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Biometrical analysis of *Helicoverpa armigera* (Hübner) Hardwick on pigeonpea

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ABSTRACT

Studies on biometrical analysis were carried out at Junagadh Agricultural University campus, Junagadh (Gujarat) during 2006-07 to test the applicability of Dyar's law to the larvae of *H. armigera*, when reared on pigeonpea variety BDN-2 at a constant temperature of 28±1°C in BOD incubator. The measurements of head capsule width of the larvae fell into six well defined groups each indicating an instar. The mean values of the observed (0.285 to 2.657 mm) and calculated head capsule width (0.287 to 2.819 mm) and progression factors were closed to each other which indicated that an increase in head width during successive instar was in geometrical progression, when larvae were reared on pigeonpea and it followed the Dyar's law. The observed mean body length and width ranged from 1.712 to 28.378 mm and 0.306 to 3.643, respectively, for first to six instars on pigeonpea. The observed and estimated progression factors for the larval body length and width passed through six instars were 1.77 and 1.75 and 1.66 and 1.63, respectively. The progression factors determined from body length and width indicated the great deviation to provide any support for the theory suggested by Przibram's and Megusar law. The multiple correlation co-efficient (R^2=0.9996) also indicated a very high predictability of head capsule width through larval body length and width.

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INTRODUCTION

The study of insect host plant relationship is of fundamental importance, which helps to know the possible effect of host plants on insect development (Dubey *et al.*, 1981). It is also a fact that food plants and their physical and chemical constituents play a vital role in survival and reproductive potential of insects (Painter, 1951). The growth of insects follows a series of moulting or ecdysis under control conditions. The increase in size can be expressed as growth law, which indicates that head capsules of caterpillar increases in width with each moult by a geometrical progression (Dyar, 1890). This factor can be used for identifying the instars (Beri, 1961). Bilapate *et al.* (1981) concluded that there were 5 or 6 larval instars of *Helicoverpa armigera* and head capsule width more or less followed the geometrical progression, which supported Dyar's law. Przibram and Megusar (1912) generalized a rule that the weight was double during each instar and at each moult all linear dimensions were increased by the ratio of '1.26'. Since, pigeonpea is grown very extensively as *Kharif* crop in Saurashtra region of Gujarat and no detailed information regarding biometrical analysis at constant laboratory temperature is available, thus, the present study was carried out.

MATERIAL AND METHODS

Seven hundred newly emerged larvae were transferred individually in separate plastic container (8 cm×4.5 cm) and reared at a constant temperature of 28±1°C on pigeonpea variety BDN-2. Fresh food was provided everyday. In order to determine the larval instars, the individual larva was observed daily for the exuva as well as head capsule. The moulting was confirmed by the presence of casted off head capsule. Freshly moulted 30 larvae were killed in hot water (60°C) and head capsule width, body length and body width of each larva were measured with the help of a stage and ocular micrometer. The application of Dyar's law (1890) was tested for the number of larval instars, when reared on pigeonpea. For the purpose of assigning single individual to their respective instars, regression relationship between instar and the mean head capsule width were tested for the applicability of Przibran and Meagusar's rule (1912). The regression relationship between the instars, mean body length and width were also calculated. The regression equation used was :

$$\mathbf{Log_{10}\ Y = a + bx}$$

where,

Y = body length/width/head capsule width of larva,

a = constant,

b = logarithm of growth ratio,

x = number of instars

Growth ratio, progression factor, differences and difference per cent were calculated as per the following equations (Bilapate *et al*., 1981) :

$$\textbf{Growth ratio} = \frac{\textbf{Value of succeeding instar}}{\textbf{Value of proceding instar}}$$

Progression factor = regression factor = b

Difference = Observed values of instar - estimated value of instar :

$$\textbf{Difference per cent} = \frac{\textbf{Difference}}{\textbf{Estimated value}} \times \mathbf{100}$$

Multiple correlation and partial regression studies on larval body length, body width and head width were calculated by using the following equation :

$$\mathbf{Y = a + b_1x_1 + b_2x_2}$$

where,

Y = Mean width of head capsule,

x_1 = Mean larval length,

x_2 = Mean larval width

a = regression constant, b_1 and b_2 = co-efficient of partial regression.

The value of a, b_1 and b_2 were calculated with the help of data analysis tool pack in Microsoft Excel.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads :

Head capsule width :

Perusal of data on mean values (Table 1) of larval head capsule width revealed that the larvae, when reared on pigeonpea variety BDN-2, passed through six distinct instars. The observed mean head width was recorded as 0.285, 0.441, 0.695, 1.283, 1.789 and 2.657 mm with the estimated (calculated) width of 0.287, 0.454, 0.717, 1.131, 1.786 and 2.819 mm for the first to sixth instars, respectively. The mean measurements showed that the head width fell into six distinct groups which evidently characterized as an instar. The differences in the measurements of a stage and that of the succeeding one were sufficient enough to assign reliably of single individuals to their proper instars. The mean progression factor of observed and calculated head capsule width was worked out as 1.57 and 1.58 for six instars. It is evident from the data that the calculated or estimated head width as well as progression factor are in closed proximity to the observed head width and progression factor.

When log head capsule widths on BDN-2 were plotted against each of instars, almost straight regression line was obtained and the following equation was fitted between the mean head width and the instars.

$$\mathbf{Log\ (10Y) = 0.2603 + 0.1982\ x}$$

Attempts were made to study the applicability of Dyar's law to the larval stage of *H. armigera*, when the larvae were reared on pigeonpea. Dyar (1890) concluded in his studies

Table 1 : Comparison of observed and estimated values for larval head capsule width of *H. armigera* on pigeonpea var. BDN-2

Details	Mean larval head capsule width (mm) in different instars						Progression factor
	I	II	III	IV	V	VI	
Observed	0.285	0.441	0.695	1.283	1.789	2.657	
S.E. ±	0.007	0.080	0.013	0.018	0.016	0.009	
Growth ratio		1.55	1.57	1.85	1.39	1.49	1.57
Estimated	0.287	0.454	0.717	1.131	1.786	2.819	1.58
Difference	-0.003	-0.013	-0.022	0.152	0.003	-0.162	
Difference (%)	-0.982	-2.760	-3.047	13.455	0.165	-5.738	

that the width of head capsule of Lepidopterous larva was more or less constant for given instar of a given species. He also stated that the successive larval instars of a given species showed more or less regular geometrical progression in the growth of head capsule and this has been called the Dyar's law. Fisher (1924) worked on Tortrix pronubana Hb. and he has confirmed the conclusion of dyar. Miles (1931) found that width of head capsule in successive instrars of four species of Tenthredinidae follows a rugular geometrical progression in initial stage of growth. Hawever, in the later instars, the growth becomes irregular owing to sex differentiation and the occurrence of the pre-pupal stadium.

The width of head capsule within an instar did not vary much and it indicated that there was no over lapping in size from the first to last instar. Further, the data indicated that in first and second instars, there was not much variation but in second and Third instars, there was variation just double in the observed head width. However, it was slightly more in the sixth instar. The growth ratio of the mean head width of each instar and that of the preceding one indicated that the greater growth of each instar, greater the growth ratio. It was noted that the observed ratios ranged from 1.39 to 1.85. Peterson and Heoussler (1928) have studied on oriental fruit moth and they concluded that the measurements of head width of larva fell into different groups which evidently characterized a specific instar. The results obtained in the present investigation showed that the estimated head width was almost closed to the observed one which indicated that the head width of successive instars was more or less in geometrical progression as stated in Dyar's law.

In the present experiment (Table 1), the observed and estimated progression factors were in closed to each other which indicated that the width of head capsule of *H. armigera* was more or less constant for that particular instar and the increase in head capsule width followed Dyar's law on pigeonpea. Slight variation in ratios might be due to small number of measurements taken in each instar.

Bilapate *et al.* (1978) reported five larval instars of this pest on sorghum and alfalfa. Bilapate *et al.* (1981) concluded that there were 5 or 6 larval instars on chickpea. Ismail and Swailem (1976) reported six larval instars on cotton in Egypt. Reed (1965) reported six instars on cotton, however occasionally five to six instars on tomato were reported by Pointout and Cayrol (1969). In present study, larvae of *H. armigera* passed through six instars on both the hosts. This may be due to nutrition, which may be suspected causing supernumerary instars. Thus, the present findings are more or less in agreement

Table 2 : Comparison of observed and estimated values for larval body length of *H. armigera* on pigeonpea *var.* BDN-2

Details	Mean larval head capsule width (mm) in different instars						Progression factor
	I	II	III	IV	V	VI	
Observed	1.712	3.604	6.435	12.650	18.233	28.378	
S.E. ±	0.028	0.020	0.018	0.015	0.011	0.010	
Growth ratio		2.105	1.786	1.966	1.441	1.556	1.77
Estimated	1.973	3.452	6.039	10.567	18.488	32.347	1.75
Difference	-0.261	0.152	0.396	2.083	-0.254	-3.969	
Difference (%)	-13.219	4.403	6.558	19.714	-1.376	-12.270	

Table 3 : Comparison of observed and estimated values for larval body width of *H. armigera* on pigeonpea var. BDN-2

Details	Mean larval head capsule width (mm) in different instars						Progression factor
	I	II	III	IV	V	VI	
Observed	0.306	0.559	1.099	1.848	2.300	3.643	
S.E. ±	0.007	0.080	0.011	0.016	0.009	0.016	
Growth ratio		1.828	1.965	1.681	1.244	1.584	1.66
Estimated	0.351	0.573	0.935	1.527	2.492	4.068	1.63
Difference	-0.045	-0.014	0.164	0.321	-0.192	-0.424	
Difference (%)	-12.862	-2.413	17.514	21.053	-7.708	-10.429	

Table 4 : Multiple correlation and partial regression of *H. armigera* on pigeonpea var. BDN-2

Instars	Head capsule width ± S.E (mm)	Body width ± S.E.(mm)	Body length ± S.E. (mm)	Co-efficient of determination (R2)
1.	0.285 0.007	0.306 0.007	1.712 0.028	0.9996
2.	0.441 0.080	0.559 0.080	3.604 0.020	
3.	0.695 0.013	1.099 0.011	6.435 0.018	
4.	1.283 0.018	1.848 0.016	12.650 0.015	
5.	1.789 0.016	2.300 0.009	18.233 0.011	
6.	2.657 0.009	3.643 0.016	28.378 0.010	

with the result recorded by earlier workers.

Larval body length and width :

The result presented in Table 2 revealed that the mean body length for first to six instar larvae ranged from 1.712 to 28.378 mm on BDN-2 variety of pigeonpea. The mean observed and estimated progression factors obtained from the mean growth ratios for different instars were 1.77 and 1.75, respectively. The values of 'a' and 'b' were calculated with the help (data analysis tool pack) in Microsoft Excel and the following regression equation was fitted :

$$\mathbf{Log\,(10Y) = 1.0521 + 0.2429\ x}$$

The data in Table 3 clearly indicated that the body width measurements of the larvae fell into six distinct groups. Data on mean body width ranged from 0.306 to 3.643 mm with the estimated values of 0.351 to 4.068 mm. The observed and estimated geometrical progression factors were worked out as 1.66 and 1.63, respectively. The regression equation obtained for six larval instars was :

$$\mathbf{Log\,(10Y) = 0.3327 + 0.2127\ x}$$

Log measurements of larval body length and larval body width in different instars were considered to test the applicability of Przibram and Megusar's (1912) rule. They generalized a rule stating that at each moult, all linear dimensions are increased by a ratio of 1.26. The observed mean progression factors of larval body length and width when larvae undergone different instars ranged from 1.75 to 1.77 and 1.63 to 1.66, respectively.

Multiple correlation and partial regression study :

The multiple correlation and partial regression analyses were carried out to study the strength of association among three parameters *viz*., larval head capsule width (Y), body width (X_1) and body length (X_2) by using the following form of regression equation :

$$\mathbf{Y = a + b_1x_1 + b_2x_2}$$

The value of R^2 was 0.9996 on this crop. This indicated a very high predictability of head capsule width through larval body length and larval body width. It is evident from Table 4 that the values of multiple correlation co-efficients (R_2 = 0.9996) for the fitted equation, indicated that the body width (X_1) and body length (X_2) determined head width (Y) quite satisfactorily. The multiple regression equation was fitted as

$$\mathbf{Y= 0.1334 - 0.0212x_1 + 0.0922x_2}$$

This investigation is in close conformity with work done by Bilapate *et al.* (1978), Reed (1965), Ismail and Swailem (1976) and Bapodra (1988) on cotton, Bilapate *et al.* (1981); Bhatt and Patel (2001) on chickpea.

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