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Comparative Study on the Larval Development Duration of 51 Different Peanut Cocoon Strains of Iran Silkworm *Bombyx mori* (Lepidoptera: Bombycidae) Gene Bank

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Abstract: The present study aims at shedding more light to larval duration and development of silkworm lines from Iranian silkworm gene bank and comparison of the results using statistical models for selection of the superior strains. Feeding and other conditions of larval rearing were conducted following the standard procedure and all germplasm strains were reared under standards protocols in all rearing steps. From obtained results, it is showed that the larval duration of the 101 (608.000 h), 5118×10133-3-3 (588.670 h), 307-300-2 (584.000 h), 105 (584.000 h) and 31 (584.000 h) strains remained significantly at upper level than other strains, respectively. The feeding larval duration in B2-09 (574.000 h), N19 (533.000 h), 1433-9 (525.000 h), BH-2 (517.330 h) and 1433-15 (511.330 h) strains increased significantly in comparison with other strains. Molting larval duration remained significantly at upper level in I 20 (197.670 h), 107-K (113.000 h), Black Larvae-White Cocoon (104.000 h), 101(104.000 h) and Shaki (103.000 h) increased significantly in comparison with other strains. From obtained results, it is showed the 1-3 instars larval duration of the Black-White (292.670 h), 101 (290.000 h), 1003-5 (288.670 h), 101×F6 (286.000 h) and 31 (286.000 h) strains remained significantly at upper level than other strains, respectively. Totally, 7409 (577.881), Black Larvae-White Cocoon (577.508), 236 (570.769), M-1-2(5) (568.583) and T5-M (566.602) showed higher evaluation index values. Also, 7409 (5.374), 236 (5.267), T5-M (5.183), 113-K (5.163) and White Larvae-Yellow Cocoon (5.027) showed higher sub-ordinate function values.

Key words: Larvae, development, germplasm, strain, silkworm

INTRODUCTION

The silkworm *Bombyx mori* is a domesticated insect reared by the farmers to produce silk. Sericulture is an agro-based cottage industry, which provides substantial income to the farmers and helps to produce high-quality raw silk (Velu *et al*., 2008).

Organization and maintenance of silkworm genetic resources as germplasm has become very important for meeting the desired objectives of the breeder for immediate or long-term

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utilization in silkworm breeding programmes. But, it is necessary to maintain them in their original form for their rational use in different breeding and other research purposes (Mukarjee *et al*., 1999; Basavaraja *et al*., 2003; Thangavelu *et al*., 2003; Yamaguchi, 2003; Rao *et al*., 2006).

Owing to the long history of sericulture practice and wide diversity of geographical conditions, there is a very rich resource of silkworm germplasm bank in Iran. At present there are 51 strains preserved in the Iran Silkworm Research Center (ISRC). As the progress in silkworm germplasm collection and investigation, many of the strains are used in silkworm breeding for commercial activity and played significant role in the advance of commercial silkworm varieties (Sohn, 2003).

As Zanatta *et al*. (2009) stated an extensive study is needed to improve existing lines for commercial purposes and to develop new strains through silkworm breeding programs aimed at improving silk productivity (Sen *et al*., 1999; Li *et al*., 2001). Several studies related to the use of productivity markers and morphological dissimilarity (Zanatta *et al*., 2009) as indicators of the best lines for breeding.

Iran Silkworm Research Center (ISRC), Rasht, Iran holds 51 silkworm varieties. These silkworm varieties show wide diversity in the phenotypic parameters. There is currently no immediately accessible data on peanut cocoon strains of Iranian silkworm germplasm. Therefore, the present study aims at shedding more light to larval duration and development of silkworm lines from Iranian silkworm gene bank and comparison of the results using statistical models for selection of the superior strains.

MATERIALS AND METHODS

This study was conducted in Islamic Azad University, Ghaemshahr Branch, Iran and Iran Silkworm Research Center from December 2008 till December 2009. Fifty one silkworm strains were used in the present study. These strains included 107-K, 119-K, 113-K, 105, 31, 51, 103, BH-2, B2-09, 1003-4, 1003-5, 1005, M2-6-22-2, M2-6-18(109), M-1-2(5), M2-6-22(107), M2-6-18.3, 307-300-2, 202A-204B, I 20, 101433-9-5, 101433-1-4, 101433-6-6, 1126 (111), 113 (2029), 151 (103×M-1-1), Xihang 2.3, Xihang 3.3, 153 (Xihang-1), 5118×10133-2-2, 5118×10133-3-3, Black-White, 101×F6, F6×101, Kinshu, M-1-1×31, 31×M-1-1, M-1-1×103, 103 Poly Marking, Shaki, 101, T1-J, T5-M, 236, 1524, 1433-15, 1433-9, 7409, N19, White Larvae-Yellow Cocoon and Black Larvae-White Cocoon.

All silkworm germplasm rearing steps including egg, larvae, pupae and moth cycles were conducted at Iran Silkworm Research Center (ISRC) before this study as annual and routine germplasm conservation program. Their silkworm rearing technique included single batch rearing system. Feeding and other conditions of larval rearing were conducted following the standard procedure (ESCAP, 1993) and all germplasm strains were reared under standards protocols in all rearing steps. After hatching from the eggs, neonates were brushed and reared up separately on fresh leaves of mulberry (*Morus alba*). One-day-old 1st instar larvae from all strains were reared for experiment. Individual laying were prepared for each strain before rearing and each individual laying consisted of about 500 eggs taken from one disease free laying and decreased to 250 larvae at beginning 4th instar. The silkworm eggs had incubated in the controlled environment chamber. When there were 95% of eggs having little black dots on the surface of eggs, they were shaded with black gobo to prevent the light irradiation for about 48 h for making the larvae emerge form the eggs at one time. After most of them hatched, the silkworm larvae were fed on leaves of mulberry. Brushing was done carefully. The batches of 500 silkworm larvae were reared. The young larvae (1st-3rd instars) were reared at 27-28°C with 85-90% relative humidity and the late age larvae (4th and 5th instars) were maintained at 24-26°C with a relative humidity of 70-80%. The larvae were fed *ad libitum* mulberry leaves three times a day. Studied quantitative characteristics included larval duration (h), feeding larval duration (h), molting larval duration (h), 1-3 instars larval duration (h), 1-3 instars feeding larval duration (h), 1-3 instars molting larval duration (h), 4-5 instars larval duration (h), 4-5 instars feeding larval duration (h), 4-5 instars molting larval duration (h), 5 instar feeding larval duration (h) and cocoon spinning duration (h).

It was used for data analyzing from CRD model, GLM approach and SAS software (SAS, 1977). Under model was used for data analyzing for each strain: $y_{ij} = \mu + G_i + e_{ij}$ which y_{ij} was record or observation from trait, μ was trait average, G_i was group effect (strain) and e_{ij} was residual effects. Furthermore, it was used appropriate transformation like angle transformation for those data which did not followed by normal distribution. The DNMRT method was used for average compares (Duncan, 1951).

Also, evaluation index value and sub-ordinate function value were calculated for nutritional indices. Evaluation Index (EI) value for silkworm strains performance were calculated by using the following equation (Mano *et al*., 1993; Rao *et al*., 2006):

$$EI = [(A-B)/C] \times 10+50$$

where, A is mean of the particular trait in a strain; B is overall mean of particular trait in all strains; C is standard deviation of a trait in all strains; 50 is constant.

Sub-ordinate function is calculated by utilizing the following equation based on Gower (1971) and Rao *et al*. (2006):

$$Xu = (Xi-X_{min})/(X_{max}-X_{min})$$

where, Xu is sub-ordinate function; Xi is measurement of trait of tested strain; X_{min} is minimum value of the trait among all the tested strains; X_{max} is maximum value of the trait among all the tested strains.

The evaluation index (Table 2) and sub-ordinate function values (Table 3) for the all traits were calculated separately and average index value was obtained. Then studied silkworm strains are ranked based on average of evaluation index method and sub-ordinate function method (Table 4).

RESULTS AND DISCUSSION

From the obtained results, it was clear that different strains of silkworm *Bombyx mori* showed different performance based on larval development duration. The analysis of variance regarding to studied traits, showed that different strains have significant different for traits ($p<0.01$).

Based on Table 1 it is showed the larval duration of the 101 (608.000 h), 5118×10133-3-3 (588.670 h), 307-300-2 (584.000 h), 105 (584.000 h) and 31 (584.000 h) strains remained significantly at upper level than other strains respectively. The feeding larval duration in B2-09 (574.000 h), N19 (533.000 h), 1433-9 (525.000 h), BH-2 (517.330 h) and 1433-15 (511.330 h) strains increased significantly in comparison with other strains. Molting larval duration remained significantly at upper level in I 20 (197.670 h), 107-K (113.000 h), Black Larvae-White Cocoon (104.000 h), 101 (104.000 h) and Shaki (103.000 h) increased significantly in comparison with other strains. From obtained results, it is showed the 1-3 instars larval duration of the Black-White (292.670 h), 101 (290.000 h), 1003-5 (288.670 h), 101×F6 (286.000 h) and 31 (286.000 h) strains remained significantly at upper level than other strains, respectively (Table 1).

The 1-3 instars feeding larval duration in 105 (232.330 h), 101433-1-4 (232.000h), 1003-4 (231.670 h), 236 (231.330 h) and 5118×10133-3-3 (230.330 h) strains increased significantly in comparison with other strains. The 1-3 instars molting larval duration remained significantly at upper level in the 107-K (81.000 h), 1126 [111] (72.000 h), 101×F6 (70.333 h), BH-2 (69.667 h) and 31 (69.000 h) increased significantly in comparison with other strains (Table 1).

From obtained results, it is showed the 4-5 instars larval duration of the 101 (318.000 h), 1005 (312.000 h), N19 (312.000 h), Black Larvae-White Cocoon (310.000 h) and 307-300-2 (308.000 h) strains remained significantly at upper level than other strains, respectively. The 4-5 instars feeding larval duration in N19 (303.000 h), 1433-9 (297.000 h), M2-6-22-2 (288.000 h), 51 (288.000 h) and 307-300-2 (284.000 h) strains increased significantly in comparison with other strains. The 4-5 instars molting larval duration remained significantly at upper level in the 101 (41.000 h), 1005 (39.000 h), Black Larvae-White Cocoon (39.000 h), 5118×10133-2-2 (34.333 h) and White Larvae-Yellow Cocoon (33.667 h) increased significantly in comparison with other strains. From obtained results, it is showed the 5 instar feeding larval duration of the N19 (193.000 h), T1-J (187.000 h), M-1-2(5) (187.000 h), 1524 (187.000 h) and 1433-9 (187.000 h) strains remained significantly at upper level than other strains, respectively. The cocoon spinning duration in I 20 (21.000 h), N19 (19.333 h), 107-K (17.333 h), 51 (12.000 h) and M2-6-22-2 (11.000 h) strains increased significantly in comparison with other strains (Table 1).

Also, based on larval development of strains were assessed on different parameters including larval duration, feeding larval duration, molting larval duration, 1-3 instars larval duration, 1-3 instars feeding larval duration, 1-3 instars molting larval duration, 4-5 instars larval duration, 4-5 instars feeding larval duration, 4-5 instars molting larval duration, 5 instars feeding larval duration and cocoon spinning duration. Recorded characteristics of larval development using the evaluation index (Table 2, 4) and sub-ordinate function (Table 3, 4) methods and the details are as follows.

Based on Table 2 among germplasm strains, as per the evaluation index method, the all strains had equal score values for larval duration (40.230) and feeding larval duration (40.230) and 1-3 instars feeding larval duration (49.080), 4-5 instars larval duration (68.742), 4-5 instars feeding larval duration (51.999).

Meanwhile, as per the evaluation index method, the strains N19 (79.279), 1433-9 (75.646), M2-6-22-2 (61.113), 101 (61.113) and 1433-15 (61.113) showed higher evaluation index values for molting larval duration. Among germplasm strains, as per the evaluation index method, the strains 119-K (56.234), 51 (56.234), 103 (56.234), BH|-|2 (56.234) and 31 (56.234) showed higher evaluation index values for 1-3 instars larval duration. Meanwhile, as per the evaluation index method, the strains 7409 (65.115), 1433-15 (63.031), 1433-9 (63.031), 1524 (60.948) and 105 (56.781) showed higher evaluation index values for 1-3 instars molting larval duration (Table 2). Meanwhile, as per the evaluation index method, the strains 1433-9 (80.484), N19 (80.484), M2-6-22-2 (62.832), T5-M (54.889) and 236 (54.889) showed higher evaluation index values for 4-5 instars molting larval duration. Among germplasm strains, as per the evaluation index method, the strains 113-K (74.323), White Larvae-Yellow Cocoon (74.323), 107-K (52.936), 119-K (52.936) and 105 (52.936) showed higher evaluation index values for 5 instar feeding larval duration. Also, as per the evaluation index method, the strains M-1-2[5] (110.853), 31 (76.430), 101×F6 (76.430), 1005 (72.267) and M2-6-18.3 (70.346) showed higher evaluation index values for and cocoon spinning duration (Table 2).

Table 1: Mean±SD performance of larval traits in studied silkworm pure lines of gene bank

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
107-K	578.0±0.00^{a}	465.0±0.00^{b-e}	113.0±0.00^{b}	286.0±0.00^{a}	205.0±0.00^{a}	81.0±0.00^{a}	292.0±0.00^{ab}	268.0±0.00^{bc}	24.0±0.00^{e-h}	172.0±0.00^{a-e}	17.333±9.07^{abc}
119-K	555.0±0.00^{a}	470.0±0.00^{b-e}	85.0±0.00^{bc}	272.0±0.00^{a}	217.0±0.00^{a}	55.0±0.00^{k-m}	283.0±0.00^{ab}	253.0±0.00^{bc}	30.0±0.00^{c-f}	164.0±0.00^{a-e}	0.697±0.00^{e}
113-K	536.0±0.00^{a}	444.667±2.00^{e}	91.330±2.00^{bc}	272.0±0.00^{a}	206.0±0.00^{a}	67.333±2.30^{ef}	264.0±0.00^{ab}	240.0±0.00^{d}	28.0±6.92^{c-f}	145.0±0.00^{e}	0.0±0.00^{e}
105	584.0±0.00^{a}	508.333±13.86^{abc}	75.667±13.86^{c}	281.333±8.08^{a}	232.333±5.50^{a}	49.0±9.53^{k-m}	302.667±8.08^{ab}	276.0±11.13^{bc}	26.667±4.61^{c-f}	175.333±4.61^{bc}	0.0±0.00^{e}
31	584.0±0.00^{a}	491.0±2.00^{abc}	93.0±2.00^{bc}	286.0±0.00^{a}	217.0±2.00^{a}	69.0±2.00^{bc}	298.0±0.00^{ab}	274.0±0.00^{bc}	24.0±0.00^{e-h}	175.333±4.61^{bc}	4.667±0.08^{de}
51	582.330±2.88^{a}	501.0±3.00^{abc}	81.333±3.00^{bc}	287.0±10.29^{a}	222.0±6.92^{a}	56.0±3.46^{k-m}	304.333±9.29^{ab}	285.0±1.73^{bc}	25.333±1.15^{e-h}	171.0±1.70^{a-e}	12.0±1.39^{bcd}
103	565.0±14.79^{a}	483.667±11.93^{b-e}	81.333±11.93^{bc}	272.0±0.00^{a}	212.333±2.30^{a}	59.667±2.30^{k-m}	293.0±14.79^{ab}	271.333±10.69^{bc}	21.667±11.67^{e-h}	166.0±2.08^{a-e}	0.0±0.00^{e}
BH-2	555.0±0.00^{a}	517.333±10.10^{abc}	97.667±10.15^{bc}	272.0±0.00^{a}	202.333±3.51^{a}	69.667±3.51^{bc}	283.0±0.00^{ab}	255.0±3.46^{bc}	28.0±3.46^{c-f}	164.0±0.00^{a-e}	0.0±0.00^{e}
B2-09	574.0±0.00^{a}	574.0±0.00^{a}	77.0±10.15^{bc}	272.0±0.00^{a}	219.0±0.00^{a}	53.0±0.00^{k-m}	302.0±0.00^{ab}	278.0±0.00^{bc}	24.0±0.00^{e-h}	183.0±0.00^{bc}	6.0±1.39^{de}
1003-4	584.0±0.00^{a}	506.333±5.77^{abc}	77.667±11.84^{bc}	281.333±8.08^{a}	231.667±1.15^{a}	49.667±9.23^{k-m}	302.667±8.08^{ab}	274.667±4.61^{bc}	28.0±3.46^{c-f}	187.0±0.00^{abc}	2.333±4.04^{de}
1003-5	584.0±0.00^{a}	491.333±11.84^{abc}	91.0±11.84^{bc}	288.0±2.30^{a}	225.0±7.21^{a}	63.667±9.01^{ef}	293.667±4.50^{ab}	266.333±8.62^{bc}	27.333±4.16^{c-f}	182.0±6.55^{abc}	8.0±8.54^{cde}
1005	584.0±0.00^{a}	491.333±15.11^{abc}	92.667±15.17^{bc}	272.0±0.00^{a}	218.333±15.17^{a}	53.667±15.17^{k-m}	312.0±0.00^{ab}	273.0±0.00^{bc}	39.0±0.00^{ab}	174.0±0.00^{a-e}	5.667±9.81^{de}
M2-6-22-2	574.0±0.00^{a}	507.33±12.22^{abc}	66.667±12.22^{bc}	272.0±0.00^{a}	219.333±7.50^{a}	52.667±7.50^{k-m}	302.0±12.48^{ab}	288.0±13.07^{abc}	14.0±8.66^{g}	182.0±13.07^{abc}	6.0±1.39^{de}
M2-6-18(109)	580.0±3.46^{a}	497.333±6.00^{abc}	82.667±6.35^{bc}	272.0±0.00^{a}	213.333±9.81^{a}	58.667±9.81^{k-m}	308.0±3.40^{ab}	284.0±3.46^{bc}	24.0±0.00^{e-h}	164.0±3.46^{a-e}	0.0±0.00^{e}
M-1-2(5)	572.0±10.39^{a}	480.667±11.01^{bc}	92.0±11.01^{bc}	272.0±0.00^{a}	203.333±2.31^{a}	68.667±2.30^{ef}	306.0±0.00^{ab}	282.0±0.00^{bc}	24.0±0.00^{e-h}	187.0±0.00^{abc}	2.333±4.04^{de}
M2-6-22(107)	578.0±0.00^{a}	483.0±8.66^{bc}	95.0±8.66^{bc}	272.0±0.00^{a}	206.0±0.00^{a}	66.0±0.00^{ef}	306.0±0.00^{ab}	277.0±8.66^{bc}	29.0±8.66^{fc}	187.0±0.00^{abc}	2.333±4.04^{de}
M2-6-18.3	580.0±3.46^{a}	500.667±4.72^{abc}	79.333±6.35^{bc}	272.0±0.00^{a}	216.667±1.52^{a}	55.333±1.52^{k-m}	308.0±3.46^{ab}	284.0±3.46^{bc}	24.0±0.00^{e-h}	182.0±6.53^{abc}	8.0±0.04^{c}
307-300-2	584.0±0.00^{a}	494.0±0.00^{abc}	90.0±0.00^{bc}	272.0±0.00^{a}	206.0±0.00^{a}	66.0±0.00^{ef}	308.0±3.46^{ab}	284.0±3.46^{bc}	24.0±0.00^{e-h}	174.0±0.00^{a-e}	5.667±9.81^{d-e}
202A-204B	578.0±0.00^{a}	482.667±14.43^{bc}	95.333±14.43^{bc}	264.0±13.27^{a}	201.0±27.71^{a}	63.333±14.43^{b-f}	301.333±8.08^{ab}	269.333±8.08^{bc}	32.0±0.00^{b-e}	182.0±13.07^{abc}	6.0±1.39^{d-e}
I 20	578.0±0.00^{a}	480.333±7.50^{bc}	197.667±7.50^{a}	272.0±0.00^{a}	206.0±0.00^{a}	66.0±0.00^{k-m}	306.0±0.0^{ab}	274.333±7.50^{bc}	31.667±7.50^{bc}	164.0±3.46^{a-e}	0.0±0.00^{e}
101433-9-5	578.0±0.00^{a}	493.0±6.92^{abc}	85.0±6.92^{bc}	276.667±8.08^{a}	215.667±1.15^{a}	61.0±6.92^{e-m}	301.333±8.08^{ab}	277.333±8.08^{bc}	24.0±0.00^{e-h}	169.0±0.00^{a-e}	21.0±0.00^{a}
101433-1-4	576.667±2.30^{a}	503.333±5.77^{abc}	73.333±5.77^{bc}	280.0±8.08^{a}	232.0±0.00^{a}	49.333±8.08^{k-m}	295.333±5.77^{ab}	271.333±5.77^{bc}	24.0±0.00^{e-h}	182.0±8.66^{abc}	0.0±0.00^{e}
101433-6-6	578.0±0.00^{a}	498.333±14.04^{abc}	79.667±14.04^{bcb}	276.0±8.08^{a}	226.0±7.00^{a}	50.667±8.50^{k-m}	301.333±8.08^{ab}	272.333±8.38^{bc}	29.0±8.66^{c-f}	175.0±3.46^{a-d}	0.0±0.00^{e}
1126 (111)	578.0±0.00^{a}	481.333±6.92^{bc}	97.0±3.21^{bc}	286.0±0.00^{a}	214.0±2.64^{a}	72.0±2.64^{ab}	292.0±0.00^{ab}	267.0±0.00^{bc}	25.0±0.00^{e-h}	172.0±3.46^{a-e}	0.0±0.00^{e}
113 (2029)	578.0±0.00^{a}	482.333±3.05^{bc}	89.667±3.05^{bc}	286.0±0.00^{a}	220.333±7.57^{a}	65.667±7.57^{k-m}	292.0±0.00^{ab}	268.0±0.00^{bc}	24.0±0.00^{gh}	186.0±0.00^{ab}	0.0±0.00^{e}
151 (103×M-1-1)	560.0±0.00^{a}	477.667±9.23^{bc}	82.333±9.23^{bc}	276.0±8.08^{a}	218.333±16.04^{a}	58.333±9.23^{k-m}	283.333±8.08^{ab}	259.333±8.08^{bc}	24.0±0.00^{e-h}	172.0±4.60^{a-e}	0.0±0.00^{e}
Xihang 2.3	572.667±21.93^{a}	481.333±19.85^{bc}	91.333±19.85^{abc}	272.0±0.00^{a}	218.667±7.23^{a}	67.333±7.23^{ef}	190.333±0.00^{c}	262.667±21.93^{bc}	24.0±0.00^{e-h}	154.0±8.66^{cde}	0.0±0.00^{e}
Xihang 3.3	371.0±21.00^{b}	309.0±26.73^{d}	94.0±266.73^{d}	181.0±0.00^{a}	202.0±16.04^{a}	70.0±39.83^{ab}	285.0±16.96^{c}	261.0±15.11^{e}	24.0±0.00^{e-h}	166.667±6.35^{a-e}	0.0±0.00^{e}
153 (Xihang-1)	578.0±0.00^{a}	483.0±4.24^{bc}	95.0±4.24^{bc}	286.0±0.00^{a}	219.0±0.00^{a}	67.0±0.00^{ef}	292.0±0.00^{ab}	264.0±4.24^{bc}	28.0±13.27^{c-f}	111.0±0.00^{f}	0.0±0.57^{e}
5118×10133-2-2	578.0±0.00^{a}	486.0±5.19^{bc}	92.0±5.19^{abc}	286.0±0.00^{a}	228.333±1.15^{a}	57.667±1.15^{k-m}	292.0±0.00^{ab}	257.667±4.04^{bc}	34.333±4.24^{abc}	164.0±0.00^{a-e}	0.0±0.00^{e}
5118×10133-3-3	588.667±8.08^{a}	503.0±7.54^{abc}	85.667±7.54^{abc}	286.0±0.00^{a}	230.333±0.57^{a}	55.667±0.57^{k-m}	302.667±8.08^{ab}	272.667±7.02^{bc}	30.0±4.04^{c-f}	172.0±0.00^{a-e}	0.0±0.00^{e}
Black-White	583.0±1.73^{a}	498.0±7.54^{abc}	85.0±7.50^{b-e}	292.666±5.77^{a}	229.667±1.15^{a}	63.0±0.57^{b-f}	290.333±6.80^{ab}	268.333±10.21^{bc}	22.0±3.46^{e-h}	174.700±0.00^{abc}	6.0±1.39^{de}
101×F6	580.0±0.00^{a}	491.0±0.00^{abc}	89.0±0.00^{abc}	286.0±0.00^{a}	223.0±3.46^{a}	63.0±3.46^{b-f}	294.0±3.46^{ab}	268.0±3.46^{bc}	26.0±3.46^{c-g}	166.667±21.93^{a-e}	10.333±9.29^{a-d}
F6×101	583.0±1.73^{a}	482.667±3.78^{bc}	100.333±3.78^{bc}	286.0±0.00^{a}	215.667±1.15^{a}	70.333±1.15^{abc}	297.0±1.73^{ab}	267.0±4.58^{bc}	30.0±0.00^{c-f}	166.0±95.26^{f}	4.667±8.08^{de}
Kinshu	584.0±0.00^{a}	492.0±1.00^{abc}	92.0±1.00^{bc}	286.0±0.00^{a}	219.333±1.15^{a}	66.667±0.57^{ef}	298.0±0.00^{ab}	272.667±1.15^{bc}	25.333±1.15^{gh}	164.0±0.00^{cde}	0.0±0.00^{e}
M-1-1×31	583.0±1.73^{a}	488.0±5.19^{bc}	95.0±5.19^{bc}	286.0±0.00^{a}	219.0±0.00^{a}	67.0±0.00^{ef}	297.0±1.73^{ab}	269.0±5.19^{bc}	28.0±3.46^{e-h}	166.667±4.61^{a-e}	0.0±0.00^{e}
31×M-1-1	575.333±2.30^{a}	499.0±8.54^{abc}	76.333±8.54^{bc}	276.677±8.08^{a}	224.333±9.81^{a}	52.333±9.07^{k-m}	298.667±5.77^{ab}	274.667±5.77^{bc}	24.0±0.00^{e-h}	174.667±8.00^{bc}	0.0±0.00^{e}
M-1-1×103	578.0±0.00^{a}	495.333±2.51^{abc}	85.667±2.51^{bc}	276.677±8.08^{a}	215.0±5.29^{a}	61.66±3.05^{k-m}	301.333±8.08^{ab}	277.33±38.08^{bc}	24.0±0.00^{e-h}	177.0±1.73^{bc}	0.0±0.00^{e}
103 Poly Marking	584.0±0.00^{a}	501.667±5.50^{abc}	81.333±5.50^{bc}	286.0±0.00^{a}	228.667±5.68^{a}	57.333±5.68^{k-m}	297.0±1.70^{ab}	273.0±1.73^{bc}	24.0±1.73^{e-h}	166.0±3.46^{a-e}	0.0±0.00^{e}
Shaki	554.0±0.00^{a}	451.0±0.00^{bc}	103.0±0.00^{bc}	250.0±0.00^{a}	199.0±0.00^{a}	52.0±0.00^{k-m}	282.0±0.00^{ab}	252.0±0.00^{bc}	30.0±0.00^{c-f}	169.0±1.73^{a-e}	0.0±0.00^{e}
101	608.0±0.00^{a}	504.0±1.73^{abc}	104.0±1.73^{bc}	290.0±0.00^{a}	227.0±0.00^{a}	63.0±0.00^{ef}	318.0±0.00^{a}	277.0±1.73^{bc}	41.0±8.66^{a}	163.0±4.61^{b-e}	0.0±0.00^{e}
T1-J	578.0±0.00^{a}	497.0±0.00^{abc}	81.0±0.00^{bc}	272.0±0.00^{a}	215.0±0.00^{a}	57.0±0.00^{k-m}	306.00±0.00^{ab}	282.0±0.00^{bc}	24.0±8.66^{e-h}	169.0±1.73^{cde}	0.0±0.00^{e}
T5-M	555.0±0.00^{a}	481.667±9.81^{bc}	73.333±9.81^{bc}	272.0± 0.00^{a}	217.667±1.15^{a}	54.333±1.15^{k-m}	283.0±0.00^{ab}	264.0±8.66^{bc}	19.0±8.66^{ghi}	179.333±6.35^{bc}	0.0±0.00^{e}
236	558.333±2.88^{a}	481.667±12.70^{bc}	69.0±12.70^{bc}	281.0±8.08^{a}	231.333±1.15^{a}	50.0±6.92^{k-m}	277.0±5.19^{ab}	258.0±13.85^{bc}	19.0±8.66^{ghi}	172.0±0.00^{cde}	0.0±0.00^{e}
1524	578.0±0.00^{a}	489.333±8.14^{abc}	69.667±8.14^{bc}	272.0±0.00^{a}	226.333±8.14^{a}	45.667±8.14^{k-m}	306.0±0.00^{ab}	282.0±0.00^{bc}	24.0±0.00^{e-h}	162.0±1.73^{b-e}	0.0±0.00^{e}

Table 1: Continued

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
1433-15	578.0±0.00^{a}	508.333±1.15^{abc}	66.667±1.15^{bc}	272.0±0.00^{a}	229.333±1.15^{a}	42.667±1.15^{op}	306.0±0.00^{ab}	282.0±0.00^{bc}	24.0±0.00^{e-h}	163.0±0.00^{cde}	0.0±0.00^{e}
1433-9	578.0±0.00^{a}	525.0±0.00^{abc}	53.0±0.00^{c}	272.0±0.00^{a}	228.0±0.00^{a}	44.0±0.00^{opq}	306.0±0.00^{ab}	297.0±0.00^{ab}	9.0±0.00^{j}	178.0±0.00^{b-e}	0.0±0.00^{e}
7409	559.333±5.77^{a}	490.0±0.00^{abc}	66.0±0.00^{bc}	272.0±0.00^{a}	230.0±0.00^{a}	42.0±0.00^{p}	284.0±0.00^{ab}	260.0±0.00^{bc}	24.0±0.00^{e-h}	187.0±0.00^{ab}	0.0±0.00^{e}
N19	584.0±0.00^{a}	533.0±0.00^{ab}	51.0±0.00^{c}	272.0±0.00^{a}	230.0±0.00^{a}	0.0±0.00^{q}	312.0±0.00^{ab}	303.0±0.00^{a}	9.0±0.00^{j}	164.0±0.00^{cde}	0.0±0.00^{e}
White Larvae-Yellow Cocoon	558.0±1.73^{a}	457.333±11.50^{bc}	100.667±1.15^{bc}	276.0±8.88^{a}	209.667±4.72^{a}	67.0±3.60^{ef}	281.333±6.35^{ab}	247.667±11.59^{cd}	33.660±10.59^{bc}	193.003±7.63^{cde}	19.333±0.00^{ab}
Black Larvae-White Cocoon	582.0±3.46^{a}	478.0±5.19^{bc}	104.0±8.66^{bc}	272.0±0.00^{a}	207.0±8.66^{a}	65.0±8.66^{ef}	310.0±3.46^{ab}	271.0±3.46^{bc}	39.0±0.00^{ab}	149.300±0.00^{de}	0.0±0.00^{e}

Means in each column followed by the same letters superscripted are not significantly different at α=0.01

Table 2: Evaluation index values for larval traits in studied silkworm pure lines of gene bank

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
107-K	40.230	40.230	39.314	36.363	49.080	40.114	45.429	51.999	50.035	52.936	51.454
119-K	40.230	40.230	50.214	56.234	49.080	52.614	68.742	51.999	46.063	52.936	42.167
113-K	40.230	40.230	46.581	56.234	49.080	46.364	68.742	51.999	47.387	74.323	42.167
105	40.230	40.230	53.847	56.234	49.080	56.781	45.429	51.999	47.828	52.936	42.167
31	40.230	40.230	46.581	36.363	49.080	44.281	45.429	51.999	50.035	52.936	76.430
51	40.230	40.230	50.214	56.234	49.080	52.614	45.429	51.999	48.711	52.936	55.456
103	40.230	40.230	50.214	56.234	49.080	50.531	45.429	51.999	51.800	52.936	42.167
BH-2	40.230	40.230	42.947	56.234	49.080	44.281	68.742	51.999	47.387	52.936	42.167
B2-09	40.230	40.230	53.847	56.234	49.080	54.698	45.429	51.999	50.035	31.548	57.217
1003-4	40.230	40.230	53.847	56.234	49.080	56.781	45.429	51.999	47.387	52.936	42.167
1003-5	40.230	40.230	46.581	36.363	49.080	48.448	45.429	51.999	47.828	52.936	42.167
1005	40.230	40.230	46.581	56.234	49.080	54.698	45.429	51.999	42.974	52.936	72.267
M2-6-22-2	40.230	40.230	61.113	56.234	49.080	54.698	45.429	18.014	62.832	52.936	56.737
M2-6-18(109)	40.230	40.230	50.214	56.234	49.080	50.531	45.429	51.999	50.035	52.936	68.905
M-1-2(5)	40.230	40.230	46.581	56.234	49.080	46.364	45.429	51.999	50.035	31.548	110.853
M2-6-22(107)	40.230	40.230	46.581	56.234	49.080	46.364	45.429	51.999	46.504	31.548	62.181
M2-6-18.3	40.230	40.230	53.847	56.234	49.080	52.614	45.429	51.999	50.035	52.936	70.346
307-300-2	40.230	40.230	46.581	56.234	49.080	46.364	45.429	51.999	50.035	52.936	68.905
202A-204B	40.230	40.230	42.947	56.234	49.080	48.448	45.429	51.999	45.180	52.936	42.167
I 20	40.230	40.230	24.781	56.234	49.080	46.364	45.429	51.999	45.622	52.936	49.852
101433-9-5	40.230	40.230	50.214	56.234	49.080	48.448	45.429	51.999	50.035	31.548	42.167
101433-1-4	40.230	40.230	57.480	56.234	49.080	56.781	45.429	51.999	50.035	52.936	42.167
101433-6-6	40.230	40.230	53.847	56.234	49.080	56.781	45.429	51.999	46.504	52.936	42.167
1126 (111)	40.230	40.230	42.947	36.363	49.080	44.281	45.429	51.999	49.152	31.548	42.167
113 (2029)	40.230	40.230	46.581	36.363	49.080	46.364	45.429	51.999	50.035	52.936	42.167
151 (103×M-1-1)	40.230	40.230	50.214	56.234	49.080	50.531	68.742	51.999	50.035	52.936	42.167
Xihang 2.3	40.230	40.230	46.581	36.363	49.080	46.364	45.429	51.999	50.035	52.936	42.167
Xihang 3.3	40.230	40.230	46.581	56.234	49.080	44.281	68.742	51.999	50.035	52.936	42.167
153 (Xihang-1)	40.230	40.230	46.581	36.363	49.080	46.364	45.429	51.999	47.387	52.936	42.167
5118×10133-2-2	40.230	40.230	46.581	36.363	49.080	50.531	45.429	51.999	44.298	52.936	42.167
5118×10133-3-3	40.230	40.230	50.214	36.363	49.080	52.614	45.429	51.999	46.063	52.936	68.905
Black-White	40.230	40.230	50.214	36.363	49.080	48.448	45.429	51.999	51.358	52.936	57.698

Table 2: Continued

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
101×F6	40.230	40.230	46.581	36.363	49.080	48.448	45.429	51.999	48.269	52.936	76.430
F6×101	40.230	40.230	42.947	36.363	49.080	44.281	45.429	51.999	46.063	52.936	42.167
Kinshu	40.230	40.230	46.581	36.363	49.080	46.364	45.429	51.999	48.711	52.936	42.167
M-1-1×31	40.230	40.230	46.581	36.363	49.080	46.364	45.429	51.999	47.387	52.936	42.167
31×M-1-1	40.230	40.230	53.847	56.234	49.080	54.698	45.429	51.999	50.035	52.936	42.167
M-1-1×103	40.230	40.230	50.214	56.234	49.080	48.448	45.429	51.999	50.035	52.936	42.167
103 poly marking	40.230	40.230	50.214	36.363	49.080	50.531	45.429	51.999	50.035	52.936	42.167
Shaki	40.230	40.230	42.947	56.234	49.080	54.698	68.742	51.999	46.063	52.936	42.167
101	40.230	40.230	42.947	36.363	49.080	48.448	45.429	51.999	42.091	52.936	42.167
T1-J	40.230	40.230	50.214	56.234	49.080	52.614	45.429	51.999	50.035	31.548	42.167
T5-M	40.230	40.230	57.480	56.234	49.080	52.614	68.742	51.999	54.889	52.936	42.167
236	40.230	40.230	57.480	56.234	49.080	56.781	68.742	51.999	54.889	52.936	42.167
1524	40.230	40.230	57.480	56.234	49.080	60.948	45.429	51.999	50.035	31.548	42.167
1433-15	40.230	40.230	61.113	56.234	49.080	63.031	45.429	51.999	50.035	52.936	42.167
1433-9	40.230	40.230	75.646	56.234	49.080	63.031	45.429	18.014	80.484	31.548	42.167
7409	40.230	40.230	61.113	56.234	49.080	65.115	68.742	51.999	50.035	52.936	42.167
N19	40.230	40.230	79.279	56.234	49.080	15.114	45.429	18.014	80.484	31.548	50.493
White Larvae-Yellow Cocoon	40.230	40.230	42.947	56.234	49.080	46.364	68.742	51.999	44.739	74.323	42.167
Black Larvae-White Cocoon	40.230	40.230	42.947	56.234	95.984	46.364	45.429	51.999	42.974	52.936	62.181

Table 3: Sub-ordinate function values for larval traits in studied silkworm pure lines of gene bank

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
107-K	0.0	0.0	0.267	0.0	0.0	0.500	0.0	1.0	0.207	0.500	0.135
119-K	0.0	0.0	0.467	1.0	0.0	0.750	1.0	1.0	0.103	0.500	0.0
113-K	0.0	0.0	0.400	1.0	0.0	0.625	1.0	1.0	0.138	1.0	0.0
105	0.0	0.0	0.533	1.0	0.0	0.833	0.0	1.0	0.149	0.500	0.0
31	0.0	0.0	0.400	0.0	0.0	0.583	0.0	1.0	0.207	0.500	0.499
51	0.0	0.0	0.467	1.0	0.0	0.750	0.0	1.0	0.172	0.500	0.193
103	0.0	0.0	0.467	1.0	0.0	0.708	0.0	1.0	0.253	0.500	0.0
BH-2	0.0	0.0	0.333	1.0	0.0	0.583	1.0	1.0	0.138	0.500	0.0
B2-09	0.0	0.0	0.533	1.0	0.0	0.792	0.0	1.0	0.207	0.0	0.219
1003-4	0.0	0.0	0.533	1.0	0.0	0.833	0.0	1.0	0.138	0.500	0.0
1003-5	0.0	0.0	0.400	0.0	0.0	0.667	0.0	1.0	0.149	0.500	0.0
1005	0.0	0.0	0.400	1.0	0.0	0.792	0.0	1.0	0.023	0.500	0.438
M2-6-22-2	0.0	0.0	0.667	1.0	0.0	0.792	0.0	0.0	0.540	0.500	0.212
M2-6-18(109)	0.0	0.0	0.467	1.0	0.0	0.708	0.0	1.0	0.207	0.500	0.389
M-1-2(5)	0.0	0.0	0.400	1.0	0.0	0.625	0.0	1.0	0.207	0.0	1.0
M2-6-22(107)	0.0	0.0	0.400	1.0	0.0	0.625	0.0	1.0	0.115	0.0	0.291
M2-6-18.3	0.0	0.0	0.533	1.0	0.0	0.750	0.0	1.0	0.207	0.500	0.410
307-300-2	0.0	0.0	0.400	1.0	0.0	0.625	0.0	1.0	0.207	0.500	0.389
202A-204B	0.0	0.0	0.333	1.0	0.0	0.667	0.0	1.0	0.080	0.500	0.0
I 20	0.0	0.0	0.0	1.0	0.0	0.625	0.0	1.0	0.092	0.500	0.112

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Table 3: Continued

Traits pure lines	Larval duration	Feeding larval duration	Molting larval duration	1-3 instars larval duration	1-3 instars feeding larval duration	1-3 instars molting larval duration	4-5 instars larval duration	4-5 instars feeding larval duration	4-5 instars molting larval duration	5 instar feeding larval duration	Cocoon spinning duration
	(h)										
101433-9-5	0.0	0.0	0.467	1.0	0.0	0.667	0.0	1.0	0.207	0.0	0.0
101433-1-4	0.0	0.0	0.600	1.0	0.0	0.833	0.0	1.0	0.207	0.500	0.0
101433-6-6	0.0	0.0	0.533	1.0	0.0	0.833	0.0	1.0	0.115	0.500	0.0
1126 (111)	0.0	0.0	0.333	0.0	0.0	0.583	0.0	1.0	0.184	0.0	0.0
113 (2029)	0.0	0.0	0.400	0.0	0.0	0.625	0.0	1.0	0.207	0.500	0.0
151 (103×M-1-1)	0.0	0.0	0.467	1.0	0.0	0.708	1.0	1.0	0.207	0.500	0.0
Xihang 2.3	0.0	0.0	0.400	0.0	0.0	0.625	0.0	1.0	0.207	0.500	0.0
Xihang 3.3	0.0	0.0	0.400	1.0	0.0	0.583	1.0	1.0	0.207	0.500	0.0
153 (Xihang-1)	0.0	0.0	0.400	0.0	0.0	0.625	0.0	1.0	0.138	0.500	0.0
5118×10133-2-2	0.0	0.0	0.400	0.0	0.0	0.708	0.0	1.0	0.057	0.500	0.0
5118×10133-3-3	0.0	0.0	0.467	0.0	0.0	0.750	0.0	1.0	0.103	0.500	0.389
Black-White	0.0	0.0	0.467	0.0	0.0	0.667	0.0	1.0	0.241	0.500	0.226
101×F6	0.0	0.0	0.400	0.0	0.0	0.667	0.0	1.0	0.161	0.500	0.499
F6×101	0.0	0.0	0.333	0.0	0.0	0.583	0.0	1.0	0.103	0.500	0.0
Kinshu	0.0	0.0	0.400	0.0	0.0	0.625	0.0	1.0	0.172	0.500	0.0
M-1-1×31	0.0	0.0	0.400	0.0	0.0	0.625	0.0	1.0	0.138	0.500	0.0
31×M-1-1	0.0	0.0	0.533	1.0	0.0	0.792	0.0	1.0	0.207	0.500	0.0
M-1-1×103	0.0	0.0	0.467	1.0	0.0	0.667	0.0	1.0	0.207	0.500	0.0
103 Poly Marking	0.0	0.0	0.467	0.0	0.0	0.708	0.0	1.0	0.207	0.500	0.0
Shaki	0.0	0.0	0.333	1.0	0.0	0.792	1.0	1.0	0.103	0.500	0.0
101	0.0	0.0	0.333	0.0	0.0	0.667	0.0	1.0	0.0	0.500	0.0
T1-J	0.0	0.0	0.467	1.0	0.0	0.750	0.0	1.0	0.207	0.0	0.0
T5-M	0.0	0.0	0.600	1.0	0.0	0.750	1.0	1.0	0.333	0.500	0.0
236	0.0	0.0	0.600	1.0	0.0	0.833	1.0	1.0	0.333	0.500	0.0
1524	0.0	0.0	0.600	1.0	0.0	0.917	0.0	1.0	0.207	0.0	0.0
1433-15	0.0	0.0	0.667	1.0	0.0	0.958	0.0	1.0	0.207	0.500	0.0
1433-9	0.0	0.0	0.933	1.0	0.0	0.958	0.0	0.0	1.0	0.0	0.0
7409	0.0	0.0	0.667	1.0	0.0	1.0	1.0	1.0	0.207	0.500	0.0
N19	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.121
White Larvae-Yellow Cocoon	0.0	0.0	0.333	1.0	0.0	0.625	1.0	1.0	0.069	1.0	0.0
Black Larvae-White Cocoon	0.0	0.0	0.333	1.0	1.0	0.625	0.0	1.0	0.023	0.500	0.291

Table 4: Ranking of studied silkworm germplasm based on average of evaluation index method and sub-ordinate function method for larval traits

	Evaluation index method		Sub-ordinate function method	
Pure lines	Value	Rank	Value	Rank
107-K	497.183	48	2.609	48
119-K	550.510	13	4.820	7
113-K	563.338	6	5.163	4
105	536.761	22	4.016	21
31	533.593	28	3.189	37
51	543.133	16	4.083	19
103	530.850	29	3.928	24
BH-2	536.234	24	4.555	11
B2-09	530.547	30	3.751	27
1003-4	536.320	23	4.005	22
1003-5	501.290	43	2.716	43
1005	552.657	10	4.153	16
M2-6-22-2	537.533	20	3.711	29
M2-6-18(109)	555.822	9	4.271	14
M-1-2(5)	568.583	4	4.232	13
M2-6-22(107)	516.380	34	3.431	31
M2-6-18.3	562.980	7	4.400	12
307-300-2	548.022	14	4.121	18
202A-204B	514.881	35	3.580	30
I 20	502.758	40	3.329	34
101433-9-5	505.614	39	3.340	33
101433-1-4	542.601	17	4.140	17
101433-6-6	535.437	26	3.982	23
1126 (111)	473.426	51	2.101	51
113 (2029)	501.413	41	2.732	41
151 (103×M-1-1)	552.398	12	4.882	6
Xihang 2.3	501.413	42	2.732	42
Xihang 3.3	542.515	18	4.690	46
153 (Xihang-1)	498.765	46	2.663	46
5118×10133-2-2	499.843	45	2.666	45
5118×10133-3-3	534.062	27	3.209	36
Black-White	523.984	33	3.101	39
101×F6	535.994	25	3.226	35
F6×101	491.725	50	2.520	49
Kinshu	500.089	44	2.697	44
M-1-1×31	498.765	47	2.663	47
31×M-1-1	536.884	21	4.032	20
M-1-1×103	527.001	31	3.840	26
103 Poly Marking	509.213	37	2.882	40
Shaki	545.327	15	4.728	9
101	491.920	49	2.500	50
T1-J	509.780	36	3.424	32
T5-M	566.602	5	5.183	3
236	570.769	3	5.267	2
1524	525.380	32	3.724	28
1433-15	552.484	11	4.332	13
1433-9	542.093	19	3.892	25
7409	577.881	1	5.374	`1
N19	506.134	38	3.121	38
White Larvae-Yellow Cocoon	557.057	8	5.027	5
Black Larvae-White Cocoon	577.508	2	4.773	8

Totally, 7409 (577.881), Black Larvae-White Cocoon (577.508), 236 (570.769), M-1-2(5) (568.583) and T5-M (566.602) showed higher evaluation index values (Table 4).

Based on Table 3 among germplasm strains, as per the sub-ordinate function method, the all strains had equal score values for larval duration (0.000), feeding larval duration (0.000), 1-3 instars larval duration (1.000), 1-3 instars feeding larval duration (0.000), 4-5 instars larval duration (1.000), 4-5 instars feeding larval duration (1.000) (Table 3).

Meanwhile, as per the sub-ordinate function method, the strains N19 (1.000), 1433-9 (0.933), M2-6-22-2 (0.667), 1433-15 (0.667) and 7409 (0.667) showed higher sub-ordinate function values for molting larval duration (Table 3). Meanwhile, as per the sub-ordinate function method, the strains 7409 (1.000), 1433-15 (0.958), 1433-9 (0.958), 1524 (0.917) and 105 (0.833) showed higher sub-ordinate function values for 1-3 instars molting larval duration (Table 3). Meanwhile, as per the sub-ordinate function method, the strains N19 (1.000), M2-6-22-2 (0.540), T5-M (0.333), 236 (0.333) and White Larvae-Yellow Cocoon (0.069) showed higher sub-ordinate function values for 4-5 instars molting larval duration (Table 3). Among germplasm strains, as per the sub-ordinate function method, the strains 113-K (1.000), White Larvae-Yellow Cocoon (1.000), 107-K (0.500), 119-K (0.500) and 105 (0.500) showed higher sub-ordinate function values for 5 instar feeding larval duration (Table 3). Also, as per the sub-ordinate function method, the strains M-1-2[5] (1.000), 31 (0.499), 101×F6 (0.499), 1005 (0.438) and M2-6-18[109] (0.410) showed higher sub-ordinate function values for and cocoon spinning duration (Table 3).

Based on Table 4 totally, 7409 (5.374), 236 (5.267), T5-M (5.183), 113-K (5.163) and White Larvae-Yellow Cocoon (5.027) showed higher sub-ordinate function values (Table 4).

The results on germplasm evaluation of the different silkworm strains tested in the present study indicate genotype significant effects on performance evaluation. To date there is not report regarding investigation and assessment of larval development duration of Iranian peanut germplasm silkworm strains using evaluation index method and sub-ordinate function method. Hence, it can claim this report is the first report regarding application of these methods for comparison of larval development traits in Iran silkworm germplasm.

The obtained results relate to earlier findings and supported many previous reports regarding performance differences of various silkworm strains. For example, Ramesha *et al.* (2009) evaluated various silkworm strains and stated selection of suitable parents and information on nature and magnitude of gene action of traits of economic importance determine the success of any crop. They believed critical assessment of variability present in the breeding materials is one of the pre-requisites for paving the way of combining most of the desirable traits present in different genotypes into a single hybrid combination. However, the per se performance of parental breeds is not always be the good reflection of the combining ability and its analysis therefore helps the breeders to understand the nature of gene action to identify prospective parents/hybrids (Ramesha *et al.*, 2009).

Enguku *et al.* (2007) also compared performance of various silkworm strains in germplasm. Meanwhile Malik *et al.* (2005) evaluated some silkworm strains and stated there are different performance among various strains.

Of course, our findings added to data also, since, there is not any report regarding Iranian peanut silkworm germplasm to date.

Most of the quantitative traits of commercial importance in silkworm are under complicated polygenic control under the influence of the environment (Rao *et al.*, 2006). For synthesizing the potential polyvoltine cross breeds, usually, the high yielding traits of bivoltine varieties and fitness traits of strains are hybridized as proper selection of potential and homozygous parents is very important (Rao *et al.*, 2006).

As Kumaresan *et al.* (2007) presented there is an optimum level of genetic divergence between parents to obtain heterosis in F1 generation and it may not be logical to advocate the use of extreme diverge parents to obtain heterotic combination (Arunachalam *et al.*, 1984; Kumaresan *et al.*, 2007).

As Mirhoseini *et al.* (2004) stated the cocoon characteristics are important economical characteristics of silkworm and due to their high heredity, the efficiency of direct selection of them is very high. Efficiency of heterosis in the improvement of the mean of cocoon characteristics in the hybrids will be manifold than the inter-strain selections.

Other reports clarified the undeniable role of heterosis in the technology of silkworm egg production. As a result, the better hybrid must be determined from adding the amounts of the heterosis of the characteristics related to cocoon and resistance and with using other information like GCA and SCA, evolvement of appropriate maternal bases to produce commercial silkworm eggs could be conducted (Mirhoseini *et al*., 2004).

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