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Comparative biology of *Maruca vitrata* (Geyer) on greengram and pigeonpea

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Abstract
A comparative biology of *Maruca vitrata* was carried out on greengram and pigeonpea under laboratory conditions with room temperature ranging from 26 to 27 ºC at Department of Entomology, UAS, Dharwad, Karnataka. The *M. vitrata* culture was maintained on greengram and pigeonpea under laboratory conditions and recorded stage-wise comparison of developmental stages and biometrics on both the hosts. Total larval period ranged 15 to 17 days on greengram with an average of15.97 ± 1.407 days and that of on pigeonpea was 15 to 19 days with an average of 17.63 ± 1.17 days. The pupation took place in the webs of greengram and pigeonpea leaves within silken cocoon. The recorded pupal duration in greengram and pigeonpea was respectively 7.78 ± 0.46 and 8.49 ± 0.584 days. The longevity of male moth ranged from 4-6 days on both hosts with an average of 5.29 ± 0.33 and 5.19 ± 0.85 on greengram and pigeonpea, respectively. Whereas the female adult average longevity was 7.30 ± 0.330 and 7.04 ± 0.69 days, respectively on greengram (range = 6-8days) and pigeonpea (5-8days). The duration of total developmental period of *M. vitrata* reared on greengram (34.00 ± 1.221) and pigeonpea (36.27 ± 1.728).

Keywords: Biology, greengram, pigeonpea, *Maruca vitrata*

Introduction
Maruca vitrata is one among more than 300 insect and mite pests recorded on different pulse crops and now considered as a serious pest of grain legumes in the tropics and subtropics, due to extensive host range, destructiveness and distribution. The pest is reported to feed on 39 host plants including wild hosts and a serious pest on cowpea, pigeonpea, blackgram, greengram, beans and soyabean in Asia and Africa. The insect pest becoming serious on hosts like groundnut at Dharwad, since 2011 (Annon.2015) [1]. In pulses the larvae feed on flowerbud, flowers and pods by webbing them this typical feeding habit protects the larvae from the from the natural enemies and application of insecticides. In major pulse crops like cowpea and pigeonpea, the damage by *M. vitrata* ranges from 25 to 40 per cent, respectively across the globe (Ganapathy, 2010) [2]. There is a greater need to better understand the bio-ecology of *M. vitrata* on pulse crops such as pigeonpea and greengram. Hence the present study is envisaged to know the comparative biology of *Maruca vitrata* on greengram and pigeonpea under laboratory conditions.

Material and methods
The experiment to know the comparative biology of *Maruca vitrata* on on greengram and pigeonpea was conducted in Department of Agricultural Entomology, College of Agriculture, Dharwad under laboratory condition during the respective seasons. The initial culture of *M. vitrata* was developed by collecting larvae from unsprayed greengram and pigeonpea fields and reared in laboratory by providing fresh leaves, flowers and pods of the respective crop plant. Once after adult emergence, ten pairs of freshly emerged female and male moths were confined to big glass jar containing tender shoots, flowers and pods of respective crop plants for oviposition. A cotton swab soaked in five per cent sucrose solution was provided as their food. Number of eggs laid were counted using magnifying glass daily till the death of adult moth. Twenty freshly laid eggs were kept in the petridish separately on parts of respective crop plants and observed for hatching. All necessary biological parameters were recorded *viz.* duration of incubation period, duration of different larval instars, pupal period and adult period and number of eggs laid by female moths The freshly hatched larvae were taken individually in plastic specimen tubes and fresh food from respective host plant given.

The biological parameters recorded were expressed in terms of range, mean along with standard deviation. Further, biological parameters of maruca recorded on greengram and pigeonpea were compared by following student "t" test.

Results

Freshly laid eggs were light yellow, translucent, dorsoventrally flattened in shape firmly glued to the surface and the chorion was with a sculpturing pattern. Eggs were laid singly or in overlapping groups of 2-10. Eggs were laid on the flower buds and flower surface or on the outer surface of the young pods. Each egg measured about 0.61 ± 0.057 in length and 0.35 ± 0.075 in width. Freshly laid eggs were light yellow in colour turns to dark brown colour before hatching (Table 2). Incubation period in greengram ranged from 2 – 3 days with an average of 2.35 ± 0.232 days and that of pigeonpea was 2-4 days with a mean of 3.08 ± 0.658 days (Table 1). The pest moulted four times and included five instars during its entire life cycle. The characteristics of each larva and the period occupied by each instar under laboratory condition at room temperature were recorded. The length and width of body and head capsule of larvae at each instar were measured and average values were given in the later part of information of experimental results.

The newly hatched larva appeared greenish white with a brown head and short hairs on black warts all over the body. There were two light brown spots running on dorsoventral side and one light brown spot at the lateral side of each abdominal segment on the body. The larva moves fast immediately in search of food. It consisted a pair of true legs on each prothoracic segments, a pair of prolegs on third to sixth abdominal segments and a pair of anal prolegs visible on tenth abdominal segments. Whole body was covered by hairs. Duration of first larval instar recorded during the study on greengram and pigeonpea was respectively 2.44 ± 0.327 and 2.36 ± 0.327 mm with a range of 2-3 days on greengram and pigeonpea (Table1). The average length of the larvae were 1.90 ± 0.50mm in greengram and 2.08 ± 0.45 mm in pigeonpea. The average width of larvae in greengram was 0.68 ± 0.10mm and that of pigeonpea 0.61 ± 0.15 mm. The average length of head capsule on greengram and pigeonpea were 0.36 ± 0.05 and 0.31 ± 0.03mm respectively. Whereas the average width of head capsules were 0.16 ± 0.04 and 0.20 ± 0.06mm on greengram and pigeonpea, respectively. There was marginal difference in the measurements recorded from larvae reared on greengram and pigeonpea without any statistical significance (Table 2 and 3).

The second instar larva was creamy white in colour similar to first instar larvae but with greater size and slightly red coloured head capsule. After 3 to 4 hours of moult, colour of head and prothoracic shield turned to black and body became dirty white colour with spots on it. Head and body of freshly moulted larva was creamy white in colour excluding eye spots which were dark brown to black in colour. Duration of second larval instar recorded during the study on greengram and pigeonpea was respectively 3.27 ± 0.623 and 3.79 ± 0.615 mm with a range of 3-4days and 3-5 respectively, on greengram and pigeonpea (Table 1). The average larval body on greengram was measured as 4.08 ± 0.47 mm in length and 0.85 ± 0.12 mm in width. Whereas in pigeonpea it was 3.69 ± 0.55 mm in length and 0.85 ± 0.12 mm in width. Head capsule measured about 0.34 ± 0.06mm in length and 0.40 ± 0.06mm in width on greengram. Larvae fed on pigeonpea recorded to be 0.41 ± 0.05 mm length and 0.34 ± 0.04mm in width. There was marginal difference in the measurements recorded from larvae reared on greengram and pigeonpea without any statistical significance (Table 2 and 3).

Larva with more prominent dark coloured spots on its body with black coloured head capsule later head capsule was turned to dark brown colour. The duration of greengram fed larvae were ranged from 2-4 days with an average of 3.16 ± 0.131days and that of pigeonpea were 3-4 days with an average of 3.39 ± 0.161 (Table 1). Head capsule was measured about 0.47 ± 0.05mm (length) and 0.51 ± 0.07mm (width) in greengram and it was 0.52 ± 0.06 mm in length and 0.59 ± 0.06mm in width on pigeonpea. Larval body length and width in greengram was 7.08 ± 0.72mm and 1.75 ± 0.22mm width, respectively and the same was in pigeonpea was 6.49 ± 0.82 mm and 1.50 ± 0.24mm, respectively. There was marginal difference in the measurements recorded from larvae reared on greengram and pigeonpea without any statistical significance (Table 2 and 3).

Freshly moulted larva was cream coloured without eye spots on it and which differed from third instar by having more distinct dark black coloured spots on its body with black coloured head caspule. There is no visible difference in the colour of the larvae fed on greengram and pigeonpea hosts. Duration of larvae were ranged from 2-4 days with an average of 3.39 ± 0.662(days) in greengram and that of pigeonpea was 2-5 days with an average of 3.51 ± 0.359 (days) in pigeonpea (Table 1). The average larval length and width on greengram and pigeonpea were respectively 10.04 ± 0.49 mm and 2.61 ± 0.43mm and 9.82 ± 0.24 mm and 2.51 ± 0.41mm.The average length of head capsule on greengram and pigeonpea were 0.63 ± 0.08mm and 0.74 ± 0.06mm respectively, breadth measured about 0.74 ± 0.06mm and 0.89 ± 0.10 mm on respective hosts. There was significant difference in the head capsule length and width in this instar reared on greengram and pegionpea. However, the length and breadth of the larvae was insignificant (Table 2 and 3).

Fully grown fifth instar larvae were creamish green in colour with slightly dull brown spots all over the body along with light brown coloured head capsule and prothoracic shield. The brown spots running all body were bigger in size than fourth instar. Maximum growth of larvae were observed during fifth instar and the body was tapered at both the ends with maximum girth was observed in the middle. This instar larva had longest duration and the larvae fed on greengram and pigeonpea, respectively recorded to be 3.71 ± 0.365 and 4.19 ± 0.437 days with a range of 3-5 days on both the hosts (Table1). Larval body length and width in greengram was 14.41 ± 0.70 mm and 3.29 ± 0.39 mm width, respectively and the same was in pigeonpea was 13.81 ± 0.86 mm and 2.34 ± 0.39 mm, respectively. Head capsule in greengram measured about 1.15 ± 0.05mm length and 0.98 ± 0.27 mm width and that of on pigeonpea was 1.14 ± 0.03 mm and 0.82 ± 0.06 mm. There was marginal difference in the measurements recorded from larvae reared on greengram and pigeonpea without any statistical significance (Table 2 and 3).

Total larval period ranged 15 to 17 days on greengram with an average of 15.97 ± 1.407 days and that of on pigeonpea ranged 15 to 19 days with an average of 17.63 ± 1.174 days (Table 1). Before attaining pupa fifth instar larvae were stopped feeding and started spinning a loose silken webs and inside that it constructed a oval shaped regular arrangement of silken threads around the body. In this stage body was shrinked in length and breadthwise, legs were stretched ahead. Black spots on the body were vanished larva became light

green in colour later on colour of pre-pupa turned to brown colour. Duration of pre-pupae ranged from 1 to 3 days on both the hosts. Larvae took an average of 1.68 ± 0.356 days and 1.52 ± 0.445 days to complete its pre-pupal period, respectively on greengram and pigeonpea. The pupa took place on the silken webbings formed on the sides of the rearing boxes or in the leaf and flower debris or on the pods of greengram and pigenopea under laboratory condition. (Table1).

The pupation took place in the webs of greengram and pigeonpea leaves within silken cocoon. Freshly formed pupae were greenish later turned pale yellow to gray coloured. Before emergence the color of the pupa turned dark brown and duration of pupa measured 7.78 ± 0.462 in greengram and 8.49 ± 0.584 in pigeonpea (Table 1). Length and width of pupa was 11.96 ± 0.56 mm × 2.33 ± 0.24 mm in greengram and 11.86 ± 0.58 mm × 2.33 ± 0.23 mm in pigeonpea (Table 2 and 3).

Adults of both male and female had light brown coloured forewings and yellow to brown body with long legs. Forewings with small semi-transparent band reaching horizontally from the coastal or central margin ended towards the anal margin. The margin of the each semitransparent bands was dark brown in colour. The forewings also possessed two small irregular semi-transparent bands above the dark band near the wing base. Hind wings are silvery white with patchy brown band on the apical margin of the wing. In male abdomen was narrowed towards the posterior end and having black colour at its tip. Incase of female, abdomen was long and slightly swollen and hairy at the tip. Head was smaller than thorax and the compound eyes are larger in size. The longevity of male moth ranged from 4-6 days on both hosts with an average of 5.29 ± 0.325 and 5.19 ± 0.851 on greengram and pigeonpea, respectively. Whereas the female adult average longevity was 7.30 ± 0.330 and 7.04 ± 0.69 days, respectively on greengram (range = 6-8days) and pigeonpea (5-8days) (Table 1).

One day old age moths were kept in the same cage for mating. Mating took place during night within two days after adult emergence, mostly at night hours. Both male and female actively move towards the wall of cage mated in end to end position. Observations on adult mating showed that some males mated more than once but females mated only once. Mating with equal sex ratio (10 pairs per cage) gave highest egg count. After mating eggs were laid on flower buds, or under surface of the leaves. egg laying started on the same or second night after mating. Fecundity per female ranged from 80 to 134 eggs in greengram and 80 to 103 eggs when reared on pigeonpea. Female laid egg either individually or in a group of 2- 4 eggs on flower buds, flowers, tender pods or on the lower surface of the leaves with an average number of 95.60 ± 16.324and 88.90 ± 10.969 eggs per female on greengram and pigeonpea, respectively. The *M. vitrata* took 34.00 ± 1.221(range = 31-34) and 36.27 ± 1.728(range = 36-40) days to complete its generation on greengram and pigeonpea hosts, respectively. Duration of life cycle of pest on greengram was shorter than pigeonpea (Table 1).

There was significant statistical difference in the incubation, pupal and total developmental duration of *Maruca vitrata* reared on greengram and pigeonpea. Further, none of the morphometry differed statistically significant. However there was significant difference in the head capsule with and length of larvae reared on greengram and pigeonpea.

Table 1: Biology of *Maruca vitrata* on greengram and pigeonpea under laboratory condition

Biological events	Life stage duration (days)				t_{cal}	t_{tab}	Statistical Significance
	Greengram		Pigeonpea				
	Range	Mean duration	Range	Mean duration			
Incubation period	2- 3	2.35 ± 0.232	2-4	3.08 ± 0.658	3.32	2.87	S
1 instar	2-3	2.44 ± 0.327	2-3	2.36 ± 0.327	-1.86	2.87	NS
2 instar	3-4	3.27 ± 0.623	3-5	3.79 ± 0.615	-1.86	2.87	NS
3 instar	2-4	3.16 ± 0.131	3-4	3.39 ± 0.161	2.38	2.87	NS
4 instar	2-5	3.39 ± 0.662	2-4	3.51 ± 0.359	-2.45	2.87	NS
5 instar	3-5	3.71 ± 0.365	3-5	4.19 ± 0.437	-1.37	2.87	NS
Total larval period	15-17	15.97 ± 1.407	15- 19	17.63 ± 1.174	-2.15	2.87	NS
Pre-pupa	1-3	1.68 ± 0.356	1-3	1.52 ± 0.445	0.89	2.87	NS
Pupa	6-8	7.78 ± 0.462	7-10	8.49 ± 0.584	6.29	2.87	S
Longevity of adult	5-7	6.20 ± 0.162	5-7	5.96 ± 0.484	1.50	2.87	NS
Male	4-6	5.29 ± 0.325	4-6	5.19 ± 0.851	0.34	2.87	NS
Female	6-8	7.30 ± 0.330	5-8	7.04 ± 0.69	2.62	2.87	NS
Total developmental period	31 - 36	34.00 ± 1.221	34-40	36.27 ± 1.728	-3.45	2.87	S
Fecundity per female	80 – 134	95.60 ± 16.324	80- 103	88.90 ± 10.969	1.07	2.87	NS

NS = Non significant, S = Significant

t_{cal}: "t calculated value" (p= 0.01), t_{tab}: "t table value (p = 0.01)

Table 2: Morphometrics of *Maruca vitrata* larvae on greengram and pigeonpea

Life stages	Greengram	Pigeonpea	Length		Statistical Significance	Greengram	Pigeonpea	Width		Statistical Significance
	Length (mm)	Length (mm)	t_{cal}	t_{tab}		Width (mm)	Width (mm)	t_{cal}	t_{tab}	
Egg	0.61 ± 0.05	0.66 ± 0.05	0.57	2.87	NS	0.35 ± 0.07	0.38 ± 0.07	0.26	2.87	NS
1st instar	1.90 ± 0.50	2.08 ± 0.45	0.87	2.87	NS	0.68 ± 0.10	0.61 ± 0.15	0.29	2.87	NS
2nd instar	4.08 ± 0.47	3.69 ± 0.55	1.78	2.87	NS	0.85 ± 0.12	0.85 ± 0.12	-0.09	2.87	NS
3rd instar	7.08 ± 0.72	6.49 ± 0.82	1.70	2.87	NS	1.75 ± 0.22	1.50 ± 0.24	-2.47	2.87	NS
4th instar	10.04 ± 0.49	9.82 ± 0.24	1.01	2.87	NS	2.61 ± 0.43	2.51 ± 0.41	-0.50	2.87	NS
5th instar	14.41 ± 0.70	13.81 ± 0.86	1.73	2.87	NS	3.29 ± 0.39	3.24 ± 0.39	2.55	2.87	NS
Pupa	11.96 ± 0.56	11.86 ± 0.58	1.78	2.87	NS	2.33 ± 0.24	2.33 ± 0.23	0.16	2.87	NS

NS = Non significant, S = Significant

t_{cal}: "t calculated value" (p= 0.01), t_{tab}: "t table value (p = 0.01)

Table 3: Head capsule measurements of *Maruca vitrata* larvae on greengram and pigeonpea

Instar	Greengram	Pigeonpea	Length		*Statistical*	Greengram	Pigeonpea	Width		*Statistical*
	Length (mm)	Length (mm)	t_{cal}	t_{tab}	*significance*	Width(mm)	Width(mm)	t_{cal}	t_{tab}	*significance*
I	0.36 ± 0.05	0.31 ± 0.03	2.40	2.87	NS	0.16 ± 0.04	0.20 ± 0.06	-1.60	2.87	NS
II	0.34 ± 0.06	0.41 ± 0.05	-2.06	2.87	NS	0.40 ± 0.06	0.34 ± 0.04	2.76	2.87	NS
III	0.47 ± 0.05	0.52 ± 0.06	-2.17	2.87	NS	0.51 ± 0.07	0.59 ± 0.06	-2.71	2.87	NS
IV	0.63 ± 0.08	0.74 ± 0.06	-3.40	2.87	S	0.74 ± 0.06	0.89 ± 0.10	-4.10	2.87	**S**
V	1.15 ± 0.05	1.14 ± 0.03	0.59	2.87	NS	0.98 ± 0.27	0.82 ± 0.06	1.62	2.87	NS

NS = Non significant, S = Significant

t_{cal}: "t calculated value" (p= 0.01), t_{tab}: "t table value (p=0.01)

Discussion

The *M. vitrata* larvae were reared on greengram and pigeonpea under laboratory conditions and recorded stage-wise comparison from the viewpoint of growth & development and morphometrics on both the hosts. Freshly laid eggs were light yellow, translucent, dorsoventrally flattened in shape firmly glued to the surface and the chorion was with a sculpturing pattern. Eggs were laid singly or in overlapping groups of 2-10. Taylor (1967) [3] described the *M. vitrata* eggs as round to slightly elongated, oval, light yellow, translucent and feature faint reticulate sculptures on the thin and delicate chorion. Incubation period in greengram ranged from 2 – 3 days with an average of 2.35 ± 0.232 days and that of pigeonpea was 2-4 days with an average of 3.08 ± 0.658 days with a difference of 0.7 days. There existed a significant difference when compared by "t" test between the incubation period of eggs laid by adults whose larvae were reared on greengram and pigeonpea. The findings of Panickar (2004) [4] that incubation period of *M. vitrata* differed significantly on greengram and pigeonpeais similar to present findings.

The pest moulted four times and included five instars during its entire life cycle. The *M. vitrata* took 34.00 ± 1.221 (range = 31-34) and 36.27 ± 1.728 (range = 36-40) days to complete its generation on greengram and pigeon pea hosts, respectively. There was 2.27 days difference in total developmental period on two different host and it was longer on pigeonpea than on greengram. The difference was compared statistically and found significant. The difference may be due to effect of host as well as prevailed weather, especially lower average temperature coincided with pod formation to maturity stage in pigeonpea. A slight difference in the findings of Rachappa *et al.* (2015) [5] that life span of male was 36.21 (days) and that of female was 37.87 (days) in pigeonpea. This may be due to change in prevailed weather during the study period.

The larvae passed through five instars in 15.97 ± 1.40 days on greengram and 17.63 ± 1.174 days on pigeonpea with four moults. These findings nearer to reports of Panickar (2004) who revealed that *M. vitrata* reared on greengram (14.95) took lower number of days than pigeonpea (16.00). He further opined that difference may be due to change of host and weather related parameter.

There was marginal difference of 1.66 days in total larval duration when reared on greengram (15.97 ± 1.407) and pigeonpea (17.63 ± 1.174) without any statistical significance. There was marginal variation in total larval period with minor contribution from each instar. This may be due to change of host and also prevailing weather during the study. Further the difference in total larval duration was not amounting enough to be significant when compared statistically. Panickar (2004) reported that mean duration of first, second, third, fourth and fifth instar larvae were significantly different when reared on greengram and pigeonpea. A slight difference may be due to difference in the prevailed weather conditions.

There was no significant difference when body length and width of the larvae reared on greengram and pigeonpea was compared by "t" statistics. However there existed numerical difference between the larvae reared on above mention hosts. This difference might be due to the inborn nutritional difference of two hosts which ultimately influenced the larvae fed on them. However, Panickar (2004) reported a significant difference in the length and width of the larvae reared on greengram and pigeonpea. This difference may be due to the variety of the said host plants and to prevailed weather during rearing period.

The head capsule parameters were differed significantly only in fourth instar of the insect reared on greengram and pigeonpea. There was numerical difference in head capsule parameters of I, II, III and V instars of the pest reared on those two hosts. Panickar (2004) also reported the significant difference in the headcaspule size of larvae reared on greengram and pigeonpea. There was minor difference in the pre pupal period (in days) on greengram and pigeonpea Similar observations were also recorded by Chinnabbai *et al*. (2002) [6] on greengram and blackgram.

Before attaining a pre-pupal stage, the fifth instar larva stopped feeding and spun a transparent silken webbing around the body. In pre-pupal stage the body contracted length and breadth-wise, lost the spots on body and became light green in colour. These observations also tally similar to that of Veeranna *et al*. (1999) [7].

There was significant difference in the pupal duration on greengram (1.68 ± 0.356 days) and pigeonpea (1.52 ± 0.44 days) in the present investigation. The reported significant difference in pupal duration by Panickar (2004) on greengram (2.28 days) and pigeonpea (2.72 days) from Gujrat is in line with present findings. This difference may be due to change in host as well as prevailed weather during the pupal period on both hosts.

Adults of both male and female had light brown coloured forewings and yellow to brown body with long legs. Forewings with small semi-transparent band reaching horizontally from the coastal or central margin ended towards the anal margin. The margin of the each semitransparent bands was dark brown in colour. The forewings also possessed two small irregular semi-transparent bands above the dark band near the wing base. Hindwings are silvery white with patchy brown band on the apical margin of the wing. In male abdomen was narrowed towards the posterior end and having black colour at its tip. Incase of female, abdomen was long and slightly swollen and hairy at the tip. Head was smaller than thorax and the compound eyes are larger in size. There was difference in the duration of male (5.29 ± 0.325 & 7.30 ± 0.330) and female (5.19 ± 0.85 & 7.04 ± 0.69) in greengram and pigeonpea, but was not statistically significant. However, Panickar (2004) revealed the significant difference

in the duration of male and female adults of *M. vitrata* reared on greengram and pigeonpea. Further and he opined this might be due to change in host and weather related factors might have caused the difference.

Duration of total developmental period of *M. vitrata* reared on greengram was 34.00 ± 1.221 days and that on pigeonpea was 36.27 ± 1.728 days. There was 2.27 days difference between the hosts and it was statistically significant. Panickar (2004) reported the significant difference in the total developmental period of the pest reared on greengram (30.38 days) and pigeonpea (31.08 days). This difference may be due to prevailed weather factors and also change in hosts during rearing period.

There existed a difference in fecundity of 6.7 eggs per female between greengram (95.60 ± 16.324) and pigeonpea (88.90 ± 10.969). However it was not statistically significant. The similar study of comparative biology conducted by Panickar (2004) at Gujarat reported the difference of 12.7 eggs per female when reared on greengram (37.90 eggs/female) and pigeonpea (25.20 eggs /female)

The biological parameters of *M. vitrata* reared on greengram in the present study was similar to studies conducted by Sravani and Mahalaksmi (2015) [8] who studied the biology of spotted bollworm on green gram at Guntur, Andhra Pradesh and the recoded parameters are almost similar to the present study. Similarly biological parameters of the pest reared on pigeonpea by Chaitanya *et al.* (2012) [9] is inline with the observations made during present study.

Conclusion

The most of biological parameters of *Maruca vitrata* were similar when reared on greengram and pigeonpea. The variation in one or two parameter may be due to weather effect. Based on the present study, it was concluded that the Maruca vitrata causing damage to greengram and pigeonpea are one and the same.

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