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RESEARCH ARTICLE

Effect of Milk Yield on Economic Profitability of Holstein Friesian Cows under Intensive Production System in Egypt

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ABSTRACT

Data of productive and reproductive traits of 1961 of lactation records were obtained from 763 Dutch Friesian cows grew up at Wadi El-Sharkia farm, El-Salheia, Egypt. These data were analyzed to empirical comparison between the profitability of three herds under intensive production system in Egypt. The second herd (H_2) produced average milk yield of 8619 kg/lactation, followed by first herd (H_1) (5138 kg/lactation) which was lower than the H_2 by at least one standard deviation (SD = 2935 kg). The third herd (H_3) produced high milk yield equal to the average of H_2 plus at least one standard deviation. Traits studied were milk yield per day (M/D, kg), total milk yield (TMY, kg), lactation period (LP, day), dry period (DP, day), annual milk yield (AMY, kg), days open (DO, day), number of services per conception (NSPC), calving interval (CI, day), number of lactation completed (NLC) and age at first calving (AFC). Least squares analysis of variance showed highly significant ($P<0.01$) effects of all factors on all traits studied except the effect of month and year of calving on NSPC that was non-significant. For comparing between the three herds, the deterministic model was used to estimate the annual gross margin and benefit/cost ratio as economic parameters. Prices of inputs and outputs were based on market and farm gate prices during the period from 1998 to 2007. DO, CI and NSPC were increased in H_3 vs. H_2 and H_1, indicating poorer reproductive efficiency of high yielding herd. Moreover, H_3 gave 1.03 and 1.5 parity less for each cow than that of H_2 and H_1, respectively. Economic evaluations indicated that the annual variable cost were (LE) (Egyptian pound = 0.17 USD and = 0.13 EUR) 5136, 6910 and 7845 of H_1, H_2 and H_3, respectively. However, the annual gross margin of H_3 was higher than that of H_1 and H_2 by 79 and 24%, respectively, and the benefit/cost ratio of H_3 was 1.90 relative to 1.63 and 1.68 for H_1 and H_2, respectively. The profit per cow during the lifetime production of H_3 was 72 and 19.04% more than of H_1 and H_2, respectively. It is concluded that under intensive production system, extension of calving interval for high yielding herds seem more profitable than the herds that have shorter calving interval and lactation period.

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INTRODUCTION

Profitability of dairy cows is influenced by the herd's level of production and reproduction (Baharizadeh, 2012). Milk yield is considered the major source of farm revenues (Rehman and Khan, 2012). Annual milk yield is an index, which reflects the intensity of lactation and combines milk yield and reproductive efficiency of a dairy cow (Gorgulu, 2011; Katok and Yanar, 2012). Producing more milk annually is a primary measure of efficiency because maximum production of dairy cows has typically occurred with optimal management conditions (Kellogg *et al*., 2001; Khan *et al*., 2012). Milk production in Egypt is less than the threshold of self-sufficiency representing 72% of the domestic demand (MALR, 2000). Because the low milk production of local breeds, exotic breeds are adopted to increase milk production in commercial herds where intensive systems are followed.

The revenues of milk production depend on the reproductive efficiency of the herd (Ahmed *et al*., 2000). Days open and NSPC of the cows have been studied by several investigators due to the economic importance

associated with the reproductive efficiency and fertility in dairy cattle. They are important in determining calving interval and influencing milk production (Ali *et al*., 2003; Riecka and Candrak, 2011). Regular calving (every 12-13 months) is one of the main targets of dairy farmers. Thus, we can reach the available maximum number of lactations per lifetime production of cows and provide the farmer with more progenies for replacement or sale.

Long calving interval may be the main reproductive disorder of high yielding dairy cattle. Mainly, that is due to either low conception rate (40-50%) and/or high early embryonic mortality (Rossi *et al*., 2008). The poor reproductive performance of high yielding cows may affect the overall economic performance of the herd especially under high ambient temperature (Jainudeen and Hafez, 2000).

We can judge the profitability of farm by the gross margins of the enterprise. A major reason for difference of gross margin is the level of yield obtained and price of the products. High yielding cows need additional costs. When this incurred, we must take the decision based on whether the extra returns would be greater than the additional costs involved or not. Therefore, the aim of the present study was to evaluate the economic performance of three Holstein Friesian herds having different levels of milk production and calving intervals under intensive farming system.

MATERIALS AND METHODS

Data and management: Productive and reproductive data of 1961 lactation records, starting from 1961 to 2007, obtained from 763 Dutch Holstein Friesian cows mating by 171 sires, belonging to Wadi El-Sharkia farm, El-Salheia, Egypt, were analyzed for empirical comparison between the profitability of three herds under intensive production system. According to the level of milk yield, the records were divided into three herds. The first herd (less than 20 kg/day) having average milk production decreased at least by one standard deviation ($x^- - 1$ SD, SD = 2935 kg), the second herd (between 20-25 kg/day) had milk production equal to the average of Holstein Friesian under the intensive dairy farms in Egypt (8719 kg). The third herd contained the high yielding cows (more than 25 kg/day) which produced more than the average milk production at least by one standard deviation.

Animals of the three herds were kept under the same system of feeding and management in the original farm. Cows were fed according to their live body weight, milk production level, and pregnancy status (National Research Council, 2001). Cows were fed on corn silage along with Egyptian clover (*Trifolium alexandrinum*) for about six months during the year from December to May with concentrate ration. During summer and autumn cows were fed by corn silage along with Barseem hay and concentrate ration (total mixed ration). Percentage of protein in the concentrate mixture ranged from 17 to 19% for high milk yield herd, from 16 to 17% for medium milk yield herd and from 14 to 16% for low milk yield herd. Clean water and mineral mixture were available all time. Cows were artificially inseminated within 12 hours after the detection of heat using frozen semen (Friesian Bulls) imported from Germany, Netherlands and USA. Pregnancy test was made after 42 days of insemination by rectal palpation. Cows in estrus before pregnancy test were artificially inseminated immediately. Cows were initially served 60–70 days after parturition. Cows with less than 3 or more than 5 lactations were excluded.

Cows were milked 2-4 times daily according to their milk production level. Milk yield was recorded to the nearest 0.1 kg daily at each milking. Costs and revenues were estimated according to technical coefficients and management practices in the farm.

Traits, technical coefficients and assumptions: Data were statistically analyzed to estimate the productive technical coefficients of the three herds. The terms of productive traits study were, milk production per day (M/D, kg), total milk yield (TMY, kg), lactation period (LP, day), dry period (DP, day), and annual milk yield (AMY, kg equals TMY, kg divided by CI in days multiplied by 365), while reproductive traits terms were, days open (DO, day), number of services per conception (NSPC), calving interval (CI, days), number of lactations completed [parities of the cow (NLC)] and age at first calving (AFC). Table 1 shows assumptions that were adopted in calculating the farm budget.

* Number of lactations completed (NLC) by herd 1 (H_1) assumed to be 4 according to (El-Gharabawy, 2008) as a control.
* Culling age = [AFC of H_1 + (4 NLC x CI of H1)]
= (24 month x 30.5 day) + (4 x 442)
= 732 + 1768 = 2500 days (6.85 years).
* The prices of inputs were estimated based on the market price during the period from 1998 to 2007.
* The prices of outputs were estimated based on the Wadi El-Sharkia farm gate price during the period from 1998 to 2007.
* Gross margin is one of the more realistic measures to evaluate farm profitability (Barnard and Mix, 1993). To compare among three herds, the annual gross margins as well as, discounted measure, benefit/cost ratio (present worth of benefits divided by present worth of costs) were used as economic tools for comparing three herds.

Statistical analysis: Data were analyzed using General Linear Model (GLM) procedure of SAS (2006) to determine the fixed effects and to develop technical coefficients of the three herds. The statistically model included months (1 to 12) and years (1998 to 2007) of calving, parity of cow (1 to ≥5), herds (1, 2 and 3). The following statistically model was used:

$$Y_{ijklm} = \mu + M_i + R_j + T_k + H_l + \beta\,(AFC) + e_{ijklm}$$

Where:
Y_{ijklm} = observation of productive and reproductive traits,
μ = the overall mean,
M_i = fixed effect of month of calving k (i=1, 2,…,12),
R_j = fixed effect of year of calving l (j =1, 2, …….,10),
T_k = fixed effect of parity m of the cow (k=1, 2,…….,≥5),
H_l = fixed effect of herd level production (l =1, 2 and 3),
β = the linear regression coefficient of the studied trait on AFC and
e_{ijklm} = random error.

RESULTS AND DISCUSSION

Means and standard deviation (SD) for productive and reproductive traits studied in all parities at three herds are shown in Table 2. TMY of H_3 increased as 1.60 and

2.71 times more than H_2 and H_1, respectively, while H_2 increased as 1.70 times more than H_1 for the same trait. The results showed that H_3 had poorer reproductive performance than H_2 and H_1. Table 2 indicated that high milk producer cows had longer interval from calving to the conception. This consequently prolonged the calving interval due to the increase in number of services per conception by about 1.44 times (H_3 vs. H_2), 2.25 times (H_3 vs. H_1) and 1.56 times (H_2 vs. H_1).

This result may be attributed mainly to the negative energy balance of the high yielding cows particularly during the peak of lactation (Rossi *et al*., 2008). High milk production mainly at high ambient temperature can cause physiological stress that may lead to a depression of the interior pituitary secretion. Such depression causes delay in resumption of ovarian activity post-partum which explains the increase of post-partum service interval. Moreover, the early embryo mortality (Dunne *et al*., 2000) is a major cause of reproductive failure in cattle and of serious financial loss to dairy and beef farmers, therefore, leading to increased number of services per conception and prolonged calving interval. The low reproductive efficiency for high milk producing cows observed in the present study was similar to those reported by Muller *et al*. (2000) and Rossi *et al*. (2008).

Economic evaluation: Income (gross output) of H_3 was more than that H_2 and H_1 as about 17.61 and 62.91%, respectively, while H_2 increase than H_1. This may be attributed to the higher milk revenues. The current study showed 75.84, 83.65 and 88.11% of the total gross output for H_1, H_2 and H_3, respectively (Table 3).

Annual variable cost per cow of H_3 was higher ($P<0.01$) than those of H_2 and H_1 by about 13.53 and 52.78%, respectively, while H_2 was higher than H_1 by about 34.57%. This difference among three herds can attributed mainly to the extra feeds to cover extra milk production, labor and semen cost for breeding, while cows in H_3 needed more semen doses to get pregnant. Feeding represented the major element of the variable cost. It represented 91.53, 92.62 and 93.97% for H_1, H_2 and H_3, respectively (Table 3).

In Morocco, Taher (2011) revealed that a balanced development of the dairy chain urgently requires a fairer distribution of the revenue it generates. And this will require negotiation among all operators on such issues as milk prices and quality assessment, so that they are all remunerated according to the value of their efforts. This will create business climate conducive to further investment in the dairy chain.

The current results revealed that, although the H_3 needs a cost of 13.53 and 52.78% more than the H_2 and H_1, respectively, due to the high needs of the production milk and even though the revenues that come from the calves of the H_3 are less than of H_1 and H_2 by 30.39 and 22.66%, respectively, because of low reproductive efficiency, the annual gross margin of H_3 increased by 79 and 24.00% than H_1 and H_2, respectively. Also benefit/cost ratio increased in H_3 by 27 and 22% than H_1 and H_2, respectively (Table 3). Ahmed *et al*. (2002) worked on two herds, the first (H_1) was supposed to produce milk equal to the average lactation milk yield and the second (H_2) to produce high milk yield equal to the average plus at least one standard deviation. They found that the annual gross margin of H_2 increased by 18.5 and 3.9%, respectively as compared with H_1.

Table 1: Assumptions adopted in calculating the farm budget

Items	Herds		
	H_1	H_2	H_3
* Number of cows (763)	168 (22%)	435 (57%)	160 (21%)
* Mature body weight (kg)	550	600	600
* Average of age at first calving(months)	24.00	25.82	27.66
* Conception rate per herd (%)	90	82	78
* Calf sale price at birth (L.E)**	2000	2000	2000
* Semen dose (LE.)	50	50	50
* Annual veterinary care cost (L.E)	65	80	100
* Annual manure production per head (m^3)	15.0	16.5	19.0
* Price of m^3 manure (L.E)	25	25	25
* Rectal palpation/time (L.E)	20	20	20
* Sale price of 1 kg milk in farm (L.E)	1.5	1.5	1.5

** The Egyptian pound is the current legal currency of Egypt. The pound is divided into 100 piaster (qirsh) or 1000 milliemes (malleem). The ISO 4217 code for the Egyptian pound is EGP. Locally, the abbreviation LE or L.E., which stands for livre égyptienne (French for Egyptian pound), is frequently used. E£ and £E are also much less-frequently used. The Egyptian Arabic name, ginaih, may be related to the English name guinea and L.E = 0.17 USD and = 0.13 EUR).

Table 2: Means and standard deviations for productive, reproductive and lifetime production traits for the three herds investigated.

Trait	Herds		
	H_1	H_2	H_3
Productive traits			
Daily milk yield (M/D, kg)	5.06±0.27^c	22.41±0.78^b	26.32±0.64^a
Total milk yield (TMY, kg)	5138±742^c	8719±839^b	13935±808^a
Lactation period (LP, day)	58±13.06^c	396±11.52^b	528±9.80^a
Dry period (DP, day)	83.70±3.77^c	96.53±5.91^b	108.41±4.88^a
Annual milk yield (AMY, kg)	4243±669^c	6482±870^b	8030±913^a
Reproductive traits			
Days open (DO, day)	158±4.21^c	211.80±7.66^b	359±10.57^a
No. of services per conception (NSPC)	1.53±0.04^b	2.39±0.09	3.44±0.09^a
Calving interval (CI, day)	442.0±11.8^c	491.50±5.3^b	635.0±8.6^a
No. of lactations complete (NLC)	4.51±0.36^c	4.04±0.17^b	3.01±0.29^a
Age at first calving (AFC)	24.01±1.03^c	25.82±1.99^b	27.66±2.21^a

^{a,b,c}Means with different superscripts are significantly different at $P<0.01$.

Table 3: Analysis of the annual gross output (income) and variable costs per cow of the three herds

Item	Herds		
	H_1	H_2	H_3
Gross output (income)			
Milk	6364	9723	12045
Calves	1652	1487	1150
Manure	375	413	475
Total gross output	8391	11623	13670
Variable cost (outcome)			
Feeding	4700	6400	7215
Insemination	50	100	140
Palpation	20	30	40
Veterinary care	65	80	100
Labor	300	300	350
Total variable cost	5135	6910	7845
Gross margin	3256	4713	5825
Benefit / cost ratio	1.63	1.68	1.90
Annual gross margin (consider H_1 as the unit)	1.00	1.45 (H_2 vs H_1)	1.24 (H_3 vs H_2) 1.79 (H_3 vs H_1)

From the economic point of view, the average of the annual variable cost of H_1 decreased than H_2 by 26% and H_3 by 36%, therefore, these cows are suitable under small farmer's conditions while cows in H_3 are desirable under

intensive production system. Due to longer calving interval of H_3, each cow gave 1.03 and 1.5 parity less than that of H_2 and H_1, respectively (Table 2). In this respect, Ahmed *et al*. (2002) reported that the high yielding cows gave 0.9 parity less than that of the H_1 which produced the average lactation yield of Holstein. Results of Table 4 showed that the average variable cost for the whole lifetime production of H_3 exceeded that of H_1 and H_2 by 46.62 and 9.36%, respectively. On the other hand, the total gross output of H_3 exceeded those of H_1 and H_2 by 56.00 and 13.28%, respectively. Moreover, the profit per cow during the lifetime production of H_3 was 72 and 19.04% more than of H_1 and H_2, respectively.

Table 4: Financial analysis (LE) for lifetime production per cow of the three herds and percentages of difference among herds investigations

Item	Herd			% difference between the herds		
	H_1	H_2	H_3	H_2 vs H_1	H_3 vs H_1	H_3 vs H_2
Cross output	45815	63231	71630	+38.00	+56.00	+13.28
Variable cost	28037	37590	41108	+34.01	+47.00	+9.36
Gross margin	17778	25641	30522	+44.04	+72.00	+19.04

Khan *et al.* (2010) calculated the economic profitability for Red Chittagong cows (RCC) under the rural area in the Chittagong district of Bangladesh by using a deterministic linear model. The income was derived from the sale of milk, beef and manure and costs included only for feed and fixed costs. The milk payment for the farmers was based on milk volume only and was used to calculate the profit. They found lower profitability than the present finding. Also they added that differences of profitability were attributed due to the differences of the prices of feed, milk, meat and the differences of breeds.

Uddin *et al*. (2010) concluded that the degree of intensification and potential availability of input and support services play a great role in reducing the costs by increasing the return and improving productivity. The institutional arrangements and natural resource endowments in each system also influence the costs of inputs and support services. They added that the intensive dairy farming system produces higher milk with lower cost, hence it is more competitive. Moreover, the intensive farmers are at better position in terms of costs and profits than extensive and traditional systems and are more competitive, due to lower per unit costs, higher milk prices, higher milk production, higher land and labour productivity.

Conclusion: From the results, it can conclude that under the intensive production system, high milk producer cows with longer calving interval are more profitably than those having regular calving every 12-13 months, regardless the value of genetic losses in the form of heifers for replacement and/or bulls for insemination. This needs more investigations to quantify the value of such losses and its impact on herd dynamic. Furthermore, from the genetic point of view, criteria of selection planning would be more efficient when information comes from high yielding cows.

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