Optimization Of Selection For Multiple Traits Using An Economic Model For Layer Chicken Enterprise

Ali Alshami

Abstract: This paper discussed how to optimize production traits for two layer breeds in Egypt. The first breed is indigenous Fayoumi and the second exotic Leghorn. Both breeds have their different performances and each breed was preferred over the other for some particular traits. By crossing the two breeds, the crossbreds could benefit from the strengths of the purebreds for particular traits. The economic model has been developed for commercial layer enterprise in Egypt to determine the economic value of genetic change for various traits. The economic value was then used in selection index to optimize selection for multiple traits. The economic model was also used to compare the performance of purebreds, crossbreds, and the hybrid line. In general the profits in F1 crossbred and hybrid line were higher than those in Leghorn and Fayoumi at following values of $2065, $1987, $1681 and $1763, respectively.

Introduction:

People started to domesticate poultry poultry includes chicken, duck, etc., please be specific! in South Asia approximately 2,000 years ago Looks incorrect unless a reference to support this claim!. The first type of domesticated bird was called the Asian Red Jungle Fowl, which is the origin of our modern poultry breeds. A widely held belief is that this type of bird originated in China (Ketelaars, 2005). The different poultry breeds began to spread around the rest of the world, where they all evolved and began to differ from each other in appearance and performance. Today, most poultry enterprises depend upon pure breeds such as the White Leghorn, but are divided into different groups of crossbreds. Most commercial layer farms use crossbreds for breeding stock of various purebred lines that are kept by large breeding companies (Ketelaars, 2005. Egg production is influenced by many factors which include environmental and genetic factors. The environmental factors such as climate which may be hot in tropical areas and disease infections effect on egg production of layer hen. There are some traits which are related to egg production which effect the production Unclear writing!. Some of these traits have direct effect on egg production whereas others have not incomplete sentence! (Morris, 1980 and Koutoulis, 1997). Poultry breeding programmes have been developed for many years, especially in broilers and layers.In the 1940s, there were already many instances in poultry breeding where Mendel's principles and selective breeding from superior parents were applied to produce new offspring (Ketelaars, 2005). Mendel's theory suggested that the genes have two copies from each parent's side (maternal and parental) and their offspring inherit just half of those copies from each side (50% from the mother and 50% from the father). At that time, reproductive technologies such as artificial hatching, incubation and lighting programmes started to be applied as well.

- *Ali Alshami under supervision of Prof/ Julius van der Werf (2013), New England University. Armidale, NSW, Australia.*

Fisher's theory in 1918 suggested that there are many genes that contribute to quantitative traits of chickens. This theory has shown how the quantitative traits transfer from one generation to another. There are covariances between phenotype and breeding value, and between relatives. There is a heritability that determines what parts of phenotypic differences are passed on (Fisher, 1918). A breeding program is defined as a structured program to change the genetic composition of the population on the basis of objective performance standards. In poultry, the most common breeding programs involve genetic selection within a population and crossbreeding between populations (or selection lines).There are many studies that have addressed the issue of optimizing such breeding programs. Some of those studies highlighted the advantages of the crossing between local breeds and exotic breeds. The local breed has the ability to adapt to the local conditions, but their productive characteristics are low. The exotic breeds have usually a low ability adapting and high productive performance. Crossing can occur in design crossing system, where the pure parental lines are kept and each generation of first cross is produced for entering a commercial production unit. Alternatively, once the parental lines are crossed, further breeding can occur from these crossbred animals, i.e. first cross animals (F1) are mated to form an F2, etc. This crossing of lines into a new breed is called a composite, where the individuals in that generation get the benefits from both parents (Besbes, 2009). In breeding programmes, a chicken breeder is able to improve his flock and reach a high level of performance and production efficiency. Poultry breeding programmes typically use selection within lines or breeds, but the commercial product is ultimately a crossbred chicken, resulting from several lines (usually 4). Genetic information on crossbred animals could be valuable in breeding programmes, as it would more directly reflect the breeding objective, which is production efficiency in crossbreeds. However, obtaining information on crossbreeds is more difficult than obtaining it on pure breeds, as the latter material is usually measured in the nucleus (Ketelaars, 2005).

Egg production traits of study:

Egg production is a complex metric trait affected by the growth period of the pullet. The study of egg production and its related traits, such as age and body weight at sexual maturity and rate of laying, attracted the attention of several investigators who found that there were wide variations in these traits among different breeds of chickens (El-Soudany 2000; Iraqi et al. 2007). Partial recording of egg production in hens was used to increase the efficiency of genetic selection as well as to shorten the generation interval. The results of many studies showed that a high genetic gain could be obtained in egg production when using partial recording (El-Labban et al. 1991; El-Labban et al. 2011).

Egg number (EN):
This trait is defined as the average of number of eggs produced by the hen during a production period (year). It can vary between layer breeds; it is about 280-300 eggs/hen/year for the White Leghorn and about 180-250 eggs/hen/year for the Fayoumi. At the beginning of a production period, the number of laid eggs is small, and then it grows rapidly up to the normal average (one egg per day at least). In this study, the benefit of this trait is increased egg production when it is assumed to be improved by one unit (1 egg), which leads to increase the profits that come from that extra egg number.

Body weight at sexual maturity (BWSM):
In general, the layer breeds are characterized by low weight when the hen reaches production time, but it depends upon the type of breeds. The heavier breed is more likely to give more profits as salvage value at the end of production period. The average body weight at sexual maturity is about 2 kg for the WL and 1.7 kg for the FAY. There is a negative relationship between body weight and age at sexual maturity, as the hen starts to lay eggs with minimum weight. There is a negative genetic or phenotypic correlation between body weight and egg production, and there is a positive (unfavourable) correlation with age at sexual maturity. The benefit of this trait is that each increase in body weight of chicken leads to raise the profits more. Those profits gain from sale of bird as salvage value/kg.

Age at sexual maturity (ASM):
The ASM is measured as the age at which the hen begins to lay her first egg. The layer breeds differ in this trait. For example, in the WL breed, the hen starts to lay eggs at 25 weeks of age while the ASM is 24 weeks of age for the FAY. Both breeds seem to be able to reach the ASM early. The benefit of this trait is that the hen starts early to lay and the production period will be longer. Once the age at sexual maturity declines by one unit (1 day), the egg production increases and leads to increase in incomes of extra produced eggs. In other breeds such as the Rhode Island Red, the hen starts to lay eggs at 24 weeks, and the Barred Plymouth Rock starts to lay eggs at 32 weeks.

Survival ability (SA):
Survival ability is defined as the ability of the bird to survive until the first day of the production period, i.e. survival of the adolescent period. The importance of this trait is that the egg production which produce from survival birds increase with increase the survival ability as well as the incomes those comes from the eggs increase. This trait is high in indigenous breeds such as the Fayoumi, which has 90% survival rate under different conditions (including rural conditions), whereas the exotic breeds such as the White Leghorn has low survival ability (70%) under significant conditions. Crossing the Fayoumi with other standard exotic breeds improved egg size, growth rate and adaptability to farm conditions in Bangladesh (Ali, 1989). A crossbreed of the Fayoumi female and the Rhode Island Red male has a higher egg production and a better chance of survival under semi-scavenging conditions compared with other exotic breed combinations (Rahman et al. 1997).

Disease resistance (DR):
Disease resistance is defined as the ability of the animal not to get sick during the laying period. There are some diseases which affect the egg production of laying hens, such as coccidiosis and Marek's disease. The exotic strains have poor immune system, whereas the local chickens have high immunity, which help them to resist disease Mostly it is about tolerance rather resistance!. Infected birds will have lower egg production and potentially die, therefore effectively producing fewer eggs than healthy birds. Birds that get sick will have lower egg production. Once the number of resistant birds rises the extra produced eggs from those birds will lead to increased income and profit. At the same time, the infected birds produce about 75% of egg production of healthy birds. The studied breeds, WL and FAY, have different percentages of disease resistance, around 50% and 70%, respectively, Which means there are 50% of the birds from WL in the flock are infected and others resisted whereas there are 70% of the birds from FAY are resisted and 30% are infected. In previous studies, it has been found that the WL has low resistance for some diseases, such as Marek's disease. On the other hand, studies reported that the FAY has a high percentage of this trait, which its offspring will inherit when crossing these two breeds. The level of disease resistance of chicken breeds has been found to differ depending upon the bird body's immune system and the genes that are responsible (Hossary and Galal 1994). In the study the economic model will be developed for a commercial layer enterprise in Egypt, to determine the value of genetic changes in the population. The model yields an economic value of genetic trait changes, as used in selection index, and to compare profitability of pure and crossbred genotypes, that differ in trait means. The improvement focuses on the commercial traits of the birds, such as egg production traits: egg number, body weight and age at sexual maturity, survival ability, and disease resistance, to have the required outcomes for the poultry enterprise.

Materials and methods:
Developing a model to predict the economic efficiency of various genetic improvement programs by showing the profits of a farm of layer chickens and know which genotype is more profitable. Firstly, defining a breeding objective, nominates the traits of value that improvement is sought for, and derives their economic weight using a production model. Secondly, describing a method to predict a response to selection within pure lines using selection index theory. Thirdly, predicting performance of crossbreds, and selection response in a hybrid line and presents the genetic parameters and other variables that are relative to this model study. Eventually, the efficiency of a crossbred system with ongoing selection in the pure breeds is compared with ongoing selection in a cross of the parental lines (i.e. forming a new hybrid line). A production model for a layer farm of 500 birds is used to derive the profit based

on a set of trait averages. This model can be used to assess the change in profit of individual trait changes (giving economic values for the breeding objective traits) and it can be compared with such changes for a set of trait means relevant to the two different pure breeds (Leghorn which is an exotic breed and Fayoumi which is an endogenous breed in Egypt) or a hybrid line. To derive the total number of animals needed for each breeding system, it is assumed that for each purebred or hybrid line a nucleus is needed using 100 sires (roosters) and 500 dams (hens). Genetic and phenotypic parameters used in this study included heritability, phenotypic standard deviation, and phenotypic and genetic correlations among the egg production traits.

Economic model:

The study focuses on five common traits, which have different performances in both purebreds in Egypt. These traits include egg number, body weight and age at sexual maturity, survival ability, and disease resistance. Table 1 shows the mean performance of purebreds (Leghorn and Fayoumi) of those traits.

Table (1): Mean performance of purebreds (Leghorn and Fayoumi) in some traits.

Traits \ Bree	Egg number (egg/hen/yr)	Body weight* (kg)	Age* (week)	Survival ability (%)	Disease resistance (%)
Leghorn	280	2.5	25	70	50
Fayoumi	240	2	24	90	70

Source: El- Hossari (1997), and Rajput et al (2005). *body weight measured at sexual maturity, *age recorded at sexual maturity.

The incomes and costs of the farm are calculated and then the profits are derived from this. The incomes of each trait can be divided into two main items including egg incomes and bird sales at the end of the production period as shown in Table 2. The management costs include all services that need to be provided to the flock during production period like energy costs, labour costs, vaccination costs, and fixed costs which are constant on the farm and do not directly depend on the trait means. The incomes components of the farm include eggs incomes/flock, which is calculated as shown in the formulas in Table 2, as well as the salvage value, i.e. the price for the meat of the bird after its egg laying cycle is completed. Survival rate is defined as the percentage of birds that does not die during brooding period and will actually start laying eggs. Disease resistance rate is defined as the percentage of birds that starts with the laying period and produces normally, whereas the infected birds will have subdued production levels. The income from sale of a bird will depend on its body weight. In terms of costs components, the farm has several elements of costs including feed costs, maintenance costs, brooding costs, and fixed costs (Table 2). All of these costs will explain how they are calculated in the following formulas in the table below. Net incomes of each trait have been increased by increasing the incomes from egg production or sale of birds. The costs mostly change with that increase. Profit changes come from increase in the production of egg and kg of sold bird as the traits improved such as egg number, body weight, and age as well as the increase of the number of survived or resistant birds resulting in produce more extra eggs and lead to increase the profits. All the traits contribute to the profits where the productions of egg and birds number increase as a result of improvement of those traits. The 500 hens in the flock produce a particular number of egg/yr depending on the breed. If egg number increases by 1 unit per bird, the whole farm production will increase, leading to an increase in profit. With higher body weight, the hen to be sold after the egg laying period will give a higher salvage price. The age at which the hen starts to lay is different among the breeds. For instance, Leghorn hen starts at 175 days of age, while Fayoumi hen starts aerial at 168 days of age. This trait improves by declining the days of age leading to a longer production period. Survival ability is defined as the number of birds that will survive and produce normally and also this trait differs between the layer breeds. When the number of surviving birds increases the farm egg production will increase and there will be more profits. Similarly, disease resistance trait refers to the number of resistant birds. Those do not suffer from common disease outbreaks and will produce normally and give the profits to the breeder. The birds which are infected produce nearly 75% of egg production. In the case of this study, each 1% improvement in the last two traits can lead to increase the survived and disease resistant birds to 5 birds which lay more eggs and raise the birds' number to be sold for more profits. The total percentage of birds completing the egg laying period is equal to 100%-survival rate (%) and 100%-disease resistance (%). The birds that do not survive are assumed to have no egg income and no salvage values, and they also have no feed costs. The non-resistant birds are also culled during the production period and for those which were counted number eggs of 75% of normal production, and salvage value, and feed cost (80% of normal). The prices of layer hens and eggs in Egypt are about $0.16 per egg and $0.5 per chick. At the beginning of the enterprise, the farm of 500 birds buying of breed Leghorn and Fayoumi. The price of feed is about $0.8 per kg of fodder, which costs around $0.0008 per g feed. At the end of the production period, the bird is sold for nearly half of their costs at this age (75weeks) which is about $1.2/kg. Each hen consumes from 80 to 140g feed per day depending on the breed, which is divided into 82.5g (75%) to produce 1 egg/day and 27.5g (25%) as maintenance feed (Mian M A, 1994) and (Qunaibet et al, 1992). Feed costs depend on the cost for the food quantity that is consumed by the birds and the prices of the feed, and also maintenance costs depending upon birds' number. There are other calculations that should be taken into consideration such as brooding costs for purebreds and F1 crossbred and fixed costs of the layer chicken farm which remain stable through the production period and it is valued at $1000 (Table 2). These fixed costs include the labour cost, building cost, chock cost and vaccination cost during the brooding period.

Table (2): economic model of layer chicken farm.

Costs	Incomes	Profit
FC = (FC/g * FQ/day * B No * SA * DR) *	E Inc/hen = EP * EN/hen/yr	N Inc = T Inc - T C
MC = (MnC/day/hen * B No * SA * DR *	E Inc/flock = (B No * SA * DR) * E Inc/hen + (inf B * PEP * EP)	
T C = FC + MC + BroC + FixC	B Inc = S B/kg * BW * B No * SA	
	T Inc = E Inc/flock + B Inc	

where: FC is feed costs, FC/kg is feed costs per kg, FQ/day is feed quantity per day, B No is birds number, SA survival ability, DR is disease resistance, PP is production period, MC is maintenance costs, MnC/day/hen is management costs per day epr hen, BC is bird costs, TC is total costs, BroC is brooding costs, Fix C is fixed costs.

Economic model for purebreds:

The incomes and costs that come from economic model of layer breeder production farm have been calculated. The formulas that are shown above describe those calculations. The profit of each purebred is calculated by using that breed's traits mean into the production model. Also, economic weights can be worked out for each trait in the purebreds by changing the mean performance of each trait by one unit, one trait at a time. The economic value of each trait can be derived by changing the mean of that trait by one unit while the other traits remain the same. In the Leghorn breed, the income and costs are lower than that in Fayoumi and F1 crossbred because of the lower number of birds that survive and is the lower number that is resistant against disease. The breeds are different in mean performances such as egg number and body weight which leads to the differences in feed consumption per bird per year as shown in Table 6. Those two elements of performance determine the quantity of feed that is required for each bird per year. Consequently the costs of feed and maintenance are different between the breeds.

Economic model of F1 crossbred:

Crossbred performance can be predicted from purebred means and from estimated heterosiseffects as shown in Table 3. The resulting trait means have been used in the economic model to calculate the incomes and costs and observe how they differ from those in purebreds. Hence, the same economic model can be used for various genotypes, which basically differ in trait means, and thus incomes can be calculated and costs and derive profit of various genotypes. The number of birds is the same 500 birds, but at this time the bird costs are not used because they have been calculated already.

Predicting crossbred and hybrid performance:

A crossing program exists of crossing two purebred lines reciprocally to produce a first cross F1. The number of males is 100 roosters and of females are 500 hens, where the meeting ratio will be (1:5). To calculate the mean performance of crossbreds F1, a formula that includes the heterosis percentage of each trait with the mean performance of purebreds was used. Mahmud el al (1981), and Bordas et al (1996), estimated the heterosis of the studied traits: EN, BWSM, ASM, SA, and DR at 17.2, 9.3, -11.5, 12.2, and 10.5% respectively. Further crosses will have the same predicted mean as the F2, and additionally might have different means due to selection response, which can be predicted from selection index theory (section 3.5).The formula that is used to calculate the crossbred performance is:

1-Mean performance of F1crossbred = (0.5 * P1) + (0.5 * P2) + H …..............(1)

2-Mean performance of F2 hybrid = (0.5 * P1) + (0.5 * P2) + 0.5 * H ……..(2)

Where:
*P1 is trait mean of parental breed 1 (Leghorn)
*P2 is trait mean of parental breed 2 (Fayoumi)
*H is heterosis effect of the traits.

Table (3): mean performance of F1 crossbred and F2 hybrid in studied traits.

Traits	Mean performance				
	Leghorn	Fayoumi	Heterosis (%)	F1 crossbred	F2 hybrid
EN (eggs)	280	240	17	304	282
BWSM (kg)	2.5	2	9	2.4	2.3
ASM (days)	175	168	-11	153	162
SA (%)	70	90	12	89	85
DR (%)	50	70	10	66	63

Some of performances of the traits in F1 crossbred and F2 hybrid were higher than Fayoumi and lower than Leghorn in egg production traits and vice versa in the fitness traits such as (SA and DR) except egg number was higher than both purebreds. F1 generation got the benefits from Leghorn in egg production traits (EN, BWSM, and ASM) and from Fayoumi in fitness traits (SA and DR) as shown in Table 3.

Genetic parameters and prediction of selection response:

Selection response of the quantitative traits in the program MTINDEX, which is set up by http://wwwpersonal.une.edu.au/~jvanderw/ depends upon phenotypic standard deviation, heritability, and economic values of improving those traits. The analyses in this chapter aim to find out the selection response of each trait. The genetic parameters (heritability, phenotypic SD, and correlations) of the traits are taken from the literature and are shown in Tables 4 and 5. The MTINDEX program in excel uses the information in Tables 4 and 5 to have the selection responses in the trait units and response in dollar values (monetary) units. Wei and van der Werf(1994), and Ellen et al (2008) reported that heritability of studied traits (EN, BWSM, ASM, SA, and DR) is 0.33, 0.30, 0.31, 0.05, 0.04 respectively, and Gorge, H et al (2010) published correlations between some studied traits as shown in Table 4 and 5. The value of the phenotypic standard deviation was approximated by assuming a coefficient of variation (SD as percentage of the mean) of 10%.

Table (4): the genetic parameters of the traits in purebreds and hybrid.

Traits / parameters	Phenotypic SD			Heritability
	Leghorn	Fayoumi	hybrid	
Egg number (egg/hen/yr)	28	24	30.4	0.33
Body weight at sexual maturity (kg)	0.25	0.2	0.24	0.3
Age at sexual maturity (days)	17	14	19.03	0.31
Survival ability (%)	7	9	8.9	0.05
Disease resistance (%)	5	7	6.6	0.04

Source: Wei and van der Werf (1994), and Ellen et al (2008).

Table (5): the genetic (below diagram) and phenotypic (above diagram) correlation between the traits.

Traits	1	2	3	4	5
1	1	-0.28	-0.59	0.2	0.15
2	-0.11	1	0.38	0.34	0.3
3	-0.46	0.31	1	0.2	0.22
4	0.25	0.4	0.25	1	0.21
5	0.2	0.32	0.26	0.24	1

Source: Gorge, H et al (2010).

Genetic and phenotypic correlations between the traits are shown in Table 5. The genetic and phenotypic correlations between the traits: egg number and body weight, and age at sexual maturity are negative at (-0.11, and -0.46 for genetic correlation and -0.28, and -0.59 for phenotypic correlation) respectively, while they are positive in the trait with survival ability and disease resistance at (0.25 and 0.2 for genetic correlationand 0.2 and 0.15 for phenotypic correlation) respectively (Gorge et al, 2010). Body weight trait has a positive correlation with the rest of other traits. The fitness traits like survival ability and disease resistance have a positive correlation with all the traits (Table 5).

Results:

Economic model for layer:

This chapter will present the results from the economic modelling from previous chapter and give economic values and profit of purebreds and F1 crossbreds as well as the hybrid selection line. Table 6 shows that the costs and incomes of Leghorn and Fayoumi are lower than those in F1crossbred because of the performance in F1 is much higher than in purebreds and also the number of disease resistant and surviving birds are higher in F1 as it is shown in Table 3. Once the traits have been improved by one unit, this improvement leads to an increase in the production of eggs and sale of bird/kg.

Table (6): the costs, incomes and profits of layer chicken in a farm of 500 birds.

Profits elements	WL	FAY	F1	F2 hybrid
Birds No:				
Birds starting No	500	500	500	500
Infected birds	175	135	152	158
Resistant birds	175	315	293	267
Complete production (birds)	350	450	445	425
Production period:				
Total eggs No (1000eggs)	85.7	99.9	123.78	108.68
Egg/bird/yr	280	240	304	282
Feed consumption (kg/bird/yr)	43	37	42	40
Body weight (kg)	2.5	2	2.4	2.3
Costs per flock:				
Costs of feed ($,000)	6.11	9.17	11.18	9.35
Costs of maintenance ($,000)	3.75	3.18	4.53	3.95
Fixed costs ($,000)	1	1	1	1
Production period costs ($,000)	10.9	13.17	16.64	14.3
Brooding period costs ($,000)	2.2	2.12	2.41	2.33
Total incomes ($,000)	15	17	21.12	18.52
Total costs ($,000)	13	15.74	19.06	16.6
Profits:				
Profits of farm ($)	1681	1763	2065	1987
Profits per bird ($)	3.36	3.83	4.1	3.97

In Table 6 above, the complete production of survived birds which reach the production period and continue up to the end is different among the purebreds, F1 crossbred and F2 hybrid. Leghorn has less than F1crossbred and F2 hybrid at 350, 445, and 425 birds respectively, while Fayoumi has the highest number of surviving birds 450 birds. By this difference, the total number of surviving birds in each breed is different where it increases rapidly and effect on egg incomes of the flock. The survived birds are divided into resistant and infected bird. The first group produces the normal number of egg (280) such as in Leghorn, whereas the second group produces around 75% of the egg production because they suffer from diseases. Total incomes and costs of the farm depend on the survived and resistant birds and their egg production. In Leghorn 350 birds survived divided to 175 resistant yielding 280 eggs and 175 infected yielding 210 eggs per for each and in total they lay about 85,750 eggs leading to a profit of $14,770. For Fayoumi, there are 450 surviving birds separated to 315 resistant birds producing 240 eggs and 135 infected producing 180 eggs and total number of 99,900 eggs that give $17,064 incomes. Compared to F1 crossbred, the survived birds valued less than Fayoumi at 445 include 293 resistant generated 304 eggs and 152 infected generated 228 eggs, therefore total egg number valued at 123,780 eggs and has $21,120. However; in F2 hybrid the number of surviving birds decreased considerably to 425 divided into 267 resistant birds yielding 282 eggs, while 158 non-resistant birds yielded 211 eggs giving in total 108,681 eggs and worth $18,523 of incomes on the farm. Those incomes include the sale of bird/kg at the end of production period. In terms of costs, there was a rapid rise in the costs according to increase in the number of feed consumption and body weight of each breed separately valued at $13,143, $15,740, $19.058, and $16,600 respectively as Table 6 is shown. The profits of the farm also have grown significantly where the highest profits were from F1 crossbred at $2065, while the lowest were from Leghorn at $1681 for 500 starting birds. The economic model that has been undertaken for layer chicken farm was derived from the economic weight of each trait by improving them by one unit and gain extra production whether by egg or by kg of sold bird at the end of the production period. This extra production in turn will contribute to increase the profits of the farm as shown in Table 6. Each trait improvement results in extra egg production or sold birds. For instance, an egg number improves by one egg/yr per bird results in 500 eggs more for 500 hens in each breed and gain more profits ($) depending upon the egg number of each breed. Similarly, for other traits, if body weight increases by 1 kg than the whole farm increase will be 500kg of weight and more profits ($) depending on the weight of each breed. Age at first egg improved by reducing one day leads to more produced eggs (400 eggs) and more profit ($64). Survival ability and disease resistance improved by 1% leads to more survived and disease resistant birds (5birds). These extra birds produce more eggs taking into consideration those infected birds lay half of the normal production of each breed.

Economic values of the improved traits:

The economic weight of each of studied traits shows different values among the purebreds (Leghorn and Fayoumi) and hybrid (Table 7). These differences accrue as a result of the differences in the performances of each trait. Table 7 shows that the economic weight of egg number is lower in Leghorn at ($0.06) than that in Fayoumi and hybrid at ($0.10) because the number of survival birds in Leghorn is lower than others as shown in Table 13. Body weight trait has the same economic weight in Fayoumi and hybrid at ($1.9), whereas it was lower ($1.5) in Leghorn because the different between the costs and benefits is small in Leghorn and bigger in Fayoumi and Hybrid. In age at sexual maturity the economic value was negative in both purebreds and crossbred because the age was reduced by 1 day. In this case, the hen will start to lay early and gain extra egg production (400 eggs) overall. In both traits: survival ability and disease resistance was different in both purebreds and hybrid at ($0.07, 0.08, and 0.06/% for SA and $0.05, 0.04, and 0.05/% for DR) respectively (Table 7).

Table (7): economic weight of the traits in purebreds and hybrid.

traits	economic weight ($)/unit per bird per yr		
	Leghorn	Fayoumi	Hybrid
EN (eggs)	0.06	0.1	0.1
BWSM (kg)	1.5	1.9	1.9
ASM (days)	-0.03	-0.04	-0.05
SA (%)	7	8	6
DR (%)	5	4	5

Selection response:

MTINDEX program is used to determine selection response and dollar value for the traits in purebreds and crossbred F1. By knowing the selection response of each trait in F1, the mean performance of hybrid lines can be predicted by adding the mean performance of each trait in F1 to the response for those traits. Table 8 shows the selection response per unit of standard deviation of the selection index, where all the responses were positive except for ASM. Trait responses are shown for both purebreds and the hybrid line. Those responses were different because of differences in standard deviation and economic values in each line. In addition, there was almost no response in body weight at sexual maturity. In terms of dollar value which means the economic accumulated gains over the traits in $ value, the response in all traits was positive in both purebreds and crossbred. Most of the traits have shown different dollar values. The dollar value of genetic improvement in egg number was considerably increased at $0.73, $1.05, and $1.33 respectively as shown in Table 8. For age at first egg, the dollar value was rising rapidly through the purebreds and hybrid at $0.10, $0.13 and $0.20. The dollar value of the genetic improvement in survival ability was in $0.03, $0.04, and $0.03 respectively. The change in disease resistance was the same in all valued at $0.01 (Table 8). Generally, some of the dollar values of Leghorn are more than Fayoumi and hybrid in egg production traits except for egg number, while it is higher for Fayoumi in fitness traits such as survival ability and disease resistance. The dollar value of one unit of genetic standard deviation of the traits, indicating the genetic variation in profit for that trait, was highest for egg number at $16.08, $13.79 and $17.47 for WL, Fay and hybrid, respectively. The values of genetic standard deviation of all traits in Fayoumi are lower than those in others (Table 8). The SD index of the whole traits was $0.89 in Leghorn, while the SD index in Fayoumi was $1.25, and for hybrid SD index was $1.58. There are some differences in information assumed known about males and females line in each breed from purebreds and hybrid. In the male line, there are records for own performance in body weight and no information for other traits, no information for sire and there are in dam, half sibs is 100% and 50% for full sibs. In female line, there are records for own information for all the traits, no information for sire and there are for dam, half sibs is 100% and 50% for full sibs.

Table (8): genetic SD, selection response for a female index per unit of selection index SD, dollar value of the trait response.

Traits	Genetic SD			Selection response			Dollar value ($)		
	Leghorn	Fayoumi	Hybrid	Leghorn	Fayoumi	Hybrid	Leghorn	Fayoumi	Hybrid
EN (eggs)	16.08	13.79	17.47	12.2	10.54	13.33	0.73	1.05	1.33
BWSM (kg)	0.14	0.11	0.13	0.01	0.01	0.01	0.02	0.01	0.01
ASM (days)	9.74	9.35	10.6	-3.3	-3.22	-3.99	0.1	0.13	0.2
SA (%)	1.57	2.01	1.99	0.39	0.49	0.43	0.03	0.04	0.03
DR (%)	1	1.4	1.32	0.19	0.25	0.21	0.01	0.01	0.01
Total dollar value ($)							0.89	1.25	1.58

*Genetic SD = genetic standard deviation of the traits.

The total dollar valueof selection response is calculated by adding each dollar value of the traits together, where it was in Leghorn is lower than those in Fayoumi and hybrid, valued at $0.89, $1.25 and $1.58, respectively. This is because the economic weight of most of the traits is higher in Fayoumi and hybrid than that in Leghorn. Selection response of each trait in breed will be used to have the predicted means in each year of selection in purebreds and hybrid. To get the response per year for each trait in purebreds and hybrid, selection intensity and generation interval need to be identified. There are 500 hens in the breeding program and those hens produce many progeny, but only a limited number toward will select from each family to avoid inbreeding. The maximum number of animal available per family were 1 male and 5 female, hence we had 500 males and 2500 females selection candidates.

The age structure of breeding program:

Age (year)	1	Total
Males	100	100
Females	500	500

- The proportion of Males selected = 100 / 500 * 100% = 20%, therefore the selection intensity of males = im = 1.40
- The proportion of females selected = 500 / 2500 * 100% = 20%, thus the selection intensity of females = if = 1.40
- Generation interval of males (Lm) = 100 * 1 / 100 = 1 year
- Generation interval of females (Lf) = 500 * 1 / 500 = 1 year
- The accuracy of male = 0.67 and of female = 0.77

The males can be selected at 1 year and females can be selected at 1 year also when their offspring are born. They are selected toward the end of the first year and on average drop their progeny at 1 year of age, both males and females. Response per year for each trait (R_{yr}) = [(im / (Lm + Lf) * Rm) + (if / (Lm + Lf) * Rf)]......(3) Where: Rm and Rf are the vectors representing the gain per trait per unit of selection index SD for male and female as shown in Table 9.

Table (9): the vectors representing the gain per unit traits of selection index SD.

Traits	Leghorn		Fayoumi		Hybrid	
	Rm	Rf	Rm	Rf	Rm	Rf
EN (eggs)	10.61	12.2	9.23	10.56	11.63	13.33
BWSM (kg)	0.01	0.01	0	0.01	0	0.01
ASM (days)	-3.45	-3.3	-3.52	-3.31	-4.1	-3.99
SA (%)	0.31	0.39	0.35	0.47	0.32	0.43
DR (%)	0.14	0.19	0.16	0.24	0.15	0.21

So R_{yr} of each trait use the same previous equation and multiply by the vectors representing the gain per trait per unit of selection index SD as shown in the following Table 10.

Table (10): selection response per year for each trait in each of the selection lines.

Traits	Response per year for each unit		
	Leghorn	Fayoumi	Hybrid
EN (eggs)	15.97	13.85	17.47
BWSM (kg)	0.01	0.01	0.01
ASM (days)	4.72	4.78	5.66
SA (%)	0.49	0.57	0.52
DR (%)	0.23	0.28	0.26

Discussion:

This section will give a clear picture of all the results that have been reached in previous section. The study aimed to compare two crossing systems and find out which one is more profitable. The economic weight that determines the change of profits in each trait resulting for improves that trait by one unit. This economic weight is derived by making an economic model of layer chicken farm which has been given the profits as shown in Table 6 in previous section. This part of this thesis helps to find out the economic weight of each trait that can be used in a selection index and to predict the response to index selection both in units of the trait and dollar value. In this process we also needed estimates of genetic parameters like heritability and phenotypic standard deviation as explained in Tables 4, 5 and 8. In the current study, the purebreds and crossbred have been selected for egg production traits: egg number, body weight and age at sexual maturity, and also two fitness traits including survival ability and disease resistance. Those traits have a mean performance in crossbred and hybrid which is more than the average of the purebreds. The crossbreds produced more eggs, which resulted in each of crossbred and hybrid getting more benefits than the purebreds and each breed influence on offspring performance by specific trait. For example, in body weight at sexual maturity in F1 crossbred and F2 hybrid was 2.3 and 2.4kg, while the average of purebreds was lighter at 2.25kg. On the other hand, the hen in F1 crossbred and F2 hybrid starts to lay early at 153 and 162 days respectively which are close to Fayoumi's age at sexual maturity at 168 days. Barua in (1998) and Okada et al in (1987) in Bangladesh found similar results in their study on crossing between Fayoumi breed and Rhode Island Red breed, where the offspring has heavy weight at sexual maturity, which influenced by dam of Rhode Island Red and earlier starting for egg laying that influenced by sire of Fayoumi. The economic model that has been set up for the parents flock and their offspring conducted to show differences between the purebreds flock (Leghorn and Fayoumi) and their offspring (F1 crossbred and F2 hybrid) after the crossing process. These differences are a result of the differences in survivability and the ability to resist the disease risk. Fayoumi flock has the highest number of survival birds (450 birds), whereas the lowest number was in Leghorn flock at (350 birds). On the other hand, the costs of feed and feed consumption have clear effect on the profits. Fayoumi had higher profits than Leghorn because the number of survived birds was the higher in Fayoumi at (450 birds), although the feed consumption was lowest compared to others and valued 37kg/yr. In this case, the difference between the costs and incomes will be more. Egg production has significant effect on the profits. F2 hybrid is more profitable than Fayoumi because the late one has less egg production than first one, even though that the survival birds are more in Fayoumi. Generally, the profits in purebreds' farms are less profitable than the profits of crossbred and hybrid farms (Table 6). The genetic parameters of the traits are shown heritability and the standard deviation was assumed to be 10% of the means performances. It was difficult to find the actual standard deviation for all traits, hence using assumed values standard deviation equals 10% of the traits means. The correlation between the traits was negative between body weight and both egg number and age at first egg laying. There is negative relationship between the age, body weight and egg number, where both first traits cause decline in egg production when they increase. On the other hand, the fitness traits (survival ability and disease resistance) show positive correlation with all traits, where they lead to increase in egg production. Some of the genetic parameters reported in previous studies have been conducted for the same traits by Wei and van der Werf (1994), and Gorge, H et al (2010). In term of crossing between exotic breed (Leghorn) and indigenous breed (Fayoumi), the results in F1 are shown high performance in egg production traits which came from Leghorn. Increase in fitness traits however came from Fayoumi (Table 3). Similarly, Arad and Marder (1982) showed that Sinai breed when crossed with Leghorn produced crossbred that has high egg production but the size of egg is still small. There were other studies which showed the same result such as (Khalil et al. 2003) who found some results from crossing between Leghorn and Balady Saudi. The crossbred that came from crossing between exotic breed and indigenous breed has ability performance of exotic parent and adaptation of moderate conditions particularly in hot climate. The effect of environment and disease risk on the performance of the birds during egg production period is very a significant issue. In this study, it is clear to see that the parents' flock are different in their ability to survive and resist the proper diseases that they can suffer from. In both of these performances, Fayoumi performed better than Leghorn especially under hot climate like Egypt. Those traits have significant influence on egg production, where the bad environmental conditions and disease infection reduce the number of birds to produce the eggs. As a result, the profits that can come from egg production will decrease too. The infected birds could produce around 75% 0f the egg production as shown in this study where the infected birds from Leghorn produced 210 eggs, and 180 eggs form the infected Fayoumi birds. The results as reported by Khalil et al (2003) were similar to the results of this study, where the local breed (Balady Saudi) crossing with exotic breed (Leghorn) under hot environment. The exotic breed showed less performance than the local breed under those difficult conditions in Saudi Arabia.

Conclusion:
Poultry breeding programs have been used for many years and all those applications in this sector were concerned about improving the efficiency of the chicken flock in egg or meat productions and to reach the target of the market. Those applications conducted in different countries around the world on different breeds and strains of layer and broiler chickens. Most of the studies have been conducted on crossbreds or selection and mostly the breeds that were used in those studies were indigenous and exotic breeds. The results that came out of those studies reported that the offspring of the breeding program acquired benefits from both its parents. The performance of the parents has since improved successfully. In this study, indigenous (Fayoumi) and exotic (Leghorn) breed in Egypt were used and two breeding systems were applied (crossbred and hybrid systems), where the latter system was more profitable than the former system after 10 years of selection. That means the hybrid chickens are more profitable than crossbreds, and therefore most chicken layer companies depend on commercial hybrid chickens. However, the commercial hybrid chickens are produced from specific sire and dam lines selected for very different production traits including e.g. egg laying, adaptation and disease resistance.

References:
[1]. Ali, I (1989). Reproductive performances of Fayoumi, Rhode Island Red and Fayoumi x Rhode Island Red crossbred hens and subsequent growth rate of their offspring up to sexual maturity. M. Sc. Thesis. Department of Poultry Science, Bangladesh Agricultural University.

[2]. Barua, A., M.A.R. Howlider and Y. Yoshimura (1998). A study on the performance of Fayoumi, Rhode Island Red and Fayoumi X Rhode Island Red chickens under rural condition in Bangladesh. Asian-Aust. J. Anim. Sci., 11: 635-641.

[3]. Besbes, B (2009). Genotype evaluation and breeding of poultry for performance under sub-optimal village conditions.World's Poultry Science Journal 65: 260-271.

[4]. Bordas, A.; Merat, P. and Minvielle, F (1996). Heterosis in Egg-Laying lines under divergent selection for residual feed consumption. Poult. Sci. 75: 20 –24.

[5]. El-Hossari, M. A(1970). Effects of Natural Selection on selection for high body weight at 8 genetic and phenotypic variation in two strains of Fayoumi chickens. U.A.R., J. Anim. Prod.10 (1): 55-63.

[6]. El-Labban A M, Iraqi M M, Hanafi M S and Hassan Heba, A (2011). Estimation of genetic and non-genetic parameters for egg production traits in local strains of chickens. Livestock Research for Rural Development 23 (1) 2011.

[7]. EL-Labban, A. F. M.; Hanafi, M. S. and Khalil, M. H (1991). Genetic studies on egg production in Dokki-4 chicken. Annals of Agric. Sci. Moshtohor, 29 (3): 1081 – 1094.

[8]. El-Soudany, S. M (2000). Effect of rearing system on performance of chickens. M. Sc. Thesis, Faculty of Agriculture, Ain Shams University, Egypt.

[9]. Fisher, R. A (1918). “The Correlation between Relatives on the Supposition of Mendelian Inheritance.” Transactions of the Royal Society of Edinburgh 52: 399 –433.Food and Agriculture Organization Statistics Division (2002).

[10]. Huseyin Goger et al (2010). Effects of Applied Index Selection Approach on Egg Production Traits in Two Pure Breed Brown Egg Layers. Trends Anim Vet Sci J 2010 1(2):75-78.

[11]. Hossary, M.A. &Galal, E.S.E (1994). Improvement and adaptation of the Fayoumi chicken. Animal Genetic Resources Information, 14: 33–41.

[12]. Iraqi, M. M (2008). Estimation of crossbreeding effects for egg production traits in crossbreeding experiment involving two local strains. Egyptian Poultry Science 28(3): 867-882.

[13]. Ketelaars, E.H (2005) and Saxena, H.C (1992). What is this? Management of Poultry Production in the Tropics. Benekon, Holland, 11 pp.

[14]. Khalil M H, Al-Homidan A H and Hermes I H (2002). Genetic evaluation for egg components in crossbreeding experiment of Saudi chickens with White Leghorn. Egyptian Journal of Animal Production 39(1): 67-76.

[15]. Koutoulis K.C., G.C. Perry and P.D. Lewis (1997). Effect of lighting regimen, calcium supply and age at first egg on tibia stiffness and breaking strength, and shell quality in laying hens. Br. Poult. Sci. 39 (suppl): S9 – S10.

[16]. Mahmoud, T. H.; Kosba, M. A.; Safaa, M. H. and Afaf, I. E (1981). Breed by Location interaction and crossbreeding as factors influenced Egg production. Agricultural Research Review, (59) 6: 233 - 248, Cairo, Egypt.

[17]. Mian M A (1994). Poultry Production. In; Animal Husbandry. National book Foundation, Islamabad. pp.294.

[18]. Morris, T.R (1967). Light requirements of the fowl. In Environmental control in poultry production (BEMB).

[19]. Morris, T.R (1980). Recent developments in lighting patterns for poultry in light-proof housing.

[20]. Qunaibet M H, Elwafa E A and Mansour M M (1992). Improving the competitive status of Saudi broiler industry. J. King Saud University Agri. Sci. 4(2):164-184.

[21]. Rahman M, Sorensen P, Jensen H A and Dolberg F (1997). Exotic hens under semi scavenging conditions in Bangladesh. Livestock Research for Rural Development Volume 9 (3) http://www.cipav.org.co/lrrd/lrrd9/3/bang931.htm.

[22]. Rajput, N., M. L. Rind and R. Rind (2005). Effect of flock size on Fayoumi layer production. J. Anim. Vet. Adv., 4: 842-844.

[23]. Wei, M., and J.H.J. van der Werf (1993). Animal model estimation of additive and dominance variances in egg production traits of poultry. J. him. Sci. 7157.