Short Communication: Heritability Estimation of Birth Weight of Swamp Buffalo in Sabah, Malaysia

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Abstract: Data on birth weight of Swamp buffalo calves that were born between 2015 and 2017 were collected and analyzed for this study. The objective was to estimate the effect of heritability and to evaluate the influence of environmental factors on the birth weight of swamp buffalo calves. The heritability was estimated using parent-offspring regression method while the environmental factors were measured using linear regression analysis. The average birth weight for swamp buffalo calves was 31.5 ± 5.33kg. It was significantly ($p<0.05$) affected by the age of dam and the year of birth but the body weight of the dam and the sex of calves did not significantly ($p>0.05$) influence the birth weight. The heritability of birth weight was estimated to be 0.29, which is low. Therefore, environmental and herd management factors seem to play a larger role in birth weight than genetics. The low estimated heritability obtained from this work indicates that improvement through selection may not be feasible.

Keywords: Heritability estimation, birth weight, swamp buffalo calves, environmental factors.

1. INTRODUCTION

The swamp buffaloes, *Bubalus bubalis*, are the indigenous buffalo of Southeast Asia and are well adapted to the environment. They are highly capable of utilizing agricultural waste products or low-quality feed for conversion into meat and draught power [1]. In most Southeast Asian countries, the population of buffalo is continuously decreasing, and among the most important reasons for the decline are the long calving interval and low calving rate [2]. However, there is potential for the swamp buffaloes to be reared commercially if the genetics could be improved [3], as they are an alternative for beef requirements.

Generally, reproductive traits have low heritability; therefore, they are less responsive in breeding programs [4]. Notwithstanding their low heritability, there's evidence of a genetic correlation between body growth and reproductive and productive traits, which makes the former an important selection criterion [5]. This is particularly important in dual-purpose animals. Consequently, estimates of genetic parameters for weight at different ages, using various animal models, have been reported by many studies [6, 7].

Genetic improvement of the swamp buffalo is necessary to increase the performance, particularly the meat and milk productions. However, the growth traits of buffalo are not only influenced by their genetic make-up but also by many environmental factors [8]. To determine the rate of phenotype evolution in response to artificial or natural selection, the estimate of heritability is necessary [9]. This is particularly important in artificial selection designed to improve certain desirable traits [10]. Therefore, in the selection of breeding animals, it is important to determine the prospective values of the desirable traits in early life [11]. Birth weight is one of the most reliable criteria for prenatal growth, and it is also a significant factor affecting growth and development in the postnatal period [12]. There is, therefore, the need to study the mechanisms, such as birth weight and growth, which have a direct bearing on reproductive traits like oestrus cycle, comprehensively to improve reproductive efficiency in buffaloes [13]. Therefore, this study aims to estimate the heritability of birth weight and measure the magnitude of various environmental factors on growth trait of swamp buffalo.

2. MATERIALS AND METHODS

The Farm

This study was conducted at the Buffalo Breeding and Research Centre Farm located in Sabah, Malaysia ($5^0$30' N, $117^0$7' E) with 399 acres of pasture land. The land was divided into paddocks containing *Brachiaria decumbens* and wallowing sites. This farm practices extensive 30-day rotational grazing system. The average daily temperature and annual rainfall were between 29˚C and 30˚C and 200 and 400 mm/year,

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respectively [1]. During the present study, the farm had a total of 323 swamp buffaloes where 82 were breeder females, 82 breeder heifers, 85 heifers, 5 breeder bulls, 41 young bulls and 28 calves. Three of the breeder bulls were introduced into the farm in 2012, while the remaining two were introduced in 2017.

Source of Data

Data on pedigree and body weight at birth of all swamp buffalo calves that were born between 2015 and 2017 and birth weight of the respective dams were collected and analyzed retrospectively, for estimation of heritability of birth weight. The effects of environmental factors, particularly the sex of calf, year of birth, and the birth weight and age of dam, were also evaluated.

The years were divided into three different years, 2015, 2016 and 2017. The dams were grouped equally into five categories according to their weights; the <360kg, 360-392kg, 393-408kg, 408-450kg and the >450kg. They were also divided into three age categories, the 2-5 years old, 6-9 years old and more than 10 years old. After eliminating all the incomplete data, a total of 45 complete records belonging to 45 dams, 4 sires, 45 calves (21 female and 24 males) were used for the analyses.

Statistical Analyses

Heritability Estimation

Generally, there are two methods that were used for the estimation of heritability, the resemblance between parents and offspring and the estimation of variance components. In this study, we performed the offspring-parent regression calculation, where the birth weights of swamp buffalo calves were plotted against the birth weight of the parents using the regression line to observe how much the offspring resemble their parents [14]. Offsprings' birth weight (y-axis) was plotted against the birth weight of the dam (x-axiss) and the best fit, which represent the linear relationship between y and x, was obtained. Akesson *et al*., [14]. The slope of the regression line was the estimate of narrow-sense heritability. The higher the slope, the more the resemblance between offspring and their parents. The slope of the regression line was obtained from the equation of the regression line ($y_i = a + bx_i + \varepsilon_i$), where *b* is the slope of regression [15].

Another approach in estimating the regression parameters is by using the Bayesian approach [16]. To estimate the regression line, $y_i = a + bx_i + \varepsilon_i$, where $\varepsilon_i \sim N(0, \tau)$, Bayesian framework requires a prior specification for each of the regression parameters. Therefore, priors assigned to parameters a, b and τ are [17];

$$a, b \sim Normal\,(\mu_a, \sigma^2)$$

$$\tau \sim Gamma\,(p, q).$$

We set $\mu_a = p = 0$ and $\sigma^2 = q = 10^6$ to ensure such vague priors are used to make sure it covers a wide range of values. The inference regarding the parameters is made from the posterior distribution of the parameters sampled from Markov chain Monte Carlo (MCMC) simulations. The MCMC was run 6000 times with a burn-in period of 1000 iterations in WinBUGS.

Evaluation of Environmental Effects

The effect of environmental factors on birth weight of swamp buffalo calves was evaluated using linear regression analysis in SPSS to determine the relationship between birth weight and environmental factors, particularly sex, year of birth, age and bodyweight of the dam at P = 0.05.

Under the Bayesian approach, the significance of environmental factors on birth weight of swamp buffalo calves was evaluated from their corresponding 95% Bayesian intervals. Intervals that include 0 imply that there is no significant effect of the factor on the birth weight.

3. RESULTS & DISCUSSION

Heritability Estimation

In this study, the regression equation was $\hat{y} = 0.146x + 27.151$. Hence, the slope of the regression line was 0.146, which also means that the heritability estimate of birth weight was 0.146 (Figure **1**). In cases of observation involving only one of the parents, as in this study, the heritability estimate does not truly reflect complete heritability since the gene of only one of the parents was assessed. To make a rough estimate of the effect of both parents, we need to multiply by two. Hence, the total estimated heritability (h^2) for birth weight of Swamp buffalo was 0.29, which was still low. This is not in agreement with the study of swamp buffalo in Thailand, which was 0.66 [18]. Generally, the estimate of heritability is not constant but is specific for a particular population in a specific environment.

Under the Bayesian approach, the estimated regression line is $\hat{y} = -0.098x + 34.41$, which indicated

that the estimated heritability of birth weight was -0.098. The total estimated heritability for birth weight of Swamp buffalo was $h^2 = (-0.098)^2$.

Low heritability in this study was probably due to the inbreeding since the same breeder bulls were used for breeding since 2012. Therefore, a larger proportion of phenotypic variation in this population was influenced by the environmental factor or management. Higher birth weight can be achieved by improving the management and environment [19].

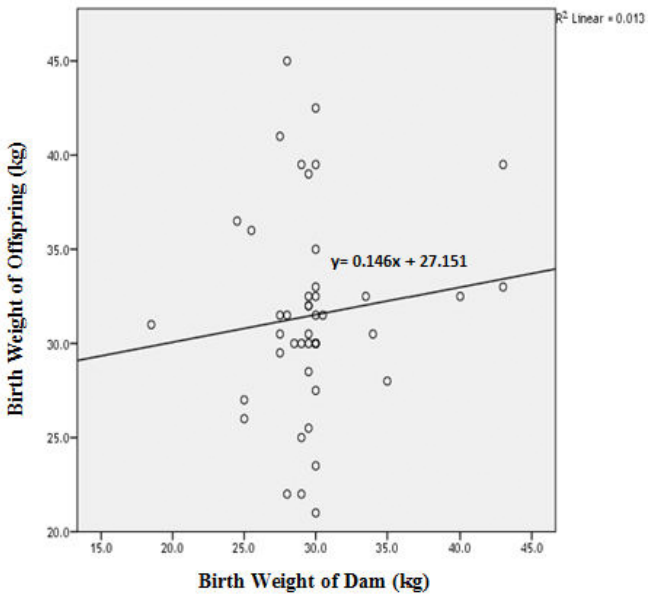

Figure 1: Scatterplot of progeny phenotypes (birth weight of offspring) and the average of parental phenotypes (birth weight of dam).

Influence of Environmental Factors

The average birth weight of Swamp buffalo calves born between 2015 and 2017 was 31.5± 5.33kg [18] reported the average birth weight of 30.11± 4.49kg. The mean birth weight of male calves was 32.0 ± 5.6kg, while the female was 30.9 ± 5.1kg (Table **1**). However, sex of calves has no significant (P>0.05) influence on the birth weight of calves, although [18] revealed a significant effect (Table **2**).

The year of birth had a significant effect (P< 0.05) on the birth weight of Swamp buffalo. The highest birth weight (35.6 ± 4.5 kg) was in 2015, while the lowest (27.3 ± 3.4) was in 2017 (Table **1**). This is in agreement with several earlier studies Na-Chiangmai *et al.* and Tevamanoharan *et al*., [20, 21]. The same effect was also reported in other breeds such as Murrah [22], Surti [23] and Nili Ravi [19] buffaloes. The time of birth is reflective of the season and the availability of feed as well as other environmental effects such as differences in temperature and humidity at different period of birth [19].

Table **1** also reveals that calves that were born from the dam with body weight ranging between 408 and 450kg had the highest average birth weight of 34.1 ± 6.0kg, while those from the dam with body weight ranging between 360 and 392kg had the lowest birth weight (29.0 ± 3.3kg). However, the differences were not significant (P> 0.05), which was in contrast to the previous report in Nili Ravi buffaloes [19]. However, the age of the dam had a statistically significant (P< 0.05)

Table 1: The Overall Mean and Standard Deviation of Birth Weight of Swamp Buffalo Calves with Different Environmental Factors

Descriptions		Mean ± S.D (kg)
Overall Mean		31.5 ± 5.33
Sex	Male	32.0 ± 5.6[a]
	Female	30.9 ± 5.1[a]
Year of Birth	2015	35.6 ± 4.5[a]
	2016	33.0 ± 3.8[a]
	2017	27.3 ± 3.4a
Body Weight of Dam (kg)	<360	30.7 ± 5.2[a]
	360 - 392	29.0 ± 3.3[a]
	393 - 408	31.7 ± 6.7[a]
	408 - 450	34.1 ± 6.0[a]
	>450	31.9 ± 4.7[a]
Age of Dam	2 - 5 years old	32.9 ± 6.7[a]
	6 - 9 years old	30.9 ± 4.9[b]
	>10 years old	31.0 ± 1.2[b]

Table 2: The Posterior Estimates of the Mean, Standard Deviation (sd) and 95% Bayesian Interval (BI) of the Parameters Corresponding to Different Environmental Factors

Environmental factors	mean	sd	2.50% BI	97.50% BI
Sex	-1.1660	1.1330	-3.4680	1.0040
Year of birth	-4.4230	0.8130	-6.0510	-2.8590
Body weight of dam	0.0052	0.0118	-0.0181	0.0288
Age of dam	-0.5288	0.2225	-0.9764	-0.1048

effect on the birth weight (Table **1**). Calves that were born from the dam aged between two and five years old showed the highest average birth weight as compared to the older dam. Many authors have reported the relationship between the age of the dam and weight of calves, as observed in this study. Ugur *et al*., Yanar *et al*. and Kocak *et al*. [24-26] reported similar findings that the birth weight increases with the age of dam until they reached the age of five to six before the birth weight remained constant and then decreased. Tevamanoharan *et al*. [18] also reported the increased in birth weight in association with the increased in the age of dam until the fourth lactation.

Under the Bayesian approach, the significance of environmental factors on birth weight of swamp buffalo calves was evaluated from their corresponding 95% Bayesian intervals. Intervals that include 0 imply that there is no significant effect of the factor on the birth weight. Table **2** summarizes the posterior estimates of the parameters corresponding to different environmental factors. Year of birth and age of dam were found to be significant factors influencing the birth weight of swamp buffalo calves with 95% BI (-6.0510, -2.8590) and (-0.9764, -0.1048), respectively. The coefficient for the age of dam was -0.5288, indicating that younger dams produce a higher birth weight of swamp buffalo calves.

Sex of calves and bodyweight of the dam did not significantly contribute to the birth weight of swamp buffalo calves. These findings are in accordance with findings obtained using frequentist statistics.

4. CONCLUSION

This study reveals that the heritability for birth weight of swamp buffalo in Sabah was low. The environmental factors, particularly the year of birth and the age of dam, play a significant and important influence on the average birth weight. Therefore, improving the environment and management may results in higher birth weight in the future.

REFERENCES

[1] Zamri-Saad M, Azhar K, Zuki AB, Punimin A, Hassim HA. Enhancement of performance of farmed buffaloes pasture management and feed supplementation in Sabah, Malaysia. Pertanika Journal of Tropical Agricultural Science 2017; 40(4): 553-563.

[2] Wan ZM, Ariff OM. Current status of buffalo production in Malaysia–A review. Mal J Anim Sci 2001; 7 (1): 13-24.

[3] Iannuzzi L. The genetic improvement of the water buffalo (Bubalus bubalis): The contribution of the cytogenetics. Revista Veterinaria 2010; 21(Suppl.1): 66-71.

[4] Siddiky M, Faruque M. Buffaloes for dairying in South Asia: potential, challenges and way forward. SAARC Journal of Agriculture 2018; 15(2): 227-239.

[5] Vercesi Filho AE, Madalena FE, Albuquerque LG, Freitas AF, Borges LE, Ferreira JJ, Faria FJC. Parâmetros genéticos entre características de leite, de peso e a idade ao primeiro parto em gado mestiço leiteiro (Bos taurus x Bos indicus). Arquivo Brasileiro de Medicina Veterinaria e Zootecnia 2007; 59(4): 983-990.

[6] Malhado CHM, Malhado ACM, Ramos AA, Carneiro PLS, Siewerdt F, Pala A. Genetic parameters by Bayesian inference for dual purpose Jaffarabadi buffaloes. Archiv Tierzucht 2012; 55: 567-576.

[7] Agudelo-Gómez DA, Savegnano RP, Buzanskas ME, FerraudoAS, Munari DP, Cerón-Muñoz MF. Genetic principal components for reproductive and production traits in dual-purpose buffaloes in Colombia. Journal of Animal Science 2015; 93: 3801-3809.

[8] Thevamanoharan K, Vandepitte W, Mohiuddin G, Chantalakhana C. Environmental factors affecting various growth traits of swamp buffalo calves. Pakistan Journal of Agricultural Sciences 2001; 38(3-4): 5-10.

[9] Bonnet A. Heritability estimation in case-control studies. Electronic Journal of Statistics 2018; 12(1): 1662-1716.

[10] Dujardin JP. Modern Morphometrics of medically important insects. In Genetics and Evolution of Infectious Diseases. Elsevier Inc. 2011; pp. 473-501.

[11] Miglior F, Fleming A, Malchiodi F, Brito LF, Martin P, Baes CF. A 100-Year Review: Identification and genetic selection of economically important traits in dairy cattle. Journal of Dairy Science 2017; 100(12): 10251-10271.

[12] Aksakal V, Bayram B, Yanar M, Akbulut O. Estimation of variance components and heritability of birth weight through different methods in Swedish Red and White cattle. J Anim Plant Sci 2012; 22(1): 39-43.

[13] Safari A, Hossein-Zadeh NG, Shadparvar AA, Arpanahi RA. A review on breeding and genetic strategies in Iranian buffaloes (Bubalusbubalis). Tropical Animal Health and Production 2017; 50(4): 707-714.

[14] Åkesson M, Bensch S, Hasselquist D, Tarka M, Hansson B. Estimating heritabilities and genetic correlations: comparing the 'animal model' with parent-offspring regression using data from a natural population. PLoS One 2008; 3(3): e1739.

[15] Conner JK, Hartl DL. A primer of ecological genetics. Sinauer Associates Incorporated 2004.

[16] Mair C, Stear M, Johnson P, Denwood M, de Cisneros JPJ, Stefan T, Matthews L. A Bayesian generalized random regression model for estimating heritability using overdispersed count data. Genetics Selection Evolution 2015; 47(1): 51.

[17] Mathew B, Bauer AM, Koistinen P, Reetz TC, Léon J, Sillanpää MJ. Bayesian adaptive Markov chain Monte Carlo estimation of genetic parameters. Heredity 2012; 109(4): 235-245.

[18] Thevamanoharan K, Vandepitte W, Mohiuddin G, Chantalakhana C. Restricted maximum likelihood animal model estimates of heritability for various growth traits and body measurements of swamp buffaloes. Pakistan Journal of Agricultural Sciences 2001; 38(1-2): 19-23.

[19] Akhtar P, Kalsoom U, Ali S, Yaqoob M, Javed K, Babar ME, Sultan JI. Genetics and phenotypic parameters for growth traits of Nili-Ravi buffalo heifers in Pakistan. Journal of Animal and Plant Sciences 2012; 22(Suppl. 3): 347-352.

[20] Na-Chiangmai A, Allen JM. Genetic improvement of swamp buffalo in Thailand. Asian Australasian Journal of Animal Sciences 2000; 13: 349-352.

[21] Thevamanoharan K, Vandepitte W, Mohiuddin G, Shafique M. Genetic, phenotypic and residual correlations between various performance traits of Nili-Ravi buffaloes. Buffalo Bull 2000; 19(4): 80-86

[22] Peeva T, Aleksandrov A. Study of buffalo-cow reproduction. Animal Science 1994.

[23] Pandya GM, Joshi CG, Rank DN, Kharadi VB, Bramkshtri BP, Vataliya PH, Solanki JV. Genetic analysis of body weight traits of Surti buffalo. Buff Bul 2015; 34: 189-195.

[24] Ugur F, Yanar M, Ozhan M, Tuzemen N. Reproductive performance of Simmental cattle raised in eastern Turkey. World review of animal production 1994.

[25] Yanar M, Tuzemen N, Akbulut O, Aydin R, Ugur F. The reproductive performance of Brown Swiss cattle raised in the Eastern Turkey. Indian Journal of Dairy Science 1997; 50: 307-313.

[26] Koçak S, Tekerli M, Özbeyaz C, Demirhan I. Some production traits of holstein, brown-swiss and simmental cattle reared in lalahan livestock research institute. Journal of Lalahan Livestock Research Institute (Turkey) 2008.

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