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Research Paper

COMPARATIVE STUDY ON OVA RECOVERY IN *Bos indicus* AND *Bos taurus* CATTLE: A SYSTEMATIC ANALYSIS STUDY

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ARTICLE HIGLIGHTS

- Domestic cattle sub species of *Bos indicus* shows higher ova in their reproduction than *Bos taurus*
- In vitro techniques produce higher ova recovery than in vivo techniques.
- Dairy cattle showed higher ova recovery than in beef cattle or dual-purpose cattle

Article Information

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ABSTRACT

Embryo transfer biotechnology has long been applied and is widely used to increase the reproductive capacity of female cattle, thereby increasing livestock productivity. Extensive research has been carried out and the responses of each cattle breed show variation across studies, likely due to differences in management practices and physiological characteristics. Our study aimed to determine whether cattle breed influences the oocyte and embryo recovery rates during the embryo transfer process. A meta-analysis was conducted using published research on the ova recovery potential of *Bos indicus* and *Bos taurus*. The screening process identified 21 studies documented across 14 publications suitable for further analyses. The effect of cattle breeds on ova recovery was indicated by a standardized mean difference (SMD) of 0.72 ± 0.206 (95% CI; range of 0.32 – 1.11). The heterogeneity test showed significant difference among studies (I2 = 89.99, P < 0.01), with the effect size classification as medium. Moderator analyses revealed that *Bos indicus* had a higher ova recovery potential compared to that of *Bos taurus* when using in vitro techniques. Subgroup analysis of cattle types showed that the difference in ova recovery between the two breeds was significant in dairy cattle (P < 0.01), while there was no difference observed between dual-purpose and dairy cattle.

Keywords: dairy, in vitro, ova, reproduction, zebu

INTRODUCTION

Zebu cattle (*Bos indicus*) can adapt to tropical environments better than *Bos taurus* due to its thermoregulatory adaptability. They are rustic, resilient to parasites, and capable of bearing the hot and humid climates of the tropics (Porto-Neto *et al.* 2014), as well as low-quality forage, and a tendency to have a higher number of oocytes (Vasconcelos *et al.* 2020; Lacerda *et al.* 2020; Oliveira *et al.* 2019; Sales *et al.* 2015). Zebu cattle are characterized by their hump, large ears, and loose skin (Utsunomiya *et al.* 2019). Research examining productivity differences between the two cattle breeds shows the superiority of *Bos taurus* in meat and milk production. On the other hand, studies comparing reproductive performance between the two breeds report varied results.

Sartori *et al.* (2016) examined differences in the reproductive physiology of *Bos taurus* and *Bos indicus*. *Bos indicus* has nearly twice as many antral follicles (range of 25 – 100) as *Bos taurus* (range of 5 – 40). Research by Baldrighi *et al.* (2014) and Batista *et al.* (2014) showed that the high number of antral follicles is associated with anti-Mullerian hormone (AMH). *Bos indicus* also exhibits a high occurrence of four follicular waves (Bo *et al.* 2003). According to Martinez *et al.* (2003), the inter-ovulation rate is positively correlated with the number of follicular waves, and the time to the appearance of the second follicular wave decreases as the number of follicular waves per cycle increases.

Research comparing the potential of ova recovered from the two breeds exhibits varying results using both in vitro and in vivo methods. To conclude the results of these studies, a meta-analysis is needed. This approach is needed to summarize the results and find quantitative conclusions from a large cattle population. A quantitative analysis of ova recovered from *Bos indicus* and *Bos taurus* was carried out using a meta-analysis. This approach was performed to provide a theoretical basis for the reproductive potential of female cattle between the two breeds. The resulting information is expected to provide more in-depth knowledge, especially regarding the reproductive difference between *Bos indicus* and *Bos taurus*, especially in cattle reared in tropical regions.

MATERIALS AND METHODS

Data Resources and Search Strategy

Publications searches were conducted using the keywords "*Bos taurus*," "*Bos indicus*," "oocytes," "embryo," and "*Bos taurus*" AND "*Bos indicus*" AND Oocytes OR Embryo." The target databases were ScienceDirect (https://www.sciencedirect.com/), Scopus (https://www.scopus.com/), and PubMed (https://pubmed.ncbi.nlm.nih.gov/). The publication period was determined to be in the range of 2003 – 2023. Additional search was conducted using other sources (Google Scholar, Springer, SAGE, Taylor and Francis, Oxford, Nature, and Cambridge). The PRISMA framework was used in the search strategy (Fig. 1).

Article Inclusion and Exclusion Criteria

Criteria for selection include: 1) accessible and available in English; 2) studies come from peer-reviewed journals; and 3) studies compare differences in ova recovery of *Bos indicus* and *Bos taurus*. The articles must meet the following criteria: 1) include information regarding ova recovery from both breeds; 2) provide data on the mean, standard deviation or standard error and number of samples; 3) be published in the form of a research journal article. Articles were excluded if: 1) they reported only one mean value for ova recovery without a standard deviation or did not include the number of samples; and/or 2) they were published in the form of review journals, posters, abstracts, theses, or dissertations.

Data Extraction

There were 21 studies across fourteen articles that compared ova production between *Bos indicus* and *Bos taurus*. Studies that meet the criteria were grouped as follows: 1) first author and year of publication; 2) characteristics of the cattle population, including number, breed, production type (dairy, beef, dual-purpose), age, body weight, body condition score, rearing management, estrus synchronization, and physiological status (heifer/cow); and 3) numerical data, including the mean value of ova recovery, standard deviation or standard error, and number of samples.

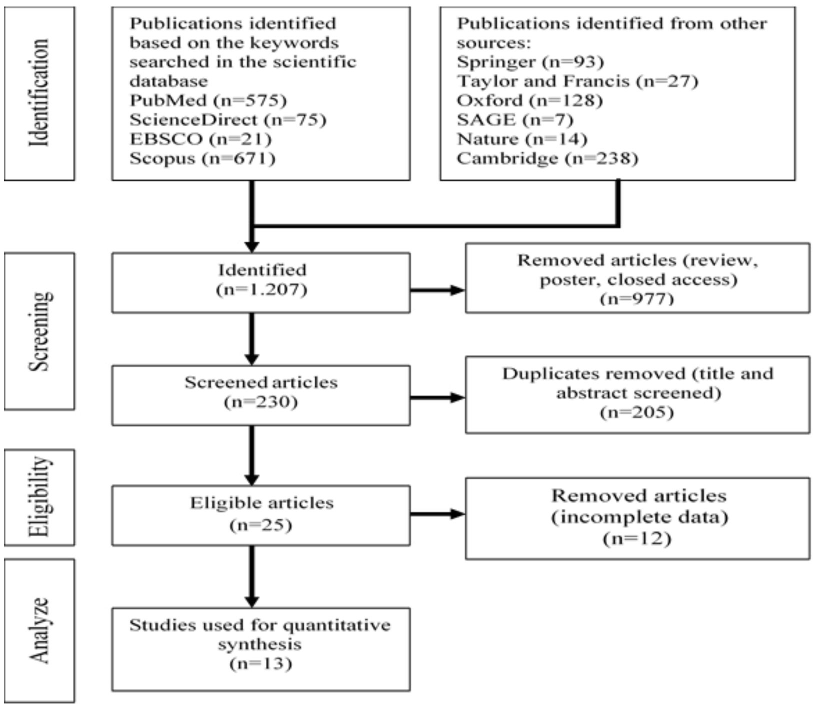

Figure 1 Flowchart PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analysis)

Statistical Analysis

The data analysis was conducted by measuring the effect size, heterogeneity, and publication bias. The effect size is defined as an estimate of the standardized mean difference. The calculation was carried out using OpenMEE software (Wallace *et al.* 2016), using the following formula according to Rosenberg *et al.* (2000) and Sanchez-Meca and Martin-Martinez (2010):

$$d = \frac{\overline{X_1} - \overline{X_2}}{S_{within}} \qquad S_{within} = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$$

where:

d = effect size

($\overline{X}_1$) = average ova recovery of *Bos indicus*

($\overline{X}_2$) = average ova recovery of *Bos Taurus*

S_{within} = combined standard deviation

n_1 = sample size of *Bos indicus*

n_2 = sample size of *Bos taurus*

S_1 = standard deviation of *Bos indicus*

S_2 = standard deviation of *Bos taurus*

RESULTS AND DISCUSSION

Description of Studies

The ova recovery potential in *Bos taurus* and *Bos indicus* cattle was discussed in 21 studies listed in 14 publications published from 2003 to 2023. The population of *Bos indicus* cattle was 1,385 heads consisting of Nellore, Gyr, Brahman, and PO. Population of *Bos taurus* cattle was 645 heads consisting of Holstein, Simmental, and Belgian Blue. Gyr and Holstein cattle are dairy breeds, while Nellore (Ongole) cattle are dual-purpose breed used for both beef and dairy production. Dual-purpose systems are non-specialized, where calves are weaned between eight months and one year of age and raised under restricted milk suckling, allowing for partial milk harvest (Restrepo *et al.* 1991).

The total population comprised 2,030 animals, including beef, dairy, and dual-purpose types. Nellore, Gyr, and Brahman cattle are zebu breeds originating from the Indian subcontinent, which is considered the treasure house of *Bos indicus* cattle breeds most suited for livestock production in the tropics, providing draught power, milk, or meat. The synchronization methods reported in the six studies include CIDR (Controlled Internal Drug Release), progesterone (P4 device), Norgestomet ear implant, and GnRH (Gonadotropin-Releasing Hormone), as summarized in Tables 1 and 2.

Pasteur management was reported in six studies with several types of feed: *Brachiaria humidicola*, silage, hay, molasses, and corn silage. The physiology of female cattle consisted of prepubertal, heifer, lactating, and non-lactating cows. Body weight ranged from 102 – 487 kg with an age range of 3 months – 8 years. The type of semen used in four studies was sexing. All studies were conducted in Brazil during winter, spring, and fall. According to FAO (2019), approximately 1.48 billion cattle are reared worldwide, with over half of this population concentrated in Brazil, India, and the USA. Brazil currently ranks first in the world for the largest cattle herds, with 218 million head of cattle, followed by India which has a herd of 186 million animals.

Ova collection was performed using two methods, namely in vitro (ovum pick up), reported in 12 studies and in vivo (flushing), reported in eight studies. In *Bos indicus*, the range of ova recovery was 5 – 45 ova, while in *Bos taurus*, it was 6 – 22 ova. Using in vitro techniques, *Bos indicus* cattle produced around 10 – 45 ova, while *Bos taurus* cattle yield around 6 – 22 ova. In vivo collection produced 3 – 38 ova in *Bos indicus* and around 10 – 16 ova in *Bos taurus*. The ova recovery potential of *Bos indicus* was higher than that of *Bos taurus* (Table 3).

Based on Table 3, six studies compared dairy cattle breeds (Gyr vs. Nellore), one study compared beef cattle breeds (Brahman vs. Simmental), one study compared beef and dairy breeds (Brahman vs. Holstein), and 12 studies compared dual-purpose cattle and dairy breeds (Nellore vs Holstein). Research indicated that the collection techniques in the same breed can exhibit different results within a breed, and using the same methods across the same breed can also produce varying outcomes. Previous studies suggest that differences in results are influenced by the ova collection techniques, with in vitro providing higher ova recovery in *Bos indicus* cattle. Among the 12 studies using invitro technique, three reported a significant effect of breed on the number of ova recovered ($P < 0.05$). Similarly, three of eight studies using invivo technique also found a significant breed effect on ova recovery ($P < 0.05$). Five studies, however, reported no significant relationship between breed and ova recovery ($P > 0.05$).

Table 1 Summary of study used in meta-analysis (from BCS to Semen)

No	**Study**	**BCS**	**Synchronization**	**Technique**	*Bos indicus*	*Bos taurus*	**Semen**
1	Viana *et al.* (2011)	2.7 ± 0.6	CIDR	Ovum pick up	Gyr, Dairy	Holstein, Dairy	-
2	Vasconcelos *et al.* (2020)	5-7 (1-9)	-	Flushing	Brahman, Beef	Simmental, Beef	-
3	Soares *et al.* (2011)	3.6 ± 0.1 (1-5)	P4 Device	Flushing	Nellore, Beef	Holstein, Dairy	Sexing
4	Sales *et al.* (2015)	3.2 ± 0.3	Norgestomet Ear	Ovum pick up	Gyr, Dairy	Holstein, Dairy	-
5	Pontes *et al.* 2010	3.5 ± 0.5	-	Ovum pick up	Gyr, Dairy	Holstein, Dairy	Sexing
6	Oliveira *et al.* (2019)	-	-	Ovum pick up	Gyr, Dairy	Holstein, Dairy	Sexing
7	Lacerda *et al.* (2020)	-	-	Ovum pick up	Gyr, Dairy	Holstein, Dairy	Sexing
8	Krininger *et al.* (2003)	-	GnRH	Flushing	Brahman, Beef	Holstein, Dairy	-
9	Guerrero *et al.* (2014)	-	-	Ovum pick up	Nellore, Beef	Holstein, Dairy	-
10	Gimenes *et al.* (2015)	-	Norgestomet Ear	Ovum pick up	Nellore, Beef	Holstein, Dairy	-
11	Carter *et al.* (2016)	-	-	Flushing	Nellore, Beef	Angus, Beef	-
12	Camargo *et al.* (2007)	3-4 (1-4)	-	Flushing	Gyr, Dairy	Holstein, Dairy	-
13	Batista *et al.* (2016)	-	CIDR	Ovum pick up	Nellore, Beef	Holstein, Dairy	-
14	Irma *et al.* (2023)	3-3.5	CIDR	Flushing	PO	Belgian Blue	Unsexing

Table 2 Summary of study used in meta-analysis (from Age to Weight)

No	Study	Age	Management	Feed	Season	Physiology	Weight (kg)
1	Viana *et al.* (2011)	5.38 ±1.50					
2	Vasconcelos *et al.* (2020)	7.00 ±3.00	-	Brachiaria, silage		Cow	337 – 803
3	Soares *et al.* (2011)	4-10	Pasture			Cow, non-lactated	487.8 ±36.6
4	Sales *et al.* (2015)	5.21 ±0.56			Winter-Spring	Cow, non-lactated	
5	Pontes *et al.* 2010	5 ± 2.3				Cow, non-lactated	
6	Oliveira *et al.* (2019)	-	Pasture			Cow, non-lactated	452 ± 63
7	Lacerda *et al.* (2020)	-	-	-	-	-	-
8	Kríninger *et al.* (2003)	-	Pasture	Hay, molasses	Autumn	Cow, non-lactated	-
9	Guerrero *et al.* (2014)	-	-	Brachiaria, silage	-	Prepuberty-heifer-cow	-
10	Gimenes *et al.* (2015)	-	Pasture	Corn silage	-	Heifer	409.5 – 467.7
11	Carter *et al.* (2016)	7.5-8.6	Pasture	-	-	Cow, non-lactated	-
12	Camargo *et al.* (2007)	-	Pasture	-	-	Cow, non-lactated	-
13	Batista *et al.* (2016)	3-4 months, 1-2 years	-	-	-	Prepuberty, heifer	102 – 119
14	Irma *et al.* (2023)	4-6 years	Intensive	Brachiaria	Summer	Cow, heifer	475 – 535

Table 3 Data extraction of ova production *Bos indicus* and *Bos taurus*

No.	Studies	Technique	Cattle type	P - value	*Bos indicus*			*Bos taurus*		
					Mean	n	Breed	Mean	n	Breed
1	Pontes *et al.* (2010)	In vitro	Dairy vs Dairy	P < 0.05	17.1 ± 4.4	617	Gyr	11.4 ± 3.9	180	Holstein
2	Oliveira *et al.* (2019)	In vitro	Dairy vs Dairy	P < 0.05	10.0 ± 0.7	12	Gyr	6.3 ± 0.4	13	Holstein
3	Vasconcelos *et al.* (2020)	In vitro	Beef vs Beef	P < 0.05	17.2 ± 0.4	184	Brahman	12.2 ± 0.5	99	Simmental
4	Sales *et al.* (2015)	In vitro	Dairy vs Dairy	P < 0.05	22.8 ± 1.5	14	Gyr	14.6 ± 0.9	14	Holstein
5	Batista *et al.* (2016)	In vitro	Dual purpose vs Dairy	P < 0.05	13.5 ± 3.6	15	Nellore	11.7 ± 2.4	12	Holstein
6	Batista *et al.* (2016)	In vitro	Dual purpose vs Dairy	P < 0.05	29.9 ± 5.3	15	Nellore	9.2 ± 1.7	10	Holstein
7	Guerrero *et al.* (2014)	In vitro	Dual purpose vs Dairy	P < 0.05	13.4 ± 1.7	18	Nellore	9.0 ± 0.9	32	Holstein
8	Guerrero *et al.* (2014)	In vitro	Dual purpose vs Dairy	P < 0.05	45.3 ± 6.4	16	Nellore	17.3 ± 1.5	27	Holstein
9	Lacerda *et al.* (2020)	In vitro	Dairy vs Dairy	P < 0.05	14.9 ± 0.2	363	Gyr	9.0 ± 0.4	109	Holstein
10	Batista *et al.* (2016)	In vitro	Dual purpose vs Dairy	P > 0.05	20.9 ± 5.1	15	Nellore	22.4 ± 5.4	12	Holstein
11	Camargo *et al.* (2007)	In vitro	Dairy vs Dairy	P > 0.05	15.3 ± 1.3	9	Gyr	16.2 ± 2.0	13	Holstein
12	Carter *et al.* (2016)	In vitro	Dual purpose vs Dairy	P > 0.05	11.6 ± 1.8	12	Nellore	17.5 ± 1.6	56	Holstein
13	Gimenes *et al.* (2015)	In vivo	Dual purpose vs Dairy	P < 0.05	37.5 ± 4.4	3	Nellore	16.2 ± 2.2	3	Holstein
14	Gimenes *et al.* (2015)	In vivo	Dual purpose vs Dairy	P < 0.05	38.5 ± 4.3	3	Nellore	16.2 ± 2.3	3	Holstein
15	Gimenes *et al.* (2015)	In vivo	Dual purpose vs Dairy	P < 0.05	35.2 ± 4.8	3	Nellore	13.8 ± 1.8	3	Holstein
16	Soares *et al.* (2011)	In vivo	Dual purpose vs Dairy	P > 0.05	8.0 ± 3.2	17	Nellore	10.4 ± 3.4	11	Holstein
17	Soares *et al.* (2011)	In vivo	Dual purpose vs Dairy	P > 0.05	7.1 ± 3.3	18	Nellore	11.3 ± 4.4	11	Holstein
18	Soares *et al.* (2011)	In vivo	Dual purpose vs Dairy	P > 0.05	9.0 ± 3.8	19	Nellore	12.4 ± 3.8	11	Holstein
19	Viana *et al.* (2011)	In vivo	Dairy vs Dairy	P > 0.05	5.8 ± 1.7	12	Gyr	10.7 ± 2.3	8	Holstein
20	Krininger *et al.* (2003)	In vivo	Beef vs Dairy	P > 0.05	9.3 ± 2.9	10	Brahman	10.9 ± 2.9	10	Holstein
21	Irma *et al.* (2023)	In vivo		P < 0.05	11.83 ± 1.9	10	PO	4.86 ± 1.3	8	Belgian Blue
	Total					**1,385**	**heads**		**645**	**heads**
	Minimum				**5.8 ± 1.7**			**4.86 ± 1.3**		
	Maximum				**38.5 ± 4.3**			**22.4 ± 5.4**		

Potency of Ova Recovery in *Bos indicus* and *Bos taurus*

Differences in cattle breeds influenced ova production, based on 21 studies reported in 14 publications (SMD: 0.72 ± 0.206, 95% CI: 0.32 – 1.11), with significant heterogeneity (I2 = 89.99, P < 0.001). The results showed a difference in ova recovery between *Bos indicus* and *Bos taurus*. According to the effect size classification of Cohen (2018), the difference in the combined mean value (in vivo and in vitro) of 0.724 falls within the medium category (0.50 ≤ effect size < 0.80). The heterogeneity test indicated that there was a varying effect size among studies (P < 0.001), with heterogeneity of I2 = 89.99, suggesting high diversity may have been caused by systematic differences between studies. Higgins *et al.* (2003) categorized heterogeneity < 25% as low diversity, 50 – 75% as medium diversity and >75% as high diversity. Higgins heterogeneity test I2 shows that there is high diversity among studies, thus, subgroup analysis was carried out to analyze the diversity that occurred among studies (Table 4).

Subgroup analysis was carried out based on collection technique and cattle type considering that the information was completely obtained from publications. Collection techniques were divided into in vitro and in vivo, while cattle type was divided into dairy, beef, and dual-purpose. Subgroup analysis of the in vivo method showed no differences in ova production between cattle breeds. A significant difference was shown by the in vitro technique, with the SMD value (SMD: 1.01, 95% CI: 0.618 – 1.410) being higher than the cumulative SMD (SMD: 0.72, 95% CI: 0.320 - 1.127). This result showed that in vitro technique has a significant impact on ova production. Subgroup analysis of cattle types showed that the difference in ova production between the two breeds was significant (P < 0.01) in the dairy type, while there was no difference in the dual-purpose vs. dairy breeds.

The forest plot shows the difference in in vitro mean values to the right of the cumulative mean difference line. This result confirmed that the technique provides significant differences between the two breeds (Fig. 2).

Table 4 Estimation of standardized mean differences and heterogeneity

Description	Estimation	Standard error	P - value
Standardize Means Difference or SMD (d)	0.72	0.206	< 0.001
- d subgroup in vitro	1.01	0.202	< 0.001
- d subgroup in vivo	0.27	0.410	0.510
- d subgroup dairy purpose cattle	1.00	0.250	< 0.001
- d subgroup dual purpose vs dairy cattle	0.76	0.410	0.057
Higgins Heterogeneity (I2)	89,99		< 0.001
- I2 subgroup in vitro	88.45		< 0.001
- I2 subgroup in vivo	79.64		< 0.001
- I2 subgroup dairy purpose cattle	85.84		< 0.001
- I2 subgroup dual purpose vs dairy cattle	88.84		< 0.001

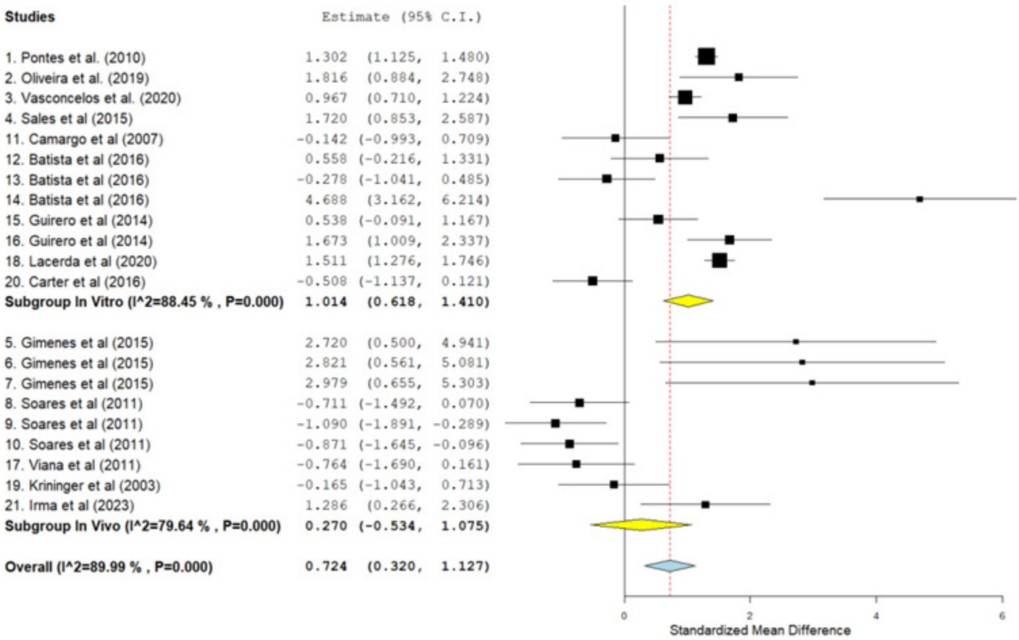

Figure 2 Forest plot on ova recovery of *Bos indicus* and *Bos taurus* based on ova collection techniques
Notes: ■ = weighted study; ── = confidence interval; ◊ = effect size.

The difference in the mean value of in vivo ova recovery was lower (SMD: 0.27, 95% CI: -0.534 – 1.075) than that of the cumulative SMD value (SMD: 0.72, 95% CI: 0.320 – 1.127) and the confidence interval estimates touched the Y = 0 axis, indicating that ova recovery between the two breeds was similar. Several in vitro studies provided the highest differential impact, namely study of Pontes *et al.* (2009) with (SMD: 1.302, 95% CI: 1.125 – 1.1480), study of Lacerda *et al.* (2020) with (SMD: 1.511, 95% CI: 1.276 – 1.746) and study of Vasconcelos *et al.* (2020) with (SMD: 0.967, 95% CI: 0.710 – 1.224). The findings of the three studies may have been caused by the large sample size (1,164 individuals). The ova production potential of *Bos indicus* was reported to be greater in nine in vitro studies, while three other studies stated it was lower (P < 0.05). This result contrasts with studies using in the vivo techniques, which showed *Bos taurus* producing more ova.

According to Marsisco *et al.* (2019), in vivo technique produces good-quality embryo with higher pregnancy success and lower mortality (Sartori *et al.* 2016). The in vivo and in vitro techniques play an essential role in increasing the productivity of female livestock by shortening generation intervals and increasing selection intensity and selection accuracy (Jaton *et al.* 2016). The existence of diverse individual responses and the low number of transferable embryos is a barrier to the development of embryo transfer biotechnology (Center *et al.* 2018).

Fertility is a characteristic of reproduction influenced by breeds (Gomez *et al.* 2020). Several scientific reviews discuss differences in reproduction between the two breeds. It is thought that the differences in reproduction also influences the differences in ova recovery due to: 1) *Bos indicus* has higher antral follicles; 2) the number of follicle waves per cycle of *Bos indicus* is more significant; 3) anti-circulation Mullerian Hormone (AMH), progesterone, insulin, Insulin-like Growth Factor 1 (IGF1), cholesterol and estradiol levels are higher in *Bos indicus* (Alvarez *et al.* 2000; Buratini Jr *et al.* 2000; Carvalho *et al.* 2008; Gimenes *et al.* 2000; Gimenes *et al.* 2009; Bastos *et al.* 2010, 2013, 2016; Bo *et al.* 2003). These findings confirm that *Bos indicus* and *Bos taurus* do have different physiology. The differences between the two breeds may have occurred due to domestication in different environments.

Utsunomiya *et al.* (2019) reported that the landscape of genomic diversity in the *Bos indicus* subspecies seems different. *Bos indicus* is more diverse and is domesticated 2,000 years later than that of *Bos taurus* cattle. The genetic signals that make up the phenotypic are expected from the genetic dissection of morphological, adaptive, and reproductive traits. According to Roth (2015), the environment, particularly temperature conditions, significantly influences ovarian dynamics in female reproduction. The detrimental effects of high temperatures and heat stress on fertility levels underscore the urgent need for further research.

Several environmental mechanisms may influence ovarian dynamics in cattle that can be described by: 1) inhibiting the development of small antral follicles (0.5 – 3.0 mm); 2) decreasing follicular cell viability, which has an impact on reducing steroidogenesis; 3) weak ability of the dominant follicle, which results in a decrease in estrogen concentration; 4) decreased concentration of inhibin results in an increase in FSH (Follicle Stimulating Hormone), which increases the development of medium and large follicles, thereby inducing double ovulation; 5) decreased concentration of estrogen and LH (Luteinizing Hormone), which results in a decreased duration and intensity of estrus; and 6) disruption of ovulation and the formation of the corpus luteum, which produces progesterone in low concentrations. Apart from disrupting ovarian dynamics, heat stress affects oocyte maturity, especially by inhibiting the cell nucleus and cytoplasm's maturation, which reduces the oocyte's ability and embryo development (Roth 2015).

Type of Cattles: Dairy, Beef and Dual-Purpose as Donor

Holstein and Gyr are dairy types in both breeds (Table 3). Holsteins in the *Bos taurus* group numbered 538 out of 645 (83.41%), while Gyr in the *Bos indicus* group numbered 1,027 out of 1,385 (74.15%). The difference in ova recovery was higher in the dairy type (SMD: 1.003, 95% CI: 0.513 – 1.494) than that in the dual-purpose vs dairy type (SMD: 0.761, 95% CI: -0.204 – 1.546). The study forest plot based on cattle type is presented in Figure 3.

The forest plot shows the difference in ova production for the dairy type on the right side of the cumulative ova recovery line, while for the dual-purpose type, it is close to cumulative. This finding showed that the difference in ova recovery is more contrasting in the dairy type (Gyr vs. Holstein) compared to that in the dual-purpose vs dairy type (Nellore vs. Holstein). According to Ortega (2018), fertility in dairy type decreases along with the intensity of selection on milk production. Sartori *et al.* (2010) reported that the average dominant follicle in Holstein dairy is around 8 – 9 with an ovulatory diameter of around 14 – 18 mm, while the dual-purpose Nellore type has a more significant number of small follicles with a diameter of 2 – 5 mm and fewer dominant follicles with a smaller diameter (Fig. 4).

According to Sartori *et al.* (2016), progesterone metabolism in dairy cattle is higher than that in beef cattle. Panjaitan *et al.* (2019) found that embryo death occurs due to reduced luteal function caused by low progesterone concentrations. Decreased progesterone secretion on the seventh day after artificial insemination causes endometrial disorders, disturbs protein secretion and embryonic life, obstructs embryo development, and causes early embryo death (McNeill *et al.* 2006).

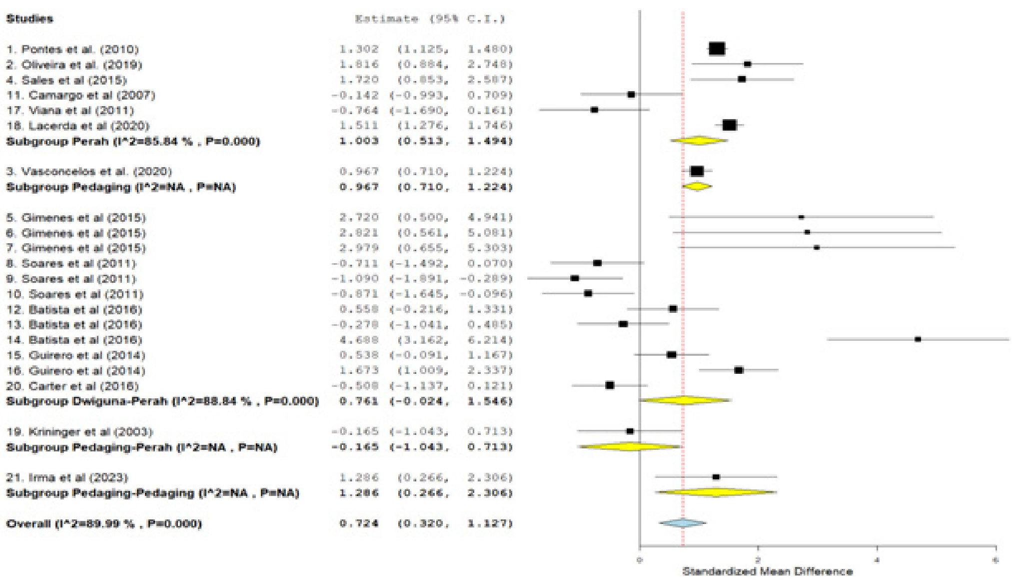

Figure 3 Forest plot on ova recovery of *Bos indicus* and *Bos taurus* based on cattle type

Notes: ■ = weighted study; — = confidence interval; ◊ = effect size.

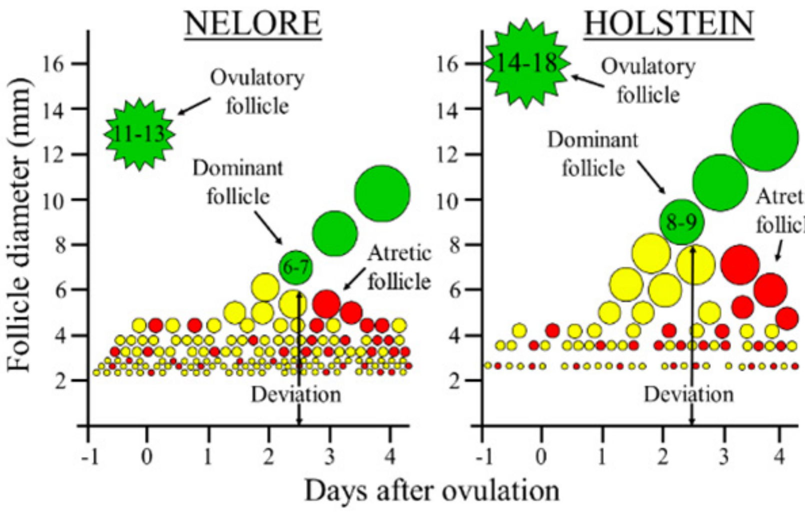

Figure 4 Follicular dynamic in Nellore and Holstein dairy cattle
Source: Sartori *et al.* (2010)

Limitations of the Study

We define Nellore cattle as dual-purpose cattle that can be used as meat and milk producers and draught cattle. This defines the type of subgroup in the moderator variable analysis. Studies on types of beef cattle in both breeds are limited to analysis because there is only one study, and studies comparing beef with dairy cattle cannot be analyzed further.

CONCLUSION

Bos indicus showed higher ova production than that of *Bos taurus*. A subgroup analysis of technique collection and cattle indicated that the differences in ova recovery between the two breeds were significant based on in vitro technique and the dairy cattle type. Appropriate ova harvesting techniques to obtain oocytes in *Bos indicus* must be considered to maximize the potency of reproduction in zebu.

The results of this research showed that the zebu cattle, besides having good adaptability to tropical environments, partial resistance to ticks, and low nutritional requirements, also show reproductive superiority in ova recovery. These advantages must be made efficient by applying appropriate ova harvesting technology, namely ovum pick-up, especially in diary type cattle. The research location was limited to two places: Brazil and Indonesia. Thus, the reproductive performance of the two breeds in subtropical conditions needs to be more representative.

RECOMMENDATION

The findings of this study support the following recommendations:

1. Selection of zebu cattle having superior reproductive performance to serve as donors at livestock embryo center and maintain bulls at artificial insemination center.
2. Developing breeding policies to increase the zebu cattle population in Indonesia and improve them genetic quality by pure breeding.
3. Adopting reproductive technologies, such as ultrasound-guided ovum pick-up to optimize ova recovery.
4. Utilizing ovaries from zebu cattle at slaughterhouses for in vitro embryo production.

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