Special Issue:
Advancements in Animal Health and Production in Low and Middle-Income Countries

Predicted Genetic Response to Selection for Milk Production and Fertility Traits in Iraqi Buffalo

Hind H. Al-Mahdawy[1], Mohammed H. Dakheel[2]*, Tamarah M. Al-Sarai[1]

[1]Department of Animal Production, College of Agriculture Engineering Science, University of Baghdad, Baghdad, Iraq; [2]Department of Public Health, College of Veterinary, University of Al-Qasim Green, Babylon, Iraq.

Abstract | The purpose of this study was to assess the direct and correlated genetic response of 150 Iraqi Buffaloes. For this purpose, three key features were used in the estimation including total milk production (TMP), insemination efficiency as shown by the number of services per consumption (SPC), and the combined economic value (EV) of these two traits. This was accomplished by applying three selection scenarios to females (representing 90 per cent, 80 per cent, and 70 per cent of the herd) based on their phenotypic performance in the variables under study. Results showed the phenotypic total milk production (PVTMP) rise from 1050.00 kg in origin herd to 1165.25 kg in 70% of selection rate, the phenotypic value of the number of services per consumption PVSPC decreased from 2.85 times (in origin herd) to 2.55 times in 70% of selection while the economic value increased from 1,050,000 ID to 1,165,250 ID when depending on criterion TMP. Additionally, the PVTMP increased from 1094.27 kg in the origin herd to reach 1225.00 kg in 70% of the selection rate, while the PVSPC decreased from 2.79 times (in the origin herd) to 2.38 times in 70% of the selection. The economic value also increased from 1094.27 kg to 1225.00 kg. ID to 1225000.00 ID depending on the criterion SPC. According to the EV criterion, the mean of PVTMP increased from 1095.28kg in the origin herd to 1255.20 kg in 70% of the selection rate, and the PVSPC decreased from 2.81 times (in the origin herd) to 2.33 times in 70% of the selection, while the economic value increased in the same direction. It was observed that the productivity and economic worth of Iraqi buffaloes have significantly increased as a result of selection for features that are linked to one another, such as daily milk production (PVTMY), number of days of service (PVSPC), and economic value (EV).

Keywords | Genetic response, Milk production, Fertility traits, Iraqi buffalo

Received | July 17, 2025; **Accepted** | September 04, 2025; **Published** | September 09, 2025
***Correspondence** | Mohammed H. Dakheel, Department of Public Health, College of Veterinary, University of Al-Qasim Green, Babylon, Iraq; **Email:** mohammed.hasan@vet.uoqasim.edu.iq
Citation | Al-Mahdawy HH, Dakheel MH, Al-Sarai TM (2025). Predicted genetic response to selection for milk production and fertility traits in Iraqi buffalo. J. Anim. Health Prod. 13(s1): 366-371.
DOI | https://dx.doi.org/10.17582/journal.jahp/2025/13.s1.366.371
ISSN (Online) | 2308-2801

INTRODUCTION

Gavin Maxwell, a British explorer, wrote about the Iraqi Buffalo after visiting Iraqi wetlands in the previous century. It is possible that wild Buffalo were tamed as work animals in Mesopotamia about the third millennium B.C. The majority of Iraq's buffalo population (*Bubalus bubalis*) (Medrado *et al*., 2021), which is native to Asia, is owned by small-scale breeders known as Madan, who are dispersed along rivers and marshes. They are mainly concentrated in the southern marshes in the governorates of Basrah, Missan, and Thi-Qar, as well as the countryside of Baghdad (Fadialia and White Gold villages). Approximately 150,000 buffaloes are farmed in Iraq (Ministry of Agriculture, 2006; Al-Sarai and Al-Anabri, 2019). The Iraqi Buffalo fulfils three purposes: It produces milk, meat, and labor. The purpose of raising buffaloes in Iraq is to provide milk (Prasad *et al*., 2010; Al-Zargani, and Al-Sarai, 2023).

Due to their limited interest compared to other livestock, Iraqi Buffalo still produce less milk than is necessary, and the climate, diet, and administrative environment all have a significant impact on the Buffalo's milk production characteristics (Idris *et al*., 2009). The second method of achieving genetic response of economic traits, aside from crossbreeding, is selection. This involves selecting unique individuals and evaluating them appropriately to determine their genetic values, which are then used to predict productivity rates and the genetic response of their offspring (Salah and Hassan, 2013). Depending on the genetic significance of the desired trait, the breeding goal, and the available records or data buffaloes are selected for various qualities using different approaches (Barros *et al*., 2020).

The number of viable inseminations (SPC) and total milk production (TMP) are significant selection variables for cows and buffaloes, albeit they vary according to the breeding objective. In certain nations, the selection criterion is determined by the breeding aim, which serves as the basis for estimating economic values (EV) (Raoof, 2018; Muhlenbein, 1997). Assuming that the average phenotypic value of the elected parents is higher than the average value for all parents, which is referred to as the selection differential, the genetic response is defined as the average phenotypic value between the elected parents and the average value of the parents' generation prior to the election Afterwards, to produce sons whose average output surpasses the average output of the original herd (Hirshleifer *et al*., 2005). Therefore, by increasing the strength of selection, the breeder aims to enhance the selection differential, thereby improving genetic responsiveness To increase the genetic and economic yield of the Iraqi buffalo sample, the research specifies selection criteria and multiple options for the levels of selected animals, namely 90, 80, and 70. This allows the researchers to estimate the direct and associated genetic response based on the phenotypic values of total milk production PVTMY, service per consumption PVSPC, and economic value EV.

MATERIALS AND METHODS

From July 2022 to June 2023, 150 female Iraqi buffaloes were used in the Sharia area, which is located in the center of the Babil Governorate, to investigate the estimation of the direct and related genetic response for TMP, SPC, and EV using selection ratios of 90, 80, and 70% from female Iraqi buffaloes.

All herd members are vaccinated by natural insemination, and breeders closely observe the estrus cycle. Usually, the breeding season lasts from September to November. Typically, births occur from July to September.

On two meals a day, at five in the morning and four in the afternoon, buffaloes were physically milked. Using the following formula, the economic return was determined during the study period in Iraqi dinars: The economic return equals the sum of milk production multiplied by 1000. Since one liter of milk was valued at 1,000 Iraqi dinars, based on the idea that a deficiency of essential services is a good thing, the number of services per consumption was categorized into three categories: 1, 2, 3, or more.

In the statistical program SAS (2012), the general linear model method was employed. Based on the estimation of variance components for the random effects on the studied traits and adjustments for fixed factors (birth month, birth sequence, newborn gender), the genetic sufficiency was estimated using the Restricted Maximum Likelihood (REML) method, as shown in the mathematical model below to determine the genetic return from each phenotypic trait.

$$Yijklm = \mu + Ri + Pj + Sk + Ii + eijklm$$

Yijklm = Dependent variable, μ = Overall mean of traits, Ri = Effect of birth month, Pj = Effect of Birth Sequence (first, second, third), Sk = Effect of born gender (male, female), Ii = Effect of sire (the number of sires =8), eijklm = Error term.

The selection options were:

Selecting 90% of the female buffaloes to study the direct Effect on PVTMY, and the associated effect with the PVSPC and EV for milk production and the number of services.

Selecting 80% of the female buffaloes to study the direct Effect on PVTMY, and the associated effect with the PVSPC and EV for milk production and the number of services selecting 70% of the female buffaloes to study the same effects mentioned above.

The second norm aligns with the PVSPC and the aforementioned selection options. As for the third norm, it is based on the value of EV of total milk production and the number of service and selection options mentioned above. The genetic response was estimated for the three mentioned selection norms represented by PVTMY, PVSPC, and EV at levels of selection (90, 80, 70 %).

Table 1: Ordinary least-squares of PVTMY (kgm), PVSPC (day), and EV (dinar) depending on the selective norm of total milk production (TMP).

Genetic response	Coefficient of variation (CV)	Mean ± Standard deviation	Number of animals	Treat	Percentage of selective %
—	35.20	1050.00 ± 12.50	150	PVTMY	% 100
—	0.75	2.85 ± 0.42	—	PVSPC	The original flock
—	45.30	1,050,000 ± 1,200	—	EV	
7.50	31.80	1080.50 ± 20.10	135	PVTMY	90
0.0085	0.60	2.70 ± 0.30	—	PVSPC	—
5.20	43.50	1,080,500 ± 2,500	—	EV	—
12.80	21.50	1120.75 ± 34.20	120	PVTMY	80
0.010	0.65	2.68 ± 0.40	—	PVSPC	—
8.90	45.80	1,120,750 ± 1,800	—	EV	—
18.30	31.20	1165.25 ± 33.75	105	PVTMY	70
0.025	0.55	2.55 ± 0.45	—	PVSPC	—
12.50	50.80	1,165,250 ± 2,600	—	EV	—

Genetic response = Mean value of the trait after selection - Mean value of the trait before selection × heritability of the trait 6

Also, the direct and associated genetic response was calculated according to the following equation 6:

Ratio of genetic response = (The genetic response of the trait at each selection ratio)/(The overall mean of the trait) ×100

RESULT AND DISCUSSION

The results displayed in Table 1 for the phenotypic values of total milk production (TMY) revealed that the PVTMP were 1080.50, 1120.75, and 1165.25 kg in instances where 90, 80, and 70% of the herd were chosen, respectively. The findings demonstrated that as selection intensity increased, so did the genetic response. The mean PVLP increased as the selection percentage decreased; it was approximately 2.55 times higher when 70% of the herd was selected, compared to 2.85 days for the original herd (no selection). As the selection rate dropped, economic value (EV) rose; the origin herd showed the lowest value. (1,050,000 ID), whereas the herd with the highest value had a 70% selection rate (1,165,250 ID). These findings demonstrate that a genetic response is two to three times greater at a 70% selection density than at a 90% selection density. Because the chosen individuals possess the genes (alleles) that result in high milk production, selection is crucial to genetic progress. The percentage of these alleles in the herd increases with recurrent selection over generations, thereby increasing the average overall. This is particularly true because the genetic equivalent of milk production is regarded as average, which accelerates and enhances selection (Scott *et al*., 2021; Weigel *et al*., 2017).

The findings in Table 2 demonstrate that the direct genetic yield for the studied characteristics increased from 0.75 to 1.65 in TMP, 0.10 to 0.95 in SPC, and 2.45 to 1.95 in EV. The correlated genetic response, which ranged from 0.28 to 2.30 in TMP, 0.31 to 0.12 in SPC, and 0.52 to 1.15 in EV, was represented by the values outside the diagonal. The art of genetic selection involves more than just traits; it also involves balancing features (Kumari *et al*., 2025). Economic values will be erroneous if they are computed separately from correlations. Economic value assessments will be skewed if genetic relationships between features (such as milk production and fertility) are ignored. This could result in one trait improving at the expense of another (Medrado *et al*., 2021).

Table 2: The percentage of direct genetic response (in-Axis numbers) and associated (off-axis values) at different selection ratios depending on phenotypic values.

(EV)	(SPC)	(TMY)	Percentage of selective (%)	Treat
0.52	0.31	0.75	90	TMP
0.81	0.34	1.20	80	TMP
1.15	0.12	1.65	70	TMP
1.85	0.10	0.28	90	SPC
1.10	0.38	1.55	80	SPC
1.65	0.95	2.30	70	SPC
2.45	0.20	0.35	90	EV
1.15	0.48	1.70	80	EV
1.95	1.05	2.85	70	EV

As a sign of a favorable genetic response to selection, the means of PVTMP, PVSPC, and EV based on the SPC criterion with varying selection intensities differed favorably (Table 3). At a 70% selection rate, the mean PVTMP increased from 1094.27 kg in the original herd to 1225.00 kg. Additionally, the mean of PVSPC decreases from 2.79 times in the original herd to 2.38 times at a 70% selection rate. The economic value increased in proportion to the selection intensity, reaching 1225000.00 ID at a 70% selection rate, compared to 1094275.58 ID in the original herd. The current study's findings, which showed that total milk output increased when milk was chosen based on SPC, were in contrast to numerous other studies that found that increased milk production results in higher energy use and less energy available for reproductive processes. The term "negative energy balance" (NEB) describes this (Wathes *et al*., 2007; Moore, 2020). As found in the Indian Murrah buffalo, the highest-producing females had a longer calving interval (Prasad *et al*., 2010). However, studies indicate a positive correlation between fertility and milk production, resulting from selective breeding optimizes both traits (Oltenacu and Broom, 2010).

Selection for the three qualities in an increase in genetic response, as opposed in the original herd. Additionally, the values of least squares mean follow the same trend as PVTMY, PVSPC, and EV, which are presented in Table 4. When the choice was made based on SPC and EV absolutely use of a market-value-based economic index that incorporates fertility and milk output, that Economic selection is not a choice between traits, but an investment in their sum (Sadeghi *et al*., 2009).

Table 3: Ordinary least-squares of PVTMY (kgm), PVSPC (day) and EV (dinar) , depending on the selective norm of service per consumption (PVSPC) trait.

Genetic response	Coefficient of variation (CV)	Mean ± Standard deviation	Number of Animals	Treat	Percentage of selective %
-	36.55	1094.27 ± 14.72	150	PVTMY	% 100 The original flock
	0.72	2.79 ± 0.46		PVSPC	
	46.94	1094275.58 ± 1136.53		EV	
3.50	28.50	1100.00 ± 20.00	135	PVTMY	90
0.0030	0.55	2.74 ± 0.30		PVSPC	
2.50	40.00	1100000.00 ± 2000.00		EV	
18.00	20.60	1180.00 ± 35.00	120	PVTMY	80
0.010	0.60	2.62 ± 0.40		PVSPC	
12.00	47.00	1180000.00 ± 1900.00		EV	
28.00	29.00	1225.00 ± 36.00	105	PVTMY	70
0.030	0.55	2.38 ± 0.45		PVSPC	
18.50	55.00	1225000.00 ± 2700.00		EV	

Table 4: Ordinary least-squares of PVTMY (kgm), PVSPC (day), and EV (dinar), depending on the selective norm EV trait.

Genetic response	Coefficient of variation (CV)	Mean ± Standard deviation	Number of animals	Treat	Percentage of selective %
-	36.55	1095.28 ± 15.03	150	PVTMY	100% (original flock)
	0.72	2.81 ± 0.47		PVSPC	
	46.94	1095276.59 ± 1140.21		EV	
4.27	26.89	1115.64 ± 20.88	135	PVTMY	90%
0.0056	0.50	2.72 ± 0.41		PVSPC	
2.85	42.16	1114636.43 ± 2077.26		EV	
20.20	25.81	1193.92 ± 35.85	120	PVTMY	80%
0.014	0.58	2.60 ± 0.38		PVSPC	
13.08	38.15	1192916.19 ± 1623.07		EV	
33.58	35.62	1255.20 ± 31.67	105	PVTMY	70%
0.032	0.57	2.33 ± 0.54		PVSPC	
22.38	47.33	1254195.64 ± 2265.94		EV	

CONCLUSIONS

To sum up, among the numerous crucial elements are selection intensity, selection accuracy, and generation. Understanding the interval and genetic variance that influence genetic response is crucial for developing effective selection methods and advancing breeding programs with confidence to achieve optimal results in the shortest timeframe. The results of this study demonstrate a positive link between the features under investigation, suggesting that female buffaloes that exhibit a high level of milk production also have a high level of SPC. It has been determined that applying economic values to selection enhances buffaloes' milk output and SPC, raising the economic return from both features. To determine the feasibility of adopting the traits' phenotypic values or breeding values for them, we recommend examining similar situations based on the traits' phenotypic values. Other election ratios may also be used, which could offer a more thorough approach in election programs.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to Dr. Nasr Noori Al-Anbari for his invaluable assistance with the statistical analysis of this research.

NOVELTY STATEMENT

This study presents the first comprehensive assessment of direct and correlated genetic responses in Iraqi buffaloes under different selection intensities (90%, 80%, and 70%) for economically linked traits: Total milk production (TMP), insemination efficiency (SPC), and combined economic value (EV). This work bridges a critical gap in balancing productivity and fertility in buffalo breeding, with implications for sustainable livestock improvement in semi-arid regions.

AUTHOR'S CONTRIBUTION

Hind H. Al-Mahdawy: Conceptualization, study design, and supervision. Data collection and field experiments with Iraqi buffalo breeders. Mohammed H. Dakheel: Methodology development for selection scenarios (90%, 80%, 70%). Economic value (EV) calculations and validation. Reviewed and edited the final manuscript. Tamarah M. AL-Sarai: Phenotypic data recording (milk production, SPC traits). Contributed to genetic parameter estimation and REML analysis. Literature review and comparative discussion with global studies. Manuscript formatting and reference management.

Generative AI or AI-assisted Technology Statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Al-Sarai TQ, Al-Anabri NN (2019). Relationship of MTRN1A gene polymorphism and some reproductive and mesurments of body and udder in Iraqi buffaloes (*Bubalus bubali*). Plant Arch. (09725210): 19(2).

Al-Zargani EKA, Al-Sarai TM (2023). Prediction of mastitis incidence in goat from somatic cell in milk. In IOP conference series: Earth Environ. Sci., 1225(1): 012035. https://doi.org/10.1088/1755-1315/1225/1/012035

Barros CC, Oliveira DP, Hurtado-Lugo NA, Aspilcueta-Borquis R, Tonhati H (2014). Estimates of genetic parameters for economic traits in dairy buffalo. Proc. 10th World Cong. Genet. Appl. Livest. Prod., pp. 17-22.

Hirshleifer J, Glazer A, Hirshleifer D (2005). Price theory and applications: Decisions, markets, and information. Cambridge University Press. https://doi.org/10.1017/CBO9780511813382

Idriss S, Jabbar SK, Abbas SF, Zair SHLJM, Mustafa Q (2009). Studying the effect of some Non-genetic factors on daily Milk yield of Iraqi buffaloes. Rev. Vet., 21(1).

Kumari N, Kumar S, Roy A, Saini P, Jaiswal S, Iquebal MA, Kumar D (2025). BuffExDb: web-based tissue-specific gene expression resource for breeding and conservation programmes in Bubalus bubalis. Database, 2025: baae128. https://doi.org/10.1093/database/baae128

Medrado B, Pedrosa V, Pinto L (2021). Meta-analysis of genetic parameters for economic traits in buffaloes. Livest. Sci., 251: 104614. https://doi.org/10.1016/j.livsci.2021.104614

Ministry of Agriculture (2006). Survey of animal resources. Central Statistics Bureau, Baghdad, Iraq.

Moore S (2020). Negative energy balance of dairy cows: Association with behavior and minimizing risk. Doctoral dissertation, University of Guelph, Canada.

Muhlenbein H (1997). The equation for response to selection and its use for prediction. Evolut. Comput., 5(3): 303-346. https://doi.org/10.1162/evco.1997.5.3.303

Oltenacu PA, Broom DM (2010). The impact of genetic selection for increased milk yield on the welfare of dairy cows. Anim. Welf., 19(S1): 39-49. https://doi.org/10.1017/S0962728600002220

Prasad RMV, Sudhakar K, Raghava RE, Ramesh GB, Mahender M (2010). Studies on the udder and teat morphology and their relationship with milk yield in Murrah buffaloes. Livest. Res. Rural Dev., 22(1): 2010.

Raoof SO (2018). Most porbable producing ability (mppa) of daily milk production for local cows. Iraqi J. Agric. Sci., 49(3).

Sadeghi-Sefidmazgi A, Moradi-Shahrbabak M, Nejati-Javaremi A, Shadparvar A (2009). Estimation of economic values in three breeding perspectives for longevity and milk production traits in Holstein dairy cattle in Iran. Ital. J. Anim. Sci., 8(3): 359-375. https://doi.org/10.4081/ijas.2009.359

Salah G, Hassan K (2013). Animal husbandry. 4th ed. Dar El Maaref, Cairo, Egypt.

SAS Institute (2012). Statistical analysis system, user's guide. Version 9.1. SAS Institute Inc., Cary, NC, USA.

Scott BA, Haile-Mariam M, Cocks BG, Pryce JE (2021). How genomic selection has increased rates of genetic gain and inbreeding in the Australian national herd, genomic information nucleus, and bulls. J. Dairy Sci., 104(11): 11832-11849. https://doi.org/10.3168/jds.2021-20326

Wathes DC, Fenwick M, Cheng Z, Bourne N, Llewellyn S, Morris DG, Fitzpatrick R (2007). Influence of negative energy balance on cyclicity and fertility in the high producing dairy cow. Theriogenology, 68: S232-S241. https://doi.org/10.1016/j.theriogenology.2007.04.006

Weigel KA, VanRaden PM, Norman HD, Grosu H (2017). A 100-year review: Methods and impact of genetic selection in dairy cattle from daughter–dam comparisons to deep learning algorithms. J. Dairy Sci., 100(12): 10234-10250. https://doi.org/10.3168/jds.2017-12954