tana Toraja. Performa inseminator berpengaruh nyata (P<0,05), sehingga inseminator di kabupaten Tana Toraja meski kurang baik memiliki efisiensi reproduksinya yang terbaik. Sebaliknya di kabupaten Soppeng persentase inseminator baik akan tetapi memiliki efisiensi reproduksi yang rendah (P<0,05). Dengan demikian, kinerja efesiensi reproduksi sangat dipengaruhi oleh lokasi (tofografi kabupaten) dan performa inseminator, sedangkan pengaruh bangsa tidak mempengaruhi nilai S/C dan persentase kebuntingan. Hasil analisis korelasi menunjukkan bahwa S/C berkorelasi positif dengan kinerja inseminator yaitu sebesar 44,3%.
Kata kunci: inseminasi buatan, reproduksi sapi potong, service per conception, Sulawesi Selatan

INTRODUCTION

Demand for beef in Indonesia is increasing due to population growth, rising income levels, and increased awareness of meat consumption to fulfill animal protein needs (Rusono, 2015). One of the efforts to meet the domestic demand for beef is to increase the beef cattle's productivity. In 2022, there were 18,610,148 heads of beef cattle nationwide, with 1,483,709 heads in South Sulawesi Province (Directorate General of Animal Husbandry and Animal Health, 2022).

The global demand for food is driving the use of artificial insemination (AI) techniques in

livestock to improve efficiency and reproductive capabilities (Kusumawati & Leonndro, 2014; Susilawati, 2011). AI is known as an effective reproductive technology in Indonesia, used to accelerate genetic improvement and facilitate the distribution of high-quality and affordable semen, thus increasing breeders' income (Diskin, 2018). Parameters such as conception rate, service per conception, calving intervals, percentage of pregnancy, and birth rate are used to evaluate the reproductive efficiency of cattle (Harjopranjoto, 1995).

In South Sulawesi Province, AI and natural mating are used in livestock breeding. AI activities are primarily focused on Bali cattle and cemental and limousine crossbreed cattle. The success rate of AI is influenced by interrelated factors such as the selection of acceptors, accurate heat detection by breeders, inseminator skills, semen quality testing, and feed and environmental management (Hastuti, 2008).

Bali cattle have advantages compared to other cattle, such as a fast growth rate, good environmental adaptation, and efficient reproductive performance (Nubatonis & Dethan, 2021). They are commonly kept on small farms due to their fertility and low mortality rate (Purwantara et al., 2012). Simmental and limousine-cross cattle show higher performance but have lower reproductive abilities compared to local cattle due to adaptability issues and inadequate feed management.

The role of the inseminator is crucial to the success of AI. Inseminators require extensive experience, which improves their performance quality over time (Kotur & Anbazhagan, 2014). Breeders and inseminators play a significant role in the success of AI in beef cattle, accounting for 78.4% of the success rate (Ardhani et al., 2021). Inseminators must undergo training and obtain certificates and permits. Various aspects, including the ability to detect heat, sanitize tools, handle frozen semen, and perform AI, contribute to the success of AI (Herawati et al., 2012). The ratio of inseminators to acceptors in an area also affects the success rate, with an insufficient number of inseminators leading to delays in serving acceptors (Kusumawati & Leonndro, 2014).

The altitude of several districts/cities in South Sulawesi is 0 - 3,469 meters above sea level (BPS Sulsel, 2013). The topography of South Sulawesi, which ranges from lowlands to highlands, affects temperature and humidity levels. These factors, in turn, impact adaptability and heat stress, especially in crossbreeds. Heat stress can affect the development of oocytes and follicles, leading to decreased estradiol concentration (a hormone responsible for the expression of estrus) and delayed fertilization (De Rensis et al., 2002). Reduced estradiol levels can result in silent heat, where cattle do not exhibit behaviors associated with heat due to heat stress. Given these factors, it is crucial to research the factors influencing reproductive efficiency in applying AI technology in South Sulawesi Province.

MATERIALS AND METHODS

Sample Collection

The material used is IB-PKB secondary data from 14 regencies in South Sulawesi Province sourced from iSIKHNAS (https://www.isikhnas.com). The variables used in this research were service per conception and the pregnancy percentage in Bali cattle, Simmental, and Limousine cattle. The independent variables included cattle breed, the ratio of inseminators to acceptors, and the topography of each district. The success parameters for artificial insemination (AI) were determined by calculating the S/C value and the percentage of pregnancy. These parameters were derived from the formula provided by Mardiansyah et al. (2016):

$$S/C = \frac{Number\ of\ Cows\ Receiving\ AI}{Number\ of\ Pregnant\ Cows\ after\ AI}$$

$$Pregnancy\ \% = \left(\frac{Number\ of\ Pregnant\ Cows\ after\ AI}{Number\ of\ Cows\ Receiving\ AI}\right) \times 100\%$$

DATA ANALYSIS

Analysis of variance and correlation on reproductive traits

Reproduction performance in different districts were analyzed using one-factor analysis of variance (Ansira). The effect of topography and breed on reproductive traits was evaluated using a multivariate general linear model (GLM) with two factors. The models used were:

$Y_i = \mu + \Omega_i + \varepsilon_i$, and

$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha * \beta)_{ij} + \varepsilon_{ij}$.

Where:

Y_{ij}	:	reproductive trait variable analyzed in each cow
μ	:	population mean
Ω_i	:	fixed effect of the district of origin of the livestock
α_i	:	fixed effect of the topography of the ith livestock
β_j	:	fixed effect of the j^{th} breed
$(\alpha*\beta)_{ij}$	:	the interaction between topography and breed, and
ε_i and ε_{ij}	:	treatment errors.

The correlation was analyzed using the Pearson analysis method. All data was processed using the IBM SPSS Statistics 25® software.

Multiple Linear Regression.

Prior to analysis, the breed, inseminator, and topography data were coded to ease the analysis. The variable with the largest P value was excluded from modeling and re-analyzed until a model with a P <0.10 was obtained (Sarwono, 2006). Furthermore, to find out what factors influence the success of AI, a stepwise multiple regression analysis was used with the following equation model:

$$y = \alpha + \beta_1 x_1 + \beta_1 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \varepsilon$$

with:

y	:	successful AI based on the S/C
α	:	constant
x_1	:	livestock origin district
x_2	:	percentage of pregnant cows due to AI (% pregnancy)
x_3	:	cow breed
x_4	:	year
x_5	:	the ratio of inseminators to acceptors (% inseminators)
x_6	:	topography
β	:	variable coefficient
ε	:	residual or interfering variable (error term)

RESULTS AND DISCUSSION

Difference in performance reproduction based on location and cattle breed

The evaluation of livestock reproductive efficiency through artificial insemination (AI) is crucial for understanding their ability to produce offspring. The assessment includes service per conception (S/C), or the number of artificial inseminations required to achieve pregnancy in cattle. Normal S/C in cattle ranges from 1.6 to 2.0, indicating a pregnancy potential of 50% to 62.5% (Borkowska et al., 2012). The livestock's fertility value decreases with an increase in S/C score, and vice versa.

It is crucial to have enough inseminator officers in the field to cover a wide range of cows acceptors in a given area. The percentage of inseminator officers to acceptors indicates the capacity of the officers to artificially inseminate the animals. The more livestock in the area, the more inseminator officers are required to reach them.

Table 1 displays the reproductive efficiency performance of Bali, Limousine, and Simmental cattle in each district of Sulawesi. The reproductive efficiency of cattle was significantly affected by the district area (P<0.05). The cows in Palopo, Barru, Sidenreng Rappang, Jeneponto, North Luwu, Sinjai, Bantaeng, and Tana Toraja showed the best reproductive efficiency and had low S/C numbers (<2.00). On the other hand, cows from Pinrang, Maros, Pangkajene Islands, Pare Pare, Selayar, and Soppeng had highly inefficient S/C figures. A livestock business can be most efficient when the S/C (service per conception) number is less than 2, since it takes only two estrus periods (2-3 months) to produce offspring, resulting in one calf per year. However, if the S/C value is higher than 2, the ideal calving interval cannot be achieved, resulting in lower efficiency and losses for farmers due to additional costs of feed, maintenance, and AI.

AI success can be achieved by minimizing the S/C value, which is influenced by the inseminator's skills, time taken perform AI, and breeder's knowledge in detecting estrus (Sulaksono et al., 2012). The availability of inseminators (%) in Selayar, Tana Toraja, and Palopo districts is not ideal as only a small number (P<0.05) of field inseminators can support a much larger population of cows. Tana Toraja and Palopo exhibit good reproductive efficiency (S/C < 2.00), indicating the competence of the inseminator officers despite their heavy AI responsibilities. Conversely, although Soppeng Regency has an adequate number of inseminators, it exhibits the worst reproductive efficiency compared to other districts (Figure 1).

The demand for AI in South Sulawesi province is highest for Bali cattle, Simmental,

and Limousines. The reproductive efficiency of these three breeds did not significantly differ (P>0.05) between highland and lowland locations. This result differs from previous research that reported a lower reproductive efficiency in crossbred cattle than in local cattle (Diwyanto & Inounu, 2009; Pribadi et al., 2015).

Table 1. Differences in reproductive value between districts in South Sulawesi Province

Regency	Altitude	S/C		% Pregnancy		% Inseminators	
		Means	SE	Means	SE	Means	SE
Bantaeng	Low	1.85 ^{ef}	0.45	54.62 ^{cdes}	3,148	0.007 ^{f}	0.002
Barru	Low	1.36 ^{f}	0.49	81.26 ^{a}	3,401	0.009 ^{ef}	0.002
bones	Low	2.38 ^{cdf}	0.45	43.28 ^{def}	3,148	0.005 ^{f}	0.002
Bulukumba	Low	2.24 ^{cdef}	0.45	45.62 ^{def}	3,148	0.004 ^{f}	0.002
Enrekang	Low	2.2 ^{cdef}	0.45	47.5 ^{def}	3,148	0.006 ^{f}	0.002
Gowa	Tall	2.07 ^{def}	0.45	51.71 ^{def}	3,148	0.005 ^{f}	0.002
Jeneponto	Low	1.44 ^{f}	0.45	70.90 ^{a}	3,148	0.005 ^{f}	0.002
Palo City	Low	1.23 ^{f}	0.82	83.81 ^{a}	5,784	0.055 ^{c}	0.002
Luwu	Low	2.12 ^{cdef}	0.58	57.04 ^{cdes}	4,064	0.014 ^{ef}	0.002
East Luwu	Low	2.46 ^{cdef}	0.45	41.59 ^{gfe}	3,148	0.005 ^{f}	0.002
North Luwu	Low	1.50 ^{f}	0.45	67.19 ^{ab}	3,148	0.006 ^{f}	0.002
Maros	Low	3.48 ^{cds}	0.45	30.98 ^{gh}	3,148	0.025 ^{d}	0.002
Commander of the Archipelago	Low	3.97 ^{c}	0.61	29.24 ^{h}	4,263	NA	NA
Pare Pare	Low	4.38 ^{cds}	0.69	40.88 ^{fgh}	4,809	0.023 ^{d}	0.002
Pinrang	Low	3.37 ^{cds}	0.45	30.55 ^{gh}	3,148	0.006 ^{f}	0.002
Selayar	Low	9.00 ^{b}	0.95	11,11 ^{i}	6,679	0.337 ^{a}	0.003
Sidenreng Rappang	Low	1.36 ^{f}	0.45	74.28 ^{a}	3,148	0.005 ^{f}	0.002
Sinjai	Low	1.74 ^{ef}	0.45	57.9 ^{bc}	3,148	0.007 ^{f}	0.002
Soppeng	Low	11.11 ^{a}	0.49	11.23 ^{i}	3,401	0.014 ^{ef}	0.002
Takalar	Low	2.45 ^{cdef}	0.45	44.42 ^{def}	3,148	0.006 ^{f}	0.002
Tana Toraja	High	2.00 ^{def}	0.95	50.00 ^{def}	6,679	0.174 ^{b}	0.003
Wajo	Low	2.59 ^{cdf}	0.45	42.90 ^{def}	3,148	0.008 ^{ef}	0.002
Average		2.96	0.11	48.55	0.790	0.340	0.000

^{ai} Different subscript letters in the same column indicate a significant difference (p<0.05).

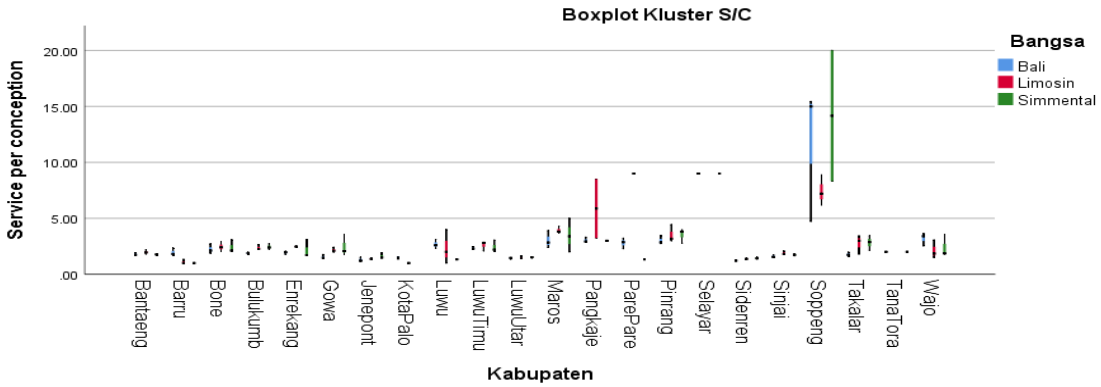

Figure 1 . Distribution of service per conception for each district in South Sulawesi Province

Table 2. Reproductive traits on different topography and cattle breeds

Reproductive Parameters	Cattle Breed	Lowland		Plateau		Total	
		Average	SE	Average	SE	Average	SE
SC	Bali	2.77	0.34	1.67	1.25	2,22	0.65
	Limousine	2.71	0.36	2,16	1.45	2.44	0.75
	Simmental	2.86	0.37	2.36	1.25	2.61	0.65
	Total	2.78	0.21	2.06	0.76	2,42	0.40
Pregnancy (%)	Bali	49,21	2.75	60,88	10,11	55.04	5,24
	Limousine	48,38	2.89	46,57	11.68	47,48	6.01
	Simmental	49.50	2.98	45,53	10,11	47,52	5,27
	Total	49.03	1.66	50.99	6,15	50.01	3,19
Inseminators (%)	Bali	0.015	0.003	0.030	0.012	0.022	0.006
	Limousine	0.008	0.004	0.004	0.014	0.006	0.007
	Simmental	0.011	0.004	0.033	0.012	0.022	0.006
	Total	0.011^{b}	0.002	0.022^{a}	0.007	0.017	0.004

Description: Different superscript signifies significant difference (P<0,05)

Factors influencing the service per conceptions success

An animal can be perceived as having a successful reproductive efficiency if it has a low or less than two services per conception (Borkowska et al., 2012). In most cases, a high S/C score is caused by: (1) the breeder's delay in estimating their cow's estrous period, (2) reproductive system disorders in cows, (3) low-skilled inseminators, (4) limited insemination service facilities or affordability, and (5) transportation problems (Iswoyo & Widiyaningrum, 2008).

The average cows' S/C in South Sulawesi Province was 2.96 or with a pregnancy rate of 48.5%. Several factors influenced the success rate of AI. This study tried to analyze them by multiple regression based on topography and livestock origin, % of pregnancy, breed of cattle, year of measurement, and % of inseminators. Based on this analysis, the S/C of cattle in South Sulawesi Province can be predicted with the regression equation $y = 94{,}066 + 0{,}045x_1 - 0{,}077x_2 + 0{,}044x_3 - 0{,}0441x_4 + 3{,}645x_5 - 0{,}061x_6$.

This equation reveals that breed, district location and inseminator % significantly affected the S/C of cattle (P<0.05). Every 1% increase in inseminators can increase the S/C level by 13,645 units. While location influences S/C with 0.045 units, the success of artificial insemination is supported by a small S/C and the availability of adequate inseminators. Cities/districts that have adequate facilities, culture, and good regulations encourage the reproductive efficiency of livestock (XX). Meanwhile, remote locations such as Selayar and Soppeng are difficult to access, reducing reproductive efficiency. Similarly, fewer inseminator in a location may cause uneven AI distribution, as there are too many insemination responsibilities for the available insemination officers.

Table 3. Analysis of factors influencing service per conception (S/C) in beef cattle in South Sulawesi Province using multiple regression analysis

Variable	Symbol	Variable coefficient	Significance (P)
(Constant)	α	94,066	0.79
Regency	x_1	0.045*	0.05
Pregnancy (%)	x_2	-0.077*	0.00
Cows breed	x_3	0.044	0.80
Year	x_4	-0.044	0.81
Inseminators (%)	x_5	13,645	0.05
Topography	x_6	-0.061	0.85
R Square	R^2	0.51	

* Correlation is significant at the 0.05 level

Correlation between reproductive traits

Table 4. Correlation between cattle reproductive traits

	S/C	% Pregnancy	% Inseminators
S/C		-,789**	,443**
% Pregnancy	0.000		-,156**
% Inseminators	0.001	0.008	

The number above the diagonal indicates the correlation and below the diagonal indicates the significance of the correlation. ** Correlation is significant at the 0.01 (2-tailed) level.

It has been observed that the success of artificial insemination is directly related to the number of inseminators available. A positive correlation of 44.3% has been found between the nature of S/C and the percentage of inseminators. On the other hand, the percentage of pregnancies has a negative correlation of -78.9% with the value of S/C and -15.6% with the percentage of inseminators. A low S/C percentage, a high number of pregnancies, and a sufficient number of inseminators available promotes the success of artificial insemination.

CONCLUSION

Bali, Limousine, and Simmental cattle had similar S/C values (2.24, 2.44, and 2.61, respectively). The districts of Palopo, Barru, Sidenreng Rappang, Jeneponto, North Luwu, Sinjai, Bantaeng, and Tana Toraja had good S/C reproductive efficiency performance, with an S/C value of less than 2. Tana Toraja, despite having a lower percentage of inseminators, showed superior reproductive efficiency. In contrast, Soppeng Regency, which had a higher percentage of inseminators, had the lowest reproductive efficiency. The S/C value is significantly affected by the livestock's district of origin and the percentage of inseminators. The percentage of available inseminators has a positive correlation with the S/C value, of around 44.3%.

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