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Economic values of production and functional traits in Egyptian buffalo

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ABSTRACT

This investigation was carried out to estimate the economic values (EVs) of production and functional traits of Egyptian buffalo to determine relative importance breeding objectives in Egyptian buffalo to design breeding programs for genetic improvement. Bioeconomic model with socioeconomic questionnaire of eight farms was used to estimate the EVs. The breeding objective involved milk production (MP), fat production (FP), lactation length (LL), longevity (L), age at first calving (AFC), calving interval (CL), clinical mastitis (CM) and stillbirth (SB). The economic value of MP, FP, LL, L, AFC, CI, CM, and SB was 0.33, 3.07, 3.56, 0.174, -0.34, -2.12, -38.59 and -8.01 US$, respectively. The highest emphasis on traits in the estimated EVs of the current study was LL (31.41%). It was followed by MY (29.45%), FY (22.78%), CM (11.71%), CI (3.36%), L (0.675), SB (0.0.589%) and AFC (0.019%). This investigation showed that 50% of those studied traits (production traits) positively influenced profitability, and the other 50% (functional traits) negatively influenced profitability. The current study revealed the importance of economic values for production and functional traits in Egyptian buffalo that enable farmers and producers to adjust their selection programs to achieve the highest profitability.

Introduction

The total number of buffalos' population in Egypt is 3.4 million head producing about 45% of total milk production in Egypt (FAO, 2018). Egyptian buffalo has an economic importance for small holders in Egypt. They have a great adaptability to harsh conditions (uneven rainfall, humidity and high temperature). Not only are they well-known for their resistance to long productive life, diseases and parasites, and adaptation to low-quality feed and poor management. But also with inferior reproduction characteristics such long calving interval and days open, late reproductive maturity with higher age at first calving (Amin *et al*., 2021; Aziz *et al*., 2001; Nasr 2017a, b; Safari *et al*., 2019). Furthermore, Italian buffalo is well known for its higher milk yield which is considered the highest milk producers in the world (Varricchio *et al*., 2007). Albeit, Egypt has a larger number of buffaloes than Italy, due to lack of genetic improvement to enhance performance of buffalo in Egypt causing a lesser milk yield. However, Italy has spent immense amount of hard work for recording, selecting, breeding and developing the feeding strategies of Italian buffalo populations (Borghese, 2010).

In an aspiration of imitating the Italian success story, an endeavor has been made by the Egyptian dairy producers to enhance and foster production traits and reproductive fitness of Egyptian buffaloes (Nasr, 2016; Nasr *et al*., 2016; Nasr 2017c). Consequently, there is a request to design genetic improvement programs to improve the production and reproduction traits of Egyptian buffalo with knowing which trait had higher impact on farm profitability (Simões *et al*., 2020).

Designing animal breeding programs depend on defining breeding goals which are linear combinations of breeding values of animals for many traits and their economic values (Safari *et al*., 2019; Theodoridis *et al*., 2018). Study the production cost is very important for breeders and stakeholders to determine which traits have a greatest effect on profitability, consequently, facilitate selection decision (Simões *et al*., 2020). Choosing a trait in genetic selection programs should depend on economic relevance (Amer *et al*., 2001; Campos *et al*., 2014; Pravia *et al*., 2014).

Maximizing profitability of dairy cattle projects is the main goal of the producers (Ghiasi *et al*., 2016). The profitability mainly depends on milk production traits and reproduction traits of animals (Amer *et al*., 2001; Ghiasi *et al*., 2016). The economic traits are either increasing income or lower costs (Safari *et al*., 2019). Milk production is the main income of dairy farms, consequently it is considered the first goal in selection programs. However, selection for milk traits only could decrease revenue and increase production cost through negative genetic correlation with reproduction traits (Ghiasi *et al*., 2016).

Bio-economic model is considered the best method for assessing the economic gain of livestock performance, in addition it helps to determine economic levels of genetic variations of different traits, moreover, to assess the vigor of these traits to fluctuations in environmental aspects and market prices (Åby *et al*., 2012). There is a lake of studies that investigating the economic values of traits in buffalo and to our knowledge this is the first study to describe economic value of important traits in Egyptian buffalo under subtropical environmental condition. Thus, the objective of the current study was to use the bioeconomic model to estimate the economic value of production and functional traits of Egyptian buffalo.

Materials and methods

Four steps were used to identify the breeding objectives (Ponzoni and Newman, 1989). First step is to determine breeding, production and marketing system; second step is to determine the sources of income and expense; third step is to identify the biological traits affecting income and expense; finally, derivation of economic value of each trait.

Production and marketing system

Livestock production systems in Egypt could be classified into three broad categories: I) Mixed Production System, II) Commercial Production System and III) Grazing Production System. In the terms of animal units (AU), about 93% of the total livestock population is involved in mixed (crop/livestock) production systems. Other production systems such as grazing (4%) and commercial (3%) play only a minor role (Tabana, 2000). Although the feeding system differs from farm to another, all of them introduce a meal consisting of concentrates and roughage such as alfalfa and corn silage. The buffalo milk pricing depends on price for kg of base milk (BM) and the percentage of fat content of milk without taking the protein content into account. The base milk is expressed as one kg of milk with 7% fat. The price of milk increases with each percent increase in fat content of milk.

Bioeconomic model

The bioeconomic model was used to analysis the data of production system that obtained from the socioeconomic questionnaire of eight farms in Egypt (Table 1). In the current investigation, prices and costs are presented in US ($). Calves, heifers and buffalo cows were used to calculate profitability. The profit function was evaluated using total income minus total costs. Profit is expressed/cow calving/year. Total profit function as described by Sadeghi-Sefidmazgi *et al.*, (2012) was as the follow:

$$P = \sum_{i=1}^{3} P_i = \sum_{i=1}^{3} (R_i - C_i)$$

P is the total profit of herd/cow/year; P_i, R_i, and C_i, are profits, revenues, and costs, respectively for the given animal group/animal/year. Three groups were used to estimate total profitability in current study (calves, heifers, and dairy buffalo). Costs involved feeding, labor, breeding, veterinary, shelter, fuel, and insurance expenses. While feed prices were dependent on energy and protein supplies. The profit from calves, heifers and buffalo cows' groups was described in details in Sadeghi-Sefidmazgi *et al.* (2012).

The economic value (EV) of each trait is expressed as the difference in profit/unit increase of that trait, with other traits in breeding objectives remain constant. Consequently, EV calculated as the difference between profit (P') after increasing a specific trait one unit and profit of the system (P) (Groen *et al.*, 1997; MacNeil *et al.*, 1994) as follow: EV = (P' − P),

The EV of each trait in the breeding objective was standardized by multiplying it with genetic standard deviation (σ_a) for that trait to produce the relative economic value (REV). The emphasis (as percentage) for each trait was calculated by dividing the REV for that trait into the sum of REV of all traits.

Results

Descriptive statistics of production and reproduction traits used for evaluating the economic estimates are presented in Table 1. Descriptive statistics for unit prices and costs for evaluating the economic estimates are presented in Table 2. Three different group of animals were used to calculate the total profitability from Egyptian buffalo. The first group was calves, and the average baseline profit from calve/cow/ year was 49.97US$, the maximum was 66.99US$, and the minimum was 20.71US$.

The second group was buffalo heifers, and the average baseline profit was 346.07US$, the maximum was 555.95US$, and the minimum was 187.26US$. The last group was buffalo cow, and the average baseline profit was 564.84US$. The maximum was 1036.08US$, and the minimum was 286.05US$. The average total profit from all groups was 960.70US$, the maximum was 16959.04US$, and the minimum was 701.70US$. The feeding cost represents the most significant percentage (about 69.5%) of the total cost in the current study.

The descriptive statics of economic values (EVs) are presented in Table 3. An increase in MY and FY by 1kg changed the profit of 0.33 and 3.07US$/buffalo cow/year, respectively. An increase in LL by 1 day caused a change in profit of 3.56US$ /buffalo cow/year. An increase of the longevity by one month caused a change in profit of 0.174US$ buffalo cow/year. The EV of 1% increase in CM was -38.59US$. Which means that the increase 1% in CM will reduce the profitability by 38.59US$ /buffalo cow/year. For reproduction traits, increased AFC and CI by 1 day decreased the profitability by 0.34 and 2.12US$ /buffalo cow/year. The EV of 1 unit increase in SB rate caused change in profit of -8.01US$ per calf born. The REV, emphasis, GSD and h^2 are presented in Table 4. The highest emphasis of traits in the breeding objective of the current study was LL (31.41%). It was followed by MY (29.45%), FY (22.78%), CM (11.71%), CI (3.36%), L (0.675), SB (0.0.589%) and AFC (0.019%).

Table 1. Descriptive statistics for traits considered for calculation of economic values.

Production item	Mean	SD	Minimum	Maximum
Total milk yield, kg	2142.5	426.04	1760	3080
Total fat yield, kg	176.32	44.21	123.2	246.4
Longevity, year	6.63	1.3	5	8
Age at first calving, month	29.38	2.92	25	35
Calving interval, d	436.25	26.83	395	485
Stillbirth, %	0.04			
Calf mortality, %	0.06	0.02	0.03	0.09
Productive cow mortality, %	0.02	0.01	0.01	0.03
Number of male and female calves	0.76	0.05	0.66	0.81
Involuntary culling rate of calves	0.09	0.05	0.01	0.15
Proportion of male calves sold to feedlot	0.35	0.03	0.29	0.39
Number of female calves/cow/years	0.35	0.03	0.29	0.39
Survival rate of heifers	1	0.01	0.99	1
Involuntary culling rate of all reared female calves	0.04	0.01	0.03	0.05
Body weight of culled calf, kg	60			
Body weight of culled heifer, kg	550			
Body weight of culled cow, kg	650			

SD: Standard deviation.

Table 2. Descriptive statistics for prices and costs considered for calculation of economic values.

Item	Mean	SD	Minimum	Maximum
Price				
Base milk price, $/kg	0.81			
Male calf price, $/calf	478.52	37.78	437.5	525
Replacement heifer price, $/heifer	1375	128.3	1250	1562.5
Accessory payment for milk fat, $/kg	3.13			
Price per kilogram for culled calves, $	3.13			
Price per kilogram for culled heifers, $	3.13			
Price per kilogram for culled cows, $	1.95			
Cost				
Costs per kg dry matter of concentrate, $	0.38			
Costs per kg dry matter of roughage, $	0.19			
Base milk costs, $/kg	0.54	0.07	0.44	0.63
Accessory costs for milk fat, $/kg	0.07	0.06	0	0.21
Calf-rearing costs, $/calf	134.68	9.79	124.62	156.56
Costs of Rearing from 3 months of age to calving, $/heifer	1866.05	152.03	1653.75	2076.25
costs of Rearing from 3 to 23 months of age, $/heifer	1032.58	75.07	955.45	1200.31
Labor cost, $/day/mature buffalo cow	0.52	0.17	0.31	0.75
Veterinary cost, $/year/animal	1.35	0.38	0.60	1.68

SD: Standard deviation.

Table 3. The descriptive statics of economic weights (in US dollars per buffalo cow/year) calculated for studied traits across 8 buffalo dairy farms.

Item	Mean	SD	Minimum	Maximum
Milk yield, kg	0.33	0.05	0.25	0.41
Fat yield, kg	3.07	0.08	2.9	3.18
Lactation length, d	3.56	0.61	2.85	4.7
Longevity, d	0.17	0.08	0.07	0.32
Clinical mastitis%	-38.59	4.64	-44.56	-31.83
Age at first calving, d	-0.34	0.07	-0.46	-0.26
Calving interval, d	-2.12	0.35	-2.59	-1.55
Stillbirth%	-8.01	1.2	-9.64	-6.39

SD: Standard deviation.

Table 4. Economic value, relative economic value (REV), emphasis, heritability (h^2) and genetic standard deviation (GSD) for each trait in breeding objective.

Objective trait	Economic value	REV	emphasis, %	h^2	GSD
Milk yield, kg	0.33	61.5	29.45	0.16	186.41
Fat yield, kg	3.07	47.58	22.78	0.21	15.52
Lactation length, d	3.56	65.6	31.41	0.27	15.91
Longevity, month	0.17	1.41	0.68	0.50	8.13
Clinical mastitis%	-38.59	-24.46	11.71	0.25	0.63
Age at first calving, d	-0.34	-0.04	0.02	0.12	0.19
Calving interval, d	-2.12	-7.02	3.36	0.00	3.31
Stillbirth%	-8.01	-1.23	0.59	0.03	0.15

[1]retrieved from Salem *et al*. (2021); [2]retrieved from Aspilcueta-Borquis *et al*. (2010); [3]retrieved from EL-Hedainy *et al*. (2020); [4]retrieved from Amin *et al*. (2021); [5]retrieved from Salem and Amin (2017).

Discussion

The economic value studies of buffalo are scarce, therefore most of the results obtained in current study compared with dairy and beef cattle. The profit obtained in current study was higher than the profit estimated by Safari *et al.* (2019) in Iranian buffalo. This difference may be attributed to the higher milk and fat yield of the current study (2142.5 and 176.32kg) compared with Iranian buffalo (1050 and 125kg). Hassanvand-Javanmard *et al.* (2017) found that the profit from Holstein cow enterprise in Iran was US$1096.19 that is higher than the profit estimated of the current study. Whereas Holstein cattle are the highest milk producing breed, so it is logical to profit more than buffalo. The feeding cost represents the most significant percentage (about 69.5%) of the total cost in the current study. The obtained results were comparable to the findings of others Safari *et al.* (2019) who found that the feed cost of Iranian buffalo was 78%.

The EVs of MY and FY of current results were close to the results reported by Safari *et al.* (2019), who reported EVs for MY and FY of 0.18 and 4.46US$ in Iranian buffalo. Sadeghi-Sefidmazgi *et al.* (2012) estimated EV in Iranian Holstein, that was 0.15 and 1.36US$ for milk and fat yield, respectively. Also, Gonzalez-Recio *et al*. (2004) reported that the EV of 0.13 and 1.02US$ for milk and fat yield, respectively in Spanish dairy cattle. The EV of LL was 3.56US$ /buffalo cow/year. Although the EV of LL was ignored in all breeding objectives studies of cattle and buffalo, the LL of the current study showed higher EV than that of milk and fat yield. These results indicated that using LL in breeding programs would improve the profitability of buffalo enterprise instead of using milk and fat yield together.

The EV of longevity was 0.174US$ buffalo cow/year. The EV of longevity was estimated to be 88.2 EUR in Finnish Ayrshire dairy cattle (Hietala *et al*., 2014). The high estimate of the previous study was due to the unit of change, which was the year compared with unit of change in the current study which was the month. In addition to, the EV of longevity in Holstein dairy cattle was 10.13US$ (Sadeghi-Sefidmazgi *et al*., 2012) that is higher than the corresponding estimate of the current study. This reflected the importance of longevity traits of Holstein cattle compared with buffalo. The average of longevity for Holstein cattle for example about 3-4 years (Hietala *et al*., 2014; Hu *et al*., 2021; Sadeghi-Sefidmazgi *et al*., 2012), and the corresponding value in the current study was 6.6 years. Although buffalo produce less milk with short lactation length, the yearly profitability of the current study was close to the corresponding estimate of Holstein cattle (Hassanvand-Javanmard *et al*., 2017). This may be due to the high longevity of buffaloes.

The EV of CM was -38.59US$. The clinical mastitis is considered the highest EV in the current study that reflected the veterinary cost to treat it. Hietala *et al*. (2014) estimated the EV for somatic cell score (SCS) to be -84.3 EUR in Finnish dairy cattle. Furthermore, Sadeghi-Sefidmazgi *et al*. (2012) estimated the EV for SCS to be -105.67US$ in Iranian Holstein cattle. For reproduction traits, shortened CI has a greater impact to increase profitability than earlier AFC. These results were in agreement with Sadeghi-Sefidmazgi *et al*. (2012) who reported the EV for previous traits were to be -1.73 and -0.72US$ in Holstein dairy cattle. Also, the EV for AFC and CI in Japanese Black cow to be -7293.9 and -1505.4 JPY (Ogawa *et al*., 2021). The EV of SB rate was -8.01US$ per calf born. This value was higher than the corresponding value (-5.6$ and -4.14 $) that estimated by Hietala *et al*. (2014) and Sadeghi-Sefidmazgi *et al*. (2012), respectively.

Using the economic value for direct comparison among different traits is difficult because economic values were expressed in different units. For the previous reason the REV and emphasis were calculated. The highest emphasis of traits in the breeding objective of the current study was LL (31.41%). It was followed by MY (29.45%), FY (22.78%), CM (11.71%), CI (3.36%), L (0.675), SB (0.0.589%) and AFC (0.019%). Both additive genetic variance and EV affect the relative importance of traits included in breeding objective (MacNeil *et al*., 1994). For this reason, CM was the highest EV but standardized it using GSD made it the fourth trait of the breeding objective of the current study. Moreover, the economic values of studied traits could be ordered by traits category as follows: milk production traits represented about 83.64% followed by health traits about 12.30%, then reproduction traits about 3.4% and finally the longevity traits about 0.675. Therefore, all genetic improvement programs should give priority to improving milk production traits than other buffalo traits. In contrast to our study, Sadeghi-Sefidmazgi *et al*. (2012) found that average relative emphasis were 41, 37.5, 21.5% for production, durability, health and production traits, respectively.

Conclusion

All traits of this investigation had positive consequences on profitability except reproduction and health traits. The EVs of the current study could be organized in four trait group components. First group was the milk production traits that represented 83.64% of emphasis, then followed by health, reproduction and finally longevity traits that represented 12.30%, 3.4% and 0.675%, respectively. These EVs provide farmers and dairy producers with the ability to adjust their breeding objectives to achieve the highest profitability.

Conflict of interest

The authors have no conflict of interest to declare.

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