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STUDIES ON THE APPLICATION OF DYAR'S AND PRZIBRAM'S RULE TO THE DEVELOPMENT OF MULBERRY SILKWORM RACE NISTARI *BOMBYX MORI* LINN.

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The present investigation was undertaken to study the application of Dyar's and Przibram's rule in the light of development of different larval instars of an indigenous mulberry silkworm race, Nistari *B. mori* L. Growth trend in the body length and head width indicated a linear progression after Dyar's. The growth ratio for body weight at each successive instar exceed the value required under Przibram's theory. The body length, head width and body weight increases 18 461, 12.309 and 10165 folds respectively from hatching to matured larvae.

INTRODUCTION

A new born larva of *B mori* has to pass through five instars before undergoing pupation. Each of these instar is punctuated by a moulting at the end. These moults show a slow and gradual development of different parts of body.

Dyar (1890) first reported that head capsule of caterpillar grows in regular geometrical progression at each moult with a ratio ranging from 1.10 to 1.97 (average 1.40). Tessier (1936) pointed out that as per Dyar's rule when the log of measurements of any part of an insect body is plotted against the number of instars, a straight line is generally obtained. Ripley (1923), Calvert (1929), and Gaines & Campbell (1935) raised some doubt for the use of such rule in corroborating the number of instars However, Dyar's rule got wide acceptance in the light of recent studies (Rao & Tonapi, 1970; Behura *et al* , 1976; Sorenson & Thompson, 1979; Goel & Kumar, 1982; Singh, 1983; Rao & Goel, 1986; Singh & Goel, 1987).

Przibram & Megusar (1912) proposed another growth rule and pointed out that weight of insect is doubled during each instar and at each moult all linear dimensions are increased by the ratio of 1.26. Bodenhemier (1933), Harries & Henderson (1938), Rao & Tonapi (1970), Goel & Kumar (1982) and Singh & Goel (1987) observed much variation in the value of the progression factor among different species and remarked that Przibram's progression principal is of doubtful significance.

Except the work of Itaya (1936), Ito & Kobayashi (1978) and Sakaguchi (1978), hardly any other information is available even on the growth index in mulberry silkworm *Bombyx mori*.

In the present investigation an attempt has been made to study the applicability of Dyar's and Przibram's rules in the light of development of different larval instars of Nistari (*B. mori*), an indigenous multivoltine mulberry silkworm race of West Bengal.

MATERIAL AND METHODS

Stock colonies of indigenous mulberry silkworm race Nistari, *Bombyx mori*, chosen for the purpose of study was reared as per schedule recommended by Krishnaswami *et al.* (1973). The present study was undertaken during June–July and August–September, 1985 when the mean room temperature was $30 \pm 2°C$ and $28 \pm 2°C$ and humidity $75 \pm 5\%$ and $80 \pm 5\%$ respectively.

The measurements of lengths of body and width of head of 20 larvae of each instar and their body weight just after hatching and moulting in each season were recorded and the average values were calculated. Measurements and weights were also recorded after every 24 hours in the 5th instar upto the stage of spinning. The ratio between succeeding and preceding instars was calculated as growth ratio for each parameter gave the progression factor. To ascertain the nature of growth in each case, the instar stages were recorded on X-axis and logarithmic measurements of variable on Y–axis. Also to varify relationship between the observed and calculated values, X^2– square test was applied. The regression equation so obtained further assisted in plotting best fit regression line for body length, head width and body weight. The growth index for all the three characters were also calculated.

RESULTS AND DISCUSSION

The measurements of body length, head width and body weight of different larval instars in the silkworm, *Bombyx mori* race Nistari are presented in Table I. A trend of sequential increase in body length and head width was noticed in the present study. The growth ratio of body length and head width ranges in between 1.750–1.904 and 1.607–1 866 respectively with an average progression factor of 1 812 and 1.759 (Table III). These values are within the range of Dyar's original value of 1.10–1.97, which he recommended for caterpillars.

Table I. Measurements of Body length, Head width and Weight of different larval instars of *B. mori* (Nistari).

Stages	Body length (mm)	Head width (mm)	Weight of larvae (mg)
1st Instar (just after hatching)	3 25 (1.000)	0 42 (1.000)	0.181 (1.000)
2nd Instar (just after moult)	6.00 (1.846)	0 75 (1.785)	3.100 (17.127)
3rd Instar (just after moult)	10.50 (1.750)	1.40 (1.866)	21 600 (6.967)
4th Instar (just after moult)	20.00 (1.904)	2 25 (1.607)	106.600 (4.935)
5th Instar (just after moult)	35.00 (1.750)	4.00 (1.777)	377.800 (3 544)
24 hrs Old	40.00 (1.142)	5.00 (1.250)	489.500 (1 295)
48 hrs Old	45.00 (1.125)	5.10 (1.020)	713.000 (1.456)
72 hrs Old	50.00 (1.111)	5.15 (1.009)	984 000 (1 3 0)
96 hrs Old	60 00 (1.200)	5 17 (1.003)	1266.500 (1.287)
120 hrs Old	60.00 (1 000)	5.17 (1.000)	1462 500 (1.154)
144 hrs Old	60.00 (1.000)	5.17 (1.000)	1840.000 (1.258)

Figures in brackets indicate growth rate

The logarithms of mean values of body length, head width and body weight against the number of instars were calculated on a simple equation of straight line Y = a + bx, where a and b being constant and X served as the number of larval instars. The regression equation calculated gave the expected values, whereas, the logarithm of mean values for individual parameter instarwise established the values in a geometrical progression with linear relationship A best fit straight curve was evolved ultimately Furthe , very poor values of calculated X^2–square compared at 5% and 1% levels, respectively also supported an insignificant difference between the observed and theoritical values for a perfect linear relationship.

In the present study during the successive larval instars of *B. mori* race Nistari, the regression line and the points plotted for the body length and head width follow quite closely to geometrical progression. The progression factor and the straight line graph for both body length and head width have been in agreement with Dyar's constant growth ratio.

From the above observation it may be concluded that the Dyar's rule is sufficient to serve his original purpose for which it was framed Similarly, Taylor (1931) after an analysis of measurements of 46 species of sawflies and 28 species of Lepidoptera stated that Dyar's rule will be more reliable and may be utilised with more confidence when calculated for head dimensions. After a comprehensive study, Gains & Campbell (1935) in *Heliothis obsoleta*, Goettel & Philogene (1979) in *Pyrrharctia isabella* and Smith (1984) in *Mythimna convecta*, pointed out that use of Dyar's rule for corroborating the number of instars is hardly to be recommended. However, Rao & Bucker (1975) in *Hymenia recurvalis* and *Orgyia postica*, Behura *et al.* (1976) in *Aphis craccivora*, Deshmukh *et al.* (1977) and Goel & Kumar (1982) in *Diacrisia obliqua*, Tanaka (1981) in *Blattella germanica*, Singh (1983) in *Lipaphis erysimi*, Rao & Goel (1986) in *Trabala vishnu* and Singh & Goel (1987) in *Lymantria marginata*, reported that not only the head capsule width but also many other parts of the body of larvae in successive instars follow a geometric progression as stated by Dyar (1890).

With the growth of larvae, the gain in body weight successively increased in linear sequence instarwise However, the values obtained for the growth ratio (Table I) are being 17.127, 6.967, 4 935 and 3.544 for I to V instars respectively with an average progression factor value of 8 143 (Table III). These values are much deviated from the Przibram's original value of 2

Przibram & Megusar (1912) pointed out that in *Sphodromantis*, the body weight is approximately doubled in successive instars, which has also been proved by Eidmann (1924) in *Carausius* sp Bodenheimer (1933) after analysing many of the available data, concluded that insect growth in most cases does follow the progression factor of 2 for the weight and 1.26 for the linear growth However, in *Philosamia ricini*, Joshi (1987) noticed an average progression factor value of 4.655 – 4.787.

In the present observation, the values obtained for body weight at its successive stages and also the average progression factor showed a marked tendency to exceed the value required under Przibram's theory. Such doubtful significance of Przibram's theory was also observed by Goldschmidt (1933) who mentioned that this rule is often so inexact that it becomes of no practical value and Bodenheimer (1933) who stated that it is of doubtful value, also where the weight increases several time at each moult. Similar observations were also made by Key (1936), Rao & Tonapi (1970), Goel & Kumar (1982), Rao & Goel (1986)

Table II. Growth index of different characters in different larval instars of *B. mori* (Nistari).

Stages	Body length	Head width	Weight of larvae
1st Instar (just after hatching)	1 000	1.000	1.000
2nd Instar (just after moult)	1 846	1.785	17.127
3rd Instar (just after moult)	3.230	3.333	119.337
4th Instar (just after moult)	6.153	5.357	588.950
5th Instar (just after moult)	10.769	9.523	2087.292
24 hrs Old	12.307	11.904	2704.419
48 hrs Old	13.846	12.142	3939.226
72 hrs Old	15.384	12.261	5436.464
96 hrs Old	18.461	12.309	6997.237
120 hrs Old	18.461	12.309	8080.110
144 hrs Old (mature)	18.461	12.309	10165.745

and Singh & Goel (1987).

The growth index (Table II) obtained in the present study reveals that body length, head width and body weight in full grown larvae of *B. mori* race Nistari are 18.461, 12 309 and 10165.745 times respectively more than that of newly hatched larva. Itaya (1936) stated that silkworm shows variable growth index in respect of body weight ranging from 8000–10833 times according to races, nutrition and season. Kuroda *et al.* (1981) observed a significant difference

Table III. Progression factor and growth equations in *B. mori* (Nistari) with X^2 between observed and calculated values being insignificant.

Characters	Progression factor	Growth equation (Log Y = a+b^x)	X^2
Body length	1.812	Log Y = 0.2551 +· 0 2587x	0.0C03
Head width	1.759	Log Y = –0.6107 + 0.2435x	0.0059
Body width	8.143	Log Y = –1.3150 + 0 8176x	0.0215

in growth index of body weight between the races. Sakaguchi (1978) clearly demonstrated that the larva attains a maximum body weight 1 or 1.5 days before the onset of cocoon spinning, being about 12,000 times that of newly hatched worm. The present observation reveals an increase of approximately 10,000 times weight of body from hatching to fully matured larvae. The morphogenetic variation among the races, bioecological factors and influence of food may be found responsible for the difference in the index of body weight.

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