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SPATIAL DISTRIBUTION AND SEASONAL INCIDENCE OF COCCID MEALYBUGS (COCCOIDEA: HOMOPTERA) IN JAHANGIRNAGAR UNIVERSITY CAMPUS, BANGLADESH

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Abstract: Coccids are amongst the most destructive pests of horticultural, agricultural, household ornamental plants, and wild plants in varying degrees. To evaluate the prevalence of its fauna in Jahangirnagar University Campus (JUC), Savar, Dhaka, Bangladesh, a year-long study was conducted from September 2004 to August 2005, by visual counting in regular fortnightly visits. A total of 99755 insects of 13 coccid species were recorded from 12 study sites. They infested 41.2% plants of 786 individuals under 17 host plant species. Coccid incidence varied greatly according to seasons, plant numbers, and study sites. Significant differences were observed in the mean number of coccid fauna ($F = 3.87$, $df = 12$, $P < 0.05$) in different study sites. The highest infestation was observed by *Ferrisia virgata* followed by *Chloropulvinaria pisdii, Planococcus pacificus, Perissopneumon ferox, Icerya aegyptiaca, Aspidiotus destructor, Crypticerya jacobsoni, Icerya minor, Rastrococcus spinosus, Pseudococcus citriculus, Maconellicoccus hirsutus, Cerococcus indicus,* and *Coccus hesperidum*. The total number of plants present in the study sites was positively correlated with the total infested plants ($r = 0.451$). Highly infested plants attracted more insects than less infested plants ($r = 0.813$). The coccid population started to increase after the winter season and maintained a steady level up to the end of the rainy season (March to August). All study sites contained insect populations but SS-6, 7, 8, and 10 harbored significantly higher numbers of them. Rain did not make any significant differences ($F = 1.445$, $df = 11$, $P = 0.168$) in the pest infestation. The mean number of coccids at different months was positively correlated with the monthly average temperature ($r = 0.390$) and relative humidity ($r = 0.412$). The present findings may help in designing an integrated coccid management system.

Key words: Coccid, Scale insects, Mealybugs, Insect Pest, Jahangirnagar University, Prevalence, Bangladesh.

INTRODUCTION

Coccids are homopteran scale insects and mealybugs under the Superfamily

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Coccoidea. The name refers to their secretion of waxy scale or mealy that serves as a protective covering. It is a large insect group with 10,450 species worldwide (Deng *et al.* 2016) from small to moderate in size of 1.5mm to 25mm in length. Most of them are harmless in appearance and they are commercially important (Varshney *et al.* 2014) for making shellac, dye, and wax. The cysts or ground pearls of certain fossorial margarodids are used to make necklaces in some countries (Miller and Kosztarab 1979). The fat extracted from the bodies of some margarodids has been used by natives of Mexico, Central America, and other countries for water-proofing wood as a lacquer-like coating. Scales are also potential biological control agents of weeds in many countries (McFadyen 1979, Rochat and Gutierrez 2001, Santos *et al.* 2009, Delrio and Foxi 2010).

Despite various beneficial roles, many scale insects create havoc in almost all parts of the world (Stratopoulou and Kapatos 1990, Velimirovic 1994, Santos 2007, Tena *et al.* 2008). They cause major damage (Moffit 1999) by sucking the cell sap or plant juice from the hosts by their sucking mouthparts disowning plants essential nutrients which causes even death of the infested plants (Pellizzari 1997). The host plants are affected by the drainage of saps retarding the vegetative growth of nursery plants and the fruit-bearing capacity of mature trees (Hanson and Miller 1984). In many cases, the host plants are partially destroyed or deformed, including chlorotic spots, pits, and galls due to the injection of toxic substances or plant pathogens into the plant tissues. They usually appear in huge crowds and cover the leaves, shoots, stems, and fruits or fruit stalks in lifeless heaps (Ullah 1987).

Very few attempts were made to record the coccid incidence in Bangladesh. Some intermittent attempts were made to investigate damages by specific coccid insects on different crops (Ahad *et al.* 2015). There were 14 species of mealybugs recorded from 26 major agronomic districts of Bangladesh. They invaded 103 genera of host plants at different stages and grades (Islam *et al.* 2017). As a predominantly agricultural country, more area-wise cataloging should be made in Bangladesh to evaluate the pest status and abundances of different coccid species in different areas. Since Jahangirnagar University Campus (JUC) is an undeclared sanctuary with a rich natural habitat of different flora and fauna, including several coccid species, which was not been studied previously, demands an intensive study. Therefore, the present research was undertaken to understand the abundance and seasonal patterns of coccid insects in JUC to design an integrated coccid pest management system.

MATERIAL AND METHODS

Study sites: The study was conducted at the Jahangirnagar University Campus (JUC). It is situated in the central zone of Bangladesh. Geographically the campus is at the 30°16'N latitude and 90°52'E longitude, which is 32 km Northwest of Dhaka city. The University consists of an area of 280 hectares, which is approximately 6 meters above the mean sea level.

The JUC was divided into twelve (Fig. 1) different study sites (SS). They were demarcated as SS-1: Choirangi to Kabir Sarani; SS-2: Choirangi to School and College; SS-3: School to Bishmile Gate; SS-4: Kabir Sarani to Botanical Garden; SS-5: Cafe Gate to Kamaluddin Hall; SS-6: Choirangi to Old Kala Bhaban; SS-7: Choirangi to Prantik Gate; SS-8: Transport to Medical Centre; SS-9: Kamaluddin Hall to Al-Beruni Extension; SS-10: Botanical Garden to Gate No. 2; SS-11: MH Gate to Cafe Gate and SS-12: Cafe Gate to NF Hall Gate.

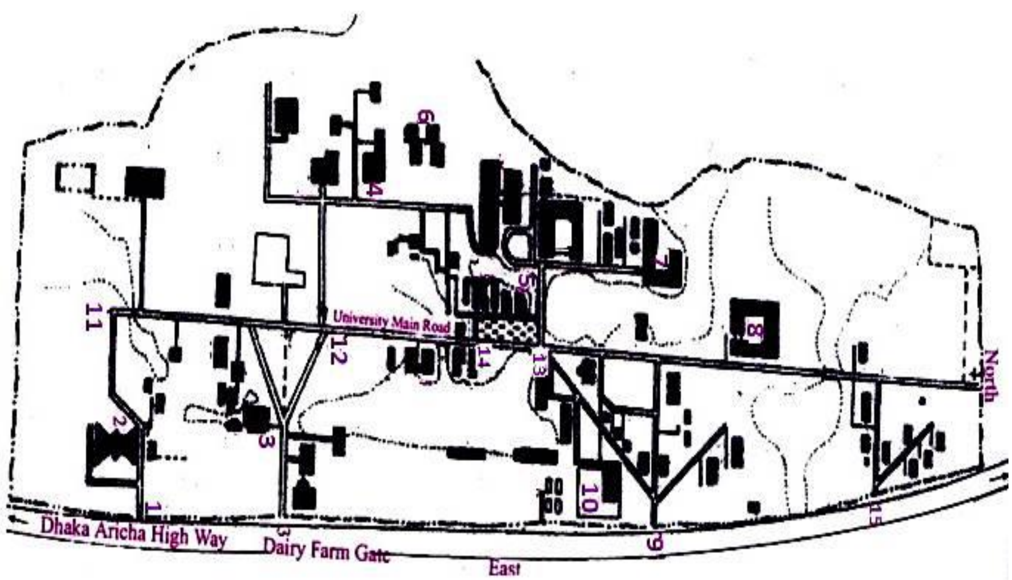

Fig. 1. Jahangirnagar University Campus

Different locations in JUC

1. Gate No. 2
2. M.H. Hall
3. Central Cafetaria
4. A.F.M. Kamaluddin Hall
5. Medical Centre
6. Al-Beruni Hall (Extension)
7. Old Kalabhaban
8. University School & College
9. Prantik Gate
10. N.F. Hall
11. Botanical (Bot.) Garden Gate
12. Kabir Sarani
13. Choirangi
14. Transport Office
15. Bis-Mile Gate

SS- Study Sites

SS-1: 13-12
SS-2: 13-8
SS-3: 8-15
SS-4: 11-12
SS-5: 3-4
SS-6: 13-7
SS-7: 13-9
SS-8: 5-14
SS-9: 4-6
SS-10: 1-11
SS-11: 2-3
SS-12: 3-10

Methodology: The SS were visited fortnightly for 12 months. All existing plants in different SS under 17 species were selected and tagged at the beginning of the study based on their visual abundance. The plant species were identified with the help of a plant taxonomist from the department of Botany of the same university. The host plants were *Albizia procera* Benth., *Albizia lebbeck* (L.) Benth., *Mangifera indica* L., *Artocarpus heterophyllus* Lamarck, *Citrus medica* L., *Citrus grandis* (L.) Osbeck, *Aegle marmelos* (L.) Correa, *Psidium guajava* L., *Zizyphus mauritiana*, *Ficus bengalensis* Linnaeus, *Gossypium hirsutum* L., *Hibiscus rosa-sinensis* L., *Achras sapota* L. *Mimosops elengi* L., *Alstonia scholaris* L., *Cassia javanica* L., and *Codiaeum variegatum* Bl.

The selected plants were inspected visually by using a 10x magnification lens and recorded the data according to the standard methods (Prasanna and Balikai 2015, Akter *et al.* 2017, Shanbhag and Sundararaj 2017). The surfaces, barks, and crevices of branches, leaves, trunks, and rootstock of all plants were inspected up to an average height of 2 meters from the ground for nymphs and adults of mealybugs and scales. They were collected, killed, and preserved directly in 70% alcohol in the field in separate plastic containers with proper labels mentioning the date, SS, plant's name, etc. Then they were carried to the laboratory, counted, and transferred to the Pampel's fluid for further investigation. The samples were identified up to the species level according to the standard taxonomic keys followed by others (Morrison 1928, Takahashi 1955, Ullah 1987, Williams 2004, Japoshvili *et al.* 2008, Almeida *et al.* 2018, Jendoubi 2018).

Statistical analysis: The field-collected data were analyzed by one-way analysis of variance (ANOVA) with a significance level of $P = 0.05$ by using IBM SPSS Statistics 28.0.0.0. LSD tests were run to observe the Least Significance Differences in pest infestation in different study sites and plant species in different months. The correlations of pest infestations were observed with the number of plant species, plant diversity, humidity, and temperature by using the statistical software JASP 0.16. Moreover, percent value, mean, and standard error values were used for making graphs and charts.

RESULTS AND DISCUSSION

Faunal diversity of coccid insects: The diversity of coccid species in different study sites has been shown in Table 1 and Fig. 2 & 3. A total of 99755 coccid insects of 13 species were identified from all SS. A significant difference was observed among the mean number of individuals of different species ($F = 3.87$, $df = 12$, $P < 0.05$) collected from different SS (Table 4). The highest mean density was *Ferrisia virgata* followed by *Chloropulvinaria pisdii, Planococcus pacificus,*

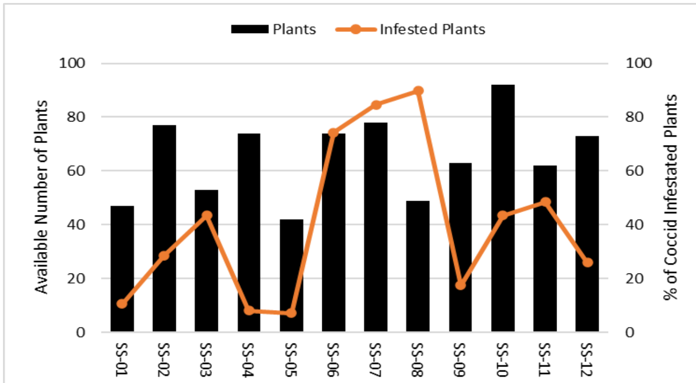

Fig. 2. Available plants and coccid infestation rate in different study sites of JUC, Savar, Dhaka

Table 1. Available coccid insects in different study sites

Insect Species	No. of Insects	Study Sites	No. of Plants	Infested Plants	Total No. of Insects
P. ferox	8028	SS-01	47	5	1519
C. jacobsoni	3812	SS-02	77	22	2148
I. aegyptiaca	7717	SS-03	53	23	2194
I. minor	3272	SS-04	74	6	1567
F. virgata	27344	SS-05	42	3	77
M. hirsutus	2702	SS-06	74	55	20199
P. pacificus	10309	SS-07	78	66	14722
R. spinosus	3368	SS-08	49	44	22219
P. citriculus	2741	SS-09	63	11	10061
C. hesperidum	1425	SS-10	92	40	16284
P. psidii	22136	SS-11	62	30	7077
C. indicus	1697	SS-12	73	19	1688
A. destructor	5204				
Total	**99755**		**784**	**324**	**99755**

Table 2. Available coccids in twelve different locations of JUC

Species	Study sites											
	SS-01	**SS-02**	**SS-03**	**SS-04**	**SS-05**	**SS-06**	**SS-07**	**SS-08**	**SS-09**	**SS-10**	**SS-11**	**SS-12**
P. ferox	✓	✓	x	x	x	✓	✓	✓	x	✓	✓	x
C. jacobsoni	x	x	x	x	x	✓	x	✓	x	✓	✓	x
I. aegyptiaca	✓	x	x	x	x	✓	✓	✓	✓	✓	✓	✓
I. minor	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓	✓
F. virgata	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓
M. hirsutus	x	✓	x	x	x	✓	x	✓	x	✓	x	x
P. pacificus	x	✓	✓	✓	x	✓	✓	✓	✓	✓	x	x
R. spinosus	x	✓	✓	✓	x	✓	✓	✓	x	✓	✓	✓
P. citriculus	x	✓	✓	✓	x	✓	✓	✓	x	✓	✓	✓
C. hesperidum	x	x	x	x	x	✓	x	✓	x	✓	x	x
P. psidii	x	x	x	x	x	✓	✓	✓	✓	✓	✓	x
C. indicus	x	✓	x	x	x	✓	✓	✓	x	✓	✓	✓
A. destructor	x	x	x	x	x	✓	x	✓	x	✓	✓	x

(Note: ✓ & x indicate present & absent respectively).

Perissopneumon ferox, Icerya aegyptiaca, Aspidiotus destructor, Crypticerya jacobsoni, Icerya minor, Rastrococcus spinosus, Pseudococcus citriculus, Maconellicoccus hirsutus, Cerococcus indicus, and *Coccus hesperidum.*

Infestation of coccid insects in different study sites: Coccid insects were present in all SS. The mean infestation of coccid insects significantly varied in different study sites in JUC (F = 3.44, df = 11, $p > 0.05$). Study sites 6, 7, 8, and 10 harbored a significantly higher number of insect populations. Whereas SS-9 and SS-11 contained moderately high, SS-1, SS-4, SS-12, SS-3, and SS-2 contained medium and SS-5 contained an extremely low number of pest population (Table 3, Fig. 3). Among the pest insects, *F. virgata* was present in 11 SS out of 12. But *C. pisdii* was absent from 50% of the SS, though represented the 2nd highest population. These two pest species were significantly higher in number than all other insects in the study areas (Table 3). Alternatively, three locations viz. SS-6, SS-8, and SS-10 sheltered all the thirteen coccid species but SS-11 missed only three species and SS-5 contained only one species of the pest insects (Table 2).

Table 3. Differences in pest infestation status in different study sites of JUC

	Study Sites	N	Subset for alpha = 0.05			
			1	2	3	4
Duncan[a]	SS-08	13	1709.1538			
	SS-06	13	1553.7308	1553.7308		
	SS-10	13	1252.5769	1252.5769		
	SS-07	13	1132.4615	1132.4615	1132.4615	
	SS-09	13	773.9615	773.9615	773.9615	773.9615
	SS-11	13		544.4231	544.4231	544.4231
	SS-03	13			168.8077	168.8077
	SS-02	13			165.2308	165.2308
	SS-12	13			129.8462	129.8462
	SS-04	13			120.5385	120.5385
	SS-01	13			116.8077	116.8077
	SS-05	13				5.9231

Means for groups in homogeneous subsets are displayed; a. Uses Harmonic Mean Sample Size =13.000.

The abundance of pests compared with the plant population: A total of 324 plants were found infested in the study area. Each study site contained 42-92 plants. The total number of plants present in the SS showed a moderately positive correlation with total infested plants (r = 0.451). Though the pest insects showed a lower positive correlation with the number of plants present in a study site (r = 0.281), the positive correlation of insect pests was highly significant with infested plants (r = 0.813) (Fig. 3, 5 a, b, c). It indicated that infested plants attracted more insects or offspring that come from the existing generation making the population larger.

Table 4. Differences among pest insects in the study site

	Pest_Spp_No	N	Subset for alpha = 0.05	
			1	2
Duncan[a]	05. *F. virgata*	12	2278.6667	
	11. *P. psidii*	12	1844.6250	
	07. *P. pacificus*	12		859.0833
	01. *P. ferox*	12		669.0000
	03. *I. aegyptiaca*	12		643.0833
	13. *A. destructor*	12		433.6667
	02. *C. jacobsoni*	12		317.7083
	08. *R. spinosus*	12		280.6667
	04. *I. minor*	12		272.6250
	09. *P. citriculus*	12		228.4267
	06. *M. hirsutus*	12		225.1667
	12. *C. indicus*	12		141.4167
	10. *C. hesperidum*	12		118.7917

Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 12.000.

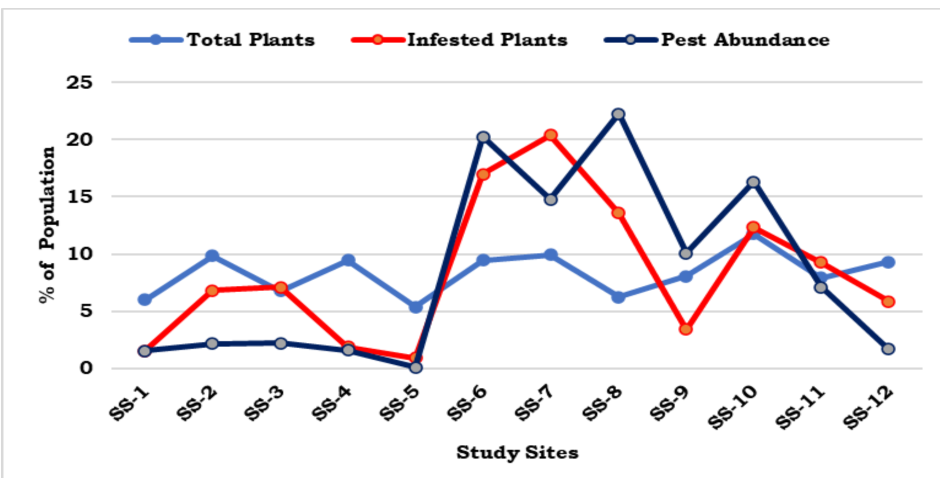

Fig. 3. Pest infestation nature in different study sites

Infestation of coccid insects in different study sites: The highest number of plants was present in SS-10 followed by SS-7, SS-2, SS-6, SS-4, SS-5, SS-12, SS-9, SS-11, SS-3, SS-8, SS-1 and SS-5 (Fig. 2). The last three study sites contained less than 50 plants. The highest percent of the plants was infested in

SS-8 followed by SS-7, SS-6, SS-11, SS-3, SS-10, SS-2, SS-12, SS-9, SS-1, SS-4, and SS-5. Less than 20 percent of them were infested in the last four study sites (Fig. 2). A positive correlation was observed among study sites and infested plant population (r=0.355) (Fig. 5d). On the basis of higher correlation between total plants and infested plants, the study sites can be categorized as SS-7 (r=0.982), SS-8 (r=0.908), SS-2 (r=0.875), SS-6 (r=0.826), SS-3 (r=0.815), SS-12 (r=0.770), SS-10 (r=0.739), SS-11 (r=0.661), SS-9 (r=0.377), SS-1 (r=0.337), SS-4 (r=0.244) and SS-5 (r=0.137).

Seasonal prevalence of coccid species: Monthly incidence of coccid insects varied significantly (F value > F critical value, $p < 0.05$). Total incidence was highest in April (13326), followed by May, July, June, March, August, February, January, September, November, December, and October. The monthly incidence of coccids showed that the coccids were higher in spring followed by summer, winter, and autumn (Fig. 4).

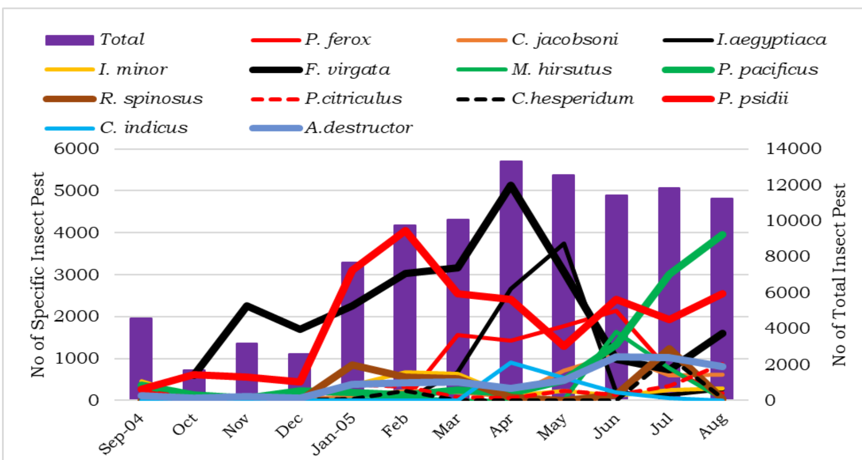

Fig. 4. Monthly fluctuation of coccid insects in JUC.

Correlation of pest infestation with environmental factors: The mean number of coccids at different months correlated positively with the monthly average temperature (r = 0.390). A positive correlation (r = 0.412 of the average number of coccids with the average relative humidity was listed during the full study session (Table 1, Fig. 5 e, f). Since insect population started to increase after winter and peaked in April, but maintain a steady level up to the end of the rainy months. So, no significant differences (F = 1.445, df = 11, $p = 0.168$) of the insect population were observed in rainy months (Fig. 4).

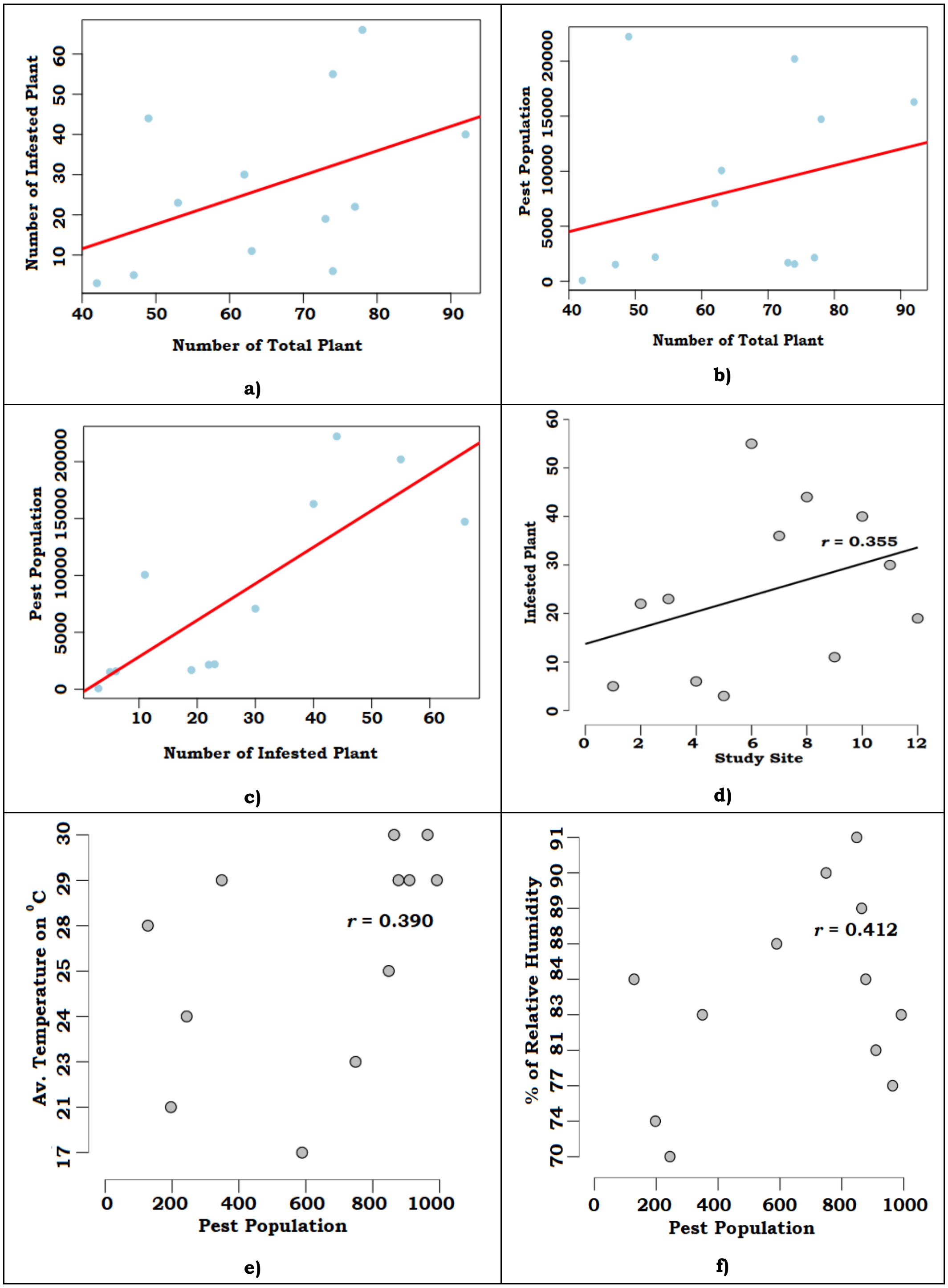

Fig. 5. Correlation of different parameters of pests and plants in different study areas

DISCUSSION

The coccid insect population was present throughout the year in JUC. The more or less same scenario was observed previously, especially for cotton mealybugs in the Indian sub-continent. In Pakistan, coccid pests were present throughout the year (Shahid *et al.* 2012). Among 13 species, some of them could not maintain their population at a steady level around the year or declined for a few months but again returned with the help of environmental pleasant factors. Generally, the pest infestation gradually increased in one spot and then spread in the surrounding areas or plants in different ways including crawling, environmental driven factors, different insects, animals, people, etc. as commonly observed in many countries (Yukawa 1984, Tanwar *et al.* 2007). The infested plants were found to attract more insects to lay their eggs, thus the pest insects increased rapidly on the infested plants.

The increasing and declining phases of specific insects differed based on season, host plant availability or density, and different environmental situations. In the maximum cases, the mealybugs are not host-specific. In Bangladesh, 13 species of mealybugs from 22 agricultural districts were found to infest 103 kinds of plants (Islam *et al.* 2017). On the other hand, the same pest was not dominant in all fields having the same crop as seen in sugarcane and sesame cultivation in Brazil and Ethiopia (Gebregergis 2018, Monteiro *et al.* 2021). In addition, under similar ecological conditions, all plants of a single species were not equally infested with the pest insect (Akter *et al.* 2017).

The present study found *F. virgata* as the dominant pest species. They were concentrated in some closely related or adjacent areas round the year. Thus, produced the highest population and maintain a continuous colony. The same picture was found in India (Shanbhag and Sundararaj 2017) and Egypt (Adly *et al.* 2016), though the peak period differed in different countries. It was also observed that *A. destructor, C. jacobsoni, I. minor, P. pacificus, P. citriculus, P. psidii, and A. destructor* were found round the year. Though their population fluctuated in different seasons. The maximum of them increased in the rainy season except for *P. psidii.* They also showed another peak in the winter season. However, these insects produced a higher population. In the future, they may be a more dangerous pest. So, their population management should attract more attention.

Some species were not abundant during the whole year. But they showed a similar seasonal trend of population fluctuation in maximum areas of the world. They increased in a certain period then declined. For example, *I. aegyptiaca* started to reduce after the rainy season and was absent in winter then started to appear again from February and peaked in April in the present experiment. The same scenario was observed in Egypt (Awadalla 2017). Incidence of *P. ferox* started in February and peaked in August, though absent from November to January. The highest incidence of *I. minor* was found in February and declined in November. Incidence of *P. pacificus* was highest in the rainy season then reduced as observed for *P. citri* in one study in Egypt (Hanan 2020) but in another study in the same country, *P. citri* was found highest in autumn and lowest in winter and spring (Awadalla 2017). The almost same trend was observed for *R. spinosus* which is similar to *R. invadens* (Hala *et al.* 2011). They should monitor keenly and take proper short- or long-term management action when necessary.

The occurrence of some insects was irregular and periodic and the population was always low. The coccid, *C. hesperidum* was highest in the warm and rainy weather of July and absent from March-June as seen in other studies (Talhouk 1969, Zalomi and Morse 1991, Williams 2000, Mohamed 2014). Small numerical mass was observed in the spring and summer months (Moursi *et al.* 2012). The insect *C. indicus* is only found in the rainy season and its population was not that much. Thus, action measures may not be essential at present but have to keep on watch regarding their population dynamics and pest infestation nature.

The peak abundance period of some pests varied in different regions. In India, the abundant population of mealy bugs was found from August to October and peaked in August and September (Harde *et al.* 2018). In another place, they increased in spring and remain high until August (Tsai *et al.* 2011), which is in harmony with our findings. The highest population of *M. hirsutus* was found in June and declined in March and April in the present study as well as in Egypt (Hendawy *et al.* 2013) but differed in India where the top plague was observed from February-March and remained little from October-November (Manjunath 1985). In South India, this mealybug population was plenty between January to May but less from June to December in the vineyards (Mani 1989). The population of *A. destructor* was highest in June and absent in December in JUC. But in Pakistan, the maximum *A. destructor* infestation was in November and the lowest in February (Bitanni 2016). In Nigeria, its peak was found in the dry season (May and November) and absent in the rainy season (July) (Aisagbonhi *et al.* 1985). The pest insect *C. indicus* was most abundant in April and absent from August to March in JUC but they were abundant from October to February in Tamil Nadu, India (Suresh and Kavitha 2007). The population of *C. psidii* was highest in February and lowest in September in the present study but Baker *et al.* (2012) found the top incidence in May and the deepest dumps time in March.

In maximum cases, pest population abundance was related to environmental factors. Sometimes population increased with increasing rainfall and humidity (Shahid *et al.* 2012, Harde *et al.* 2018), sometimes these factors were responsible for the declining population (Bhute *et al.* 2012). So, the latter population increased in the dry season. The present study has made this scenario clear in the result sections as well as in the above discussion as seen in previous studies, i.e., the population of *A. destructor* was negatively correlated with humidity and rainfall (Aisagbonhi *et al.* 1985). Tropical countries have a consistent pattern of rainfall round the year. Accordingly, they contain some specific species, But Bangladesh as a subtropical country contains several seasons with diversified pest insects. Consequently, they must be closely monitored and take necessary initiatives according to the problem.

In conclusion, the field incidence of coccid insects was found to vary according to the plant density, availability of host plants, weather, and insect's biological nature. Some pest species showed a changing attitude toward infestation due to the altered environment to adapt to them. As a primary work, the present study has shown an indication of the presence of a good number of pest insects in a microhabitat, which can cause a serious infestation or damage to economic crops in a larger habitat of the erratic future environment. However, this is kind of work is not adequate in this region to compare as well as understand the nature of the pest population. Therefore, further studies should be conducted in the different agricultural districts to predict pest outbreak nature and determine a better Integrated Pest Management practice. In addition, with the present findings, the pest association with the host plants will be addressed in the next communication.

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