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Modifications of evaluation index and subordinate function formulae to determine superiority of mulberry silkworm crosses

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KEYWORDS

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Subordinate function formulae;
Single hybrids

Abstract Characters of silkworm could be divided into positive and negative directions. Highest values were preferred for positive direction while lowest performance was preferred for negative direction traits such as mortality, duration, double cocoon, etc.

Since 1993, evaluation index formula, as well as subordinate function formula was used in 1971 for determines superior silkworm varieties.

It is very easy to apply these formulae on positive direction characters. But these formulae are not suitable for negative direction characters. Some researchers were applying these formulae on both positive and negative characters. Other researchers neglected calculations of evaluation index and subordinate function for negative direction characters.

The present study suggested new modifications of evaluation index and subordinate function formulae for easily calculation of all characters. Thirteen single hybrids of mulberry silkworm *Bombyx mori* L. were used in this investigation.

Results reveal that, using suggested modified formulae would change the decision of judgment of superiority of some hybrid genotypes.

Abbreviations: CW, cocoon weight; CSW, cocoon shell weight; PW, pupal weight; CSR, cocoon shell ratio; SP, silk productivity; PR, pupation ratio; CP, cocooning percentage; No. of fertile eggs, number of fertile eggs; Fecun, fecundity; Fertil, fertility; Co-egg laying, coefficient of laying eggs; FD, fifth instar duration; LD, total larval duration; Mort, mortality percentage during fourth and fifth instar; DCP, double cocoon percentage; C/L, number of cocoon per liter; No. of unfertile eggs, number of unfertile eggs; No. of undepo, number of undeposited eggs; Co-unlaid eggs, co-efficient of unlaid eggs; F1, first generation of the hybrid; EI, Evaluation Index; SF, Sub-ordinate Function

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Introduction

The silkworm, *Bombyx mori* L. is an important economic insect and also a tool to convert mulberry leaf protein into silk. Industrial and commercial use of silk, the historical and economic importance of production and its application all over the world finely contributed to the silkworm promotion as a powerful laboratory model for the basic research in biology (Babu et al., 2009).

Exploitation of heterosis through hybrids in silkworms for economic traits triggered a revolutionary change in overall qualitative and quantitative silk output (Hirobe, 1957; Harada, 1961; Kobayashi et al., 1968; Gamo, 1976; Subba Rao and Sahai, 1990; Nagaraju et al., 1996; Mal Reddy et al., 2012).

The improvement of indigenous breed could be achieved through hybridizations utilizing exotic breeds. Harada (1956) revealed that new silkworm breed has been evolved through hybridization followed by selection. The F1 hybrids are more productive and robust, which can be easily reared by the farmers by adopting appropriate rearing technology (Ramesha et al., 2009; Seshagiri et al., 2009; Manohar Reddy et al., 2010; Kiran Kumar and Sankar Naik, 2011). New best hybrids can be exploited in commercial scale. Also, local races can be evolved using the hybridization, inbreeding and selection program (Ghazy, 2012).

Evaluation index and subordinate function formulae were used to determine superiority hybrids according to Mano et al. (1993), Gower (1971), respectively. But when adopting these formulae on the data of negative direction characters such as larval duration, larval mortality, double cocoon percentage ... etc problems would be faced. Because of better performance evaluation index or subordinate function values differed. This means that low duration have low value of evaluation index and subordinate function values. Many researchers faced this problem in their investigations while others avoiding to estimate the evaluation index and subordinate function for characters with negative directions.

The present study is an attempt to overcome these problems. A suggested modification was made of evaluation index and subordinate function equations. Also, superior silkworm single hybrids were determined under Egyptian conditions by using regular and modified evaluation index and subordinate function formulae.

Materials and methods

Silkworm resources and hybridization

Ten silkworm races of RBMJ1, RBPCH1, RBMJ2, RBPCH2, RBMJ3, RBPCH3, RBMJ4, RBPCH4, F272 and G155 were obtained from Sericulture Research Department-Plant Protection Research Institute-Agricultural Research Center. Thirteen hybrids resulted from crossing; there are C1 (F272 X G155), C2 (RBMJ1 X RBPCH3), C3 (RBMJ1 X RBMJ4), C4 (RBPCH1 X RBMJ4), C5 (RBMJ2 X RBMJ1), C6 (RBMJ2 X RBMJ4), C7 (RBPCH2 X RBMJ1), C8 (RBPCH2 X RBMJ2), C9 (RBMJ3 X RBMJ1), C10 (RBPCH3 X RBMJ1), C11 (RBMJ4 X RBMJ3), C12 (RBPCH4 X RBMJ1) and C13 (RBPCH4 X RBPCH1).

Rearing silkworm procedure

Larvae of silkworm were fed four times daily. Mulberry leaves of *Morus alba* var Kanava 2 were used for feeding larvae. Foam and polythene cover and bottom used during the young instars (Ghazy, 2008). Each hybrid was represented by three replicates. The experiment was conducted at the Sericulture Research station – El Qanater El-Khyria.

Investigated characters

Nineteen parameters were taken into consideration. There were cocoon weight (CW), cocoon shell weight (CSW), pupal weight (PW), cocoon shell ratio (CSR), silk productivity (SP), pupation ratio (PR), cocooning percentage (CP), number of fertile eggs (No. of fertile eggs), fecundity (Fecun), fertility (Fertil), coefficient of laying eggs (Co-egg laying), fifth instar duration (FD), total larval duration (LD), mortality percentage during fourth and fifth instar (Mort), double cocoon percentage (DCP), number of cocoon per liter (C/L), number of unfertile eggs (No. of unfertile eggs), number of undeposited eggs (No. of undepo) and co-efficient of unlaid eggs (Co-unlaid eggs).

Double cocoon percentage and pupation ratio were calculated according to the following formulae of Lea (1996).

The Co-efficient of laid and unlaid eggs was calculated using the following formulae of Narain et al. (2003).

$$\text{Co-efficient of laying eggs} = \text{Number of eggs laid}/\text{Total number of laid and unlaid eggs} \times 100$$

$$\text{Co-efficient of unlaid eggs} = \text{Number of unlaid eggs} / \text{Total number of laid and unlaid eggs} \times 100$$

Eleven positive traits were taken into consideration. These were cocoon weight, cocoon shell weight, pupal weight, cocoon shell ratio, silk productivity, pupation ratio, cocooning percentage, number of fertile eggs, fecundity, fertility and coefficient of laying eggs.

Eight negative directions were used. These were fifth instar duration, total larval duration, mortality percentage, double cocoon percentage, number of cocoon per liter, number of unfertile eggs, number of undeposited eggs and co-efficient of unlaid eggs (Sudhakara et al., 2001; Jaiswal and Goel, 2003 and Suresh Kumar et al., 2011).

Equations of evaluation index

Evaluation index

Evaluation index was calculated using the following formula according to Mano et al. (1993):

$$Evaluation\ index\ (EI) = ((A - B)/C \times 10) + 50$$

where A = Value obtain for a particular trait of the particular hybrid. B = Mean value of the particular trait of all the considered hybrids. C = Standard deviation (n-1) of a particular trait of all the considered hybrids. 10 = standard unit, 50 = Fixed value.

In order to judge superiority of hybrid genotypes impartially, a common evaluation index is necessarily adopted giving equal emphasis to all the commercial economic traits. The average of evaluation index value fixed to select a hybrid