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10 October 2014

Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 4(3) pp. xxx-xxx, March, 2015.
Available online http://garj.org/garjas/index.htm

Full Length Research Paper

Techno-Economic Factors Affecting Genetic Investment in Dairy Cattle in Egypt

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ABSTRACT

Vertical expansion in Egyptian livestock is the only feasible approach for development, particularly, milk production. This is due to lack of natural range, enough feed supply and competition between food production and feed production in using the very limited water resources supply and irrigated agricultural land in Egypt. In addition Egypt has a comparative advantage in milk production. However, the milk yield of the domestic cattle is still much below the world average. Vertical expansion means to raise the productivity, via genetic investment. The study used a field sample survey data to apply a designed mathematical investment flow model up to fifth calving of the dam's daughter, to test the impact of a set of technical and economic factors on the predicted economic rate of return (ERR) of the genetic improvement via an artificial insemination (A.I) program of the domestic dairy cattle.

The results showed that (ERR) at the most probable level of both economic and productive variables was 23.3%, when A.I. of a sire's semen with PDM around 865 Kg **of** milk was applied, which was much higher than the average interest rate in Egyptian market (14%) and the inflation rate in milk price (11%). If the genetic improvement faced 10% increase in the number of services for conception, age at first calving and calving interval, the ERR decreased by 6%. An increase in the feed costs by 10% regressed the ERR by 7%. A 10% increase in the number of service for conception, age at first calving and the calving interval decreased the ERR by 3.1%, 2% and 1.1%, respectively. Such model is suitable for assessment of the feasibility of genetic improvement programs in developing countries.

Key Words: Vertical expansion, Genetic investment in dairy cattle, Economic Rate of Return

INTRIDUCTION

There are evidences that Egypt has a comparative advantage in milk production, rather than red meat production, (Soliman and Mashhour, 2004). Therefore, the feasible development plan supposed to give the first priority for increasing the domestic milk supply rather than red meat production, particularly that, import prices of fresh milk and dairy products are too high as highly perishable food commodities, (Soliman & Basioni, 2012). The importance of increasing the domestic production of milk in Egypt via genetic improvement stems from the lack of horizontal expansion in cattle population due to the limited feeds production because of water and agricultural land resources constraints. In addition, there is high competition between human demand for food production and livestock demand for feed production from such limited resources and Egypt has almost no natural range land, (Sharaf, Soliman and Salim, 1987). The main fodder is Egyptian clover (Berseem). It is a winter season crop (Oct. – May) which determines the milking head numbers and then the calf-crop. Therefore, the increase in dairy heads beyond the carrying capacity goes for slaughter, (Soliman, 2007). Above all, the milk yield of domestic cattle is below the world average, while there is a deficit in domestic milk production to cover the Egyptian effective demand, (Soliman, 2008). Accordingly, the only possible approach for livestock development in Egypt is to fix the stock capacity within the balanced number with feed availability, and focusing on the vertical expansion in yield, particularly, milk yield, (Soliman, 2007).

As livestock is a dynamic investment model of production not as ordinary investment types that characterized by depreciation pattern and treated via a systematic annual cash flow of inflow of costs and outflow of revenues, it needs special financial treatment, (Soliman, 1985). The time horizon of the project life span is determined by the production cycle of the dairy cow and its daughters. The reproductive criteria are all functions of time. The major reproductive criteria are age at first calving, service period, calving interval. The milk yield level and persistency period requires adjustment for cow age and milking season order (Mashhour, 1995). Feed efficiency is also an important techno-economic variable that affect the milk productivity and profitability and represents the highest proportion of the operation costs of dairy cattle farms, (Brown, 1979). Most, of text books on feasibility studies of agricultural projects avoided such dynamic models, (Lumby, 1991), (Gittenger, 1982), (Barnard, and Nix, 1979), (Brown, 1979). Even the previous studies applied assessment of the sire's Predicted difference restricted the analysis to compare among sires in terms of the net present value (NPV) of the first caving of the daughter, (Blake, 1989) and (McMahon, 1985). This study has designed and implemented a mathematical model to estimate the economic rate of return (ERR) along the full productive life of the daughter of the cow served by A.I of the concerned sire's semen. Thereof, the study compared scenarios of the most probable estimates of ERR versus less productive and/or economic unfavorable level of milk price, price of one unit of the sire's semen, feed costs, age at first calving, number of A.I. services required for conception and calving interval.

The study was keen to quantify the productive and reproductive performance of domestic dairy cattle, either the commercial or the traditional farming system, from a sample field survey. This is because most of the published estimates of the Egyptian livestock performance were from official farms (either experimental-state farms or extension farm stations). Therefrom, such published data carried much of either positive or negative biasness, (Nigm and Soliman, 1986).

DETA BASE

The data of the reproductive and productive performance criteria of the domestic dairy cattle were derived from a sample field survey in 2013. The sample strata represented the traditional mixed (livestock and crop production) small farming system and the commercial specialized livestock system. The commercial system was classified as large scale farms (more than 50 dairy cows) and small ones (less than 50 dairy cows).The sampling method was a proportioned stratified cluster random sample. The clusters were from two governorates in the East Nile delta region, which hold more than one-third of the livestock population in Egypt (Dakahlia and Sharkia governorates). The strata were the farm size classes. The total sample size was 100 farms. The subsample size of the commercial farms was 50 farms. They were classified as 33 large commercial farms and 17 small commercial farms. The subsample from traditional small farm system was 50 farms. They were selected randomly under each farm size class. They were proportional as their percentage in the cattle population structure. Therefore, 44 farms were less than 5 feddans (1-feddan = $4200M^2$), i.e. 88% of the total and 12 farms with more than 5 feddans, i.e. 12% of the total. As the traditional farms are of mixed system (cattle and buffalo), the study focused only on the cattle herd on these farms. It should be mentioned that the small farms usually do not keep livestock production records, (Soliman, 2013). However, the researchers designed the questionnaire form to be able to predict the required reproductive performance criteria, assuming that the farmers usually remember the important dates along the productive cycle of his (her) herd. This, mainly, because he (she) holds almost few breeding heads and the stall is at the back of the household's house.

METHODS & ANALYTICAL PROCEDURES

The presentation of the analytical procedure was presented in a comprehensive approach via four sections. These are: the model's hypothesis, the model's equations, the definition of the model's variables and the model's assumptions.

The Model Hypothesis

The cash flow of the investment analysis, as a stream of both inflows (costs) and outflows (benefits) was not the classical one that changes annually, due to the nature of reproductive cycle of dairy cattle which is identified by variables that are measured in days and months. These performances are mainly the service period (the period between calving and conception of the cow), the calving interval (the sum of the gestation period and service period or a lactation period and dray period), the average number of services required for conception. Therefore, the discounting procedure used to estimate the discount rate that maximizes the return to investment was on nonsystematic periods measured in months. In addition the outflows (revenues or benefits) are generated from the improved milk yield of the daughters of the inseminated dam from the concerned breeding sire. That sire supposed to transfer what is called the "**Predicted Selection** Difference of milk of the semen**, i.e. PDM**". It is a potential quantity of milk which is expected to be added to the average yield of his daughters. The investment costs in this study, was the price of the units of A.I from a certain sire's semen. The level of such price is associated with the volume of PDM. The only considered operating costs in this model were the feed costs. This is because the feeding policy is considered a variable affecting, directly or indirectly, the productive and reproductive performance of cattle, (Pryce, 2001), (Mara, 2005). Even though, the model is valid for being expanded to include other operating costs.

The Mathematical Model's Equations

The model composes of seventeen equations, some are structural equations and others are definition ones:

$$\mathbf{NPV = nP_1 - nP_2\,(1+i)^{-a} - nP_3\,(1+i)^{-b} + I_1(1+i)^{-c} + I_2(1+i)^{-d} + I_3(1+i)^{-e} + I_4(1+i)^{-f} + I_5(1+i)^{-g}} \quad \text{(1)}$$

$$\mathbf{i = r_c - r_p} \quad \text{(2)}$$

$$\mathbf{\sum NPW = Zero \sim I = ERR} \quad \text{(3)}$$

$$\mathbf{n = 100/\ ACR} \quad \text{(4)}$$

$$\mathbf{ACR = CR\,(1 - MR/100)} \quad \text{(5)}$$

$$\mathbf{I_k = M_k\,(1\text{-}R)} \quad \text{(6)}$$

$$M_k = P_m (PDM/MEM_k) W_1 + P_f (PDF/MEF_k) W_2 + p_p (PDP/MWP_K) W_3 \quad (7)$$
$$R = (M_a - FC)/M_a \quad (8)$$
$$CI = LP + DP \quad (9)$$
$$Pk = Ps * E \quad (10)$$
$$a = AGC \quad (11)$$
$$b = a + CI \quad (12)$$
$$c = b + AGC + 0.5LP \quad (13)$$
$$d = c + CI \quad (14)$$
$$e = d + CI \quad (15)$$
$$f = e + CI \quad (16)$$
$$g = f + CI \quad (17)$$

Definition of the Mathematical Model's Variables

NPV = Net present value
n = Average number of semen units per calving interval, for k intervals, where k = 1, 2, 3, **4, and 5**
ACR = Average calving rate (%)
CR = Conception rate from the 1st service (%)
MR = Mortality rate of females (%)
P_k = Real price per unit of semen of the concerned sire ($) at calving interval k
P_s = price per unit of semen of the concerned sire measured in Egyptian pounds (EGP) at calving interval k
E = Exchange rate of 1-EGP for 1-$. It was 7.06 EGP/$ in 2013
AGC = Age at first calving in months
r_c = interest rate in the Egyptian financial market
r_p = inflation rate of producer milk price
$\mathbf{r_m}$ **=** **(**r_c/12) monthly interest rate in the Egyptian financial market
I_k = gross margin above feed costs at calving interval k, generated by a daughter of the concerned sire in (EGP)
M_k = Milk income of the predicted selection difference of milk adjusted for Mature equivalent factor to milk, to adjust predicted difference for fluid milk, to predicted differences in the k lactation
PDM = Predicted selection difference for milk yield (Kg) for the concerned Breeding Sire
MEM = the mature equivalent factor to adjust predicted difference for milk to predicted differences in the k lactation
P_m = Average price/ 1-kg of milk at the base year (EGP)
R = Percent of feed costs in total milk income from a daughter of the concerned Breeding sire
M_a = Average income of milk production of milking season a
CI = Calving interval
DP = Dry period

The Model's Assumptions

(1) The investment period expanded to 10 years, as the outflows of the genetic investment cover the five successive milking seasons of a daughter of the domestic dairy cow served by the concerned sire, (2) The average age at the first calving was estimated from the field survey data, (3) An assumption was applied that the first replacement heifer of the offspring comes from the second calving of the served dairy cow, (4) An assumption was applied to avoid the exact date of the

conception, where the cost of the semen insemination was allocated at the onset of each calving interval, (5) The gross margin above the feed costs were introduced in the mode as a ratio of the total income, (6) As the model focused on genetic improvement of the milk yield and assuming that the off-take rate for slaughter is mainly affected by the calving rate and calves mortality rate, thereby the income generated from the calves crop was neglected, (7) The minimum nominal interest rate was the interest rate associated with the loans for purchasing cattle for breeding in 2013, (8) Such interest rate was used as a standard to compare it with the rate of investment generated from the dairy cattle genetic improvement. The later was considered feasible if it was higher than the standard rate and also above the inflation rate in milk price, (9) the base period was considered as the time of introducing the first semen service, (10) the discounted net present value was calculated on monthly base rather than yearly base

RESULTS & DISCUSSION

The most probable reproductive performance of the domestic dairy cattle was presented in (Table, 1). The average age at first calving was around 33.7 months and the calving interval reached 387 days. The required number of services for conception was around 1.59. However, the impacts of the cow age and the order of the lactation season have been taken into consideration via correction for the Mature Equivalent Factor of milk, (MEM), of Dairy cattle as shown in (Table 2)

Table 2, shows the mature equivalent factor (MEM) to adjust predicted difference of milk (PDM) in the k lactation. It is assumed in the implemented model that the mature calving season is the 4^{th} season. At the mature season the predicted difference of milk would reach its full performance, i.e. MEM equals 1, and no more increase in the milk yield of the daughter. Therefore, the increase in the daughter milk yield would reach its full potential incremental increase (865 kg) of milk, as PDM in (Table 1). Such amount would be fully added to the average milk yield per cow of the herd.

The most probable Economic Rate of Return (ERR) was the discount rate, which made the sum of the Net Present Value (NPV) equaled zero, at the most probable levels of the performance profile shown in (Table 1). It was around 23.3% (Table 3). It was much higher than both annual inflation rate in milk price (8.5%) and interest rate of loans for purchasing cattle (14%), presented in (Table 1). Therefore, the genetic improvement in domestic dairy cattle is significantly feasible. The number of milking domestic cows in Egypt was around 1.58 million heads in 2012, (FAOSTAT, 2013). Thereof, an expected additional increase in domestic milk supply per year due to genetic investment would be around 1.367 million tons. Such incremental quantity reached around 42% of the existing cattle milk production of Egypt, which was around.325 million tons in 2012 (FAOSTAT, 2013.)

The sensitivity analysis of the ERR towards Undesirable deterioration in reproductive performance of the domestic cattle would affect negatively such return to genetic investment, (Table3). A 10 percent increase in the number of services for conception, associated with a decrease at the same rate in age at first calving and calving interval would aggregately decrease the ERR to 17.3%, even though still feasible (higher than the interest rate on livestock loans). However it weakened the competitive opportunity of such development program to compete for getting national finance among other candidate programs for development. An increase in feed costs by 10% showed the highest negative impact on ERR. It dropped by 7% to reach around 16%. Such increase in feed costs could be due to either an increase in feed prices and/or a decrease in feed efficiency.

The most effective reproductive performance criterion was the number of services required for conception. An increase of 10% in such number would decrease the ERR by 3.1%, followed by the age at first calving, where an increase in such age by 10% would decrease the ERR by 2%. An increase in the calving interval would decrease the ERR by 1%.

Precise heat detection on time and proper application would help in decreasing the number of services required for conception. It, also, would shorten the service period and consequently the Calving Interval. A training program for the inseminators and dairy cattle holders, associated with sufficient communication system for calling the inseminators on time and availability of sufficient infrastructure and transportation in the villages would be the basic elements of a successful genetic improvement program. A proper feeding system for replacement heifers would enable them to reach the appropriate age for breeding. Accordingly, they would reach a less age at first calving. Livestock Extension institutions and finance institutions should work on a target oriented credit line to approach such goals.

The model presented in this study is recommended for assessment of the feasibility of the A.I program applied in many developing countries for genetic improvement of the domestic dairy cattle. Other traits of milk quality, particularly milk fat and milk protein contents could be added to the model when such quality criteria have significant impacts on milk demand and price.

Table 1 Average Prices and Reproductive traits Introduced in the Model

Variable	Symbol	Unit	Average
Farm Gate Price of Milk	P_m	EGP	2.50
Interest rate on breeding cattle loans	r_c	%	14%
Annual Inflation rate of producer Price milk	r_p	%	8.5
Average Monthly Interest rate	rm	%	1.2%
Semen Price per unit	P_s	EGP	157.80
Proportion of milk Cost in Total Revenue	R	%	0.55
Expected Selection Difference of the semen	PDM	Kg	865.00
Average Number of services for Conception	ACR	number	1.59
Conception rate from the First Service	CR	%	81.08
Adjusted Conception Rate	ACR	%	72.03
Mortality rate of Dairy Cows	MR	%	1.88
Age at the First Calving	AGC	Month	33.71
Lactation Period (Days)	LP	Day	243
Dray Period	DP	Day	144
Calving Interval	CI	Day	387
Service Period	CP	Day	117

Source: Compiled and Calculated from:

(1) Field Sample Survey Data,

(2) USDA (2013) "DHIA Active AI Sire Summary List" , December, 2013

Table (2) Mature Equivalent Factor of Dairy cattle

Calving Season	kg of Milk	Mature Equivalent Factor
1st	1,400	1.28
2nd	700	1.12
3rd	300	1.05
Mature	0	1

Source: compiled from: Miller, Paul (1985)

Table (3) predicted the Most Probable Economic rate of Return and Sensitivity Analysis

Variables of The Investment Analysis Model	Expected Change	Estimated ERR	Change from the most probable rate
The Most Probable level of All variables	None	23.29%	None
Change in milk price	10% decrease	19.90%	3.39%
Change in semen unit price	10% Increase	20.22%	3.07%
Change in proportion of feed costs in milk income	10% Increase	16.26%	7.04%
Change in average number of services for conception	10% Increase	20.22%	3.07%
Change in age at the first calving	10% Increase	21.37%	1.93%
Change in calving interval	10% Increase	22.19%	1.11%
Change in all reproductive performance criteria	10% more	17.29%	6.00%

Source: Calculated from the Model Equations (1-17) and Tables (1 and 2)

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