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To study and compare the mass rearing and biology of Eri silkworm *Samia cynthia ricini* with Rice meal moth *Corcyra cephalonica* for *Trichogramma chilonis* multiplication

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Abstract
The basic aim of mass production of any parasitoid is the quality production of natural enemies at quicker and economical rates. *Trichogramma chilonis* is generally mass reared on the factitious host *Corcyra cephalonica*, but eri silkworm, *Samia cynthia ricini*, is one of the most exploited, domesticated and commercialized non mulberry silkworm. It is also used as an alternate host for multiplication of *Trichogramma chilonis*. The present study mainly focuses on observing the differences in the biology of different stages i.e., egg, larva, pupa and adult in both rice moth and eri silkworm to choose the best alternate host for *T. chilonis* multiplication. In case of eri silkworm the incubation period of eri silkworm egg was observed as 6-7 days, On the other hand incubation duration of rice moth egg was observed as 3-4 days. The larval, pupal duration, total life cycle period of eri silkworm was observed as 25, 15-19, 46 - 51 days. Where as the rice moth larval pupal duration, total life cycle period period were observed as 23, 10, 36 days. Which indicated that duration of life cycle of rice moth was shorter when compared to eri silkworm and it was mostly preferred for parasitization by *T. chilonis*.

Keywords: rearing, life cycle, *T. chilonis*, rice moth, eri silkworm

1. Introduction
The basic aim of mass production is the quality production of natural enemies at quicker and economical rates, the two basic components for *T. chilonis* rearing are mass production of factitious host and the parasitoid. The production of potential Trichogrammatids depends on the quality of the host egg which inturn depends on the nourishment of the host. Therefore, the diet of the host is of potential importance to the nutritional quality of host eggs and the survival of *Trichogramma* and other egg parasitoids released in the environment as biological control agents [2].

Eri silkworm is a domesticated and commercialized non mulberry silkworm [2], it can be used an alternate host for *T. chilonis* multiplication, for eri silkworm larval rearing Castor (*Ricinus communis*) is the mostly used [3].

Growth, development and economic traits of silkworms are influenced by the host plants and their nutritive contents, where as materials like heat sterilized broken maize grains, yeast, streptomycin sulphate, protinex, vitamin E tablets are used for rearing rice moth which is the basic factitious host for *T. chilonis* multiplication [4]. The basic aim is to conduct a study and compare the life cycles of eri silkworm and rice moth and find which host is most suitable for *T. chilonis* multiplication.

2. Materials and Methods
2.1 Collection and rearing of the test insect *Corcyra cephalonica*
The initial nucleus culture of host insect rice moth, *Corcyra cephalonica* National accession number: NBAII-MP-PYR-O1 and egg parasitoid *T. chilonis* reared on *C. cephalonica* with National accession number NBAII-MP-TRI-13 were maintained at AICRP on biological control, Regional Agricultural Research Station, Anakapalle and were subsequently utilized for conducting the present study. The culture of *Corcyra cephalonica* was reared as per the mass rearing protocol (methodology) developed at NBAIR, Bengaluru.

Rice moth, *C. cephalonica* was cultured on broken grains of maize in plastic basins. Heat sterilized broken grains were added @ 2.5 kg per basin to which 100 g of groundnut meal and

5 g of yeast powder were added. To prevent bacterial contamination 1 vial of streptomycin sulphate (0.05%) was incorporated per basin, half capsule (tablet) of vitamin E, 2 grams of proteinex was used per basin to which *C. cephalonica* eggs were added @ 0.25cc/basin.

After 30-35 days the adult moths of *C. cephalonica* started emerging from the medium and continued upto 90 days .The emerged adults that rested on the inner side of the muslin cloth were collected during morning hours in glass specimen tubes (15 x 2.5cm) then transferred to a mating drum from where the eggs were collected daily, After 90 days, the contents of the basins were discarded and basin was cleaned, washed, disinfected with 2 per cent formalin solution and dried thoroughly before reusing.

2.2 Collection and rearing of the test insect *Samia cynthia ricini*

The initial nuclear culture of the host insect, eri silkworm (Esw) with national accession number NBAII-MP-SAT-01, and eri trichocard *i.e*., egg parasitoid *T. chilonis* reared on eri silkworm with National accession number NBAII- MP –TRI-26, were collected from National Bureau of Agriculture Insect Resources (NBAIR), Bengaluru. The insect cultures were maintained at AICRP centre on biological control, Regional Agricultural Research Station, Anakapalle and utilized for conducting the experiments.

2.2.1 Larval rearing

The newly hatched eri silkworm larvae were brushed on to the tender castor leaves during morning hours for feeding. Tender castor leaves were fed to the freshly hatched larvae or neonates of eri silkworm in plastic tubs covered with black cloth. The eri silkworm larvae were provided with fresh leaves daily two times during first instar, three times during second and third instar and four times during fourth and fifth instars. The first three instar larvae were fed with tender castor leaves whereas the fourth and fifth instar larvae were fed with mature coarse leaves (Fig 1).

Bed cleaning was carried out once in first instar, just before entering into first moult, twice during second instar, after the first moult and second time before settling for the second moult, In third instar three times after second moult, in the middle of third instar and third time before worms settle for third moult. Daily bed cleaning was done in fourth and fifth instars. At the end of the fifth instars, spinning worms were hand picked and released into basket with paper folds or cramps for cocoon construction. Cocoons were formed within fed leaf bits in the corners of the trays in 25 to 35 days. Cocoons were collected and kept in cages for adult emergence (pupal period 15 to 19 days).

2.2.2 Adult rearing

A rectangular cage fabricated with iron rods measuring 40×40×45 cm, with four legs measuring 6 cm each and covered with nylon mesh with an opening (with a zip) on one side was used for releasing the moths. The freshly emerged adults of Esw (Fig 1) were released into the cage for mating subsequently, only female moths were retained for egg laying.

2.3 Statistical analysis

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

3. Results and Discussion

3.1 Mass rearing of eri silkworm *Samia cynthia ricini*

The morphological characteristics of the eri silkworm, were observed during the rearing period where in the colour of the egg shell was white with cream coloured yolk. The colour of the egg changes to greyish blue one day prior to hatching. Generally, eggs hatch in the morning hours between 7 and 9 a.m. The newly hatched larvae are yellow in colour with tufts of black hairs all over the body.

Newly hatched eri silkworm larvae are brushed to rearing trays over which few tender castor leaves are spread, When the worms crawled on to the leaves, they were transferred to a separate tray and fed with castor leaves as per the requirement of different instars. To avoid overcrowding the worms were spaced adequately during different instars. Body colour of eri silkworm larvae varied from yellow / cream / blue / green with weak thorny skin. Cocoons are white flossy without peduncle (Fig 1) enclosing a brown coloured pupa. Eri silkworm adult moths emerged from morning to mid day; males emerged earlier than the females. After an hour of emergence mating occured and continued till evening. Both male and female adults have brown (chocolate) coloured wings with white crescent markings and woolly white abdomen.

The male moth is smaller than female and bears narrow abdomen where as the female bears a stout and robust abdomen. Eri silkworms were continuously reared for four generations with an optimum temperature of 28±2°C and relative humidity of 65 to 75 per cent under controlled conditions in laboratory. The different parameters studied during rearing are presented here under.

3.1.1 Egg period

The incubation period of eri silkworm egg was observed as 6-7 days with an average of 6.25 days (Table 1 and Fig 3) during the study period. Several researches reported that the incubation period of the eri silkworm eggs as 8 days for those larvae which fed on castor leaves [5].

3.1.2 Larval period

The newly emerged first instar larvae were light yellow in colour with brown head and black segmentation and its duration lasted for four days. The second instar larvae appeared yellow in colour slightly larger than first instar with a duration of four days. The third and fourth instars were white in colour with small thorny projections and the larval duration of third instar was five days and fourth instar was six days. The fifth instar larva was larger and stouter compared to all instars with creamy white or light yellow colour and its duration lasted for six days. In total, the average larval duration of eri silkworm was observed as 25 days (inclusive of moulting period) during the study period of four generations. Similar results were observed of five larval instars of eri silkworm reared on castor leaves as 3.5 days; 4 days; 3.5-4 days 4.5-5.0 days and 7.0 days for the first, second, third, fourth and fifth instars respectively and the total larval duration of eri silkworm was recorded as 22.5 days [6].

3.1.3 Pupal period

The pupal period was recorded to be 15-19 days with an average of 17.75 days (Table 1) during the study period of four generations. In support of the present result the pupal period of eri silkworm was recorded as 17.70 days 18.00 days and 18.80 days during the months of September-October,

November-December and January-February, respectively [7]

3.1.4 Life cycle
The total life cycle of eri silkworm was completed in 46 -51 days (Table 1) with an average of 49 days during the study period of four generations. Documentation of results revealed that. The life cycle of eri silkworm was reported as 46.49 days when the larvae were reared on leaves of castor [8].

3.2 Mass rearing of rice moth (*C. cephalonica*)
3.2.1 Egg period
Freshly laid eggs of rice moth were glistening pearly white in colour and pear shaped Egg duration of rice moth was observed as 3-4 days (Table 2 and Fig 4) with an average of 3.5 days. Reports confirmed that the duration of egg period of rice moth egg as 4-7 days with an average of 4.66 days and the findings are in agreement with the present results [9].

3.2.2 Larval period
Larvae were observed under calibrated stereo zoom trinocular microscope to determine the larval stages. The rice moth larval development was inside the grain cluster. Tiny larva after hatching were creamy-white with a prominent pink coloured head. They move actively and feed on broken grains and then start spinning web to join grains. Fully grown larva are pale whitish in colour (Fig 2). The mean rice moth larval period was noted as 23.5 days (23 to 24 days). (Table 2 and Fig 4). Documentation of results revealed that the total rice moth larval period as 28 to 36 days with an average of 31.26 days [9].

3.2.3 Pupal period
The pupal period of rice moth was observed to be 10 days. (Table 2 and Fig 4). Pupation takes place inside opaque whitish pale yellow cocoon surrounded by webbed grains. These results can be confirmed by the findings of the researchers where they reported the duration of pupal period of rice moth as 9-16 days [9].

3.2.4 Life cycle
The total mean duration for development of *C. cephalonica* reared on maize was 36.5 days (Table 2 and Fig. 4). The present observations confirmed with the findings that the developmental period of *C. cephalonica* was shortest when reared on maize (36 days) [10]. These studies confirmed that duration of life cycle of *Corcyra cephalonica* was shorter compared to eri silkworm and it was most preferred for parasitization by *T. chilonis.* Hence basing on the above research finally it can be concluded that though the number of trichogrammatids that are emerged from a single egg of eri silkworm are higher in number compared to rice meal moth, Trichogrammatids prefer rice meal moth eggs for parasitization as they easily get attracted to the scales of *Corcyra cephalonica* and the chorion layer of rice moth egg is easily penetrable compared to the thicker chorion layer of eri silkworm egg.

Fig 1: Life cycle of *Samia cynthia ricini*

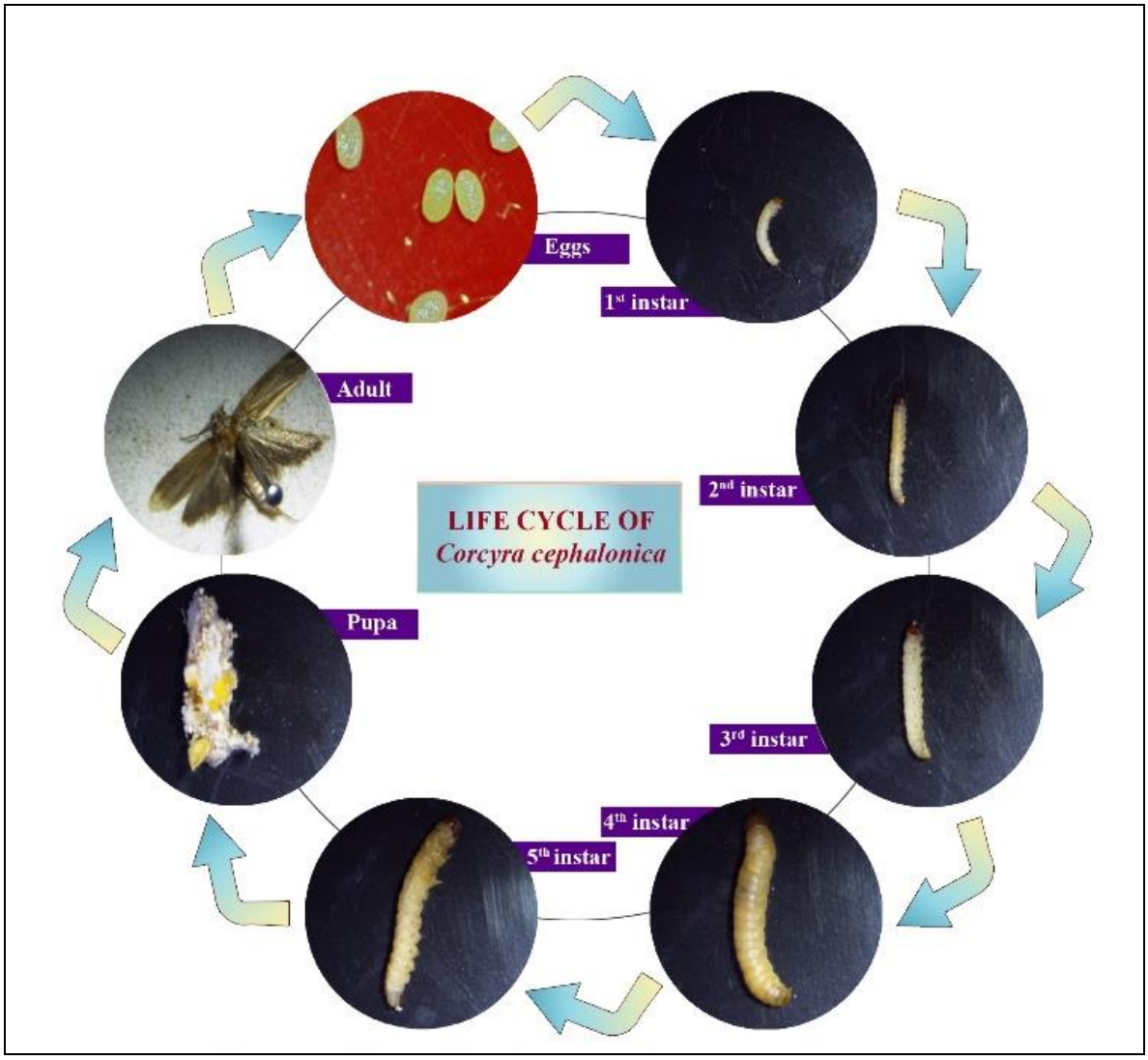

Fig 2: Life cycle of *Corcyra cephalonica*

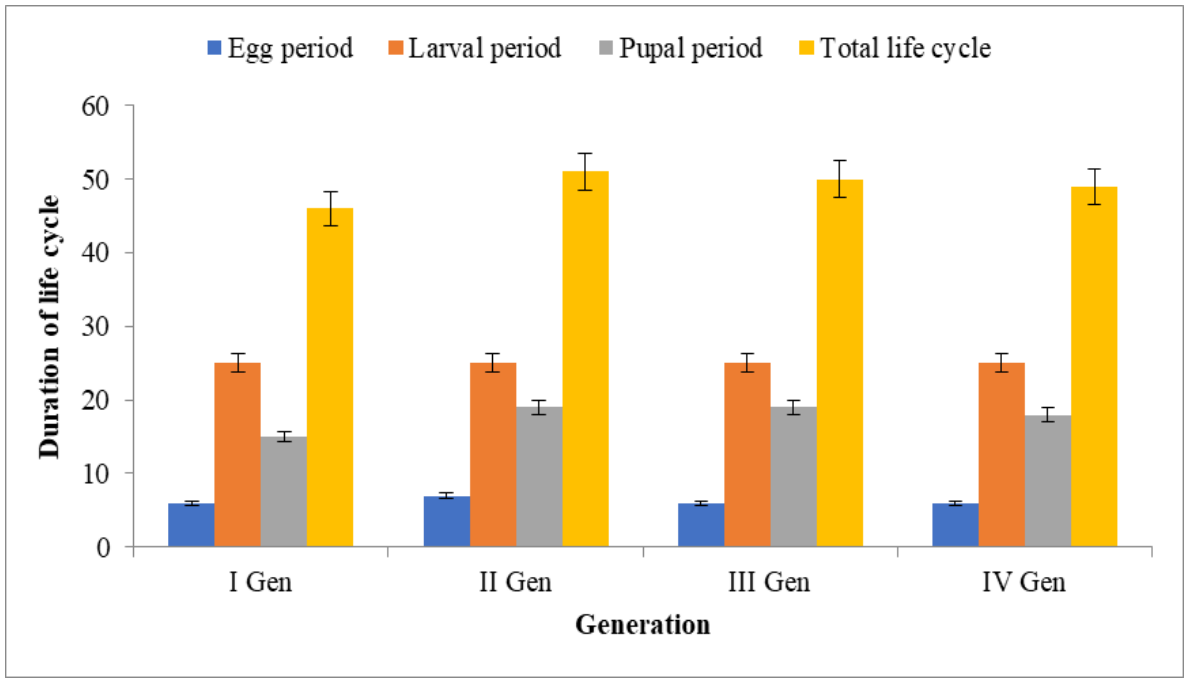

Fig 3: Duration of different stages of *Samia cynthia ricini*

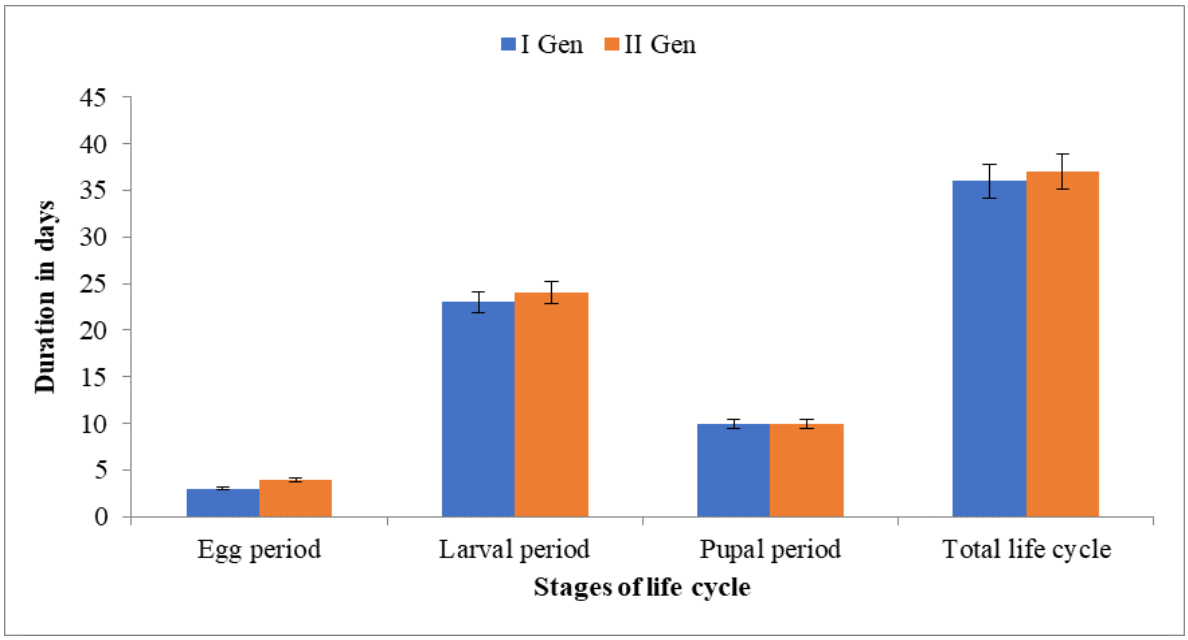

Fig 4: Duration of different stages of *Corcyra cephalonica*

Table 1: Duration of different life stages of *Samia cynthia ricini*

S. No.	Duration (days)	I Gen	II Gen	III Gen	IV Gen	Mean±S.E
1	Egg period	6	7	6	6	6.25±0.25
2	Larval period	25	25	25	25	25±0.01
3	Pupal period	15	19	19	18	17.75±0.94
4	Total life cycle	46	51	50	49	49±1.07
5	Adult longevity	4-5	4-5	4-5	4-5	4.5±0.10
6	Fecundity	300-350	300-350	300-350	300-350	325±0.12

Gen = Generation. No. of replications in each generation = 15

Table 2: Duration of different life stages of *Corcyra cephalonica*

S. No.	Duration of Stage (days)	I Gen	II Gen	Mean± S. E
1	Egg period	3	4	3.5±0.49
2	Larval period	23	24	23.5±0.49
3	Pupal period	10	10	10±0.10
4	Total life cycle	36	37	36.5±0.48
5	Adult longevity	2-4	2-4	3±0.11
6	Fecundity	150-200	150-200	175±0.15

Gen =Generation. No of replications in each generation=15

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