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Correlation Analysis between Longevity of Adult Moths and Economic Traits in Few Bivoltine Silkworm Races/Breed.

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ABSTRACT
Mean adult life span was correlated with larval weight, cocoon weight, shell weight, shell percentage and filament length in the four bivoltines. Based on the Pearson correlation co-efficient estimations, there is correlation between adult longevity and larval weight. Based on the Pearson correlation co-efficient estimations there is strong correlation between adult longevity and three cocoon characters namely cocoon weight, shell weight and shell percentage. Insignificant correlations were observed among races/breed between adult life span and filament length. Among the four bivoltines C_{108} was included under group I with lowest R^2 values. Whereas KA and NB_4D_2 races may be included under group II. However, CSR_2 breed is distinct with highest Pearson correlation co-efficient (R^2) values comes under group III. The results obtained in the present studies clearly demonstrates that there is significant correlation between adult longevity and four economic traits, larval weight, cocoon weight, shell weight, shell percentage. However for the trait filament length such correlation could be possible only among selected breeds/hybrids.

KEYWORDS: *Silkworm, bivoltine, yield, correlation co-efficient, adult, longevity, economic traits, seasons.*

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I. INTRODUCTION

The silkworm *Bombyx mori* ranks next only to the fruit fly, *Drosophila melanogaster* and has been exploited for various genetical studies (Tazima, 1978) among domesticated insect species. In addition, to its utility as a laboratory tool for various experimental studies (Na *et al*., 2008), it is an important economic insect by virtue of the lustrous silk fibre it produces at the end of its larval life cycle to protect itself from external environmental condition and to undergo metamorphosis into pupal stage, further into an adult moth. But the silk formed in the form of cocoons been utilized by humans for various purposes. Hence the entire sericulture industry is mainly based the quality and quantity of the silk produced by the different silkworm races/breeds/hybrids. Thus the silkworm breeding programmes are the integral part of the industry and have been continued since time immemorial when the silkworms were discovered for the first time in China way back in 3000BC. In silkworm breeding, numerous traits are considered as important for improving them to increase the benefits to silk producers. In recent years, several breeders have added further dimensions by including biochemical characteristics, nutritional aspects of silkworm and mulberry food plant as surrogate breeding parameters or markers for septic yield traits. Genetic variability is a prerequisite for an effective selection and as a result genetic variability is essential for developing high yielding varieties (Akanda *et al*., 1998;Rohith, 2015; Venkateshkumar, 2015). Yields are the multiplicative and product of many factors which jointly or singly influences it. Grafius (1959) and House *et al*. (1958) are also of the opinion that yield is not an independent character; rather it results from the multiplicative interactions between various yield components. The selection of best genotypes depends on a number of characters. Therefore, a clear understanding and knowledge of association and contribution of various yield components is essential for any selection programme aimed at yield improvement (Ashan and Rahman, 2008). The pioneering work in this regard has been undertaken by many investigators in plants (Tanksley and Rick, 1980; Van Gyet *et al*., 1990). In animals too, Bullifield *et al*. (1998) and Jung *et al*., (1989) have reported the importance of biochemical parameter relevant to animal breeding.

Correlation studies carried out in silkworm between different characters has been worked out by selection experiments. Gamo and Shimazaki (1967) was the first sericulture scientist who came with the idea of finding and exploiting the correlation between biochemical parameters and yield attributes. Similarly, correlations were observed for cocoon weight, larval weight and shell weight by Sen *et al*. (1976), Yan (1983), Rajanna and Sreerama Reddy (1990) and Jayaswal *et al*. (2000). Shamachary *et al*. (1980) found significant positive correlation of mature larval weight with cocoon weight and shell weight and cocoon weight and pupal weight in both sexes of *Bombyx mori.* Singh *et al*., (1994) reported the similar results between shell weight and fecundity. The studies have shown that direct selection for one trait has correlation with genetic changes with other quantitative characters. The correlation of some character was found to be positive, while for others it was negative (Umashankara and Subramanya, 2001). Selection based on heritability coefficients of single cocoon weight and shell weight, can be applied successfully for genetic gain to improve other traits as well (Kumaresan *et al*., 2002). Several reports on correlation between larval weight and cocoon traits are recorded both among tropical and temperate race (Umashankara and Subramanya 2002). For instance Nagaraju *et al*. (2002) revealed change in V instar larval weight, the cocoon weight and the pupal weight showed the interdependence for each other, when the regression lines were drawn which clearly demonstrate that V instar larval weight plays an important role in estimating the total cocoon productivity of the races of cocoon weight and larval weight are important characters of single shell weight. Chatterjee and Pradeep (2003) investigated the relationship between yield potential and molecular markers in silkworm. The molecular markers and the productivity characters were correlated by multiple variable analyses. The analysis permitted the identification of molecular markers associated with cocoon weight or the shell weight separately. Some markers were associated with both the characters (Gaviria *et al*., 2005). Similarly, genotype correlation was higher than the corresponding phenotypic correlation coefficient in monsoon and premonsoon followed by post monsoon season and heritability together with genetic advance in percent of mean were higher for most of the important characters. The estimates of genotypic and phenotypic variance for various economic traits and their heritability in both multivoltine and bivoltine races was reported by Rohith and Subramanya (2010a, 2010b, 2010c and 2010d) where the higher values of heritability was recorded for the traits of yield by number, shell weight and shell percentage indicating the role of environmental influence. Though, a lot of base line information is available on the adult longevity of silk moth in different races of *Bombyx mori* but the information regarding correlation with the adult longevity of silk moth *Bombyx mori* in relation to economic trait in mulivoltine or bivoltine or hybrids are meager. Keeping this in view, an attempt has been made through the experiments to know the relation between the adult longevity of silk moth *Bombyx mori* with quantitative traits in four bivoltines races/breeds.

II. MATERIALS AND METHODS

In the present study four bivoltine races/breed C_{108}, KA, NB_4D_2 and CSR_2 are utilized (Table 1). The material was derived and reared according to the standard rearing techniques (Krishnaswami, 1973). The data related to larval weight (g), cocoon weight (g), shell weight (g), shell ratio (%), filament length (m), and adult longevity of the respective races/breed and hybrids were recorded in three different seasons of the year *viz*., pre-monsoon, monsoon and post-monsoon. The yield related parameters were subjected to correlation co-efficient analysis with respect to silkworm, *Bombyx mori* moth longevity. The data was analyzed by employing the following statistical methods. The relationship between two continuous variables was computed following Pearson's correlation co-efficient method as described by Singh (1998) utilizing the following formula.

$$R = \frac{N\Sigma\, XY - (\Sigma\Sigma X)(\Sigma Y}{(N^2)(SD_X)(SD_Y)}$$

Where, R = Co-efficient of correlation

N = Number of pair of observation.

SDx = Standard deviation of X series (independent variable or subject series)

SD_Y = Standard deviation of Y series (dependent variable or relative series)

The probable error of correlation coefficient and test of significance of correlation coefficient was computed following the methods of Bailey (1994).

Probable Error (r)= 0.6745 X S.E. (r)

$= 0.6745X_n^{(1-r2)}$

Test of significance (r) $t = r_{1-r2}^{n-2}$

The regression function between the two variables to find out the best fitted straight line or prediction line was also computed following the methods of Palanichamy and Manoharan (1990) and multiple regression function following Bailey (1994) and Singh (1998) using the formula; $Y = a+b_X$

Where, a = Intercept of the straight line or regression constant which denotes the value of Y when the value of X is zero.

b = Slope of straight line or regression coefficient which gives an idea that how change will occur in variable Y when values of X varies by 1 unit.

X and Y = Represents the co-ordinates of points of the line. Multiple Regression (X 1.23) = a 1.23 +b $12.3X_2$ + $13.2X_3$.

The co-efficient of determinations ($R= r^2$) which is the ratio of predicted and total variance was calculated to represent the variability in dependent variable in percentage due to variation of independent variable.

Table-1.The morphological characteristic features of four selected bivoltine pure races / breed.

Sl. No.	Races/breed	Origin	Larval Markings	Cocoon Colour	Cocoon Shape	Voltinism
1	C_{108}	China	Plain	White	Oval	Bivoltine
2	KA	India	Plain	White	Oval	Bivoltine
3	NB_4D_2	India	Plain	White	Dumbbell	Bivoltine
4	CSR_2	India	Plain	White	Oval	Bivoltine

III. RESULTS AND DISCUSSION

The four bivoltine race/breed's male and female populations rearing results data on the mean values of five economic traits *viz*., weight of the V age larvae(g), single cocoon weigh(g), single shell weight(g), shell ratio(%), filament length(m) and adult longevity(h) in three seasons are presented in tables 2-4 and depicted in figures 1-10. Similarly, the co-efficient of correlation calculated by pooling all the data for the three seasons between adult longevity and five economic traits of female and male population are presented in the tables 5. The diagrammatic representations of the results related to correlation co-efficient are shown in figures 1-10. The detailed results on the above aspects are described below.

Table 2, presents the data pertaining to five economic traits and mean longevity in four bivoltine races/breed of silkworm in the pre-monsoon season. Based on the data presented in table- 2 and figures 1-10 it is very clear that the weight of V instar larvae ranges from mean value of 37.27±0.16g. (males of C_{108}) to a highest of 45.84±0.05g.(females of CSR_2 breed). The relavant 'F' values for this trait is 168.33. In regard to the three cocoon characters *viz*., single cocoon weight, single shell weight and shell percentage the data followed a uniform pattern wherein C_{108} males recorded the lowest values of 1.55±0.005g and 0.30±0.005g for single cocoon weight and single shell weight respectively. On the other hand, the females of C_{108} recorded 18.35±0.29g for the trait shell ratio which is the highest among the bivoltines. The relevant 'F' values for these three traits are 70.10, 14.76 and 7.47. It is also evident from the table that the females of C_{108} recorded a filament length of 868±4.61m whereas, the longest filament length was observed in CSR_2 races with a filament length of 998±4.04m. (The F value for this trait is 169.39). From the mean adult longevity recorded in the table-2, it is very clear that the longevity ranges from a lowest of 156±3.46h. in the males of C_{108} to a highest of 216±6.92h. in females of CSR_2 breed with an 'F' value for this trait was 16.37. The data pertaining to five economic traits and adult longevity in table 2 pertaining to the two races KA and $NB_4D_{2,}$ it is very clear that the values are intermediatory between C_{108} and CSR_2 races/breed. The statistical analysis clearly indicates that there is significant differences between the four races/breed ($P<0.05$).

Table-3 and figures 1-10, presents the data pertaining to five economic traits and mean longevity in monsoon season among four bivoltine races/breed. It is very clear that the weight of V instar larvae ranges from mean value of 38.03±3.72g. (males of C_{108}) to a highest of 46.89±4.63g.(females of CSR_2 breed). In regard to the three cocoon characters viz., single cocoon weight, single shell weight and shell percentage the data followed a uniform pattern, wherein C_{108} males recorded the lowest values of 1.74±0.01g and 0.35±0.001g for single cocoon weight and single shell weight respectively. On the other hand, the females of C_{108} recorded 18.75±0.76g for the trait shell ratio. It is also evident from the table that the females of C_{108} recorded a filament length of 967±2.51m, where as the longest filament length was observed in CSR_2 breed with a filament length of 1090±5.19 m. The 'F' value for this trait was 169.39. From the mean adult longevity recorded in the table-3, it is clear that the longevity ranges from a lowest of 180±3.46h (in males of C_{108}) to highest of 234±3.46h (in females of CSR_2 breed) with the 'F' value for this trait was 88.46. The data pertaining to all the five economic traits and adult longevity presented pertaining to the two races KA and NB_4D_2 it is very clear from the table-3 that the values are intermediatory between C_{108} and CSR_2 races/breed. The statistical analysis clearly indicates that there is a significant differences between the four races/breed ($P<0.05$).

The statistical data related to the economic traits and adult longevity in post monsoon season for four bivoltine races/breed are presented in the table-4 and in figures 1-10. From the data presented in the table it is clear that, the mean weight of fifth age larvae (female) ranges from 38.91± 0.81g in C_{108} to 46.24 ± 0.64g in females of CSR_2. Similarly, in males it ranges from 37.67 ± 0.61g in C_{108} to a highest of 46.24 ± 0.72g in CSR_2. The data in regard to cocoon weight, shell weight and shell percentage revealed uniform trend, where in C_{108} race recorded lowest values for the above three traits both in male and female. The concordant 'F' values for cocoon weight, shell weight and shell percentage are 71.40g, 61.71g and 44.20g, respectively which are statistically significant ($P<0.05$) among the four bivoltine races. In regard to filament length, the data clearly demonstrated that the race C_{108} exhibited lowest filament length of 904 ± 2.30m in the female population and highest filament length of 1005 ± 2.8m in the male populations of CSR_2 breed. The results for filament length revealed statistically significant results among the races (P<0.05). The data pertaining to adult longevity in the four bivoltine races/breed clearly indicated racial differences between them. While, the lowest adult longevity of 204 ± 3.46 hours was recorded by the females of C_{108} and the longest adult longevity was recorded in the females of CSR_2 with a value of 276 ± 6.92h. The data for this trait revealed statistically significant results (P<0.05) with an 'F' value of 16.75.

Table-5 also clearly demonstrates a clear correlation between each of the five economic traits understudy in all the seasons for the five traits are significant at 1% in bivoltine races/breed and are presented in the figures 1-10. The detailed results on correlation are as follows.

Table 2: Mean values of the five economic traits and adult lifespan in four bivoltine races/breed of the silkworm, *Bombyx mori* in pre-monsoon season.

Races/Breed \ Economic Traits		Weight of 10 V-age larvae (g)	Single Cocoon Weight (g	Single Shell weight (g))	Shell ratio (%)	Filament length (m)	Adult lifespan (h)
C_{108}	Female	38.52±0.61	1.58±0.01	0.28±0.01	18.35±0.29	868±4.61	192±6.92
	Male	37.27±0.16	1.55±0.005	0.30±0.005	19.35±0.30	879±4.61	156±3.46
KA	Female	40.76±0.04	1.69±0.02	0.32±0.02	18.93±0.55	890±3.17	198±6.92
	Male	39.46±0.06	1.64±0.01	0.33±0.02	20.11±0.56	906±1.73	162.±3.46
NB_4D_2	Female	41.93±0.03	1.73±0.02	0.34±0.02	19.65±0.53	894±2.30	198±6.92
	Male	40.53±0.04	1.68±0.02	0.35±0.01	20.82±0.54	911±2.88	162±3.46
CSR_2	Female	45.84±0.05	1.81±0.01	0.38±0.02	20.99±0.50	971±1.73	216±6.92
	Male	44.24±0.023	1.79±0.011	0.41±0.011	22.73±0.64	988.00±4.04	168.00±3.46
F-value	Female	2.25	113.26	84.53	13.15	5.52	202.72
	Male	2.00	1155.07	91.38	19.92	7.50	178.99
Signi-ficant	Female	NS	**	**	NS	NS	**
	Male	NS	**	**	**	*	**
CD at 5%	Female	25.27	1.13	0.03	0.03	1.76	11.50
	Male	12.63	0.29	0.03	0.03	1.92	12.77
Index: NS: Non Significant. *: Significant at 5% level (P<0.05). **: Significant at 1% level (P<0.01).							

Table 3: Mean values of the five economic traits and adult life span in four bivoltine races of silkworm, *Bombyx mori* in monsoon season.

Races/Breed \ Economic Traits		Weight of 10V-age larvae (g)	Single Cocoon weight (g	Single Shell weight (g))	Shell ratio (%)	Filament length (m)	Adult life span (h)
C_{108}	Female	39.40±3.89	1.78±0.08	0.33±0.35	18.75±0.76	967±2.51	204±3.80
	Male	38.03±3.72	1.74±0.01	0.35±0.01	20.11±0.26	984±5.19	180±3.46
KA	Female	43.61±4.10	1.87±0.08	0.36±0.38	19.24±0.32	1012±6.84	258±3.74
	Male	42.21±2.12	1.84±0.01	0.38±0.01	20.64±0.25	1029±5.19	216±3.46
NB_4D_2	Female	43.81±4.30	1.89±0.09	0.38±0.42	20.09±0.19	1068±7.87	244±6.76
	Male	41.94±2.17	1.87±0.02	0.4±00.02	21.3±0.54	1085±5.77	216±3.46
CSR_2	Female	46.89±4.63	1.98±0.02	0.43±0.47	21.63±0.73	1071±8.32	276±3.80
	Male	45.53±2.30	1.94±0.02	0.39±0.02	23.70±0.45	1090±5.19	234±3.46
F-value	Female	13.38	540.14	103.52	21.20	8.42	91.56
	Male	42.75	262.02	82.70	25.90	15.90	88.46
Signi ficant	Female	*	**	**	**	*	**
	Male	**	**	**	**	*	**
CD at 5%	Female	30.52	0.47	0.02	0.02	1.59	18.95
	Male	12.63	0.69	0.02	0.02	1.45	19.50
Index: NS: Non Significant. *: Significant at 5% level (P < 0.05). **: Significant at 1% level (P < 0.01).							

Table 4: Mean values of the five economic traits and adult life span in four bivoltine races of silkworm, *Bombyx mori* in post-monsoon season.

Races/Breed (Economic Traits)		Weight of 10 V-age larvae (g)	Single Cocoon weight (g	Single Shell weight (g))	Shell ratio (%)	Filament length (m)	Adult life span (h)
C_{108}	Female	38.91±0.81	1.63±0.02	0.31±0.05	19.01±0.21	898±4.61	240±6.92
	Male	37.67±0.61	1.60±0.01	0.32±0.04	19.99±0.21	904±2.30	204±3.46
KA	Female	41.16±0.61	1.74±0.01	0.33±0.04	18.95±0.20	930±5.19	258±6.92
	Male	39.86±0.78	1.68±0.02	0.34±0.05	20.22±0.20	932±4.04	222±7.21
NB_4D_2	Female	42.33±0.71	1.77±0.02	0.35±0.05	19.77±0.23	926±4.61	264±6.92
	Male	40.93±0.82	1.72±0.02	0.38±0.05	22.08±0.18	940±5.19	240±3.46
CSR_2	Female	46.24±0.64	1.89±0.01	0.42±0.06	21.86±0.38	991±2.30	276±6.92
	Male	44.64±0.72	1.85±0.01	0.43±0.04	23.23±0.16	1005±2.8	264±3.46
F-value	Female	4.68	19.19	75.21	68.75	25.35	81.86
	Male	29.86	15.41	81.68	70.75	63.41	128.06
Signi-ficant	Female	NS	*	**	**	**	**
	Male	**	*	**	**	**	**
CD at 5%	Female	7.29	2.55	0.04	0.02	0.98	15.79
	Male	17.11	2.70	0.04	0.02	0.70	13.77

Index: NS: Non Significant. *: Significant at 5% level (P < 0.05). **: Significant at 1% level (P < 0.01).

Table 5: Correlation between longevity and economic traits among four bivoltine races/breed of silkworm,
***Bombyx mori* in three seasons of the year.**

Economic traits	Sex	Adult longevity	Weight of larvae	Weight of cocoon	Shell weight	Shell percentage	Season
Weight of the larvae	Female	0.399 *					Pre-monsoon
	Male	0.468 *					
Cocoon weight	Female	0.521 *	0.953**				
	Male	0.559 *	0.985**				
Shell weight	Female	0.675 **	0.887**	0.956**			
	Male	0.646 *	0.947**	0.976**			
Shell percentage	Female	0.742 **	0.783 *	0.872**	0.977**		
	Male	0.710 **	0.869**	0.919**	0.981**		
Filament Length	Female	0.650*	0.630*	0.790**	0.795**	0.741*	
	Male	0.0.704*	0.678*	0.758**	0.753**	0.794**	
Weight of the larvae	Female	0.695 **					Monsoon
	Male	0.771 **					
Cocoon weight	Female	0.667 **	0.985**				
	Male	0.778 **	0.979**				
Shell weight	Female	0.605 *	0.921**	0.972**			
	Male	0.700 **	0.928**	0.951**			
Shell percentage	Female	0.526 *	0.826 *	0.900**	0.972**		
	Male	0.627 *	0.863**	0.887**	0.986**		
Filament Length	Female	0.623*	0.684*	0.690*	0.676*	0.617*	
	Male	0.692*	0.653*	0.638*	0.665*	0.689*	
Weight of the larvae	Female	0.729 **					Post-monsoon
	Male	0.775 **					
Cocoon weight	Female	0.689 **	0.971**				
	Male	0.779 **	0.976**				
Shell weight	Female	0.631 *	0.976**	0.957**			
	Male	0.784 **	0.962**	0.982**			
Shell percentage	Female	0.569 *	0.920**	0.870**	0.960**		
	Male	0.763 **	0.921**	0.938**	0.986**		
Filament length	Female	0.622*	0.761**	0.756**	0.775**	0.710**	
	Male	0.748**	0.761**	0.789**	0.762**	0.705**	

Index: NS: Non Significant. *: Significant at 5% level (P < 0.05). **: Significant at 1% level (P < 0.01).

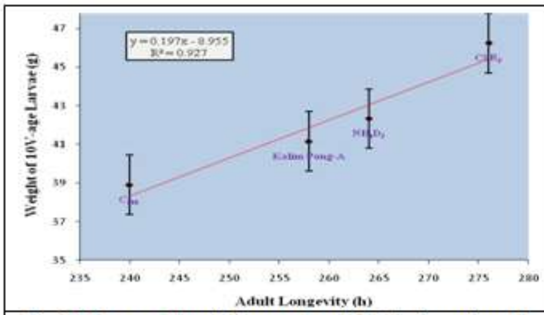

Fig. 1: Longevity v/s Larval weight in four female bivoltine races

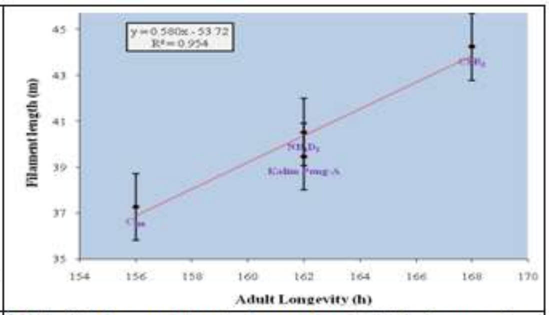

Fig. 2: Longevity v/s Larval weight in four male bivoltine races

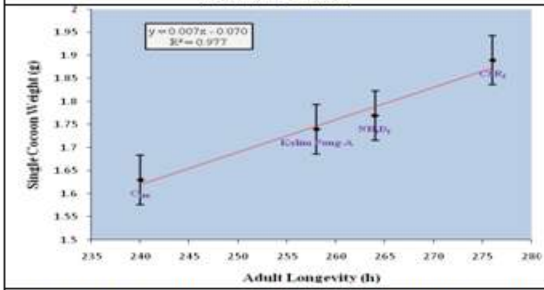

Fig. 3: Longevity v/s single cocoon weight in four female bivoltine races

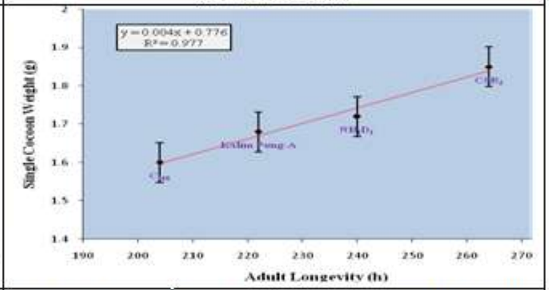

Fig. 4: Longevity v/s single cocoon weight in four male bivoltine races

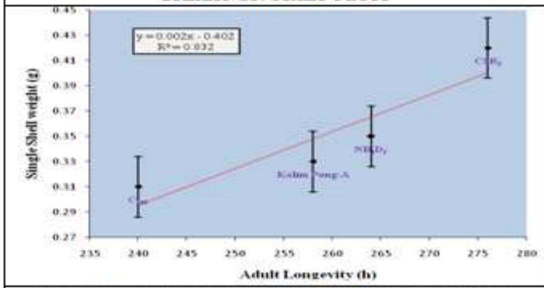

Fig. 5: Longevity v/s single shell weight in four female bivoltine races

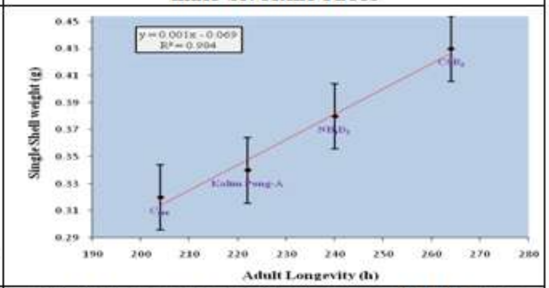

Fig. 6: Longevity v/s single shell weight in four male bivoltine races

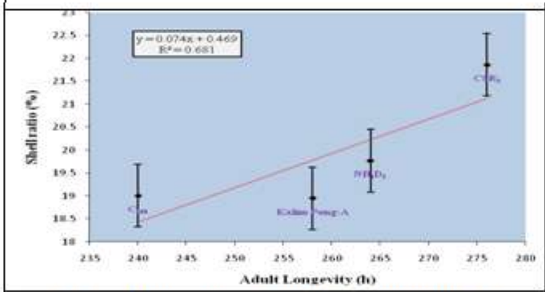

Fig. 7: Longevity v/s shell ratio four female bivoltine races

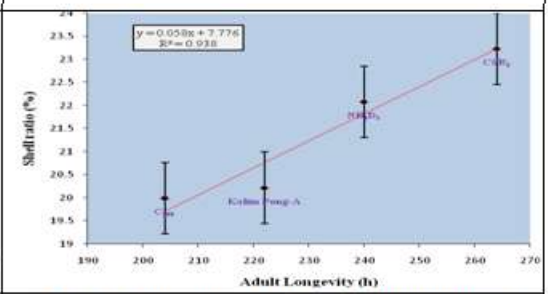

Fig. 8: Longevity v/s shell ratio in four male bivoltine races

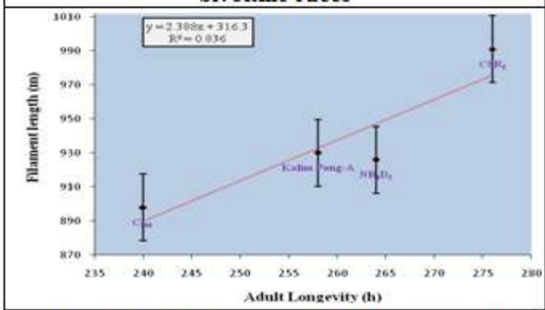

Fig. 9: Longevity v/s Filament length in four female bivoltine races

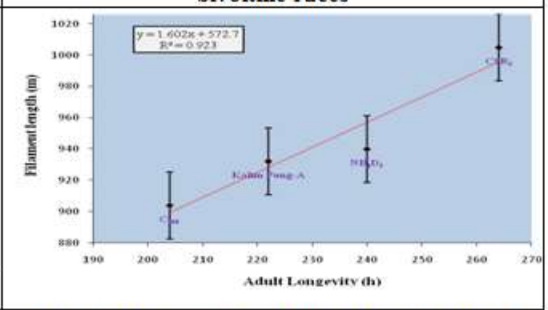

Fig. 10: Longevity v/s Filament length in four male bivoltine races

Relations between weights of the V instar larvae and adult longevity;

The co-efficient correlation (r) between weight of larvae and longevity exhibited a significant positive correlation only for the females with an 'r' value of 0.599 during pre-monsoon season. However, there is correlation between these two traits in females and males (0.668 which is significant at 5% level). However, data revealed for monsoon season clearly indicated that there is correlation between the above traits irrespective of the sexes. The 'r' value for females 0.895 and r = 0.971 for males which are significant at 1% level. The regression of Y and X axis recorded as regression function as Y = 0.197, X - 8.955 with a slope of prediction line value of 0.927 for females (Figure 1-2). On the other hand the regression of Y= 0.580, X -53.72 with prediction line value of 0.954.

Relation between cocoon weight and adult longevity;

Perusal of the data (Table-2) to understand the relation between the cocoon weight and adult longevity, it is clear that 'r' values between the above two traits during pre - monsoon season are 0.721 and 0.759, both in males and females respectively. The data is significant at 5% level. In the monsoon season the 'r' value are 0.867and 0.978, which are significant at 1% level. On the other hand, during post monsoon season there is significant correlation at 1% level where in the 'r' values are 0.889 and 0.779 for females and males respectively. Based on figures 3-4, the regression of Y and X axis is recorded regression function as Y= 0.007 X - 0.070 with a slope of predicted line value of 0.977 in females and in males the regression function Y = 0.004 X + 0.776 with a slope of prediction value of 0.977 in males.

Relation between shell weight and adult longevity;

The relation between shell weight and adult longevity is shown in the table- 2. It is evident that in pre-monsoon season the shell weight exhibited positive correlation with a 'r' value of 0.942 in females and 0.910 in the males which are significant at 1% level. During monsoon season the regression (r) values for females and males are 0.726 and 0.827 respectively. But in post - monsoon season the 'r' value for female was 0.831 which is significant at 5% level and in male 'r' value is 0.984 (significant at 1% level). Based on the 'r' values, it is clearly evident that there is association between shell weight and adult longevity (Figure 5-6). The prediction line R^2 = 0.832 in females and R^2 = 0.984 in males. Based on the results it is clear that there is a relation between adult life span and shell weight.

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Relation between shell percentage and adult longevity;

There is a significant positive correlation between shell percentage and adult longevity in all the three seasons of the year. The 'r' value for these traits during pre –monsoon season was 0.942 in female whereas, it is 0.910 for males which are statistically significant at 5% level. The 'r' values during monsoon season are 0.726 for females and 0.827 for males. Similarly, during post- monsoon season the 'r' values 0.769 and 0.963 for females and males respectively. Based on the regression of Y and X axis recorded in the graph 7-8 exhibited a regression function as Y = 0.074 X + 0.469 and slope of prediction line R^2 = 0.681 in females. Similarly, the regression value Y = 0.058 X +7.776 is clearly evident in the males with a slope of prediction line value of 0.938. Based on the results it is clear that there is a relationship between the adult life span and shell ratio.

Relation between filament length and adult longevity;

Based on the data presented in table 2 it is clear that 'r' values between the two traits filament length and adult longevity during the pre- monsoon season is 0.750, 0.704 in both males and females respectively and the data is significant at 5% level. During monsoon season the 'r' value is 0.723, which is significant at 5% level in females, and in males it is 0.892, which significant at 1 % level. Similarly, during post- monsoon season the 'r' value is 0.822 ($P<0.05$) in females and in males the 'r' value is 0.948 ($P<0.01$). The prediction line value from the figure 9-10 for females revealed 0.836, where as in males the prediction line value is 0.923.

Perusal of the data in table 5, in regard the correlation studies between adult longevity and five economic traits in the six bivoltine races in the two sexes, it is clearly evident that in pre- monsoon season there is relation between adult longevity and weight of the larva and other three cocoon characters namely, cocoon weight, shell weight and shell percentage with adult longevity. The data also presents correlation co-efficient values between filament length and adult longevity. It is clear that there is a positive and significant correlation between male and female sexes between these traits & longevity of moths. For instance based on the 'r' value, which is the ratio of predicted and total variance, which was calculated to represent the variability in dependent variable in percentage due to variation of independent variable and as result there exists significant correlation between adult longevity and five traits under study.

The present data on the significant difference between the larval weight and adult longevity revealed an 'r' value of 0.399 for females and 0.468 for males of pre-monsoon season which are significant at ($P < 0.05$) and at 1% level in monsoon and post monsoon. The literature survey pertaining to the correlation of other traits with those of larval weight was reported by Chatterjee *et al*. (1992) who have revealed negative correlation of larval weight with digestive amylase. Similarly, Umashankara and Subramanya (2002) demonstrated the correlation between larval weight and cocoon characters. But, in pioneer experiments Kang *et al*. (1999) demonstrated correlation between longevity and commercial characters in the temperate bivoltine races that tally with the results of present study for larval weight and adult longevity. A similar trend in regard to the correlation of these two traits was also clearly evident from the results of the author during monsoon, post monsoon season. The figures (1-10) clearly indicate the scattered dots between X and Y-axis and the regression line drawn indicate stronger relationship between larval weight and longevity. It is important to note that in the bivoltine races (Table- 5) the co-efficient of correlation values for females and for males, which is positively correlated. The regression equations of the two variables recorded by bivoltines are on the higher side. Thus, it is a clear indication that correlation is more evident in bivoltine. As a result, the degree of straight-line association between the values of two variables is different in both the races. The data pertaining to the correlation between the three cocoon characters namely, cocoon weight, shell weight and shell percentage in the bivoltine races/breeds in the two sexes in three seasons of the year clearly demonstrated that there is a positive and significant correlation between adult longevity and three cocoon characters. In a detailed experiment utilizing temperate bivoltine races Murakami (1989a, 1989b) demonstrated that the adult lifespan in silkworm *Bombyx mori* is one of the important biological characters in the life history of silkworm *Bombyx mor*i and opined that this particular biological character denoted as "longevity of moths" can be used as a important breeding index in the evolution of races. But a detailed investigation utilizing several temperate races in order to understand the relevance (correlation) of lifespan with commercial characters was attempted by Kang *et al*. (1999). The present studies of the author corroborates with the findings of the Kang *et al*. (1999) by exhibiting higher correlation coefficient values in all the three seasons for these traits in all four bivoltines. One interesting aspects of the present study is that the correlation coefficient value between the three cocoon characters and adult longevity is comparatively lesser than the ' r' values obtained for correlation of different characters. 'r' values ranges from a lowest of 0.521 for coon weight and longevity in females and to a highest of 0.985 for larval weight and cocoon weight in males of pre-monsoon. In monsoon lowest between shell percentage and longevity of 0.526 in females and highest for shell percentage and shell weight in males and in post monsoon season lowest is for shell weight and longevity of 0.569 in females and the highest of 0.986 for shell percentage and shell weight in males (Table 5).

The perusal of literature in regard to the longevity studies and its relevance to the economic characters has also been reported in many of the dipteron insects *viz*., fruit fly *Drosophilla melanogastor* and house fly *Musca domestica*. Lee *et al*., (1985) demonstrated the relevance of longevity with those of fecundity in *Musca domestica*. Similarly, Paukku and Kotiaho (2005) demonstrated the effect of mating and its relevance to the longevity in the seed beetles *Calloso bruchus maculatus*. Further, Partridge and Farquhar (1991) demonstrated that increasing sexual activity reduces longevity in the male fruit fly *Drosophilla melanogastor*. He has also correlated the longevity with those of the size of the fly. In an interesting experiment Hempel and Wolf (1988), demonstrated that there is inverse relationship between foraging strategy and life span in the worker honey bee *Apes meliphera*. But Burger and Promislow (2004) reported in *Drosophilla* and mice that the dietary restriction is one of the most successful ways to extend longevity. Contrary to these, Hopkin (2003) while experimenting on longevity in many species of live stock animals demonstrated that restricting diet yields animals that are leaner and have increase longevity. The correlation of environmental factors such as larval density, temperature, photoperiod and adult diet with those of adult longevity in Mosquito species *C. quinquefasciatus*, *A. Egyptius* is well documented (Calvin *et al*., 1972). Another, important aspects involved in the study are correlation of filament length with longevity. For instance the correlation co-efficient values between the above two variables is 0.741 and 794 in pre-monsoon, 0.617 and 0.689 in monsoon and 0.710 and 0.705 in post-monsoon season form females and males respectively. In a similar correlation studies Kang *et al*. (1999), demonstrated the relationship between longevity and filament length, though he has shown lower "r" values in temperate races.

IV. CONCLUSION

Based on the above studies to understand the relationship between the correlation of five economic characters with one of the biological character "longevity" that the long living moths has revealed higher R^2 values in the present study. It is evident from the results of tables 2-4 for three different seasons and table 5 that siginificant correlation was existed between longevity and the five traits studied. Among the bivoltine races/breed (Figures 1-10) the three groups can be identified in relation to the economic characters on the Y axis and adult longevity on the X axis. It is clear from the graphical representation that C_{108} falls in to first group, NB_4D_2 and KA are grouped in the second category, whereas, CSR_2 is categorized under the third group. Though, there is exists relationship between the two variable the economic characters have clearly indicated that lower the adult life span the lesser will be the economic traits and longer the life span the higher will be the economic traits. The linear Pearson correlation line drawn from figures clearly supports the above findings.

However, present study indicates that there are many instances positive correlations could not be drawn between longevity and filament length. A similar conclusion can be drawn wherein the mean longevity was correlated with the data *viz*., larval weight, cocoon weight, shell weight, shell percentage and filament length. So the above results corroborates with the findings of the pioneer works conducted utilizing temperate races by Kang *et al*. (1999). The overall picture that emerges out of the correlation studies is that adult longevity may be considered as one of the "breeding index" in addition to the analysis of quantitative traits during hybridization and selection of silkworms by the breeders (Murakami and Ohtsuki, 1989). Though, there is disparity in the results (correlation values) in the races/breed, it may be due to racial differences. Thus, it is pertinent to mention here that adult life span in silkworm is one of the biological character which can be used as an important breeding index in the evolution of races.

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