DIVERSITY AND DAMAGE SEVERITY OF INSECT AND MITE PESTS OF CITRUS IN BANGLADESH

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DECEMBER, 2014

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REGISTRATION NO. : 09-03337

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE IN
ENTOMOLOGY
SEMESTER: JULY-DECEMBER, 2014

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CERTIFICATE

This is to certify that thesis entitled, "**DIVERSITY AND DAMAGE SEVERITY OF INSECT AND MITE PESTS OF CITRUS IN BANGLADESH"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **S. M. WAKILUZZAMAN, Reg. No. 09-03337** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Dated: December, 2014

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ACKNOWLEDGEMENT

Alhamdulillah, All the praises, gratitude and thanks are due to omniscient, omnipresent and omnipotent Allah who enables the author to complete this thesis work successfully.

The author expresses his sincere appreciation and profound gratitude to his reverend supervisor Prof. Dr. Md. Abdul Latif, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his constant guidance, keen interest, immense advice and encouragement during the period of thesis work.

He also wishes to express his sincere thanks, earnest obligation and profound gratitude to honorable Co-supervisor Prof. Dr. Mohammed Ali, Department of Entomology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his valuable suggestions and gratuitous labor in conducting the research work and preparation of this thesis.

He humbly expresses his grateful appreciation and thanks to Citrus growing farmers of the respected 20 districts of Bangladesh for their participation and information sharing. He humbly expresses his cordial thanks to SAAO, UAO, AEO, DD/DTO, BARI scientists/researchers of the selected citrus growing districts of Bangladesh for their co-operation.

He is highly grateful to other honorable teachers of the Department of Entomology, SAU for their kind co-operation and helps during the study period of MS program.

He founds no word to thank his parents, sisters, relatives and well-wishers for their unquantifiable love and continuous support, their sacrifice, never-ending affection, immense strength and untiring efforts for bringing his dream to proper shape. They were constant source of inspiration, zeal and enthusiasm in the critical moment of his study.

The Author
December, 2014

DIVERSITY AND DAMAGE SEVERITY OF INSECTAND MITE PESTS OF CITRUS IN BANGLADESH

ABSTRACT

The present research work on diversity and damage severity of insect and mite pests of citrus was conducted in 60 upazilas under 20 districts of Bangladesh during April to August 2014. Data were collected through personal interviews of farmer's, DAE Officials and BARI Scientist and by direct survey of farmers' citrus orchard. Nine different Citrus cropsnamely lemon,lime, mandarin, sweet orange, pummelo, jamir, satkara, adalebu and jara lebuwerefound in different districts of Bangladesh of which satkara was recorded only in Sylhet, Moulvibazar and Hobigonj districts. From both farmers information and field survey data, 15 insect and mite pests were found in survey areas of Bangladesh. Citrus leaf miner and lemon butterfly were recorded in all 20 citrus growing areas under study with high level of infestation (farmer's information 39.25± 7.66 and 63.75 ± 05.82 %, respectively and field survey data 44.85 ± 07.23and 70.90 ± 06.26%, respectively) and severity. Citrus green stink bug was recorded in Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong, and Jhenaidah districts with high level of infestation (farmer's information 18.79 ± 02.56% and field survey data 22.60 ± 03.58%) and severity as a major pest. Asian citrus psyllidwas recorded in Sylhet, Moulvibazar and Chittagong districts with low level of infestation and severity. Citrus blackfly, Citrus red mite, citrus red scale, bark and stem borer, citrus stem borer and citrus mealybug were minor pests. Citrus aphid, citrus whitefly, Citrus thrips, termite and citrus leaf folder were recorded as minor pest with medium to low level of infestation and severity.

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CHAPTER I

INTRODUCTION

The citrus fruits are very common in Bangladesh and majority of which are grown abundantly in the country. The genus *Citrus* includes several species such as sweet orange (*Citrus sinensis* L.), mandarin (*Citrus reticulate* L.*)* lemon (*Citrus limon* L.), lime (*Citrus aurantifolia* L.), grapefruit (*Citrus paradise* L.), pummelo (*Citrus grandis* L.), other varieties and hybrids. Citrus is the third largest fruit industry of the world and occupies 6 per cent of the total area under various fruits. World annual production of citrus fruits in 2012 was 131.28 million metric ton (Mmt) (FAO, 2012). In Bangladesh, the total acreage under citrus fruits (2010-2011) was about 5995 ha while the total production was around 1, 36,756 mt (BBS, 2011). Citrus plants are grown in all homesteads, nurseries as well as most of the orchard of all over Bangladesh. Although Bangladesh, being an important centre of origin especially for limes and lemons, the citrus industry is not developed so far. The yield is very low compared to other countries due to various problems such as insect pests, diseases and low yielding varieties. Citrus is affected by a large number of insect pests which contribute towards citrus decline (Chanda, 1970). Among the factors responsible for low production and also low fruit quality, insect pests are of major concern. In India about 250 species of insects have been reported on various citrus species (Nayar *et al.,* 1976). Of these only a few pests are of major importance that causes regular heavy loss, namely, lemon butterflies, citrus leaf miners, whiteflies, scale insects, and mealy bugs. Besides, bark eating caterpillars, bark boring beetles, fruit sucking moths and fruit flies also cause serious damage but occur occasionally. Among minor pests mention may be made of aphids, thrips, hairy caterpillars,

leaf eating beetles and weevils, blossom midges, flower moths, fruit sucking bugs, rind borers, pomegranate butterfly, wasps, termites, etc.

The lemon butterfly is one the most important pests of all citrus plants especially lemon. The insect is widely distributed throughout East Pakistan (Alam, 1962). Lemon butterflies are found throughout the year, though rare during winter. Their attack is more pronounced in nurseries and young plantations where the seedlings and trees may be completely defoliated (Butani, 1979). *Phyllocnistis citrella inflicts* considerable economic damage to various citrus plants in the South and South East Asian countries (HilI, 1987; Butani, 1979; Atwal, 1976; Vevai, 1969 and Alam, 1962). *Phyllocnistis citrella* badly attacks citrus in the nurseries or young plantation (Batra *et al.*, 1998; Panday and Panday, 1964). Citrus plants of North-Western belt of Bangladesh suffer seriously from the attack of the pest (Ali, 1989). The damage is caused by the larva only. The larvae after hatching penetrate through cuticles layer of the leaf tissue and mine the upper and lower surface of newly formed leaves, which results in crumbling of leaf, reduction in plant vigor by making zigzag silvery gallery and thereby reduce the photosynthetic activity and encouragement of citrus canker (Patel and Patel, 2001; Muller, 1995 and Prodhan, 1992). The mining action of the larva through leaf tissue causes the leaf deformed and curled in shape, defective in function, and finally the leaf dries and falls off. The pest usually occurs severely on the tender leaves of new flashes, but young shoots and fruits are also found to be attacked (Beanie, 1989; Panday and Panday, 1964; Latif and Yunus, 1951). Sometimes heavy infestation can retard the growth of nursery and newly planted trees causing considerable loss in yield (Muller, 1995).

Citrus aphid is found throughout the year on citrus and other host plants in East Pakistan. Citrus aphid is dark colored and sometimes found causing damage to the young orange shoots and leaves (Alam, 1962). Citrus leaf eating beetle is a minor pest of citrus. Citrus leaf eating beetle is found all over

India, Bangladesh and Burma (Butani, 1979). Citrus leaf eating beetle was recorded as a minor pest (Alam, 1962). In Bangladesh, Citrus *sinensis* L. is attacked by lemon butterfly, leaf miner, leaf roller, aphids, bark and stem borer, scale insect, mealybug, stem borer, orange bug, citrus thrips, fruit fly, fire ant, termites and citrus red mite (Ullah *et al.*, 2011). Although reports on different insect pests of citrus are found elsewhere, reports on those of the citrus are not available in Bangladesh. Thus the present research work was undertaken to fulfill the following objectives:

1. To study the insect and mite pests of citrus in Bangladesh.
2. To study the distribution of different insect and mite pests in major citrus growing districts of Bangladesh.
3. To observe the intensity of damage caused by different insect and mite pests of citrus.

CHAPTER II

REVIEW OF LITERATURE

Citrus is the first fruit crop in international trade in terms of value (UNCTAD, 2006). It is widely grown in most areas with suitable climate tropical, sub-tropical, and boarder line subtropical temperate (Lee and Leader, 2004). World citrus production and consumption has grown strongly since the mid-1980s (FAO, 2003a). Annual Citrus production of the world (from l992 to 2002) grew at a rate of 2.3% and the growth is projected to be continued at a rate of l.1% annually upto 2010 (FAO, 2003a and 2003b; Spreen, 2001). There are not many published literatures available on citrus pests. Only a few researchers have studied the diversity, nature of damage and damage severity of the pests. The related available literatures are reviewed below:

2.1 General review

Citrus (*Citrus limon* L.) is one of the important, popular and nutritious fruits in the world. In Bangladesh it has a great demand due to its nutritive value, aroma and taste. Many people of our country are suffering from the deficiency of vitamins in their daily diet. About 91 percent people of Bangladesh are suffering from the deficiency of vitamin C (Haque, 2005). It stands second in position of the world and third in position among all the subtropical fruits (Samson, 1986). Fruits are used as fresh and for juice. Besides, it is also used in the preparation of squash, lemonade, and marmalade, flavoring agents, cosmetics and for the production of oil, citric acid and pectin (Singh, 1990). *Citrus sinensis* is one of the major commercial fruit crops that is widely consumed both as fresh fruit or juice attributed to its high vitamin C content and it antioxidant potential (Kiong *et.al.,* 2008). *Citrus sinensis* is a member of Rutaceae family (Citrus family) and has the

common name like sweet orange or naval orange. Different species of citrus fruits have different chemical compositions like sugars (glucose and sucrose) and acids (primarily citric acid and little of malic acid). The rind of citrus fruits is rich in pectin and certain essential oils. The rind also contains certain glucosidcs (hesperidin in oranges, lemons and aringins in the grapefruits). Citrus fruits contain considerable amount of ascorbic acid, the vitamin C (Butani, 1979). Vitamin C is very essential for human health and cannot be stored in the human body; The daily requirement of vitamin C is 30 mg per person. Citrus fruits are the important source of vitamin C. It has some medicinal and digestive value too (Reuther *et al.,* 1967). Thus, citrus fruits play an important role in human health. Jam. jelly, prickle etc. are produced from them. Some of them are used in the juice industry. From the byproduct of juice industries, palatable molasses is produced which is a good feed for livestock (Rizk *et al*.,1980).

Citrus aphid is an important insect pest of citrus plants. It belongs to the family aphididae and order homoptera. Two major species of citrus aphid attacking citrus are brown citrus aphid *(Toxoptera citricida)* and black citrus aphid *(Toxoptera aurantii).* The real importance of aphids is due to their relation with the tristeza virus. Brown citrus aphid is the efficient vector of tristeza virus. Five species of aphids, namely brown citrus aphid, *Toxoptera citricida and Aphis citricidus,* black citrus aphid, *Toxoptera aurantii,* green peach aphid, *Myzus persicue* and green apple aphid, *Aphis pomi have* been reported to occur in citrus in India (Pruthi and Mani, 1945). Both adults and nymphs of aphid cause damage from seedling to mature green plants (lmms, 1957). The citrus aphids are well known for their complex life cycle, which involve various combinations of parthenogenesis, sexual generation, wingless and winged forms and alternation of host plant (Romoser, 1968). The life history of this Insect was studied by lmms (1957).

2.2 Insect pests of Citrus in Bangladesh

Many insect pests attack citrus in field during production. Some of them are major and cause heavy damage.

2.2.1 Field insect pests of Citrus

Citrus butterfly and citrus leaf miner are major pests of orange in Bangladesh. Besides them, citrus leaf roller, aphid, bark and stem borer, scale insect, mealybug, stem borer, orange bug, citrus thrips, fruit fly, fire ant, termites and citrus red mite also cause damage of orange in Bangladesh (Ullah *et al.*, 2011).

Anonymous (2010) reported that most of the insect pests were common for all citrus fruits. Elachi lebu was found to be infested by 15 insect pests of which lemon butterfly and citrus leaf miner were major and the rests were minor. Similarly there were 12 insect pests for Kagozi lebu with Lemon butterfly and Citrus leaf miner as major. Kamala had 17, Malta had 17, Batabi lebu had 14, Jamir had 10, Satkara had 10, Ada lebu had 10 and Jara lebu had 10 insect pests. Total nine different crops and 21 different species of insect pests *viz*. two species of lemon butterfly, citrus leaf miner, citrus leaf folder/roller, black citrus aphid, citrus blackfly, citrus red scale, citrus yellow scale, two species of citrus mealybug, Asian citrus psyllid, oriental fruit fly, two species of orange bug, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite were found in Bangladesh.

2.2.2 Insect pests of Citrus world wide

Many insect pests attack Citrus in field and cause significant damage during production. Buker *et al.* (2006) concluded that Citrus tree is affected by numerous species of insect pests, mites, and disease pathogens that infest the leaves, flowers, bark, fruits, and branches of citrus. The most common sucking pests attack citrus are aphids, mealy bugs, scales insects and mites. The small

leaf miner moth or the citrus leaf miner, *Phyllocnistis citrella* (Lepidoptera: Gracillariidae). It is potentially a series pest of citrus and related Rutacae and some ornamental plants (Beattie, 1989). In India, Citrus is commercially grown over 140,000 hectares which is about 15% of the total area under citrus cultivation in the world. The main citrus growing states in India are Andhra Pradesh (29000 hectares), Maharashtra (26000 hectares) and Punjab (21000 hectares) (Butani, I979).

Papilio demoleus described originally by Linnaeus (I758) is widely distributed from North Australia to Arabia, including, Iran. Pakistan, India, SriLanka, Bangladesh, Burma, China, Taiwan, South-East Asia, Indonesia and Philippines (Butani, 1979).

A widespread Asian species, described from Calcutta, India, citrus leaf miner is known from East Africa-Sudan to Yemen (Badawy, 1967), through Southern Asia-Saudi Arabia to India and Indonesia (Kalshoven. 1981). It is also found in New Guinea and nearby pacific Islands and Australia (Beattie, 1989; Wilson, 1991).

Citrus aphid is found in the western hemisphere: Argentina, Belize, Brazil, Bolivia, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Florida in the USA, Guyana, Haiti, Jamaica, Nicaragua, Peru, Puerto Rico, St. Lucia, Surinam, Trinidad, Uruguay, and Venezuela. (Rocha-Pena *et al.*, I995; Yokomi *et al*., 1994; Aubert *et al*., 1992; Halbert and Lastra *et al.*, I991 and 1992; Roistaeher, 1988; Geraud, 1976; Squire, 1972; Bisessar, 1968). It has been reported in the Pacific region including China, Taiwan, India, Japan, Laos, the Philippines, Vietnam, Thailand, Nepal, Indonesia, Malaysia, Sri Lanka, Hawaii, Fiji, Mauritius, Samoa, Tonga, Australia and New Zealand (Carver *et al.*, 1994; Banziger, 1977; Hely, 1976; Gavarra and Eastop, 1968).

The origin of citrus aphid is thought to be in Southeast Asia (Rocha-Pena et *al.*, 1995). Citrus aphid has been recorded in Africa including Cameroon, Congo, Ethiopia, Ghana, Kenya, Morocco, Mozambique, Somalia, South Africa, Tanzania, Tunisia, Uganda, Zaire, and Zimbabwe (Halima *et al.*, 1994).

Butani (1979) found citrus leaf eating beetle all over India and Burma. The pest is also found in Bangladesh (Ahmad and Hossain, 1979; Alam, 1962).

Papilio demoleus attacks almost all cirrus Species but prefers *C. sinensis* and *C. grandris*. Besides citrus, it has been recorded on bael (*Aegle marmelo* Correa), ber (*Zizyphus spp.)*, wood apple (*Feronia* species) and some ornamental and medicinal plants (Butani. 1979).

Lemon butterfly (*Papilio demoleus* L.*)* and citrus leaf miner (*Phyllocnstis citrella* Station*)* are major and citrus aphid (*Toxoptera aurantii* B.) and citrus leaf eating beetle are minor pests of citrus plant (Butani, I979).

Citrus Leaf Miner (CLM) is most commonly found on leaves of grapefruit Citrus X paradise Macfad and pummelo (pomelo) (*Citrus grandis* Merr.), (Badawy, 1967) and various native Rutaccae in Indonesia (Kalshoven, 1981). CLM is common Species of citrus plant and related Rutaceac within its range (Kalshoven, 1981). Other reported hosts include *Jasminum sambac* L. Aiton (Oleaceae) and *Alseodaphne semecarpifolia* Nees (Lauraceae) in India (Latif and Yunus, 1951).

Several other hosts have been reported for CLM, but larvae do not complete their life cycle on these incompatible hosts *Murray akoenigii* L. Sprengel (Rutaceae) *Jasminum sp*., *Dalbergia sissoo* Roxb. Ex DC (Leguminosae) and *Grewia asiatica* L. (Tiliaceae) in India (Latif and Yunus. 1951).

The reports on the association of citrus aphid with many species of Anacardiaceae, Bombaceae, Bureraceae, Camelliaceae, Caryophyllaceae, Dioscuraeeae, Ebenaceae, Ericaceae, Euphorbiaceae, Fagaceae, Flacouatiaceae, Juglandaceae, Leguminoceae, Lauraceae, Malpighiaceae, Malvaceae, Moraceae, Mysinaceae, Nyctaginaceae, Oxalidaceae, Passifloraceae, Rosaceae, Robiaceae, Rutaceae, Temstroemiaceae, Ulmaceae and Urticaceae have recently been reviewed and summarized by Michand (1998). Many observations of citrus aphid associated with the non-rutaceous plants could be attributable to misidentifications (Stoetzel, 1994). Most researchers generally agree that collections or

observations of citrus aphid from the non-rutaceous plant species do not necessarily mean these are suitable for development and reproduction for citrus aphid unless a host suitability study has been conducted to support the fact. For example, the tender shoots of Ficusretusa *var. nitida* (Thumb) Miq. had often been observed to be colonized by citrus aphid in citrus grove in South Florida; however, many attempts were made to rear this insect on this host in the laboratory (Tsai, 1998).

Butani (1979) observed that citrus leaf eating beetle was a specific pest of citrus. There was no alternative host of the insect.

Kaila and Baruah (2001) observed the abundance of the pest leaf miner throughout the year and reached its peak in the month of May with a daily catch of 0.93 and l.06 during 1997 and 1998 respectively.

Morales *et al.* (2000) studied on population fluctuations during 1996-98 at various locations in Venezuela and found that the greatest populations occurred during rainy season with an increase in the number of buds which the insect requires for oviposition.

Narayanamma and Sabithri (2002) studied the seasonal abundance of citrus butterfly on 'Sathgudi' sweet orange and 'Tenali' acid lime during July 2000 to June 2001 in Tirupati, Andra Pradesh, India and found that butterfly population was negligible during July and August, 2000 and from April to June, 2001. Pest incidence was first initiated from the second fortnight of August on sweet orange and from the first fortnight of September on acid lime. Peak activity was synchronized with the emergence of new foliage. Sunita (2003) conducted a field experiment in Kanpur, Uttar Pradesh, India during 1995-96 to observe the population dynamics of citrus butterfly on different lime cultivars were found that the population of lemon butterfly was highest from February to November and peak in August.

Patel and Patel (200l) stated that the activity of *P. citrella* on lime was found throughout the year and found higher population of the pest in last week of September but later on it was reduced and reached

the lowest density in the 1st week of January. The rise in population was again observed from the 2nd week of January and reached a peak in the 2nd week of February, and then it was found decreasing until end of May. The rise was again observed from 1st week of June and reached in peak by end of August. It was noted, that the activity of *P. citrella* during July, August and September remained high in comparison to January, February and March.

Alam (1962) observed that first generation of aphid started from the month of February and the population increased gradually which reach its peak in the months of May and June. Afterwards it decreased gradually. Alam (1962) reported that leaf eating beetle was abundant during June to August. The young caterpillar after hatching begins to eat young leaves by biting them from the edges and feeds on leaves throughout the larval stages (Alam, l962). The young caterpillars first eat the empty egg shells and then start feeding voraciously on leaves. Usually they are found on dorsal surface of leaves feeding by biting and gnawing the leaf lamina from edges inwards. The fully fed caterpillars remain motionless in an exposed condition (Butani, 1979).

Alkhateeb *et al.* (1999) carried out an experiment to study the population dynamics of citrus leaf miner in Syria and observed that no differences in infestation level were observed on four citrus species (grapefruit, lemon, Washington navel, Clementine), with highest infestation level in July. During 1996 and 1997, irrespective of citrus species, infestation with the citrus leaf miner was rare on the spring flush. The leaf miner was rare on the spring flush, low on the fall flush and it peaked during summer (July and August) reaching 100%.

Atwal (1976) described the nature of damage of *P. citrella* by making zigzag silvery mines in the young leaves and the injured epidermis takes the shape of twisted silvery galleries. Similar description was also made by Butani (1979). Berkani *et al.* (1996) studied the population dynamics of *P. citrella* on two citrus species in Algeria and observed many eggs in May but development was completely

inhibited by leaf lignifications resulting in no effect on spring shoots. The adult activity was correlated with the vegetative development of citrus trees. It was observed that 5 generations per year and the length of each generation was dependent on the prevailing temperature and humidity conditions during growing and non-growing seasons.

Boughdad *et al.* (1999) observed that the average infestation rate varied from 17 to 57% of examined citrus leaves depending on variety and also noted that each larva destroyed from 4 to 100% of the leaf surface before reaching pupal stage and found a correlation between the mined Surface and the destroyed surface.

Lara *et al.* (1998) conducted field studies from April to September 1995 in a citrus nursery in Mexico and reported that the incidence of leaf miner was 60% at the start of the study and 100% by the last week of May, remaining at this level until September when all plants sampled had mines. Percentage of damage varied from 12.0 to 35.6% reaching its highest level between 23 June and 22 July.

Pena *et al.* (I996) found that the percentage of leaf area damage was linearly correlated with the average number of mines per leaf, average mine days and cumulative mine days in 5 and I5 years old orchard of lime.

Satpathi *et al.* (1994) Studied on *P. citrella* infesting lemon leaves collected from an orchard in India found that the length of mine created by the larvae was correlated with instar up to the 3rd instar, but for last-instar larvae no correlation was found.

Wu and Wu (2000) reported that citrus leaf miner attacked severely to the leaves of the shoot. The damaged trees were weak and did not flower and bear fruit normally. Observations revealed that during the period of July to September the summer and the autumn shoots were usually badly attacked.

Alam (1962) observed that aphids remained in colonies and sucked the Cell sap from the young parts and leaves of citrus plants and thus retarded their growth. When abundant, the pests caused considerable damage.

Bose *et al.* (1990) observed that leaf eating beetle cut the newly emerged leaves at the base of the lamina in the form of a clear and sharp cut.

Butani (1979) found that leaf eating beetle attacked the new flushes of leaves and destroyed the same completely leaving only the mid rib of the leaf. Young trees suffered comparatively more than the older ones.

CHAPTER III

MATERIALS AND METHODS

The present research work on diversity and damage severity of insect pests of citrus were undertaken in 60 upazilas of 20 major citrus growing districts of Bangladesh. The research materials and methods were as follows:

3.1 Duration of the study

The surveys, interviews, group discussion with relevant respondents of major citrus growing areas in Bangladesh were conducted during April to August, 2014.

3.2. Study area

To collect the information and present status of different insect and mite pests of citrus in field, an extensive survey was conducted at 60 upazilas of selected 20 major citrus growing districts of Bangladesh. The study districts and upazilas are presented in Table 1 and 20 selected citrus growing districts of Bangladesh are shown in Figure 1.

Table 1. List of districts and upazilas selected for prevalence of insect pests of Citrus in Bangladesh

Sl. No.	District	Upazila
01	Sylhet	Golapganj
		Gowainghat
		Jaintiapur
		Balaganj
		Bianibazar
02	Moulvibazar	Sreemangal
		Kulaura
		Juri
		Barlekha
03	Hobigonj	Chunarughat
		Bahubal
		Sadar
04	Narsingdi	Shibpur
		Monohardi
		Belabo

Sl. No.	District	Upazila
		Raipura
05	Gazipur	Kaligong
		Kapasia
06	Dhaka	Savar
		Dhamrai
07	Manikganj	Singair
		Saturia
08	Mymensingh	Sadar
		Gauripur
		Ishwarganj
		Haluaghat
09	Tangail	Sakhipur
		Modhupur
		Dhanbari
		Delduar
10	Sherpur	Sadar
		Nalitabari
11	Comilla	Chandina
		Daudkandi
		Burichang
12	Chittagong	Potiya
		Mirsharai
		Shitakunda
13	Khagrachari	Sadar
		Dighinala
		Panchari
		Mahalchari
		Ramgarh
		Matiranga
14	Rangamati	Kaptai
		Langadu
		Bagaichari
15	Bandarban	Sadar
		Lama
		Ruma
16	Pabna	Ishwardi
		Atgharia
17	Rajshahi	Paba
		Puthia
18	Jessore	Bagherpara
		Jhikorgacha
19	Chuadanga	Sadar
		Alamdanga
20	Jhenaidah	Sadar
		Kaliganj

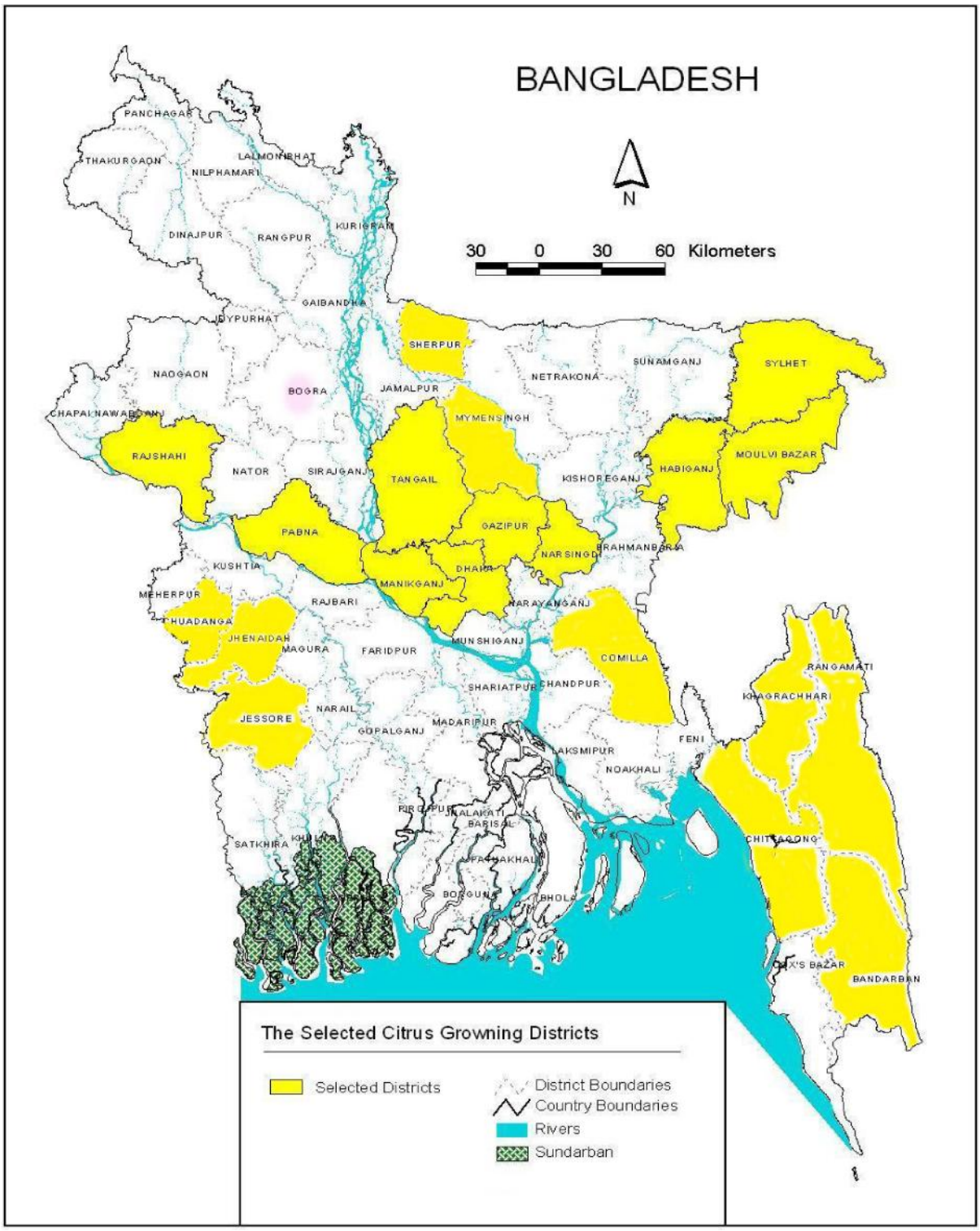

Figure 1. Map showing the selected 20 districts of citrus production under study.

3.3 Respondents of the study

The field survey was conducted to find out the present status of insect and mite pests of citrus in the sampled districts of Bangladesh. The study was done through survey questionnaires and interviews with the relevant respondents. The four categories of respondent's namely citrus growers, policy and field level officers of Department of Agriculture Extension (DAE) and scientists of Bangladesh Agricultural Research Institute (BARI) research stations were interviewed using structured questionnaire to record the present status of insect pests of citrus.

3.4 Sample size

In the field survey 25 citrus farmers from 5 blocks, five Sub-Assistant Agriculture Officer (SAAO), one Upazila Level Officer (UAO, AEO) for each upazila and one district level DAE officials (DD/DTO) for each district were interviewed by the predesigned questionnaires. In addition, information was also collected from BARI scientists/researchers or concerned resource personnel. The sample farmers were selected in consultation with the Upazila Agriculture Officer (UAO) and Sub-Assistant Agriculture Officer (SAAO) of DAE. The total sample size was 1890 as shown in Table 2.

Table 2. Sample respondents of the field survey

Respondents	Sample size
District level officials of DAE	20
Upazila level officials of DAE	60
Sub-Assistant Agriculture Officer (SAAO) of DAE	300
Citrus farmers	1500
BARI scientists	10
Total	1890

3.5 Variables covered

Considering the study objectives the following variables were considered during development of questionnaire/checklist for data collection from the respondents.

Demographic : Name, age, sex, farming area

Social : Education, Profession

Employment : Designation

Experience : Farming and citrus cultivation experience, training

3.6 Study related indicators

Variety of citrus for cultivation

Name of pests attack citrus in field

Damage status/infestation intensity and severity of the insect pests in field

Name of pests attack citrus fruit

Damage status/infestation intensity and severity of the pests

Any new insect pests observed during last 5 years

3.7 Development of study questionnaire

The draft questionnaires were prepared based on the objectives of the work and indicators for the study. The draft questionnaires were pre-tested in the selected study location and finalized with due care to be able to include appropriate questions for collection of necessary information from different levels and types of respondents to reflect the indicators relevant to the objectives of the study.

3.8 Methods of data collection

Two types of data were collected for the study such as primary data and secondary data. The methods of data collection used in the study are discussed below:

3.8.1 Primary data collection

Primary data were collected by direct personal interview and field survey.

3.8.1.1 Data collection by direct personal interview

Direct personal interview approach was adopted for collection of primary data. Personal contact was done with the respondents and obtained desired information by explaining the objectives of the study to the respondents. Reaching the target area, a respondent was selected and made self-introduction. Then purpose of the interview and objectives of the study were described to the farmers. Colored photograph of different insect pests were shown to the farmers for identification of insect pests. Lastly data sheet was filled up discussing with the respondents. After completion of filling up one questionnaire from one respondent, then moved to another respondent for fulfill the target respondents. The data were recorded only after fully being satisfied that the respondent was able to understand the question and offering any of the probable answers in his own perception. The investigators had been made all efforts to have a friendly and open-minded interaction with the respondent instead of asking question like a school teacher to his students. All question had to ask one by one and data sheets were filled up on the spot by districts. As per sample design the 1890 survey respondents had been interviewed for sampled 60 upazilas of 20 major citrus growing districts.

Adult Larva Infested leaves

Figure 2. Adult, larva and damaging symptom of lemon butterfly.

Adult Infested leaves

Figure 3. Adult and damaging symptom of citrus leaf miner.

Adult Nymph Infested leaves

Figure 4. Adult, nymph and infested leaves of citrus thrips.

Adult Infested twigs Infested leaves

Figure 5. Adult and damaging symptom of Asian citrus psyllids.

Adult Larva Infested stem

Figure 6. Adult, larva and damaging symptom of citrus stem borer.

Adult Infested leaves Infested leaves

Figure 7. Adult and damaging symptom of citrus blackfly.

Larvae

Infested leaves

Figure 8. Larvae and damaging symptom of citrus leaf roller**.**

Infested leaves

Infested fruit

Figure 9. Damaging symptom of citrus red scale insects.

Infested leaves

Infested leaves

Figure 10. Damaging symptom of citrus aphid.

Infested leaves

Infested leaves

Figure 11. Damaging symptom of citrus whitefly.

Adult

Infested leaves

Figure 12. Adult damaging symptom of citrus mealybug.

Adult

Figure 13. Adult of citrus green stink bug

3.8.1.2 Field survey

Direct personal field survey was conducted on selected 60 upazilas of 20 districts of major Citrus growing areas of Bangladesh. Reaching the target areas insect pests of Citrus was identified through careful observation of Citrus leaves, twigs, fruits and stem. Percent infestation of insect pests of Citrus was measured based on number of insect per leaf or twig or fruit or stem of a plant. Data were taken from 3 twigs or fruits or stems from randomly selected lower, middle and upper part of the plant. Severity of insect pests attacked was measured based on percentage of infestation. Severity was classified as low (below 10 percent of infestation), medium (≥10 and below 20 percent of infestation) and high (≥ 20 percentage of infestation). Then average percentages for different insect pests were listed. These data were checked with farmer's information, DAE officials and BARI scientist's information and the final list of insect pests was prepared.

Field survey at Chittagong

Field survey at Dhaka

Field survey at Sylhet

Field survey at Rajshahi

Field survey at Jessore

Field survey at Bandarban

Figure 14. Photographs of field survey data collection.

3.8.2 Secondary Data Collection

The secondary information on insect pests of citrus was collected from Bangladesh Agricultural Research Institute (BARI) and Department of Agriculture Extension (DAE), Journals, published

reports and internet. The Internet searching was done to collect information on insect pests of citrus Worldwide. These data were checked with primary data and the final list of insect pests was prepared.

3.9 Data analyses and interpretation of results

The collected data on insect pests of citrus from different locations were analyzed using the computer software Microsoft Office and MS Excel. Results were interpreted with the aim to find out variations in respect of incidence, status and severity of each insect pest. The severity for insect pests attack was also determined based on both primary and secondary data. Finally, a check list was prepared based on locally available insect pests of citrus in Bangladesh.

CHAPTER IV

RESULTS AND DISCUSSION

The results on different Citrus species and their insect and mite pests at 60 upazilas under 20 districts have been presented and discussed with possible interpretations under the following headings and subheadings:

4.1 Citrus spp. in Bangladesh

A total of nine different citrus crops are cultivated in Bangladesh namely lemon (elachi lebu), lime (kagozi lebu), mandarin (kamola), sweet orange (malta), pummelo (batabi lebu), jamir (citron), satkara, ada lebu and jara lebu. The distribution of different *Citrus spp.* in 20 districts of Bangladesh under study is shown in Table 3.

Table 3. Distribution of different *Citrus spp* in 20 districts of Bangladesh

Sl. No	Name of the crops	Scientific name	Growing Districts
01	Lemon	*Citrus limon* L.	All 20 Districts under study
02	Lime	*Citrus aurantifolia* L.	All 20 Districts under study
03	Mandarin	*Citrus reticulata* L.	Sylhet, Moulvibazar, Hobigonj, Mymensingh, Pabna, Sherpur, Chittagong, Jessore, Rangamati, Khagrachari, Bandarban, Rajshahi and Jhenaidah
04	Sweet orange	*Citrus sinensis* L.	Sylhet, Moulvibazar, Hobigonj, Rangamati, Pabna Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Sherpur, Chittagong and Jhenaidah
05	Pummelo	*Citrus maxima* L.	All 20 Districts under study
06	Jamir	*Citrus jamhiri* L.	Sylhet, Moulvibazar, Hobigonj, Sherpur and Chittagong
07	Satkara	*Citrus macroptera* L.	Sylhet, Moulvibazar and Hobigonj
08	Ada lebu	*Citrus assamensis* L.	Moulvibazar and Hobigonj
09	Jara lebu	*Citrus pennivesiculata* L.	Sylhet, Moulvibazar and Hobigonj

4.2 District wise diversity and damage severity of citrus insect and mite pests

The recorded insect and mite pests of 20 districts with their percent damage, status and severity are discussed below:

4.2.1 Diversity and damage severity of citrus pests in Sylhet District

Fourteen Insect and mite pests of citrus were recorded in Sylhet district with their percent of damage and severity. The recorded insect and mite pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, citrus stem borer, citrus thrips, termite and citrus red mite. The percent of infestation of citrus leaf miner was found highest with high level of severity (farmer's information 65.00 percent and field survey data 70.55 percent) (Table 4). The infestation and severity of lemon butterfly and citrus green stink bug were also high. Citrus aphid, citrus blackfly and termite caused medium damage. Asian Citrus Psyllid was found in Sylhet with low level of severity. Citrus red scale, citrus mealybug, citrus whitefly, leaf folder, stem borer and citrus red mite were found with low level of severity (Table 4).

4.2.2 Diversity and damage severity of citrus pests in Moulvibazar District

In Moulvibazar district, 12 insect pests were recorded with their variable infestation levels and damage severity. The recorded insect pests include lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus whitefly, citrus leaf folder, citrus stem borer, citrus thrips and termite. The most important pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 75.00 percent) and high level of severity followed by lemon butterfly having infestation (farmer's information 35.00 percent and field survey data 40.00 percent) and high level of severity (Table 5). The level of infestation and severity of citrus green stink bug was also high. The lowest

infested pest was Citrus leaf folder with low level of severity (Table 5). Citrus aphid, citrus whitefly and citrus stem borer were found in Moulvibazar with medium level of severity. Citrus red scale, citrus mealybug, Asian citrus psyllid, citrus thrips and termite were found with low percent of infestation and low level of severity.

4.2.3 Diversity and damage severity of citrus pests in Hobigonj District

Eleven Insect and mite pests of citrus were recorded in Hobigonj district with their percent of damage and severity. The recorded insect pests include lemon butterfly, citrus leaf miner, citrus green stink bug, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips and termite. The important insects recorded with high level of severity and infestation levels are leaf miner (farmer's information 70.00 percent and field survey data 75.50 percent) and lemon butterfly (farmer's information 30.00 percent and field survey data 40.50 percent) (Table 6). Citrus thrips and termite were found with low level of severity in Hobigonj. Citrus blackfly and citrus green stink bug were found with medium level of severity and percent of infestation (farmer's information 10.00 percent and field survey data 15.00 percent) in Hobigonj (Table 6). Citrus mealybug, citrus aphid, citrus leaf folder and bark and stem borer were also found in Hobigonj district with low level of infestation and severity.

Table 4. Insect and mite pests of citrus with their infestation and severity in Sylhet district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	40.00	Major	50.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	65.00	Major	70.55	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	22.00	Major	25.50	Major	High
04	Citrus red scale	*Aonidiella aurantii* Maskel	05.00	Minor	02.50	Minor	Low
05	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	03.50	Minor	Low
06	Asian citrus psyllid	*Diaphornia citri* Kuwayana	05.00	Minor	05.50	Minor	Low
07	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	10.00	Minor	15.55	Minor	Medium
08	Citrus blackfly	*Aleurocanthus woglumi* Ashby	15.00	Minor	16.60	Minor	Medium
09	Citrus whitefly	*Dialeurodes citri* Ashmead	05.00	Minor	08.50	Minor	Low
10	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.75	Minor	Low
11	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	05.00	Minor	06.65	Minor	Low
12	Citrus thrips	*Scirtothrips citri* Moulton	05.00	Minor	06.50	Minor	Low
13	Termite	*Odontotermes obesus* Rambur	12.00	Minor	15.50	Minor	Medium
14	Citrus red mite	*Tetranychus* spp.	05.00	Minor	03.00	Minor	Low

Table 5. Insect and mite pests of Citrus with their infestation and severity in Moulvibazar District

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	35.00	Major	40.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	75.00	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	26.50	Major	High
04	Citrus red scale	*Aonidiella aurantii* Maskel	05.00	Minor	05.50	Minor	Low
05	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	03.00	Minor	Low
06	Asian citrus psyllid	*Diaphornia citri* Kuwayana	05.00	Minor	02.50	Minor	Low
07	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	10.00	Minor	12.50	Minor	Medium
07	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	13.00	Minor	Medium
09	Citrus leaf folder	*Psorosticha zizyphi* Stainton	03.00	Minor	04.50	Minor	Low
10	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	10.00	Minor	10.50	Minor	Medium
11	Citrus thrips	*Scirtothrips citri* Moulton	05.00	Minor	06.25	Minor	Low
12	Termite	*Odontotermes obesus* Rambur	06.00	Minor	08.50	Minor	Low

Table 6. Insect and mite pests of citrus with their infestation and severity in Hobigonj district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	40.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	75.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	15.00	Minor	16.50	Minor	Medium
04	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	08.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	05.00	Minor	09.50	Major	Low
06	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	15.00	Minor	Medium
07	Citrus whitefly	*Dialeurodes citri* Ashmead	05.00	Minor	08.00	Minor	Low
08	Citrus leaf folder	*Psorosticha zizyphi* Stainton	08.00	Minor	10.50	Minor	Low
09	Bark and stem borer	*Indarbela quadrinotata* Walker	05.00	Minor	07.50	Minor	Low
10	Citrus thrips	*Scirtothrips citri* Moulton	05.00	Minor	04.50	Minor	Low
11	Termite	*Odontotermes obesus* Rambur	05.00	Minor	04.50	Minor	Low

4.2.4 Diversity and damage severity of citrus pests in Narsingdi District

In Narsingdi districts, 11 insect pests were recorded with variable infestation levels and damage severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, Citrus thrips, termite and citrus red mite. Citrus leaf miner (farmer's information 65.00 percent and field survey data 75.50 percent) and lemon butterfly (farmer's information 45.00 percent and field survey data 50.00 percent) were major pests in Narsingdi with high level of severity (Table 7). The lowest infestation was found in citrus red mite with low level of severity. Citrus leaf folder, bark and stem borer and citrus mealy bug were also found with low level of severity. Citrus aphid, citrus blackfly, citrus whitefly, citrus thrips and termite were found with medium level of severity (Table 7).

4.2.5 Diversity and damage severity of citrus pests in Gazipur District

Ten insect pests were recorded in Gazipur district with variable infestation levels and severity. The recorded insect pests include lemon butterfly, citrus leaf miner, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips and termite. The most important pest was leaf miner with highest infestation (farmer's information 70.00 percent and field survey data 75.50 percent) followed by lemon butterfly with infestation (farmer's information 50.00 percent and field survey data 55.50 percent) (Table 8). The lowest infestation was found in bark and stem borer which infestation varied from 4.00-4.50 per cent. Citrus aphid, citrus blackfly, citrus whitefly and citrus thrips were found in Gazipur with medium level of severity. Citrus mealybug, citrus leaf folder, bark and stem borer and termite were found with low level of infestation and severity (Table 8).

Table 7. Insect and mite pests of citrus with their infestation and severity in Narsingdi district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	65.00	Major	75.50	Major	High
03	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	05.50	Minor	Low
04	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.00	Minor	Medium
05	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	12.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	11.50	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.50	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	04.00	Minor	03.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	12.50	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	10.00	Minor	15.00	Minor	Medium
11	Citrus red mite	*Tetranychus* spp.	03.00	Minor	03.50	Minor	Low

Table 8. Insect and mite pests of citrus with their infestation and severity in Gazipur district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	50.00	Major	55.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	75.50	Major	High
03	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	06.00	Minor	Low
04	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	10.00	Minor	15.00	Minor	Medium
05	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	11.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.00	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	04.00	Minor	04.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	15.00	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	05.00	Minor	08.00	Minor	Low

4.2.6 Diversity and damage severity of citrus pests in Dhaka District

In Dhaka district, 11 insect pests were found with variable infestation levels and severity. The recorded insect pests include lemon butterfly, citrus leaf miner, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips, termite and red mite. Leaf miner was found with highest infestation (farmer's information 75.00 percent and field survey data 80.50 percent)followed by lemon butterfly (farmer's information 45.00 percent and field survey data 50.00 percent). Both were highly severe (Table 9). Citrus leaf folder, bark and stem borer, termite and red mite were found in Dhaka with low level of severity. Citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, and citrus thrips were found in Dhaka with medium level of severity.

4.2.7 Diversity and damage severity of citrus pests in Manikgonj District

In Manikgonj district, 11 insect pests were found with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus Leaf miner, citrus red scale, citrus mealybug, citrus aphid, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips, termite and citrus red mite. The most important insect pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.50 percent) and high level of severity (Table 10). The next important insect pest was lemon butterfly with high level of infestation (farmer's information 35.00 percent and field survey data 40.00 percent) and high level of severity (Table 10). The lowest infestation was found in case of citrus red mite. Citrus red scale, citrus mealybug, citrus leaf folder and bark and stem borer were found in Manikgonj with low level of severity. The severity of citrus aphid, citrus whitefly, citrus thrips and termites were of medium.

Table 9. Insect and mite pests of citrus with their infestation and severity in Dhaka district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	75.00	Major	80.50	Major	High
03	Citrus mealybug	*Pseudococcus citri* Risso	10.00	Minor	12.50	Minor	Medium
04	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	20.00	Minor	Medium
05	Citrus blackfly	*Aleurocanthus woglumi* Ashby	12.00	Minor	15.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	15.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.50	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	08.00	Minor	08.00	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	15.00	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	05.00	Minor	07.50	Minor	Low
11	Citrus red mite	*Tetranychus* spp.	05.00	Minor	03.50	Minor	Low

Table 10. Insect and mite pests of citrus with their infestation and severity in Manikgonj district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	35.00	Major	40.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.00	Major	High
03	Citrus red scale	*Aonidiella aurantii* Maskel	09.00	Minor	08.00	Minor	Low
04	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	05.00	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	20.00	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	10.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.00	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	08.00	Minor	08.00	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	10.00	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	12.00	Minor	15.00	Minor	Medium
11	Citrus red mite	*Tetranychus* spp.	04.00	Minor	03.50	Minor	Low

4.2.8 Diversity and damage severity of citrus pests in Mymensingh District

In Mymensingh district, 13 insect pests were recorded with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips, termite and citrus red mite. The most important insect pest was leaf miner with highest infestation (farmer's information 55.00 percent and field survey data 60.50 percent) and high level of severity (Table 11). The level of infestation and severity of lemon butterfly and citrus green stink bug was also high. The lowest infestation was found in case of Citrus red mite with low level of severity. Citrus red scale, citrus mealybug and citrus leaf folder were found as minor pest with low level of severity. Citrus aphid, citrus blackfly, citrus whitefly, bark and stem borer and citrus thrips were also found in Mymensingh district with medium level of severity (Table 11).

4.2.9 Diversity and damage severity of citrus pests in Tangail District

Thirteen insect pests were recorded in Tangail district with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite. The most important insect pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.50 percent) and high level of severity (Table 12). The level of infestation and severity of lemon butterfly and citrus green stink bug was also high. The lowest infestation was found in case of citrus red mite with low level of infestation (farmer's information 55.00 percent and field survey data 60.50 percent) (table 12). Citrus red scale, citrus leaf folder, bark and stem borer,

citrus stem borer and citrus thrips were found in Tangail district with low level infestation and severity. The infestation of citrus aphid, citrus blackfly, citrus whitefly and citrus thrips were of medium level (Table 12).

4.2.10 Diversity and damage severity of citrus pests in Sherpur District

In Sherpur district, 11 insect pests were recorded with their various infestation levels and severity. The recorded insect pests include lemon butterfly, citrus leaf miner, citrus green stink bug, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips and termite. The most important pest was Leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.00 percent) and high level of severity followed by lemon butterfly with high level of infestation (farmer's information 30.00 percent and field survey data 35.00 percent) and high level of severity (Table 13). The infestation of bark and stem borer, citrus mealybug, citrus leaf folder, citrus thrips and termite were low with low level of severity. Citrus aphid, citrus blackfly, citrus green stink bug and citrus whitefly were recorded in sherpur district with medium level of severity (Table 13).

4.2.11 Diversity and damage severity of citrus pests in Comilla District

Nine insect pests were recorded in Comilla district with variable infestation levels and severity. The recorded insect pests include lemon butterfly, citrus Leaf miner, citrus reds scale, citrus mealybug, citrus aphid, citrus whitefly, citrus leaf folder, citrus thrips and termite. The most important pest was leaf miner with highest infestation (farmer's information 55.00 percent and field survey data 60.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 40.00 percent and field survey data 45.50 percent) and high

level of severity (Table 14). The Citrus reds scale, citrus mealybug, citrus leaf folder, citrus whitefly and termite were recorded as minor pests with low level of severity. Citrus aphid and citrus thrips were recorded with medium level of infestation and severity in Comilla district (Table 14).

4.2.12 Diversity and damage severity of citrus pests in Chittagong District

In Chittagong district, 13 insect pests were recorded with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips, termite and citrus red mite. The most important insect pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.00 percent) and high level of severity (Table 15). The next important insect pest was lemon butterfly with high infestation farmer's information 45.00 percent and field survey data 50.00 percent) and high level of severity. The level of infestation and severity of citrus green stink bug was also high. The lowest infestation was found in case of Citrus red mite followed by Citrus red scale, Citrus leaf folder and bark and stem borer. Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus thrips and termite were recorded in Chittagong with medium level of infestation and severity (Table 15).

Table 11. Insect and mite pests of citrus with their infestation and severity in Mymensingh district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	35.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	55.00	Major	60.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	22.50	Major	High
04	Citrus reds scale	*Aonidiella aurantii* Maskel	05.00	Minor	06.50	Minor	Low
05	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	07.50	Minor	Low
06	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.50	Minor	Medium
07	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	12.00	Minor	Medium
08	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	12.00	Minor	Medium
09	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	05.50	Minor	Low
10	Bark and stem borer	*Indarbela quadrinotata* Walker	08.00	Minor	09.50	Minor	Medium
11	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	12.00	Minor	Medium
12	Termite	*Odontotermes obesus* Rambur	10.00	Minor	15.00	Minor	Medium
13	Citrus red mite	*Tetranychus* spp.	04.00	Minor	04.50	Minor	Low

Table 12. Insect and mite pests of citrus with their infestation and severity in Tangail district

Sl. No	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	35.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	22.00	Major	24.50	Major	High
04	Citrus red scale	*Pseudococcus citri* Risso	04.00	Minor	05.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.00	Minor	Medium
06	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	12.00	Minor	Medium
07	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	16.00	Minor	Medium
08	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	05.00	Minor	Low
09	Bark and stem borer	*Indarbela quadrinotata* Walker	08.00	Minor	10.00	Minor	Low
10	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	05.00	Minor	08.00	Minor	Low
11	Citrus thrips	*Scirtothrips citri* Moulton	05.00	Minor	08.50	Minor	Low
12	Termite	*Odontotermes obesus* Rambur	12.00	Minor	15.50	Minor	Medium
13	Citrus red mite	*Tetranychus* spp.	03.00	Minor	02.50	Minor	Low

Table 13. Insect and mite pests of citrus with their infestation and severity in Sherpur district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	35.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.00	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	16.00	Major	28.50	Major	Medium
04	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	07.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.00	Minor	Medium
06	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	12.00	Minor	Medium
07	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.50	Minor	Medium
08	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	06.50	Minor	Low
09	Bark and stem borer	*Indarbela quadrinotata* Walker	03.50	Minor	04.50	Minor	Low
10	Citrus thrips	*Scirtothrips citri* Moulton	04.50	Minor	05.50	Minor	Low
11	Termite	*Odontotermes obesus* Rambur	05.50	Minor	06.50	Minor	Low

Table 14. Insect and mite pests of citrus with their infestation and severity in Comilla district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	40.00	Major	45.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	55.00	Major	60.50	Major	High
03	Citrus reds scale	*Aonidiella aurantii* Maskel	08.00	Minor	09.50	Minor	Low
04	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	06.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	10.00	Minor	15.00	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	07.50	Minor	08.50	Minor	Low
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	03.00	Minor	04.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	10.50	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	04.50	Minor	05.50	Minor	Low

Table 15. Insect and mite pests of citrus with their infestation and severity in Chittagong district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.00	Major	High
02	Citrus leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.00	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	23.50	Major	High
04	Citrus red scale	*Pseudococcus citri* Risso	05.00	Minor	04.50	Minor	Low
05	Asian citrus psyllid	*Diaphornia citri* Kuwayana	10.00	Minor	12.50	Minor	Medium
06	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	20.00	Minor	Medium
07	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	10.00	Minor	Medium
08	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	10.00	Minor	Medium
09	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.00	Minor	Low
10	Bark and stem borer	*Indarbela quadrinotata* Walker	08.00	Minor	08.00	Minor	Low
11	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	10.00	Minor	Medium
12	Termite	*Odontotermes obesus* Rambur	10.00	Minor	10.00	Minor	Medium
13	Citrus red mite	*Tetranychus* spp.	03.00	Minor	03.50	Minor	Low

4.2.13 Diversity and damage severity of citrus pests in Khagrachari District

In Khagrachari district, 9 insect pests were recorded with variable infestation levels and severity. The recorded insect pests include lemon butterfly, citrus green stink bug, citrus leaf miner, citrus aphid, citrus whitefly, citrus leaf folder, citrus stem borer, citrus thrips and termite. The most important pest was Leaf miner with highest infestation (farmer's information 70.00 percent and field survey data 75.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 35.00 percent and field survey data 40.00 percent) and high level of severity (Table 16). The level of infestation and severity of citrus green stink bug was also high. Citrus leaf folder, citrus stem borer and termite were recorded with low level of infestation and severity. Citrus aphid, citrus whitefly and citrus thrips were recorded in Khagrachari district with medium level of infestation and severity (Table 16).

6.1.14 Diversity and damage severity of citrus pests in Rangamati District

Twelve insect pests were recorded in Rangamati district with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus Leaf miner, citrus green stink bug, citrus red scale, citrus aphid, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, Termite and Citrus red mite. The most important insect pest was leaf miner with highest infestation (farmer's information 70.00 percent and field survey data 75.50 percent) and high level of severity (Table 17). The next important insect pest was lemon butterfly which infestation varied from 45.00 to 50.50 per cent. The level of infestation and severity of citrus green stink bug was also high. Citrus red mite, citrus red scale, citrus leaf folder, bark and stem borer, citrus stem borer

and termite were recorded with low level of infestation and severity. Citrus aphid, citrus whitefly and citrus thrips were recorded in Rangamati district with medium level of severity.

4.2.15 Diversity and damage severity of citrus pests in Bandarban District

In Bandarban district, 11 insect pests were recorded with variable infestation levels. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus aphid, citrus whitefly, citrus leaf folder, citrus stem borer, citrus thrips, termite and Citrus red mite. The most important pest was leaf miner with highest infestation (farmer's information 70.00 percent and field survey data 77.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 45.00 percent and field survey data 50.50 percent) and high level of severity (Table 18). The level of infestation and severity of citrus green stink bug was also high. The lowest infestation was found in case of citrus red mite, citrus blackfly, citrus whitefly, citrus leaf folder and citrus stem bore. Citrus red scale, citrus aphid, citrus thrips and termite were recorded in Bandarban district with medium level of infestation and severity (Table 18).

4.2.16 Diversity and damage severity of citrus pests in Pabna District

Thirteen insect pests were recorded in Pabna district with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, citrus stem borer, citrus thrips, termite and Citrus red mite. The most

important pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.00 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 30.00 percent and field survey data 35.50 percent) and high level of severity (Table 19). Citrus green stink bug, citrus aphid, citrus blackfly, citrus whitefly, citrus thrips and termite were recorded with medium level of infestation and severity. Citrus red scale, citrus mealybug, citrus leaf folder, citrus stem borer and citrus red mite were recorded in Pabna district with low level of infestation and severity (Table 19).

4.2.17 Diversity and damage severity of citrus pests in Rajshahi District

In Rajshahi district, 12 insect pests were recorded with variable infestation levels. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus mealybug, citrus aphid, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite. The most important pest was leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 75.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 30.00 percent and field survey data 35.50 percent) and high level of severity (Table 20). The level of infestation and severity of citrus green stink bug was also high. Citrus aphid and citrus whitefly were recorded in Rajshahi with medium level of infestation and severity. Citrus mealybug, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite were recorded in Rajshahi district with low level of severity (Table 20).

Table 16. Insect and mite pests of citrus with their infestation and severity in Khagrachari district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	35.00	Major	40.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	75.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	21.00	Major	25.00	Major	High
04	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	15.00	Minor	20.00	Minor	Medium
05	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	12.50	Minor	Medium
06	Citrus leaf folder	*Psorosticha zizyphi* Stainton	04.50	Minor	03.50	Minor	Low
07	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	05.00	Minor	04.50	Minor	Low
08	Citrus thrips	*Scirtothrips citri* Moulton	08.00	Minor	10.00	Minor	Medium
09	Termite	*Odontotermes obesus* Rambur	06.00	Minor	08.50	Minor	Low

Table 17. Insect and mite pests of citrus with their infestation and severity in Rangamati district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	75.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	23.50	Major	High
04	Citrus red scale	*Pseudococcus citri* Risso	08.00	Minor	05.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	10.00	Minor	10.50	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	04.50	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	05.00	Minor	08.00	Minor	Low
09	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	08.00	Minor	09.00	Minor	Low
10	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	12.50	Minor	Medium
11	Termite	*Odontotermes obesus* Rambur	08.00	Minor	10.00	Minor	Medium
12	Citrus red mite	*Tetranychus* spp.	03.00	Minor	03.50	Minor	Low

Table 18. Insect and mite pests of citrus with their infestation and severity in Bandarban district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	77.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	22.50	Major	High
04	Citrus red scale	*Pseudococcus citri* Risso	10.00	Minor	08.50	Minor	Medium
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	08.00	Minor	08.50	Minor	Low
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	06.50	Minor	Low
08	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	05.00	Minor	07.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	15.00	Minor	15.50	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	10.00	Minor	11.50	Minor	Medium
11	Citrus red mite	*Tetranychus* spp.	04.00	Minor	04.50	Minor	Low

Table 19. Insect and mite pests of citrus with their infestation and severity in Pabna district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	35.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.00	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	15.00	Major	17.50	Major	Medium
04	Citrus reds scale	*Aonidiella aurantii* Maskel	05.00	Minor	06.50	Minor	Low
05	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	03.50	Minor	Low
06	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.50	Minor	Medium
07	Citrus blackfly	*Aleurocanthus woglumi* Ashby	10.00	Minor	12.50	Minor	Medium
08	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.00	Minor	Medium
09	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	08.00	Minor	Low
10	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	04.00	Minor	05.50	Minor	Low
11	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	12.50	Minor	Medium
12	Termite	*Odontotermes obesus* Rambur	10.00	Minor	15.50	Minor	Medium
13	Citrus red mite	*Tetranychus* spp.	04.00	Minor	04.50	Minor	Low

Table 20. Insect and mite pests of citrus with their infestation and severity in Rajshahi district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	30.00	Major	35.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	75.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	16.00	Major	18.50	Major	Medium
04	Citrus mealybug	*Pseudococcus citri* Risso	06.00	Minor	07.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.00	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	06.50	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	02.00	Minor	03.50	Minor	Low
09	Citrus stem borer	*Chelidonium cinctum* Guerin Meneville	04.00	Minor	03.50	Minor	Low
10	Citrus thrips	*Scirtothrips citri* Moulton	08.00	Minor	09.00	Minor	Low
11	Termite	*Odontotermes obesus* Rambur	05.00	Minor	07.50	Minor	Low
12	Citrus red mite	*Tetranychus* spp.	04.00	Minor	03.50	Minor	Low

4.2.18 Diversity and damage severity of citrus pests in Jessore District

In Jessore district, 11 insect pests were recorded with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, citrus aphid, citrus whitefly, citrus leaf folder, citrus thrips, termite and citrus red mite. The most important pest was Leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 65.00 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 45.00 percent and field survey data 50.00 percent) and high level of severity (Table 21). The level of infestation and severity of citrus green stink bug was also high. Citrus aphid, citrus whitefly, citrus thrips and termite were recorded with medium level of infestation and severity. Citrus red scale, citrus mealybug, citrus leaf folder and citrus red mite were recorded in Jessore district with low level of infestation and severity (Table 21).

4.2.19 Diversity and damage severity of citrus pests in Chuadanga District

In Chuadanga district, 9 insect pests were recorded with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus mealybug, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, citrus thrips and termite. The most important pest was Leaf miner with highest infestation (farmer's information 60.00 percent and field survey data 72.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 50.00 percent and field survey data 56.50 percent) and high level of severity (Table 22). Citrus aphid, citrus

blackfly, citrus whitefly and citrus thrips were recorded with medium level of infestation and severity. Citrus mealybug, citrus leaf folder and termite were recorded in Chuadanga district with low level of infestation and severity (Table 22).

4.2.20 Diversity and damage severity of citrus pests in Jhenaidah District

Ten insect pests were recorded in Jhenaidah district with variable infestation levels and severity. The recorded insect pests are lemon butterfly, citrus leaf miner, citrus mealybug, citrus aphid, citrus whitefly, citrus leaf folder, bark and stem borer, citrus thrips and termite. The most important pest was leaf miner with highest infestation (farmer's information 70.00 percent and field survey data 77.50 percent) and high level of severity followed by lemon butterfly with high infestation (farmer's information 50.00 percent and field survey data 56.50 percent) and high level of severity (Table 23). Citrus green stink bug, citrus aphid, citrus whitefly, citrus thrips and termite were recorded with medium level of infestation and severity. Citrus mealybug, citrus leaf folder, bark and stem borer and citrus thrips were recorded in Jhenaidah district with low level of infestation and severity (Table 23).

Table 21. Insect and mite pests of citrus with their infestation and severity in Jessore district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	45.00	Major	50.00	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	65.00	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	20.00	Major	23.50	Major	High
04	Citrus reds scale	*Aonidiella aurantii* Maskel	05.00	Minor	08.50	Minor	Low
05	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	05.50	Minor	Low
06	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	20.00	Minor	Medium
07	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.00	Minor	Medium
08	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	06.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	8.50	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	12.00	Minor	15.00	Minor	Medium
11	Citrus red mite	*Tetranychus* spp.	04.00	Minor	05.50	Minor	Low

Table 22. Insect and mite pests of citrus with their infestation and severity in Chuadanga district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	50.00	Major	56.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	60.00	Major	72.50	Major	High
03	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	08.50	Minor	Low
04	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	12.00	Minor	15.50	Minor	Medium
05	Citrus blackfly	*Aleurocanthus woglumi* Ashby	15.00	Minor	12.50	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	15.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	06.50	Minor	Low
08	Citrus thrips	*Scirtothrips citri* Moulton	10.00	Minor	13.00	Minor	Medium
09	Termite	*Odontotermes obesus* Rambur	05.00	Minor	8.50	Minor	Low

Table 23. Insect and mite pests of citrus with their infestation and severity in Jhenaidah district

Sl. No.	Insect and mite pests	Scientific name	Farmer's information		Field survey data		Severity
			% infestation	Status	% infestation	Status	
01	Lemon butterfly	*Papilio demoleus* L.	50.00	Major	56.50	Major	High
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	70.00	Major	77.50	Major	High
03	Citrus green stink bug	*Nezara viridula L.*	16.00	Major	18.50	Major	Medium
04	Citrus mealybug	*Pseudococcus citri* Risso	05.00	Minor	06.50	Minor	Low
05	Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolombe	10.00	Minor	12.00	Minor	Medium
06	Citrus whitefly	*Dialeurodes citri* Ashmead	12.00	Minor	13.00	Minor	Medium
07	Citrus leaf folder	*Psorosticha zizyphi* Stainton	05.00	Minor	05.50	Minor	Low
08	Bark and stem borer	*Indarbela quadrinotata* Walker	05.00	Minor	08.50	Minor	Low
09	Citrus thrips	*Scirtothrips citri* Moulton	12.00	Minor	10.00	Minor	Medium
10	Termite	*Odontotermes obesus* Rambur	12.00	Minor	15.50	Minor	Medium

4.3 Distribution, diversity, infestation and severity of Citrus Pests in Bangladesh

The recorded insect and mite pests of citrus from 20 major citrus growing districts of Bangladesh with their distribution, host plants, infected parts, infestation, severity and pest status are discussed below:

Lemon butterfly, citrus leaf miner, citrus aphid, citrus whitefly, termite, citrus thrips and citrus leaf folder were found in all citrus growing districts of Bangladesh under study (Table 24). Citrus green stink bug was recorded in Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong, and Jhenaidah. Citrus red scale was recorded in Sylhet, Moulvibazar, Manikgonj, Mymensingh, Tangail, Comilla, Chittagong, Rangamati, Pabna, Bandarban and Jessore districts. Citrus mealy bug was recorded in all districts under study except Tangail, Chittagong, Rangamati, Khagrachari and Bandarban. Asian psyllid was recorded in Sylhet, Moulvibazar and Hobigonj. Citrus blackfly was recorded in Sylhet, Narsingdi, Hobigonj, Gazipur, Mymensingh, Tangail, Dhaka, Chittagong, pabna and sherpur. Bark and stem borer was recorded in Jhenaidah, Rajshahi, Rangamati, Chittagong, Sherpur, Tangail, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi and Hobigonj. Citrus stem borer was recorded in Jhenaidah, Rajshahi, Rangamati, Chittagong, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi Sherpur, Tangail, and Hobigonj. Citrus red mite was recorded in Sylhet, Narsingdi, Dhaka, Manikgonj, Mymensingh, Tangail, Chittagong, Rangamati, Bandarban, Pabna, Rajshahi and Jessore districts.

Nine citrus crops recorded were the host plant of lemon butterfly, citrus leaf miner, citrus aphid, citrus whitefly, termite, citrus thrips citrus leaf folder, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf

folder, bark and stem borer, citrus stem borer and citrus red mite (Table 24). The host plant of citrus green stink bug was sweet orange and mandarin.

Fifteen insect and mite pests have been identified but there was variation in infestation percent, severity and distribution (table 25). Some of them are major and cause heavy damage but some are minor pests. The recorded insect and mite pests are lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite. Citrus leaf miner and citrus butterfly are major insect pests of citrus in Bangladesh and cause heavy damage. Other insect and mite pests were minor pests in Bangladesh. The results partially agrees with the reports of Ullah *et al.* (2011) who reported 14 insect pests of orange (*Citrus Sinensis* L.) of Bangladesh namely lemon butterfly, leaf miner, leaf roller, aphids, bark and stem borer, scale insect, mealybug, stem borer, orange bug, citrus thrips, fruit fly, fire ant, termites and citrus red mite.

Lemon butterfly was recorded as major pest of citrus with high level of infestation (farmer's information 39.25± 7.66 percent and field survey data 44.85 ± 07.23 percent of infestation) and severity (Table 25). The caterpillars can completely defoliate young citrus trees and devastate citrus nurseries. In mature trees, caterpillars may prefer young leaves and leaf flush. It was recorded in all citrus growing districts under study of Bangladesh with high level of infestation and severity. Citrus leaf miner larvae feed by creating shallow tunnels, or mines, in young leaves of citrus trees. The pest was most commonly found on citrus (oranges, mandarins, lemons, limes, grapefruit, and other

varieties). Citrus leaf miner was recorded as major pest of citrus with high level of infestation (farmer's information 63.75 ± 05.82 percent and field survey data 70.90 ± 06.26 percent of infestation) and severity in Bangladesh. It was recorded in all citrus growing districts of Bangladesh (Table 25). All plant parts are likely to be fed upon, but growing shoots and developing fruit are preferred by citrus green stink bug. Citrus green stink bug was recorded in Bangladesh with high level of infestation (farmer's information 18.79 ± 02.56 percent and field survey data 22.60 ± 03.58 percent of infestation) and severity (Table 25). Citrus green stink bug was recorded as major pest in Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong, and Jhenaidah (Table 24). Butani (1979) reported that lemon butterfly (*Papilio demoleus L.)* and citrus leaf miner (*Phyllocnistis citrella* Station*)* are major and citrus aphid (*Toxoptera aurantii* B.) and citrus leaf eating beetle are minor pests of citrus plant.

Citrus red scale infests all above-ground parts of a citrus tree. When the red scale is dense on leaves and wood, it defoliates portions of the tree and either kills all or parts of branches within the tree. Citrus red scale was recorded with low level of infestation (farmer's information 06.27 ± 02.05 percent and field survey data 06.27 ± 02.23 percent of infestation) and severity (Table 25). Citrus mealybug suck cell sap from young tender parts of citrus such as leaves young stems and fruits. Citrus mealybug was recorded as minor pest with low level of infestation (farmer's information 05.40 ± 01.30 percent and field survey data 06.29 ± 02.38 percent of infestation) and severity (Table 25). The Asian citrus psyllid damages citrus when its nymphs feed on new shoots and leaves (flush growth). They remove sap from the plant tissue and inject a salivary toxin as they

feed. Asian citrus psyllid was recorded as minor pests with low level of infestation (farmer's information 06.67 ± 02.89 percent and field survey data 07.83 ± 04.04 percent of infestation) and severity (Table 25). Both nymph and adult of citrus aphid suck the cell sap from leaves, fruits and plant parts. Citrus aphid was recorded in all citrus growing districts of Bangladesh with medium level of infestation (farmer's information 11.30 ± 01.89 percent and field survey data 13.75 ± 02.84 percent of infestation) and severity (Table 25). Booker *et al.* (2006) were concluded that the most common sucking pests attack citrus are aphids, mealy bugs, scales insects and mites.

Citrus blackfly damages citrus by sucking nutrients from foliage which weakens the plants. Citrus blackflies excrete honeydew on which sooty molds develop. Sooty molds coat citrus leaves, causing them to appear black. It was recorded as minor pest with medium level of infestation (farmer's information 11.09 ± 02.02 percent and field survey data 12.92 ± 01.95 percent of infestation) and severity(Table 25). The Citrus whitefly injures the plant by consuming large quantities of sap, which it obtains with its sucking mouth parts. Further injury is caused by sooty mold fungus which grows over fruit and foliage in the copious amount of honeydew excreted by the whitefly. Citrus whitefly was recorded as minor pest with medium level of infestation (farmer's information 10.27 ± 02.28 percent and field survey data 12.13 ± 03.08 percent of infestation) and severity (Table 25).

Citrus leaf folder folded the leaves, flowers, fruits and growing parts of citrus. Citrus leaf folder was recorded in all citrus growing districts of Bangladesh with low level of infestation (farmer's information 04.93 ± 00.95 percent and field survey data 07.19 ±

02.65 percent of infestation) and severity (Table 25). Bark and stem borer bore into bark and Stem by feeding woods. Bark and stem borer was recorded as minor pest with low level of infestation (farmer's information 06.08 ± 02.46 percent and field survey data 06.89 ± 03.97 percent of infestation) and severity (Table 25). Citrus stem borer bore into the living wood damaging it. They will open holes to the outside world to get rid of their frass (waste products). Damage caused by lemon tree bore can eventually kill the tree. It was also recorded as minor pest with low level of infestation (farmer's information 05.75 ± 02.12 percent and field survey data 06.89 ± 03.97 percent of infestation) and severity (Table 25). Citrus thrips puncture epidermal cells, leaving scabby, grayish or silvery scars on the rind. They feed mainly under the sepals of young fruit. Citrus thrips were recorded in all Citrus growing districts of Bangladesh with medium level of infestation (farmer's information 08.86 ± 02.73 percent and field survey data 10.36 ± 03.10 percent of infestation) and severity (Table 25). Termite damage to citrus trees can cause severe decline and death of Citrus plant. Termite was recorded in all citrus growing districts of Bangladesh with medium level of infestation (farmer's information 08.25 ± 02.99 percent and field survey data 10.93 ± 03.92 percent of infestation) and severity (Table 25).

Citrus red mite infests leaves, fruits, twigs and limbs of all varieties of citrus. Citrus red mite was recorded as minor pest with low level of infestation (farmer's information 03.83 ± 00.69 percent and field survey data 03.79 ± 01.77percent of infestation) and severity (Table 25).

Table 24. Distribution and host plant of different insect and mite pests of citrus

Sl. No.	Common name	Scientific name	Family: Order	Distributions	Host plants
01	Lemon butterfly	*Papilio demoleus* L.	Papilionidae: Lepidoptera	All 20 Districts under study	All citrus crops
02	Citrus Leaf miner	*Phyllocnistis citrella* Stainton	Phyllocnistidae: Lepidoptera	All 20 Districts under study	All citrus crops
03	Citrus green stink bug	*Nezara viridula L.*	Pentatomidae : Hemiptera	Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong and Jhenaidah	Malta and orange
04	Citrus red scale	*Aonidiella aurantii* Maskel	Cicadae: Hemiptera	Sylhet, Moulvibazar, Manikgonj, Mymensingh, Tangail, Comilla, Chittagong, Rangamati, Pabna, Bandarban and Jessore	All citrus crops
05	Citrus mealybug	*Pseudococcus citri* Risso	Pseudococcidae: Homoptera	All districts under study except Tangail, Chittagong, Rangamati, Khagrachari and Bandarban	All citrus crops
06	Asian citrus psyllid	*Diaphornia citri* Kuwayana	Psyllidae: Homoptera	Sylhet, Moulvibazar and Hobigonj	All citrus crops
07	Citrus aphid	*Toxoptera aurantii* B. Fonscolombe	Aphididae: Homoptera	All 20 Districts under study	All citrus crops
08	Citrus blackfly	*Aleurocanthus woglumi* Ashby	Aleyrodidae: Homoptera	Sylhet, Narsingdi, Hobigonj, Gazipur, Mymensingh, Tangail, Dhaka, Chittagong, pabna and sherpur	All citrus crops

Sl. No.	Common name	Scientific name	Family: Order	Distributions	Host plants
09	Citrus whitefly	*Dialeurodes citri* Ashmead	Aleyrodidae: Homoptera	All 20 Districts under study	All citrus crops
10	Citrus leaf folder	*Psorosticha zizyphi* Stainton	Oecophoridae: Lepidoptera	All 20 Districts under study	All citrus crops
11	Bark and stem borer	*Indarbela quadrinotata* Walker	Metarbelidae: Lepidoptera	Jhenaidah, Rajshahi, Rangamati, Chittagong, Sherpur, Tangail, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi and Hobigonj	All citrus crops
12	Citrus stem borer	*Chelidonium cinctum* G. Meneville	Cerambycidae: Coleoptera	Jhenaidah, Rajshahi, Rangamati, Chittagong, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi Sherpur, Tangail and Hobigonj	All citrus crops
13	Citrus thrips	*Scirtothrips citri* Moulton	Thripidae: Thysanoptera	All 20 Districts under study	All citrus crops
14	Termite	*Odontotermes obesus* Rambur	Termitidae: Isoptera	All 20 Districts under study	All citrus crops
15	Citrus red mite	*Tetranychus* spp.	Tetranychidae: Acarina	Sylhet, Narsingdi, Dhaka, Manikgonj, Mymensingh, Tangail, Chittagong, Rangamati, Bandarban, Pabna, Rajshahi and Jessore	All citrus crops

Table 25. Infested plant parts, infestation, severity and pest status of insect and mite pests of citrus in Bangladesh

Sl. No.	Common Name	Infested plant parts	% Infestation (Mean±SD)		Severity	Status
			Farmer's information	Field survey data		
01	Lemon butterfly	Leaves	39.25 ± 07.66	44.85 ± 07.23	High	Major
02	Citrus Leaf miner	Leaves	63.75 ± 05.82	70.90 ± 06.26	High	Major
03	Citrus green stink bug	Shoots , fruits and leaves	18.79 ± 02.56	22.60 ± 03.58	High	Major
04	Citrus red scale	Leaves, stems and fruits	06.27 ± 02.05	06.27 ± 02.23	Low	Minor
05	Citrus mealybug	Leaves , stems and fruits	05.40 ± 01.30	06.29 ± 02.38	Low	Minor
06	Asian citrus psyllid	Leaves, stems and fruits	06.67 ± 02.89	07.83 ± 04.04	Low	Minor
07	Citrus aphid	Leaves, fruits and twigs	11.30 ± 01.89	13.75 ± 02.84	Medium	Minor
08	Citrus blackfly	Leaves, fruits and twigs	11.09 ± 02.02	12.92 ± 01.95	Medium	Minor
09	Citrus whitefly	Leaves, fruits and twigs	10.27 ± 02.28	12.13 ± 03.08	Medium	Minor
10	Citrus leaf folder	Leaves	04.93 ± 00.95	07.19 ± 02.65	Low	Minor
11	Bark and stem borer	Bark and stem	06.08 ± 02.46	06.89 ± 03.97	Low	Minor
12	Citrus stem borer	Stem	05.75 ± 02.12	06.89 ± 03.97	Low	Minor
13	Citrus thrips	Leaves, fruits and twigs	08.86 ± 02.73	10.36 ± 03.10	Medium	Minor
14	Termite	Stem	08.25 ± 02.99	10.93 ± 03.92	Medium	Minor
15	Citrus red mite	Leaves, fruits and twigs	03.83 ± 00.69	03.79 ± 01.77	Low	Minor

CHAPTER V

SUMMARY AND CONCLUSION

Insect and mite pests of citrus were recorded from the farmer's information and field survey data of 60 upazilas of 20 districts during April to August, 2014. Data were recorded from both farmer's information and field survey. From both farmer's information and field survey data, 15 insect and mite pests were found in Bangladesh. The Recorded insect and mite pests were lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite.

Fourteen insect and mite pests in Sylhet and Pabna districts, 13 insect and mite pests in Mymensingh, Tangail and pabna districts, 12 insect and mite pests in Moulvibazar, Rajshahi, Chittagong and Rangamati districts, 11 insect and mite pests in Hobigonj, Narsingdi, Dhaka, Manikgonj, Sherpur, Bandarban, Jessore and Jhenaidah districts, 10 insect and mite pests in Gazipur and Comilla districts, 9 insect pests and mite in Khagrachari and Chuadanga districts, were recorded with variable infestation levels and severity.

Lemon butterfly, citrus leaf miner, citrus aphid, citrus whitefly, termite, citrus thrips and citrus leaf folder were found in all citrus growing districts of Bangladesh under study. Citrus green stink bug was recorded in Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong, and Jhenaidah districts. Citrus red scale was recorded in Sylhet, Moulvibazar, Manikgonj, Mymensingh, Tangail,

Comilla, Chittagong, Rangamati, Pabna, Bandarban and Jessore districts. Citrus mealy bug was recorded in all districts under study except Tangail, Chittagong, Rangamati, Khagrachari and Bandarban. Asian psyllid was recorded in Sylhet, Moulvibazar and Hobigonj districts. Citrus blackfly was recorded in Sylhet, Narsingdi, Hobigonj, Gazipur, Mymensingh, Tangail, Dhaka, Chittagong, pabna and Sherpur districts. Bark and stem borer was recorded in Jhenaidah, Rajshahi, Rangamati, Chittagong, Sherpur, Tangail, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi and Hobigonj districts. Citrus stem borer was recorded in Jhenaidah, Rajshahi, Rangamati, Chittagong, Mymensingh, Manikgonj, Dhaka, Gazipur, Narsingdi Sherpur, Tangail, and Hobigonj districts. Citrus red mite was recorded in Sylhet, Narsingdi, Dhaka, Manikgonj, Mymensingh, Tangail, Chittagong, Rangamati, Bandarban, Pabna, Rajshahi and Jessore districts.

Lemon butterfly, citrus leaf miner and citrus green stink bug were major pest with high level of infestation (farmer's information 39.25± 7.66 , 63.75 ± 05.82 and 18.79 ± 02.56 percent and field survey data 44.85 ± 07.23, 70.90 ± 06.26 and 22.60 ± 03.58 percent of infestation respectively) and severity.

Citrus aphid, citrus blackfly, citrus whitefly, citrus thrips and termite were minor pests with medium level of infestation (farmer's information 11.30 ± 01.89, 11.09 ± 02.02, 08.25 ± 02.99, 08.86 ± 02.73 and 10.27 ± 02.28 percent and field survey data 13.75 ± 02.84. 12.92 ± 01.95, 12.13 ± 03.08, 10.36 ± 03.10 and 10.93 ± 03.92 percent of infestation respectively) and severity.

Citrus red scale, citrus mealybug, Asian citrus psyllid, citrus leaf folder, bark and stem borer, citrus stem borer and citrus red mite were minor pests with low level of infestation (farmer's

information 06.27 ± 02.05, 05.40 ± 01.30, 06.67 ± 02.89, 04.93 ± 00.95, 06.08 ± 02.46, 05.75 ± 02.12 and 03.83 ± 00.69 percent and field survey data 06.27 ± 02.23, 06.29 ± 02.38, 07.83 ± 04.04, 07.19 ± 02.65, 06.89 ± 03.97, 06.89 ± 03.97 and 03.79 ± 01.77percent of infestation respectively) and severity.

A total of fifteen insect and mite pests of citrus were found in Bangladesh. The Recorded insect and mite pests were lemon butterfly, citrus leaf miner, citrus green stink bug, citrus red scale, citrus mealybug, Asian citrus psyllid, citrus aphid, citrus blackfly, citrus whitefly, citrus leaf folder, bark and stem borer, citrus stem borer, citrus thrips, termite and citrus red mite. Citrus leaf miner and lemon butterfly were recorded as major pest with high level of infestation and severity in all districts under study. Citrus green stink bug was major pest of citrus in Sylhet, Moulvibazar, Hobigonj, Rangamati, Khagrachari, Bandarban, Rajshahi, Jessore Mymensingh, Tangail, Pabna, Sherpur, Chittagong, and Jhenaidah districts. Other recorded pests were minor pest with low to medium level of infestation and severity.

Based on the results of the present study the following recommendations may be suggested-

1. Management practices are needed for citrus leaf miner, lemon butterfly and green stink bug.
2. Seasonal abundance of major insect and mite pests of citrus in Bangladesh in relation to environmental factors.

CHAPTER VI

REFERENCES

Anonymous. (2010). Pest risk analysis of citrus and cucumber. Department of Agricultural extension URL: http://daeext.info/pdf/publication/Final-Report-pest-Risk-Analysis-DAE-june2010.pdf

Ahamad, M. and Hossain, M.B. (1979). Notes on weevil (Curculionidae: Coleopteran) of Bangladesh Agricultural University. Mymensingh. *Bangladesh J. Zool.* **7**(1): 61-66.

Alam, M.Z. (1962). Insect and Mite Pest of Fruits and Trees in East Pakistan and Their Control. East Pakistan Govt. Press, Department of Agriculture, Dacca. 48-59p.

Ali, M. (1989). Bionomics and Management of *Citrus psylla* and leaf miner. Annual Research Report (1988-89). Department of Zoology. Rajshahi University. Bangladesh. 42p.

Alkhatab, N., Raie, A., Gazal, K., Shamseen, F. and Kattab, S. (1999). A study on population dynamics of citrus leaf miner (*Phyllocnistis citrella* Station) and its parasitoids. *Arab J. Plant Protect.* **17**(2): 60-65.

Atwal, A.S. (1976). Agricultural Pest of India and South East Asia. Kalyani publishers, New Delhi. 529p.

Aubert, B., Etienne, I., Cottin, R., Leelant, F., Cao-Van, P. Vuillaumc, C, Jammino, C. and Garbeasu, G. (1992). Citrus tristeza disease a new threat for the Caribbean basin. Report of a survey to Colombia, Dominican Republic, Guadeloupe, Martinique and Trinidad. *Fruits.* **47**: 393-404.

Badawy, A. (I967), The morphology and Biology of *Phyllocnistis citrella* Staint a citrus leaf miner in the Sudan. *Bull. Ento. Soci. Egypt*. **51**:95-103.

BADC (Bangladesh Agricultural Development Corporation), (1995). Fruit production manual: Horticultural Research and Development Project (FAQ/UNDP/ASDB Project). Department of Agril. Extention. 225- 231p.

Banziger, H. (1977). Keys to the identification of aphids (Homoptera).Winged aphids of species economically important in Thailand. *F.A.O. Plant Protect. Bull.* **36**: 2-41.

Batra, R.C. and Bindra, O.S. (1982). Studies for the control of citrus pests in the Punjab. *Indian J. Hort*. **39**(3-4): 285.

Batra, R.C., Nadia, S., Aurora, P.K. and Shanna, N. (1998). Population studies of *Phyllocnistis citrella* Station on some commercial root stocks of citrus under nursery conditions. *Pests Manag. Hort. Ecosys.* **4**(2): 61-64.

BBS. (2012). Monthly statistically Bulletin. Bangladesh, Bureau of Statistics, Planning Division, Ministry of Planning Govt. of the People's Republic of Bangladesh.

Beattie, G.A.C. (1989). Citrus leaf miner. NSW Agric. and Fisheries, Agfact, H2. AE. 4:1-4.

Berkani, A., Moats, A. and Druid, B. (1996). Study on the population dynamics of *Phyllocnistis citrella* Station in Algeria. *Fruits Paris*. **51**(6): 417-424.

Bissesssar, S. (1968). Citrus tristeza in Guyana. *F.A.O. Plant Protect. Bull*. **16**: 45- 48.

Boughdad, A., Bouazzaoui, Y, and Khalek, A.L. (1999). Pest status and biology of the citrus leaf miner, *Phyllocnistis citrella* Station in Morocco. Pro. 7-9 December, 1999: 251-259.

Buker, V.R.S. and Manner, H.I. (2006).Citrus species. Elevitch. C.R. and Smith, Easton Z.I,. Hawaii. Holualoa, (PAR), Resources Agriculture Permanent Agroforestry. Island Pacific for Profiles S. pecies (ed.). C. R. Elevitch, In: http://www.traditionaltree.org

Butani, D.K. (1979). Insect of Fruits. *Indian Agric. Res. Inst*. New Delhi. 123-129 pp.

Carver, M., Hart, P.J. and Wellings, P.W. (1994). Aphids (Hemiptera: Aphididae) and associated biota from the Kingdom of Tonga, with respect to biological control. *Plant Protect. Entomol*. **69**: 250-260.

Chanda, K.L. (1970). Citrus production in India *J. Res. Punjab Agric. Univ.* Ludhiana, India, pp. 9-25.

Clausen, C.P. (1927). The citrus insects of Japan. USA, Washington, DC. *Tech. Bull*. **15**:1-15.

Clausen, C.P. (1933). The citrus insects of tropical Asia. USA, Washington, DC *Tech. Bull.* **266**:135.

Clausen, S.P. (1931). Two citrus leaf miners of the far East. USA, Washington, DC *Tech. Bull.* **252**: 1-13.

Ebling, W. (1959). Sub-tropical Fruit Pests, University of California Press, Loss Angeles. 123, 138, 147pp.

FAO. (1982). Food composition table for Near East. Food and Agriculture Organization of the United Nations. Rome. **26**: 74-75.

FAO. (2003a). Citrus Fruit. Medium-term prospects for agricultural commodities projections to the Year 2010. Series tite: FAO Commodities and Trade Technical papers – 1, Food and Agriculture Organization or the United Nations, Rome. URL: www.fao.org/docrep/006 /y5143e/y5143e12.htm

FAO. (2003b). Selected indicators of food and agriculture development in Asia Pacific region 1999-2002. Food and Agriculture Organization of the United Nations. Regional Office for Asia and Pacific, Bangkok. URL: www.fao.org/docrep/004/AD452E/ ad452e00.htm

FAO. (2012). citrus fruit fresh and processed annual statistics. URL: http://www.fao.org/ fileadmin/templates/est/COMM_MARKETS_MONITORING/Citrus/Documents/CITRUS_BULLETIN_2012.pdf

Farha, J. (2005). Characterization of some Citrus fruits using morphological traits and isozymes. Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 1-110.

Gavarra, M.R. and Estop, V.F.(1976). Notes on the estimation of alate aphid populations using Moericke yellow trays. *Philippine Entomol*. **3**: 246-249.

Geraud, F. (1976). Elafidonegro de los citricos Toxopremcitricida (Kirkaldy) en Venezuela (Resumen). Premier Encuentro Venezuelano de Entomologia. Universidad central de Venezuela. Faculdadde Agronomia lnstituto de Zoologia Agricola. Maracay. Venezuela.

Halima, K.M.B., Rabasee. J. M. and Hamouda, M.H.B. (1994). The aphids of citrus fruits and their natural enemies in Tunisia. Tropicultura. *Portect. Eng. Sum.* **12**: 145-147.

Haque, M.A. (2005). Lebu Pholer Adhunik Udpadan Projokti. Horticultural Research Center. BARI, Gazipur.

Hay, M.A. and Nguyen, R. (1997). Classical biological control of Citrus leaf miner *Phyllocnistis citrella* Station. *Tropical Lepidoptera.* **8**(1): 2-7.

Hely, P.C. (1968). The entomology of citrus in New South Wales. *Misc. Pub. Aust. Entomol. Soc.* **1**: 1-20.

Hill, D.S. (1937). Agricultural Insect Pest of the Tropics and their Control. 2nd edn. Cambridge University Press. 747p.

Hill, G.F. (1918). History of Citrus cankers in the northern Territory (The flows of its occurrence elsewhere). *Northern Territory Bull. Australia*. **18**: 1-8.

Huang, H. and Baruah, B.P. (2001). Population buildup of certain citrus pests in relation to weather factors. *J. Appl. Zool. Res***. 12**(1): 51-52.

Kiong, A.L.P., Wan, L.S., Hussein, S. and Ibrahim, R. (2008). Induction of somatic embryos from explants different of *Citrus sinensis*. *J. Sci.* **3**: 18-32.

Lal, K.B. (1950). Insect Pests of Fruit trees grown in the plains. *Agric. Anim. Husb. U.P.* **1**(4): 30-45.

Lara, G.I., Quiroz. M.H., Sanchez, J. A., Badii, M.H. and Rodriguez, C.V. (1998). Citrus leaf miner *Phyllocnistis citrella* Station, incidence, damage and natural enemies in Montemorelos, Nuevoleon. Mexico. *South Western Entomol.* **23**(1): 9394.

Lastra, R., Meneses, R., Still. P.E. and Niblett. C.L. (1991). The citrus tristeza virus situation in Central America. p. 156-159. In. Brlanski, R.H., Lee, R.F. and Timmer, L.W. eds. *Proc. Conf. Intl. Org. Citrus Virol.* 11th, Riverside, California.

Latif, A. and Yunus, C.M. (1995). Food plants of citrus leaf miner. *Punjab Bull. Entomol. Res.* **42**: 311-316.

Lee, R. and Leader, R. (2004). USDA-ARS National clonal germplasm repository for Citrus and Dates in Riverside. California- Annual Report. p. 2.

lmms, A.D. (1957). A General Text book of Entomology. English Language Book Society, London. 447p.

Lo, K.C. and Chiu, S.C. (1998). The illustrations of citrus insect pests and their natural enemies in Taiwan. Taichung Taiwan Agricultural Research Institute. 75p.

Margabandhu, V. (1933). Insect Pest of oranges in the northern Citrus. *Madras Agric. J.* **21**: 60-68.

Michand, J.P. (1998). A review of the literature on Toxoptera citricida (Kirkaldy) (Homoptera: Aphididae). *Florida Entomol.* **81**: 37-61.

Moghahed, M.I. (I999). Susceptibility of some citrus trees varieties to infestation with the citrus leaf miner, *Phyllocnistis citrella* Station. *Annals Agric. Sci. Cairo*. **44**(2): 761-774.

Morales, P., Cermeli, M., Godoy, F. and Flores, B. (2000). The citrus leaf miner: Population fluctuation of the insect. *Fonaiap Divulga Venezuela.* 65: 42-44.

Muller, G.W. (1995). IPM working for development. Bulletin of Pest Management. *Lnstituto Agronomica Av. Barao de Hapura. Brazil*. 12p.

Narayanamma, V.L. and Savithri, P. (2002). Seasonal abundance of citrus butterfly, *Papilio demoleus* Linn. On Sathgudi sweet orange and Tenali acid lime. *J. Appl. Zool. Res.* **13**(1): 54-56.

Panday, N.D. and Panday, Y.D. (1964). Bionomics of *Phyllocnistis citrella* Stt. (Lepidoptera: Gracillariidae). *Indian J. Entomol*. **26**: 417-423.

Patel, G.P. and Patel, J.R. (2001). Population dynamics of *Phyllocnistis citrella* on citrus in middle Gujrat. *Indian J. Entomol*. **63**(1): 41-48.

Pena, J.E., Duncan, R. and Browning, H. (1996). Seasonal abundance of *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) and parasitoids in South Florida citrus. *Environ. Entomol.* **25**(3): 698-702.

Prodhan, S. (1992). Insect Pest of Crop. lst edn. National book trust. Kalyani Publishers, New Delhi, India. 129p.

Pruthi, H.S. and Mani, M.S. (1945). Our knowledge of insects and mite pests in India and their control IMP. *Conc. Agric. Res. Sei. Manager*. **16**. 42.

Reuther, W., Bachdor, L.D. and webber, H.J. (1967). The Citrus Industry. University California. USA.

Rizk. S.S., Shcrbiny, G.E.D and Wasef, R.A. (1980). Citrus molasses: As a byproduct of balady orange peel residue. *Agric. Res. Rev.* **58**(3):269-274

Rocha, P.M.A., Lee, R.F. Lastra, R., Niblett, C.L., Ochoacorona, F.M., Garnsey, S.M. and Yokomi, R.K. (l995). Citrus tristeza virus and its aphid vector Toxopreracitricida: Threats to citrus production in the Caribbean and Central and North Merica. *Plant Dis*. **79**: 437-443.

Roistacher, C.N. (1988). Observations on the decline of sweet orange trees in coastal Peru caused by stem pitting tristeza. *Plant Protect. Bull. India*. **36**: 19-26.

Samson, J.A. (1986). Tropical Fruits. 2nd edn. Wiley Blackwell. Surinam, Longman. 43p.

Satpathi, C.R., Bhusan, T.K., Singh, R.S. and Pramanik, A.(1994). Relationship between larval length of citrus leaf miner *Phyllocnistis citrella* St. and the leaf miner. *Environ. Ecol*. **12**(l): 216-217.

Singh, A. (1990). Fruit Physiology and Production. Kalyani publishers. New Delhi, 3rd edn. 304-313.

Spreen, T.H. (2001). Projections of World Production and Consumption of Citrus to 2010. Proc. China/FAO citrus Symp.,14-17 May 2001 - Beijing. URL: www.fao.org

Squire, F. (1972). Entomological Problems in Bolivia. P.A.N.S. 18: 249-268. British Mission in Tropical Agriculture, Cochabamba, Bolivia.

Stoentzel, M.B. (1994). Aphids (Homoptera: Aphididae) of potential importance on citrus in the United States with illustrated keys to species. *Proc. Entomol. Soc. Washington*. **96**: 7490.

Sunita, A. (2003). Population dynamics of lemon butterfly in citrus crops. *Farm Sci. J.* **12**(2): 159-160.

UNCTAD. (2006). Citrus fruits: Market information's in the commodities area. United Naions Conference on Trade and Development URL: www.unctad.org/infocomm/anglars/orange/market.htm#prod

Ullah, M.H., Hossain, M.S. and Rahaman, M.J. (2011). Kamla chasher unnoto projukti. Horticulture research centre, BARI. Joydebpur, Gazipur. 10-19.

Vevai, E.J. (1969). Know your Crops, its pest problems and control of citrus. *Pesticides*. **3**(8): 32-37.

Wilson, C.G. (1991). Notes on *Phyllocnistis citrella* Station attacking four citrus varieties in Darwin. *J. Australian Entomol. Soc.* **30**(1): 77-78.

Wu, X.F. and Wu, X.F. (2000). Control of the citrus leaf miner for Sijiju mandarin variety. *South China Fruits.* **29**(4): 19-20.

Yokomi, R.K., Lastra, R., Stoentzel, M.B., Lee, R.F., Gamsey, S.M., Gottwald, T.R., Rocha, M.A. and Niblett, C.L. (l994). Establishment of the brown citrus aphid (Homoptera: Aphididae) in Central America and the Caribbean basin and transmission of citrus tristeza virus. *J. Econ. Entomol*. **87**: 1078-1085.

You, M., Wang, L., Zheng, Q. and Fang, Z. (1995). Influence of temperature on an experimental population of citrus leaf miner. *J. Fujian Agric. Univ.* **24**(4): 414-419.

APPENDICES

Appendix 1. Questionnaire for collecting information from the farmers

A. Farmers Interview Date of Interview:

1. Name of Farmer:

Village: Union: Upazila: District:

2. Male-1 /Female-2:

3. Age:

4. Education (No education=1, Primary=2, Secondary=3, Higher secondary/above=.4):

5. Agricultural Farming Experience (No of years.):

6. Which citrus crop generally you cultivate?

7. Area of citrus crop cultivated by you? (in decimal):

8. Name of Citrus crops cultivated in your area:

9. Are you a member of any farmer's organization (Yes-1, No-2):

If yes, Name of the Organization:

10. Did you ever participate in any Training on Citrus crops (Yes-1, No-2):

If yes, where and on which citrus crops ? :

11. Did any insect pests attack your citrus crops and what percent of infestation and severity you observed?

Name of Crops	Name of the Insect Pests	Percent infestation	Severity

Appendix 2. Format for collecting information from DAE/BARI personnel

Date:

Name of the DAE/BARI Officials:

Designation:

Name of Upazila: District:

1. What are the citrus crops generally grown in your upazila/district?

2. Total Area under Citrus crops in your upazila/district.

3. How many farmers cultivate citrus in your upazila/district?

4. Name of major citrus crops and growing locations in your upazila/district.

Name of Crops	***Growing location*** **(Village, Block, Union)**

5. Recorded name of pests of citrus crops and their status, percent of infestation with severity

Name of Crops	**Insect Pests**	Percent of infestation	Status	Severity

Signature and name of interviewer

Appendix 3. Format for field data collection of insect pests of Citrus

Sl. No	Crops	Variety	Infestation (%)	Status (Major-1 Minor-2)	Severity

Signature and name of data collector