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Bionomics, nature of damage and control of *Galerucella birmanica* Jacoby — Pest of waternut

(Coleoptera: Chrysomelidae)

Introduction

The waternut (*Trapa bispinosa* Roxburgh) popularly known as Singhara in Uttar Pradesh and other parts of Northern India is extensively cultivated in stagnant water in lakes, ponds and tanks. It occurs all over India, Pakistan, Ceylon, South Eastern Asia, Malaya, tropical Africa (Hooker 1879) and Burma (Ghosh 1940). In the State of Uttar Pradesh waternut is mainly cultivated during rainy season (July to November), but where water is available during summers two crops are taken. The most dreaded and serious pest of this crop, which occurs from year to year, is *Galerucella birmanica* Jacoby, locally known as Singhara beetle. This pest has also been recorded from other States of India viz., Madhya Pradesh, Assam, Punjab and Kashmir (Srivastava 1956).

The genus *Galerucella* was earliest recorded by Crotch (1873). Jacoby (1889) was first to describe *Galerucella birmanica* Jacoby, under the name *Lachmoea birmanica*. Cotes (1891–93) while summarising the available information on *Aulacophora abdominalis* Fabricius, mistakenly mentioned that it has been reported attacking water caltrop (*Trapa bispinosa*) in North Western Provinces. It is evident that *Galerucella birmanica* Jacoby, was confused with *Aulacophora abdominalis* by some earlier workers and hence this mistake crept into the record of Cotes. *Aulacophora abdominalis* does not feed on *Trapa bispinosa* Roxburgh. Lefroy (1909) reported *Galerucella* as destructive to the waternut and in the year 1910 he named this pest as *Galerucella singhara* Lefroy. Possibly he did so as the original account of this pest given earlier by Jacoby (1889) escaped his notice. Husain and Shah (1926) in their work on *Aulacophora foveicollis* Fabricius, mentioned that the occurrence of *Aulacophora abdominalis* on *Trapa bispinosa* as reported by Cotes (1891–93) was a case of mistaken identity because real pest of this plant was *Galerucella singhara* which resembled to *Aulacophora fovicollis* in general form and colour. The description given by Jacoby in 1889 was modified by Maulik (1936), who correctly named this pest as *Galerucella birmanica* Jacoby. Maulik also contradicted the earlier reports of Husain and Shah (1926) that *Aulacophora foveicollis* and *Galerucella birmanica* resemble each other in colour and form. According to this author the waternut beetle has no resemblence to *Aulacophora foveicollis*. His comment that Lefroy did not publish any description of *Galerucella singhara* is not correct, because Lefroy had already described the general characters and life history of this pest in 1910. Possibly Lefroy's description might have escaped Maulik's notice as there is no reference to Lefroy's work in the bibliography published by him.

Nature and extent of damage

The entire life of the beetle and its immature stages is passed on the leaves of waternut plants. The adults as well as the various stages of grubs feed on the

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leaves, petioles and sometimes also on the integument of the fruits. The integument of the fruits, under the natural condition, is generally not damaged by the insects but under laboratory conditions they feed and survive on it. These feed on the epidermis of the upper side of the leaves constantly and by their continuous feeding small holes are formed. In severe cases of infestation the leaves riddled with small holes are of common sight. The damage done by grubs is much more than the adults. A single adult on an average was found to consume 17.4 mg. green material in 24 hours. The third stage grubs are the most voracious feeders and cause very heavy loss. As a result of the feeding by the insect the leaf area of the plant is very much reduced thereby causing the retardation in the growth of the plant and eventually leading to marked reduction in the flowers and nut formation. Not only the yield is considerably reduced due to its attack, but in serious cases the damaged plants get sub-merged into the water resulting in the total failure of crop. The authors have found some cultivators replanting the whole crop again in the month of August. The complete failure of the crop has been observed by the authors in several cases when the owners seeing no possibility of getting any return from the crop, neglected them completely.

Alternative hosts and food plants

Galerucella birmanica JACOBY has so far been observed feeding on waternut plants alone and no other alternate host plant has been observed or recorded as yet (KHATIB, 1934 and BINDRA, 1959). In the present study the leaves of many plants growing by the side of the ponds and some common acquatic plants like *Azolla* sp., *Eichornia crassipes* and *Nelumsium* or lotus were supplied to the pest in the laboratory but neither the adults nor the grubs fed on them; the pest died of starvation, while under the similar environmental conditions they fed and thrived well on waternut leaves.

Life history

Very little work on the life and seasonal history of this pest has been reported so far. LEFROY (1910), KHATIB (1934), GHOSH (1940), BHATIA & SIKKA (1952) and SRIVASTAVA (1956) have reported their observations on the life history of the pest. The observations of LEFROY are referrable to November and those of KHATIB to October and November only. BHATIA & SIKKA (1952) carried out studies on the seasonal history of this pest.

The life history of this pest was studied in detail under the laboratory conditions (Average temperature 86.960 F $\pm$ 10 F and 74% Relative Humidity) at Kanpur. Copulation occurs freely in the laboratory. The precopulation period ranges from 2 to 5 days during July to October and 5 to 7 days in November. The copulation lasts from 15 minutes to 1 hour 55 minutes. Both male and female copulate several times in their life time. The preoviposition period ranges from 14 hours and 13 minutes to 4 days.

The female lays the eggs on the upper sides of the leaves. Under laboratory conditions the oviposition was also observed on petioles, surfaces of petri dishes and jars. The eggs are laid in clusters. The female may lay all her eggs in one

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big cluster or generally in 2 to 5 clusters on a single or a number of leaves. Each cluster contains 2 to 22 eggs and a single female at a time lays 2 to 25 eggs. The whole process of egg laying takes about 15 to 20 minutes depending upon the number of eggs laid. The eggs are laid generally in the night but frequently egg laying is also observed during day time. The oviposition period varies from 6 to 19 days. The following Table shows the total number of eggs laid by a single female and also the total oviposition period.

Table 1

Oviposition period and the number of eggs laid by females of *Galerucella birmanica* JACOBY

Sl. No.	Date of 1st oviposition	Date of last oviposition	Oviposition period in days	Total number of eggs laid by a single female
1	14. 7. 64	26. 7. 64	12	84
2	27. 7. 64	6. 8. 64	10	103
3	7. 8. 64	17. 8. 64	10	102
4	11. 9. 64	17. 9. 64	6	52
5	27. 9. 64	6. 10. 64	9	203
6	28. 9. 64	7. 10. 64	9	68
7	29. 9. 64	13. 10. 64	14	116
8	3. 10. 64	22. 10. 64	19	139
9	4. 10. 64	21. 10. 64	17	83
10	21. 10. 64	27. 10. 64	6	67

It is evident from the above Table that single female lays 52 to 203 eggs during its life time. The average number of eggs laid by a female comes to about 101.

The eggs are rounded, pale yellowish with a light tint of reddish brown colour when freshly laid but later on they assume a reddish brown colour. The incubation period varies from 4 to 7 days as evident from the following Table.

Table 2

Incubation period of eggs of *Galerucella birmanica* JACOBY

Sl. No.	Date of egg laying	Date of hatching	Total egg period in days
1	2	3	4
1	21. 7. 64	25. 7. 64	4
2	4. 8. 64	9. 8. 64	5
3	11. 9. 64	16. 9. 64	5
4	12. 9. 64	17. 9. 64	5
5	27. 9. 64	2. 10. 64	5
6	28. 9. 64	2. 10. 64	4
7	29. 9. 64	3. 10. 64	4
8	30. 9. 64	5. 10. 64	5
9	4. 10. 64	8. 10. 64	4
10	5. 10. 64	10. 10. 64	5
11	6. 10. 64	13. 10. 64	7
12	8. 10. 64	14. 10. 64	6
13	27. 10. 64	2. 11. 64	6
14	28. 10. 64	4. 11. 64	7

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The newly hatched grub is yellowish brown, but soon chitin darkens and it assumes a dark greyish brown colour. It is cruciform, elongate and somewhat flattened on the ventral side and has a well developed head. The grubs after hatching disperse on the leaves in different directions and then remain inactive for sometime before they start feeding. There are three instars in the grubs and they undergo three moults before pupation. Before each moulting the grub fixes itself to the surface of the leaf. The process of moulting takes 1 to $1^1/_2$ hours. The first stage grub measures about 1 mm in length. The full grown second stage grub measures about 4 mm in length. After moulting the third stage grub measures on an average 5 mm in length and when full grown 6 mm. The following Table shows the total grub period in days during the different months.

Table 3

Duration of three instars of grubs of *Galerucella birmanica* JACOBY

Sl. No.	Egg hatched on	1st moulting	Duration of 1st instar in days	2nd moulting	Duration of 2nd instar in days	3rd moulting	Duration of 3rd instar in days	Total grub period in days
1	25. 7. 64	28. 7. 64	3	1. 8. 64	4	8. 8. 64	7	14
2	9. 8. 64	13. 8. 64	4	17. 8. 64	4	23. 8. 64	6	14
3	16. 9. 64	18. 9. 64	2	20. 9. 64	2	25. 9. 64	5	9
4	17. 9. 64	20. 9. 64	3	22. 9. 64	2	27. 9. 64	5	10
5	2. 10. 64	5. 10. 64	3	8. 10. 64	3	15. 10. 64	7	13
6	3. 10. 64	6. 10. 64	3	9. 10. 64	3	15. 10. 64	6	12
7	5. 10. 64	8. 10. 64	3	10. 10. 64	2	15. 10. 64	5	10
8	8. 10. 64	11. 10. 64	3	14. 10. 64	3	21. 10. 64	7	13
9	14. 10. 64	17. 10. 64	3	20. 10. 64	3	26. 10. 64	6	12

The full grown grub of the third instar fixes itself on the surface of the leaf and under laboratory conditions also to the walls of the glass jars and inner surface of the petri dishes by pouring a gummy matter from its anus. The body then contracts for about 2 to 3 days and during this period it does not feed. After the expiry of this period the skin of grub opens along the mid dorsal line and the pupa is formed. In Table 4 given below, the resting period of fully grown grub before pupation is shown.

Table 4

Resting period of fully grown grub of *Galerucella birmanica* JACOBY

Sl. No.	Resting stage started on	Date on which pupa was formed	Duration of resting period in days
1	6. 8. 64	8. 8. 64	2
2	20. 8. 64	23. 8. 64	3
3	23. 9. 64	25. 9. 64	2
4	24. 9. 64	27. 9. 64	3
5	13. 10. 64	15. 10. 64	2
6	19. 10. 64	21. 10. 64	2
7	23. 10. 64	26. 10. 64	3

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The body of pupa is bright yellow when freshly formed but this colour gradually changes to yellowish brown. The pupa is of exarate type and measures from 4 to 5 mm in length and 3.5 mm across the thorax. The pupal period recorded during different months is tabulated below.

Table 5
Pupal period of *Galerucella birmanica* JACOBY

Sl. No.	Date of pupation	Date of adult emergence	Total pupal period in days
1	8. 8. 64	11. 8. 64	3
2	23. 8. 64	26. 8. 64	3
3	25. 9. 64	28. 9. 64	3
4	26. 9. 64	29. 9. 64	3
5	27. 9. 64	30. 9. 64	3
6	15. 10. 64	18. 10. 64	3
7	21. 10. 64	24. 10. 64	3
8	26. 10. 64	30. 10. 64	4
9	30. 10. 64	3. 11. 64	4
10	31. 10. 64	4. 11. 64	4
11	1. 11. 64	5. 11. 64	4

The colour of newly emerged beetle is bright yellow but within 2 to 3 hours of emergence from pupa it changes to reddish brown. The female is slightly larger than the male. The beetles are not active flier and are also sluggish in their movements. They can very conveniently be captured from the pond. The adult male and female were observed to survive from 11 to 28 days and 13 to 33 days respectively which shows that the female lives longer than the male. The total life cycle from egg to adult stages takes 17—22 days. SRIVASTAVA (1956) has reported nine overlapping generations in a year on waternut crop in Uttar Pradesh.

Seasonal history

The adult beetles become inactive by the beginning of December and stop reproduction. The pest carries over to next season through the adult stage. In the ponds no grubs or adults could be observed on the plants left over in the first week of December. Twelve beetles were found at four different places in cracks and crevices by the side of the pond during this week. In the laboratory all the adults and immature stages of this pest died by the last week of November. Under natural conditions with the advent of winter the population of the beetles diminishes and by beginning of January their number is gradually reduced. The adult beetles appear on the new crop of the next season in the beginning of April and start breeding.

Chemical control

BHATIA & SIKKA (1952) reported efficacy of 2.5 to 5 percent BHC dusts and 10 percent DDT dust against this pest. They observed that after dusting

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the crop with 5 percent BHC dust some of the adults succumbed within an hour of dusting and after 72 hours no live adults or grubs could be found on the crop. According to these authors neither the emergence of bettles from pupae nor hatching of eggs was observed subsequently. The other synthetic insecticides used by them were Pyrodust and Nicotine dust. SRIVASTAVA (1956) found dusting the waternut crop with tobacco dust or Pyrodust 4000 at the rate of 40 pounds per acre effective in killing the grubs and adults but treatment of infested plants with 5 percent BHC dust at 25 to 30 pounds per acre was extremely effective and destroyed all the grubs and adults. REDDY (1962) also recommended dusting the crop with 5 percent BHC to control this pest.

Recently PRADHAN, JOTWANI & SARUP (1963) reported that the mortality of adults and grubs dusted with 10 percent BHC and 1.5 percent gamma BHC (other strengths of gamma BHC tried were 0.5 percent, 0.7 percent and 1.0 percent) was found to be 25.0 percent and 14.7 percent and 31.2 and 29.0 respectively. Further these authors carefully covered the test insects (adults and grubs) with 1.5 percent gamma BHC and 10 percent DDT and after 48 hours of treatment there was 55.6 percent and 25.0 percent mortality of adults and grubs respectively in case of 10 percent DDT and 52.8 percent and 30.8 percent mortality of adults and grubs respectively in case of 1.5 percent gamma BHC dust. According to these authors the waternut beetles collected from a particular locality in the suburbs of Delhi have developed resistance to some pesticides which used to control them effectively earlier. The reasons attributed for development of such resistance are firstly waternut being a good cash crop, the cultivators have been extensively using insecticides to control the pest and secondly inbreeding of this pest occurs from year to year in restricted areas.

Recently reports received from different localities of State of Uttar Pradesh indicated that the application of 5% or 10% BHC dust did not kill this pest very effectively. As such few laboratory trials and two field insecticidal trials were conducted during the kharif season 1964. The insect collections were made for laboratory experiments from the village, Kharauli district Meerut, from where the reports about the inefficacy of the BHC dust treatments in controlling them were received earlier.

Laboratory trials

Four days old adults of *Galerucella birmanica* JACOBY and 6 to 8 days old grubs both raised in the laboratory from the insect collection made from village, Kharauli, district Meerut, were kept as test insects. In the specimen tubes each measuring 7.5 cm × 2.5 cm, 2 grams of each of 10% DDT, 10% BHC and 10% Carbaryl dusts were taken separately. 30 grubs and 30 adults were kept in each of these specimen tubes which were lightly shaken for 1 minute by hand with a view to cover these test insects thoroughly with the insecticides. The treated adults and grubs were carefully taken out from the specimen tubes and 30 adults and 30 grubs treated with each of these insecticides were kept in three different six 1 b capacity glass jars each containing 5 cm deep water and four fresh

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waternut leaves. Each treatment was replicated thrice. Untreated 30 adults and 30 grubs were kept in glass jars in the similar manner detailed above. The observations after 24 hours, 48 hours and 72 hours after the dust application were recorded and are tabulated below.

Table 6

Showing the mortality of adults and grubs of *Galerucella birmanica* JACOBY treated with insecticidal dusts

Stage/ Treatment	10% BHC dust			10% Carbaryl dust			10% DDT dust			Control		
	Percentage of mortality after											
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
Adults	90.0	96.6	100.0	96.6	100.0	–	86.6	93.33	93.33	00	00	00
Grubs	60.0	60.0	80.0	100.0	–	–	100.0	–	–	00	00	00

It is evident from the Table above that all the treated grubs in case of 10% Carbaryl dust and 10% DDT dust died within 24 hours of the dust application, while in case of 10% BHC 20% of the grubs survived after 72 hours of the application. In case of adults 100% mortality was obtained in the insects treated with 10% BHC and 10% Carbaryl dust. Only 6.67% of adults survived after 72 hours of 10% DDT dust application.

Field Trials

With a view to test the efficacy of different insecticides against *Galerucella birmanica* JACOBY under field conditions, two insecticidal trials were conducted during 1964. One of these trials was conducted at village Kharauli, district Meerut, in a pond in which waternut crop is being grown for the last many years and the infested crop has also been regularly treated with insecticides like BHC and DDT dusts of different strengths. The treatments included in this field trial were dusting the crop with (i) 5% Chlordane (ii) 10% Carbaryl (iii) 4% Malathion (iv) 5% DDT (v) 10% DDT (vi) 10% BHC (vii) Control (no treatment) and (viii) Control (no treatment). The insecticidal dusts were applied at the rate of 25 lbs per acre. A randomised block design with three replications was adopted and a single application of the treatments was given in the last week of August. The size of the each experimental bed was kept as 1/80 th of an acre. Observations were taken before and after 24 hours, 48 hours and 72 hours of the application of the treatments, when population of the adults and grubs found in 1 sq. feet area selected at random in each experimental bed at five places was counted and recorded. The data was statistically analysed. With a view to ascertain the relationship of the population after 72 hours with the population before the application of the treatments, the technique of analysis of variance and covariance has amply borne out that the regression of the former on the latter in both the cases i. e., adults and grubs is not significant and it does not, therefore, necessitates adjustment in the latter population. Conse-

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quently the analysis of variance of this latter population (72 hours after the application) has revealed that the variations due to treatments versus control in both (adults an grubs) are significant.

The summary of results giving the mean number of adults and grubs after the application of the insecticidal treatments is presented below in Table Nos. 7 and 8 respectively.

Table 7

Summary of results — Adults

	Treatments	Mean No. of adults
1	Dusting with 10% Carbaryl dust at 25 lbs per acre	2.3
2	Dusting with 5% Chlordane dust at 25 lbs per acre	3.3
3	Dusting with 4% Malathion dust at 25 lbs per acre	4.0
4	Dusting with 10% BHC dust at 25 lbs per acre	4.0
5	Dusting with 10% DDT dust at 25 lbs per acre	4.3
6	Dusting with 5% DDT dust at 25 lbs per acre	5.0
	Mean	3.8
	Control	13.2
	Critical difference at 5% level of significance for treatment means versus control	2.13

Table 8

Summary of results — Grubs

	Treatments	Mean No. of grubs
1	Dusting with 10% Carbaryl dust at 25 lbs per acre	2.0
2	Dusting with 10% DDT dust at 25 lbs per acre	4.0
3	Dusting with 10% BHC dust at 25 lbs per acre	4.3
4	Dusting with 5% Chlordane dust at 25 lbs per acre	5.0
5	Dusting with 5% DDT dust at 25 lbs per acre	5.0
6	Dusting with 4% Malathion dust at 25 lbs per acre	6.0
	Mean	4.4
	Control	16.8
	Critical difference at 5% level of significance for treatment means versus control	4.5

It would appear from the above Tables that the mean number of adults and grubs for control are significantly superior to those of all the treatments (taken together) in both the cases separately. By examining the individual figures it has been found out that the dusting of the infested waternut crop with 10% Carbaryl dust at the rate of 25 lbs per acre has proved to be best of all the treatments included in this trial against the adults and grubs of *Galerucella birmanica* JACOBY. Similar insecticidal trial conducted on field scale in Varanasi district has confirmed that 10% Carbaryl dust is most efficacious in controlling this pest when compared with other treatments included in the trial viz., dusting the crop with 10% BHC dust, 10% DDT dust and 5% Aldrin dust each used at 25 lbs per acre and spraying the crop with 0.1% Phosdrin emulsion and 0.1% Endrin emulsion each used at 44 gallons per acre.

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Summary

Galerucella birmanica JACOBY is exclusively a pest of waternut, *Trapa bispinosa* ROXBURGH, and occurs throughout India. Probable causes for the confusion in defining the genus *Galerucella* are reviewed. Nature and extent of damage as well as its life and seasonal histories are described. These beetles are found to be partially resistant to BHC or other chlorinated hydrocarbons. As a result of insecticidal trials conducted on field scale to evolve alternative methods of control 10% Carbaryl dust at the rate of 25 lbs per acre has proved effective in controlling this serious pest.

Zusammenfassung

Galerucella birmanica JACOBY ist ein Schädling, der nur die Wassernuß *Trapa bispinosa* ROXBURGH befällt und in ganz Indien verbreitet ist. Die wahrscheinlichen Gründe für die Unsicherheit in der Abgrenzung der Gattung *Galerucella* werden erörtert. Art und Umfang des Schadens sowie Leben und jahreszeitliche Entwicklung des Insekts werden beschrieben. Es wurde festgestellt, daß diese Käfer teilweise gegen BHC und andere chlorierte Kohlenwasserstoffe resistent sind. Bei Freilandversuchen mit Insektiziden zur Entwicklung anderer Bekämpfungsmethoden erwies sich zehnprozentiger Carbarylstaub in einer Dosierung von umgerechnet 25 kg/ha als wirksam in der Bekämpfung dieses gefährlichen Schädlings.

Резюме

Galerucella birmanica JACOBY вредитель, который отмечается только на *Trapa bispinosa* ROXBURGH. Обсуждаются вероятные причины ненадёжности обграничивания рода *Galerucella*. Описывается вред, жизнь и развитие этого насекомого. Отмечался, что этот жук частично показывает сопротивление против BHC и других хлоровых углеводородов. При полевых опытах с инсектицидами для развития других методов борьбы оказался десятипроцентный порошок Carbaryl в дозировке 28кг/га эффективный для борьбы с этим опасным вредителем.

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