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Study of Diversity and Abundance Pattern of Natural Enemies Associated with the Mango Mealy Bug (*Drosicha mangiferae* G) at Malda of West Bengal, India

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ABSTRACT

Background: As a pest, the mango mealy bug (*Drosicha mangiferae* G) is very important as it ranks second in terms of damage inflicted to the fruit crop. Natural enemies such as predators, parasitoids are considered to be significant deterrent of mango mealy bug. These natural enemies can act as biological control agent which can bring about pest suppression as an important tool of integrated pest management. Therefore, studies of natural enemy complex of mango mealy bug become pertinent. In the current study the available predators, parasitoids of mango mealy bug was surveyed at different regions of Malda.

Methods: The predators of mango mealy bugs were studied by sampling mealy bug infested colonies present in the inflorescence and in 20 cm^2 area of trunk. Sampling was carried out by visualization of predatory behavior of the entomophagous insects. Parasitoid was studied by observing the emergence of adults from infested mealy bugs in a closed container.

Result: Ladybird beetles and Green lacewings were the most abundant predators; their relative abundance was 48.96% and 37.30%. Among the coccinellids, *Rodalia amabilis* and one unidentified coccinellid were found as dominant. The green lacewing larva, *Chrysoparla* sp. acted as important predator. Besides Ladybird beetles and Green lacewings, the spiders and bugs were also noticed in the predatory guild. Only one dipteran parasitoid species, *Cryptochetum sp. nr. iceryae* (Williston) was found to parasitize the mealy bugs. The standardization of mass rearing techniques for the three predators and one parasitoid and their release in the mealy bug infested orchards can bring about efficacious control of this menacing pest.

Key words: Coccinellids, *Cryptochetum* sp. nr. *iceryae* (Williston), Green lacewing, Mango mealybug, Parasitoids.

INTRODUCTION

Mango (*Mangifera indica* L.) is deliberated to be the 'King of fruits', because the presence of its unique sweet taste and nutritional as well as medicinal values (Litz, 1997). On the basis of the production data, in India, the total production of mango is around 3.95 million tons, which is about 57.18% of the world fabrication (Sahoo and Jha, 2009). The Gangetic plain of West Bengal contributes immensely to the total production of West Bengal State with a variety of mango cultivars (Jha *et al.,* 2006). In terms of production Malda tops the list amongst different districts of West Bengal with an annual production of about 292.28 metric tons (Anonymous, 2018).

Besides the rampantly changing climatic conditions during the mango growing time, the insect pests inflict major damage to mango production (Ishaq *et al.,* 2004). There are about 260 insect species that wreak havoc on mango orchards (Pena *et al.,* 1998). If the insect pests of major importance is considered then mango mealy bug, *Droschia mangiferae* (G.) is hugely important for the mango growers as it causes quantum fruit drop and loss (Karar, 2010). The coating of wax all over the body of mango mealy bug (MMB) makes skin impervious to water so it is very difficult to manage this insect pest with contact pesticide application. Farmers adopt array of different combinations of practices like cultural, mechanical, biological and chemical methods of control to avoid the yield loss. Insecticides, though used widely, have environmental constrains. Therefore, natural enemies such as predators and parasitoids are very important for lowering the pest and for the reduction of pesticide application. Predatory coccinellids and Chalcid parasitoid wasps, encyrtids (Hymenoptera, Encyrtidae) act as the most important natural enemies for mango pests (Iperti, 1999). Mango mealy bugs in India are known to be

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predated by four different genera of lady bird beetles belonging to Chilocorinae (Sub-Family) and six genera of Scymninae (Sub-Family); the Chilocorinae beetles are *Brumus*, *Stictobura*, *Orcus* and *Aspidimerus* and *Cryptolaemus, Nephus, Diomus, Sidis, Parasidis* and *Pseudoscymnus* belonging Scymninae subfamily also prey preferentially on mealy bugs population (Iperti, 1999). Beside Coccinellidae, brown lacewings (Neuroptera; Hemerobiidae) and predatory gall midges (Diptera; Cecidomyiidae) are important predator of scale insects (Tandon and Lal, 1978). A wide array of predators and parasitoids has been found to be present and they play important role to control the mango mealy bug populations in mango orchards (Jakhar *et al.,* 2016; Hayat, 2009). Nevertheless, there is no published literature on predator abundance or diversity against mango mealy bug of the species (*D. mangiferae*) which is one of the important pests of mango.

Hymenopteran and Dipteran parasitoids are considered to be very effective against scale insects and as found elsewhere (Larson, 2013). But work on dipteran parasitoid of mango mealy bug has not been reported from India till date. Information pertaining to parasitoid species of a pest is very important to formulate biological control strategies. In the backdrop of this context the current study was undertaken to measure the abundance and diversity of predators and parasitoids associated with mango mealy bug pest at Malda region of West Bengal.

MATERIALS AND METHODS

Site of study

Seasonal periodicity, incidence and abundance of mango mealy bug (MMB), *D. mangiferae* and occurrence of its natural enemies in the form of predators and parasitoids was noted from selected villages of the Malda District of West Bengal during 2020 and 2021. The villages had mostly langra, fazli, lakhanbhog, gopalbhog and himsagar cultivars. The villages were Manikchak (25°03′45″N-87°54′33″E), Ratua (25°20′01″N-87°92′74″E) and Chanchal (25°39′N-87°99′E) of the District Malda, West Bengal.

In inflorescence

Ten mealy bug infested inflorescence from each of the two selected orchards from each village were primarily taken in to the laboratory after wrapping it in a plastic bag with proper aeration. For observation and identification of predators these MMB infested inflorescence were rinsed in 70% alcohol to kill and preserve predators. Side by side, the large and medium sized agile predators were captured on observational day using an aspirator and also preserved in 70% alcohol.

In the tree trunk

Presence of natural enemy in 20 cm^2 area of tree trunk was located and visually counted from randomly chosen three trees from two different mango orchards. Individual sample of predator was kept as type specimen and also for further taxonomic identification.

Study on the incidence of MMB parasitoids

During March-April 2018, 100 randomly collected mealy bugs from two different orchards were kept in a plastic jar, covered with organza material that was tied with rubber band. 50% honey soaked cotton was kept over the organza to ensure as food source for the emerging parasitoid, if any, that came out of the mealy bug. Fresh mango leaves as food was given to the mealy bugs. The leaf-petioles were tied with water soaked cotton to keep the moisture level. After 20-25 days flies emerged from mealy bugs. Fly was etherized and accordingly counted and the extent (%) of parasitization was further assessed (Chrysantus, 2012). The study was carried out at laboratory of insect ecology and pest management, Department of Zoology, Raiganj University.

Taxonomic identification

i) The adults of Coccinellids were identified using one stereo zoom microscope and available standard key (Jouveau *et al.,* 2018 and Angelfire, 2022).
ii) The larvae of lady beetles were identified after consulting available literature. (Bugguide, 2022).
iii) Spiders were identified using available pictorial keys (Yadav *et al.,* 2004).

Some important predators found during the study were identified by Scientist C of ZSI, Kolkata. Parasitoid was identified by Principal Scientist, National Research Centre for Banana (NRCB), Trichyrappally, Tamil Nadu.

RESULTS AND DISCUSSION

Study of the existing predators in the mango orchards

During 2020 and 2021 at specific mango orchards, grossly 20 species of predators are noticed. Ladybird beetles (Family: Coccinellidae), Green lacewings (Family: *Chrysopidae*), spiders (Family: Oxyopidae, Family: Lycosidae, Family: Salticidae and Family: Tetragnathidae), green stinkbug (Family: Pentatomidae, *Chivaria* sp.), brown marmorated stink bug (Family: Pentatomidae, *Halyomorpha* sp.) and Mediterranean red bug (Family: Pyrrhocoridae, *Scantius aegypticus*) were identified to feed on mealybug colony.

Ladybird beetles (Family: Coccinellidae) such as *Rodolia amabilis* (Kapur), *Harmonia axyridis* (Pallas), *Chelomenes sexmaculatus* Fabricius, *Micraspis discolor* Fabricius, *Coccinella transversalis* Fabricius, *Propylaea japonica* Thunberg, *Scymnus (pullus) posticalis* Motschulsky were found. Among the spiders, *Oxyopes tridens* Brady, *Oxyopes javonicus* Thorell, *Plexxipuspa kulli* Audouin, *Hyllus semicupreus* Simon, *Pardosa agricola* Thorell, *Leucauge decorata* Walckenaer are identified.

Apart from, green stinkbug (*Chivaria* sp.), brown marmorated stink bug *(Halyomorpha* sp.) and Pyrrhocorid bug (*Scantius* sp.) are identified. Considerable variation of the natural enemies is observed between the selected orchards in both insecticide treated and untreated fields.

Rodalia amabilis and Chrysopidae larva was found to be the most abundant followed by one unidentified Coccinellidae A larva and others (Fig 1, 2, and 3) (Table 1, 2).

Parasitoid in mango orchards

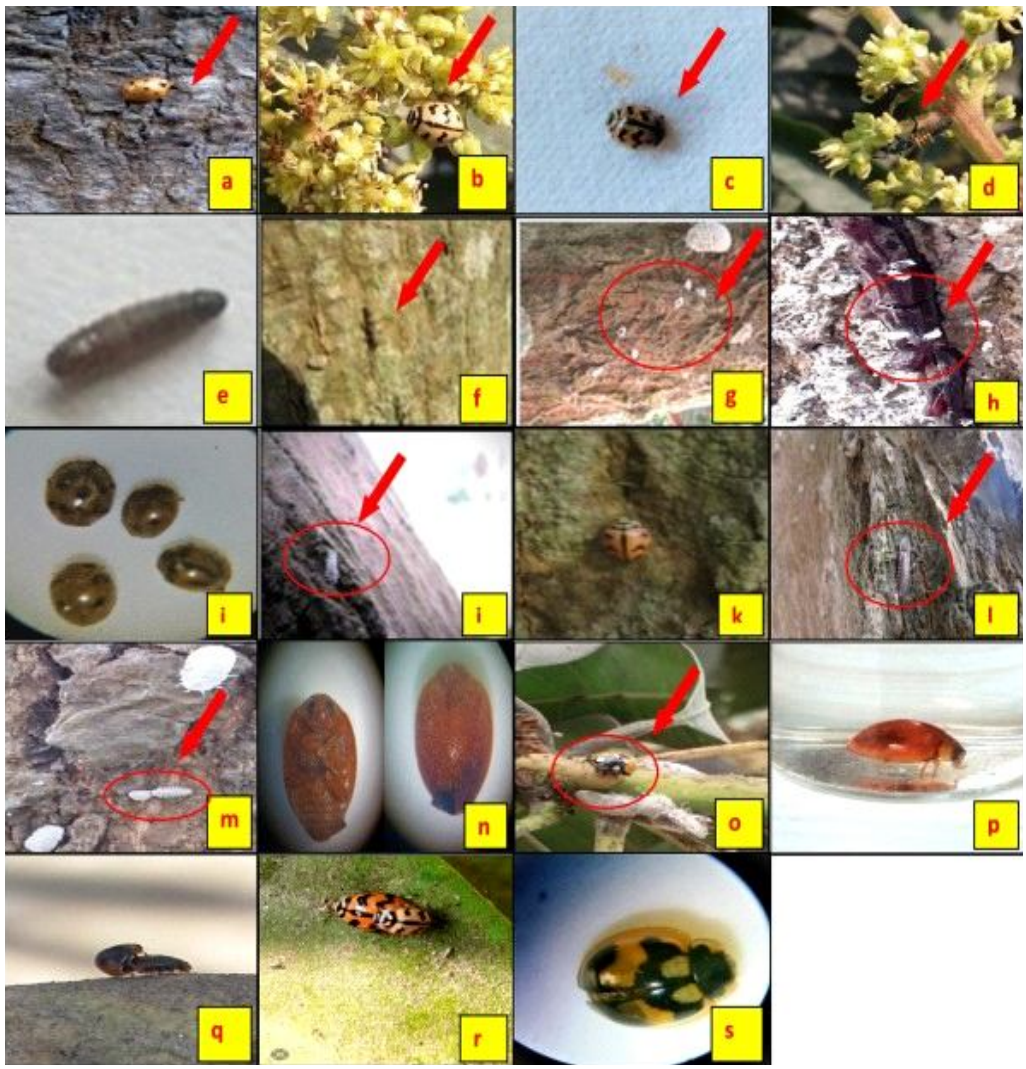
In the duration of the study only one species of parasitoid *Cryptochaetum* sp. nr. *iceryae* (Williston), had found to have emerged from mango mealy bug when reared in the laboratory for at least 3 weeks. The emerged parasitoid was identified as a dipteran fly, *Cryptochaetum* sp. nr. *iceryae* (Williston) (Fig 4) (NBAIR, 2022).

The identifying characteristics feature of the *Cryptochaetum* sp. nr. *iceryae* (Williston):

i) Small sized body having dark bluish body color.
ii) Length of the body 2-2.5 mm. with dark radish eyes.
iii) Antenna with three segments along with terminal spine (small and heavy).
iv) At the terminal segment of the antenna extended in the region of to inferior margin of the eyes.

Abundance and diversity of predators in three different places of study area at Malda, West Bengal

The numerical abundance is expressed as the exact cumulative number of individual predators found during the total period of study at three different areas *i.e.* at Manikchak, Ratua and Chanchal of Malda. The numerical abundance,



(a) *Harmonia axyridis*, (b) *Cheilomenes sexmaculata* (male), (c) *Coccinella transversalis*, (d) *Harmonia axyridis* (larva), (e) predatory larva A (unknown), (f) Larva of *Coccinella sp.*, (g) and (h) An unidentified *coccinellidae* larva, (i) Unidentified Coccinellidae A (Adult) (j) unidentified predatory larva B, (k) *Cheilomenes sexmaculata* (female), (l) and (m) *Rodolia amabilis* (Larva), (n) *Rodolia amabilis* (Adult), (o) *Harmonia axyridis*, (p) *Micraspis discolor*, (q) *Scymnus (pullus) posticalis*r), (r) *Cheilomenes sexmaculata* (During copulation and (s) *Propyalea japonica*.

*Note: Indicating arrows: →

Fig 1: Coccinellidae predators of the MMB in mango orchards,at Malda, West Bengal.

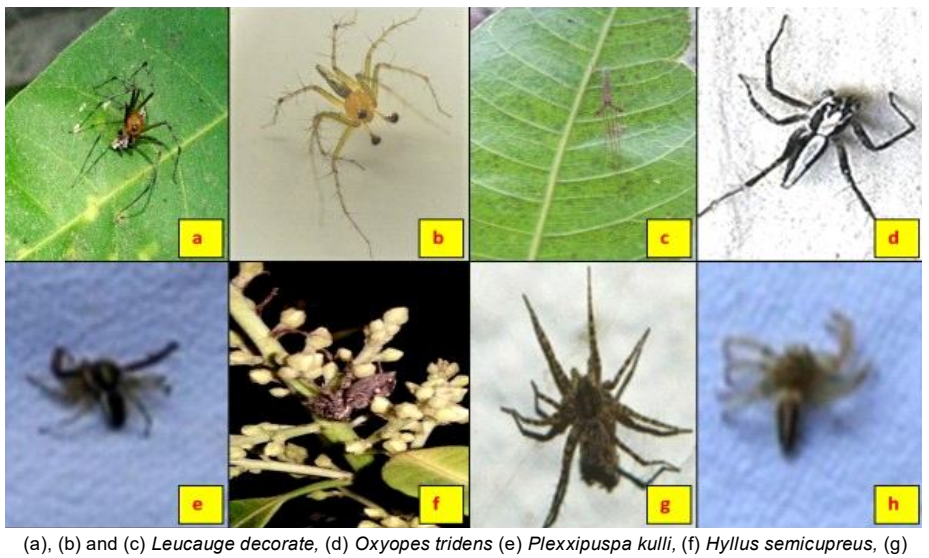
diversity indices, as well as relative abundance of those predator species were calculated and depicted here. For counting the predators, ten inflorescences from three trees and 20 cm^2 areas of 10 trunks of three different trees were chosen at the particular orchards of those three different areas. The number given in Table 2 is the cumulative number of predators found during the total period of study from 7SMW-20 SMW, *i.e.*, starting from the 3rd week of February (7 SMW) to the 2nd week of May (20 SMW) in 2020 and 2021.

During 2020 and 2021, predators of 20 different species belonging to the five different insect orders were identified from the mango inflorescence and trunk. Along with the increase of pest number the number of predators also started to increase from 12 SMW and attains its peak during 20 SMW. Among them, lady bird beetle was the most abundant group and a total of 448 individuals of lady bird beetles was obtained which included *R. amabilis* (202), unidentified Coccinellidae A (104), *H.axyridis* (39), *C. sexmaculatus* (34), *C.tranversalis* (8), *M. discolor* (11), *P. japonica* (16), *S. (pullus) posticalis* (20), unidentified Coccinellidae B (11), *Coccinella* sp. (03). The total number of green lacewing (Chrysopidae) was 335. The total number of hemipteran insects was 74 which included Brown marmorated stink bug (12), *Scantius* sp. (45), *Chivaria sp.* (17). The total number of predatory spiders was 41 which included *O. tridens* (06), *P. agricola* (01), *O. javonicus* (06), *P. pakulli* (04), *L. decorata* (15), *H. semicuprius* (09). On the basis of the insects order, the most abundant order was the Coleoptera (448) followed



(a) *Scantius* sp. (b) *Chivaria* sp. (c) and (d) Larva of green lacewing (e) and (f) Adults of Green lacewing.

Fig 2: Some significant Hemipteran and Neuropteran insects act as predators of the MMB in mango orchards.



(a), (b) and (c) *Leucauge decorate,* (d) *Oxyopes tridens* (e) *Plexxipuspa kulli,* (f) *Hyllus semicupreus,* (g) *Pardosa agricola* and (h) *Oxyopes javanus*.

Fig 3: A few significant spiders act as predators of the MMB in mango orchards.

by Neuroptera (335). Then again on the basis of the individual taxa wise the most abundant was the Neuropteran green lacewings (335) followed by *R. amabilis* (202), unidentified Coccinellidae A (104), *Scantius* sp. (45), *H. axyridis* (39) and others.

The abundance of green lacewing larva is 37.30% followed by *Rodalia amabilis* (22.49%) and others. Coccinellids ladybird beetles, bugs and spiders were also found to be active predator but less abundant (Fig 5). Among the spiders *L. decorate* was most prevalent. The diversity indices of the predatory arthropods have been depicted in Table 3.

The results of the current study have clearly demonstrated that mango mealy bug serve as a most notorious sucker pest on the mango inflorescence by causing severe damage. During the observation in the year 2020 and 2021 at the selected places of Manikchak, Ratua and Chanchal of the district Malda, West Bengal significant MMB infestation was seen. In the year 2020, MMB started to appear either from 5 or 6 SMW and then the number gradually increased from 7 SMW to the 15 SMW, in inflorescence and then subsequently decreased from 19 SMW. Similarly, it was also noticed that the number of MMB gradually increased from 7 SMW to the 20 SMW, on the trunk of the mango tree.

In the year 2021, it was observed that the the number of MMB steadily increased in inflorescence from 7 SMW to the 18 SMW, in inflorescence. In case of the trunk, the number of MMB gradually increased proportionally with the SMW, from 7 SMW to 20 SMW.

This current observation corroborated with the findings of Kumar *et al.* (2009), who had depicted that the incidence of MMB *i.e*. *D. mangiferae* stared from January-February (4-7 SMW) and then peaked up in April (12-16 SMW) and then subsumed from 18 SMW i.e. May onwards. The pest dynamics result of current study also in line with Sarkar *et al.* (2017), where it has been observed that occurrence of MMB started from December remains active in the inflorescence and trunk till May.

According to Rahman and Khan (2009), the beneficial insect such predators and parasitoids play crucial role in the agricultural ecosystem by diminishing insect pest populations in the field. Rahman and Khan (2009) had reported a few natural enemies of mango insect pest but has found that even that low number was good enough to prevent the pest to go beyond economic thresholds (ET) for avoiding the yield loss inflicted by the pest. In this study the beneficial insects and spiders can also able to reduce the number of pest population successfully. The repeated use of huge amount of insecticide can be curbed by using beneficial insects in the orchard system (Kalita and Borah 1993). The predator diversity study of mango mealy bug in the current observation is corroborating with the findings of Pickett *et al*. (1946), Duale, (2005) and Chatterjee *et al.* (2009). According to their observations, coleopteran beetles

Table 1: The relative demonstration of the changeable species presence of predators in mango tree inflorescence and its trunk in relation to the three specified orchards.

Natural enemies	Occurrence of natural enemies*					
	Orchard 1		*Orchard 2*		*Orchard 3.*	
	INFLR	Trunk	INFLR	Trunk	INFLR	Trunk
Rodolia amabilis	●	●	●	●	●	●
Unidentified Coccinellidae A	❍	❍	●	●	●	●
Green lacewing (family chrysopidae)	❍	●	❍	●	●	●
Harmonia axyridis	●	●	❍	●	●	●
Chelomenes sexmaculatus	●	❍	❍	●	❍	●
Coccinella tranversalis	❍	❍	❍	●	❍	❍
Coccinellidae sp.	●	❍	❍	❍	❍	❍
Micraspis discolor	❍	❍	❍	❍	●	●
Propylaea japonica	●	●	❍	❍	❍	●
Scymnus (pullus) posticalis	●	●	❍	❍	❍	●
Unidentified *coccinellidae* B	❍	❍	●	●	❍	❍
Brown marmorated stink bug	●	●	❍	❍	❍	●
Scantius sp.	❍	●	❍	●	❍	●
Chivaria sp.	❍	❍	❍	●	❍	●
Oxyopes tridens	❍	❍	●	❍	●	❍
Pardosa agricola	❍	❍	❍	❍	❍	●
Oxyopes javonicus	❍	❍	❍	●	❍	●
Plexxipuspa kulli	❍	❍	❍	❍	❍	●
Leucauge decorate	❍	●	❍	●	❍	●
Hyllus semicuprius	❍	●	❍	●	❍	❍

Table 2: Comparative study of relative incidence of the predators found in the inflorescence of insecticide treated (INSTR) and untreated (INSUR) orchards.

Predators	Area-I Manikchak				Area-II Ratua				Area-III Chanchal			
	Insecticides treated		Insecticides untreated		Insecticides treated		Insecticides untreated		Insecticides treated		Insecticides untreated	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
R. amabilis	12 (3.54)	18 (4.30)	22 (4.74)	28 (5.34)	07 (2.74)	17 (4.18)	19 (4.42)	37 (6.12)	15 (3.94)	05 (2.35)	09 (3.08)	13 (3.67)
Unidentified Coccinellidae A	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	06 (2.55)	08 (2.92)	13 (3.67)	19 (4.42)	02 (1.58)	15 (3.94)	10 (3.24)	31 (5.61)
Green lacewing (family Chrysopidae)	16 (4.06)	16 (4.06)	32 (5.70)	38 (6.20)	13 (3.67)	24 (4.95)	36 (6.04)	43 (6.60)	13 (3.67)	24 (4.95)	43 (6.60)	37 (6.12)
H. axyridis	02 (1.58)	00 (0.71)	04 (2.12)	04 (2.12)	04 (2.12)	02 (1.58)	07 (2.74)	05 (2.35)	04 (2.12)	02 (1.58)	02 (1.58)	03 (1.87)
C. sexmaculatus	03 (1.87)	02 (1.22)	06 (2.55)	05 (2.35)	02 (1.58)	01 (1.22)	04 (2.12)	04 (2.12)	01 (1.22)	00 (0.71)	03 (1.87)	03 (1.87)
C. tranversalis	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	00 (0.71)	03 (1.87)	04 (2.12)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)
Coccinella sp.	02 (1.58)	00 (0.71)	00 (0.71)	01 (1.22)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)
M. discolor	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	03 (1.87)	03 (1.87)	05 (2.35)
P. japonica	02 (1.58)	00 (0.71)	04 (2.12)	03 (1.87)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	02 (1.58)	05 (2.35)	00 (0.71)
S. (pullus) posticalis	04 (2.12)	02 (1.58)	02 (1.58)	06 (2.55)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	02 (1.58)	04 (2.12)	00 (0.71)
UnidentifiedCoccinellidae B	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	02 (1.58)	01 (1.22)	04 (2.12)	04 (2.12)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)
Brown marmorated stink bug	02 (1.58)	01 (1.22)	03 (1.87)	04 (2.12)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	00 (0.71)	01 (1.22)
Scantius sp.	07 (2.74)*	05 (2.35)	11 (3.39)	08 (2.92)	00 (0.71)	02 (1.58)	03 (1.87)	04 (2.12)	00 (0.71)	02 (1.58)	01 (1.22)	02 (1.58)
Chivaria sp.	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	02 (1.58)	02 (1.58)	04 (2.12)	03 (1.87)	02 (1.58)	00 (0.71)	01 (1.22)	03 (1.87)
O. tridens	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	00 (0.71)	00 (0.71)	02 (1.58)	00 (0.71)	01 (1.22)	01 (1.22)	01 (1.22)
P. agricola	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	00 (0.71)
O. javonicus	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	01 (1.22)	01 (1.22)	00 (0.71)	01 (1.22)	01 (1.22)	01 (1.22)
P. pakulli	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)	01 (1.22)	01 (1.22)	02 (1.58)
L. decorate	01 (1.22)	02 (1.58)	04 (2.12)	02 (1.58)	01 (1.22)	00 (0.71)	02 (1.58)	00 (0.71)	01 (1.22)	01 (1.22)	00 (0.71)	01 (1.22)
H. semicuprius	00 (0.71)	01 (1.22)	01 (1.22)	03 (1.87)	00 (0.71)	02 (1.58)	01 (1.22)	01 (1.22)	00 (0.71)	00 (0.71)	00 (0.71)	00 (0.71)

and spiders serve as two important groups of predators which feed on a diverse insect pest population. In the current study of predators of mango mealy bug, the existence of ten ladybird beetles belonging to family Coccinellidae and six different species of spiders were also noticed belonging to family Lycosidae, Oxyopidae, Tetragnathidae, Salticidae. The ladybird beetles which were found to act predators were *R. amabilis,* unidentified Coccinellidae A, *H. axyridis, C. sexmaculatus, C. tranversalis, Coccinella* sp., *M. discolor, P. japonica, S. (pullus) posticalis* and Unidentified Coccinellidae B. Besides the ladybird beetles and spiders one larva of Green Lacewing was very much abundant as predator as per the present observation. It has been found elsewhere that these Green Lacewing larva perform a key role in the predatory guild of scale insects like mealy bug (Tanga *et al.,* 2013).

In the present finding there were only two kinds of effective hemipteran insects showing predatory effects on MMB, those were brown marmorated stink bug, *Scantius* sp. and *Chivaria sp.* This current observation on predator abundance and diversity study is very much similar to the observation of Tanga *et al.* (2013) who had reported that the both larvae and adults of lacewings, a few species of spiders and various ladybird beetles and bugs act as the most important dominating predatory organisms of the *D. mangiferae.* He had also reported that in Tanzania and Kenya, the most abundant predatory spider families of mango mealy bug are Oxyopidae, Salticidae and Thomisidae. Six different species of spiders belonging to different families were identified during the current study and the most abundant were spiders of the families Oxyopidae, Salticidae, Lycosidae. So, it very much similar to the observation of Tanga (2013). According to the (Tanga *et al.,* 2013; Moore 1988; Iperti 1999) the beetles belonging from the Coccinellidae act as most abundant natural enemies in the each and every mango orchards. Just similar to these earlier observations in current study also a huge numbers of lady bird beetles were found devouring the mealy bug colonies found in the inflorescence as well as trunk. Instead of the diverse predators the mealy bugs were still persisting in high numbers. The number of the predators/ inflorescence or in the trunk was not enough to curb the

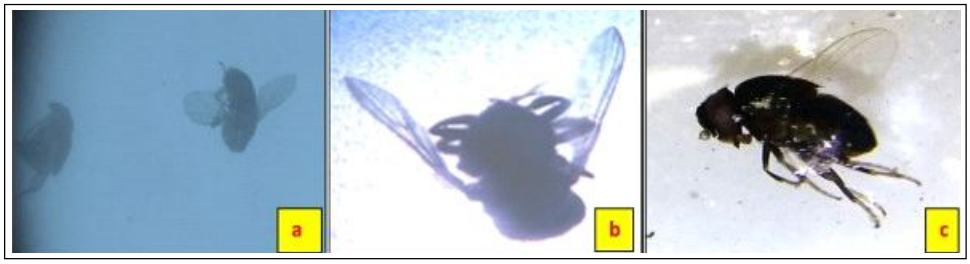


Fig 4: Stereo-microscopic view of the *Cryptochaetum* sp. nr. *iceryae* (Williston) of (a) and (b) Dorsal view (c) Lateral view.

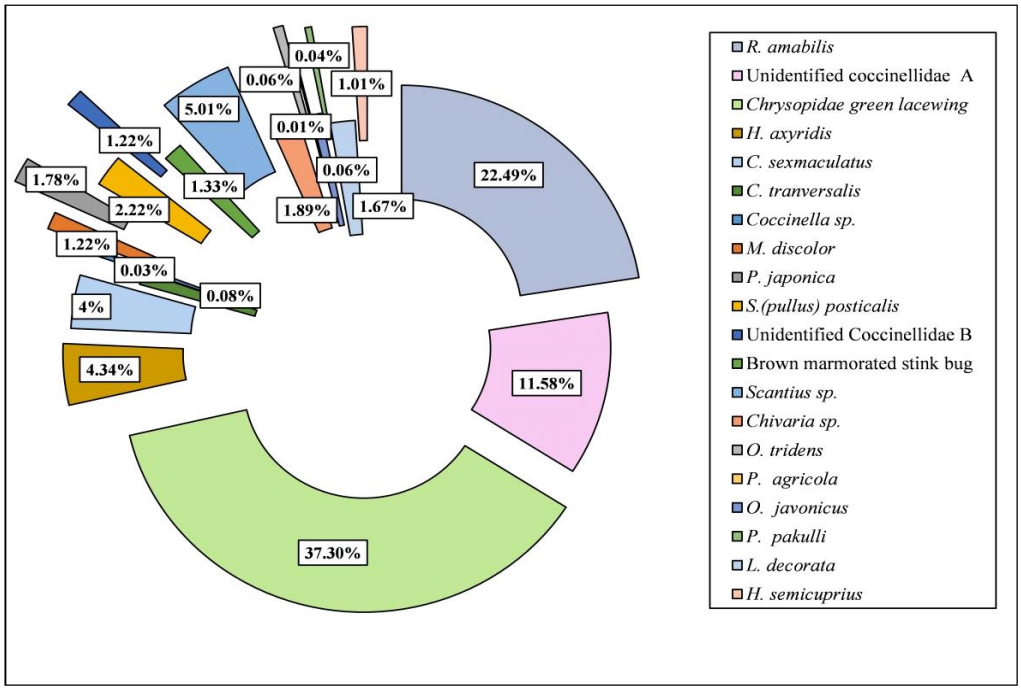


Fig 5: Relative abundance of different predators of mango mealy bug at Malda.

Table 3: Diversity indices of the predators in the study area.

Ecological Index	Value
Dominance (D)	0.21
Simpson (1-D)	0.78
Shannon(H)	2.03
Evenness- e^H/S	0.38
Margalef	2.79
Equitability (J)	0.67
Fisher (alpha)	3.62
Berger-parker	0.37

mealy bug growth. So, mass rearing of these predators and release in natural adobe should be done if possible to check mango mealy bug.

According to the (Heong and Escalada, 1997) in Philippine, there were 14 hymenopteran insect species and 46 bugs species can successfully reduce insect pests by parasitizing on those particular insects. According to the reports by (Tanwar *et al.,* 2008) there was only one parasitoid species, *Aenasius bambawalei* belonging to the Family Encyrtidae (Order - Hymenoptera) had emerged out from body of the MMB. Hayat (2009) reported that, in India *A. bambawalei* serve as one of the major copious parasitoid in the mealy bug affected orchard system. According to the reports of Noyes and Hayat (1994) in India a few parasitoids genus of MMB were *R. iceryoides* namely *Leptomastrix* sp., *Anagyrus* sp. and *Praleurocerus* sp and *Cryptochaetum* sp.nr. *iceryae* serve as the parasitoid insect of MMB. In the current study also only one parasitoid was found to emerge from mango mealy bug and that was *Cryptochaetum* sp. nr. *iceryae* (Williston) which is an established effective parasitoid dipteran insect against the MMB, *D. mangiferae*. In present study average parasitization percentage in insecticide untreated orchard was 14.83% while emergence from the two different dates was considered. The application of insecticide reduced the parasitization percentage. On the contrary average parasitoid emergence percentage was in insecticide tread field was found to be 7.66% much lesser compared to insecticide untreated field. Therefore, it can be concluded with lesser use of chemical pesticide parasitization percentage increases which can bring about natural control if these parasitoids can be reared and released in sufficient quantity in the field. There are so many case studies where parasitoid release had brought about significant reduction of pest number.

CONCLUSION

The conservation of the natural enemies can act as one of the main strategies to combat mango mealy bug. Moreover, augmentation of the most abundant predators and parasitoids through mass rearing and then releasing them in the infested orchard can bring down the pest number drastically. Therefore this natural enemy study of mango mealy bug can open new vistas in biological pest control in near future.

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Conflict of interest

The authors declare that there is no conflict of interest among the authors.

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