Genetics and Reproduction

Original

Dairy Yields by Water Buffaloes in Cuba

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Received: May 2024; Accepted: May 2024; Published: June 2024.

ABSTRACT

Background: Water buffalo raising for milk production purposes has been active for 41 years in Cuban livestock production. **Aims.** Dairy performance was evaluated in different herds in the country, and the results were compared to the records at Los Naranjos Company. Among the parameters analyzed were the most probable productive ability (MPPA), and the genetic components for different dairy traits from buffalo cows at this particular company were estimated. **Methods:** Overall, 24 907 lactating cows from different herds in the country and 6 498 cows from Los Naranjos Company (2013-2020) were studied using multi-character linear models with random factors from the father and the mother in the records, models to estimate some environmental and genetic factors affecting milk production at 100 days (L100); 200 days (L200); total milk (Ltot); and duration of lactation (Dlac). **Results:** The females that calved in 2020 produced -62.1 kg and -96.2 kg of L200 and Ltot, respectively when compared to the 2013 calvings, even after a 15-day increase of Dlac in the same period. There was a broad variability in the most probable productive ability (MPPA), but the evolution of this indicator associated with the birth year of buffalo cows was practically null, thus indicating little selection pressure in raising. The repeatability estimates (Γ) were between 0.372 and 0.397 for L100, L200, and Ltot, almost twice as high in Los Naranjos Company as those in the rest of the country. The heredity estimates (h^2) were between ≈0.217±0.01 and 0.166±0,02, for L100, L200, and Ltot, respectively, with genetic correlations above 0.961. Based on the expected differences in progenies (EDP), the female progeny from the best 20 studs reached an EDP of +37.6±12.9 kg in L200 and +42.5±15.7 kg in Ltot. **Conclusions:** The indicators studied did not show a favorable evolution; however, there is a possibility for better selection and breeding work.

Keywords: buffalo cows in Cuba, milk production, repeatability and heredity (*Source*: *MESH*)

INTRODUCTION

In the last decade, dairy records in buffaloes have moved from their real possibilities, among other reasons by little advances in knowledge about the species, hard environmental conditions for animal maintenance, inappropriate use of double purpose tending to create more dairy

Citations (APA) Mitat Valdés, A., & Menéndez-Buxadera, A. (2024). Dairy Yields by Water Buffaloes in Cuba *Journal of Animal Prod*, *36*(1). https://rpa.reduc.edu.cu/index.php/rpa/article/view/4646

facilities, the lack of proper female selection for high dairy yields, centralized technical management, and the presence of most herd in state-owned areas under husbandry systems more suitable for cattle guided by the cattle raising program designed in the mid-1960s.

Moreover, the absence of primary information about reproduction and production in buffalo herds, and the variability of genealogical databases led to a series of phenotypical evaluations in 2000, using the most probable productive ability (MPPA), still in place.

This paper aims to conduct a retrospective analysis of the dairy productivity of buffalo cows, using the data provided by several dairy facilities throughout the country, and comparing it with the database at Los Naranjos Company. Then producing the genetic parameters of heredity and genetic correlations of several economically relevant traits.

MATERIALS AND METHODS

A database of official national records was compiled, containing 24 907 lactation events between 2013 and 2020, as well as 6 498 records in the same period, at Los Naranjos Company. The two datasets were cleared using each company-dairy facility's opinion, based on more than 10 observations, and the data outside the mean ±3 standard deviation were deleted. Because of the calving seasonality of the species (Mitat, Menendez-Buxadera, and Lamothe, 2023), calvings taking place between January and June were pooled in July, so that effect corresponded to July-December. The traits studied were accumulated milk production in the first 100 days (L100); 200 days (L200); total milk, and the duration of lactation (Dlac). The process resulted in 23 918 and 5 574 lactation events available, by 6 998 and 1 784 cows born between 1997 and 2016, respectively. Table 1 shows the indicators of both databases.

Table 1. Indicators of data about buffalo productivity in Cuba

	National data	Los Naranjos Company data
Period	2013 a 2020	2013 a 2020
Number of Lactating cows	23918	5574
Number of female buffaloes	9498	1784
Number of studs	-	83
Number of dairy facilities	108	32
Milk at 100 days (kg)	360.1(128)	334.3 (112)
Milk at 200 days (kg)	580.5 (229)	536.9 (203)
Total milk (kg)	636.1 (271)	581.9 (238)
Duration of lactation	219.1 (57)	209.1 (56)

Between parentheses, the trait's standard deviation.

Both sets were studied using a fixed effect model (proc glm, SAS, 2015) to represent the non-genetic response curves in the dairy facility year-month of calving and the number of lactation events. Then, a multi-character animal model was used to estimate the components (covariance) to estimate repeatability (Γ) and the most probable productive ability (MPPA), and associate that indicator in the two datasets. Finally, using Los Naranjos's data a multi-character father model through ASreml 4.2 (Gilmour *et al.*, 2015), to estimate Γ, heredity (**h^2**), and the genetic correlations (**r_g**), among the four characters, whereas the solution to this model permitted the estimation of expected differences in progenies (EDP) of the same traits, which were added to the year of birth for representing the timeline of productivity in this species.

The father model used was the following:

$$\mathbf{y_{ij}} = \mathbf{fixed_{ij}} + \sum_{i=1}^{i=4} \mathbf{S_j} + \sum_{i=1}^{4} \mathbf{p_{ik}} + \mathbf{residual}$$

Where:

y_{ij}: represents the **i^{th}** character vector measured in the **k^{th}** progenies from each **j^{th}** stud

$fixed_{ij}$: represents the fixed effects of the herd, year-month of calving, and lactation events.

S_j: is a randomized effect vector correlated depending on the stud, for each **i^{th}** trait.

P_{ik}: is a non-correlated randomized effect vector of the permanent environment due to repetitions of the same character in each female producing the data.

residual: is a random effect common to all observations, and not correlated to the fixed and randomized effects.

The expected co-variance components of the model were

$$\mathbf{y_{ij}} \sim \mathbf{N}\left[\mathbf{0}, \left(\boldsymbol{\sigma}_{\mathbf{y}}^{2} = \mathbf{G_0} \otimes \mathbf{I_s}\right)\right] + \left(\boldsymbol{\sigma}_{\mathbf{p}}^{2} = \mathbf{P_0} \otimes \mathbf{I_k}\right) + \mathbf{I_n} \otimes \boldsymbol{\sigma}_{\mathbf{e}}^{2}$$

In which ⊗ is a symbol, product Kronecker, **I_s**; **I_k**, and **I_{n+}** are identity matrices for the stud's effect, female included in the record, and the number of total observations, respectively. As a matrix

$$\mathbf{V}\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix} = I_s \otimes \begin{bmatrix} \sigma^2_{sx_1} & \sigma_{sx12} & \sigma_{sx13} & \sigma_{sx12} \\ \sigma_{sx21} & \sigma^2_{sx_2} & \sigma_{x23} & \sigma_{sx24} \\ \sigma_{sx31} & \sigma_{x32} & \sigma^2_{sx_3} & \sigma_{sx34} \\ \sigma_{sx41} & \sigma_{sx42} & \sigma_{sx43} & \sigma^2_{sx_4} \end{bmatrix} + \mathbf{I_p}\begin{bmatrix} \sigma^2_{px_1} \\ \sigma^2_{px_2} \\ \sigma^2_{px_3} \\ \sigma^2_{px_4} \end{bmatrix} + I_n \begin{bmatrix} \sigma^2_{ex_1} \\ \sigma^2_{ex_2} \\ \sigma^2_{ex_3} \\ \sigma^2_{ex_4} \end{bmatrix}$$

The symbols equal **X_1=dlac; X_2=l100; X_3=l200, and X_4=total milk**

With this procedure, **h^2** and **r_g** are estimated according to the classical formula for each character, considering it is a father model, so the genetic variances must be multiplied by 4. Finally, each stud's EDP is obtained as a solution to the model.

RESULTS AND DISCUSSION

Milk production and duration of lactationDuration of lactation

In addition to the general indicators, Table 1 shows the values of L200 and Dlac, 580.5 kg in 219.1 days, and 536.9,1 kg in 209.1 days in the national herd and Los Naranjos, respectively. In both cases, the results were lower than the total mean of dairy units included, and the thoroughbred Buffalypsas (Mitat, 2022), and according to the reports of García *et al*. (2021), in three more specialized companies raising this species in Cuba. In Latin America, the results of Venezuela (Menendez-Buxadera and Verde, 2014), Colombia (Agudelo-Gómez, 2019), and Brazil (de Sousa Matos *et al*., 2020; Marques *et al*., 2020), were equally higher. This lower behavior was caused by the utilization of Buffalypso cows and their crossbreds (Carabao and Mediterranea) in uncontrolled ways, with minimum management conditions (natural pasture, insufficient supplementation, drinking water shortage, and shade to prevent sun radiation), and little pressure for selection of female buffaloes.

Based on the calving year, 200-day production and duration of lactation showed significantly decreasing trends in the cows from the national herd (Figure 1).

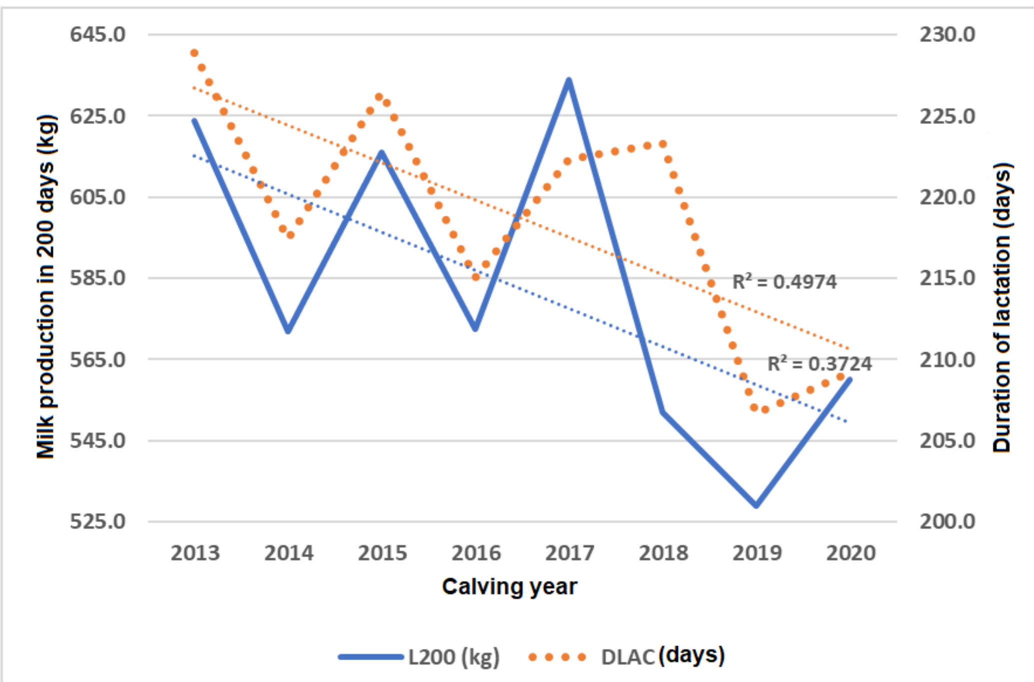


Figure 1. Milk production in 200 days and duration of lactation

The two traits decreased from the sixth and ninth lactation events (Figure 2). However, because buffalo cows are aging animals capable of calving until they are 20 years of age, the females with over 10 lactation events or more, depending on each breeder's opinion, could be transferred to raising herds to produce calves that reach more weight at weaning, for meat production, based on the development program established in a particular area.

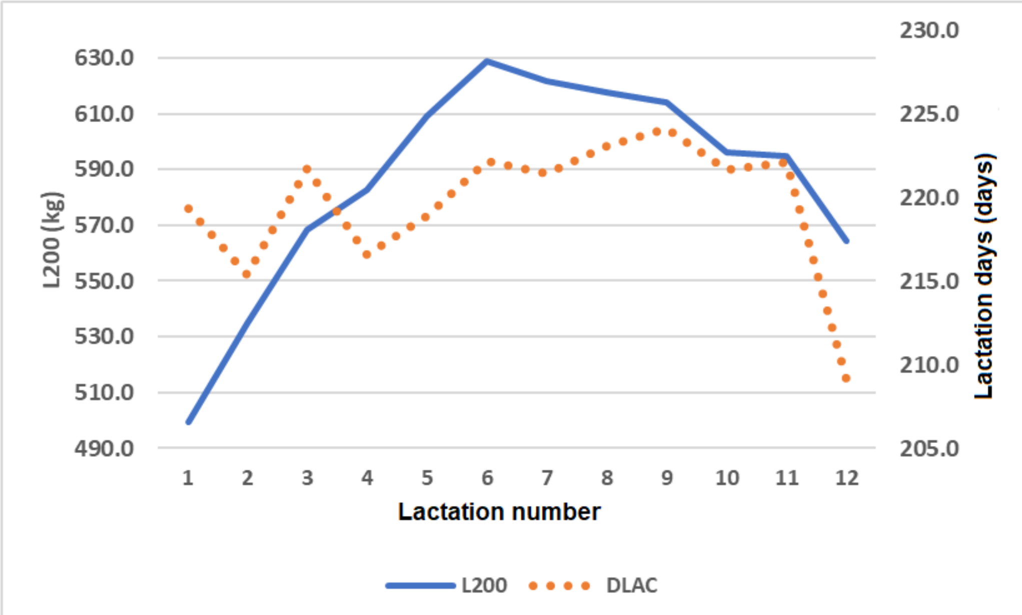


Figure 2. Milk production in 200 days and duration of lactation, according to the number of lactation events

One of the most commonly debated problems among specialists is the reduction of lactation in the last months of the year (Table 2), which should not be addressed by changing the intrinsic seasonality of calving under the current Cuban conditions, in the mid-term. On the contrary, the animals may have access to higher amounts of feed during the dry season, between November and April.

Table 2. Milk production and duration of lactation according to the calving month in the national herd

Calving month	L200 (kg)	DLAC (days)
7	686.1	237.4
8	643.1	230.8
9	5931	221.4
10	529.1	209.5
11	467.8	199.0
12	502.5	207.2

Furthermore, analyzing the evolution percentage of buffalo cows with less than 150 days of lactation (Figure 3), shows a rise, according to the year of birth of the female, possibly due to the raising conditions and little negative selection caused by this trait. So they could be transferred to breeding herds for meat production, thus increasing the efficiency of both types of productive systems. the duration of lactation of these animals is similar to Carabaos in the Philippines, which are mainly employed for meat production and as draft animals (Aquino *et al*., 2024).

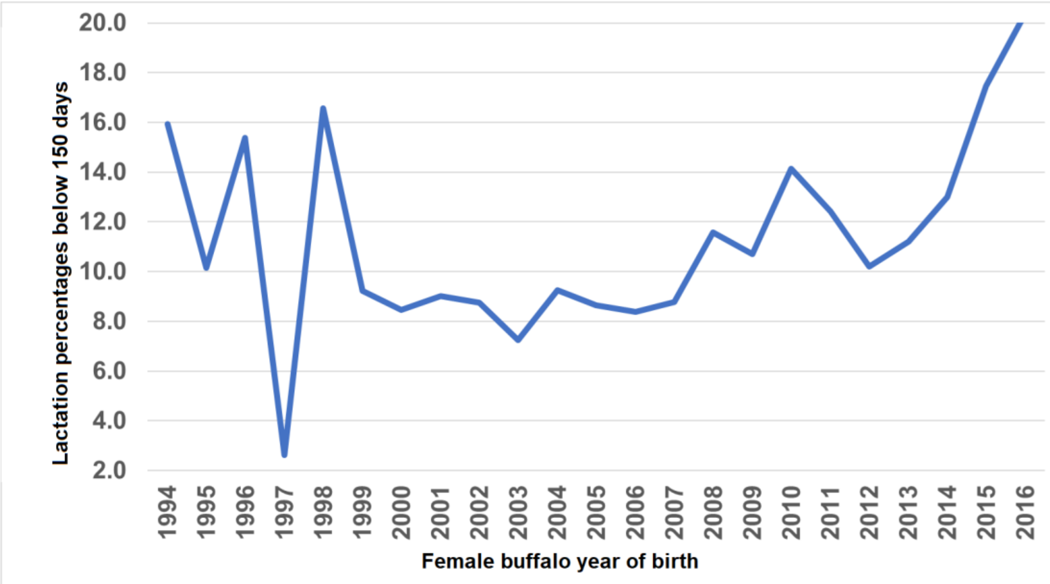


Figure 3. Percentage of females with lactation periods below 150 days, depending on the year of birth

Behavior of the most probable productive ability (MPPA)

The results of national records showed that MPPA for L200 and Dlac, dropped depending on the cow's year of birth, in the first trait, from -1.79 to -4.09 kg, and -0.30 to -0.73 days, for the duration of lactation (Figure 4).

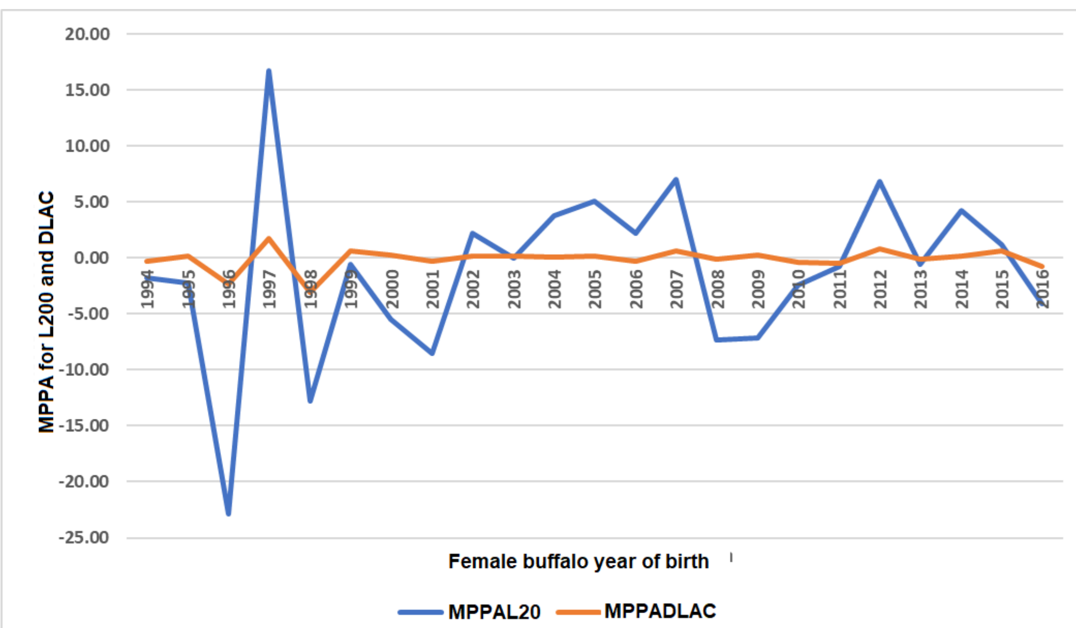


Figure 4. MPPA performance at 200 days and duration of lactation

A decrease in MPPA for the two traits in the female animals born in Los Naranjos was greater than in the rest of the country (-4.73 to -25.14 kg, and 0.10 to -6.83 days, respectively).

Repeatability estimates (Γ) and correlations between estimates of dairy production by buffalo cows

The results of Γ (Figure 5) observed in different dairy traits indicate the possibility of selection and could be used to benefit herds. The high levels of total correlations between traits favor this assertion.

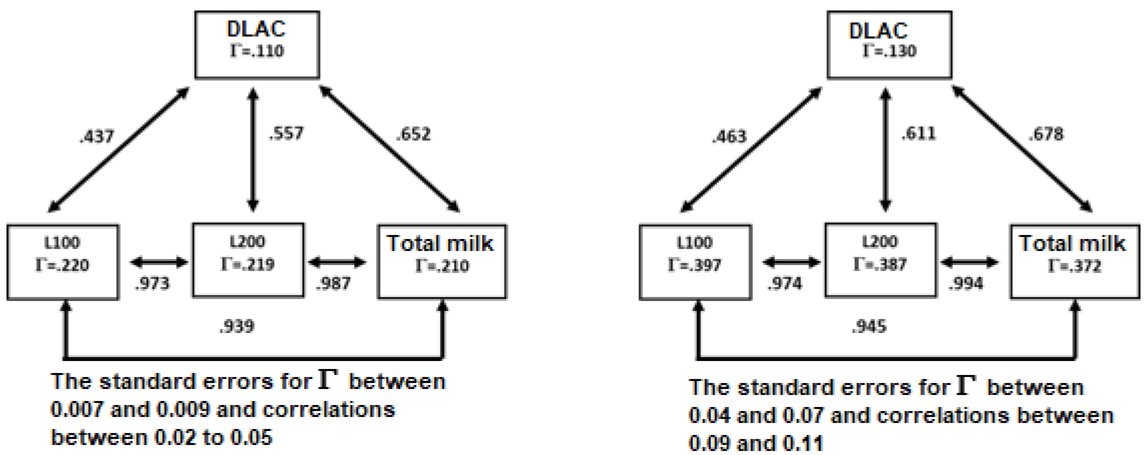


Figure 5. On the left, repeatability estimates (Γ) and correlations between estimates of dairy production by buffalo cows in all the herds of the nation. on the right, the records from Los Naranjos

In general terms, the estimated parameters were very similar in both datasets and have been reported by similar publications in Cuba, in which Γ ≈ 0.22 to 0.58, (Mitat, 2008; Suárez and Ramos, 2011; Méndez and Fraga, 2012).

The utilization of Γ in animal breeding efforts is recommended when the control systems fail to ensure other more robust parameters. However, their practical importance should not be underestimated. Repeatability means the relationship between the animal's successive records, so as Γ remains high or low, the number of periodical controls required could be more or less, thus facilitating work. Moreover, the parameter Γ has an additive genetic component, and another individual permanent environmental component, which combine to provide the animals with an additional attribute to show a higher performance than other animals of similar age. Based on those definitions, possible changes could be predicted depending on the current results (Newton Turner and Young, 1969):

$$\boldsymbol{\Delta} = \boldsymbol{\Gamma\sigma_i}$$

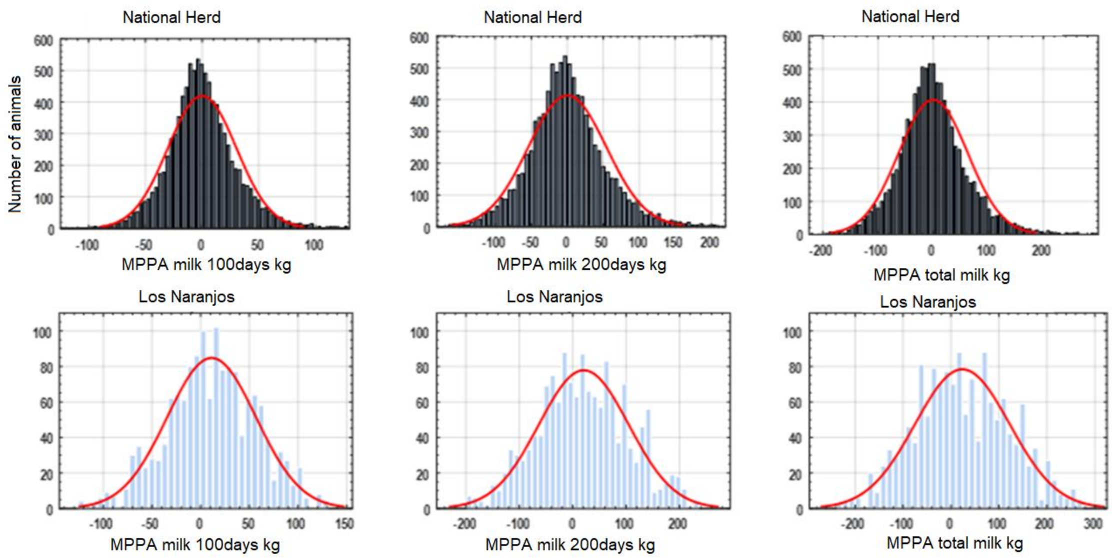
where $\boldsymbol{\sigma_i}$ is the trait's standard deviation. Analyzing just L200 in both sets, it would result as follows:

$$\Delta_{\text{Total herd}} = 0.219 * 229\text{kg} = +50.1\text{kg}$$

$$\Delta_{Los\ Naranjos} = 0.387 * 203\text{kg} = +78.1\text{kg}$$

The interpretation of these results indicates expected phenotypical increases if the animals are selected according to their MPPA current results, in which case, the process superiority would be 56% at Los Naranjos, though this not acknowledged as genetic progress.

The variability existing among the main dairy production traits was very similar for the two datasets (Figure 6), whose magnitude accounted for 40-50% of the mean in Table 1.

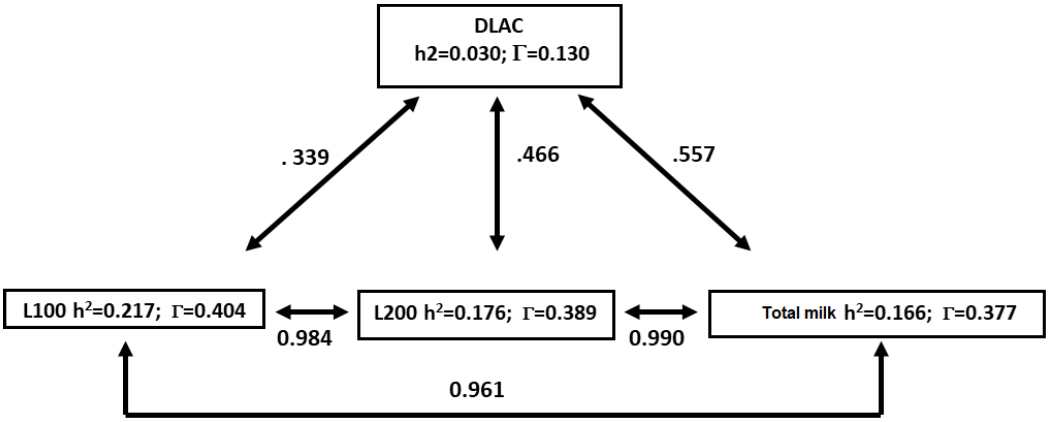


The standard errors for Γ between 0,007 and 0,009, and correlations between 0.02 - 0.05

Figure 6. MPPA variability in dairy traits of the two databases

Genetic parameters and correlations for milk production in Los Naranjos herd

The h^2 estimates decreased from 0.217 for L100 to 0.166 in total milk, though they maintained a high genetic correlation (Figura 7).



The standard errors were between 0.012 and 0.015 in Γ; between 0,015 for h^2, and between 0,035 and 0,040 in r$_g$

Figure 7. Heredity (h^2), repeatability (Γ), and genetic correlations in dairy production of buffalo cows at Los Naranjos

These values were similar to the ones reported by García *et al.* (2021) in Cuba and Herrera *et al*., (2021) in Carabao females, in the Philippines, but lower than reports made in Colombia (Agudelo-Gómez, 2019). Analyzing a pool of these results is relevant for the selection process since improving a single trait will be linked to improvements in another so that changes in the two traits would be favorable.

Likewise, there was a significant variability between EDP from the 85 studs represented (Figure 8). The best 20 animals in total milk were highlighted in green. The EDP mean from these elite studs was +37.6±12.9 kg in L200, which is practically half the $\Delta_{Los\ Naranjos}$ estimate. In this case, it was an asset with genetic value, and in keeping with this trend, the animals also showed an EDP mean of +42.5±15.7 kg in Ltotal, evidencing the important possibilities of a selection process.

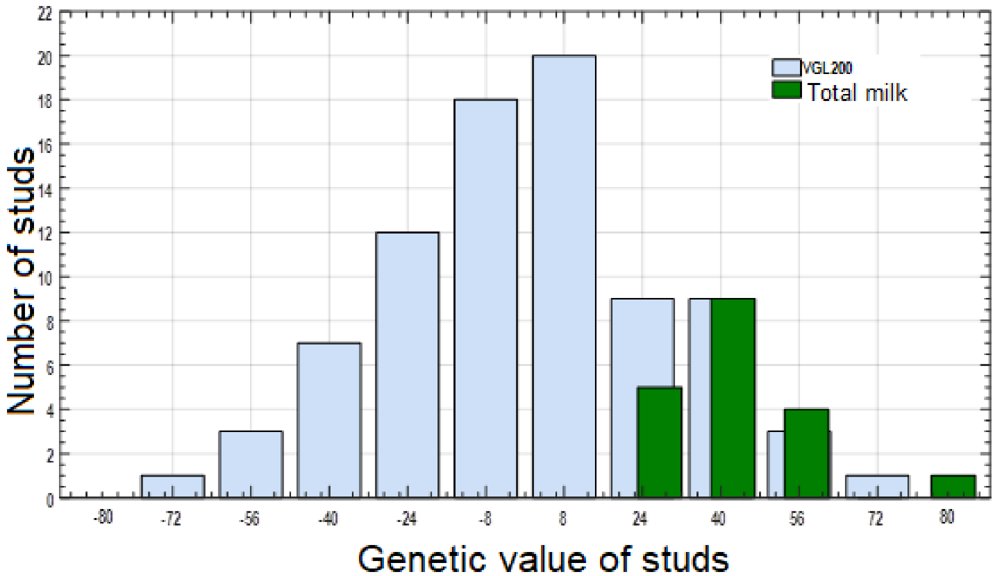


Figure 8. Frequency distribution of expected differences in the progeny of 85 studs and the best 20

Because there is no data about the fathers of buffalo cows in the national herd, the tool will not be used, so it was useful to consider the mean of the best studs according to the EDP at 200 days, and based on the MPPA estimates for their daughters. The results are shown in figure 9, which shows a practically linear relationship between the two indicators, so positive results could be expected in milk production improvements through the cow's MPPA.

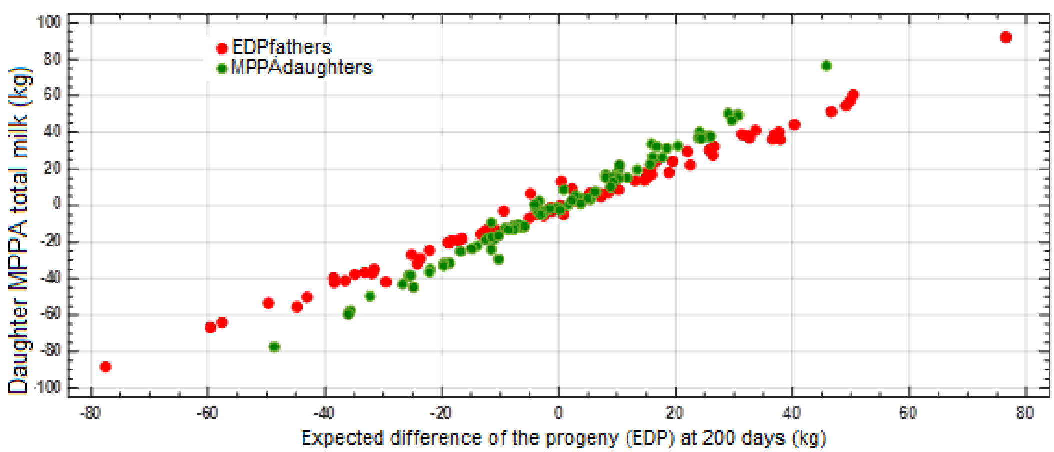


Figure 9. Relationship between EDP from fathers and that of their daughters

CONCLUSIONS

The productive dairy results and evolution of HPPA indicate that female buffalo productivity is negative, so the advantages of the species are not used for food production. Hence, it is important to improve the herd-raising conditions in the country and develop appropriate municipal programs adjusted to local environments with smaller dairy and breeding herds, through the double purpose of water buffaloes. The heredity estimates and EDP from Los Naranjos offers possibilities for selection and improvement efforts. This is a difficult alternative to implement in practical terms due to the absence of a genealogical record. However, the study demonstrated that important benefits could be obtained using MPPA results, which are highly associated with the animal's genetic merit.

REFERENCES

a (2019). Resultados evaluación genética para producción de leche hasta el día 270 en búfalas en Colombia, 2018. *CES Medicina Veterinaria y Zootecnia*, 14(1), 100-129. http://www.scielo.org.co/scielo.php?pid=S1900-96072019000100100&script=sci_arttext

Aquino, D. L., Palacpac, E. P., Molina, A. M., Lacanilao, C. C., Garcia, N. P., Del Barrio, A. N., & Fujihara, T. (2024). Enhancing growth and milk production of dairy buffaloes through home-grown forages and complete nutrient diet. *Online Journal Animal Feed Resoult*, 14(2), 95-106. https://www.researchgate.net/profile/Eric-Palacpac/publication/379643230_ENHANCING_GROWTH_AND_MILK_PRODUCTION_OF_DAIRY_BUFFALOES_THROUGH_HOME-GROWN_FORAGES_AND_COMPLETE_NUTRIENT_DIET/links/661226c57476d47e44459152/Enhancing-growth-and-milk-production-of-dairy-buffaloes-through-home-grown-forages-and-complete-nutrient-diet.pdf

de Sousa Matos, A., de Araújo, C. V., Pimentel, C. M. M., Laureano, M. M. M., Marques, L. C., Sales, R. L., Silva, C. S., da Silva Filho, E,. & Marques, J. R. F. (2020). Production of buffalo milk (Bubalus bubalis) in Brazil. *Buffalo Bulletin*, 39(3), 323-329. http://kuojs.lib.ku.ac.th/index.php/BufBu/article/view/2268

García, Y., Fraga, L.M., Hernández, A., Mora, M., García, D. & Aguiar, L. (2021). Estimación de parámetros genéticos para rasgos productivos lecheros en búfalos mestizos de Cuba. *Livestock Research for Rural Development*. 33(7), http://www.lrrd.org/lrrd33/7/3387yenny.html

Gilmour, A. R., Gogel, B. J., Cullis, B. R., Welham, S. J. & Thompson, R. (2015). ASReml User Guide Release 4.2 Structural Specification, VSN International Ltd, Hemel Hempstead, HP1 1ES, UK www.vsni.co.uk

Herrera, J. R. V., Flores, E. B., Duijvesteijn, N., Moghaddar, N. & van der Werf, J. H. (2021). Accuracy of Genomic Prediction for Milk Production Traits in Philippine Dairy Buffaloes. *Frontiers in Genetic*, 12:682576. https://doi.org/10.3389/fgene.2021.682576

Marques, L. C., Matos, A. S., Costa, J. S., Silva, C. S., Camargo Júnior, R. N. C., McManus, C., Peripolli, V., Araújo, C. V. Laireano, M. M. M., Sales, R.L. & Marques, J. R. F. (2020).

Productive characteristics in dairy buffalo (Bubalus bubalis) in the Eastern Amazon. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 72, 947-954. https://www.scielo.br/j/abmvz/a/dqBSxPJXNp87pWDCGHT6q7N/

Méndez, M., & Fraga, L. M. (2012). Producción de leche y porcentaje de grasa en el día de control de búfalas de rio en la provincia Granma. *Archivos de Zootecnia*. 61(233), 11-18. https://dx.doi.org/10.4321/S0004-05922012000100002

Menéndez-Buxadera, A. & Verde, O. 2014. Componentes de (co)varianza de la producción de leche de un rebaño bufalino venezolano estimados con modelos de lactancia completa o del día de control. *Zootecnia Tropical*, 32(1), https://www.research.net/publication/270049445.

Mitat Valdés, A. (2008). La producción de leche en el día de control para la selección de búfalas en Cuba. Tesis para optar por el grado científico de Doctora en Ciencias Veterinarias. Centro de Investigación para el Mejoramiento Animal de la Ganadería Tropical. Ministerio de la Agricultura. Cuba.

Mitat Valdés, A. (2022). Búfalos de agua. I. Comportamiento del rebaño Buffalypso puro en Cuba. *Revista de Producción Animal*, 34(1), 16-24. http://scielo.sld.cu/scielo.php?pid=S2224-79202022000100016&script=sci_arttext

Mitat Valdés, A., Menéndez-Buxadera, A. & Lamothe Crespo, Y. (2023). Estacionalidad reproductiva en hembras bufalinas en Cuba. *Revista Ecuatoriana de Ciencia Animal*, 6, (1), 118-128. https://revistaecuatorianadecienciaanimal.com/index.php/RECA/article/view/325

Newton Turner, H., & Young, Sydney S.Y. (1969). Quantitative genetic in sheep breeding. *Cornell University Press*, 331 pag.

Suárez M. A. & Ramos, F. (2011). Caracterización del comportamiento productivo y reproductivo en Búfalas Buffalypso en Cuba. Zootecnia Tropical, 29(4), 485-494. **https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=http://ve.scielo.org/scielo.php%3Fscript%3Dsci_arttext%26pid%3DS079872692011000400010&ved=2ahUKEwjE3fqSwvGFAxWfTTABHYhADigQFnoECBoQAQ&usg=AOvVaw3e7_IovhfbEJHZUYQDYuv_**

AUTHOR CONTRIBUTION STATEMENT

Research conception and design: AMV, AMB; data analysis and itnerpretation: AMV, AMB; redaction of the manuscript: AMV, AMB.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.