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Milk Production and Reproductive Performance of Retained and Culled Cows in a Large Holstein Herd in Egypt

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ABSTRACT

The study aimed to identify the culling reasons of Holstein cows raised in a large commercial herd in Egypt with emphasis on the performance of retained and culled cows. A total of 31534 complete lactation records for 10994 cows calved from 2008 to 2019 were used. The overall rate of culling per lactation was 61.1%. Involuntary culling represented 92% of all culling cases. The reasons for culling included mastitis and udder problems (24.2%), reproductive disorders (18.7%), metabolic and digestive disorders (13.6%), lameness (13%), endemic diseases (10.8%), low milk yield (8.1%), respiratory diseases (4.3%) and unknown causes (7.3%). Means of 305-day milk yield and daily milk yield were significantly lower in culled cows than the retained ones. On the other hand, no significant differences were observed between culled and retained cows for days open and the number of services/conception. The high involuntary culling rate of Holstein under the Egyptian conditions revealed that management practices regarding mastitis prevention and reproductive efficiency should be improved.

Keywords: Culling reasons, Egypt, Holstein, Milk production, Reproductive performance

INTRODUCTION

Culling refers to the process of removing animals from the herd. Culling could be voluntary due to low milk production or sale of excess animals or could be involuntary, as a result of illness, injury, infertility, or death. Both types of culling are applied to keep herd economics high. However, a high rate of involuntary culling reduces the herd profit, particularly for high-yielding cows. Replacement of heifers necessitates replacing culled cows. which adds a financial load on the dairy unit where rearing replacement of heifers represents about 20% of total variable costs (Karszes, 2014).

Culling strategies vary from one farm to another. These strategies can be also modified within the same farm over time. Culling decision is a complicated process since one should consider the price of culled cows, availability of replacement heifers within the farm, and the cost of rearing replacement heifers. Pinedo et al. (2010) studied cows calved between 2001 and 2006 in the Eastern United States and found that the main culling causes were death (20.6%), reproductive problems (17.7%), injury/other (14.3%), low production, and mastitis (12.1% for each). However, in the Polish population of Holstein, Adamczyk et al. (2017) found that the primary reasons for culling were reproductive disorders (39.6%) and udder problems (15.5%). In Spanish dairy cattle farms (2006-2016), Armengol and Fraile (2018) found that reproductive disorders were the most frequent reason for cow removal (30.2%), followed by low milk yield (23.4%), accidents (7.7%), diseases (7.2%), locomotor disorders (2.4%), and obstetrics (2.4%). Doornewaard et al. (2018) also stated that the main reasons for culling dairy cows in Wageningen, Netherland were reproduction failure, mastitis udder health, low production, and leg diseases. The rate of culling varies due to parity, stage of lactation, breed, and management strategies (Pinedo et al., 2014). De Vries (2017) reported that the rate of culling was within the range of 28-64%.

In Egypt, Holstein cattle are the main dairy cattle in commercial farms which supply the local market with milk stably and steadily. Egypt lies in the semi-arid subtropical zone where the temperature and humidity are high mainly in the summer season, besides, there are limited feed and water resources. Thus, dairy farms in Egypt have to pay for imported feeds and vaccinations and also for installing and maintaining cooling systems. These harsh conditions markedly increase culling rates, shorten Holstein's longevity, and rise the cost of raising replacement heifers. Breeding programs should take into consideration the way to diminish the causes of involuntary culling. Therefore, it is necessary to identify the reasons for culling Holstein cows raised in Egypt.

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Although the performance of Holstein in Egypt has been intensively studied, few available reports are found concerning culling reasons, therefore, the objective of this study was to identify the culling reasons, as well as, investigating the performance of retained and culled cows in large Holstein herds in Egypt.

MATERIALS AND METHODS

Source of data

Data used in the present study were collected from Dina farm, one of the largest commercial dairy farms in Egypt. This farm is placed in the Menoufia governorate in northern Egypt. The geographical coordinates of the farm are 30.14°N, 30.33°E. The location is characterized by a subtropical climate with humid summers and relatively mild winters. Data of 38060 lactation records for 12259 Holstein cows were obtained from the herd management software of Dairy Comp 305 (Valley Ag Software, Tulare, CA). A total number of 31534 records of complete lactations for 10994 cows, calved from 2008 to 2019 were extracted from the whole data and used in the current study.

Herd management

Cows were housed in shaded free stall barns with a concrete floor. Heifers were served for the first time at about 370 kg body weight and frozen semen was used in insemination. Machine-milking three times/day was performed at eight-hour intervals and cows were dried off two months before the expected calving dates. The farm was provided with a cooling system. All cows were housed, fed, and milked under the same conditions and received the same management.

Studied traits

The productive traits: included the standard lactation length (305-dMY, kg) and daily milk yield (DMY, kg).

The reproductive traits: included days open; the days from calving until conception (DO, days), and the number of services per conception for each cow (NSPC).

Data analysis

The statistical analysis was performed using the XLSTAT version 2020.3.1. The following model was applied to analyze productive and reproductive traits:

$$Y_{ijklm} = \mu + L_i + P_j + Y_k + S_l + (L_i \text{ X } P_j) + b\,(x_{ijklm} - \bar{X}) + e_{ijklm},$$

Where, Y_{ijklm} is an observation of productive or reproductive trait, µ denotes the overall mean, L_i refers to the fixed effect of the ith longevity class, (i=1,2), 1 explains cows have subsequent record(s) (retained), and 2 means cows have no subsequent records (culled), P_j is the fixed effect of the jth parity order, (j = 1, 2,…, and 6), 1=1st, 2=2nd, 3=3rd, 4=4th, 5=5th and 6=6th, Y_k serves as the fixed effect of the kth period of calving, (k = 1, 2, 3), 1 = 2008-2011, 2 = 2012-2015, and 3 = 2016-2019, S_l stands for the fixed effect of the season of calving (l = 1, 2, 3, 4), l refers to Winter (December-February), 2 denotes Spring (March-May), 3 explains Summer (June-August) and 4 indicates Autumn (September-November), $L_i XP_j$ is the interaction between longevity class and parity order, b accounts for the linear regression coefficient of the studied trait on age at first calving, x_{ijklm} shows the age at first calving, $\bar{X}$ signifies the overall average of age at first calving (AFC, month), and e_{ijklm} is random residual effect.

All possible interactions were tested, but only the interaction between longevity class and parity order was significant, therefore, the used model included only this interaction.

RESULTS AND DISCUSSION

Culling rate per lactation

The numbers and percentages of retained and culled cows across parities are shown in Table 1. The overall average culling rate was high (61.1%). The semi-arid subtropical climate prevailing in the farm location, particularly in summer times, may cause heat stress as well as adverse fertility and milk production process, and encourage causes of various diseases. Haine et al. (2017) and Rilanto et al. (2020) reported lower culling rates (35% and 26.2%, respectively) than that obtained in the present study. Bahrampour et al. (2016) stated that culling risk was clear in warm, dry, and semi-arid regions, compared to temperate or cold and wet regions. Moreover, cows in large herd sizes are more exposed to be culled as a result of stressful mechanization, less individual care, and greater levels of physiological pressure. Jankowska et al. (2014) stated that culling rates were mainly high (92%) in herds keep > 100 cows.

The culling rate increased with the parity order until the fourth one (58.1%, 59.9%, 63.4%, and 68% in the first four parities). Culling rates in the fourth to the sixth parities were higher than those in the first to third parities. The high culling rate in older cows found in the present study was also declared by Mostafa (2009), Ansari-Lari et al. (2012), and Bahrampour et al. (2016). Old cows are more susceptible to culling since they gradually consume the energy reserve in

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their bodies during milk synthesis, and pregnancy as well as overcoming diseases until they become unable to continue in the herd.

Culling reasons across parities

Table 2 presents the culling reasons across parities. The involuntary reasons formed about 92% of total culling cases. Mastitis and udder problems, as well as reproductive disorders, were the primary reasons forcing to cull cows, representing about 43% of culling cases. The same results were reported by Ansari-Lari et al. (2012) although the overall value of culling was lower (17.5%). Metabolic and digestive disorders and lameness had almost the same contribution in culling cases (about 13%). Endemic diseases were responsible for one-tenth of culling cases, whereas culling due to respiratory diseases was the lowest (4.3%). Reproductive disorders were the primary reasons for culling in the first and second lactations indicating 27.2% and 21.5% of culling cases, respectively.

Regardless of the parity order, reproductive disorders represented the second main reason for culling in this study (18.7%). The same result was obtained by Boujenane (2017) and Karrar et al. (2017). They stated that reproductive disorders were responsible for 12.5-47% of culling cases. The high risk of culling due to reproduction failure in dairy cattle has increased throughout the world as a result of intensive selection for milk yield for decades. An increase in milk yield is accompanied by a reproduction decrease due to the negative correlation between production and reproduction (Knob et al., 2016). In the present study, the proportion of culling due to reproduction disorders decreased with the increase in parity number. It is similar to the finding of Armengol and Fraile (2018) who declared that the role of reproductive failure as a culling reason greatly decreased after the third lactation. This is because cows with reproductive problems are gradually excluded from the herd.

Mastitis and udder problems were the first reasons for culling in the third till the sixth parity. The culling due to mastitis and udder problems increased as the cows got older, representing one-third of total culling in the sixth parity. The increase of culling due to mastitis and udder problems with parities was also stated by Esslemont and Kossaibati (1997). The culling of cows infected with frequent mastitis aims to reduce the risk of new infections within the herd. Mastitis is not only accompanied by a reduction in milk yield and quality, but also by its negative effects on reproduction (Pinedo et al., 2016). As it is associated with long DO, high NSPC, decrease in conception rate, and increase in early abortion (Kumar et al., 2017). The change in percentage of culling due to low milk yield or respiratory diseases across parities was narrow. The percentage of culled cows due to metabolic and digestive disorders was almost constant throughout lactations, ranging from 13% to 15%. Metabolic disorders as a reason for culling were also reported by Chiumia et al. (2013) and Rilanto et al. (2020). High milk-producing cattle are challenged by high metabolism which could put stress on these cattle causing metabolic disorders.

Lameness is the second reason for culling in the fifth and sixth parities. It is highly related to the number of parity. Similarly, Egger-Danner et al. (2015) and Gross et al. (2016) reported lameness as a reason causing culling. In the present study, the overall percentage of culls that occurred due to lameness (13%) was higher than 9.9%, 3.5%, and 2% reported by Olechnowicz and Jaskowski (2011), Ansari-Lari et al. (2012), and Karrar et al. (2017), respectively. The high rate of lameness may be rooted in the high humidity in stall barns and poor hygienic conditions surrounding cows, where cows stand in the slurry for a time on the concrete floor. The increase of culling due to lameness in old cows was also observed by Olechnowicz and Jaskowski (2011). They reported that culling due to lameness increased from 3.5% in the first lactation to 9% in the seventh one. Lameness and locomotive disorders make cows unable to perform their daily activities. So, it negatively affects milk production and reproductive performance (Pinedo et al., 2016).

Endemic diseases are viral infectious diseases. They are represented by lumpy skin disease (LSD, 42%), bovine ephemeral fever (BEF, 39%), and foot and mouth disease (FMD, 19%). They recorded the greatest percentage (16.5%) in the first parity and reached the lowest in the sixth one (6.3%). The endemic diseases are one of the causes that raise the involuntary culling rates in dairy herds in endemic countries, compared with other countries as the case in the current study. Outbreaks of these diseases occur in summer when the weather is hot and humid. The LSD and BEF are transmitted by biting insects (Sprygin et al., 2019) and FMD is spread by contact, polluted farming equipment, vehicles, clothing, or feed, and by domestic and wild predators (Salam et al., 2015). They greatly cause economic losses due to decrease in milk yield and fertility, increase in abortions, and embryo losses as well as difficulty in animal movement, vaccination, and treatment cost, all in all, may sometimes cause mortality induced by secondary bacterial infections (Ahmed and Dessouki, 2013; Knight-Jones and Rushton, 2013). Although vaccination is obligatory in Egypt, outbreaks of LSD and FMD still occur. The vaccine used against LSD depends on using strains derived from sheep. It was confirmed that these strains are not effective enough to beat the virus (Allam et al., 2020). Moreover, with the import of animals from endemic African countries and the high mutation rate, there is a possibility to develop new strains of FMD that could resist the currently used vaccine. Until developing proper vaccines for endemic diseases, management procedures should prevent the spread of infections. Applying programs that include biosafety and insect control could help in reducing the infection rate.

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Table 1. Numbers and percentages of retained and culled Holstein cows raised in a large herd in Egypt during 2008-2019

Longevity class	**Overall rate (%)**	**Parity**												**Total**
		First		**Second**		**Third**		**Fourth**		**Fifth**		**Sixth**		
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Retained	38.9	1583	41.9	1345	40.1	775	36.6	338	32	166	34.7	66	31.9	4273
Culled	61.1	2199	58.1	2009	59.9	1342	63.4	718	68	312	65.3	141	68.1	6721
Total	100	3782	100	3354	100	2117	100	1056	100	478	100	207	100	10994

Table 2. Culling reasons across parities for Holstein cows raised in a large herd in Egypt during 2008-2019

Culling reason	**Overall average (%)**	**Parity**												**Total**
		First		**Second**		**Third**		**Fourth**		**Fifth**		**Sixth**		
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
-Mastitis and udder problems	24.2	320	14.5	424	21.2	336	25.1	201	28.1	79	25.3	44	31.2	1404
-Reproductive disorders*	18.7	598	27.2	433	21.5	230	17.2	120	16.7	50	16.1	19	13.5	1450
-Metabolic & digestive disorders	13.6	289	13.1	285	14.3	176	13.1	95	13.2	41	13.2	21	14.8	907
-Lameness	13.0	178	8.1	188	9.3	162	12.1	83	11.5	55	17.6	27	19.2	693
-Endemic diseases**	10.8	362	16.5	246	12.2	129	9.6	82	11.4	27	8.6	9	6.3	855
-Respiratory diseases	4.3	110	5.1	83	4.2	62	4.6	32	4.4	16	5.2	3	2.3	306
-Unknown	7.3	179	8.1	174	8.6	129	9.6	44	6.2	18	5.7	8	5.6	552
Subtotal	91.9	2036	92.6	1833	91.3	1224	91.3	657	91.5	286	91.7	131	92.9	6167
-Low milk yield	8.1	163	7.4	176	8.7	118	8.7	61	8.5	26	8.3	10	7.1	554
Total	100	2199	100	2009	100	1342	100	718	100	312	100	141	100	6721

***Reproductive diseases included dystocia, metritis, pregnancy toxemia, uterus prolapse, uterus adhesion, and repeat breeder. ****Endemic diseases included lumpy skin disease (LSD), Bovine ephemeral fever (BEF), and Foot and mouth disease (FMD)

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Table 3. Least squares means of productive and reproductive traits for retained and culled Holstein cows raised in a large herd in Egypt during 2008-2019

Classification	N	305-dMY		DMY		DO		NSPC	
		LSM	SE	LSM	SE	LSM	SE	LSM	SE
Overall mean	10994	9321	28	26.2	0.05	161	1.0	3.4	0.03
Longevity class		***		***		NS		NS	
Retained	4273	9465 b	49	26.4 b	0.12	162 a	2.7	3.5 a	0.07
Culled	6721	9177 a	29	26.1 a	0.09	160 a	2.0	3.4 a	0.05
Parity order		***		***		***		***	
1	3782	9063 a	28	27.9 b	0.09	216 d	1.9	4.6 d	0.05
2	3354	9080 a	26	25.9 a	0.08	183 c	1.8	4.0 c	0.05
3	2117	9308 b	33	25.8 a	0.10	163 b	2.2	3.6 b	0.06
4	1056	9364 bc	109	26.2 a	0.15	141 a	3.4	3.0 a	0.09
5	478	9509 c	49	26.2 a	0.22	140 a	4.9	3.0 a	0.13
6	207	9605 c	71	25.7 a	0.34	124 a	7.5	2.5 a	0.20
Period of calving		***		***		***		***	
2008-2011	1833	9163 a	40	25.7 a	0.12	168 b	2.8	3.2 a	0.07
2012-2015	4620	9270 b	29	25.8 a	0.09	177 a	2.0	4.0 b	0.05
2016-2019	4541	9530 c	36	27.3 b	0.11	138 c	2.5	3.1 a	0.06
Season of calving		***		***		***		***	
Winter	2873	9192 a	35	25.9 a	0.11	163 b	2.4	3.4 b	0.06
Spring	2350	9266 a	36	25.9 a	0.11	174 c	2.5	3.8 c	0.06
Summer	2535	9393 b	35	26.5 b	0.11	160 b	2.5	3.5 b	0.06
Autumn	3236	9435 b	36	26.7 b	0.11	147 a	2.3	3.0 a	0.06
Longevity class X Parity		***		***		***		***	
Reg. on AFC		***		**		***		**	

LSM: Least squares means, SE: Standard error, 305-dMY: 305-day milk yield, DMY: Daily milk yield, DO: Days open, NSPC: Number of services per conception, AFC: age at first calving. Within each classification in the same column means followed by different letters differ significantly, **: ($p < 0.001$) and ***: ($p < 0.0001$).

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Milk production and reproductive performance of retained and culled cows

According to Table 3, culled cows recorded significantly lower means of 305-dMY and DMY than retained ones ($p < 0.0001$). All productive and reproductive traits were significantly affected by parity order ($p < 0.0001$). Primiparous cows recorded the lowest values of 305-dMY (9063 kg), then the value increased gradually till reached 9605 kg at the sixth lactation. The DMY decreased by an increase in parity, the primiparous had the highest value (27.9 kg/day), compared to those in the other parities. The effect of year and season of calving and the regression on age at first calving were significant on all investigated productive and reproductive traits.

Although the productive performance of culled cows was significantly lower than retained ones (Table 3), there were no significant differences in either DO or NSPC. Kalantari and Cabrera (2015) proposed that the relationship between infertility level and farm economics may not be linear and many aspects are included when estimating the losses. Moreover, the increase in NSPC and DO which result in longer calving intervals may lead to prolonged lactations as it is a herd management approach followed in the intensive dairy system in hot regions (Flores et al., 2019). The reason is that the hot climate adversely affects the conception rate and more services are needed for conception (Mellado et al., 2016). In this case, extending the calving interval may not negatively influence the profits of the farm (Inchaisri et al., 2011). Conversely, the extension of calving intervals may offer economic advantages and permits the herd managers an option for decisions regarding high-yielder cows having reproductive disorders. This could reduce the involuntary cow culling (Rodríguez-Godina et al., 2021). With the progress of parity, lower NSPC and shorter DO were recorded which was similar to the results reported by Wondossen et al. (2018). This may explain the decrease in the proportion of cows culled due to reproductive disorders with the increase of parity number. Wondossen et al. (2018) attributed the longer DO in younger cows to the requirements needed for maintenance, growth, and milk production at an early age.

The interaction effect of longevity × parity order

Effects of longevity class × parity on productive and reproductive traits are presented in Figures 1-4. In the first parity, significant differences appear clearly between retained and culled cows for all the studied traits. Figure 1 shows that values of 305-dMY of retained cows were higher than those of culled ones in all parities except for the sixth one. The same trend is also displayed in Figure 2 for DMY. Figures 3 and 4 show the traits of DO and NSPC, respectively. Their values were both significantly higher in the first parity in culled cows, compared to the retained ones ($p < 0.0001$). Their values became almost similar in the subsequent lactations compared to retained ones. Significantly greater values of DO and NSPC in culled cows were also reported by Mostafa (2009). . Moreover, it is observed that curves for both productive (Figures 1 and 2) and reproductive traits (Figures 3 and 4) belonging to retained cows show more fluctuations than curves of culled cows. This may express the effort done by retained cows to overcome challenges using different internal mechanisms to keep their performance high. So, Adriaens et al. (2021) reported that perturbation in production curves is a good approach to measure how cows respond to challenges.

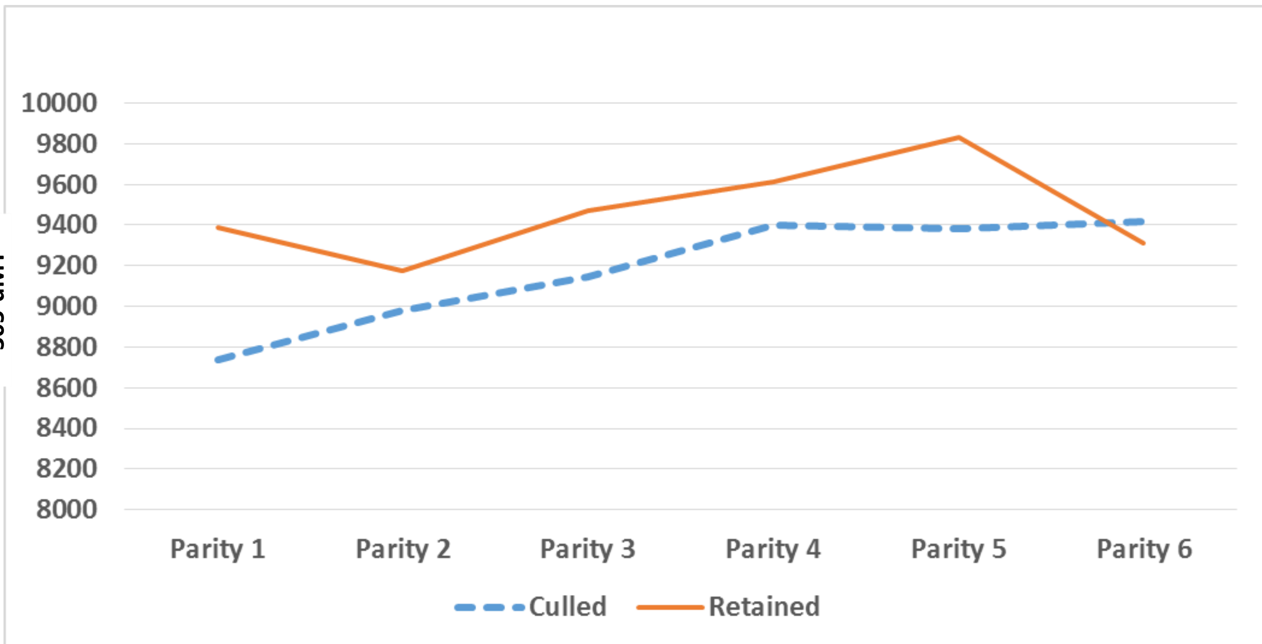

Figure 1. The interaction effect of longevity class x parity order on 305-day milk yield of Holstein cows raised in a large herd in Egypt during 2008-2019

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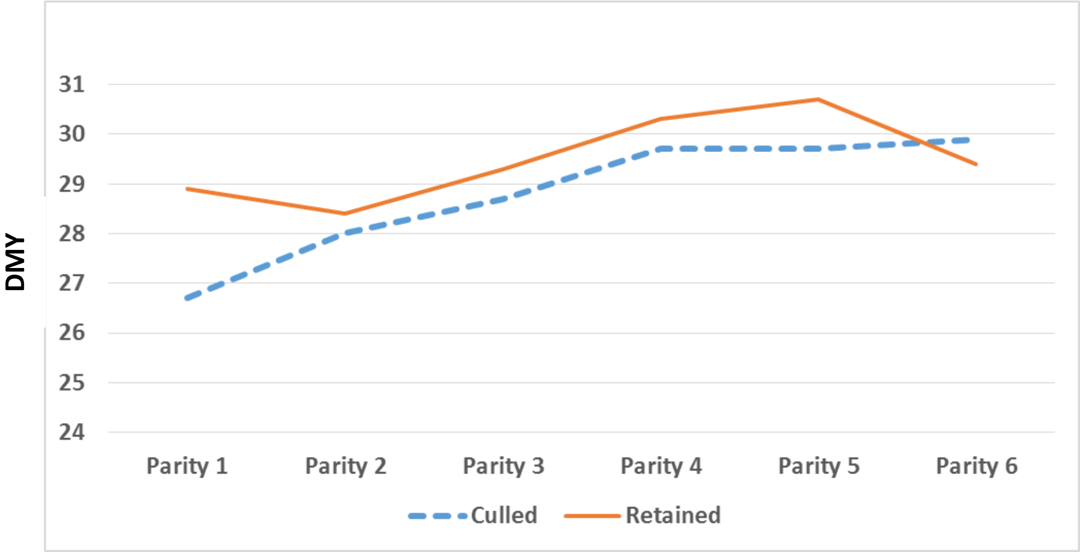

Figure 2. The interaction effect of longevity class × parity order on daily milk yield of Holstein cows raised in a large herd in Egypt during 2008-2019

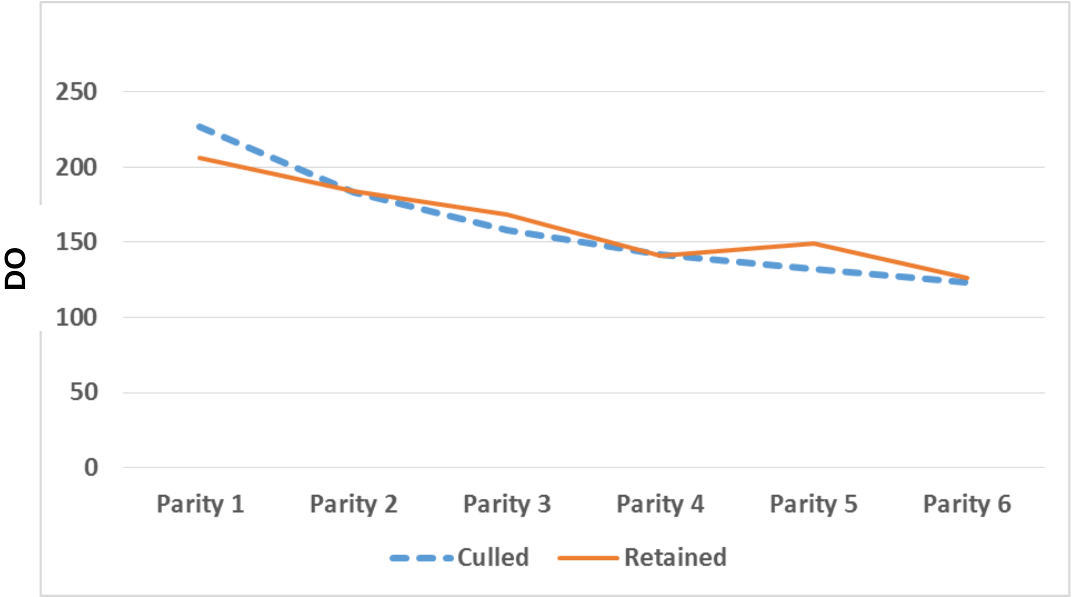

Figure 3. The interaction effect of longevity class × parity order on days open of Holstein cows raised in a large herd in Egypt during 2008-2019

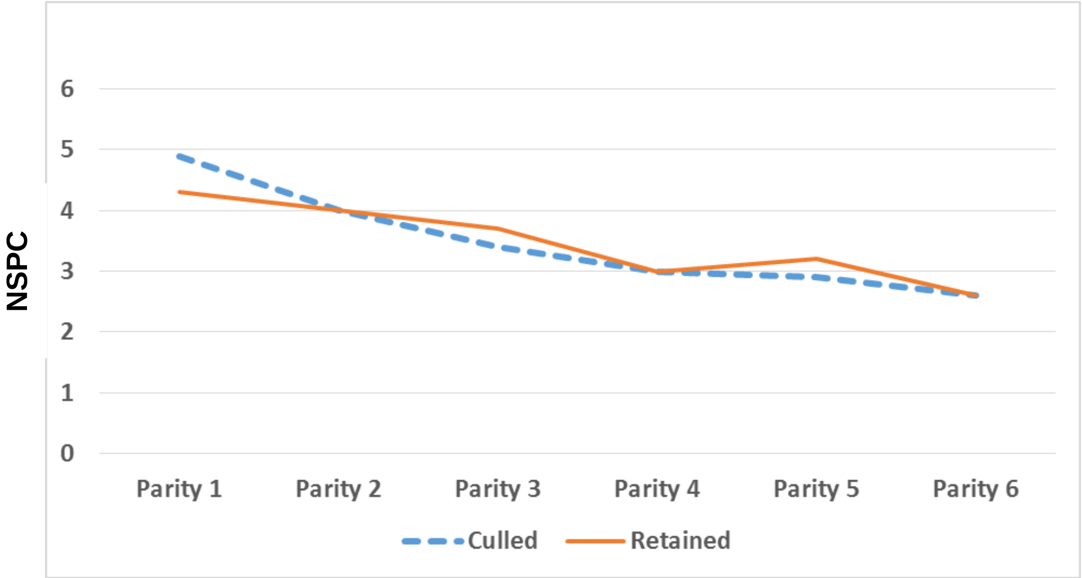

Figure 4. The interaction effect of longevity class × parity order on the number of services per conception of Holstein cow raised in a large herd in Egypt during 2008-2019

CONCLUSION

In Egypt, the culling rate for Holstein cows was higher than expected. Mastitis and udder problems and reproductive disorders were the primary causes for involuntary culling. Milk production performance of culled cows was significantly lower than that of retained ones. However, there was no significant difference between retained and culled cows regarding reproductive performance. To reduce the culling rate, it is important to set management programs that include good farming practices for mastitis prevention and improvement of reproductive efficiency.

DECLARATIONS

Authors' contribution

Nadia H. Fahim analyzed the results and wrote the manuscript, M. A. M. Ibrahim performed the statistical analysis, A. H. Amin collected the data and R. R. Sadek suggested the topic and revised the manuscript.

Competing interests

The authors certify that there is no conflict of interest.

Ethical consideration

Ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked by all the authors.

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