Minufiya J. Agric. Res. ***Vol.38 No. 1(1): 77 - 88 (2013)*** **"http://www.mujar.net"**

COMPARISON BETWEEN GENERAL AND COMPLETELY RESTRICTED INDICES BY USING DIFFERENT WAYS OF ESTIMATING RELATIVE ECONOMIC VALUES FOR SOME EGG PRODUCTION TRAITS IN SINAI FOWLS

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(Received: Dec. 27 , 2012)

ABSTRACT : *The present experiment was carried out in the Poultry Farm, Department of Poultry Production, Faculty of Agriculture, Minufiya University at Shibin El-Kom, Egypt. The local strain used was Sinai Bedouin fowl. The experimental records lasted for eight years. The aim of the experiment was to study the response of selection for egg number at 90 day, egg weight, interval clutches and clutch size by using the selection index method of laying Sinai hens and compare different (Five) methods for calculating the economic values in economic matrices for studied traits.*

The following results were obtained as :

1. Different economic values were estimated.

2. The equations of the general indices which were constructed for different four economic values:

Kolstad $I_G = 0.2032\ EN90d + 0.1094 EW_M - 0.1473\ I + 0.5719C.$

Reg $I_G = 0.2326\ EN90d + 0.0545\ EW_M - 0.1189\ I + 0.0470\ C.$

Sharma $I_G = 0.2553\ EN90d + 0.0860\ EW_M - 0.2501\ I + 0.8726\ C.$

Lamont $I_G = 0.0079\ EN90d + 0.3209\ EW_M - 1.103\ I + 3.014\ C.$

Soltan $IG = 0.03196\ EN90d - 0.0106\ EW_M - 0.0992\ I + 0.1201\ C.$

3. The equations of the completely I restricted indices ($I_{R,\ I}$) using different economic values which were supposed to stabilize the performance level of pullets concerning I were:

Kolstad $I_{R,}\ EW_M = 0.1529\ EN_{90d} + 0.1938\ EW_M - 0.5818\ I + 1.3352\ C.$

Reg $I_{R,}\ EW_M = 0.1510\ EN_{90d} + 0.1913\ EW_M - 0.5856\ I + 1.2837\ C.$

Sharma $I_{R,}\ EW_M = 0.1733\ EN_{90d} + 0.2236\ EW_M - 0.4586\ I + 2.1164\ C.$

Lamont $I_{R,}\ EW_M = 0.1129\ EN_{90d} + 0.1450\ EW_M - 0.1965\ I + 1.4252\ C.$

Soltan $I_{R,}\ EW_M = 0.0154\ EN_{90d} + 0.0196\ EW_M - 0.0592\ I + 0.1419\ C.$

4. Generally, the results show that the general index (I_G) was most efficient than each of the completely restricted index ($I_{R,EWM}$) for Sinai strain. Moreover, a single restriction ($I_{R,EWM}$) caused less deterioration in the net efficiency of I_G.

5. There are no discrepancies between the values of expected genetic change per generation for Reg and Lamont methods. The spearman rank correlation coefficient estimated between the fowls under study on the bases of the original index by the both methods was 0.999 at 0.001.

6. The breeder can use any of two methods with some restrictions on Sharma method that it may be disturbed by abnormal values which included when calculate standard deviation. Soltan method was more related to regression method this finding may be due to the use of genetic and phenotypic variances in the way of calculations.

Key words: *Sinai chickens, Selection indices, economic values.*

INTRODUCTION

The comparison between different methods of selection was studied by may investigators from Hazel and Lush, 1942, Young 1961, Abplanalp, 1973 to recently (as example) Elwardany *et al*., 1992, Enab *et al*., 2000, Ben Naser (2007) Abou Elewa (2010). All authors observed that selection index considered as the efficient selection method to evaluate the total breeding values comparing to tandem selection and independent culling levels.

The Egyptian indigenous strains have many advantageous. As example Sinai Bedouin fowls have a better heat tolerance and les evaporation from eggs (Arad and Marder (1982b), Soltan *et al.* (1985) and Mahgoub (2002) under the desert areas conditions.

In respect of Sinai Bedouin fowls, different selection methods were used to improve many economic traits such as body weights at different ages, age at sexual maturity, egg number, egg weigh and feed efficiency such as Soltan (1991), Soltan *et al.* (2009). However, till now there are no selection indices were applied to improve the productivity of Sinai fowl. Therefore, the main objective of this work is to study the possibility of improving four important traits for egg production (i.e. egg number during the first 90 days of laying, mature egg weight, interval between clutches and clutch size) by using different selection indices (i.e. general, and restricted indices for one generation with data from eight year records (from 2000 to 2007).

MATERIALS AND METHODS

The present experiment was carried out in the Poultry Farm, Department of Poultry Production, Faculty of Agriculture, Minufiya University at Shibin El-Kom, Egypt. The local strain used was Sinai Bedouin fowl. The experimental records lasted for eight years. The aim of the experiment was to study the response of selection for egg number at 90 day, egg weight, interval between clutches and clutch size by using the selection index method of laying Sinai hens and compare different (five) methods for calculating the economic values in economic matrices for studied traits.

Flock history :

Sinai chickens were characterized by laying fewer eggs which were smaller in weight. The first study with Sinai fowls was conducted by Arad and Marder (1982 a). They concluded that Sinai egg shell is thicker and stronger than that of the Leghorn. The result of Arad and Marder (1982 b) reported that Sinai strain was more resistant to the extreme conditions of desert environment. Later on, Soltan *et al.* (1985) gave an economical study for this strain. He and his research team improved egg production of this strain from 1985 till 2004 by using individual selection programs for egg number. They indicated that means of egg number till 90 days of laying, egg weight, feed consumption (g / bird / day) and feed efficiency (g / g egg mass) were 20.7 eggs, 47.2 g, 87 g and 6.34 g in the base population, respectively. Soltan and El-Nady (1986) found that average body weights were 357.6, 486.6 and 711.69 for Sinai selected line at 12, 16 and 20 weeks.

Soltan and Ahmed (1990) showed that means of egg number, age at sexual maturity and egg weight of Sinai selected line were 34.5 eggs, 186.6 days and 41.1 g. respectively. Corresponding values were 31.6 eggs, 211.9 days and 42.0 g for the control line. Soltan (1991) stated that, in general, selection is very important tool for breeders to select Sinai strains on the basis of partial records. Soltan (1992) investigated some phenotypic and genetic parameters of body reactions traits in Sinai fowl in order to utilize experimental data in breeding programs.

Mahgoub (2002) reported that Sinai strain is well adapted to high environmental temperature.

Soltan *et al.* (2009) selected for better feed efficiency of egg production (g feed / g egg) in Sinai strain and they found that selection response (ΔG) for the selected trait equal to -3.7 g feed per g egg.

Collecting Data

Data of 1600 hens and 560 sires strain over 8 years (2000 to 2007) were collected and utilized to study inheritance and relationships of some egg production traits and then formed a different selection indices for four traits (EN_{90}, EW_M, C and I) with different methods of estimating economic values of each trait. The least squares and maximum likelihood general purpose program LSMLMW (Harvey) (1990), was used to analysis the collected data in order to estimate the phenotypical, genetical and environmental parameters.

The recorded traits were as follow :

1. Egg number during the first 90 days of age.
2. Mature egg weight (in gram) at 35 weeks of age (eggs).
3. Clutch size (as average of clutch eggs per hen).
4. Interval between clutches (as average per hen) (in days).

These different selection indices (general and restricted) were conformed by using different methods for estimating economic values.

Statistical analysis :

Model (1) Estimation of genetic parameters

The least squares and maximum likelihood general purpose program – mixed model LSMLMW (Harvey, 1990) was used to estimate the values of heritability and phenotypic, genetic and environmental correlation for flock of Sinai fowl. The general random model utilized by (LSMLMW) was as follow :

$$y_{ijk} = \mu + S_i + D_{ij} + e_{ijk}$$

Where :

Y_{ijk} = Observation of the K^{th} progeny of the i^{th} sire and j^{th} dam.

μ = Common mean

S_i = Random effect of i^{th} sire

D_{ij} =Random effect of j^{th} dam within i^{th} sire.

e_{ijk} = Random error assumed to be normally distributed with zero mean and variance $\sigma^2 e$.

Phenotypic correlation

Phenotypic correlations (r_p) were calculated by the following equation :

$$rp_{(a.a')} = \left[\sigma_{e(aa')} + \sigma_{S(aa')}\right] / \sqrt{\left[\sigma^2{}_{e(a)} + \sigma^2{}_{e(a')} + \sigma^2{}_{S(a')}\right]}$$

(a) refers to the (a_{th}) trait à to another trait

Genetic correlation :

Genetic correlations were computerized by the family covariance component estimate between the two traits by the geometric mean of the two family variance component estimates, i.e.

$$r_{G(a,à)} = \sigma_{ss`} / \sigma_s \sigma_{s`}$$

where :

$r_{G(a,à)}$ is the genetic correlation between a and à traits, ($\sigma_{ss`}$) is the covariance estimate between the tow traits ($\sigma_s$) and ($\sigma_{s`}$) is the geometric mean of the two family variance.

Selection index method

Selection Index Program (Wagenaar, *et al.,* 1995, and Matlab, 2002) were used to set up and construct the selection indices. The traits under studied were used in different combinations to construct selection indices.

$$I = b_1 p_1 + b_2 p_2 + \ldots b_n p_n = \sum_{i=1}^{n} bipi$$

Where :

I = selection index,

bi = index weights for each trait in the index.

Pi = phenotypic measurement for each trait in the index.

a. General selection index (I_G) :

The general index was obtained in terms of heritability, phenotypic and genetic correlations among the studied traits by solving the following equations given in matrix expression according to Cunningham (1969) :

$$Pb = Gv \quad \text{to give} \quad b = P^{-1}\, Gv$$

Where :

P = Phenotypic variances and covariances matrix.

G = Genetic variances and covariances matrix.

V = Economic weights column vector.

b = Weighting factors column vector, which is going to be solved.

Furthermore, according to Cunningham (1969 a) the other different properties of the selection index were calculated as following:

The standard deviation of the index = σ_1 = $\sqrt{b'Pb}$

The standard deviation of aggregate genotype = σ_T = $\sqrt{v'Gv}$

The correlation between the index and the aggregate genotype = (r_{TI}) = □/ □= $\sqrt{b'Pb / V'Gv}$

The expected genetic change (D_G) in each trait, after one generation of selection on the index (i = 1) was obtained by solving either of the following equations :

$D_{Gi} = r_{GiI}\ i\ \sigma_{Gi}$

$D_{Gi} = b_{GiI}\ i\ \sigma_I$

Where : r_{GiI} = Correlation of the trait with index., I = Selection differential in standard deviation units., σ_{Gi} = Genetic standard deviation of the trait., b_{GiI} = Regression of the trait on the index., σ_1 = standard deviation of the index.

b. Completely restricted selection index (I_R) :

The general idea of this index is to keep a particular trait from changing genetically, and permit optimum genetic gains in other traits in the index from generation to generation of selection. According to Cunningham *et al.* (1970) for each completely restriction (i.e. zero change) of a particular trait a dummy variable was added to the general index; a row and column were added to the original P matrix to get P^*, the row consists of genotypic covariances of the other variables with the trait being restricted to zero change, the column is the transpose of the row and the diagonal element is zero. A row of zeros was added to the original G matrix to get G^* matrix and zero economic value attaches to every restricted trait. The weighting factors (b*) of completely restricted index could be obtained by solving the following equation :

$$b^* = P^{*-1}\ G^*\ v$$

As an example, constructing the completely restricted index for C was required to add a dummy variable to the general index. The covariance elements of P^* - and G^* - matrices of the dummy variable which were expected to keep C from any genetic changes.

The economic values (v) :

The relative economic values of the studied traits (i.e. total Egg number for the first 90 days of laying, mature egg weigh interval between clutches and clutch size duray the 90 days of laying period were calculated by :

1. Regression method to estimate the economic values (v_1)

Calculated by estimating the expected change in the target trait (Y = 1) per one egg as a marketing weight that determine the profit depends on one unit change per unit in the trait.

2. Sharma method to estimate the economic values (v_2)

Calculated as 1 / σp, where : σp is phenotypic standard deviation of each trait (Sharma, 1982).

3. Kolstad method to estimate the economic values (v_3)

The relative economic values of the studied traits (i.e. egg weight and egg number at 90 days of laying, interval between lateles (days) and clutch size (in eggs) were calculated by estimating the change of the difference between cost and income per unit change in the trait (Kolstad, 1975). Enab (1982) discussed in details this method for estimating economic values for the egg production traits according to the Egyptian quotations.

4. Lamont method to estimate the economic values (v_4)

The relative economic values of mature egg weight maturity, egg number for the first 90 days of laying interval between and dutch cluch size were calculated by using the following formula according to Lamont (1991) :

$a_i = V_i$ = Economic value

$$a_i = T / h^2 i$$

Where : $T = h^2_{EN} + h^2_{Ew} + 1/2\ (h^2_1 + h^2_C)$

5. Soltan method :

Soltan (2013) presented and obtained a new method for estimating relative economic value depending on phenotypic and genetic variance and requirement of breeder or producer or markets. Steps of estimating relative economic value of each trait were explained by (Soltan 2013) and applied on the studied traits (page 94) where :

R_i = and $\frac{I_i}{\Sigma I_i}$

R_i = Relative economic value for trait i

I_i = Absolute economic value for trait i and it was estimated according to Soltan (2013).

ΣI_i = The total absolute economic values for all traits.

The expected genetic change (DG) for each trait, after one generation of selection on the index (I = 1) was obtained by solving the following equation.

$$\Delta G_i = (i\ b'\ G_i) / \sigma_I.$$

Where :

i = Selection differential in standard deviation units.

b' = Transpose of weighting factors as column vector.

Gi = The i[th] column of the G matrix.

σ_I = Standard deviation of the index.

RESULTS AND DISCUSSION

1. The general index (I_G)

The general selection index (I_G) was constructed for Sinai strain according to the conventional method, whereas the weighting factors could be obtained by solving the equation (b $=P^{-1}$ GV) in matrix expression according to Cunningham (1969).

The relative economic values were obtained in Table (1)

From Table (2) the equations of the general indices which were constructed for different five economic values :

Kolstad I_G = 0.2032 EN90d +0.1094**EW_M** -0.1473 I + 0.5719C.

Reg I_G = 0.2326 EN90d + 0.0545 **EW_M** - 0.1189 I + 0.0470 C.

Sharma I_G = 0.2553 EN90d +0.0860 **EW_M** -0.2501 I + 0.8726 C.

Lamont I_G = 0.0079 EN90d +0.3209 **EW_M** -1.103 I +3.014 C.

Soltan **IG = 0.03196 EN90d -0.0106 EW_M - 0.0992 I +0.1201 C.**

The standard deviations (σ_I) of these indices were (1.5915, 1.7289, 1.9669, 1.6307 and 0.2419) and its correlations with the aggregate genotype were (0.4488, 0.4921, 0.4601, 0.3759 and 0.5861) for Kolstad, Reg, Sharma, Lamont and Soltan, respectively. The expected genetic changes which would be gained due to applying these indices of Sinai chickens were +2.1360,+ 2.3960, +2.305, -0.5971 and +2.635 eggs for egg number till 90 d (EN_{90d}); -0.4779, -0.7130, -0.6304, 0.9726 and -1.087 egg for weight at maturity (EW_M); -0.0323, -0.0344, -0.0331, -0.0008 and -0.0345 day for interval (I); and 0.0281, 0.0302, 0.0297, 0.0015 and 0.03104 day for clutch size, for Kolstad, Reg, Sharma, Lamont and Soltan, respectively.

2.Completely restricted indices (I_R):

Completely restricted indices ($I_{R,}$ EW_M) were imposed to keep no genetic change in I EW_M in Sinai strain. Table (3 shows completely restricted indices of EW_M, in Sinai strain using different economic values.

The presented result in Table (3) shows that the equations of the completely EW_M restricted indices ($I_{R,}$ EW_M) using different economic values which were supposed to stabilize the performance level of pullets concerning EW_M were:

Kolstad $I_{R,}$ **EW_M** = 0.1529 EN_{90d} + 0.1938 **EW_M** -0.5818 I + 1.3352 C.

Reg $I_{R,}$ **EW_M** = 0.1510 EN_{90d} +0.1913 **EW_M** -0.5856 I +1.2837 C.

Sharma $I_{R,}$ **EW_M** = 0.1733 EN_{90d} + 0.2236 **EW_M** -0.4586 I + 2.1164 C.

Lamont $I_{R,}$ **EW_M** = 0.1129 EN_{90d} + 0.1450 **EW_M** -0.1965 I + 1.4252 C.

Soltan $I_{R,}$ **EW_M** = 0.0154 EN_{90d} +0.0196 **EW_M** -0.0592 I+ 0.1419 C.

Table (1): Relative economic values (v) used to construct selection indices.

Trait	Kolstad (V_1)	Regression (V_2)	Sharma (V_3)	Lamont (V_4)	Soltan-2013 (V_5)
EN_{90d}	1	1	1	1	0.086
EW_M	2.25	0.973	1.2	2.286	0.011

I	-0.617	0.109	11.35	18.82	-0.189
C	2.594	1.021	26.71	6.957	1.09

Table (2) : Weighting factors, the value of the trait and the expected genetic changes of the general indices (I_G) were constructed using different economic values.

Trait	Kolstad			Reg		
	b	V_T	Δ_G	b	V_T	Δ_G
EN_{90d}	0.2032	51.8800	2.1360	0.2326	61.6900	2.3960
EW_M	0.1094	6.1210	-0.4779	0.0545	1.2530	-0.7130
I	-0.1473	0.1214	-0.0323	-0.1189	0.0670	-0.0344
C	0.5719	0.3366	0.0281	0.0470	0.0019	0.0302
r_{TI}	0.4488			0.4921		
σ_I (ΔH)	1.5915			1.7289		
σ_T	3.546			3.5131		
R. E.	100			100		
Trait	Sharma			Lamont		
	b	V_T	Δ_G	b	V_T	Δ_G
EN_{90d}	0.2553	54.66	2.305	0.0079	0.05548	-0.5971
EW_M	0.0860	2.431	-0.6304	0.3209	83.33	0.9726
I	-0.2501	0.2292	-0.0331	-1.103	6.707	-0.0008
C	0.8726	0.5136	0.0297	3.014	9.327	0.0015
r_{TI}	0.4601			0.3759		
σ_I (ΔH)	1.9669			1.6307		
σ_T	4.2748			4.3375		
R. E.	100			100		

Soltan			
	b	V_T	Δ_G
EN_{90d}	0.03196	57.88	2.635
EW_M	-0.0106	2.447	-1.087
I	0.0992-	2.409	-0.0345
C	0.1201	0.6432	0.03104
r_{TI}	0.5861		
σ_I (ΔH)	0.2419		

σ_T	0.41279
R. E.	100

Table (3): Weighting factors, the value of the trait and the expected genetic changes of the completely restricted indices (I_R) were constructed using studied methods to estimate economic values.

Trait	Completely restricted indices								
	Kolstad			Reg			Sharma		
	b	V_T	Δ_G	b	V_T	Δ_G	b	V_T	Δ_G
EN_{90d}	0.1529	0.3283	0.4485	0.1510	0.3283	1.4486	0.1733	0.3267	1.4415
EW_M	0.1938	0.0000	0.0000	0.1913	0.0000	0.0000	0.2236	0.0000	0.0000
I	-0.5818	-0.2832	-0.0254	-0.5856	-0.2836	-0.0254	-0.4586	-0.2750	-0.0246
C	1.3352	0.3415	0.0214	1.2837	0.3412	0.0214	2.1164	0.3450	0.0216
r_{TI}	0.4197			0.4177			0.4068		
σ_I (ΔH)	1.4884			1.4676			1.7389		
σ_T	3.5461			3.5133			4.2749		
R.E. to I_G %	93.51			84.88			88.41		

Table (3): Continued .

Trait	Completely restricted indices					
	Lamont			Soltan		
	b	V_T	Δ_G	b	V_T	Δ_G
EN_{90d}	0.1129	0.3250	1.4342	0.0154	0.3282	1.4483
EW_M	0.1450	0.0000	0.0000	0.0196	0.0000	0.0000
I	-0.1965	-0.2695	-0.0241	-0.0592	-0.2830	-0.0254
C	1.4252	0.3444	0.0216	0.1419	0.3420	0.0214
r_{TI}	0.2605			0.3497		
σ_I (ΔH)	1.1299			0.1508		
σ_T	4.3375			0.4312		
R.E. to I_G %	69.29			59.66		

The standard deviations of these indices were (1.4884, 1.4676, 1.7389, 1.1299 and 0.1508) and its correlations with the aggregate genotype were (0.4197, 0.4177, 0.4068, 0.2605 and 0.3497). The relative efficiencies of $I_{R,\ EWM}$ in relation to I_G were (93.51, 84.88, 88.41, 69.29 and 59.66%), which means that the total expected genetic changes would be decreasing due to apply $I_{R,\ EWM}$ instead of I_G. Concerning each trait the expected genetic changes were decreasing in EN by -0.688, -0.947, -0.864, -1.187 and -0.554 egg for Kolstad, Reg, Sharma, and Soltan, respectively, but it increased by 2.031 in Lamont; On the other hand, the completely restriction in EWM was expected to cause a increasing in the expected genetic changes of I by 0.007 days approximately, for Kolstad, Reg, Sharma, Lamont and Soltan, respectively (Table 4 and Fig. 1a, 1b, 1c and 1d).

Generally, the results show that the general index (I_G) was most efficient than each of the completely restricted index ($I_{R,EWM}$) for Sinai strain. Moreover, a single restriction ($I_{R,EWM}$) caused less deterioration in the net efficiency of I_G. These results were in the same trend with those found by Kolstad (1975), Abdou and Kolstad (1979b), Sinha and Biswas (1979), Thangaraju and Ulaganathan (1990 b), Enab (1991), Abdou and Enab (1994) and Barwal *et al.* (1994).

Table (4): The difference between Expected genetic changes per generation for general and restricted indices using different economic values under study.

Economic value method	Traits	Δ_G General	Δ_G Restricted	The difference between ΔG for general and restricted indices
Kolstad	EN_{90d}	2.1360	1.449	-0.688
	EW_M	-0.4779	0.0000	0.478
	I	-0.0323	-0.025	0.007
	C	0.0281	0.021	-0.007
Reg	EN_{90d}	2.3960	1.449	-0.007
	EW_M	-0.7130	0.000	0.713
	I	-0.0344	-0.025	0.009
	C	0.0302	0.021	-0.009
Sharma	EN_{90d}	2.305	1.442	-0.864
	EW_M	-0.6304	0.000	0.630
	I	-0.03312	-0.025	0.009
	C	0.02973	0.022	-0.008
Lamont	EN_{90d}	-0.5971	1.434	2.031
	EW_M	0.9726	0.000	-0.973
	I	-0.0008	-0.024	-0.023
	C	0.00146	0.022	0.020
Soltan	EN_{90d}	2.635	1.448	-1.187
	EW_M	-1.087	0.000	1.087
	I	-0.03446	-0.025	0.009
	C	0.03104	0.021	-0.010

ΔG= Expected genetic changes per generation

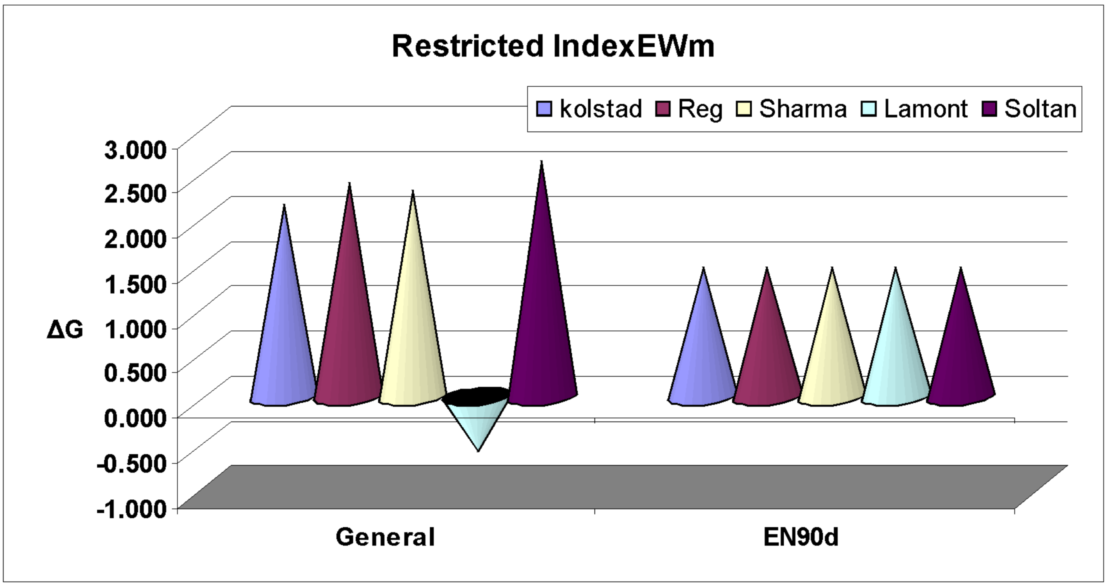

Figure (1a): The difference between ΔG for general and restricted indices using different economic values for EN90d.

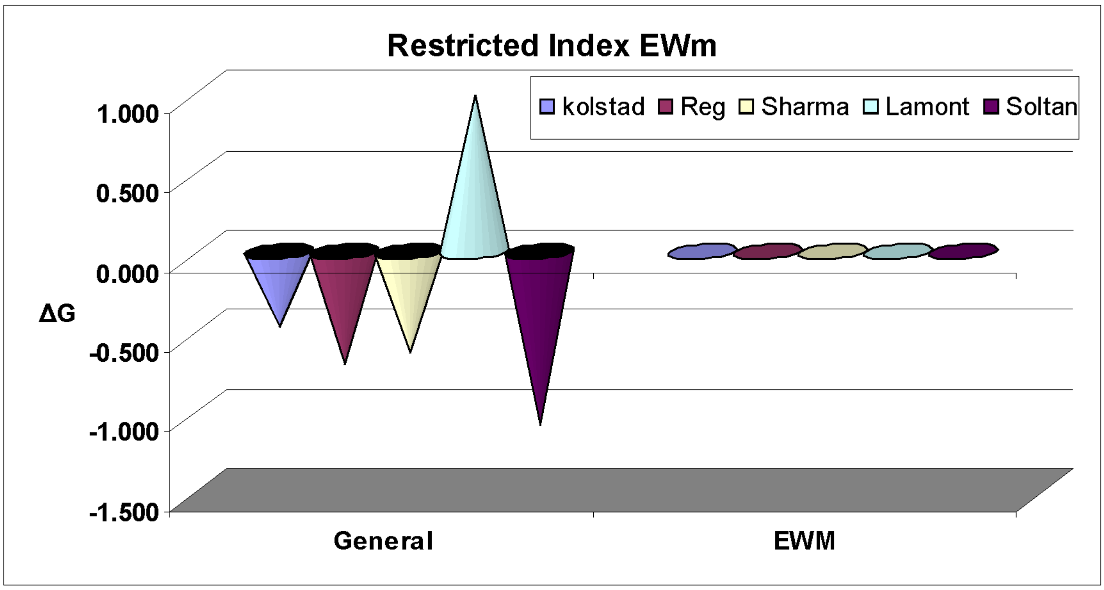

Figure (1b): The difference between ΔG for general and restricted indices using different economic values for EWm.

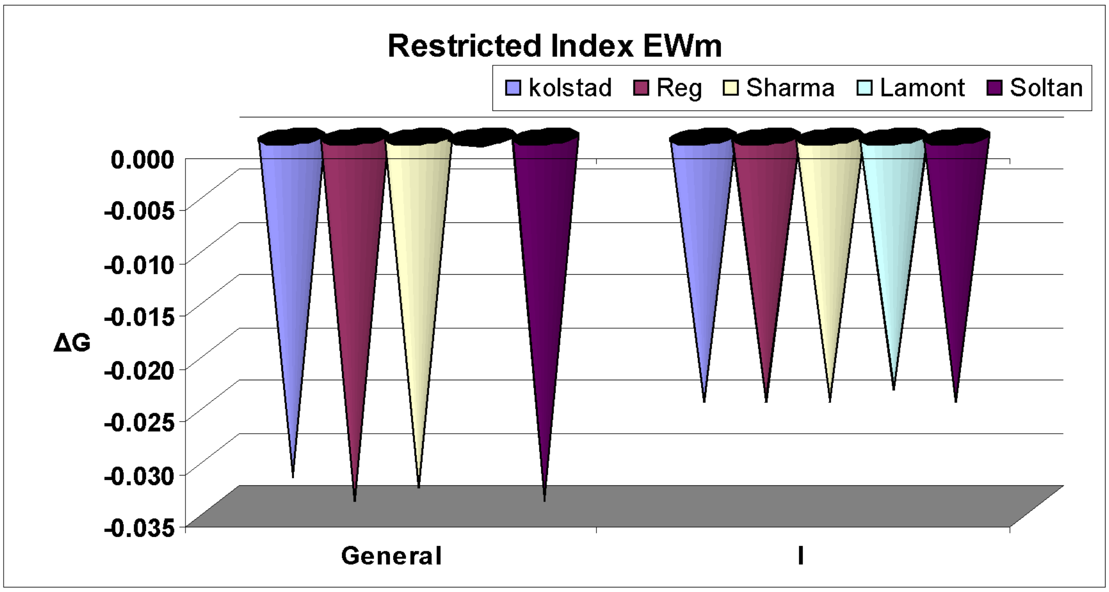

Figure (1c): The difference between ΔG for general and restricted indices using different economic values for I.

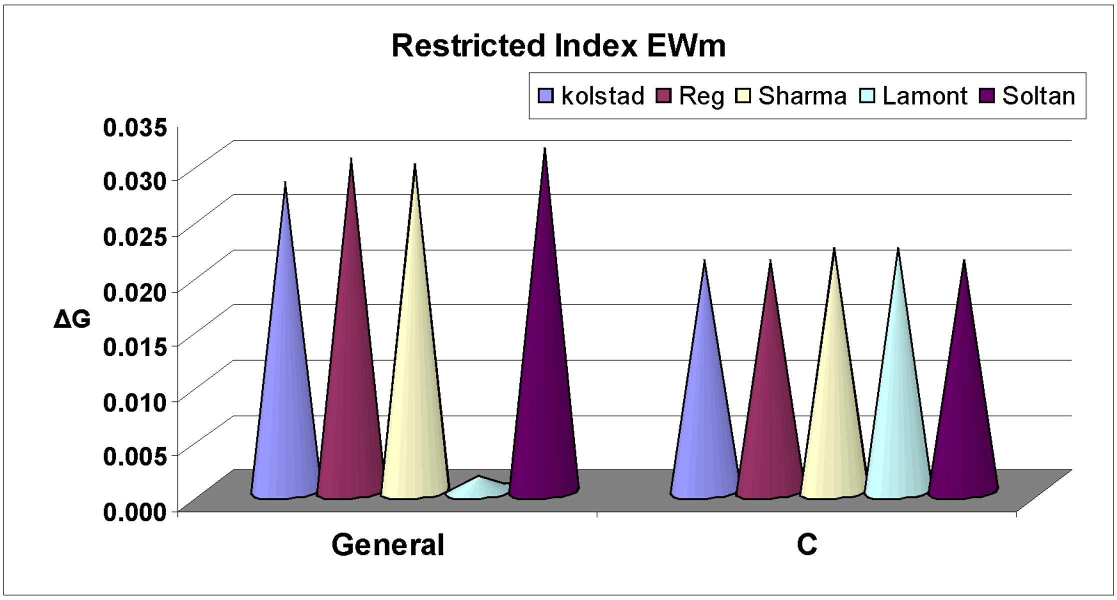

Figure (1d): The difference between ΔG for general and restricted indices using different economic values for C.

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مقارنة بين الأدلة العامة والأدلة المحددة باستخدام طرق مختلفة لحساب الأهمية الاقتصادية النسبية لبعض صفات إنتاج البيض في دجاج سيناء

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الملخص العربي

استخدمت سجلات التربية لدجاج البدو سيناء لمدة ٨ سنوات من ٢٠٠٠ حتي ٢٠٠٧ لمقارنة عدة طرق مختلفة (٥ طرق) لحساب الأهمية الاقتصادية في المصفوفة الاقتصادية التي درست .

أوضحت النتائج التالي :

١ – قدرت الأهمية الاقتصادية النسبية والتي استخدمت لتكوين الأدلة الانتخابية :

٢ – معادلات الأدلة الانتخابية العامة التي كونت طبقا لعدد ٥ طرق مختلفة لحساب الأهمية الاقتصادية كانت كالآتي :

Kolstad	I_G = 0.2032 EN90d +0.1094**EW**$_M$ -0.1473 I + 0.5719C.
Reg	I_G = 0.2326 EN90d + 0.0545 **EW**$_M$ - 0.1189 I + 0.0470 C.
Sharma	I_G = 0.2553 EN90d +0.0860 **EW**$_M$ -0.2501 I + 0.8726 C.
Lamont	I_G = 0.0079 EN90d +0.3209 **EW**$_M$ -1.103 I +3.014 C.
Soltan	**IG = 0.03196 EN90d -0.0106 EW$_M$ - 0.0992 I +0.1201 C.**

٣ – معادلات للدليل المحدد الكامل ($I_{R,I}$) باستخدام طرق مختلفة لحساب الأهمية الاقتصادية النسبية التي تحافظ علي ثبات قيمة **I** لدجاجات سيناء كالآتي :

Kolstad	$I_{R,}$ **EW$_M$** = 0.1529 EN_{90d} + 0.1938 **EW$_M$** -0.5818 I + 1.3352 C.
Reg	$I_{R,}$ **EW$_M$** = 0.1510 EN_{90d} +0.1913 **EW$_M$** -0.5856 I +1.2837 C.
Sharma	$I_{R,}$ **EW$_M$** = 0.1733 EN_{90d} + 0.2236 **EW$_M$** -0.4586 I + 2.1164 C.
Lamont	$I_{R,}$ **EW$_M$** = 0.1129 EN_{90d} + 0.1450 **EW$_M$** -0.1965 I + 1.4252 C.
Soltan	$I_{R,}$ **EW$_M$** = 0.0154 EN_{90d} +0.0196 **EW$_M$** -0.0592 I+ 0.1419 C.

٤ – لا توجد تعارضات بين قيم العائد الانتخابي المتوقع لكل جيل طبقا لطريقة كولستاد وشارما . معادل ارتباط سبيرمان ٠.٩٩٤ علي مستوي ٠.٠٠١

٥ – وأيضا لا توجد تعارضات بين قيم العائد الانتخابي المتوقع لكل جيل لكل من طريقة الانحدار و لامونت . وكان معامل ارتباط سبرمان ٠.٩٩٩ علي مستوي ٠.٠٠١

٦ – المربي يمكن أن يستخدم أي من الطريقتين مع بعض التحفظ لطريقة شارما حيث أنها تتوزع بقيم شاذة والتي تظهر في حساب الانحراف القياسي . طريقة سلطان لحساب الأهمية الاقتصادية أكثر ارتباطا بطريقة الانحدار وربما يعدد إلي استخدام البيانات المظهرية والوراثية في حساب الطريقتين .