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GEOMETRICS OF GROWTH IN FOUR SPECIES OF *SPODOPTERA*

Mogili Ramaiah*, Nagamandla Ramya Sri and Uma Maheswari, T****

Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi 110012
**Department of Entomology, College of Agriculture,
PJTSAU, Rajendranagar, Hyderabad 500030
*Email: ramaiahmogili@gmail.com (corresponding author)

ABSTRACT

Four species of *Spodoptera* (Noctuidae: Lepidoptera) viz., *S. litura* (F.), *S. mauritia* Boisduval, *S. exigua* (Hub.) and *S. frugiperda* (J.E. Smith) were reared on castor, rice, chickpea and on artificial diet, respectively under laboratory conditions during 2017- 2019 at the Department of Entomology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. The observations on the geometrics of growth in terms of width of head capsule (widest head width) confirming to Dyar's law were made. In *S. litura* the linear growth ratio was 1.45 confirming a regular geometrical progression in the consecutive larval instars. In *S. mauritia* and *S. frugiperda* it was 1.62 and 1.94, respectively; but in *S. exigua* it was observed to vary as 1.41 (between 1st and 2nd instars), 2.61 (2nd and 3rd instars), 1.05 (3rd and 4th instars) and 1.64 (4th and 5th), with a mean of 1.68, and slightly deviating from Dyar's law. In specific, it was of the ratio of 2.61 between 2nd and 3rd instars showing the maximum progression factor, and confirming the variation among the four species evaluated.

Key words: *Spodoptera litura, S. mauritia, S. exigua, S. frugiperda*, Dyar's law, larval growth, head capsule width, instars

The genus *Spodoptera* (Noctuidae: Lepidoptera) includes more than 30 species (Nagoshi et al., 2011). Their larvae are important pests of agricultural crops, and are widely distributed. Species of *Spodoptera* are polyphagous, have invasive potential and consist of closely related species that are difficult to identify at species level. The larvae are known as the cluster caterpillar, cotton leaf worm, tobacco cutworm, and tropical armyworm. Among various *Spodoptera* spp., *S. litura* (Yadav et al., 2012; Kandagal et al., 2013), *S. mauritia* (Ananthanarayanan and Ayyar, 1937), *S. exigua* (Singh and Mullick, 1997) and *S. frugiperda* (Deshmukh et al., 2018) had been reported in India infesting various crops. Geometrics of width of head capsule provide details of morphometrics in relation to ecological aspects of IPM, and the present study explores the four species commonly occurring in India.

MATERIALS AND METHODS

Laboratory experiment on the growth ratio of *Spodoptera* spp., was conducted at the Department of Entomology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during August 2017-March 2019. Larvae of *Spodoptera litura, S. mauritia, S.exigua* and *S. frugiperda* were collected from the field and reared (*S. litura* on castor, *S. mauritia* on rice *S. exigua* on chickpea and *S. frugiperda* on artificial diet- chickpea and maize flour as main ingredients). To determine growth in larval instars, the individual larva was observed daily for exuvia as well as head capsule. Moulting was confirmed by the presence of casted head capsule. Freshly moulted 10 larvae were killed in hot water at 60°C, and transferred to blotting paper to remove excess moisture. Width of the head capsule was measured in a stereozoom microscope. Dyar's law (1890) was tested for the number of larval instars in these and data obtained analysed in terms of ratio, and number of instars confirmed with computation of mean and standard deviation.

RESULTS AND DISCUSSION

The results reveal that the larval stage of *S. litura* has five instars with four moults as observed with their exuviae. The head capsule width of 1st, 2nd, 3rd, 4th and 5th larval instars was recorded as 0.25±0.02 mm, 0.36±0.02 mm, 0.50±0.02 mm, 0.70±0.01 mm and 1.11±0.03 mm respectively. It was predicted that as linear measure of size increased by a constant factor from one instar to the next, where insect growth follows Dyar's rule and growth ratio are commonly in the order of 1.4 (Dyar's, 1890). The width of head capsule showed successive increase in a specific ratio at each moult, with ratio of increase being 1.45, which could be used for the calculation of head capsule width of each larval instar.

The consecutive larval instars followed a more or less regular geometrical progression of 1.45 (Table 1).

In *S. mauritia,* there were six instars with five moults, with their size and colour varying. The mean head capsule width of 1st, 2nd, 3rd, 4th, 5th and 6th larval instars was 0.25±0.02, 0.42±0.03, 0.64±0.03, 0.94±0.04, 1.87±0.14 and 2.72±0.23 mm, respectively. There existed a successive increase in a different ratio at each moult (1.68, 1.52, 1.46, 1.98, and 1.45), with mean ratio being 1.62. In contrast, in *S.exigua* five instars were observed with four moults, and the head capsule width progressed as 0.26±0.01, 0.37±0.01, 0.99±0.09, 1.04±0.06 and 1.71±0.05 mm, respectively, with respective ration being: 1.41, 2.61, 1.05, and 1.64. The mean ratio of these was 1.68, and the instars did not follow Dyar's law.

In *S. frugiperda,* six instars and five moults were observed similar to *S. mauritia* with width of head capsule being 0.09± 0.01, 0.23 ± 0.03, 0.45 ±0.03, 0.73 ±0.04, 1.3 ± 0.14, and 2.4 ± 0.23 mm, respectively, with mean ration of 1.94. Thus, the consecutive larval instars did not follow regular geometrical progression. Dyar (1890) suggested that size of the head capsule of lepidopteran larvae increased by a factor of 1.2- 1.4/ moult.

Table 1. Width of head capsule in *Sporoptera* spp. (n=10; SD- Standard Deviation)

S.No	Larval instars	Estimated (mm)	Observed (mm)	**± SD**	Growth ratio
S. litura					
1	I instar	0.25	0.25	0.02	-
2	II instar	0.25 x 1.45 = 0.36	0.36	0.02	1.44
3	III instar	0.36 x 1.45 = 0.52	0.50	0.02	1.38
4	IV instar	0.52 x 1.45 = 0.75	0.70	0.01	1.40
5	V instar	0.75 x 1.45 = 1.08	1.11	0.03	1.59
Mean growth rate					1.45
S.mauritia					
1	I instar	0.25	0.25	0.02	-
2	II instar	0.25 x 1.62 = 0.41	0.42	0.03	1.68
3	III instar	0.41 x 1.62 = 0.66	0.64	0.03	1.52
4	IV instar	0.66 x 1.62 = 1.06	0.94	0.04	1.46
5	V instar	1.06 x 1.62 = 1.71	1.87	0.14	1.98
6	VI instar	1.71 x 1.62 = 2.77	2.72	0.23	1.45
Mean growth rate					1.62
S.exigua					
1	I instar	0.27	0.27	0.01	-
2	II instar	0.27 x 1.68 = 0.45	0.38	0.01	1.41
3	III instar	0.45 x 1.68 = 0.76	0.99	0.09	2.61
4	IV instar	0.76 x 1.68 = 1.27	1.04	0.06	1.05
5	V instar	1.27 x 1.68 = 2.13	1.71	0.05	1.64
Mean growth rate					1.68
S. frugiperda					
1	I instar	0.09	0.09	0.01	-
2	II instar	0.09 x 1.94 = 0.17	0.23	0.03	1.83
3	III instar	0.17 x 1.94 = 0.32	0.45	0.03	1.79
4	IV instar	0.32 x 1.94 = 0.62	0.73	0.04	1.62
5	V instar	0.62 x 1.94 = 1.20	1.31	0.14	1.95
6	VI instar	1.20 x 1.94 = 2.33	2.40	0.23	2.55
Mean growth rate					1.94

Thus, growth ratio of instars of *S. litura* was fit with Dyar's rule (1.45); similar results had been reported for *Helicoverpa armigera* by Khorasiya et al. (2014), and *Lymatria obfuscata* by Thakur (2016). But in contrast was the case of *S. mauritia, S. exigua* and *S. frugiperda,* with growth ratio 1.62, 1.68 and 1.94, respectively, not agreeing with Dyar's factor. Evidence from studies of 105 species showed that holometabolous insects have grown up almost twice as much in linear dimension at each moult with a factor of 1.52 as reported by Cole (1980) confirming the present result. In *S. exigua,* growth from first to second instar was linear according to Dyar's rule, but later it increased to 2.61 which later became 1.05, and again increased. Such variations due to temperature and RH influencing the development are known (Zenner-Polania and Helgesen, 1973). The present results derive support from Hutchinson and Tongring (1984) who argued that Dyar's rule might result from a maximization of growth efficiency, assuming that the size of the first instar, the number of instars and the arithmetic mean of growth ratios are predetermined. Several factors such as parasitism (Jobin et al., 1992) temperature, food availability (Zenner-Polania and Helgesen, 1973) locality, and rearing regimes might influence growth (Daly, 1985). However, the approximate constancy of growth ratios can be seen as a result of physiological base of moulting by Nijhout (1981) and Sehnal (1985). Dyar's hypothesis (1890) indicates that mean head capsule width follows a geometrical succession in lepidopteran larval development. However researchers like Camp and Neal (1993) said that Dyar's theory might have more notoriety than utility, as it applies to some insects like *Eucosema tocullionana* (De Groot, 1998) and *Diaphania indica* (Peter and David, 1991) but not in other insect like *Lymatria dispar* (Jobin et al., 1992). A constant geometric relation, in the strict sense, is not a fundamental feature of insect development in general, because growth rate can deviate from linearity when temperatures approach maximum and minimum tolerable ranges (Beck, 1983).

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