

Bionomics of slender burnished brass (*Thysanoplusia orichalcea* [Fabricius, 1775], Lepidoptera: Noctuidae) on potato (*Solanum tuberosum* L.) in Kashmir

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Abstract: A study on biology, morphometrics and geometrical progression of *Thysanoplusia orichalcea* was conducted on *Solanum tuberosum* under laboratory conditions. Different stages viz., egg, larva, pupa and adult of *T. orichalcea* were observed for their duration and morphometric measurements. The pest depicted five larval instars and moulted four times during the entire period. The average pre oviposition and oviposition period was observed to be 3.80 and 2.80 days respectively. Further, fecundity ranges between 381.0-400.0 with an average of 388.0 eggs. The mean incubation period was found to be 4.2 days. The average larval, pre pupal and pupal period was completed in 23.1, 1.4 and 9.5 days respectively. While mean adult longevity on *S. tuberosum* was 7.45 days. The total life cycle was completed in 41.0-51.0 days with an average of 45.65 days. Moreover, mean head capsule width of first, second, third, fourth and fifth larval instar was found to be 0.33, 0.54, 0.88, 1.46 and 2.24 mm respectively with Dyar's ratio/ growth ratio of 1.63 mm. The expected head capsule width of first, second, third, fourth and fifth larval instar was observed as 0.33, 0.53, 0.86, 1.40 and 2.28 mm respectively.

Key words: biology; Dyar's ratio; fecundity; larval instars; morphometry; *Solanum tuberosum*; *Thysanoplusia orichalcea*

Bionomija sovke *Thysanoplusia orichalcea* (Fabricius, 1775) (Lepidoptera: Noctuidae) na krompirju (*Solanum tuberosum* L.) v Kašmirju

Izveček: Raziskava biologije, morfometrije in geometrijske progresije sovke *Thysanoplusia orichalcea* (Fabricius, 1775) je bila izvedena na krompirju (*Solanum tuberosum* L.) v laboratorijskih razmerah. Opazovano je bilo trajanje raličnih razvojnih stadijev škodljivca, kot so jajčeca, gosonica, buba in odrasli osebki, na njih so bile opravljene morfometrične meritve. Škodljivec je imel pet razvojnih stopenj gosenic in se je v celotnem obdobju štirikrat levil. Poprečni obdobji pred in med odleganjem jajčec sta trajali 3,8 in 2,8 dni. Samice so v povprečju odložile med 381,0 in 400,0 jajčec, s povprečjem 388,0 jajčec. Poprečno inkubacijsko obdobje je trajalo 4,2 dni. Povprečna obdobja gosonice, obdobja pred za bubljenjem in bube so trajala 23,1, 1,4 in 9,5 dni. Povprečna življenska doba odraslih osebkov na krompirju je bila 7,45 dni. Celoten življenski krog se je zaključil v 41,0-51,0 dneh, v povprečju v 45,65 dneh. Povprečna širina glave je za prvo, drugo, tretjo, četrto in peto stopnjo gosonice znašala 0,33, 0,54, 0,88, 1,46 in 2,24 mm, s količnikom Dyarjevo razmerje/ rastno razmerje 1,63 mm. Pričakovana širina glave je bila za prvo, drugo, tretjo, četrto in peto razvojno stopnjo gosonice 0,33; 0,53; 0,86; 1,40 in 2,28 mm.

Ključne besede: bionomija; Dyarjevo razmerje; plodnost; larvalne stopnje; morfometrija; *Solanum tuberosum*; *Thysanoplusia orichalcea*

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1 INTRODUCTION

Vegetables are indispensable as they make up a major part of the human diet in many parts of the world. Vegetables play an imperative role in human nourishment since they supply chief phytonutrients like vitamins, minerals, dietary fiber and phytochemicals (Craig and Beck, 1999; Dias and Ryder, 2011). Amongst various vegetables, Potato (*Solanum tuberosum* L.) lines as the third vital food crop after wheat and rice. In terms of production, it is leading tuber crop all over the globe (Anonymous, 2011a). India generates about 42.34 million tons of potato from 1.86 million hectares of land, thus positions fourth in terms of area and third in terms of potato production in the entire world (Anonymous, 2011a). Around 34,000 t of potatoes are harvested in Kashmir valley from an area of about 1.7 thousand hectares (Anonymous, 2011b). Potato is professed not only as a source of carbohydrates, but also an exceptional basis of essential amino acids. The starch present in the potato augments satiety, enhances glucose tolerance & insulin sensitivity and diminishes plasma cholesterol & triglyceride concentrations (Raben et al., 1994; Cummings, 1996). Despite of the numerous health benefits of potato, its production is still less because of the massive crop damage due to amplified pest menace. Insects also act as vectors for viral diseases, thus further increases the yield losses (Shivalingswami et al., 2002). Due to the lack of resistant characters because of rigorous hybrid cultivation, vegetables are more prone to insect pests and diseases (Dhandapani et al., 2003).

Among various insect pests, *Thysanoplusia orichalcea* (Fab.) commonly called as green semilooper, slender burnished moth and golden wing moth is one of the serious polyphagous pest infesting potato in Kashmir (Bhagat, 2018). The larval stages of *T. orichalcea* are serious defoliators feeding on potato leaves from vegetative to maturity stages. The young larvae puncture holes widely into the lamina of leaves and later instars feed voraciously leaving only the main veins thus plummeting photosynthetic competence. This pest was also found feeding on other crops belonging to families Compositae, Cruciferae, Leguminosae, Linaceae, Cucurbitaceae and Chenopodiaceae (Laute et al., 2015). A little has been done on the biology of *T. orichalcea* on potato in Kashmir though its biology has been worked out on soybean (*Glycine max* (L.) Merr.) and common bean (*Phaseolus vulgaris* L.) in Akola, Maharashtra and Kishtwar, J&K respectively (Laute et al., 2015 and Kotwal & Bhatia, 2016). Therefore, the objective of the current investigation was to study the life cycle of *T. orichalcea* on potato in the laboratory.

2 MATERIAL AND METHODS

2.1 COLLECTION AND REARING OF *T. orichalcea*

For studying the life cycle and morphometrics of *T. orichalcea* on potato (*S. tuberosum* L.) variety Kufri Jyoti ??, preliminary culture of different larval instars were gathered from potato fields of Kashmir valley during the year 2018. Each larval instars collected was transferred to separate rearing boxes made of glass at the temperature of 25 °C and 65 % RH in the Entomology Research Laboratory of the Department of Zoology, University of Kashmir. Fresh potato leaves were provided as food for the larval instars on daily basis till the larvae entered into last stage and the excreta was removed regularly. The rearing boxes were monitored regularly for the exuvia. The number and duration of each larval instar was recorded. The last larval instars of *T. orichalcea* were collected from rearing boxes and transferred to pupation chambers having one-third part of it filled with soil, which provides favourable conditions for pupation. The pupae were monitored regularly until adult eclosion. In order to determine the duration of adult moths, freshly eclosed adults were individually placed in rearing boxes lined with filter paper and were provided with 10 % honey solution as food. Ten adults were used for this experiment and the duration of each adult was monitored and documented. To determine the fecundity, 10 individual pair of adult moths were placed in oviposition chambers immediately after eclosion lined with fresh potato leaves for egg laying and containing cotton swabs soaked in 10 % honey solution as food for adults at the temperature of 25 °C and 65 % RH. Each day the number of eggs produced by these moths was monitored. Further, the data on pre oviposition period, oviposition period and incubation period was also recorded. Moreover, the rearing, pupation and oviposition chambers were covered with muslin cloth fastened with rubber bands.

2.2 MORPHOMETRIC AND GROWTH STUDIES

Ten individuals of each developmental stage viz., eggs, larval instars, pupae and adults were observed under stereozoom binocular microscope and the morphometric measurements were documented with the help of vernier calliper as well as simple scale. For determining the duration of different larval instars, the individual larvae were observed regularly for exuvia and head capsule. The presence of casted head capsule corroborated the moulting. The numbers of larval instars of *T. orichalcea* were determined using Dyar's law (1890). The growth ratio (Dyar's ratio) was obtained by the following formula:

$$\text{Growth Ratio} = \frac{\text{Head capsule width of 2nd larvae}}{\text{Head capsule width of 1st larvae}}$$

2.3 STATISTICAL ANALYSIS

The data associated with different stages of insect viz., egg, larva, pupa and adult were examined for calculating mean and standard deviation using SPSS 16.0.

3 RESULTS

3.1 FECUNDITY

In the laboratory conditions, average fecundity was observed to be 388.0 (\pm 8.58) eggs with a range of 381.0 to 400.0 eggs (Table 1). The mean preoviposition period was found to be 3.80 (\pm 0.83) days with a range of 3.0 to 5.0 days. Moreover, the oviposition period lasted between 2.0 to 4.0 days with an average of 2.8 (\pm 0.83) days (Table 1).

3.2 EGGS

In the laboratory conditions, oviposition occurred during night time at 25 °C and 65 % RH and the eggs were laid on lower surface of the leaves of potato. The freshly laid eggs of *T. orichalcea* were green, spherical and shiny. Prior to hatching, egg colour changed to dark brown. The average incubation period of eggs was observed to be 4.2 (\pm 0.83) days with a range of 3.0-5.0 days (Table 7). The length of the egg varied between 0.67 mm to 0.72 mm with an average of 0.70 (\pm 0.01) mm and width ranges between 0.59 mm to 0.66 mm with an average of 0.63 (\pm 0.02) mm (Table 2).

3.3 LARVAE

The current investigation depicted five larval instars in the life cycle of *T. orichalcea*. The larvae shed its exuviae four times during the entire period. The caterpillars flaunted a typical half loop movement and thus attaining a common name as semilooper to its recognition. The neonate larvae emerging from the eggs were creamy white in colour with dark black head, which later on changes to green. The first larval period ranged for about 2.0-3.0 days with a mean duration of 2.4 (\pm 0.51) days (Table 7). The length and breadth of first larval instar ranged between 2.00-3.00 mm and 0.40-0.50 mm with a mean of 2.50 (\pm 0.52) and 0.44 (\pm 0.05) respectively (Table 3). Further, the mean width of head capsule was observed to be 0.33 (\pm 0.02) with a range of 0.29-0.37 mm before moulting (Table 3). The second larval instars were green in colour and their duration lasted for 3.0-4.0 days with an average of 3.40 (\pm 0.51) days (Table 7). The length and breadth of 2nd larval instar varied from 8.50-10.50 mm and 1.00-1.40 mm with a mean of 9.50 (\pm 0.88) and 1.27 (\pm 0.15) respectively (Table 3). Moreover, the width of head capsule ranged between 0.51-0.59 mm with a mean of 0.54 (\pm 0.03) (Table 3). The first and second larval instars were found scraping the epidermis of leaf thereby, causing their skeletonization.

The third instar larva displayed two lateral lines running along the plural region. The fourth and fifth larval instars flaunted extra blackish mid dorsal line (Fig 2). From third instar onwards, larvae starts feeding voraciously engulfing the entire leaf including mid rib and vein. The third, fourth and fifth larval period ranges between 4.0-5.0, 5.0-6.0 and 7.0-8.0 days with an average of 4.3 (\pm 0.48), 5.6 (\pm 0.51) and 7.4 (\pm 0.51) days respectively (Table 7). The mean length and breadth of third larval instar was 17.35 (\pm 1.08) and 2.40 (\pm 0.51) mm with a range of 16.00-18.50 mm and 2.00-3.00 mm respectively (Table 3). In case of fourth larval instar, the average length and

Table 1: Duration of pre oviposition period, oviposition period (days) and fecundity of *T. orichalcea*

S. No.	Stage	Minimum (days)	Maximum (days)	Mean \pm S. D.
1.	Pre oviposition period	3.00	5.00	3.80 \pm 0.83
2.	Oviposition period	2.00	4.00	2.80 \pm 0.83
3.	Fecundity	381.00	400.00	388.0 \pm 8.58

Table 2: Measurements of eggs of *T. orichalcea*

S. No.	Variable	N	Minimum (mm)	Maximum (mm)	Mean \pm S. D.
1.	Egg length	10	0.67	0.72	0.70 \pm 0.01
2.	Egg width	10	0.59	0.66	0.63 \pm 0.02

N = Number of observations; SD: Standard deviation

breadth was obtained as 24.75 (± 0.67) mm and 3.95 (± 0.43) mm with a range of 24.0-25.50 mm and 3.50-4.50 mm respectively (Table 3). The length and breadth of fifth larval instar ranged between 32.00-35.00 mm and 4.50-5.50 mm with a mean of 33.30 (± 1.15) and 4.95 (± 0.43) respectively (Table 3). The width of head capsule for third, fourth and fifth larval instar ranged between 0.85-0.90 mm, 1.39-1.50 mm and 2.19-2.28 mm with a mean of 0.88 (± 0.01) mm, 1.46 (± 0.03) mm and 2.24 (± 0.03) mm respectively (Table 3). Further, the total larval period ranged between 21.00 to 26.00 days with an average of 23.10 (± 2.52) days (Table 7).

Growth ratio (Dyar's ratio) for *Thysanoplusia orichalcea* was calculated and the expected widths of head capsule of first, second, third, fourth and fifth larval instar were 0.33, 0.53, 0.86, 1.40 and 2.28 mm respective-

ly (Table 4). The Dyar's ratio was computed as 1.63 mm (Table 4) and authenticated that successive larval instars followed a regular geometrical development (Fig 1).

$$\text{Growth Ratio} = \frac{\text{Head capsule width of 2nd larvae}}{\text{Head capsule width of 1st larvae}} = \frac{0.54}{0.33} = 1.63 \text{ mm}$$

Mean observed head capsule width of first larval instar (N =10) = 0.33 mm

Mean observed head capsule width of second larval instar (N =10) = 0.54 mm

3.4 PRE PUPA

In this stage, the mature 5th larval instar stops feed

Table 3: Morphometric measurements of larval instars of *T. orichalcea*

S. No.	Developmental stage		Minimum (mm)	Maximum (mm)	Mean \pm S. D.
1.	First larval instar	Length	2.00	3.00	2.50 \pm 0.52
		Breadth	0.40	0.50	0.44 \pm 0.05
		Width of head capsule	0.29	0.37	0.33 \pm 0.02
2.	Second larval instar	Length	8.50	10.50	9.50 \pm 0.88
		Breadth	1.00	1.40	1.27 \pm 0.15
		Width of head capsule	0.51	0.59	0.54 \pm 0.03
3.	Third larval instar	Length	16.00	18.50	17.35 \pm 1.08
		Breadth	2.00	3.00	2.40 \pm 0.51
		Width of head capsule	0.85	0.90	0.88 \pm 0.01
4.	Fourth larval instar	Length	24.00	25.50	24.75 \pm 0.67
		Breadth	3.50	4.50	3.95 \pm 0.43
		Width of head capsule	1.39	1.50	1.46 \pm 0.03
5.	Fifth larval instar	Length	32.00	35.00	33.30 \pm 1.15
		Breadth	4.50	5.50	4.95 \pm 0.43
		Width of head capsule	2.19	2.28	\pm 0.03

*Mean of 10 individuals; SD: Standard deviation

Table 4: Comparison of observed mean and expected values of head capsule widths (mm) of the larvae of *T. orichalcea*

S. No.	Larval instars	Head capsule width (mm)			Difference (mm)
		Observed (Mean \pm S. D.)	Range	Expected ^a	
1.	First larval instar	0.33 \pm 0.02	0.29-0.37	0.33	0.00
2.	Second larval instar	0.54 \pm 0.03	0.51-0.59	0.53	0.01
3.	Third larval instar	0.88 \pm 0.01	0.85-0.90	0.86	0.02
4.	Fourth larval instar	1.46 \pm 0.03	1.39-1.50	1.40	0.06
5.	Fifth larval instar	2.24 \pm 0.03	2.19-2.28	2.28	- 0.04

^a Expected width of head capsule determined by Dyar's ratio. Multiplying Dyar's ratio (1.63) with the observed width of head capsule of first larval instar provides the expected width of head capsule of second instar larva which when multiplied again with Dyar's ratio gives expected width of head capsule of third larval instar and so on.

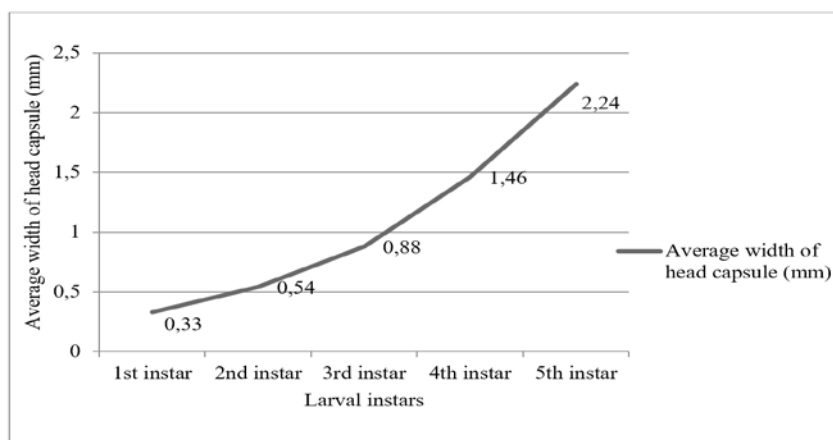


Figure 1: Relation between larval growth and head width of *T. orichalcea*

Table 5: Morphometric measurements of male and female pupae of *T. orichalcea*

S. No.	Variable	N	Minimum (mm)	Maximum (mm)	Mean \pm S. D.
1.	Pupal length (Male)	10	17.50	19.00	18.25 \pm 0.63
2.	Pupal width (Male)	10	4.50	5.50	5.05 \pm 0.43
3.	Pupal length (Female)	10	19.00	24.00	21.70 \pm 1.76
4.	Pupal width (Female)	10	5.00	6.00	5.50 \pm 0.52

N = Number of observations; SD: Standard deviation

ing and becomes sluggish by contracting its body and appendages (Fig 2). This phase lasted for 1.0-2.0 days with an average of 1.4 (\pm 0.51) days (Table 7).

3.5 PUPA

The colour of pupa appeared creamish initially which turns into deep brown towards maturity. The pupa is obtect type. Prior to pupation, a mature full grown larva starts to spin white silken cocoon around the body and protects it externally by leaf fold (Fig 2). The male pupa was found slightly smaller than female pupa. The length and breadth of male pupa varies between 17.50-19.00 mm and 4.50-5.50 mm with an average of 18.25 (\pm 0.63) mm and 5.05 (\pm 0.43) mm respectively (Table 5). Further, the length and breadth of female pupa varies

between 19.00-24.00 mm and 5.00-6.00 mm with a mean of 21.70 (\pm 1.76) mm and 5.50 (\pm 0.52) mm respectively (Table 5). The pupal period ranged between 9.0 to 10.0 days with a mean of 9.5 (\pm 0.52) days at 25 °C and 65 % RH (Table 7).

3.6 ADULT

The adult moth comes out of puparium by puncturing an escape hole with the aid of some secretions. The forewing of adult moth is olive brown in colour with large conspicuous L shaped metallic golden patch (Fig 2). The male and female moths' possess pectinate and filliform type of antennae respectively. The average male longevity was found to be 8.4 (\pm 0.51) days with a range of 8.0-9.0 days (Table 7). The female longevity lasted be

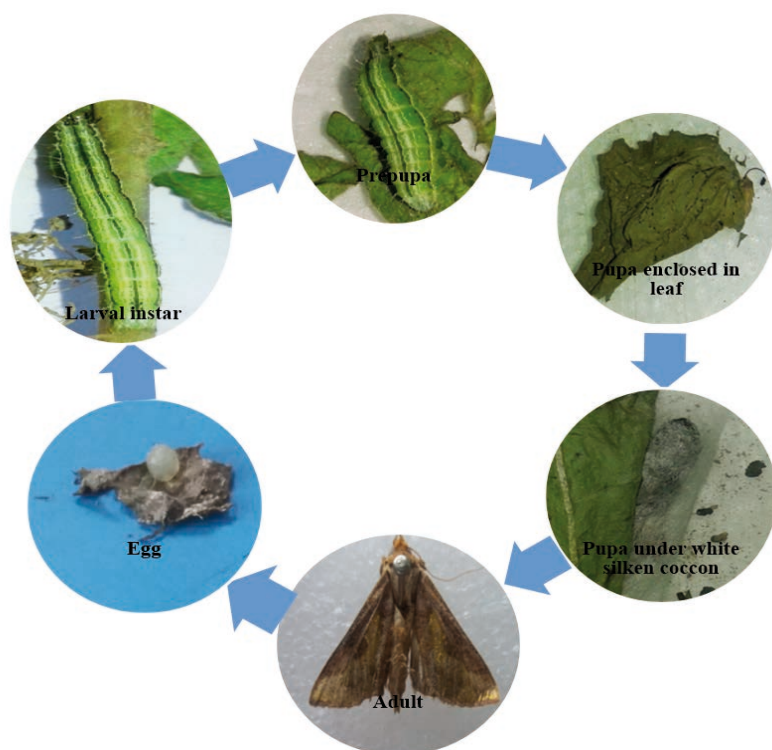
Table 6: Morphometric measurements of adult male and female of *T. orichalcea*

S. No.	Variable	N	Minimum (mm)	Maximum (mm)	Mean \pm S. D.
1.	Adult length (Male)	10	16.50	19.00	17.65 \pm 1.08
2.	Adult width (Male)	10	28.00	31.00	29.70 \pm 1.33
3.	Adult length (Female)	10	19.50	22.00	20.60 \pm 1.04
4.	Adult width (Female)	10	35.00	40.00	38.00 \pm 2.00

Table 7: Developmental period of various life stages of *T. orichalcea*

S. No.	Developmental stage	Minimum* (Days)	Maximum* (Days)	Mean \pm S.D.
1.	Incubation period	3.00	5.00	4.20 \pm 0.83
2.	First larval instar	2.00	3.00	2.40 \pm 0.51
3.	Second larval instar	3.00	4.00	3.40 \pm 0.51
4.	Third larval instar	4.00	5.00	4.30 \pm 0.48
5.	Fourth larval instar	5.00	6.00	5.60 \pm 0.51
6.	Fifth larval instar	7.00	8.00	7.40 \pm 0.51
7.	Total larval period	21.00	26.00	23.10 \pm 2.52
8.	Pre pupal period	1.00	2.00	1.40 \pm 0.51
9.	Pupal period	9.00	10.00	9.50 \pm 0.52
10.	Male longevity	8.00	9.00	8.40 \pm 0.51
11.	Female longevity	6.00	7.00	6.50 \pm 0.52
12.	Average longevity	7.00	8.00	7.45 \pm 0.51
13.	Total life cycle	41.00	51.00	45.65 \pm 4.88

*Mean of 10 individuals; SD: Standard deviation

**Figure 2:** Life Cycle of *Thysanoplusia orichalcea*

tween 6.0-7.0 days with a mean of 6.5 (\pm 0.52) days (Table 7). The average adult (male and female) longevity was found to be 7.45 (\pm 0.51) days with a range of 7.0-8.0 days (Table 7). Adults are medium in size with male moths slightly smaller than females. The length of adult male moth varies between 16.50-19.00 mm with

an average of 17.65 (\pm 1.08) mm (Table 6). The length of female moth ranges between 19.50-22.0 mm with a mean of 20.60 (\pm 1.04) mm (Table 6). Further, the width of male and female moth varies between 28.00-31.0 mm and 35.00-40.00 mm with a mean of 29.70 (\pm 1.33) mm and 38.00 (\pm 2.00) respectively (Table 6). The average life

cycle ranges between 41.0-51.0 days with an average of 45.6 (\pm 4.88) days (Table 7).

4 DISCUSSION

Thysanoplusia orichalcea (Lepidoptera: Noctuidae) is one of the serious defoliator feeding on various vegetable crops. In light of the damage caused by *T. orichalcea*, the evaluation of its bionomics could be advantageous for the better management of this obnoxious pest. The present results revealed that the total life cycle lasted from 41.0-51.0 days with an average of 45.6 days under temperate conditions of Kashmir valley. On the contrary, the total life cycle of *T. orichalcea* on *Phaseolus vulgaris* was completed in 34.5-43.7 days under semi-temperate conditions of Kishtwar (Kotwal and Bhatia, 2016). Similarly, Laute et al. (2015) found that the total life cycle on soybean was completed in 34.3 days under tropical conditions in Maharashtra. The variation in the total life cycle of *T. orichalcea* may be attributed to different climatic conditions and assessment of life cycle on different host crops. These observations revealed that the longevity in the life cycle of green semilooper declines due to higher temperature at warmer regions compared to temperate climatic conditions of Kashmir.

The current study depicted that the incubation period of *T. orichalcea* on potato lasted for 3.0-5.0 days with an average of 4.2 days. However, Laute et al. (2015) reported the average incubation period of 2.8 days on soybean. The discrepancy observed between the current and previous studies might be due to difference in host plant species and varieties. Since there was no disparity in the number of larval instars and the morphometric measurements between the host plants, this specifies that host plant does not affect these parameters. Laute et al. (2015) and Kotwal & Bhatia (2016) also found the similar results. In the present study, it was found that larval development of *T. orichalcea* on potato was completed in 21.0-26.0 days with an average of 23.1 days. Conversely, Laute et al. (2015) and Kotwal & Bhatia (2016) revealed total larval period of 16.0-23.0 and 15.0-20.0 days on soybean and common bean respectively. These differences might be due to either the variability or diminution of nutritional quality of the host plant species or ecological distinction with respect to geographical location and time of studies. Perchance of the most realistic implication of the current study is the fact that *T. orichalcea* larval development time differs considerably depending on host plants. Furthermore, the average head capsule width of first, second, third, fourth and fifth larval instar of *T. orichalcea* in the present finding was viewed as 0.33, 0.54, 0.88, 1.46 and 2.24 mm respectively which coincides with

the results of Begum, 1999. Thus it was concluded that the average head capsule widths of each larval instar did not intersect and can be employed as precise indication of each larval instar.

Laute et al. (2015) and Kotwal and Bhatia (2016) reported pupal period of 6.0-7.0 and 14.0-15.5 days on soybean and common bean respectively. However, the present investigation showed pre pupal and pupal period ranging between 1.0-2.0 and 9.0-10.0 days with a mean of 1.4 and 9.5 days respectively on potato. The discrepancy monitored between the current and earlier results might be due to the fact that life history parameters are vastly affected by host plant species and test varieties.

Generally, the present study revealed that the longevity of adult male and female moth ranged between 8.0-9.0 and 6.0-7.0 days with an average of 8.4 and 6.5 days respectively on potato. The average longevity of adults (males and females) in the present finding was observed to be 7.45 days with a range of 7.00-8.00 days. Plausibly, the male lived longer than the female. Likewise, other studies also divulged the same results (Goel and Kumar, 1987; Laute et al., 2015 and Kotwal and Bhatia, 2016).

5 CONCLUSIONS

The current investigation on biological description of *Thysanoplusia orichalcea* offers comprehensive information on fecundity, growth and survival, which provides a baseline data for any management practice. Results from these studies can remark the venerable stages of *T. orichalcea* and also may provide information important for predicting the field population phenology. *T. orichalcea* commonly called as semilooper is a polyphagous pest found feeding on many vegetables including potato. The larval instar of this pest represents the main damaging stage. The larva targets the epidermis of leaves thus causing serious defoliation. This influences the growth of plant and in turn affects the production and yield. The annotations on morphometrics and life cycle parameters will turn out to be advantageous in the identification of pest. By this approach, we can observe different stages of *T. orichalcea* and develop integrated management tactics on potato.

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