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Bionomics of rice swarming caterpillar, *Spodoptera mauritia* Boisduval

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Abstract
Biology, morphometrics and growth of *Spodoptera mauritia* was studied by rearing *Spodoptera mauritia* under laboratory conditions during August 2017. The study was mainly focused on observing morphology of different stages i.e., egg, larva, pupa and adult along with duration, *S. mauritia* had six instars. Measurements of all the stages of insect life cycle were recorded. The width of head capsule was recorded at each moult showing a minimum and maximum of 1.45 and 1.98 mm respectively. The mean values of head capsule width observed (0.42 to 2.72 mm) and estimated (0.41 to 2.79 mm) and the progression factor in the growth of *S. maurita* was observed as 1.62, which indicated that an increase in head width during successive instars was slightly varying from Dyar's law but followed geometric progression in growth.

Keywords: *S. mauritia*, biology, morphometrics, head capsule, growth ratio

1. Introduction
Rice swarming caterpillar or armyworm, *Spodoptera mauritia* Boisduval (Noctuidae: Lepidoptera) is a sporadic pest but very serious indeed whenever it appears occur in large numbers [1]. Not only it is a serious pest practically in the whole of the coastal regions of India, but its distribution is spread over large tracts of oriental and Australian regions and is reported even from West Africa [1]. As the name indicates, in caterpillar stage, this pest has a tendency to migrate from field to field in large swarms. The swarm practically grazes a field like cattle and when one field is completely finished, the swarm marches on in regular army formation to the adjoining field. Because of the behavior, this pest is also referred to as army-worm [1].
The caterpillar is essentially a polyphagous species feeding on a number of cultivated crops and wild grasses but prefers paddy, the most important crop in coastal areas where the climate is particularly suitable for this pest that turns it as a serious pest of paddy [1]. Also at times, it can so happen that the younger stages of the caterpillars are passed among wild grasses in uncultivated areas where nobody notices their presence and from there they may suddenly march into the cultivated fields. The number of generations varies in different regions of the country. During the last few years, it has emerged as a major pest in eastern India and caused severe loss to wet season rice production [2]. In Orissa, the swarming caterpillars have swarmed over thousands of hectares of land in 2009 completely damaging paddy crop in the field and look as if grazed by cattle especially in Sambalpur district where complete loss had been reported. Sundergarh district in Orissa was also severely affected by *S. mauritia* and complete loss occurred in some places [2]. It was claimed that a prolonged period of drought for a month or more followed by heavy rainfall create conditions favourable for outbreak of this pest [2].
In arthropods, growth of rigid sclerotized parts like insect head grows in a step wise manner with the help of moulting that can be easily analysed by assessing the size of body structure in successive instars. In many of the studies on growth of immature insects, width of the head capsule was used for determining stage of the instar especially in lepidotpera [2]. Hence measurement of head capsule width provide basic information for development of morphometric studies useful for pest management. Width of head capsule of different larval instars was often used to determine the age of various lepidopteran pests. The number of larval instars and other information concerning with insect biology help in the development of pest forecasting models based crop phenology, or in the refinement of existing models [3].
According to Dyar (1890) width of head capsule in caterpillars increases by a fairly constant ratio at each moult, that varies from species to species, but usually is 1.2 to 1.4 which was applied to many of insects larvae [5].

This law was used to determine the number of instars and constant development of Rice swarming caterpillar, *S. mauritia* which is an important sporadic pest of rice, studies on biology, morphometrics and growth will help in identification and management in the case of pest outbreak. In recent years, *S. mauritia* infesting rice nurseries remained unidentified causing severe loss, where systematic studies on biology, morphology and morphometrics are lacking. Hence, an attempt was made to generate detailed information about *S. mauritia* infesting rice.

2. Materials and Methods

2.1 Collection mass multiplication and biology of *Spodoptera mauritia*

The present study was conducted at Department of Entomology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during August 2017. To study biology and morphometrics of *Spodoptera mauritia*, the mass multiplication was taken up under laboratory conditions (Fig 1). Initial culture of larval population was collected from Paddy nursery of Warangal, RARS, Telangana, India. The collected larvae were reared up to adult and after adult emergence; the male and female moths were kept in plastic jar for egg laying. Cotton swab dipped in 10 percent of honey solution was kept in the jar as food for adults. After observing eggs on cloth and side walls of jar, egg mass was collected and kept in a plastic jar containing moist filter paper, Paddy seedlings were provided along with root system by keeping them in a test tube to keep them fresh, as well touch the walls of jar, so that first instar larvae immediately after hatching crawl on to the plant to provide immediate source of food. Later, the test tubes along with the first instar larvae were transferred to pre sterilized transparent plastic containers and covered with muslin cloth. The fresh leaf was provided as and when required till the larvae entered into third instar. From third instar onwards, the larvae were released on to the paddy seedlings kept in big petriplates. Again these petriplates were transvered to plastic trays containing water, so that the larvae can't move from the tray. Fresh paddy seedlings were given as and when required till the larvae entered into sixth instar. Sixth instar larvae or pre pupae were later transferred to plastic container soil for pupation. Pupae thus obtained were collected and kept in small plastic jars covered with muslin cloth for adult emergence. During the process, male and female pupae were separated by characters of external genitalia. Each sex of pupa were kept in separate small plastic jars covered with muslin cloth for adult emergence. Data was recorded on pre oviposition period, oviposition period, fecundity, incubation period, larval period, pupal period and adult longevity of male and females.

2.2 Morphometrics and growth studies

For recording data on morphometric of different stages of *Spodoptera mauritia* i.e., egg, larvae, pupae and adults were observed using stereozoom binocular microscope and by visually graphical method (Fig 2). Totally, 10 specimens were killed in hot water 60 ºC and later transferred in to blotting paper for removing moisture. Later, observed for calculating average length and width from each individual stage of insects.

In order 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. Width of the head capsule was measured with the help of stereozoom binocular microscope. Application of Dyar's law (1890) was tested for the number of larval instars of *S. mauritia.*

Growth ratio of head width in successive instars was determined by dividing the mean head capsule width of the respective instar stage with that of the previous instar stage. The exact number of larval instars was confirmed by measuring the width of head capsule of each larval instar by applying Dyar's law. The larval instars in the life cycle of *S. mauritia* were confirmed with help of Dyar's law. For this purpose, the width of head of 10 larvae for each instar was taken with help of stereozoom binocular microscope and mean was calculated.

2.3 Statistical analysis

Data collected on size of different stages of insect i.e., egg, larva, pupa and adult was analyzed for calculating mean and standard deviation.

3. Results and Discussion

Results pertaining to biology of *Spodoptera mauritia* on Paddy revealed that total life cycle period lasted for 33.75 to 43.00 days with an average of 38.37±4.62 days (Table 1 and Fig 3).

3.1 Egg

Eggs were laid in mass covered with greyish hairs with an average fecundity of 1013.50 ± 21.92 eggs. On removal of hairs, it was observed that the eggs were laid one over the other in two to three layers and were spherical in shape with green colour. Hatching of eggs was observed as 81.50±8.49 per cent during early morning hours. Few hours before hatching, eggs changed their colour from green to dark black. Incubation period was 3.00±0.00 days. An incubation period of 3.2 days and 3 days was observed in the case of *S. mauritia* supporting the present results [6, 7].

3.2 Larvae

First instar larvae were active, greyish white in color, descended by means of silken threads and were characterized by presence of large black head capsule and brown coloured body and has wart like tubercles throughout the body and these tubercles possessed small setae which later after feeding on paddy leaves, turned in to pale green. The larvae were found feeding only the green part of the leaves and moving in a characteristic leaping manner. First instar larval period lasted for about 2-3 days with an average of 2.50±0.52 days. Second instar larvae were pale green in colour and were characterized by three white longitudinal lines on the dorsal surface of the body extending from prothorax to the last abdominal segment. Two pairs of white lines were also observed on the sides of the body laterally. They retained small wart like tubercles throughout the body and larval period lasted for about 2-3 days with an average of 2.50±0.52 days. Third instar larvae were pale green in colour and possessed three white longitudinal lines, one on dorsal side and the other two on the lateral sides without wart like tubercles. They had characteristic dark reddish superspiracular lines extending from anterior to posterior end and larval period lasted for about 3-4 days with an average of 3.50±0.52 days.

Fourth instar larvae were greyish-black in colour and acquired the fundamental pattern of strips and markings, the characteristics of mature armyworm. The three longitudinal lines became dull white in colour and two lateral reddish black lines along with black intermittent dots on each segment

arranged dorso-laterally along the length of the body. The dorsum of the larvae was pale in colour than the supraspiracular area and larval period lasted for about 3-4 days with an average of 3.50±0.52 days. Fifth instar larvae were greyish-black in colour with double rows of prominent black triangular markings on dorso-lateral sides bordered with narrow white stripes. Later the supra spiracular stripes became pinkish in colour and larvae were found feeding voraciously where larval period lasted for about 2-3 days with an average of 2.50±0.52 days.

In the present study, sixth instar larvae were observed that were greyish black in colour with wider triangular markings that were darker than those of the fifth instar. These larvae fed voracious feeders during first three days and later stopped feeding form in to prepupa having highly wrinkled body. Within 18-24 h, prepupae became pupa. Similar results of having six instars were observed [7-9]. The total larval period was recorded as 17-23 days though it was recorded as 21-32 days [9].

No cannibalism was observed among the larvae in our laboratory conditions of crowding and food shortage. However, crowding caused cannibalism [8].

The newly formed pupae were light brown which later turned to reddish brown ultimately dark brown. The male pupae showed genital aperature on 9th abdominal segment on ventral side in the form of x shape and female pupae had genital aperature on 8th abdominal segment in the form of an inverted v shape. The pupal period for male and female moth was about 7 and 8 day respectively similar to the observations made earlier [7] though it varied from 5 to 10 days [9] or 10.9 days [6].

The forewings of female moth were greyish brown with wavy lines having a dark spot in the middle. Tuft of hairs were absent on forelegs of female adult whereas male moth has immense tuft of hairs on forelegs. Forewings of the male moth were bright greyish and hind wings were brownish white with black margins. Total life period lasted for about 38.37±4.62 and adult longevity of male and female was recorded as 6 and 8 days respectively. More adult longevity as 10.3 and 10.6 days for male and female respectively on lawn [4] than the present result might be due to variation in locality and rearing conditions.

Data on morphometric of *S. mauritia* on Paddy revealed the diameter of egg as 0.43± 0.00 mm, first instar larvae with 1.30 ± 0.14 mm body length and 0.38 ± 0.07 mm width, second instar with an increased body length of 2.64±0.28 mm and width of 0.51±0.02 mm. Third instar was measuring 5.56±0.22 mm in length and 1.23±0.16 mm width, fourth instar was measuring 16.50±0.23 mm in length and 2.30±0.12 mm in width, fifth instar which measured up to 27.00±0.10 mm in length and 3.49±0.28 mm in width. Sixth instar attained a maximum body length of 36.50±0.08 mm and width of 5.60±0.45mm (Table 2).

In confirmation with the current results with regard to body length and width of *S. mauritia* larvae, similar results obtained from first to sixth larval instars as 1.0 and 0.5 mm, 2.5 and 0.5 mm, 6.0 and 1.0 mm, 15.0 and 2.0 mm, 20.0 and 4.0 mm, 37.0 and 6.0 mm respectively [7]. Similarly he observed length and width of the pupa was 17 mm and 5 mm which were similar to the present studies (16.40 mm and 4.03 mm) and with a wing span of 30-35 mm and length 15 mm (30.00 to 34.00 mm and 16.00 to 18.00 mm) [7].

The head capsule width from first to sixth instar was measured as 0.25 ±0.02, 0.42± 0.03, 0.64± 0.03, 0.94± 0.04, 1.87 ± 0.14mm and 2.72± 0.23mm respectively. The average length of the pupa was about 16.40±0.25 mm and width as 4.03± 0.17mm. The wing span of male and female moths was about 30.00 ±0.38 and 34.00 ±0.18 mm (Table 3 and Fig 4).

In the case of *S. mauritia*, growth ratio between 1st and 2nd instar was 1.68, 2nd and 3rd was 1.52, 3rd and 4th was 1.46, 4th and 5th was 1.98, 5th and 6th was 1.45 showing an average ratio of 1.62 for all the consecutive larval instars (Table 4). The present studies indicated that *S. mauritia* have six larval instars and showed decrease in growth ratio from 2nd to 3rd as 1.52, 3rd to 4th as 1.46 and from 5th to 6th as 1.45. However a linear increase in head width was observed from 4th to 5th instar as 1.98 slightly deviating from Dyar's law. Similar results were observed while studying the growth of 105 species of holometabolous and hemimetabolous insects and showing the larvae grown up almost twice as much in linear dimension at each molt with a factor of 1.52 confirming the present result [10]. Constant geometric growth is not a fundamental feature of insect development in general, because growth rates can deviate from linearity when temperature approaches maximum and minimum tolerable [11]. Further, temperature and food availability [11], locality and rearing regimes may also affect growth rates and morphometrics, either between populations or between individuals of the same population [4] supporting the current study. Finally, from the present study, it can be concluded that the total life cycle for *S. mauritia* can be completed in about 38.37±4.62 days. There were six instars, where the late instars had greyish black colour with wider triangular markings on dorso-lateral surface of body. *S. mauritia* had an average growth ratio of 1.62 for all the consecutive larval instars.

4. Acknowledgements

I want to thank ICAR, for monitory support and help from HOD, Department of Entomology, PJTSAU, Hyderabad for the study.

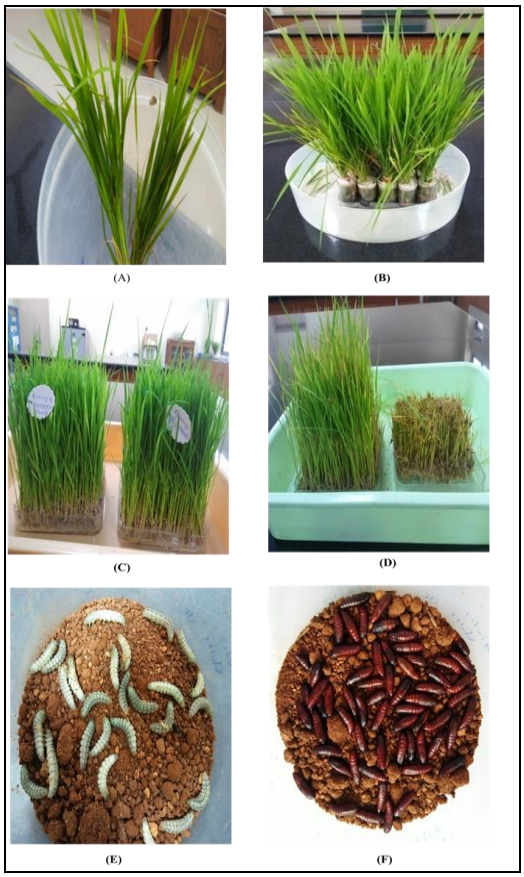

Fig 1: A, B, C, D, E & F. Mass multiplication of *S. mauritia*

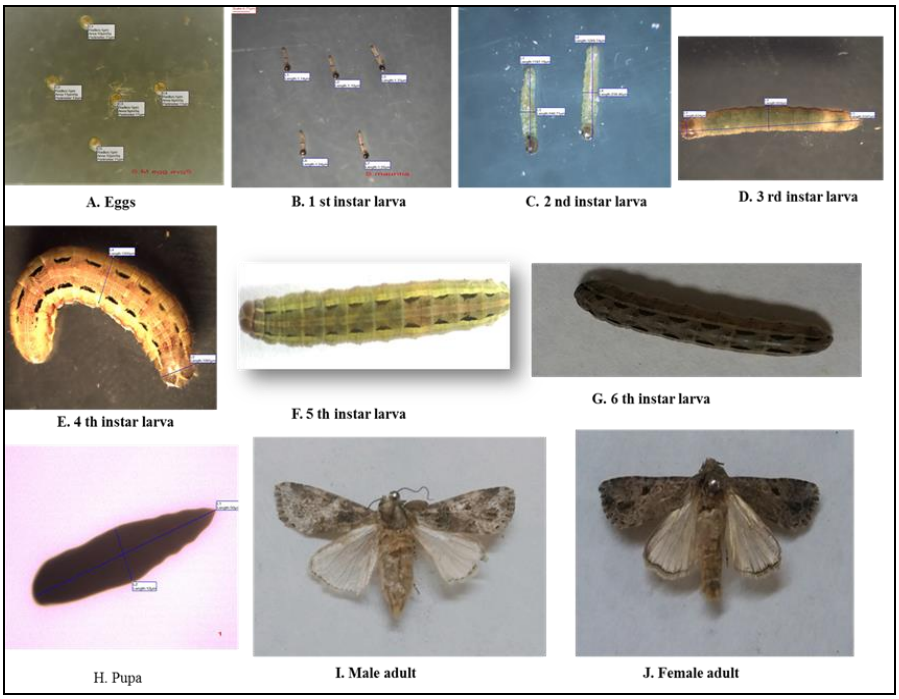

Fig 2: Morphometrics of *S.maurita* A. Eggs; B, C, D, E, F, G. Larval stages; H. Pupa; I. Male adult; J. Female adult

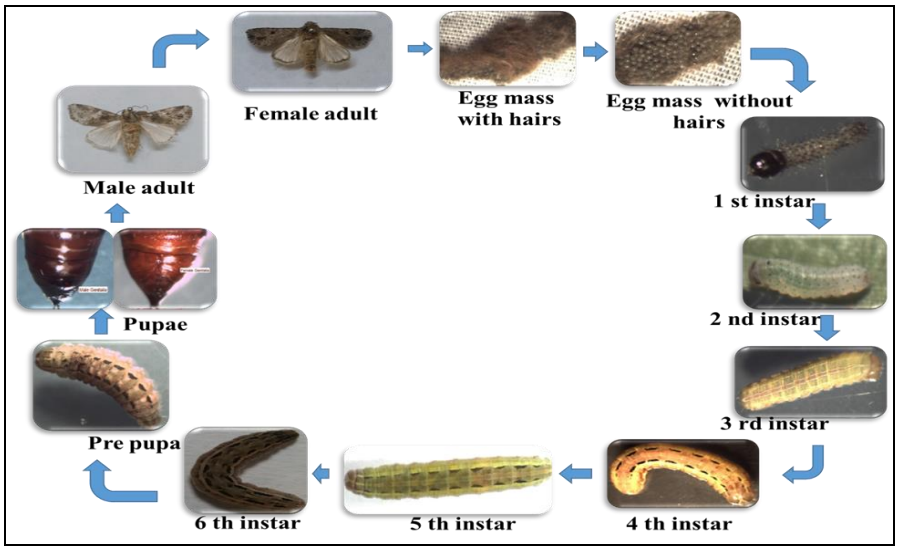

Fig 3: Life cycle of *S. mauritia*

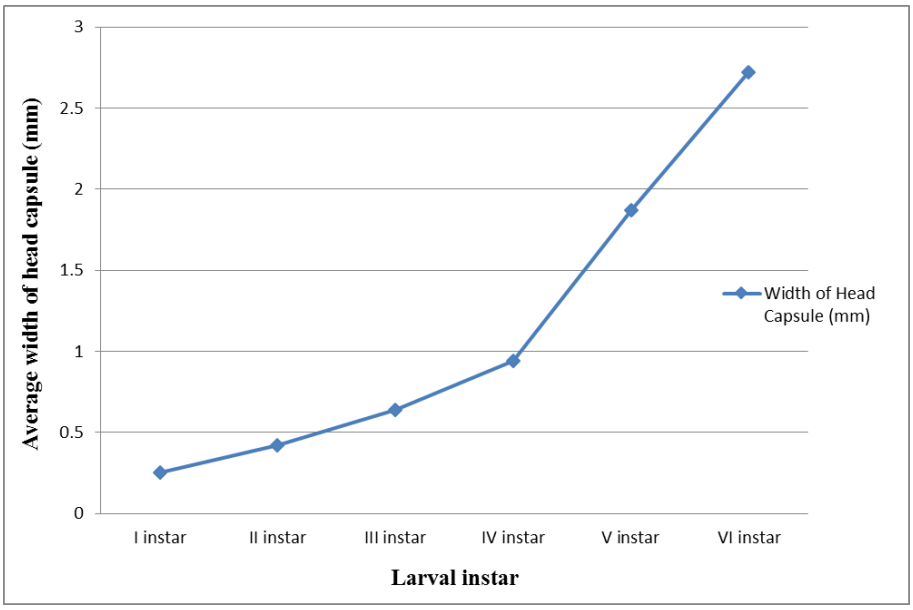

Fig 4: Relation between larval growth and head width of *S. mauritia*

Table 1: Biology of Rice swarming caterpillar, *Spodoptera mauritia* B.

S. No	Stage of the insect	Minimum * (Days)	Maximum * (Days)	Mean (days)	± SD
1	Incubation period	3.00	3.00	3.00	0.00
2.	Larval period				
a.	I instar	2.00	3.00	2.50	0.52
b.	II instar	2.00	3.00	2.50	0.52
c.	III instar	3.00	4.00	3.50	0.52
d.	IV instar	3.00	4.00	3.50	0.52
e.	V instar	2.00	3.00	2.50	0.52
f.	VI instar	5.00	6.00	5.50	0.52
	Total larval period	17	23	20.00	4.24
3.	Pre pupal period	0.75	1.00	0.88	0.12
4.	Pupal period	7.00	8.00	7.50	0.52
5.	Adult longevity				
	a. Male	5.00	7.00	6.00	1.00
	b. Female	7.00	9.00	8.00	1.00
	Average	6.00	8.00	7.00	1.00
6.	Total life cycle	33.75	43.00	38.37	4.62
7.	Pre oviposition period	1.50	2.00	1.75	0.35
8.	oviposition period	2.00	4.00	3.00	1.41
9.	Fecundity (no.)	998.00	1029.00	1013.50	21.92
10.	Percent hatching	75.50	87.50	81.50	8.49

*Mean of 10 individuals SD: Standard deviation

Table 2: Morphometrics of the life stages of Rice swarming caterpillar, *Spodoptera mauritia* B.

S. No	Stage of the insect	Minimum * (mm)	Maximum * (mm)	Mean (mm)	± SD
1	Egg				
	a. Diameter	0.42	0.43	0.43	0.00
2	I instar larva				
	a. Length	1.03	1.56	1.30	0.14
	b. Width	0.31	0.45	0.38	0.07
	c. Width of the Head capsule	0.22	0.28	0.25	0.02
3	II instar larva				
	a. Length	2.24	3.03	2.64	0.28
	b. Width	0.48	0.53	0.51	0.02
	c. Width of the Head capsule	0.37	0.47	0.42	0.03
4	III instar larva				
	a. Length	5.13	5.98	5.56	0.22
	b. Width	1.01	1.45	1.23	0.16
	c. Width of the Head capsule	0.60	0.67	0.64	0.03
5	IV instar larva				
	a. Length	13.00	20.00	16.50	0.23
	b. Width	2.15	2.45	2.30	0.12
	c. Width of the Head capsule	0.91	0.97	0.94	0.04
6	V instar larva				
	a. Length	26.00	27.90	27.00	0.10
	b. Width	3.30	3.68	3.49	0.28
	c. Width of the Head capsule	2.00	2.09	1.87	0.14
7	VI instar larva				
	a. Length	35.00	38.00	36.50	0.08
	b. Width	5.00	6.20	5.60	0.45
	c. Width of the Head capsule	3.43	3.57	2.72	0.23
8	Pupae				
	a. Length	16.10	16.70	16.40	0.25
	b. Width	3.77	4.29	4.03	0.17
9	Adult(Male)				
	a. Body length	15.00	17.00	16.00	0.12
	b. Wing span	27.00	33.00	30.00	0.38
	Adult(Female)				
	a. Body length	19.00	17.00	18.00	0.08
	b. Wing span	36.00	32.00	34.00	0.18

*Mean of 10 individuals SD: Standard deviation

Table 3: Head capsule width of different larval instars of *S. mauritia* B.

S. No	Larval instars	Range (mm) *	Mean (mm)	± SD
1	I instar	0.22-0.28	0.25	0.02
2	II instar	0.37-0.47	0.42	0.03
3	III instar	0.60-0.67	0.64	0.03
4	IV instar	0.91-0.97	0.94	0.04
5	V instar	1.64-2.09	1.87	0.14
6	VI instar	2.43-3.01	2.72	0.23

*Mean of 10 individuals SD: Standard deviation

Table 4: Average width of head capsule of *S. mauritia* and growth rate during larval development

S. No	Larval instars	Estimated Width of Head Capsule (mm)	Observed Width of Head Capsule (mm)	± SD	Growth ratio
1	I instar	0.25	0.25	0.02	-
2	II instar	0.42 x 1.62 = 0.41	0.42	0.03	1.68
3	III instar	0.64 x 1.62 = 0.66	0.64	0.03	1.52
4	IV instar	0.94 x 1.62 = 1.10	0.94	0.04	1.46
5	V instar	1.87 x 1.62 = 1.72	1.87	0.14	1.98
6	VI instar	2.72 x 1.62 = 2.79	2.72	0.23	1.45
Mean growth rate					1.62

SD: Standard deviation

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