

Bionomics and Chemical Control
of
Tur Pod Bug, Clavigralla Gibbosa Spinola
(Hemiptera : Coreidae)

THESIS

SUBMITTED TO THE
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF
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BY

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CERTIFICATE - 1

This is to certify that the thesis entitled "Bionomics and Chemical Control of Tur Pod Bug, Cladogobius gibbosus (Spinola) (Hemiptera : Coreoidea)" submitted in partial fulfilment of the requirements for the degree of "MASTER OF SCIENCE IN AGRICULTURE" of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by Shri Kamal Kishor Jain under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by him.


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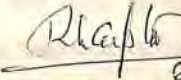



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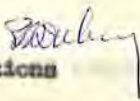
This is to certify that the thesis entitled
"ECONOMICS AND CHEMICAL CONTROL OF THE POT BUG, CLAVIDELLA
GIBBOSA (SPINOLA) (HEMIPTERA : COREIDAE)" submitted by
Shri Kamal Kishor Jain to the J.N. Krishi Vishwa Vidyalaya,
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Degree of B.Sc.(Ag.), in the Department of ENTOMOLOGY has
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Place : Sehora

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Date :

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INTRODUCTION

Pulses play an important role in human nutrition in India as majority of the people depend on vegetable proteins, the bulk of which comes from pulses especially pigeonpea (tur). According to Dr. Akroyd, three OZ of pulses/day in human diet are necessary to supply the essential proteins and other minerals. Apart from its importance in diet, the pulses increase the fertility of the soil by fixing the atmospheric nitrogen with the help of bacteria present in their root nodules.

Amongst the various pulses, Arhar or tur or pigeonpea or redgram (Cajanus cajan (L) Millsp.) is an important pulse crop, which furnishes indispensable part of daily needs of proteins. The green seeds of the Arhar are also used as vegetable, while the other plant parts make a valuable fodder for cattle. Dry stalks obtained after threshing are used for basket making or as fuel or thatching materials.

Having a wide adaptability to soil and climate, it is cultivated all over the country with the exceptions of the areas which are either excessively wet or experience severe frost. The deep root system of Arhar gives it good resistance to drought. It is widely cultivated under

semiarid conditions of central and peninsular India and the north Indian plains, Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Andhra Pradesh and Gujrat.

Table 1: Area and production of arhar (Year 1984-85)

Place	Area (Thousand hectares)	Production (Thousand tonnes)	Average yield kg/ha
India	3,213.0	3,666.0	829.75
M.P.	504.4	407.6	808.08

*Source- Ministry of Agriculture and Rural Development, Government of India.

Madhya Pradesh contributes 15.69 per cent in area and 15.28 per cent production of the crop in India with average productivity of 808.08 kg grain/ha.

In spite of large hectareage and heavy efforts being done by the government extension agencies to increase the per hectare production, the yields are quite low i.e. 808.08 kg/ha in Madhya Pradesh. These low yields may be attributed to the damage caused by number of insect pests attacking this crop at varying growth stages. The following are the important insect pests of pigeonpea at reproductive and fruiting phase which directly affect the yield in Madhya Pradesh (Bindra and Jekhuola, 1976).

Table 2: Major insect pests of Arhar in Madhya Pradesh

Common name	Entomology name	Plant part damaged
Pod borer	<u>Heliethis armigera</u> Hub.	Flower & pod
Pod fly	<u>Melanocrotona obtusa</u> Wall.	Pod
Pod bug	<u>Clavigrella gibbosa</u> Spinale	Leaves, flowers and pod
Flume moth	<u>Eucelastis atomosa</u> Wlsm.	Flowers & pod
Leaf roller	<u>Eucasma critica</u> N.	Leaves
Flea beetle	<u>Medurasia obscurella</u> J.	Leaves

Among the pod infesting insect pests, pod borer, pod fly and pod bug, are the most important pests causing heavy losses to arhar crop in Madhya Pradesh. (Oduk et al., 1976). Of these, the tur pod bug, Clavigrella gibbosa (Spin.) has assumed a status of potential pest in the state.

Mishra (1979) reported that with addition of every one nymph per plant, there was 1.65 and 2.79 per cent increase in bud and pod shedding respectively, while there was reduction in number and weight of pods and grains by 1.12, 0.5765 g; 4.73 and 0.4725 g, respectively. He also reported the economic threshold and economic injury level of C. gibbosa as 2 and 4 nymphs per plant respectively, and suggested that this pest should be

given equal priority as being given to pod borer and podfly. Its systematic position is as under :

Class	: Insecta
Order	: Hemiptera
Sub order	: Heteroptera
Family	: Coreidae
Sub family	: Pseudophloeinae
Genus	: <u>Claviralla</u>
Species	: <u>Gibbosa</u>

So far, only nine species of Claviralla are known to world of which only three species, viz. C. gibbosa Spin., C. horrens Dohrn., C. guttularia West. are found in India (Fletcher, 1914; Watson, 1921 and Bindra, 1963).

Claviralla gibbosa Spinola has a gibbous (unequally convex) abdomen without strong spines on each segment and can thus be distinguished from its close relative Claviralla horrens Dohrn. which is characterised by a nongibbous abdomen (equally convex) with its posterolateral angles produced into strong spines (Kavedia, 1962).

Keeping in view the importance and status of the pest, following studies were undertaken on this pest.

- (A) Bionomics of C. gibbosa including food preference, and
- (B) Chemical control

Findings on these, aspects form the subject matter of this thesis.

REVIEW OF LITERATURE

The tur pod bug, Clavigralla gibbosa Spinola is an important and potent pest of pigeonpea. The investigation on the major aspects of the pest is being reviewed as under:

(A) Bionomics of Clavigralla gibbosa Spin.

Gangrade (1961) studied the biology and bionomics of tur pod bug at Jabalpur. He reported that the eggs are laid in clusters of 3 to 14 eggs. The incubation and nymphal period ranged from 8 to 15 and 15 to 23 days, respectively. The complete life cycle took 39 to 56 days. The longevity of the adult was 6 to 7 days, whereas the fecundity was 140 eggs.

Kadam and Shelgaonkar (1964) studied the bionomics of tur pod bug at Nagpur. He reported that the eggs are laid in cluster of 2 to 14 eggs. The incubation and nymphal period ranged from 5 to 20 and 14 to 61 days, respectively. The life cycle was completed in 19 to 51 days. The longevity of the adult was 3 to 12 days during October to November and was 40 to 50 days in December, whereas its fecundity was 60 eggs.

Bindra (1965) studied the biology and bionomics of tur pod bug at Jabalpur. He reported incubation period

7.69 days, nymphal period 16.9 days, oviposition period 100 to 151 days, adult longevity 155 days and fecundity was 437 eggs.

Nam Singh (1965) studied the life cycle of this insect under control and uncontrolled conditions at Anand (Gujrate State). He reported that the eggs are laid in cluster of 2 to 14 eggs. The incubation period ranged 5 to 8 days under varying laboratory temperature i.e. 30° to 28°C and 4 to 14 days under controlled temperature of 34 ± 1°, 27 ± 1° and 24 ± 1°C. The oviposition period was 2 to 23 days. The life cycle was completed in 25 to 45 days. The longevity of the adult with food varied from 12 to 85 days with an average of 38.5 days, whereas the fecundity was 15 to 306 eggs with an average of 180.2 eggs.

Bindra and Vaishampayan (1965) studied the embryonic and post embryonic development of C. gibbosa at different constant temperature and reported that the effective range of temperature for the development lied between 25 to 35°C.

Kapoor (1966) studied the embryonic and post embryonic development of C. gibbosa at Sehore. He reported that the eggs are laid in cluster of 5 to 13 eggs. The incubation period and nymphal period ranged from 3 to 12 and 11 to 24 days, respectively. The life cycle was completed in 17 to 36 days, whereas the fecundity was 650 eggs with in average of 267.4 eggs. The longevity of adult with and without food varied from 13 to 92 days and 3 to 7 days, respectively.

Choudhary (1969) studied the bionomics of Clavigrella gibbosa on pigeonpea in the laboratory in Maharashtra at 80-90°F and reported incubation period 7-9 days, nymphal period 23.7 days. The adult male and female lived for 25.1 and 31.9 days, respectively. In the field he found eggs on the crop from October to harvesting of the crop and it was most active in December and January.

Saxena (1961) described the distribution, nature of damage, biology and control measures of C. gibbosa. He observed that the adult was quite active and brown in colour. The female laid shining eggs on pods in cluster. The nymphal period ranged 7 to 25 days depending upon the prevailing temperature.

Population dynamics:

A very little published work on the population dynamics of Clavigrella gibbosa is available. Hence the work available on its active period is reviewed here.

Fletcher (1917) reported this insect as a serious pest of redgram around Poona and as a minor pest of pulses in Burma.

Gangrade (1961) observed its activity from the pod formation stage till harvest at Jabalpur, i.e. upto February to March.

Bindra (1965) reported its activity from middle of October to end of May on many leguminous plants.

Kapoor (1966) reported its activity from last week of November to May at Sehore in Madhya Pradesh.

Choudhary (1967) reported pest activity from the 3rd week of November upto 25th May at Sehore in Madhya Pradesh.

Singh and Patel (1968) reported its appearance from the time of pod formation till the harvest of the crop.

Bindra and Harcharan Singh (1971) found two species of pod bug, viz. C. gibbosa Spinola, and C. horvathi Dohrn. on the crop. C. gibbosa was commonly present and was of economic importance. The pest remain active from middle of October to beginning of June with overlapping generations.

Choudhary (1973) reported that pest was active from October and disappeared shortly before harvest.

Ghosh (1982) reported first appearance of C. gibbosa in early October and peak population of pest between November and January.

Host preferences:

Ichangwan (1983) studied the effect of three food plants in laboratory in Nigeria at 25°C on the life and population parameters and found that population declined by 50% in 13 weeks on pigeonpea and 11 weeks on cowpea and bean. The maximum fecundity rate was reached much

earlier in adult life when the cocoid fed on pigeonpea or cowpea than on beans.

Rawat et al. (1985) reported that the pods of pigeonpea in the middle stages of development were most preferred; the duration of development was also shortest and adult life span greatest on these pods.

Natural enemies:

Lefroy (1909) reported some chalcids parasitising eggs of Clavigralla in the field.

Mishra (1924) while describing the mode of emergence of the parasites from the parasitised eggs stated that heavy parasitisation is caused during April and May by chalcid parasite.

Usman and Puttraudish (1954) reported Hadronotus fuviventris Crawford (Scilicidae; Hymenoptera) parasitising the eggs of C. gibbosa at Bangalore.

Bindra (1965) found a minute parasite, Hadronotus antestiae Dodd. from the eggs of C. gibbosa at Jabalpur.

(E) Chemical Control of C. gibbosa Spin.

Fletcher (1917) recommended collection and destruction of the nymphs and adults by shaking the pods in a tray containing kerosinised water.

Kašam et al. (1956) found that dusting with 5% BHC at the rate of 15 lbs per acre gave good result in controlling the pest.

Thakur et al. (1980) reported effectiveness of several insecticides against the pest in field at Jabalpur and found that 5% EHC + 10% DDT (1:1) dusts and quinalphos and dimethoate as sprays were highly effective after 3 days of application. Quinalphos was the most effective even after 15 days of treatment, followed by EHC + DDT and monocrotophos.

Rawat et al. (1981) evaluated ovicidal action of 17 insecticides against eggs of the pest and found that endosulfan (thiodan) at 0.07% and methamidophos at 0.04% were most effective which gave 76.66% egg mortality.

Singh et al. (1983) found two formulations of carbaryl (wettable and suspension) at 0.1% most effective, causing 92 and 96% egg mortality, respectively.

Singh et al. (1985) reported that the carbaryl U.C. 51762 (thiodicarb), MIPC (Isoprocarb), EPAC (fenbucarb) and sevinal (carbaryl with molasses) were highly effective against the eggs of Claviralla gibbosa.

MATERIAL AND METHODS(A) Bionomics of *Clavigralia gibbosa* Spin.:

A regular search to find out the appearance of the pest in the field was made from September, 1965. The adults were collected from the farm of R.A.K. College of Agriculture, Sehore and from the farmer's fields and brought to the laboratory and fed on developing pods of pigeonpea.

Rearing in the laboratory was started in the first week of October, 1965. The bionomic studies were conducted from second week of October, 1965 and continued till last week of January, 1966. For the rearing of different stages of bugs petridishes of different diameters, i.e. 7.5 cm, 10 cm and 15 cm were used (Photograph 1). The bugs were fed on tender pods provided daily in the morning. In order to get the adults in ample numbers mass rearing was done in glass chimneys (Photograph 2) of size 22.5 cm height. The mouth of the chimney was covered by muslin cloth tied with the rubber band. The petridishes and glass chimneys were cleaned daily with water and washing powder. Freshly emerged male and female adults were taken from the mass culture and released in petridishes of 10 cm diameter. At the bottom

of each petridishes, a circular blotting paper was provided to absorb liquid excreta secreted by the adults. The adults were provided tender pods to feed and to lay eggs upon. The eggs laid by female on the pods in the petridishes were removed daily and kept in another petridishes for further studies. The pre-oviposition, oviposition and post oviposition periods were also recorded. Just after the hatching of the nymphs, each nymph was kept in a separate petridish to record its growth, and developmental observations and measurements of each instar were also recorded.

The growth index and developmental index were worked out on the basis of the data recorded for biometric studies. The growth index was calculated by dividing the per cent adults formed with the total nymphal period whereas the developmental index was calculated by using the formula i.e. $\frac{100}{\text{period}}$

Population Dynamics:

The number of eggs, nymphs and adults per plant were recorded at weekly interval on randomly selected ten plants of tur from second October, 1985 to January, 1986.

Number of eggs and bugs i.e. nymphs and adults were calculated as weekly population. The week numbers from 1st October to last week of January were represented as standard weeks.

Host preferences:

The different stages of C. gibbosa have been reported to feed on different host plants. In order to workout the preference of this insect for different host plants, a series of experiments were planned where pods of different host plants were arranged in a circle having diameter of 43 cm in a rectangular box framed with glass on the top (Photograph 3). The measurement of box was 60 x 50 x 5 cm. Eighty adults of the same age were released in the centre of the circle. Numbers of adults found on different hosts were counted after 1, 2, 3, 4, 6 and 24 hours.

Natural enemies:

Regular weekly collection of eggs of the pest was made from cultivator's fields and reared at room temperature in the laboratory to study the parasites and extent of parasitization.

(B) Chemical control:

Comparative toxicity of some of the modern insecticides was tested in field cum laboratory trial against the adults of C. gibbosa. The different insecticides and their source of supply are given in Table 3.

Table 3: Details of different insecticides used

Common name	Trade name	Population used	Concentration used (a.i.,%)	Source of supply
Fenvalerate	Fenval	20 a.c.	0.01%	Searle (India) Ltd., 21, Damodar Das Sakhadvala Marg, Bombay, 400001
Decamethrin	Decis	2.8 a.c.	0.01%	Hoechst pharmaceuticals Ltd., Hoechst house Nariman point Bombay 400021
Fenmethrin	Parmasect	25 a.c.	0.005%	Bharat pulverising mills, Pvt Ltd., Heumar house Bombay
Flucythrinate	Pay-off	10 a.c.	0.003%	Cyanamid India Ltd., Bombay
Monocrotophos	Duvascon	36 a.c.	0.036%	Ciba Geigy of India Ltd., 14, J. hotel road, Bombay 400020
Quinalphos	Skalux	45 a.c.	0.045%	Sandoz house (India) Ltd., Bombay
Carbosulfen	Norshal	25 a.c.	0.01%	Ballis India Ltd., 21, Damodar Das Sakhadvala Marg, Bombay 400001
Cypermethrin	Cypermill	25 a.c.	0.005%	Bharat pulverising mills Pvt Ltd., Bombay
Fluvalinate	Navrak	25 a.c.	0.005%	Sandoz House Ltd (India) Bombay
A 6341 E	Polytrin (ready mix)	N 427 a.c.	1.17 ml in 1 l water	Hindustan Ciba Geigy Ltd., Bombay
-	P.F.302	5 a.c.	0.002%	Indian explosives Ltd., Agro-chemic. screening station Bangalore 560068

The required concentration of spray material of each insecticides was prepared by calculating the quantities of the particular insecticidal formulation used for the required volume of spray, as given in Table 3. The quantity of each formulation was calculated by using the following formula.

$$C \times V = C_1 \times V_1$$

where, C = given concentration of formulation

V = volume of the formulation required to be used

C_1 = required concentration of spray material

V_1 = the volume of spray liquid

The required quantities of the formulations were measured by a micropipette and mixed with required quantity of water to make 1000 ml of spray liquid. The trial consisted of 12 treatments including control and was replicated thrice. For each replication 10 adults bugs were taken for the treatment.

Technique adopted in the experiment:

Spraying was done with hand compression sprayer. For each treatment 10 meter row length was marked and the spraying of each insecticide was done @ 1 litre/10 meter row length at the podding stage of the crop. After one hour of spraying 10 pods/ replication were plucked and kept in the petridishes of 15 cm diameter. In the laboratory 10 adult bugs / replication were released and allowed to feed on the treated pods for the evaluation of mortality.

EXPERIMENTAL FINDINGS(A) Bionomics of Clavivalla gibbosa Spinola:

The life history of the pest was studied from October 1965 to January 1966 at room temperature at Baher in Madhya Pradesh. The temperature and relative humidity(%) during these months are given in Table 4.

Table 4: Average temperature ($^{\circ}\text{C}$) and relative humidity (%) during different months of study

Month	In laboratory			In field		
	Temperature		R.H. (%)	Temperature		R.H. (%)
Max.	Min.			Max.	Min.	
Oct., 65	27.23	26.48	46.93	29.45	17.12	77.1
Nov., 65	26.31	24.41	34.10	29.80	10.65	63.8
Dec., 65	23.60	21.53	38.36	28.34	11.64	71.74
Jan., 66	22.38	20.43	39.51	26.93	8.88	71.56

The eggs

The freshly laid eggs are dirty white which gradually changed to dark brown before hatching and are firmly glued on the surface of pods or leaves by a sticky secretion. The eggs are laid in clusters of 1 to 39 on pods and leaves. They are minute oval shaped, and had 5 or 6 pin head shaped raised structures on the anterior end. Each egg is 1.05 ± 0.039 mm in length and 0.8 ± 0.052 mm in breadth.

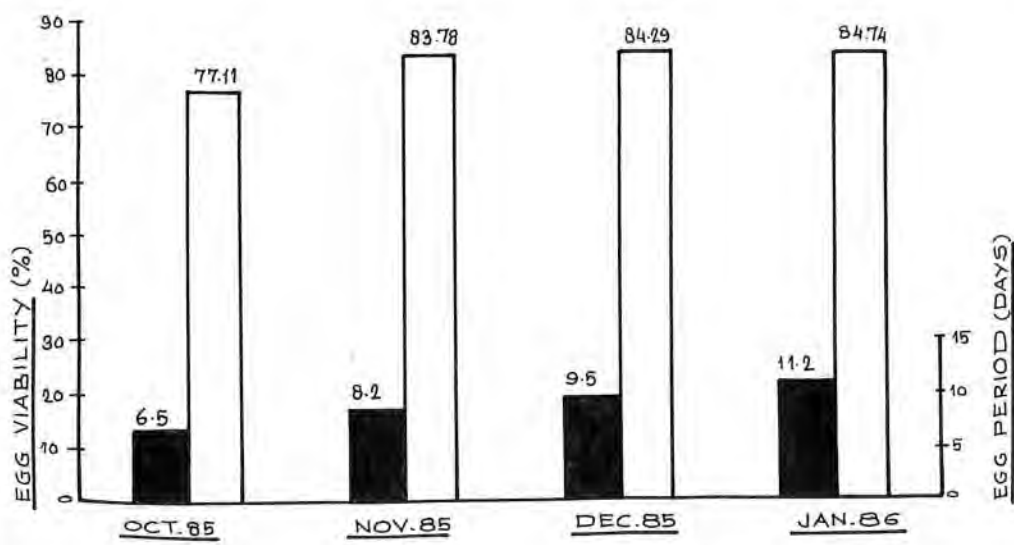
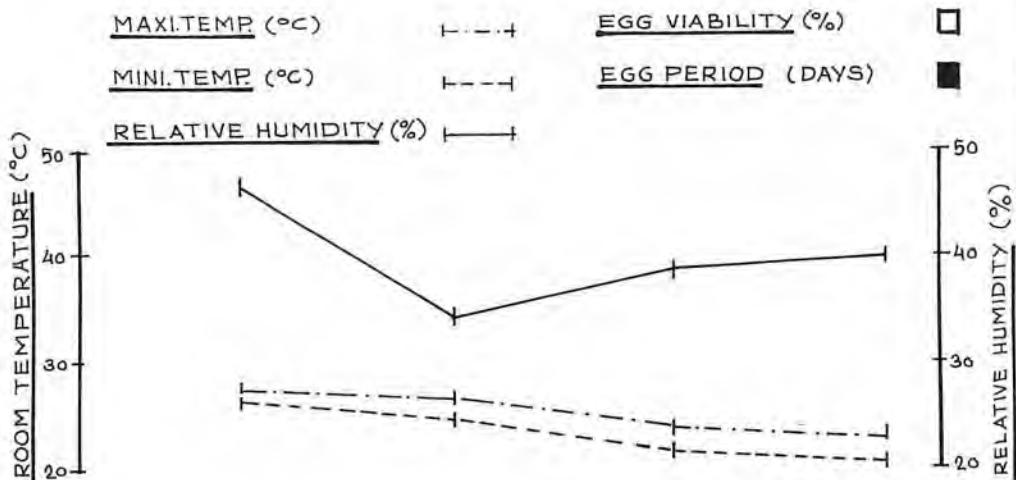


FIG.1: EGG PERIOD, PERCENT EGG VIABILITY FROM OCTOBER 1985 TO JANUARY 1986.

Incubation period:

The time that elapsed between actual egg laying and hatching was found to vary and are given in Table 5.

Table 5: Egg period, percent viability and development index at room temperature

Month	No. of eggs observed	No. of eggs hatches	Egg period(days)		% viability of eggs	Development index
			Range	Mean		
Oct., 65	923	710	4 to 8	6.5±0.87	77.11±27.22	16.6
Nov., 65	164	135	6 to 10	8.2±1.87	83.78±20.40	12.5
Dec., 65	48	40	9 to 10	9.5±0.66	84.29±12.06	11.1
Jan., 66	31	26	10 to 12	11.2±0.84	84.74± 7.93	9.09

The incubation period ranged from 4 to 8 days, 6 to 10 days, 9 to 10 days and 10 to 12 days during October, November, December, 1965 and January, 1966 respectively. The viability of the eggs was 77.11% in October, 83.78% in November, 84.29% in December and 84.74 % in January.

Mode of hatching:

Before hatching a minute circular line was observed along the raised dorsal round circle. First nymph pushes its head from inside the egg raising a lid like part comparable to a car bonnet. It forced the lid of the egg in such a way that half of the body could be seen; first its head and fore legs came out followed by antennae, mid and hind pairs of legs. Slowly and slowly the legs moved

side ways and the whole insect moveout of the egg shell. The hatching of an egg took 9 to 15 minutes.

The nymph and nymphal period.

The nymphs passed through the five moults to reach the adult stage. Each instar was distinguished by the gradual developments of the various parts of the body, wings, markings and colouration etc. The feeding started generally after the first moulting. During moulting the thorax was first found to be free from the exuviae. Just after moulting the nymph remained motionless and body colour was light yellowish to dirty red. Later on they become dull or dark brown in colour. During moulting insect bends its thorax many times and tries to free the legs and head. The legs also help in pushing out the skin from the antennae and abdomen. (Photograph 4)

First instar.

The newly hatched nymph is light yellow in colour but after 1 to 2 hours it becomes dark brown in colour.

The head is dark brown with two black dots on the fronto-clypeal region, and of episthognathus type. The bulging compound eyes are dark brown. Antennae are four segmented. Thorax is dark brown. From each side of the prothorax two spines are projected laterally. Femur is dark brown with pale ring in the centre. The tibia and tarsi are dirty yellow. The abdomen is dirty yellow in colour. There are eight dark brown spines projecting

dorsolaterally, four from each side of the abdomen. The duration of the first instar is given in Table 6 and measurement in Table 7.

Second instar.

The freshly moulted nymph is orange yellow but later on changes to dark brown in colour.

The head is orange yellow with some black setae. The eyes are reddish brown; antennae reddish brown with distal end of the 4th segment red. The rostrum is four segmented and reposed in between the fore legs.

Thorax is orange in colour; pro-thorax bears two dark red spines pointed dorsolaterally and white dots were observed on the abdomen. Six spines are present on the dorsolateral side of the abdominal segment. There is no change in antennae. The proximal half of the femur is dirty white and remainder is red in colour. One fourth proximal part of tibia is dark red and rest is white in colour. The duration of second instar is given in Table 6 and measurements in Table 7.

Third instar.

The colour pattern of freshly moulted nymph is the same as described in fresh second instar nymph.

Eyes are brownish red. Antennae and rostrum are pinkish in colour.

Thorax is orange yellow with a few red dots and blackish zigzag lines. Two spines on pro-thorax become prominent and pointed toward distal end. The coxa and trochanter are pale yellow, proximal part of femur is white and distal part reddish brown. The proximal part of the tibia is reddish brown, while remaining part dirty white with black dots. Red and white patches with two prominent dark brown raised points are seen on dorsal side of the abdomen. The duration of third instar is given in Table 6 and measurements in Table 7.

Fourth instar.

The head is yellowish with minute pinkish dots distributed all over the cephalic surface; the bulging eyes are pinkish on their lower periferal part and dark pink centrally. On the dorsal side of the head there are a large number of dark setae, and few setae are present on the lateral sides. The antennae is four segmented and pinkish in colour. Small dark setae are present all over the 1st three segments and the basal part of the fourth antennal segment. Dorsal side of the thorax is yellowish white with light pinkish minute dots and 3 longitudinal distinctly pinkish lines. On either side of the 2nd pro-thorax, there is a dorsally directed prominent yellowish spine. The distal one fourth part of the femur and the basal part of the tibia are pinkish in colour. The remaining part of the tibia and tarsi are whitish. The wing pads extended

upto the second abdominal segment. There are 6 pairs of spines arising from the lateral sides of the abdomen. These spines are dark pinkish in colour, each having a slender whitish patch on the anterior as well as on the posterior side.

The 1st pair of abdominal spines are directed dorsolaterally, but the remaining 5 pairs projecting dorsally. The ventral side of the abdominal sternite is light yellowish having pinkish tinge with large number of white dots and spots. The duration of the fourth instar is given in Table 6 and measurements in Table 7.

Fifth instar.

The colour pattern of the freshly moulted nymph remains the same as described earlier for fourth instar.

The head is orange coloured having some pinkish dots. The rostrum is light red.

Thorax is black and hairy with some pinkish dots. Two prominent dark spines with white strips are situated laterally, one on each side of the prothorax. The wing pads overlap the hind wing and reaching the middle of the third tergum. The basal half of the femur is white, the remaining distal part together with basal part of tibia is red and remaining part of the tibia is brown.

The colour of the abdomen is black or brown. First two abdominal segments are dark pinkish in colour with white spots, the posterior abdominal segments are grey in

Table 6: Duration of different stages of nymph, percent nymphal survival and developmental index

Month	Duration of								resulting							
	1st				2nd				3rd				4th			
	Range	Mean (days)	Nymphal survival	Develop-mental index	Range	Mean (days)	Nymphal survival	Develop-mental index	Range	Mean (days)	Nymphal survival	Develop-mental index	Range	Mean (days)	Nymphal survival	Develop-mental index
Oct., 65	2 to 3	2.6 ±0.51	82.65	53.05	3 to 4	3.1 ±0.37	73.55	32.4	3 to 4	3.25±0.46	60.05	33.3	4 to 5	4.4 ±0.53	50.35	24.50
Nov., 65	1 to 3	2.1 ±0.64	81.66	52.07	2 to 5	3.5 ±0.64	71.66	30.2	3 to 4	3.3 ±0.51	53.75	30.18	3 to 5	3.8 ±0.63	49.11	25.4
Dec., 65	1 to 2	1.88±0.76	75.5	50.05	3 to 4	3.3 ±0.51	70.51	30.5	3 to 5	3.5 ±0.70	51.05	29.48	2 to 4	3.5 ±0.70	43.33	29.

The nymphal period ranged from 21.95 days in October, 19.2 days in November and 18.38 days in December.

Table 7: Measurements of different stages of nymph

Stage of nymph	Total length (mm)	Head		Abdomen width (mm)	Antennae length (mm)
		Length (mm)	Width (mm)		
1st instar nymphs	1.373 ± 0.076	0.39 ± 0.03	0.442 ± 0.074	0.515 ± 0.039	1.25 ± 0.069
2nd instar nymphs	2.345 ± 0.174	0.58 ± 0.291	0.505 ± 0.03	0.795 ± 0.069	2.046 ± 0.060
3rd instar nymphs	3.514 ± 0.192	0.784 ± 0.029	0.705 ± 0.021	1.377 ± 0.164	3.003 ± 0.126
4th instar nymphs	4.731 ± 0.247	1.011 ± 0.040	0.937 ± 0.039	1.756 ± 0.155	4.424 ± 0.170
5th instar nymphs	6.55 ± 0.550	1.132 ± 0.070	1.251 ± 0.036	2.658 ± 0.156	6.1 ± 0.210

colour with small pinkish dots. There are 6 pairs of spines. The first pair of spines is not visible as the same is covered by the first pair of wing and remaining pairs are projecting dorsally. The duration of the fifth instar is given in Table 6 and measurements in Table 7.

Adult.

After the fifth moult the imago emerges. The male and female insects resemble each other in general appearance except the size; the female bug being bigger than the male (Photograph 4). The average measurements of each sex are given below -

	Male	Female
Length of body	8.4 \pm 0.516 mm	9.7 \pm 0.674 mm
Width of body	2.1 \pm 0.316 mm	3.4 \pm 0.516 mm

Body is dark brown with dirty creamy pinkish patches. Antenna is four segmented, the compound eyes are bulging out. The post-clypeus is large sclerite, ante-clypeus is small in size. Rostrum is four jointed, extending along the ventral surface of the body. The prothorax is enlarged with one spine on each dorsolateral side. Wings are most conspicuous with narrow clavus. The venation is not clear. The coxa is dark brown, trochanter creamy white with dense hairs. The pro and mesothoracic femora are simple while metathoracic femur is swollen, the tibia are simple pale white with 2 brownish bands, tarsi 3 segmented.

The abdomen is broadly attached to thorax. It is fleshy globular tapering posteriorly. Body colour is brown with dense hairs. In all eleven segments are visible. The genitalia are retracted anteriorly, wings are completely developed covering the abdomen. The adults take to flight only when they are greatly disturbed. They take shelter under foliage bearing pods. The duration of one life cycle from egg to adult is given in Table 8.

Table 8: Complete life cycle from egg to adult

Month	Incubation period (days)		Nymphal period (days)	Total life cycle (days)	Development index 100/period
	Range	Mean			
Oct., 65	4 to 8	6.5±0.67	21.95 days	27.95	3.57
Nov., 65	6 to 10	8.2±1.67	19.20 "	27.20	3.67
Dec., 65	9 to 10	9.5±0.66	18.28 "	27.28	3.66

Thus, from the above table the developmental period from egg to adult is 27.95 days in October, 27.20 days in November and 27.28 days in December.

Reproduction.

Copulation takes place in tail to tail manner which is characteristic of most hemipterous insects (Photograph 5) when the insects are active it is common sight to see large number of bugs in pairs on plants. The copulation does not affect the normal movement and feeding in any way. Male and female adults are found sensitive before copulation.

Preparatory to copulation male moves to the side of the females feet and mount the female. The male supports the posterior part of the body on the hind legs. They unite by their posterior ends and with their heads in opposite directions. Copulation can take place at any hour of the day. Durations of copulation are given Table 9.

Table 9: The copulation period

Time of start of mating	Date	Time of expiry of mating	Date	Time taken during mating (hrs)
8.00 A.M.	5.10.65	11.30 A.M.	5.10.65	3.30
2.15 P.M.	5.10.65	5.00 P.M.	5.10.65	2.45
4.00 P.M.	5.10.65	9.15 A.M.	6.10.65	17.15
4.40 P.M.	6.10.65	11.00 A.M.	7.10.65	18.20
6.00 A.M.	7.10.65	11.20 A.M.	7.10.65	3.30
3.10 P.M.	8.10.65	5.00 P.M.	8.10.65	1.50
9.00 A.M.	13.10.65	11.00 A.M.	13.10.65	2.00
3.00 P.M.	16.10.65	6.20 P.M.	16.10.65	3.20
9.00 A.M.	18.10.65	11.00 A.M.	18.10.65	2.00
3.45 P.M.	15.11.65	5.00 P.M.	15.11.65	1.15
Average	-	-	-	5.41

The copulation period varied from 1.15 to 18.20 hours with an average of 5.41 hours.

Pre-copulation, pre-oviposition and oviposition period.

The mating of male and female does not take place immediately after the last nymphal moult but it occurs after 4 to 9 days.

After copulation the female does not lay eggs immediately but after few hours (1.15 to 16.20 hrs) deposition takes place.

It was observed that the number of egg laid after one copulation was much variable in the same month. The duration of pre-copulation, pre-oviposition and oviposition period is given in Table 10.

Table 10: Pre-copulation, pre-oviposition and oviposition period

Month	Pre-copulation period (days)		Pre-oviposition period (days)		Oviposition period (days)	
	Range	Mean	Range	Mean	Range	Mean
Oct., 55	4 to 9	6.0 \pm 1.6	1 to 6	3.0 \pm 1.6	29 to 82	60.5 \pm 20.97
Nov., 55	5 to 7	6.2 \pm 0.63	1 to 7	3.1 \pm 2.2	39 to 51	45.0 \pm 4.96

The above table shows that the pre-copulation period in both sexes are 6.0 \pm 1.6 days in October and 6.2 \pm 0.63 days in November, the pre-oviposition period 3.0 \pm 1.6 days in October and 3.1 \pm 2.2 days in November and the oviposition period 60.5 \pm 20.97 days in October and 45.0 \pm 4.96 days in November.

Site and mode of oviposition.

It was observed that almost all the eggs are laid on pods. The eggs are laid at anytime of the day or night. They are laid in an irregular mass. In one cluster the female lays 1 to 39 eggs with an average of 20 eggs/bunch. During the process of oviposition the female remains stationery with her fore legs, and whole body and antennae moving slightly. The eggs are glued to the surface of the substrate by the female (Photograph 6).

Table 11: The fecundity per female

Month	Number of egg laid on			Total eggs	Duration (Days)
	Pod	Leaf	Paper		
Oct. to Dec.	67	-	42	109	15 days
Oct. to Dec.	165	-	59	224	26 "
Oct. to Dec.	115	32	45	192	21 "
Oct. to Dec.	95	16	45	156	24 "
Oct. to Dec.	173	43	11	227	30 "
Oct. to Nov.	196	7	70	273	24 "
Nov. to Dec.	61	19	-	80	20 "
Nov. to Dec.	113	30	-	143	22 "
Nov. to Dec.	47	10	-	57	14 "
Nov. to Dec.	404	7	14	425	36 "
Average	-	-	-	188.6	

Thus, the fecundity per female varied from 57 to 425 with an average of 188.6 eggs. It is also observed

that the female lay eggs till its death and the post-oviposition period may be nil.

Longevity of adult.

The total duration of adult life was worked out in the laboratory under different conditions such as males and females confined together with and without food, and male and female kept separately with and without food. In series of experiments fresh tur pods were supplied as food. Longevity of mated and unmated adults with and without food is given in Table 12 A & B.

From the Table 12 A & B, it is very evident that the nutrition is the most important factor in the longevity of both the sexes. The table also shows that longevity of mated individuals was reduced in comparison to that of unmated individuals. The longevity of unmated females was greater than that of the unmated males. Unmated female lays lesser number of eggs with no viability than mated female, (photograph 6).

Table 12 A: Longevity of mated adults with and without food

Month	With food				Without food			
	Longevity in days				Longevity in days			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Oct., 65	50 to 79	55.66±10.30	51 to 58	55.16±2.99	3 to 7	4.63±1.47	4 to 7	5.66±1.03
Nov., 65	39 to 50	44.75± 5.12	42 to 56	48.35±6.44	4 to 6	4.75±0.95	5 to 7	5.75±0.95

B: Longevity of unmated adults with and without food

Month	With food				Without food			
	Longevity in days				Longevity in days			
	Male		Female		Male		Female	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Oct., 65	42 to 54	49.50±4.37	60 to 75	68.17±5.45	4 to 7	5.5±1.04	5 to 9	6.63±1.47
Nov., 65	38 to 55	47.35±6.09	63 to 74	68.25±5.12	5 to 6	6.5±2.78	7 to 8	7.50±0.57

Sex ratio.

The adults emerged in different months in the laboratory were examined for their sexes and the data so obtained are given in Table 13.

Table 13: The sex ratio in the laboratory

Month	Number of adults observed	Male	Female	Sex ratio
Oct., 85	28	13	15	1:1.1
Nov., 85	207	75	132	1:1.7
Dec., 85	34	9	25	1:2.7
Jan., 86	32	10	22	1:2.2

From the above table it is clear that the female out numbered the male. The maximum sex ratio (1:2.7) was in December and minimum (1:1.1) in October, 1985.

Habit and habitat.

The adult feed on the tender, as well as matured pods but nymphs prefer to feed on the tender pods. The feeding activity of the insect is more at high temperature during the day time, but is retarded on cool days. The insect is diurnal, more active in the morning and prefer to go under shelter of pods and leaves in the noon and evening time. They are not very swift flier. The flying adults produce sound but the mechanism of sound production was not determined.

Nature of damage.

The damage done by this pest is not an apparent one at a glance, because the pest has got piercing and sucking type of mouth parts. Adults and nymphs of Clavigrella gibbosa Spin. suck up the cell sap by the help of their stylets. Both nymphs and adults were found to feed on pods in the fields as well as in the laboratory. Generally they start sucking juice from the middle of the pods. Newly emerged nymphs from egg mass were gregarious in nature remaining in congregations at one place for a day or two and started dispersing thereafter. The 3rd, 4th and 5th instars do not distinguish between the soft and hard pods and feed voraciously. The nymphs and adults both with the help of their stylets feed on green pods, which become dull and shrivelled, (photograph 7). The affected pods produce shrivelled grains (photograph 7).

population dynamics.

The adults of C. gibbosa were first observed on October 2, 1965 at flowering cum podding stage on the local variety of arhar, (sown in mid May, 1965) by a cultivator of village Bhagwanpura, District Sehore (M.P.). Regular observations were, therefore, started from 2nd October, 1965, i.e. 40th standard week. The number of eggs, nymphs and adults were counted at weekly interval on this crop till its maturity on randomly selected ten plants from an area of an acre and presented in the Table 14 and Fig. 2. After the maturity of this crop the observations were recorded at

Flowering and podding stage on the early varieties of arhar (ICPL-91, 97, 151, 9309 and UPAS-120) grown at the research farm of R.A.K. College of Agriculture, Sohore.

The eggs/10 plants were observed to be 4 ± 1.2 on 40th standard week (from 1 to 7 Oct.), which increased abruptly on 41st week (20 ± 3.34 egg/10 plants), and again on 42nd week (150 ± 5.91 egg/10 plants). Thereafter, the number of eggs declined gradually and reached to 11 ± 2.21 eggs/10 plants on 46th week (Nov. 12 to 18, 1985). A second flush of eggs was observed on 47th week recording 41 ± 4.32 eggs/10 plants. Thereafter the number of eggs increased tremendously on 48th week (119 ± 7.55 eggs/10 plants) and on 49th week (190 ± 15.65 eggs/10 plants). The number of eggs started declining from 51st week and on 54th week (22 to 28 Jan, 1986) no eggs were observed.

The adults of C. gibbosa were first observed on 40th week (1 to 7 October) recording 9 ± 2.7 adults/10 plants. But subsequently declined very abruptly on 41st (2 ± 0.4 adults/10 plants) and 42nd week (3 ± 0.4) and disappeared completely on 43rd week (22 to 28 Oct.) while, the nymphs populations were first recorded on 42nd week (15 to 21 Oct.), with 3 ± 0.64 nymphs/10 plants.

Thus it is believed that the adults observed on 40th week are immigrated from some other places and these adults laid eggs just after finding a suitable host, P. piperacea. After hatching of these eggs, nymphs were found feeding on the crop on 42nd week. The zero population of

Table 14: Weekly egg counts and pest population (nymphs & adults) of *G. grisea* on 10 plants of *Ashar* in relation to meteorological parameters

Month	Stand -ard week	Egg count & insect population			Meteorological parameters				
		Number of			Temperature (°C)		Average Humidity (%)	Rainfall (mm)	
		Eggs	Nymphs	Adults	Maxi.	Mini.			
Oct., 85 (1-7)	40	06± 1.2	00	09± 2.7	31.59	20.6	26.09	81.4	-
Oct., 85 (8-14)	41	20± 3.34	00	02± 0.4	26.6	20.2	23.4	93	10.6
Oct., 85 (15-21)	42	150± 5.91	03± 0.64	02± 0.4	29.6	15.6	22.6	67	-
Oct., 85 (22-28)	43	81± 2.26	106± 2.52	00	30.0	12.1	21.05	67	-
Nov., 85 (29-4)	44	35± 3.80	38± 3.52	00	30.8	12.5	21.65	61	-
Nov., 85 (5-11)	45	17± 2.79	06± 1.28	04± 0.66	29.7	10.6	20.15	60.1	-
Nov., 85 (12-18)	46	11± 2.21	71± 6.25	23± 2.14	29.1	9.2	19.15	67	-
Nov., 85 (19-25)	47	41± 4.32	63± 6.1	04± 0.66	28.6	10.3	19.45	67	-
Dec., 85 (26-2)	48	119± 7.55	71± 5.28	19± 1.13	28.1	10.8	19.45	62	-
Dec., 85 (3-9)	49	190± 15.65	135± 11.24	22± 0.74	27.7	7.7	17.7	63	-
Dec., 85 (10-16)	50	104± 8.45	67± 4.05	07± 0.78	28.3	15.3	21.8	72.7	-
Dec., 85 (17-23)	51	44± 4.67	62± 4.04	06± 0.8	27.2	8.5	17.85	73	-
Dec., 85 (24-31)	52	33± 3.76	08± 1.32	03± 0.45	30.4	16.9	23.65	89	-
Jan., 86 (1-7)	01	17± 3.16	09± 1.37	02± 0.4	23.45	5.4	14.42	60.5	-
Jan., 86 (8-14)	02	05± 1.5	02± 0.4	00	26.5	6.8	16.65	68.2	-
Jan., 86 (15-21)	03	04± 1.2	00	00	26.8	9.9	18.35	79	-
Jan., 86 (22-28)	04	00	00	00	28.3	11.2	19.75	73.4	-

Note: Weekly averages based on the data obtained from meteorological observatory P.A.R. Agricultural College, Sehore (M.P.)

adults of C. gibbosa on 43rd and 44th week shows that the immigrated adult population might have died after egg laying for these adults might have migrated to some other fields of pigeonpea. The adults were again observed on 45th week (5 to 11 Nov.) having 4 ± 0.66 adults/10 plants, and the population increased on 46th week recording 23 ± 2.14 adults/10 plants. This peak population may be attributed to the development of nymphs to adults from the nymphs developed between the 42nd week and 45th week. The adult population again reduced considerably on 47th week, but increased gradually on 48rd and 49th week. Thereafter it declined abruptly and disappeared completely on 52nd week. The data in Table 14 show that the adult population was erratic. Being the migratory pest, the adults might have migrated to other neighbouring pigeonpea fields, while the nymph population was constantly observed on pigeonpea from 42nd week to 52nd week, however, thereafter no nymph was found on pigeonpea crop.

The adults of C. gibbosa appeared on tur crop in the first week of October, 1985, when the minimum, maximum temperature and relative humidity was 20.6°C , 31.59°C and 81.4%, respectively and continued upto the first week of January, 1986, when the maximum and minimum temperature and relative humidity 23.45°C , 5.4°C and 60.5%, respectively.

Host preferences.

The different stages of C. gibbosa Spin. have been reported to feed on different parts of tur plant and other leguminous plants.

Host preference of the pest was studied on its relative numbers found on pods of different hosts in laboratory experiment. Studies were conducted with adults reared in the laboratory in mass culture. Pods of pigeonpea, lablab, clusterbean and cowpea were placed in a circle of 43 cm of diameter in a glass showcase, (photograph 3). Forty adults were released in the centre of circle. For confirmation the experiment was replicated twice. Number of adults present on each food was recorded after 1, 2, 3, 4, 8 and 24 hours. The host preference data are presented in Table 15. The numbers not found on any food have been omitted from table.

Results.

pigeonpea pods were found to be most preferred, followed by lablab and clusterbean pods after 3, 8 and 24 hours of release. Cowpea pods were least preferred. Pigeonpea pods were also preferred first after 1 and 2 hours of release, however, preference for other food was somewhat different.

Table 15: Relative numbers of adults on pods of different hosts.

Food	Experiment 1						Food	Experiment 2					
	Number of adult bug on different food pods after							Number of adults bug on different food pods after					
	1 hr.	2 hr.	3 hr.	4 hr.	6 hr.	24 hr.		1 hr.	2 hr.	3 hr.	4 hr.	8 hr.	24hr.
Tur pods	38	30	48	54	56	64	Tur pod	21	24	27	39	40	55
Sam pods	4	6	14	10	7	2	Sam pod	8	9	6	11	8	3
Clusterbean pods	6	14	8	4	4	0	Clusterbean pod	4	4	5	2	0	0
Cowpea pods	12	4	2	3	2	0	Cowpea pods	6	5	6	5	5	2

Natural enemies.

During the course of present investigations on unidentified chalcid egg parasitoid was recorded. The adults of male parasite were black in colour, while the abdomen of the female parasite was brownish yellow. Parasitised eggs were first recorded on 22nd October, 1965 (43rd standard week). The per cent eggs parasitised in different months are given in Table 16.

Table 16: Parasitisation (%) of eggs of C. gibbosa

Month	Parasitisation (%)
Oct., 65	15.30%
Nov., 65	32.10%
Dec., 65	13.36%

Lefroy (1909) and Mishra (1924) reported the eggs of C. gibbosa to be parasitised by a unidentified chalcid parasite. Usman and Puttrudish (1954) however reported Hadronotus fuviventris parasitising the egg of C. gibbosa at Bangalore and Bindra (1965) found Hadronotus antestian Dodd, parasitising the egg of C. gibbosa at Jabalpur.

(B) Chemical control of tur red bug, Clavicalia gibbosa Spin.

Comparative toxicity of some of the modern insecticides was tested in a field cum laboratory trial against the adults of C. gibbosa. The trial consisted of

12 treatments including control (i.e., water spray) and each treatment was replicated thrice. In each replicate 10 adults were released. Observations on mortality were recorded 24, 48 and 72 hours after releasing the adults (Fig. 3).

Results

Per cent mortality after 24 hr.

The average adult mortality 24 hr after the confinement revealed that all the insecticides were significantly superior to control. Monocrotophos exhibited the best performance followed by A 6341 E (polytrin). The treatments Elucythrinate, permethrin, decamethrin, fluvalinate and fenvalerate were least effective and almost identical. Quinalphos, P.P.302 and carbosulfan were intermediate in their toxicity.

Per cent mortality after 48 hr.

All the insecticidal treatments except fenvalerate and water spray (control), gave higher adult mortality in comparison to 24 hr. The trend of toxicity in all the insecticides, except cypermethrin and decamethrin was the same. The toxicity of A6341E (polytrin) and quinalphos reached in the cadre of monocrotophos and were on par.

Per cent mortality after 72 hr.

The average adult mortality 72 hr after the period of confinement revealed that all the insecticides except fenvalerate proved to be effective against the tar pod bug, Clavigralla gibbosa Spin. and the per cent mortality due to application of different insecticides ranged 16.63 to

Table 17: Per cent mortality of tur pod bug, Clavigralla albosa Spin. in different treatments of insecticides

Common name	Trade name	Formulation used	Concentration (a.i.,%)	Per cent mortality after		
				24 hrs	48 hrs	72 hrs
Monocrotophos	Nuvacron	36 s.c.	0.036%	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
A 6341 B	Polytrin (resolymix)	N 427 e.c.	1.17 ml in 1 l of water	76.66 (61.21)	96.66 (83.86)	100.00 (90.00)
Quinalphos	Ekalux	45 e.c.	0.045%	40.00 (39.14)	86.66 (72.28)	96.66 (83.85)
-	P.P.302	5 e.c.	0.002%	26.6 (30.29)	33.33 (34.92)	60.00 (56.07)
Carbosulfen	Marshal	25 e.c.	0.01%	23.33 (28.07)	26.66 (30.00)	30.00 (32.71)
Cypermethrin	Cypermkill	25 e.c.	0.005%	13.33 (21.14)	63.33 (52.70)	83.33 (66.64)
Flucythrinate	Pay-off	10 e.c.	0.003%	10.00 (11.07)	16.66 (19.22)	20.00 (21.14)
Permethrin	Basta Permasect	25 e.c.	0.005%	6.66 (8.85)	13.33 (17.21)	20.00 (21.93)
Decamethrin	Decis	2.8 e.c.	0.01%	3.33 (6.14)	40.00 (38.05)	90.00 (75.00)
Fluvalinate	Navrik	25 e.c.	0.005%	3.33 (6.14)	10.00 (15.00)	16.66 (19.22)
Fenvalerate	Fenval	20 e.c.	0.01%	3.33 (6.14)	3.33 (6.14)	3.33 (6.14)
Control	-	-	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
S.E.m ±				(1.88)	(7.05)	(9.01)
C.D. at 5%				(5.51)	(23.02)	(26.46)

Figures in parentheses are angular transformed values.

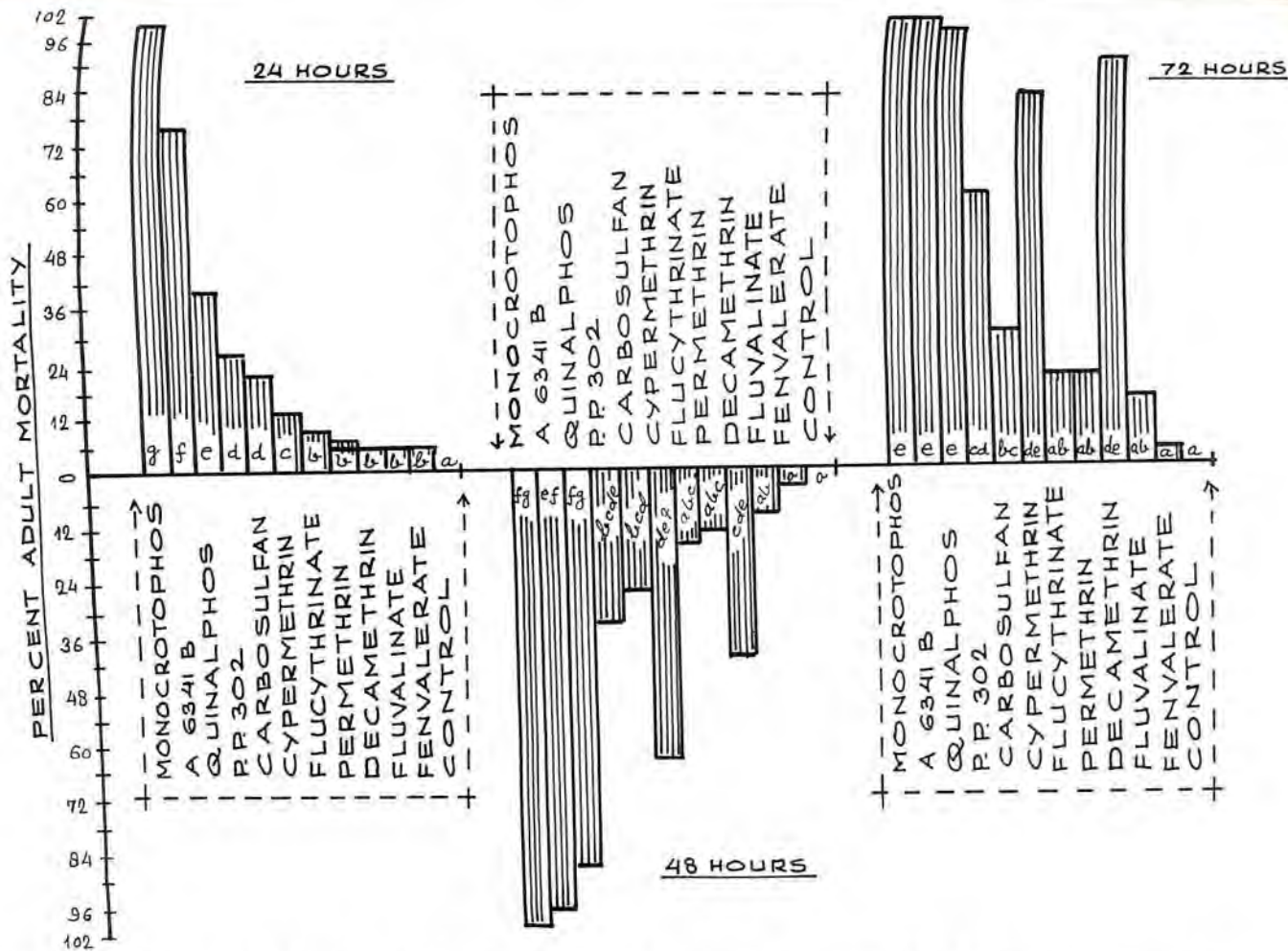


FIG. 3: PERCENT ADULT MORTALITY OF TUR POD BUG, *Clavigralla gibbosa* SPIN. IN DIFFERENT TREATMENTS OF INSECTICIDES (COLUMNS HAVING SAME LETTER DO NOT DIFFER SIGNIFICANTLY)

100.00 per cent. Monocrotophos, A6341B and quinalphos were found to be highly effective and gave 95.00 to 100.00 per cent mortality. Cypermethrin and decamethrin also reached in the rank of highly toxic insecticides and are on par with the earlier insecticides. P.P.302 proved to be intermediate in its toxicity while other insecticides were low in their toxicity.

Thus, it is observed that monocrotophos has proved highly effective and gave 100 per cent kill in 24, 48 and 72 hrs. similarly polytrin (A6341B) and quinalphos were best in their effectiveness as they also inflicted increase mortality of 76.66, 96.66 and 100 and 40.0, 86.66 and 96.66 per cent, respectively. Amongst the synthetic pyrethroids, only cypermethrin and decamethrin were found to be effective as they registered increase mortality upto 83.33 and 90.00 per cent in 72 hrs.

In general, organophosphorous compounds were superior in their toxicity than the newly introduced synthetic pyrethroids. Fenvalerate proved to be least effective as it inflicted only 3.33 % adult mortality even after 72 hr of confinement and it was also at par with control.

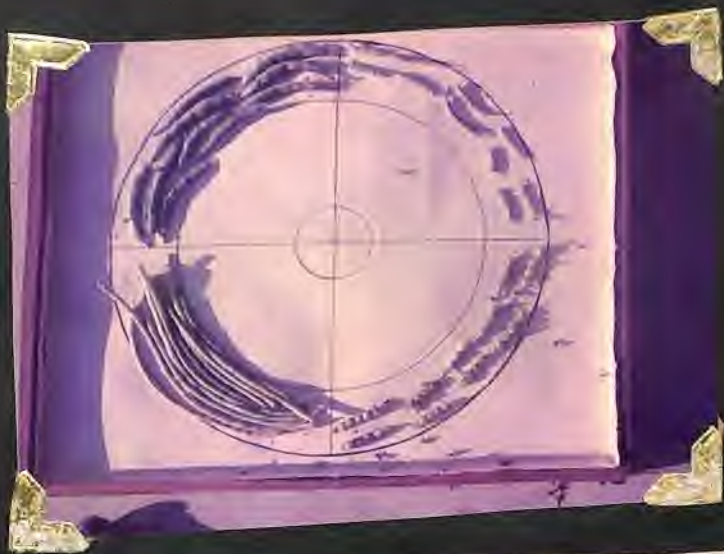




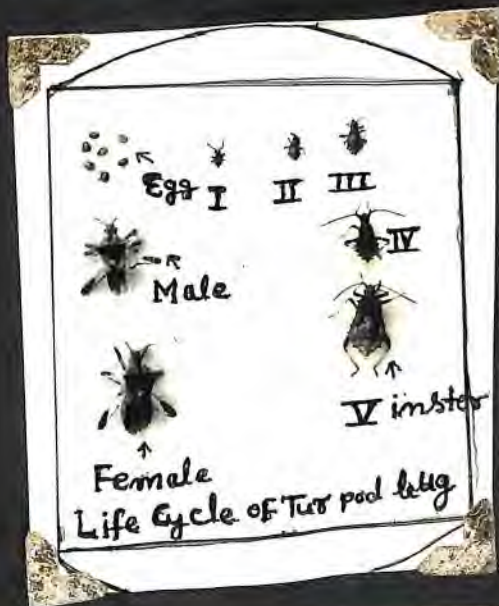
Photograph 1 : Rearing in Petri-dishes



Photograph 2 : Mass rearing of *G. gibbosa* adults in chimney



Photograph 3 : Host preference studies (pods of different hosts are kept in a circle)



Photograph 4: Life stages of tur pod bug, Clavicornia gibbosa Spinola



Photographs 7 : Damaged pods and grains of tur

DISCUSSION(A) Economics of Clavigralla gibbosa Spinola.The egg.

The female laid minute, oval shaped, 1.05 ± 0.39 mm x 0.8 ± 0.052 mm eggs in cluster of 1 to 39 and glued on the leaves and pods, which are dirty white when freshly laid and become dark brown before hatching. Similar observations on the measurement, colour and shape of egg have been reported by Kapoor (1966) and Choudhary (1967), Gangrade (1961); Kadam and Shelgaonkar (1964); Bindra (1965); Ram Singh (1965); Kapoor (1966) and Saxena (1961) also observed that they are laid in clusters of 2 to 14.

Incubation period.

The incubation period of 8 to 15 days was observed by Gangrade (1961) and 7.69 days by Bindra (1965), whereas, Shelgaonkar (1964) found it to be 5 to 20 days. Ram Singh (1965) recorded the incubation period to range from 5 to 18 days under varying laboratory temperature, 1.2 , 20° to 28° C and 4 to 14 days under controlled temperature of $34 \pm 1^{\circ}$ to $27 \pm 1^{\circ}$ C. Kapoor (1966) and Choudhary (1969) recorded it to vary from 3 to 12 days during December to April. During the course of present studies the incubation period was found to range from 4 to 8 days, 6 to 10 days, 9 to 10 days and 10 to 12 days during October, November, December, 1965 and January, 1966, respectively.

Percentage viability.

During the present investigation, the viability of the eggs was 77.11% in October, 83.78% in November, 84.29% in December, and 84.74% in January. Bindra (1965) reported the per cent viability of egg to vary from 68 to 97.91% whereas, Kapoor (1966) found it from 85 to 97.91%. Thus it confirm that the viability of the eggs is above 68 per cent.

The nymph and nymphal period.

After hatching, the nymph undergoes five moults to reach the adult stage. The newly hatched nymph was light yellow and turn dark brown after 1 to 2 hours. The nymph of second, third, fourth and fifth instars are orange yellow just after the moult and become dark brown later on. Gangrade (1961); Kadam & Shalgaonkar (1964); Bindra (1965); Kapoor (1966) and Choudhary (1969) have also mentioned 5 nymphal moults in tur pod bug.

The nymphal period was found 21.95 days in October, 19.2 days in November and 18.28 days in December. The nymphal period of 11 to 24 days was observed by Gangrade (1961) and Kapoor (1966), and 16.9 days by Bindra (1965). Kadam and Shalgaonkar (1964) reported it to vary from 14 to 81 days. Choudhary (1969) reported it to be 23.7 days, Saxena (1981) stated it to range from 7 to 25 days depending upon the prevailing temperature.



Life cycle.

Gangrade (1961) reported that a single life cycle of tur pod bug from egg to adult required 39 to 56 days at Jabalpur under laboratory condition. Kadam and Shelgaonkar (1964) and Bindra (1965) reported the total developmental period to be 19 to 51 days. Ram Singh (1965) and Kapoor (1966) reported that the insect completed its life cycle from 25 to 45 days and 17 to 36 days, respectively. During the course of present studies the developmental period from egg to adult was 27.95, 27.20 and 27.28 days in October, November and December, respectively.

Pre-copulation, pre-oviposition and oviposition period.

Bindra (1965) reported pre-oviposition and oviposition period to be 1 to 10 and 1 to 30 days, respectively. Ram Singh (1965) stated oviposition period to be of 2 to 23 days. Kapoor (1966) stated that the pre-oviposition and oviposition period ranged from $\frac{1}{4}$ th to 4 days and 3 to 47 days, respectively. During the course of present investigations the pre-copulation, pre-oviposition and oviposition period ranged from 6.0 to 6.2, 3.0 to 3.1 and 45 to 60.5 days, respectively during October and November.

Fecundity.

Gangrade (1961) reported that the maximum fecundity of female was 140 eggs. Kadam and Shelgaonkar (1964) stated that a single female lays maximum of 60 eggs. Bindra (1965)

reported that the field collected females laid upto 437 eggs, and laboratory reared ones laid upto 333 eggs at Jabalpur. Kapoor (1966) reported that the fecundity was 650 eggs with an average of 267.4 eggs. Ram Singh (1965) stated that the fecundity of single female ranged from 15 to 306 eggs with an average of 180.2 eggs. During the course of present studies the fecundity per female varied from 57 to 425 with an average of 188.6 eggs.

Longevity of adults.

During the course of present study the longevity of mated male without and with food varied from 4.63 to 55.66 days in October and 4.75 to 44.75 days in November. The longevity of mated female without and with food varied from 5.66 to 55.16 days in October and 5.75 to 48.25 days in November. The longevity of unmated male without and with food varied from 5.5 to 49.5 days in October and 6.5 to 47.5 days in November, unmated female lived without and with food from 6.83 to 60.17 days in October and 7.5 to 68.25 days in November. Kadam and Shelgaonkar (1964) mentioned that the longevity of both the sexes varied from 60 to 50 days in December and 3 to 12 days during October to November. Ram Singh (1965) reported that the longevity of the adult with food varied from 12 to 65 days with an average of 38.5 days. Kapoor (1966) reported that the longevity of mated male and female without and with food varied from 3 to 7 days and 13 to 92 days respectively. The longevity of unmated female without and with food was 6 days

and 19 to 78 days; longevity of male without and with food varied from 3 to 4 days and 23 to 67 days, respectively.

Habit and habitat.

The adult feed on the tender as well as mature pods of the arhar, but the nymphs mostly preferred tender pods. The feeding activity is more in the early hours of the day and go under shelter of pods and leaves in the noon and evening. Mishra (1924) has also found that the adults feed on the tender as well as mature pods but prefer tender pods of tur. Ayyar (1940) reported that habits of C. gibbosa are similar to that of rice bug.

Nature of damage.

The nymphs and adults of tur pod bug, Clavigralla gibbosa Spin. not only caused shedding of buds, flowers and pods but also rendered the developing grains unfit for human consumption by way of shrivelling the pods and reducing the size of grains. The bug had special preference for green tender pods. Similar type of damage has been reported by Mishra (1924); Ayyar (1940); Kadam & Patil (1956) and Kapoor (1966), except that they did not report the shedding of flower-buds, flower and pods as a result of feeding activity of bug. Bindra (1965) reported flower shedding also but did not mention anything about bud and pod shedding. Mishra (1979), however, reported shedding of flower-buds, flowers and pods as result of feeding of bug at Jabalpur. His findings are quite similar with findings

of present investigation. Saxena (1981) described the distribution and nature of damage of *C. gibbosa*. The adults and nymphs suck the sap of leaves, flower-buds and developing pods. In severe infestation the pods shrivel, but become deformed and grain do not develop properly.

Population dynamics.

Gangrade (1961) observed its activity from the pod formation stage till harvest at Jabalpur, i.e. upto Feb.-March. Bindra (1965) reported its activity from middle of October to end of May on many leguminous plants. The findings of present studies are more or less similar at Sohore. The first appearance of the pest was noted in first week of October on green pods of local variety of Aghar sown by a cultivator of village Bhagwanpura. Thus the pest was active from October and remained active throughout the investigation period, i.e. upto January, 1986. Kapoor (1966) and Choudhary (1967) reported its activity from last week of November to May at Sohore in Madhya Pradesh. In the present investigation, the eggs/10 plants were observed to be 4 ± 1.3 on 40th standard week (from 1 to 7 Oct.) and a second flush of eggs was observed on 47th week recording 41 ± 4.32 eggs. The adults of *C. gibbosa* were first observed on 40th week (1 to 7 Oct.) recording 9 ± 2.7 adults. While the nymph population were first recorded on 42nd week (15 to 21 Oct.) with 3 ± 0.64 nymph. The peak period of the pest was on 49th week of December, 1985. Choudhary (1973) reported that pest was

active from October and disappeared shortly before harvest. Ghosh (1962) reported first appearance of C. gibbosa in early October and peak population of pest between November and January.

Host preference.

Clavigrella gibbosa has been generally known as the specific pest of tur for a long time, however, some early records (Fletcher, 1917; Kadam & Patel, 1956) showed that besides tur, this pest also feeds on garden beans (Dolichus lablab). Ichagwan (1963) found that the most preferred host of C. gibbosa is pigeonpea, followed by cowpea and beans. Rawat et al. (1965) reported that the pods of pigeonpea in the middle stage of development were most preferred. During the present studies, it was also observed that the green pigeonpea pods were most preferred, followed by lablab and clusterbean pods after 3, 8 and 24 hours of release, cowpea pods were least preferred. Pigeonpea pods attracted maximum number of adults even after 1 and 2 hours of release, however, attraction for other pods was somewhat different.

(B) Chemical control of tur pod by C. gibbosa. Spin.

During the course of present studies monocrotophos (0.035%) was most effective after 24 hours of treatment, however, after 48 hours of treatment quinalphos, polytrin and monocrotophos were at par. In general, organophosphorus compounds and carbamate were most effective against adults

as compared to pyrethroids. Fletcher (1917) recommended collection and destruction of the nymphs and adults by shaking the pods in a tray containing kerosinised water. Kodam *et al.* (1956) found that dusting with 5% EHC at the rate of 15 lbs per acre gave good results in controlling the pest. Thakur *et al.* (1980) reported that 5% EHC + 10% EDT (1:1) dusts, quinalphos and dimethoate as sprays were highly effective after 3 days of application. Quinalphos was also most effective after 15 days of treatment, followed by EHC + EDT and monocrotophos. Their findings regarding toxicity of quinalphos and monocrotophos are in conformity with our findings.

SUMMARY

Pulse crops occupy an important place in Indian agricultural economy and every year suffer a substantial loss by insect pests. Clavigrella gibbosa Spin. has been found as a potential and destructive pest of pigeonpea. Its bionomics and control were studied under laboratory condition at Sehore (Madhya Pradesh).

The eggs were laid in clusters of 1 to 39 on pods and leaves. The incubation period and viability of eggs ranged from 4 to 12 days and 77.11 to 84.74%, respectively.

The nymphs passed through five moults to reach the adults stage. The duration of different instars ranged from 1 to 3 (1st instar), 2 to 5 (2nd instar), 3 to 5 (3rd instar), 2 to 5 (4th instar) and 5 to 11 (5th instar) days, respectively. The nymphal period ranged from 21.95 days in October, 19.2 days in November and 16.28 days in December.

The developmental period from egg to adult varied from 27.20 to 27.95 days during October to December, 1965. The copulation period varied from 1.5 to 18.20 hours with an average of 5.41 hours. The pre-copulation, pre-oviposition and oviposition period ranged from 6.0 to 6.2, 3.0 to 3.1 and 45 to 60.5 days, respectively during October and November.

The fecundity per female varied from 57 to 425 with an average of 188.6 eggs. The longevity of mated male and female without and with food varied from 4.75 to 5.75 days and 48.25 to 55.66 days, respectively. The longevity of unmated male and female without and with food varied from 58.25 to 7.5 days and 47.5 to 68.25 days, respectively. The female out numbered the male. The highest sex-ratio (1:2.7) was in December and lowest (1:1.1) in October in the laboratory.

The insect being diurnal, more active in the morning and adults preferred to go under shelter of pods and leaves in the noon and evening time.

The pest has got piercing and sucking type of mouth parts. The nymphs and adults both with the help of their stylets feed on green pods, leaves and flower. The affected pods produced shrivelled grains.

The adults of C. gibbosa were first observed on October, 2, 1965 at flowering cum podding stage on a local variety of ashag (sown mid May, 1965) sown in cultivator's field of village Bhagwanpura district Solapur (M.P.). The eggs/10 plants were found to be 4 ± 1.2 on 40th standard week (1 to 7 Oct.) and second flush was observed on 47th week recording 41 ± 4.32 eggs. The peak incidence of the pest was found on 46th week recording 23 ± 2.14 adults per 10 plants.

Pigeonpea pods were found to be the most preferred as compared to lablab, clusterbean and cowpea pods.

An egg parasitoid was recorded, parasitising 15.30 to 32.10 % eggs during October and November.

Toxicity of 11 insecticides as emulsifiable concentrates, were tested to control the adults of the pest in field cum laboratory. Spraying was done with hand compression sprayer in the field and treated pods were fed in the laboratory. Monocrotophos (0.036%) was most effective and gave 100 per cent kill in 24, 48 and 72 hours. Similarly polytrin (A6341B) and quinalphos were best in their effectiveness as they also inflicted inclusive mortality of 76.66, 96.66 and 100 and 40.0, 86.66 and 96.66 per cent, respectively.

In general organophosphorous compounds and carbamate were most effective against adults as compared to pyrethroids.

APPENDIX

Laboratory experiment: Analysis of variance for the percentage mortality of tur pod bug, Clovisella gibbosa Spin.

1. Percent mortality after 24 hours

Source	D.F.	S.S.	M.S.S.	F.col.
Block	2	139.301	69.65	-
Treatment	11	23789.48	2162.68	20.35
Error	22	2337.839	106.26	-
Total	35	26266.63	S.E.m=1.88	C.D. at 5% 5.51

2. Percent mortality after 48 hours

Block	2	22.59	11.29	-
Treatment	11	30139.08	2739.82	14.80
Error	22	4070.49	185.02	-
Total	35	34231.16	S.E.m=7.65	C.D. at 5% 23.02

3. Percent mortality after 72 hours

Block	2	64.44	32.22	-
Treatment	11	37262.27	3387.48	13.87
Error	22	5376.35	244.11	-
Total	35	42697.17	S.E.m=9.01	C.D. at 5% 26.46

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