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BIOLOGICAL INVESTIGATION OF THE MANGO LEAF CUTTING WEEVIL, *Deporaus marginatus* PASCOE, IN LABORATORY AND NURSERY

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ABSTRACT

The biological investigations were made in the laboratory and mango nursery on the oviposition behaviour and development of different stages of life cycle of mango leaf cutting weevil, Deporaus marginatus Pascoe along with its natural enemies. Female weevils were mated with males for less than 30 minutes and eggs were deposited singly on the tender leaves manoeuvreing with snout at some egg to egg distance followed by cutting the leaves which dropped on the soil. The work was conducted through a series of field experiments in the nursery supported by laboratory experiments from January, 2006 to December, 2008. The experiments were conducted at the Fruit Research Station, Rajshahi, Bangladesh. Observations were made on the occurrence of predators, parasitoids and pathogens in the laboratory and nurseries. Investigations were also made on any biocontrol agents attacking weevil eggs, larvae, pupae and adults .Leaf cutting weevils of each life stage were examined daily after maintaining the collections in Petri dishes. Female laid 7.14 eggs per mango leaf, usually on the dorsal side of midrib. The developmental period from egg to adult was 435.37 hours (19.06 days), the egg stage lasted for 47.83 hours (1.99 days), the three larval instars lasted 144.97 hours (6.04 days) and the pre-pupa and pupal stage took 93.40 hours (3.89 days) and 171.17 hours (7.13 days) respectively. The adult longevity was 47.50 days in male and 36.50 days in female. The larval development occurred in fallen tender cut leaves. *Deporaus marginatus* was hibernated as final instar larva during winter months when its population was not observed in the nursery. Ants and spiders were found to feed on immature larva of this insect. Ants and spiders were found to feed on the immatures of mango leaf cutting weevil, the former being the most active on immature prey.

KEYWORDS : *Deporaus marginatus*, Oviposition Behaviour, Mango Nursery, Natural Enemies, Biocontrol Agents

Popenoe (1964) called mango "the king of the oriental fruits". Mango is now cultivated in several countries of the tropical and subtropical regions of the world as a commercial crop and in Bangladesh there are major mango growing areas in the northern districts. A home garden without a mango tree is very rare in the country. A large number of insect pests cause considerable damage to mango trees as well as fruits. There are over 175 species of insects damaging mango (Vevai, 1969; Nayaret al. 1976). Only a handful of these are of major importance and others are minor. Pena et al. (1998) reported 260 species of insects and mites as minor and major pests of mango infecting fruit, foliage, inflorescence, buds, branches and the trunk. Among the pests, 48 mango leaf cutting weevil (*Deporaus marginatus* Pascoe) is considered a major pest (Hill, 1983) which causes extensive damage to the foliage. These weevils attack new flushes of leaves and destroy them completely leaving only the stem. Young trees suffer more than the older ones. After oviposition the female weevil cuts the leaf near the base in the form of a clear and sharp cut. The cut leaves drop to the ground, and the shoots are defoliated, lose vigor and become weak. The male and the female adults attack the new flushes of leaves and feed by scrapping the leaf tissues, as a result the leaves became crumpled and curled inwardly. The damage is 57 however more conspicuous in nurseries where the 57 vegetative growth of a graft is arrested. A preliminary investigation demonstrated that grafted plants of different varieties are more heavily damaged by this insect. A review of available literature did not reveal any information about the extent of damage due to *Deporaus marginatus*. However, in India the damage to some mangos by leaf cutting weevil was reported as 53.9 to 57.4 % defoliation (Rafiquzzamanet al. 1999) and this weevil caused damage as much as 53% on grafted plants (Uddinet al. 2003). Some work has been done in different countries on the biology of this pest. However, detailed information on its biology and its natural enemies is lacking and is essential for the management of this pest.

MATERIALS AND METHODS

The research works on mango leaf cutting weevil, *Deporaus marginatus* Pascoe attacking mango plants were done through a series of field experiments in the nursery supported by laboratory experiments during the period from January, 2006 to December, 2008. The experiments were conducted in the Fruit Research Station, Rajshahi,

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A colony of weevil was maintained in a Petri dish (20 cm dia) in the laboratory from collection of freshly egg deposited on just fallen cut leaves . The larval and pupal stages were allowed to complete over and inside the soil. The observations on egg, larval, pre-pupal and pupal periods and cocoon formation in earthen shell along with detailed morphology of immature and mature stages including size of eggs, larvae, pupae and adult males and females were taken. The duration of each stage was recorded frequently in hours. Mating behaviour of adults including mode of egg deposition was also recorded under laboratory condition. The time needed for boring, inserting and hole sealing during egg laying was recorded. The number of eggs hatched per pair of adult weevil was recorded. The prereproductive and reproductive periods were recorded. To measure the depth of the cocoon formation in the soil for pupation of *Deporaus marginatus*, the egg deposited on cut leaves were kept on the wooden tray (30×25×12cm) covered with glass on top, containing a layer of 10 cm moist soil at its bottom. After formation of pupal stage depth was measured by scale.

The studies were made on the occurrence of predators, parasitoids or pathogens in the laboratory and nursery field of mango. Continuous observation was made on the attack of any of the biocontrol agents to eggs, larvae, pupae and adults. Some individuals of each stage of the leaf cutting weevil were examined daily after collection and keeping them in Petri dishes. The photographs and video were taken for different stages of life cycle and natural enemies.

RESULTS

Mating and Oviposition Behaviour

Freshly emerged adults did not mate. The mating commenced after 2 days of emergence. The adults mated freely in both the field and the laboratory. The mating posture was normal; the male grasped the female and performed before this function. Adults mated repeatedly before and after oviposition. The mating continued so long the male and female were alive. The mode of egg laying was observed on the tender mango leaf. The female searched on the dorsal surface of the whole leaf before oviposition and finally rested at the midrib towards laminal base leaving a space of 1.66 ± 0.20 cm (Table 1) from the base of lamina.

Table 1 : Mating Period, Mean Oviposition Distance and Length of Ortion of Tender and.

Items	Range	Mean	SE
Mating period in lab (min)	9-50	24.20	3.97
Mating period in field (min)	6-35	17.70	2.68
Oviposition distance (mm)	2.00 - 8.00	4.15	0.40
Cut tender leaf with branch(cm)	0.30 - 3.60	1.66	0.20
Cut mature leaf with branch(cm)	1.00 - 4.00	2.28	0.18

Table 2. Time Required in Different Steps For Deposition of Eggs and Cutting Leaf By Female of Deporaus Marginatus During Laying Eggs on Mango Leaf.

Items		Range	Mean	SE
Boring time for inserting egg (sec)		48 - 105	71.64	3.49
Time needed for inserting egg (sec)		11 - 48	20.04	2.04
Time for sealing hole after inserting egg (sec)		7 - 20	12.32	0.83
Total time for egg deposition (sec)		63 - 135	104	3.93
Time for cutting leaf (min)		3.97 - 6.07	4.82	0.21
Pouch length (mm)		1.02 - 1.10	1.06	0.01
Pouch breadth (mm)		0.42 - 0.53	0.46	0.01
Time and oviposition rate	Time (Min)	5 - 16	9.08	0.58
	Egg laid (no.)	2 - 7	4.04	0.27

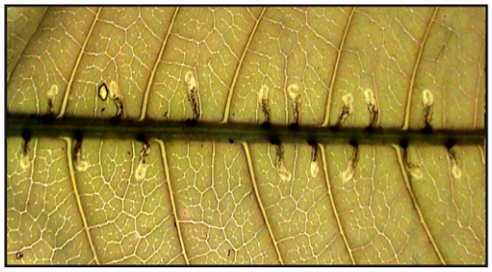

Plate 1 : Showing arrangement of hatched eggs laying alternately along the side of a midrib

Plate 2 : The process of cutting tender leaf by female mango leaf cutting weevil.

The female made a small pouch by inserting full length of snout at the side of midrib for an egg and then she turned about and bent the abdomen slightly to lay an egg inside it pushing it deep into the pouch and deposited a single egg in each pouch. Soon after deposition of egg it again turned around and covered the opening of the pouch by the exudates from around the pouch, so that the egg got full protection against any hazards. Thus the female could complete oviposition. Sometimes the female was also found to deposit the eggs on the midrib at the ventral surface of the leaf . The spots on the egg laying area appeared brownish and were found almost right and or left alternately alongside the midrib and hatched accordingly (Plate 1). The time taken for making pouch, depositing egg and repairing (sealing) of pouch was about 71.64 ± 3.49, 20.04 ± 2.04 and 12.32 ± 0.83 seconds (Table 2). To make the whole process the time needed was 104.0 ± 3.93 seconds with the mean of 104 seconds. The mean oviposition distance from egg to egg was 4.15 ± 0.40 mm (Table 1). The average length and breadth of the pouch were 1.06 ± 0.01 mm and 0.46 ± 0.01 mm respectively (Table 2).

Immediately after completion of egg laying, the female adult made an incision first in the midrib of the same leaf and then cut the laminal part along that particular point of incision on either side resulting scissor like cut (Plate 2). The egg bearing leaf then fell on the ground facilitating the newly hatched larvae to feed on the fallen leaf by making mines freely. The time taken for cutting the leaf was observed to be on an average of 4.82 ± 0.21 minutes (Table 2).

Egg and Egg Developmental Period

Freshly laid eggs were small, creamy white and nearly transparent, cylindrical, smooth, both ends rounded and without any distinct markings. It became dull yellow at

Table 3 : Morphometric Measurements of Immature and Adult Stages of Deporaus marginatus

Stages	Length (mm)				Width (mm)				Snout Length (mm)			
	Range				Range				Range			
	Min	Max	Mea	SE	Min	Max	Mea	SE	Min	Max	Mean	SE
Egg	0.57	0.73	0.66	0.02	0.25	0.32	0.29	0.01				
Larva												
First instar	1.58	2.10	1.85	0.05	0.68	1.00	0.87	0.03				
Second instar	2.97	3.34	3.13	0.05	1.01	1.50	1.21	0.05				
Third instar	4.61	5.29	4.96	0.08	1.81	2.05	1.94	0.03				
Pre pupa	5.00	5.52	5.26	0.06	1.50	1.76	1.59	0.02				
Pupa	3.76	4.49	4.02	0.07	1.50	1.76	1.65	0.03				
Adults												
Male	4.49	5.05	4.71	0.06	1.53	1.86	1.70	0.04	1.05	1.13	1.12	0.01
Female	4.79	5.58	5.15	0.09	1.53	2.10	1.96	0.06	1.32	1.42	1.39	0.02

Table 4. Duration of Egg and Immature Stages of Deporaus Marginatus on Mango Leaf

Stages	Total observed (no)	Range (hour)		Mean duration (hour)	SE	Mean duration (days)
		Min	Max			
Egg	47	45	50.67	47.83	0.53	1.99
Larva						
First instar	37	20	29.4	24.58	0.94	1.02
Second instar	37	24	34.8	29.17	1.23	1.22
Third instar	37	87	96	91.22	1.04	3.80
Pre pupa	31	89	100	93.40	1.53	3.89
Pupa	25	162	185	171.17	2.22	7.13
Egg to Adult		426	495.9	457.37		19.06

the time of hatching. Length and width of the eggs were 0.66 ± 0.02 mm and 0.29 ± 0.01 mm (Table 3). The developmental period of eggs was 47.83 ± 0.53 hours i.e 1.99 days (Table 4). The female preferred to lay eggs in the 25 per cent area from the base of fallen cut leaf where 5.2 eggs were laid (Fig. 1). A few eggs 0.14 in number were laid on the 76-100 per cent area of the cut leaf. First oviposition was done 0.60 ± 0.03 cm apart from the cut end of the fallen leaf and spread up to 4.83 ± 0.47 cm of total leaf area of 13.36 ± 0.47 cm (Table 5).

Total number of eggs laid was found to be 7.14 ± 0.53 per leaf (Table 5). Two pairs of male and female were observed to record their daily egg hatching. The daily number of hatched eggs were 2 to 28 and 12 to 25 with the total hatched eggs of 762 and 415 for the first and second pair, respectively (Table 6). Pre-reproductive period was short and reproduction period was long with the mean of 31.50 days (Table 6). Different stages of life cycle of *Deporaus marginatus* shown in Plate 3.

Larva and Larval Period

When egg hatched inside the midrib, the larva came out of the midrib. There were three larval instars showing no significant differences in the general characteristics of the three instars except for the size of the body and head capsule. The larva on hatching eggs mined and fed between leaf surface seen as small narrow galleries with full of excreta. The final instar larvae remained inside the fallen dead and dried leaves which could be exposed by breaking the leaves. The larva was apodous, moderately stout, thin and pliable, subcylindrical, flat, weakly curved; head exerted, retracted into prothorax, depressed, lightly pigmented, mouth prognathous,thorax three segmented, body hair fine. Abdomen with ten segments, exhibits transverse folds with two dorsal plicae in each segment . The third instar larva was yellowish or dirty green and more active than the preceding instars. The mean length and width of first, second and third instar larvae showed variations of 1.85 ± 0.05 mm, 3.13 ± 0.05 mm and 4.96 ± 0.08 mm and width of 0.87 ± 0.03 mm, 1.21 ± 0.05 mm and 1.94 ± 0.03 mm respectively (Table 3). The developmental period of first, second and third instar larvae were observed as 24.58 ± 0.94, 29.17 ± 1.23 and 91.22 ± 1.04 hours respectively (Table 4).

Pupa and Pupation

A full grown larva bored its way out of the withered leaves and entered into the soil. On finding a suitable location with loose soil, the larva constructed a small earthen shell or cocoon for pupation which was round and contained one full grown larva . The larva remained inactive for a period 93.40 ± 1.53 hours (3.89 days) as a prepupal stage (Table 4). Then it was transformed into a pupa. The length and breadth of pre pupa were 5.26 ± 1.06 mm and 1.59 ± 0.02 mm (Table 3).

The earthen shells (cocoon) were found normally at a mean depth of 1.50 ± 0.15 cm in the soil measuring 3.91 ± 0.10 mm in diameter (Table 7), having single pupa in each shell (Plate 4).

Newly formed pupae were uniformly whitish yellow. Body was soft with minute setae, head was little broad bearing two pairs of divergent sitae, one pair above eyes and one pair at the juncture of beak and head. Other pairs of setae were present in other positions of the body.

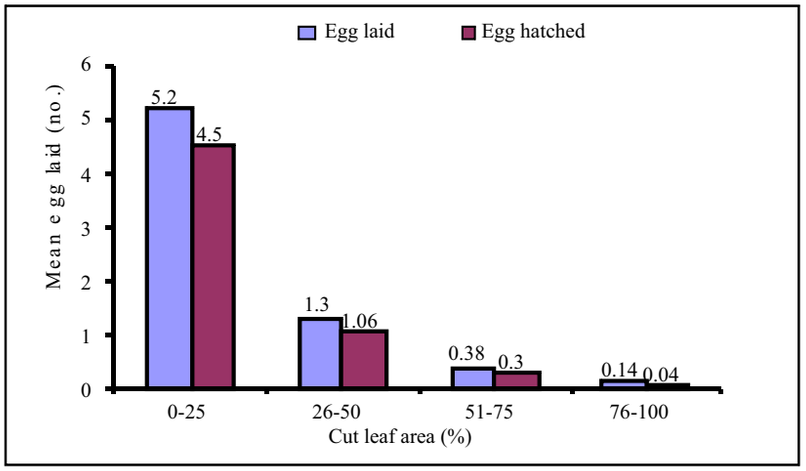

Figure 1 : Oviposition and Egg Hatching in Different Cut Leaf Areas of Mango Leaf By Leaf Cutting Weevil.

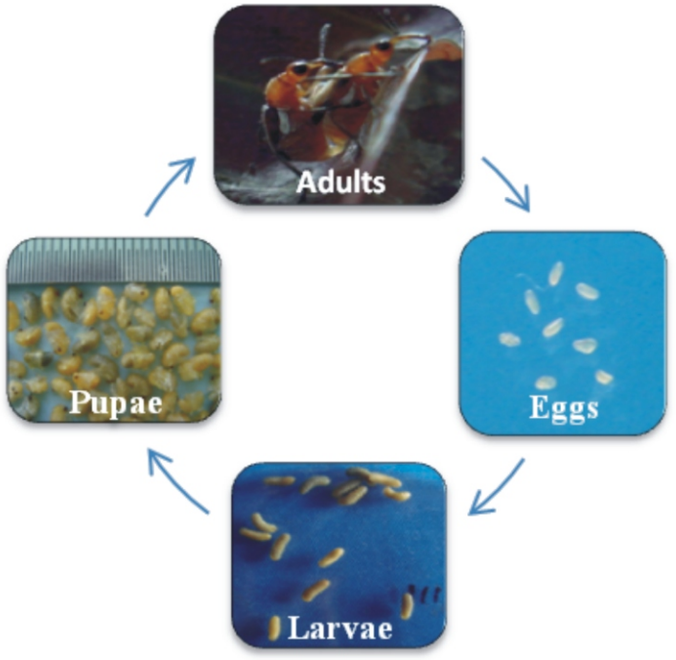

Plate 3 : Different Stages in Life Cycle of *Deporaus marginatus*

The length and width of the pupa were 4.02 ± 0.07 mm and 1.65 ± 0.03 mm (Table 3) and the pupal period was 171.17 ± 2.22 hours (7.13 days) (Table 4). The total life cycle of the leaf cutting weevil from egg to emergence of adult was 457.37 ± 7.43 hours (19.06 days) (Figure 2).

Adult Morphometrics and Duration

Adult weevil emerged out by breaking the earthen shell . The opening of the shell was 1.65 ± 0.05 mm in diameter (Table 7). The male weevil was slightly smaller than the female measuring 4.71± 0.06 mm in length and and 1.70 ± 0.04 mm in width. Both the sexes were dark brown in colour with reddish orange prothorax and femora. It exhibited differences in colour such as reddish brown with yellowish abdomen and uniform black. Snout was slender and strongly curved being shorter in male than the female. The length of the male's snout was shorter than that of

Table 5 : Oviposition, Egg Hatching and Oviposition Distance in Different Areas of Mango Leaf by *Deporaus marginatus*

Items		Range	Mean	SE
Length of cut leaf (cm)		6.80 - 21.50	13.36	0.47
Total egg laid per leaf (no.)		2 - 18	7.14	0.53
Total egg hatched per leaf (no.)		2 - 18	5.90	0.48
0 - 25% leaf area	Egg laid (no.)	2 - 15	5.20	0.35
	Egg hatched (no.)	0 - 14	4.50	0.35
26 - 50% leaf area	Egg laid (no.)	0 - 7	1.30	0.21
	Egg hatched (no.)	0 - 7	1.06	0.19
51 - 75% leaf area	Egg laid (no.)	0 - 4	0.38	0.13
	Egg hatched (no.)	0 - 4	0.30	0.11
76 -100% leaf area	Egg laid (no.)	0 - 4	0.14	0.09
	Egg hatched (no.)	0 - 1	0.04	0.03
1st oviposition distance (cm)		0.40 - 1.10	0.60	0.03
Last oviposition distance (cm)		0.70 - 14.50	4.83	0.47

Table 6 : Mean Number of Hatching Eggs, Pre-reproductive and Reproductive Period and Adult Longevity of *Deporaus Marginatus*.

Adult pair	Range of hatching eggs per day (no.)	Total hatching eggs (no.)	Pre-reproductive period (day)	Reproductive period (day)	Adult longevity (day)	
					Male	Female
Pair 1	2 - 28	762	2	41	54	46
Pair 2	12 - 25	415	2	22	41	27
Mean		588.50	2	31.50	47.50	36.50
SE		116.20	0.03	7.75	4.30	5.81

female (Table 3). The antennae was elongate and was inserted well below the middle of the snout. The longevity of male weevil was 47.50 ± 4.30 days and that of female 36.50 ± 5.81 days (Table 6). The survival of immatures emerged from egg stage were 67.62-76.79 per cent and 62.96 per cent became adults (Figure 3). The overall total life cycle duration from egg to egg was 55.56 days (Figure 2).

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Adult weevil emerged out by breaking the earthen shell . The opening of the shell was 1.65 ± 0.05 mm in diameter (Table 7). The male weevil was slightly smaller than the female measuring 4.71± 0.06 mm in length and and 1.70 ± 0.04 mm in width. Both the sexes were dark brown in colour with reddish orange prothorax and femora. It exhibited differences in colour such as reddish brown with yellowish abdomen and uniform black. Snout was slender

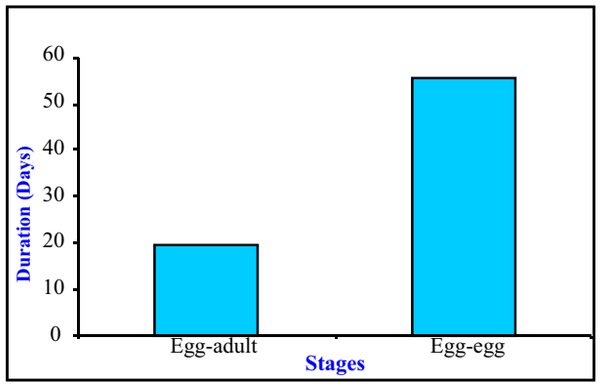

Figure 2 : Total Duration From Egg to Adult and Egg to Egg of Mango Leaf Cutting Weevil.

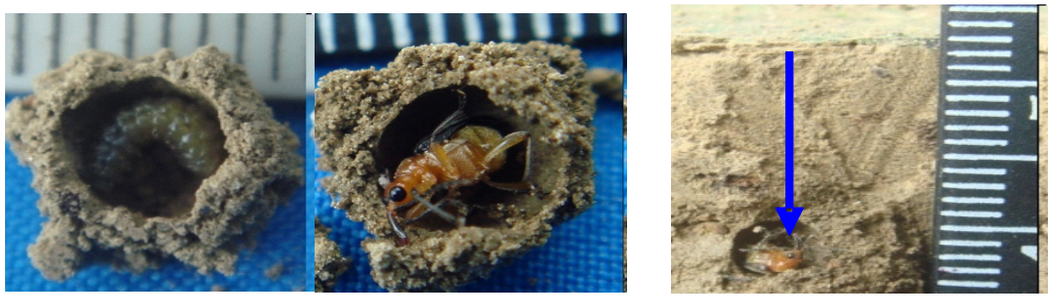

Plate 4 : The Size of Pupal Shell of Mango Leaf Cutting Weevil (Left) and Depth of Pupal Shell (Right).

Table 7 : Mean Soil Depth for Cocoon Formation, Cocoon Diameter and... Hole Diameter on Soil Surface for Adult Emergence

Items	Range	Mean	SE
Soil depth (cm)	0.50 - 3.70	1.50	0.15
Cocoon diameter (mm)	3.25 - 5.00	3.91	0.10
Hole diameter on soil surface(mm)	1.25 - 2.00	1.65	0.05

and strongly curved being shorter in male than the female. The length of the male's snout was shorter than that of female (Table 3). The antennae was elongate and was inserted well below the middle of the snout. The longevity of male weevil was 47.50 ± 4.30 days and that of female 36.50 ± 5.81 days (Table 6). The survival of immatures emerged from egg stage were 67.62 76.79 per cent and 62.96 per cent became adults (Figure 3). The overall total life cycle duration from egg to egg was 55.56 days (Figure 2).

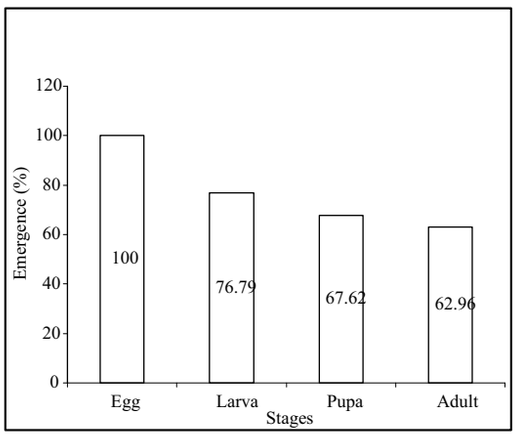

Figure 3 : Percentage of Larva, Pupa and Adult Emergence From the Eggs (100=6.98 egg/leaf).

Hibernation of Leaf Cutting Weevil

When the full fed final instar larvae entered in to the soil for pupation in the month of mid November they remained inactive showing no obvious change. It remained in this stage until mid February and thereafter pupae were formed. Thus the larvae passed the winter months without going to form pupae. The temperature began to rise from March when the adults started emerging from the soil.

Natural Enemies

Only two types of predators were found in association with this insect. The predators were ants and spiders. The ants and spiders were not identified but they were found to feed on the larva and pupa of leaf cutting weevil. Several ants attacked a single larva and also pupa (Plate 5). The ants preyed the larvae found on the surface and pupae inside the soil where the pupae remained till the emergence of adult . The ants dragged the preys during feeding. The spider of brown colour directly attacked the larvae of mango leaf cutting weevil and sucked up the body fluid by holding the prey into the mouth until its death. The larvae fed by this spider predator could not move and died (Plate 6).

Plate 5 : . Several ants attacked Larvae of Mango Leaf Cutting Weevil to Carry Them in the Nest Showing Hole

Plate 6. Spider attacked a larva of mango leaf cutting weevil and in feeding state

DISCUSSION

The results of the present investigation indicated that *Deporaus marginatus* mated two days after emergence and it occurred freely and frequently under both laboratory and field conditions. The duration of the mating lasted for 24.2 minutes in the laboratory and less by 6.5 minutes in the field. Adults mated repeatedly before and after oviposition. This was in parity with the findings of Rafiquzzaman and Maiti (1998) who reported that *Deporaus marginatus* mated freely in both field and in captivity and mating usually took place 2-3 days after adult emergence and lasted for 15-40 minutes. The duration of mating of *Deporaus marginatus* in the present study and the other workers already mentioned differed from Tigvattnanont (1988) who observed the begining of mating on 5th and 7th day after emergence. But the other aspects of mating were the same.

The female of mango leaf cutting weevil demonstrated a remarkable feature during oviposition. The whole process consisted of making pouch by boring, inserting egg and sealing hole (opening of pouch) after laying egg in order to ensure the security of the egg. The weevil took a certain time to complete this process which lasted for 104 seconds. About three-fourth of the total time was required for making pouch, and little time was spent for other events such as boring, egg insertion and sealing the opening of the pouch. The female weevil preferred for oviposition within 25 per cent area of the cut leaf from the base of lamina in which the maximum egg laying as much as 72.82 per cent egg were laid. The rest of the eggs were laid towards the tip of the lamina. It was possible that the weevil chose the wider area of the midrib for oviposition which was present within the 25 per cent area from the base of cut leaf. The midrib was narrower towards the tip and seemingly not suitable for oviposition.

The larva of mango leaf cutting weevil completed three instars with distinct morphological variations at each instar stage the last instar larva being large in size. The larva was apodous concentrating its development on the tender mango leaf in localized position and became more active in the final instar than in the preceding ones. The total larval period lasted for 6.04 days in which over 50 per cent of the period was occupied by the final instar. The pupa of mango leaf cutting weevil was of exerate type, the appendages free from the body which is the general character of coleoptera. The pupal period remained for week followed by a short pre-pupal stage which was about half the pupal period.

The life cycle of mango leaf cutting weevil from egg to adult lasted for 19.06 days and total life cycle form egg to egg was 55.56 days. The mango leaf cutting weevil at adult stage lived longer than the egg and immatures which was almost double the duration of egg-adult. The life cycle of mango leaf cutting weevil averaged 65.25 days (Bhole and Dumbre 1989). It was possible that the difference of life cycle of mango leaf cutting weevil in the present study and that of other findings was due to different ecological factors of different places influencing on the life cycle of mango leaf cutting weevil.

Mango leaf cutting weevil hibernated at the larval stage particularly when they became full grown and ready for undergoing pupation. This condition occurred in the month of mid November until February when the temperature was 25.66^0C and 19.28^0C. When the

temperature was found to increase from March the adult weevils started emerging at the end of hibernation period The peak incidence of dormancy in the larval stage was induced at the onset of winter, i.e. during November when the temperature fall below 26^0C and dormancy terminated by an increase of temperature above 26^0C during February (Rafiquzzaman and Maiti 1999).

The ant was the most important predator feeding on larvae in exposed condition as well as pupae inside the earthen shell. The spider preyed on the larvae only as it could not get access to the pupae remaining in concealed chamber.

CONCLUSION

The biological observations revealed that only the female weevils of *Deporaus marginatus* cut the tender pinkish leaves of mango plants after oviposition for the purpose of continuity of the life cycle. This insect became prevalent from March onwards till November in relation to increased temperature and relative humidity but were not present in winter months which were considered to be the period of hibernation and limiting factors for its abundance. Two types of predators such as ant and spider were found to feed on the immatures of mango leaf cutting weevil, the former being the most active on immature prey. Further study is needed to explore the biotic potential of these predators in mango agroecosystem.

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