DIVERSITY AND DAMAGE SEVERITY OF INSECT PESTS OF WHEAT IN BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled, **"Diversity and Damage Severity of Insect Pests of Wheat in Bangladesh"** submitted to the **DEPARTMENT OF ENTOMOOGY**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN ENTOMOLGY** embodies the result of a piece of bona-fide research work carried out by **MD. ARIFUZZAMAN**, **Registration No. 08-02839** 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 by him.

Dated: June, 2015
Dhaka,
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Dedicated to
My
Beloved Parents

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June, 2015 **The Author**

Diversity and damage severity of insect pests of wheat in Bangladesh

ABSTRACT

The study was undertaken to evaluate diversity and damage severity of insect pests of wheat under 60 upazilas of 20 major wheat growing districts of Bangladesh. Insect pests of wheat were recorded from the farmer's information and field survey data during November 2014 to February 2015. Data were recorded from both farmer's information and field survey. From both farmer's information and field survey data, 11 field insects and 7 storage insects were found in Bangladesh. The recorded field insects were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, flea beetle, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. Storage insects were khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer, sawtoothed grain beetle, rice moth and rice meal moth. Under the present study, Comilla, Lakshmipur, Noakhali, Dinajpur, Thakurgaon, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal districts were under observation. It was observed that among the entire field insect, wheat aphid was recorded as major pest of wheat with high level of infestation (farmer's information 11.95 ± 3.30 percent and field survey data 10.23 ± 3.42 percent of infestation) and severity. All other field insects were observed as minor pest with low level of severity. Again, in terms of storage insect pests, all the entire insects were observed as minor pest. Among them khapra beetle, rice weevil and rust-red flour beetle were more harmful for storage grain and especially, rice weevil was recorded as minor storage pest of wheat with medium level of infestation (farmer's information 7.78 ± 0.68 percent and field survey data 6.43 ± 1.70 percent of infestation) and severity.

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LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	And others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	Gram
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MOP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion concentration
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent
MY	=	Mean Year
GOB	=	Government of Bangladesh
CYMMIT	=	International Maize and Wheat Improvement Centre
PRA	=	Pest Risk Analysis
IPPC	=	International Plant Protection Convention

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the cereal food crops ranked third worldwide after maize and rice. In Bangladesh wheat is the second most important staple food after rice that accounts for about 12 percent of total cereal consumption. With the introduction of new wheat varieties developed by the Bangladesh Agricultural Research Institute (BARI), wheat yield per hectare has increased from 2.17 tons in MY 2007/08 to 2.77 tons in MY 2011/12. Assuming continuing normal weather conditions, MY 2013/14 wheat production is forecast to reach 1.2 million tons from 420,000 hectares. However, in the cropping season 2013-14 the total area came to 430000 ha, the production was 1.3 million tons while the productivity was 3.03 t/ha. As an individual country China is the World leading wheat producing country that produced 126.0 million tons (mt) during 2013 when the world production was 714.05 mt. In terms of production India placed in second position by producing 95.85 mt. Other leading wheat producing countries includes Russia, United States, Canada, Australia etc.

To meet the local demand Bangladesh imports huge quantity of wheat from abroad every year. In MY 2012/13, Bangladesh wheat imports are estimated at 2.6 million tons, a 47 percent increase from the MY 2011/12 import level. For the 2012/13 marketing year, the GOB wheat import target was 800,000 tons. As of February 2013, the GOB imported 50 percent of this targeted amount. The GOB procurement drive for wheat is through open tender. Bangladesh meets 75 percent of its wheat consumption needs through imports, sourcing lower quality wheat from India and Ukraine, and higher quality wheat from Canada, Australia and the USA. India’s export ban on wheat led Bangladesh to also import from European and South American countries. However, with the withdrawal of the export ban, India has re-emerged as the principal wheat supplier to Bangladesh. According to trade sources, about 78 percent of wheat imported during the 2012/13 marketing

year has been sourced from India. Besides for food, wheat germplasms and advanced lines are also imported from CYMMIT, Mexico for the development of modern high yielding and other stress tolerant varieties.

Wheat is vulnerable to different insect pests and diseases and cause damage to the crop leading to severe yield loss. Diseases are caused by different groups of causal agents like fungi, bacteria, virus and nematodes. Wheat is suffering from many diseases, amongst such diseases, about 50 are routinely important economically (Wiese, 1987). Among the diseases some are specific for temperate regions and others are restricted to tropical and sub-tropical climate. Comparatively less number of insect pests is known to attack wheat crops. A total of 16 insect pests and mites are so far recorded to affect wheat crop in the field. In storage wheat is subject to attack by storage molds and storage insect pests. There are many instances of international spread of devastating diseases of crop plants as well as wheat through international trade and also directly by international travelers. For example, the initial accidental introduction of Hessian fly from Europe to North America was probably in straw carried by Hessian troops at the time of the Revolutionary War and established as serious pest of wheat in USA. Wheat bunt (*Tilletia carries*) was observed for the first time in California in 1854 where seed imported from Australia has been sown (Bidwell, 1860). Flag smut (*Urocystis agropyri*) was introduced from Australia to Mexico (Borlaug *et al*., 1946) and to India in 1906. This disease was first observed in a wheat field in Madison country, Illinois, USA in 1919 and thought to be introduced on imported wheat but the source has not been discovered (Humphery and Johnson, 1919). Loose smut of wheat (*Ustilago tritici*) was first observed in Laos on a wheat variety Florence, imported from Israel (Reddy, 1970). Golden nematode of potato (*Heterodera rostochinensis*) has been introduced in Mexico and USA from European 1881. Such introduction of dangerous diseases not only reduced the potential yield of the crop but also added an additional restriction on international trade.

To limit, minimize, or prevent the international movement of devastating pests and disease organisms of plants, IPPC has taken some measures to be adopted by the member countries that include preparation of pest list for each crop and conduct PRA to identify the potential hazard for each crop of a country. Proper implementation of these will minimize the risk of introduction of unwanted pests, help stabilizing the yield and remove unnecessary barrier on international trade. Being a signatory of IPPC, Bangladesh has been started to implement the specified measures. The present activities are taken up to perform PRA for wheat to make and implement sound national and international policies to prevent or restrict entering the organisms having potential threat to wheat cultivation in Bangladesh.

Objectives

1. To study the field insect pests of wheat in Bangladesh
2. To study the storage insect pests of wheat in Bangladesh
3. To observe the intensity of damage caused by insect pests of wheat

CHAPTER II
REVIEW OF LITERATURE

Wheat (*Triticum aestivum* L.) is the most widely grown food crop in the world. It ranks first in terms of area and production (Anonymous, 1988). Nutritional values as well as diversified uses of wheat prove its importance for cultivation and expansion. Insect pest cause heavy food grain losses in storage, particularly at the farm level in particularly tropical countries. The efficient control and removal of stored grain pests from food commodities have long been the goals of entomologists throughout the world because insect infestation is the most serious problem of stored grain and stored products. Losses due to insect infestation are most serious problem of cereal rains, pulses, oil seeds in storage particularly in villages in our country and towns in developing countries. A number of studies on diversity of insect pests of wheat and its damage severity have been done and reported elsewhere in the world. However, studies in this area are very limited in Bangladesh. For a better understanding and to know the research status on damage severity of wheat insect pest, the relevant literature have been reviewed and presented below:

2.1 Field pest

Macrae (1998) revealed that although there are a number of insect pests on wheat, not all of them are problems in this region every year. An exception, perhaps, are aphids and Orange Wheat Blossom Midge (OWBM), both should be scouted for every year. Other occasional common insect pests in wheat include grasshoppers, thrips, wheat stem maggot, common stalk borer, wheat stem sawfly, and wireworms.

Freier *et al*. (2007) observed that wheat (*Triticum* spp.) is a cereal crop cultivated worldwide. Wheat insect pests and their natural enemies are evident in many wheat fields in central Germany. Pests can cause great damage during the heading

and flowering phases of wheat. Wheat productivity is seriously affected by different wheat insects.

Reed and Pike (1990) found that the potential aphid pests (rose-grass aphid, *Metopolophium dirhodum* (Walker); English grain aphid (*S. avenae*) greenbug (*S. graminum*), bird cherry-oat aphid (*R. padi*) and Russian wheat aphid (*D. noxia*) which is not found in Brazil, Paraguay or Uruguay) are held in check or at below economic injury levels under most circumstances - greenbug in Brazil's state of Parana is problematic at times on wheat and sorghum by a combination of factors.

Annonymous (2010) reported that aphids can cause damage to plants in several ways. They can reduce plant growth directly as they remove plant sap. Some aphids inject a toxin with their saliva that injures the plant host. Many aphids are known to transmit plant diseases caused by viruses. Russian wheat aphid (*Diuraphis noxia*) is another important aphid pest of winter wheat. It feeds on the newest growth on the plant, and contains substances in its saliva that effectively causes cessation of chlorophyll production. Corn leaf aphid (*Rhopalosiphum maidis*) is an occasional pest of winter wheat. Sometimes infest seedling wheat in the fall and a vector of Barley Yellow Dwarf virus. English grain aphid (*Sitobion avenae*) is more common late in the growing season, and prefers to feed on the awns and wheat head, vector of Barley Yellow Dwarf virus.

Miller (1994) stated that Aphid infestations in both Egypt and Sudan are commonly controlled by one or more applications of chemical insecticides. Field scouts monitor aphid populations and recommend spraying when densities exceed 30 percent infested plants in Egypt and 35 percent infested plants in Sudan. Several common aphid species attack wheat along the length of the Nile River Valley although the dominant aphid species change with increasing mean temperatures as one move southward. El Heneidy *et al*. (1992) reported that natural enemy surveys have shown that a number of hymenopteran parasitoids of

aphids are present in or near wheat fields in Egypt as are several predators in both Egypt and Sudan.

Annonymous (2010) reported that armyworms, *Mythimna (Pseudaletia)* unipuncta typically become a pest of wheat just before, and during heading. Damaging outbreaks are usually associated with cool, damp springs. Armyworms are often more numerous in low-lying areas, areas where wheat has lodged, or in fields that have dense plant stands. Caterpillars feed first on the leaves, then on the awns, and may finally feed on immature kernels that have not reached soft dough stage. They hide during the day, preferring to feed at night or on overcast days. Armyworms have been known to eat the green stem tissue just below the base of the grain head and clip it off; however, head clipping in wheat is rare. These caterpillars will leave mature fields and attack lawns, corn, or sorghum fields.

Walters (1984) revealed that the russian wheat aphid was reported as a pest of small grains in the USSR in the early 1900's. It subsequently spread to several other Mediterranean and Middle East countries. Under the Mediterranean climate, little population increase occurred and the RWA remained a minor pest. In 1978 RWA became established in South Africa, apparently due to a more favorable climate; severe wheat damage resulted.

Walters *et al*. (1984) point out that even a single russian wheat aphid per plant can cause the typical toxin -induced symptoms. Because many of the live aphids are protected within curled leaves, sweep-net sampling may not be particularly effective. Therefore, field scouting based on damage symptoms, coupled with the affirmation that live aphids are present may be more a more accurate means of determining the extent of infestations.

Annonymous (2010) reported that wheat stem maggot (*Meromyza Americana*) adults lay eggs on the stems and leaves of late jointing or early heading plants. Larvae hatch and bore into the upper stem, usually above the top node. As they tunnel, they sever the stem, which in turn, causes the wheat head to turn white and die.

Ryan (2014) reported that wireworms (Coleoptera: Elateridae), the subterranean larval stage of the click beetle, are becoming more prevalent in many cropping systems and posing an increasing economic threat to wheat growers in the Pacific Northwest.

Annonymous (2010) reported that fall armyworm (*Spodoptera frugiperda*) is typically a problem on newly seeded winter wheat before a killing frost occurs. Young larvae will not chew completely through a leaf creating a "window pane" effect' on the leaf. As they grow, they chew along the margins of leaves. Heavy numbers can completely destroy a planting. They are often more numerous along the edge of a field.

Baloch (1978); Nagrajan (1989) and Singh (1986) revealed that *Sesmia inferens* is an important pest of wheat and has well established pest status. In addition, *Sesmia uniformis* (Katiyar 1972), *C. partellus* (Dale 1994), *C. suppressalis* (Catindig and Heong 2003), *C. auricillius* and *C. polychrysus* (Bhuiyan *et al.* 1993) are also reported to infest wheat.

Knodel (2008) reported that wheat midge primarily infests wheat, which is seeded in the spring and harvested in late summer northern Great Plains. The wheat midge is a seed feeder and infests a wheat plant during heading through early flowering. Crop injury is caused only by the larval stage. After hatching, wheat midge larvae crawl down to feed on the developing wheat kernel. They feed by exuding enzymes that break down cell walls and convert starch to simple sugars. This causes the wheat kernel to shrivel, crack and become deformed. Wheat kernels may be partially damaged or entirely aborted.

Fengqi *et al.* (2013) stated that the english grain aphid, *Sitobion avenae* (F.), is a destructive insect pest of wheat. In this study, wheat germplasm was evaluated for resistance and tolerance to english grain aphid infestation. Except for spikelet number/spike, the 1,000-kernel weight, spike weight, grain weight/ spike, and sterile spikelet number/spike of infested plants were all significantly impacted by english grain aphid infestation.

Miller and Pike (2002) reported that damage caused by most of the insects is either insignificant or limited to isolated areas, other pests inflict serious yield and forage losses. Some of these pest problems are directly linked to the unique farming system employed in a particular area, while other pests are opportunistic or generalist herbivores that do not specifically target wheat as a host.

Srivastava *et al*. (1988) reported that some wheat pests are of such paramount importance that they bear special mention or have the potential to spread to other similar agro-climatic zones where wheat is grown. Many of these pests, or groups of pests, typically undergo annual outbreaks in many countries and cause substantial crop losses. Most are not easily controlled with conventional pest management strategies, and due to the low amount of inputs on wheat in lesser developed countries, adequate resources are not available in a timely fashion.

Khan *et al.* (2012) reported many insect pests attack wheat (*Triticum aestivum* L.) in Pakistan, severe damage is caused by aphids. Aphids cause yield losses either directly (35-40%) by sucking the sap of the plants or indirectly (20-80%) by transmitting viral and fungal diseases. Population density of aphids also depends on the abiotic factors. During spring season (February-March) aphid population is increased. The aphids are considered as serious pest of wheat crop. They can multiply very rapidly under favorable conditions on leaves, stems and inflorescence. The infestation causes severe distortion of leaves and inflorescence, and can significantly decrease the yield through direct feeding.

Duran (1971) reported that the ground pearls, *Porphyrophora tritici* Bodenheimer and *P. polonica* L., are distributed throughout the moderate to low-rainfall wheat- and barley-growing areas of western and central Asia (Miller, 1991). The heaviest infestations have been reported from central and southern Turkey and from northern Syria.

Langham *et al.* (2005) found that Cereal aphids (Homoptera: Aphididae) were abundant in three site yr. *Rhopalosiphum padi* (L.), bird cherry-oat aphid, was the most abundant cereal aphid at the Brookings site, whereas *Schizaphis*

graminum (Rondani), greenbug, predominated at Highmore. Aphid days were greater in early versus late plantings. Aphid abundance in middle plantings depended on aphid species and site, but it usually did not differ from that in early plantings.

Zeiss (1989) revealed that the most important known yield-limiting insect pests of wheat in the state are the cereal leaf beetle (*Oulema melanopus* L.), Hessian fly (*Mayetiola destructor* Say), and aphids (*Aphididae*).

EL- Serwy (1998); Salman (2000) and Berg (2005) revealed similar views that is several species of the shoot fly and it has been found attacking cereal crops such as wheat, sorghum, maize, rice, barley and various millets (Sudan and barnyard grass).

Oakley *et al.* (1998) Gaafar *et al.* (2009) found that orange wheat blossom midge (OWBM), *Sitodiplosis mosellana*, and yellow wheat blossom midge (YWBM), *Contarinia tritici* (Diptera: Cecidomyiidae) are among the major pests of wheat ears of spring and winter wheat in temperate climate zones in North America and Europe.

Kurppa (1989) and Lamb *et al.* (2002) revealed that attack by wheat blossom midges decreases grain germination capacity (5–10%), grain and flour yield and decreases the quality of the harvested grain.

Studebaker *et al.* (1990) observed that armyworms, greenbugs, bird Cherry oat aphid, corn leaf aphid, hessian fly, Grasshoppers are the wheat insects. Vickerman, G.P. and Wratten (1979) found that aphid have caused considerable damage on wheat.

Rondon *et al.* (2009) reported that true WHA (White Headed Army warm) larvae feed on wheat and various other grain and grass crops. The genus also includes *F. terrapictalis* which scientists at Oregon State University (OSU) referred to as “false” wheat head armyworm during the 2009 growing season. *Faronta terrapictalis* is native to the western United States. Its host range and pest status

are not known. All *Faronta* larvae and moths look similar, which can cause confusion as to which species has been found feeding on wheat, grains or grass.

Roberts (2008) found that armyworm caterpillars can be a troublesome pest in cereal grains grown in the Pacific Northwest states. These caterpillars, from the genus *Faronta,* have caused crop damage in Umatilla County, Oregon since 2007. In 2007 and 2008 the pest caused damage to crops in Lincoln County, Washington. Researchers also noted a 35% yield loss due to the insect in 2007 and 2008 in spring wheat trials conducted by Washington State University (WSU) near Davenport, Washington.

Larsson (1988) revealed that Thrips feeding on the ovaries of young developing ears leads to distortion, degeneration and sometimes abortion of grains whereas Andjus (1996) and Moritz (2006) revealed that most common thrips species are *Limothrips denticornis, L. cerealium, Haplothrips tritici* and *H. aculeatus*. They lay their eggs in both winter and spring wheat.

Sharma *et al.* (2004) observed that termites are the important pests of wheat in North West India affecting yields. The incidence of termites was higher during the drier year. The incidence of termites was significantly higher in FIRBS compared to other three tillage options for growing wheat.

Duyn (2005) stated that wheat fields are infested with many kinds of insects. Some feed upon the living wheat plants, others prey upon the plant feeding insects, while yet others may feed on dead organic matter or weeds, or merely be passing thorough. A few species may become pests but, although present, most often do not reach damaging, “above threshold”, numbers. However, in some seasons, or under certain circumstances, insect pests of wheat can be very damaging. The following insects may become abundant enough to significantly damage the wheat crop in North Carolina: aphids (several species), cereal leaf beetle, Hessian fly, and armyworm (sometimes called true armyworm). Other plant-feeding insects

may occasionally damage wheat, such as grasshoppers, chinch bug, or fall armyworm.

Duyn (2005) reported that there are three primary species of aphids found in NC wheat; the English grain aphid, bird-oat cherry aphid, and corn leaf aphid. He also reported that cereal leaf beetle has one generation each year and both the adult and larval stages eat leaf tissue on wheat and oats. Yield reductions of 10% to 20% are typical in infested commercial fields by cereal leaf beetle.

Larsson (2005) revealed that thrips larvae and adults cause partial or complete coloration of the ears, known as the white ear effect, drying of the flag leaf, partial ear fertilization, and incomplete grain filling. Grain weight losses is about 5–7% in mildly damaged grain, but can reach 15–31% or more in severely damaged grain.

Gaafar *et al.* (2009) revealed that the productivity of wheat, which is one of the commercially important cereal crops, is seriously affected by wheat blossom midge (WBM) infestation as well as thrips. Orange wheat blossom midge (OWBM), *Sitodiplosis mosellana*, and yellow wheat blossom midge (YWBM), Contarinia tritici (Diptera: Cecidomyiidae), are among the major pests of wheat ears of spring and winter wheat in temperate climate zones in North America and Europe.

Mound (2005) and Moritz (2006) revealed that Thrips cause evident damage to winter wheat, whose development most closely overlaps with the life cycle of thrips. The common thrips species are *Limothrips denticornis* (Hal.), *L. cerealium* (Hal.) and *H. aculeatus* (Fab.) Both adults and larvae impact winter wheat development, the latter being more destructive by affecting partial or complete white ear effect, drying of flag leaf, partial ear fertilization, and incomplete grain filling (Volkmar *et al*. 2009 and Gaafar 2010).

The majority of leafhoppers (*Javesella pellucida*, *Macrosteles laevis*, *Psammotettix alienus*) found on cereals; the latter is considered a biological vector for pathogen agents, particularly for viruses (Manurung 2002; Bressan *et al.* 2009; Finger *et al.* 2012). Cereal leaf beetles, Oulema melanopus (L.), feed in the spring

on developing winter wheat. In the fall, adults feed but do not reproduce on corn leaves (Frank *et al.* 2012).

El-Wakeil *et al*. (2009) stated that *Oscinella frit* is an economic pest to wheat, barley, oats, rye and other cereal grains in many places over the world. Frit fly overwinters as a larva within the stems of cereals (Lindblad, 1999) and pupates in spring. Adults emerge in early summer and migrate by flight from overwintering sites to spring cereals where the females lay. Damaged plants produce small panicles which mature late causing high yield losses.

Dewar and Carter (1984) and Steffey and Gray (2012) stated that wheat aphids are considered one of most destructive insects in wheat *R. padi*, *M. dirhodum*, and *Sitobion avenae* have been studied extensively to determine possible yield losses following crop infestations. Forecasting systems based on threshold damage have also been developed to assess possible yield losses (French *et al.* 2001)

2.2 Store grain pest

Gentile and Trematerra (2004) reported that twenty insect pests infested stored wheat with *Troqium pulsatorium, Ephestia elutella, Plodia interpunctella, Sitotroga cerealella, Cryptolestes ferrugineus, Oryzaephilius surinamensis, Rhyzopertha dominica, Sitophilus granaries, Sitophilus oryzae, and Tribolium castaneum* being the dominant pest while Chaudhary and Mahla (2001) observed 10 insect species (*Trogoderma granarium, Rhyzopertha dominica, Sitophilus oryzae, Tribolium castaneum, Oruzaephilus surinamensis, Tenebriodes mauritanicus, Cryptolestes ferrugineus, Ploida interpunctella and Ephestia kuehnilla*) and 1 mite (*Acarus siro*) were infested wheat in storage. Their attacks reduced both quantity and food value of stored seed (Kabir 1978).

McGaughey *et al.* (1990) found that Northen great pelian small wheat weevil susceptibility was evaluated and compared to that carried out the highest birth rate in western Sefid gharbi was found in wheat.

Earlier reviews found similar results (Hamel *et al*., 1999; Samuels and Modgil, 1999; Karim, 1987) that wheat was attacked by rice weevil (*Sitophilus oryzae*), grain moth (*Sitotroga cerealella*) and red flour beetle (*Tribolium castaneum*).

Gentile and Trematerra (2004) stated that grain moth, *Sitotroga cerealella* was the major insect pests of wheat in storage while Baloch (1992) reported that Rice weevil (*Sitophilus oryzae* L.) is one of the severe pests of cereal grains and their products.

De Lima (1979); Singhamony *et al.* (1985) and Hell *et al.* (2000) found a similar review that is wheat is susceptible to storage pests which cause substantial qualitative/nutritional and quantitative losses of various magnitudes depending on the pest species and duration of storage.

De Lima (1976) and Bourne (1977) found that the rice weevil (*Sitophilus oryzae* L.) is a pest of economic importance throughout Kenya causing losses in weight, deterioration of quality and facilitating development of micro-organisms in stored cereals. Baloch *et al*. (1994) revealed that the major biotic factors influencing wheat loss during storage are insects, moulds, birds and rats.

Moss (1975) stated that attacked seed has a lower germination, which has important implications since the farmer has to retain and plant a far larger amount of seed. Attacked seed is also unlikely to meet stringent industry standards on milling quality. Milling quality refers to the ease of separation of the desired endosperm from the fibrous outer coat and the yield of food product free of any contamination by undesirable material.

Rees (2004) and Beckett *et al.* (2007) reported that weevils, *Sitophilus granarius* (L.), *Sitophilus oryzae* (L.) and *Sitophilus zeamais* (Motsch.) are classified in the most important primary pests of stored wheat, whose adults' damage grains, and larvae inhabit and feed inside the grain.

Samuel and Modgil (1999) observed that wheat was infested by rice weevil, rust red flour beetle and angoumois grain moth when it stored in jute bags, perus, metal bins and polythene bags for 6 months. Insects infested wheat stored in different

structures had a significant effect on the biological utilization of wheat protein. Insect infested grain should not be consumed as it may pose serious health hazard in man.

Simwat and Chahal (1980) visited six farmers's wheat stores from june to October at monthly intervals in India to draw the grain samples at three depths *i.e.* 5, 30 and 75 cm and found the infestation of *R. dominica, S. cerealella, T. granarum* and *T. castaneum.* Srivastava *et al*. (1973) reported that insects viz. *S. oryzae*, *R. dominica*, *S. cerealella and T. castaneum* attack the grains of wheat and maize and responsible for severe damage.

Baloch (1978) reported that *S. inferens* occasionally causes heavy losses in wheat, in restricted areas. In Rajasthan state infestation ranging from 5.7 to 11.1% 'white heads' have been recorded in wheat varietal trials (Singh 1986). In Pakistan insects including stem borer have become a major limiting factor limiting wheat production.

Maniruzzaman (1981) reported that there are approximately 200 species of insect and mite species attacking stored grains and stored products. The study revealed that three insect pests such as grain moth (*Sitotroga cerealella*), red flour beetle (*Tribolium castaneum*), and rice weevil (*Sitophilus oryzae*) attacked wheat seriously.

Niewiada *et al.* (2005) and Yildirim *et al.* (2012) revealed that Wheat weevils (*Sitophilus granarius* L.), also known as grain weevils or granary weevils, are one of the most harmful pests of stored grain, especially in temperate regions. Germinara, De Cristofaro and Rotundo (2012) reported that the infestation of *S. granarius* causes serious quantitative and qualitative losses due to insects feeding on grains, reduction of nutritional and esthetic value, and the contamination of grain. This insect feeds on grains in the adult stage and internally on grain endosperm in the larval stage. Therefore, the larvae of *S. granarius* are typically undetected. This kind of infestation is a major problem for the grain industry

because the larvae, which are a major source of insect contamination in grain products, cannot be removed by ordinary cleaning operations.

Jood, Kapoor and Singh (1996); Keskin and Ozkaya (2013); Ozkaya, Ozkaya, and Colakoglu (2009); Sánchez-Mariñez *et al.* (1997) reached on the same views that is insects such as *Rhyzopertha dominica, Tribolium confusum,* and *Trogoderma granarium* have been reported on grain and flour during storage. Yildirim *et al.* (2012) revealed that (*Sitophilus granaries*) is a well-known pest causing economically significant yield lost in stored products in Turkey and many other countries.

Mebarkia *et al*. (2009) and Ozkaya and Ozkaya (2005) reported that insects develop more rapidly on soft wheat compared to hard wheat varieties generally whereas Nawrocka, Stępień, Grundas and Nawrot (2012) also explained that the degree of damage is directly related to the infestation rate.

Mando *et al.* (1996) found that termites consumed wheat straw mulch and cow dung manure in degraded soil without negative effect on growing crop and fertility of soil was restored is seen months.

Henderson and Chirstensen (1961) found the most common insects in stored seeds or grains were rice weevil (*Sitophilus oryzae*), granary weevil (*Sitophilus granaris*), lesser grain borer (*Rhhizopertha dominica*), Saw toothed grain beetle (*Okryzaephilus surinamensis*), Cadelle betelle (*Tenebriodes maurtanicus*), Flour beetle (*Tribolum sp*), Dermistids (*Trogokdema sp*), Bruchids, Bean and Cowpea weevils (*Callosobruchus spp*), India meal moth (*Plodia interpunceella*) and Alamond moth (*Ephestica cautella*).

Longstaff (1986) stated that rice weevil is a serious pest occurring throughout the world. Both adult and grub cause serious damage to grain of wheat, maize, sorghum particularly in the monsoon. These also cause damage to the oat, barley, cotton seed, linseed and cocoa. It can cause losses to grain either directly through consumption of the grain or directly by producing ‘hot spots’ causing increase of

moisture and thereby making grain more suitable for attack by other stored gain pests.

Alam (1971) and Husian (1995) stated both grubs and adults of red flour beetle feed on a wide range of commodities and is an important pest of stored cereal. Anonymous (1973) also stated that red flour beetle (*Tribolium castenum*) is a serious pest and occurs widely throughout the world. Metcalf and Flint (1962) stated that red flour beetle (*Tribolium castenum*) most occurs in situations where grain products are stored. Neither grub nor adult could generally damage whole or intact grains but they can feed on the partially damaged or the gain which had already been damaged by other pest.

Walter (1990) reported that red flour beetles may be present in large numbers in infested grain, but are unable to attack sound or undamaged grain. The adults are attacked to light but will go towards cover when distributed. Typically these beetles can be found not only inside infested grain products but also in cracks and crevices where grains may have spilled. This insect commonly occurs in the grain milling houses and wire houses. They are attacked to grain with high moisture content and can cause a grey tint to the grain they are infesting. The beetles give of a displeasing odor, and their presence encourages mold growth in grains and grain products.

Via (1999) found that the larvae of adult of *T. Castenum* feed on a wide range of durable commodities and important secondary pests of cereals, nuts spices dried and occasionally of pears and beans. Like most other storage beetles *T. Castenum* can penetrate deeply into the storage commodity. However, the red flour beetle can only attack the broken grains and therefore they are known as secondary stored product pests. Beside these, red flour beetles attack and damage the powdery products of cereal grains.

David *et al*. (2005) revealed that losses of grain in storage due to insects were the final components of the struggle to limit insect losses in agricultural production. Insect do not only hamper the yield but also induce fungus attack. Worldwide

losses in stored products, caused by insects have been estimated to between 5-10%. Heavy insect pest infestation caused about 30% damage in the tropics. FAO's estimation as cited by Sing (1972) also revealed similar reviews that is the damage and loss in stored grains in temperate and developed countries ranged from 5-10% of world's production.

On the other hand, Labadan (1968) observed that at least 5% of the grains weight loss is occurred due to insect pests during the first 3 months of storage and this could increase 17% for the next 6 month. Caswell (1964) observed 30-50 percent wheat grain damage is occurred after 6 month of storage.

Uichanco and Capco (1984) reported that the rice weevil (*S. oryzae* and *S. zeamais*) presents a very serious problem in the preservation of harvested grains during storage. In Philippines, over 90% of the total insect damage in stored corn may attribute to *Sitophilus spp.*

Anisur (2000) reported that there a number of storage insect of wheat. The red flour beetle (*T. casteneum*) is the serious pest of stored wheat and can penetrate deeply into the storage commodity.

CHAPTER III
MATERIALS AND METHODS

The present research work on diversity and damage severity of insect pests of wheat were undertaken in 60 upazilas of 20 major wheat 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 wheat growing areas in Bangladesh were conducted during November 2014 to February 2015.

3.2. Study area

To collect the information and present status of different insect pests, diseases and weeds in wheat field and also infestation with insect pests in the storage, an extensive survey was conducted in 60 upazilas under 20 major wheat growing districts.

Field data were collected from one selected farmer's standing wheat field of each block. Thus 10 farmer's fields of each upazila were visited and the incidence and severity of different insect pests available in the field were recorded. A list of selected districts and upazilas are provided in Table 1 and 20 selected wheat growing districts of Bangladesh are shown in Figure 1.

Table 1: List of Districts and Upazilas selected for PRA Studies of Wheat

Sl. No.	District	Upazila
1	Comilla	1. Homna
		2. Daudkandi
		3. Chandina
2	Lakshmipur	4. Ramganj
		5. Raipur
3	Noakhali	6. Begumganj
		7. Companiganj
4	Dinajpur	8. Ghoramara
		9. Birampur

Sl. No.	District	Upazila
		10. Fulbari
		11. Sadar
		12. Khanshama
		13. Birganj
5	Thakurgaon	14. Pirganj
		15. Ranishankali
		16. Haripur
6	Bogra	17. Sherpur
		18. Dhunot
7	Gaibandha	19. Polashbari
		20. Shahata
		21. Sadullapur
8	Rangpur	22. Pirganj
		23. Mithapukur
		24. Taraganj
		25. Gangachhara
9	Kushtia	26. Sadar
		27. Kumarkhali
10	Jhenaidah	28. Horinakundu
		29. Sadar
		30. Mohespur
11	Jessore	31. Sadar
		32. Monirampur
		33. Keshobpur
12	Sirajganj	34. Sadar
		35. Raiganj
		36. Ullahpara
13	Rajshahi	37. Durgapur
		38. Mohanpur
		39. Godagari
		40. Tanor
14	Naogaon	41. Patnitala
		42. Porsha
		43. Dhamurhat
15	Kishoreganj	44. Kotiadi
		45. Pakundia
		46. Sadar
		47. Hossainpur
16	Mymensingh	48. Sadar

Sl. No.	District	Upazila
		49. Muktagasa
		50. Phulpur
17	Sherpur	51. Sadar
		52. Nalitabari
18	Pabna	53. Sathia
		54. Sadar
		55. Sujanagar
19	Faridpur	56. Sadar
		57. Nagarkanda
		58. Boalmari
20	Barisal	59. Gournadi
		60. Babuganj

3.3 Respondents of the study

Field activities included interview with Sub-Assistant Agriculture Officer (SAAO), Upazila Agriculture Officer (UAO) and the Deputy Director (DD), Department of Agricultural Extension (DAE) and also concerned scientists of BARI research stations using structured questionnaire to record the present status of insect pests on wheat crop.

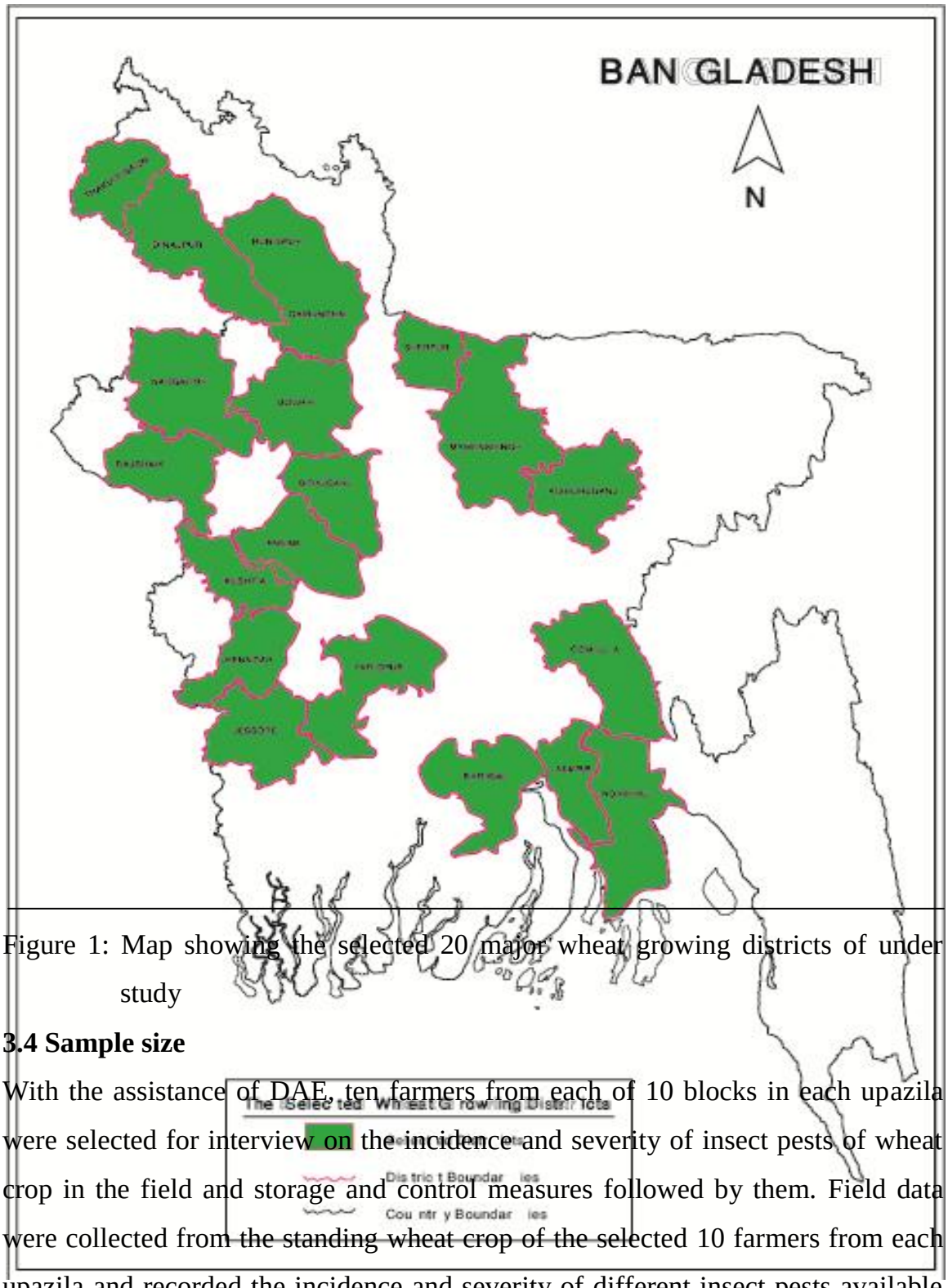


Figure 1: Map showing the selected 20 major wheat growing districts of under study

3.4 Sample size

With the assistance of DAE, ten farmers from each of 10 blocks in each upazila were selected for interview on the incidence and severity of insect pests of wheat crop in the field and storage and control measures followed by them. Field data were collected from the standing wheat crop of the selected 10 farmers from each upazila and recorded the incidence and severity of different insect pests available in the field. Additional information on the area of wheat cultivation and

production in the selected districts were collected from the DAE office. The total sample size was 6390 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
Wheat farmers	6000
BARI scientists	10
Total	6390

3.5 Variables covered

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

a) Demographic : Name, age, sex, farming area.
b) Social : Education, Profession.
c) Employment : Designation.
d) Experience : Farming and wheat cultivation experience, training.

3.6 Study related indicators

Several varieties related indicators were selected for field data collection and as follows:

a) Variety of wheat for cultivation
b) Name of pests attack in wheat field
c) Damage status/infestation intensity and severity of the insect pests in the field
d) Damage status/infestation intensity and severity of the pests
e) 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

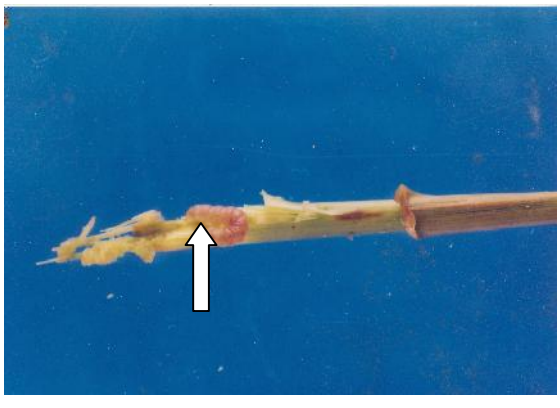
Two types of data were collected for the study such as primary data and secondary data. The methods of data collection used in the study are discussed below:

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 6390 survey respondents had been interviewed for sampled 60 upazilas of 20 major wheat growing districts.



C. Whitehead symptom showing pink borer infestation

D. Larva of pink borer

E. Cutworm infested seedlings of wheat

F. Cutworm larvae

Figure 2: Photographs of some major insect pests of wheat and their damage symptoms 26

G. Leaf feeding caterpillar infested leaves

H. Leaf feeding caterpillar

I. Rice weevil infested wheat grains

J. Red flour infested wheat grains

Figure 3: Photographs of some major insect pests of wheat and their damage symptoms

3.8.1.2 Field survey

Seven teams having two members in each team made field survey and collected necessary information based on questionnaire and format from the farmers and concerned officials of 20 major wheat growing districts. Reaching the target areas insect pests of wheat was identified through careful observation of wheat leaves, tillers, grains and stems. Percent infestation of insect pests of wheat was measured based on number of insect per leaf or tiller or grain or stem of a plant. Data were taken from 5 randomly selected plants. Severity of insect pests attacked was measured based on percentage of infestation. Severity was classified as low (below 10 percent of infestation), medium (above 10 and below 20 percent of infestation) and high (above 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 scientists' information and the final list of insect pests was prepared.

3.8.2 Secondary Data Collection

The secondary information on insect pests of wheat 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 wheat worldwide, especially in the countries from where wheat is imported to Bangladesh. Major wheat growing areas of wheat exporting countries to Bangladesh were identified and climate data of those areas were also collected so far available. Insect pests control measures taken in the field, pre-shipment phytosanitary measures and other handling procedures followed in the exporting countries were also recorded.

3.9 Data analyses and interpretation of results

The collected data on insect pests of wheat 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 wheat in Bangladesh.

CHAPTER IV
RESULTS AND DISCUSSION

The results on different wheat 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 District wise diversity and damage severity of wheat insect pests

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

4.1.1 Diversity and damage severity of wheat insect pests in Comilla district

4.1.1.1 Field insect pests

Nine field insect pests of wheat were recorded in Comilla district with their percent of damage and severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of Wheat aphid as major pest was found highest with high level of severity (farmer's information 14.00 percent and field survey data 11.00 percent) (Table 3). The infestation and severity of termite, white grub and pink borer as minor pests were low but comparatively higher than others except wheat aphid. Grasshopper, wireworms, cutworm and leaf eating caterpillar were also found with low level of severity. Cereal leaf beetle was found with lowest level of severity (Table 3).

4.1.1.2 Storage insect pests

Four storage insect pests of wheat were recorded in Comilla district with their percent of damage and severity. Rice weevil was the most sever storage pest (farmer's information 9.00 percent and field survey data 8.00 percent) and it was

Table 3. Insect pests of wheat with their infestation and severity in Comilla district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of Infestation	Status	Average percentage of Infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	3.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	3.00	Minor	2.50	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	11.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	2.50	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.00	Minor	1.50	Minor	Low
06.	White grub	*Phyllophaga* spp.	3.00	Minor	2.00	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
08.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.00	Minor	2.5	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	9.00	Major	8.00	Major	High
03.	Rust-red	*Tribolium*	5.00	Mino	4.00	Mino	Low

	flour beetle	*castaneum*		r		r	
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	2.00	Minor	1.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major
Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium
8 – 15 = High

found with high level of severity both at farmer's information and field survey data and after that Rust-red flour beetle infestation (farmer's information 5.00 percent and field survey data 4.00 percent) was found second highest with low level of severity in Comilla district. The infestation and severity of Khapra beetle and Sawtoothed grain beetle as minor pests were also found with low level of severity where the infestation of Sawtoothed grain beetle was found as lowest level of severity (Table 3).

4.1.2 Diversity and damage severity of wheat insect pests in Lakshmipur district

4.1.2.1 Field insect pests

In Lakshmipur district, 8 field insect pests were recorded with their variable infestation levels and damage severity. The recorded field insect pests included grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The most important pest was wheat aphid with highest infestation (farmer's information 9.00 percent and field survey data 8.00 percent) and high level of severity followed by pink borer having infestation (farmer's information 4.00 percent and field survey data 3.00 percent) and low level of severity (Table 4). The lowest infested pest (farmer's information 1.50 percent and field survey data 2.00 percent) was white grub with low level of severity followed by grasshopper, termite, wireworms, cutworm and leaf eating caterpillar found in Lakshmipur district with low level of severity (Table 4).

4.1.2.2 Storage insect pests

Four storage insect pests of wheat were recorded in Lakshmipur district with their percent of damage and severity. The recorded storage insect pests included khapra

beetle, rice weevil, rust-red flour beetle and rice meal moth. Rice weevil was the most severe storage pest (farmer's information 10.00 percent and field survey data 8.00 percent) and it was found with high level of severity both at farmer's

Table 4. Insect pests of wheat with their infestation and severity in Lakshmipur district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	3.00	Minor	Low
02.	Termite	*Odontotermes obesus*, *Microtermes obesi*	2.00	Minor	2.50	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis*, *Rhopalosiphum padi*, *Schizaphis graminum*	9.00	Major	8.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.00	Minor	Low
05.	White grub	*Phyllophaga* spp.	1.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
07.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera*, *Spodoptera litura*	2.00	Minor	3.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.50	Minor	4.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	10.00	Minor	8.00	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	5.00	Minor	6.00	Minor	Medium
04.	Rice meal moth	*Corcyra cephalonica*	1.00	Minor	1.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

information and field survey data and after that rust-red flour beetle infestation (farmer's information 5.00 percent and field survey data 6.00 percent) was found second highest with medium level of severity in Lakshmipur district. The infestation and severity of Rice meal moth (farmer's information 1.00 percent and field survey data 1.50 percent) was found lowest considering the level of severity (Table 4).

4.1.3 Diversity and damage severity of wheat insect pests in Noakhali

4.2.3.1 Field insect pests

There were 8 field insect pests of wheat in Noakhali district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 15.00 percent and field survey data 12.00 percent) followed by pink borer (farmer's information 5.00 percent and field survey data 4.00 percent) with low level of severity. The lowest infested pest (farmer's information 2.00 percent and field survey data 1.50 percent) was white grub with low level of severity followed by grasshopper, termite, wireworms and cutworm found in Lakshmipur district with low level of severity (Table 5).

4.1.3.2 Storage insect pests

In Noakhali district, 4 storage insect pests of wheat were recorded with their percent of damage and severity. Rice weevil was the most severe storage pest (farmer's information 10.00 percent and field survey data 7.00 percent) and it was found with high level of severity both at farmer's information and field survey data and after that rust-red flour beetle infestation (farmer's information 6.00 percent and field survey data 5.00 percent) was found second highest with medium level of severity in Noakhali district. The infestation and severity of khapra beetle

Table 5. Insect pests of wheat with their infestation and severity in Noakhali district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	2.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	3.00	Minor	2.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	15.00	Major	12.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.50	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.00	Minor	2.50	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	2.00	Minor	3.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	5.00	Minor	4.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	3.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	2.00	Minor	3.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	10.00	Minor	7.00	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	6.00	Minor	5.00	Minor	Medium
04.	Rice meal moth	*Corcyra cephalonica*	1.00	Minor	1.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

and sawtoothed grain beetle were also found with low level of severity where sawtoothed grain beetle was found with lowest level of severity (farmer's information 2.00 percent and field survey data 3.50 percent) (Table 5).

4.1.4 Diversity and damage severity of wheat insect pests in Dinajpur district

4.1.4.1 Field insect pests

Eight field insect pests of wheat were recorded in Dinajpur district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 11.00 percent and field survey data 8.00 percent) followed by pink borer (farmer's information 3.00 percent and field survey data 4.00 percent) with low level of severity. The lowest infested pest (farmer's information 1.50 percent and field survey data 1.00 percent) was wireworms with low level of severity followed by grasshopper, termite, white grub and cutworm found in Dinajpur district with low level of severity (Table 6).

4.1.4.2 Storage insect pests

In Dinajpur district, 5 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the most severe storage pest (farmer's information 8.00 percent and field survey data 6.00 percent) and it was found with high level of severity both at farmer's information and field survey data and after that rust-red flour beetle infestation (farmer's information 5.00 percent and field survey data 4.00 percent) was found second highest with low level of severity in Dinajpur district. The infestation and severity of khapra beetle and rice moth was also found with low level of severity where sawtoothed grain beetle was found with lowest level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 6).

Table 6. Insect pests of wheat with their infestation and severity in Dinajpur district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	3.00	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.50	Minor	2.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	11.00	Major	8.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.50	Minor	1.00	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.00	Minor	1.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
07.	Pink borer	*Sesamia inferens*	3.00	Minor	4.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	5.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	8.00	Major	6.00	Major	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	5.00	Minor	4.00	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low
05.	Rice moth	*Sitotroga cerealella*	2.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.5 Diversity and damage severity of wheat insect pests in Thakurgaon district

4.1.5.1 Field insect pests

Seven field insect pests of wheat were recorded in Thakurgaon district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 10.00 percent and field survey data 13.00 percent) followed by pink borer (farmer's information 3.00 percent and field survey data 2.00 percent) at low severity level. The lowest infestation (farmer's information 1.50 percent and field survey data 1.00 percent) was found from cereal leaf beetle with low level of severity followed by grasshopper, termite, leaf eating caterpillar and cutworm found in Thakurgaon district with low level of severity (Table 7).

4.1.5.2 Storage insect pests

In Thakurgaon district, 4 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the most sever storage pest (farmer's information 7.00 percent and field survey data 6.00 percent) and it was found with medium level of severity and after that khapra beetle infestation (farmer's information 4.00 percent and field survey data 3.50 percent) was found second highest with low level of severity in Thakurgaon district. The infestation and severity of rust-red flour beetle and Rice moth was also found with low level of severity where infestation of sawtoothed grain beetle was found lowest at severity level (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 7).

Table 7. Insect pests of wheat with their infestation and severity in Thakurgaon district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	1.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	1.50	Minor	2.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	10.00	Major	13.00	Major	High
04.	Cereal leaf beetle	*Oulema melanopus*	1.50	Minor	1.00	Minor	Low
05.	Cutworm	*Agrotis ipsilon*	1.50	Minor	2.00	Minor	Low
06.	Pink borer	*Sesamia inferens*	3.00	Minor	2.00	Minor	Low
07.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	3.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	6.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.00	Minor	2.00	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.6 Diversity and damage severity of wheat insect pests in Bogra district

4.1.6.1 Field insect pests

Eight field insect pests of wheat were recorded in Bogra district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 14.00 percent and field survey data 10.00 percent) followed by Pink borer (farmer's information 4.00 percent and field survey data 2.50 percent) at low severity level. The lowest infestation (farmer's information 2.00 percent and field survey data 1.00 percent) was by cutworm with low level of severity followed by grasshopper, termite, wireworm, white grub and leaf eating caterpillar found in Bogra district with low level of severity (Table 8). It was also observed that there was no insect infestation was found by cereal leaf beetle, flea beetle and shoot fly.

4.1.6.2 Storage insect pests

In Bogra district, 4 storage insect pests of wheat were recorded with their percent of damage and severity. Rice weevil was the severe storage pest (farmer's information 7.00 percent and field survey data 4.50 percent) among the entire storage pest in Bogra district and it was found with medium level of severity followed by Rust-red flour beetle infestation (farmer's information 4.00 percent field survey data 3.00 percent) and khapra beetle infestation (farmer's information 4.00 percent field survey data 2.50 percent) at low severity level. The lowest infestation among the entire stored grain pest was by lesser grain borer with lowest level of severity (farmer's information 1.00 percent and field survey data 1.50 percent) (Table 8). It was also observed that there was no infestation was found from sawtoothed grain beetle, rice moth and rice meal moth.

Table 8. Insect pests of wheat with their infestation and severity in Bogra district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	1.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.50	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	10.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.50	Minor	Low
05.	White grub	*Phyllophaga* spp.	1.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	2.00	Minor	1.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	4.00	Minor	2.50	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	2.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	2.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	4.50	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.00	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.00	Minor	1.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.7 Diversity and damage severity of wheat insect pests in Gaibandha district

4.1.7.1 Field insect pests

Nine field insect pests of wheat were recorded in Gaibandha district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 8.00 percent and field survey data 6.50 percent) followed by grasshopper (farmer's information 4.50 percent and field survey data 3.00 percent) and pink borer (farmer's information 4.00 percent and field survey data 3.00 percent) at low severity level. The lowest infestation (farmer's information 1.00 percent and field survey data 1.50 percent) was found from Wireworms and Shoot fly with low level of severity followed by termite, white grub and leaf eating caterpillar found in Gaibandha district at low severity level (Table 9). It was also observed that there was no insect infestation was found by cereal leaf beetle, flea beetle.

4.1.7.2 Storage insect pests

In Gaibandha district, 4 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the severe storage pest (farmer's information 6.00 percent and field survey data 7.50 percent) among the storage pest in Gaibandha district and it was found with medium level of severity followed by Rust-red flour beetle infestation (farmer's information 4.00 percent field survey data 3.00 percent) and khapra beetle infestation (farmer's information 3.00 percent field survey data 2.50 percent) at low severity level. The lowest infestation among the entire stored grain pest was by sawtoothed grain beetle with low level of severity (farmer's information 2.00 percent and field survey data 1.00 percent) (Table 9). It was also observed that there was no infestation was found from lesser grain borer, rice moth and rice meal moth.

Table 9. Insect pests of wheat with their infestation and severity in Gaibandha district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	4.50	Minor	3.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	8.00	Major	6.50	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.00	Minor	1.50	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	1.50	Minor	2.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	3.00	Minor	Low
09.	Shoot fly	*Atherigona naqvii*	1.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.00	Minor	2.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	6.00	Minor	7.50	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.00	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	2.00	Minor	1.00		Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.8 Diversity and damage severity of wheat insect pests in Rangpur district

4.1.8.1 Field insect pests

Field survey and farmers information in Rangpur district represented that there are 7 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 10.00 percent and field survey data 12.00 percent) followed by termite (farmer's information 4.00 percent and field survey data 2.50 percent) and pink borer (farmer's information 3.00 percent and field survey data 2.00 percent) at low severity level. The lowest infestation (farmer's information 1.50 percent and field survey data 1.00 percent) was found from cutworm with low level of severity followed by grasshopper, white grub and leaf eating caterpillar found in Rangpur district at low severity level (Table 10). It was also observed that there was no insect infestation was found from wireworms, cereal leaf beetle, flea beetle and shoot fly.

4.1.8.2 Storage insect pests

It was also found in terms of stored grain pest in Rangpur district, 4 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the severe storage pest (farmer's information 9.00 percent and field survey data 7.50 percent) among the storage pest in Rangpur district and it was found with high level of severity followed by rust-red flour beetle infestation (farmer's information 4.50 percent field survey data 3.00 percent) and khapra beetle infestation (farmer's information 3.00 percent field survey data 4.00 percent) with low level of severity. The lowest infestation among the entire stored grain pest was from lesser grain borer with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 10). It was also observed that there was no infestation was found from sawtoothed grain beetle, rice moth and rice meal moth.

Table 10. Insect pests of wheat with their infestation and severity in Rangpur district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	4.00	Minor	2.50	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	10.00	Major	12.00	Major	High
04.	White grub	*Phyllophaga* spp.	2.00	Minor	1.50	Minor	Low
05.	Cutworm	*Agrotis ipsilon*	1.50	Minor	1.00	Minor	Low
06.	Pink borer	*Sesamia inferens*	3.00	Minor	2.00	Minor	Low
07.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	2.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.00	Minor	4.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	9.00	Minor	7.50	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	4.50	Minor	3.00	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.9 Diversity and damage severity of wheat insect pests in Kushtia district

4.1.9.1 Field insect pests

Field survey and farmers information in Kushtia district represented that there are 8 field insect pests of wheat were recorded with their percent of damage and severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 14.00 percent and field survey data 10.50 percent) followed by pink borer (farmer's information 3.00 percent and field survey data 3.50 percent) with low level of severity. The lowest infestation (farmer's information 1.00 percent and field survey data 0.50 percent) was from cutworm with low level of severity followed by grasshopper, termite, white grub and leaf eating caterpillar found in Kushtia district with low level of severity (Table 11). It was also observed that there was no insect infestation was found from wireworms, cereal leaf beetle, flea beetle and shoot fly.

4.1.9.2 Storage insect pests

It was also found in terms of stored grain pest in Kushtia district, there are 4 storage insect pests of wheat with their variable infestation levels and damage severity. Rice weevil was the severe storage pest (farmer's information 7.00 percent and field survey data 5.50 percent) among the storage pest in Kushtia district and it was found with medium level of severity followed by Rust-red flour beetle infestation (farmer's information 4.00 percent field survey data 3.50 percent) and khapra beetle infestation (farmer's information 3.00 percent field survey data 2.50 percent) with low level of severity. The lowest infestation among the entire stored grain pest was as minor pest from Sawtoothed grain beetle with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 11). It was also observed that there was no infestation was found from sawtoothed grain beetle, rice moth and rice meal moth.

Table 11. Insect pests of wheat with their infestation and severity in Kushtia district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	1.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	10.50	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.50	Minor	2.00	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.00	Minor	1.50	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	1.00	Minor	0.50	Minor	Low
07.	Pink borer	*Sesamia inferens*	3.00	Minor	3.50	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.00	Minor	2.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	5.50	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.50	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	2.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.10 Diversity and damage severity of wheat insect pests in Jhenaidah district

4.1.10.1 Field insect pests

There are 10 field insect pests of wheat in Jhenaidah district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, flea beetle, white grub, cutworm, pink borer, leaf eating caterpillar, shoot fly. The percent infestation of wheat aphid as major pest was found highest with high level of severity (farmer's information 15.00 percent and field survey data 11.00 percent) followed by pink borer (farmer's information 4.00 percent and field survey data 3.00 percent) as minor pest with low level of severity. The lowest pest infestation (farmer's information 1.00 percent and field survey data 1.00 percent) was leaf eating caterpillar as minor pest with low level of severity (Table 12).

4.1.10.2 Storage insect pests

In Jhenaidah district, 5 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was considered as major pest (farmer's information 8.50 percent and field survey data 7.00 percent) and it was found with medium level of severity and after that khapra beetle infestation as minor pest (farmer's information 4.00 percent and field survey data 3.00 percent) was found second highest with low level of severity in Jhenaidah district. The infestation and severity of lesser grain borer and Sawtoothed grain beetle as minor pest was also found with low level of severity where sawtoothed grain beetle was found with lowest level of severity (farmer's information 1.00 percent and field survey data 0.50 percent) (Table 12).

Table 12. Insect pests of wheat with their infestation and severity in Jhenaidah district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	1.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.50	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	15.00	Major	11.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.50	Minor	Low
05.	Flea beetle	*Phyllotreta* spp.	1.50	Minor	2.00	Minor	Low
06.	White grub	*Phyllophaga* spp.	2.00	Minor	1.50	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
08.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	1.00	Minor	1.00	Minor	Low
10.	Shoot fly	*Atherigona naqvii*	1.50	Minor	1.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	8.50	Major	7.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.50	Minor	4.00	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	2.00	Minor	1.00	Minor	Low
05.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.00	Minor	0.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.11 Diversity and damage severity of wheat insect pests in Jessore district

4.1.11.1 Field insect pests

Based on field survey and farmers information in Jessore district represented that there were 8 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid as major pest was found highest with high level of severity (farmer's information 13.00 percent and field survey data 10.00 percent) followed by cutworm (farmer's information 4.00 percent and field survey data 3.00 percent) and pink borer (farmer's information 4.00 percent and field survey data 3.00 percent) at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 1.50 percent) was found from wireworms with low level of severity followed by grasshopper, termite, white grub and leaf eating caterpillar found in Jessore district at low severity level as minor pest (Table 13).

4.1.11.2 Storage insect pests

In Jessore district, 4 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the minor storage pest (farmer's information 6.00 percent and field survey data 7.00 percent) among the storage pest in Jessore district and it was found with medium level of severity followed by rust-red flour beetle infestation (farmer's information 4.00 percent field survey data 3.50 percent) and khapra beetle infestation (farmer's information 4.00 percent field survey data 3.00 percent) with low level of severity as minor pest. The lowest infestation among the entire stored grain pest was from sawtoothed grain beetle as minor pest with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 13).

Table 13. Insect pests of wheat with their infestation and severity in Jessore district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.00	Minor	1.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	13.00	Major	10.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.00	Minor	1.50	Minor	Low
05.	White grub	*Phyllophaga* spp.	1.50	Minor	1.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	4.00	Minor	2.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	6.00	Minor	7.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.50	Minor	Medium
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.12 Diversity and damage severity of wheat insect pests in Sirajganj district

4.1.2.1 Field insect pests

Based on field survey and farmers information in Sirajganj district represented that there were 9 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid observed as major pest from farmers information and minor pest from field survey data (farmer's information 8.00 percent and field survey data 6.00 percent) was found highest with medium level of severity followed by pink borer (farmer's information 4.00 percent and field survey data 3.00 percent), cutworm (farmer's information 3.00 percent and field survey data 2.00 percent) and grasshopper (farmer's information 4.00 percent and field survey data 2.00 percent) at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 1.50 percent) was found from cereal leaf beetle with low level of severity followed by termite and leaf eating caterpillar found in Sirajganj district at low severity level as minor pest (Table 14).

4.1.12.2 Storage insect pests

In Sirajganj district, there are also 4 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Sirajganj district were khapra beetle, rice weevil, rust-red flour beetle, and sawtoothed grain beetle. Rice weevil as minor storage pest (farmer's information 6.00 percent and field survey data 4.00 percent) showed highest infestation among the entire storage pest in Sirajganj district with medium level of severity followed by rust-red flour beetle (farmer's information 3.00 percent field survey data 3.50 percent) and khapra beetle infestation (farmer's information 4.00 percent field survey data 3.00 percent) as minor pest with low level of severity. The lowest

Table 14. Insect pests of wheat with their infestation and severity in Sirajganj district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	4.00	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	1.50	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	8.00	Major	6.00	Minor	Medium
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.00	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.00	Minor	1.50	Minor	Low
06.	White grub	*Phyllophaga* spp.	2.00	Minor	1.00	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	3.00	Minor	2.00	Minor	Low
08.	Pink borer	*Sesamia inferens*	4.00	Minor	3.50	Minor	Medium
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	6.00	Minor	4.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.00	Minor	3.50	Minor	Medium
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

infestation among the entire stored grain pest was from sawtoothed grain beetle as minor pest with low level of severity (farmer's information 1.00 percent and field survey data 1.00 percent) (Table 14).

4.1.13 Diversity and damage severity of wheat insect pests in Rajshahi district

4.1.13.1 Field insect pests

Field survey data and farmers information in Rajshahi district signified that there were 9 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, flea beetle, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 14.00 percent and field survey data 11.00 percent) was found as highest infectious insect with high level of severity followed by grasshopper (farmer's information 4.50 percent and field survey data 2.50 percent), pink borer (farmer's information 3.50 percent and field survey data 3.00 percent) and leaf eating caterpillar (farmer's information 3.00 percent and field survey data 2.00 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 1.50 percent) was found from cereal leaf beetle with low level of severity followed by cutworm, white grub and termite found in Rajshahi district at low severity level as minor pest (Table 15).

4.1.13.2 Storage insect pests

In Rajshahi district, there are also 4 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Rajshahi district are khapra beetle, rice weevil, rust-red flour beetle, and sawtoothed grain beetle. Rice weevil as minor storage pest (farmer's information 7.00 percent and field survey data 6.00 percent) showed highest infestation among the entire storage pest in Rajshahi district with medium level of severity followed

Table 15. Insect pests of wheat with their infestation and severity in Rajshahi district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	4.50	Minor	2.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	11.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.50	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.00	Minor	1.50	Minor	Low
06.	White grub	*Phyllophaga* spp.	2.00	Minor	1.00	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	1.50	Minor	1.00	Minor	Low
08.	Pink borer	*Sesamia inferens*	3.50	Minor	3.00	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	3.00	Minor	2.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	4.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	6.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.50	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

by rust-red flour beetle (farmer's information 4.00 percent field survey data 3.50 percent) and khapra beetle infestation (farmer's information 4.00 percent field survey data 3.00 percent) as minor pest with low level of severity. The lowest infestation among the entire stored grain pest was from sawtoothed grain beetle as minor pest with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 15).

4.1.14 Diversity and damage severity of wheat insect pests in Naogaon district

4.1.14.1 Field insect pests

Data collected from field survey and farmers' information in Naogaon district signified that there were 10 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 14.00 percent and field survey data 12.00 percent) was found as highest infectious insect with high level of severity followed by pink borer (farmer's information 5.00 percent and field survey data 3.00 percent), grasshopper (farmer's information 3.50 percent and field survey data 2.00 percent) and white grub (farmer's information 3.00 percent and field survey data 2.00 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 0.50 percent) was found from shoot fly with low level of severity followed by termite, wireworms, cereal leaf beetle and cutworm found in Naogaon district at low severity level as minor pest (Table 16).

4.1.14.2 Storage insect pests

It was found in terms of stored grain pest in Naogaon district, there are 5 storage insect pests of wheat with their variable infestation levels and damage severity.

Table 16. Insect pests of wheat with their infestation and severity in Naogaon district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	3.50	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	1.50	Minor	2.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	12.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	1.50	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.50	Minor	1.00	Minor	Low
06.	White grub	*Phyllophaga* spp.	3.00	Minor	2.00	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	2.00	Minor	1.50	Minor	Low
08.	Pink borer	*Sesamia inferens*	5.00	Minor	3.00	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.50	Minor	2.00	Minor	Low
10.	Shoot fly	*Atherigona naqvii*	1.00	Minor	0.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.50	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	5.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	4.00	Minor	3.50	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.50	Minor	1.00	Minor	Low
05.	Rice meal moth	*Corcyra cephalonica*	1.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

The insects attacked in storage grain in Naogaon district were khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer and rice meal moth. Rice weevil as minor storage pest (farmer's information 7.00 percent and field survey data 5.00 percent) showed highest infestation among the entire storage pest in Naogaon district with medium level of severity followed by rust-red flour beetle (farmer's information 4.00 percent field survey data 3.50 percent) and khapra beetle infestation (farmer's information 3.50 percent field survey data 3.00 percent) as minor pest with low level of severity. The lowest infestation among the entire stored grain pest was from rice meal moth as minor pest with low level of severity (farmer's information 1.00 percent and field survey data 1.00 percent) (Table 16).

4.1.15 Diversity and damage severity of wheat insect pests in Kishoreganj district

4.1.15.1 Field insect pests

Data collected from field survey and farmers' information in Kishoreganj district signified that there were 9 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, flea beetle, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid observed as major pest from farmers information and minor pest from field survey data (farmer's information 8.00 percent and field survey data 6.50 percent) was found highest with medium level of severity followed by Termite (farmer's information 4.00 percent and field survey data 3.00 percent), white grub (farmer's information 3.00 percent and field survey data 2.00 percent) and pink borer (farmer's information 3.00 percent and field survey data 2.50 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 1.50 percent) was found from Flea beetle with low level of severity followed by grasshopper, wireworms, cutworm and leaf eating caterpillar found in Kishoreganj district at low severity level as minor pest (Table 17).

4.1.15.2 Storage insect pests

It was also found in terms of stored grain pest in Kishoreganj district, there are 5 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Kishoreganj district were khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer and sawtoothed grain beetle. Rice weevil as minor storage pest (farmer's information 6.00 percent and field survey data 4.50 percent) showed highest infestation among the entire storage pest in Kishoreganj district with medium level of severity followed by rust-red flour beetle (farmer's information 3.00 percent field survey data 4.00 percent) and khapra beetle infestation (farmer's information 2.50 percent field survey data 2.00 percent) as minor pest with low level of severity. The lowest infestation among the entire stored grain pest was from lesser grain borer with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 17).

Table 17. Insect pests of wheat with their infestation and severity in Kishoreganj district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.50	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	4.00	Minor	3.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	8.00	Major	6.50	Minor	Medium
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.50	Minor	2.00	Minor	Low
05.	Flea beetle	*Phyllotreta* spp.	1.00	Minor	1.50	Minor	Low
06.	White grub	*Phyllophaga* spp.	3.00	Minor	2.00	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
08.	Pink borer	*Sesamia inferens*	3.00	Minor	2.50	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.50	Minor	3.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	2.50	Minor	2.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	6.00	Minor	4.50	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.00	Minor	4.00	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.50	Minor	1.00	Minor	Low
05.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	2.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.16 Diversity and damage severity of wheat insect pests in Mymensingh district

4.1.16.1 Field insect pests

Data collected from field survey and farmers' information in Mymensingh district signified that there were 9 field insect pests of with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 13.00 percent and field survey data 15.00 percent) was found as highest infectious insect with high level of severity followed by grasshopper (farmer's information 4.00 percent and field survey data 3.00 percent), cutworm (farmer's information 3.00 percent and field survey data 2.00 percent), pink borer (farmer's information 3.50 percent and field survey data 3.00 percent) and leaf eating caterpillar (farmer's information 3.50 percent and field survey data 2.00 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.50 percent and field survey data 1.00 percent) was found from shoot fly with low level of severity followed by termite, wireworms and white grub found in Mymensingh district at low severity level as minor pest (Table 18).

4.1.16.2 Storage insect pests

It was also found in terms of stored grain pest in Mymensingh district, there are 4 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. The insects attacked in storage grain in Mymensingh district were khapra beetle, rice weevil, rust-red flour beetle and sawtoothed grain beetle. Rice weevil as minor storage pest (farmer's information 7.00 percent and field survey data 5.50 percent) showed highest infestation among the entire storage pest in Mymensingh district with medium level of severity followed by rust-red flour beetle (farmer's information 3.50 percent field survey data 3.00 percent) and

Table 18. Insect pests of wheat with their infestation and severity in Mymensingh district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	4.00	Minor	3.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	1.50	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	13.00	Major	15.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.00	Minor	2.00	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	3.00	Minor	2.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	3.50	Minor	3.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	3.50	Minor	2.00	Minor	Low
09.	Shoot fly	*Atherigona naqvii*	1.50	Minor	1.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	2.00	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	7.00	Minor	5.50	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.50	Minor	3.00	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

khapra beetle infestation (farmer's information 2.00 percent field survey data 3.00 percent) as minor pest with low level of severity. The lowest infestation among the entire stored grain pest was from Sawtoothed grain beetle as minor pest with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) (Table 18).

4.1.17 Diversity and damage severity of wheat insect pests in Sherpur district

4.1.17.1 Field insect pests

There are 10 field insect pests of wheat were recorded in Sherpur district with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, flea beetle, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid was found highest with high level of severity (farmer's information 14.00 percent and field survey data 12.00 percent) as major pest followed by Pink borer (farmer's information 4.00 percent and field survey data 3.00 percent) and White grub (farmer's information 3.00 percent and field survey data 1.50 percent) as minor pest at low severity level. The lowest infestation (farmer's information 1.50 percent and field survey data 1.00 percent) was found from Cereal leaf beetle with low level of severity followed by leaf eating caterpillar, termite, flea beetle and cutworm found in Sherpur district with low level of severity as minor pest (Table 19).

4.1.17.2 Storage insect pests

In Sherpur district, 5 storage insect pests of wheat were recorded with their variable infestation levels and damage severity. Rice weevil was the most severe storage pest (farmer's information 10.00 percent and field survey data 8.00 percent) and it was found with high level of severity and after that khapra beetle infestation (farmer's information 4.00 percent and field survey data 3.50 percent) was found second highest infection insect with low level of severity as minor pest

Table 19. Insect pests of wheat with their infestation and severity in Sherpur district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.50	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	12.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.50	Minor	2.00	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.50	Minor	1.00	Minor	Low
06.	Flea beetle	*Phyllotreta* spp.	2.00	Minor	1.00	Minor	Low
07.	White grub	*Phyllophaga* spp.	3.00	Minor	1.50	Minor	Low
08.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
09.	Pink borer	*Sesamia inferens*	4.00	Minor	3.00	Minor	Low
10.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	1.50	Minor	2.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	5.00	Minor	3.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	10.00	Major	8.00	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	3.50	Minor	3.00	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.00	Minor	1.50	Minor	Low
05.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

in Sherpur district followed by Rust-red flour beetle as minor pest. The infestation and severity of rust-red flour beetle, lesser grain borer and sawtoothed grain beetle were also found as minor crop with low level of severity where sawtoothed grain beetle showed lowest level of severity (farmer's information 1.00 percent and field survey data 1.00 percent) (Table 19).

4.1.18 Diversity and damage severity of wheat insect pests in Pabna district

4.1.18.1 Field insect pests

Data collected from field survey and farmers' information in Pabna district signified that there were 10 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 8.00 percent and field survey data 7.00 percent) was found as highest infectious insect with high level of severity followed by Pink borer (farmer's information 4.00 percent and field survey data 3.50 percent) and termite (farmer's information 4.00 percent and field survey data 2.00 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 0.50 percent) was found from Leaf eating caterpillar with low level of severity followed by grasshopper, wireworms, cereal leaf beetle, white grub, cutworm and leaf eating caterpillar found in Pabna district at low severity level as minor pest (Table 20).

4.1.18.2 Storage insect pests

It was also found in terms of stored grain pest in Pabna district, there are 5 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Pabna district were khapra beetle, rice weevil, rust-red flour beetle, sawtoothed grain beetle and rice meal moth. Rice

Table 20. Insect pests of wheat with their infestation and severity in Pabna district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	2.50	Minor	1.50	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	4.00	Minor	2.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	8.00	Major	7.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.50	Minor	1.00	Minor	Low
05.	Cereal leaf beetle	*Oulema melanopus*	1.00	Minor	1.50	Minor	Low
06.	White grub	*Phyllophaga* spp.	2.00	Minor	1.50	Minor	Low
07.	Cutworm	*Agrotis ipsilon*	2.00	Minor	2.50	Minor	Low
08.	Pink borer	*Sesamia inferens*	4.00	Minor	3.50	Minor	Low
09.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
10.	Shoot fly	*Atherigona naqvii*	1.00	Minor	0.50	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.00	Minor	2.50	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	6.00	Minor	5.00	Minor	Medium
03.	Rust-red flour beetle	*Tribolium castaneum*	3.50	Minor	3.00	Minor	Low
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.00	Minor	1.50	Minor	Low
05.	Rice meal moth	*Corcyra cephalonica*	1.00	Minor	0.50	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

weevil as minor storage pest (farmer's information 6.00 percent and field survey data 5.00 percent) showed highest infestation among the entire storage pest in Pabna district with medium level of severity followed by rust-red flour beetle (farmer's information 3.50 percent field survey data 3.00 percent) and khapra beetle infestation (farmer's information 3.00 percent field survey data 2.50 percent) as minor pest with low level of severity. The lowest infestation among the entire stored grain pest was from sawtoothed grain beetle as minor pest with low level of severity (farmer's information 1.00 percent and field survey data 1.50 percent) (Table 20).

4.1.19 Diversity and damage severity of wheat insect pests in Faridpur district

4.1.19.1 Field insect pests

Data collected from field survey and farmers' information in Faridpur district signified that there were 8 field insect pests of with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer and leaf eating caterpillar. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 13.00 percent and field survey data 11.00 percent) was found as highest infectious insect with high level of severity followed by pink borer (farmer's information 6.00 percent and field survey data 5.00 percent) as minor pest at medium severity level. The lowest infestation as minor pest (farmer's information 1.50 percent and field survey data 2.00 percent) was found from grasshopper with low level of severity followed by wireworms, white grub, cutworm and leaf eating caterpillar found in Faridpur district at low severity level as minor pests (Table 21).

4.1.19.2 Storage insect pests

It was also found in terms of stored grain pest in Faridpur district, there are 4 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Faridpur district were khapra beetle, rice weevil,

Table 21. Insect pests of wheat with their infestation and severity in Faridpur district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	1.50	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	2.00	Minor	1.00	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	13.00	Major	11.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	2.00	Minor	2.50	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	2.00	Minor	1.50	Minor	Low
07.	Pink borer	*Sesamia inferens*	6.00	Minor	5.00	Minor	Medium
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	3.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.50	Minor	3.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	10.00	Major	9.00	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	6.00	Minor	5.00	Minor	Medium
04.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	1.50	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major

Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

4.1.20 Diversity and damage severity of wheat insect pests in Barisal district

4.1.20.1 Field insect pests

Data collected from field survey and farmers' information in Barisal district signified that there were 9 field insect pests of wheat with their variable infestation levels and damage severity. The recorded field insect pests were grasshopper, termite, wheat aphid, wireworms, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly. The percent infestation of wheat aphid as major pest obtained from both farmers information and field survey data (farmer's information 14.00 percent and field survey data 12.00 percent) was found as highest infectious insect with high level of severity followed by Pink borer (farmer's information 4.50 percent and field survey data 3.00 percent) and grasshopper (farmer's information 4.50 percent and field survey data 2.00 percent) as minor pest at low severity level. The lowest infestation as minor pest (farmer's information 1.00 percent and field survey data 1.50 percent) was found from grasshopper with low level of severity followed by wireworms, white grub, leaf eating caterpillar and shoot fly as minor pests found in Barisal district at low severity level (Table 22).

4.1.20.2 Storage insect pests

It was also found in terms of stored grain pest in Barisal district, there are 5 storage insect pests of wheat with their variable infestation levels and damage severity. The insects attacked in storage grain in Barisal district were khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer and Sawtoothed grain beetle. Rice weevil as major storage pest (farmer's information 9.00 percent and field survey data 7.50 percent) showed highest infestation among the entire storage pest in Barisal district with high level of severity followed by khapra beetle (farmer's information 3.50 percent field survey data 2.00 percent) and rust-red flour beetle (farmer's information 3.00 percent and field survey data 3.50 percent) as minor pest with low level of severity. The lowest infestation among the entire

Table 22. Insect pests of wheat with their infestation and severity in Barisal district

Sl. No.	Common name	Scientific name	Farmer's information		Field survey data		Severity
			Average percentage of infestation	Status	Average percentage of infestation	Status	
Field insect pests							
01.	Grasshopper	*Melanoplus* spp.	4.50	Minor	2.00	Minor	Low
02.	Termite	*Odontotermes obesus, Microtermes obesi*	1.00	Minor	1.50	Minor	Low
03.	Wheat aphid	*Rhopalosiphum maidis, Rhopalosiphum padi, Schizaphis graminum*	14.00	Major	12.00	Major	High
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	1.50	Minor	2.00	Minor	Low
05.	White grub	*Phyllophaga* spp.	2.50	Minor	2.00	Minor	Low
06.	Cutworm	*Agrotis ipsilon*	3.00	Minor	2.00	Minor	Low
07.	Pink borer	*Sesamia inferens*	4.50	Minor	3.00	Minor	Low
08.	Leaf eating caterpillar	*Helicoverpa armigera, Spodoptera litura*	2.00	Minor	1.50	Minor	Low
09.	Shoot fly	*Atherigona naqvii*	1.50	Minor	1.00	Minor	Low
Storage insect pests							
01.	Khapra beetle	*Trogoderma granarium*	3.50	Minor	2.00	Minor	Low
02.	Rice weevil	*Sitophilus oryzae*	9.00	Minor	7.50	Major	High
03.	Rust-red flour beetle	*Tribolium castaneum*	3.00	Minor	3.50	Minor	Low
04.	Lesser grain borer	*Rhyzopertha dominica*	1.50	Minor	1.00	Minor	Low
05.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	2.00	Minor	1.00	Minor	Low

Scale of insect status (%): 1 – 7 = Minor 8 – 15 = Major
Scale of insect severity (%): 1 – 4 = Low 5 – 7 = Medium 8 – 15 = High

stored grain pest was from lesser grain borer as minor pest with low level of severity (farmer's information 1.50 percent and field survey data 1.00 percent) followed sawtoothed grain beetle infestation (farmer's information 2.00 percent field survey data 1.00 percent) (Table 22).

4.2 Insect species

Total of 18 different field and stored insect pest were given importance based on their severity of infestation and were also selected for taking information according to incidence in the field and storage condition under the present study. Among them 11 insects were selected for field insect pest and 8 were for storage insect pest. Comilla, Lakshmipur, Noakhali, Dinajpur, Thakurgaon, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal were the selected 20 districts for the present study. The distribution of different insect pest (field and storage) in 20 districts of Bangladesh under the present study is shown in Table 24.

Only aphid was the major insect pests of wheat in field, and rice weevil, khapra beetle and red flour beetle were the major in storage. Other insect pests were minor in status (Table 3). It was also reported that termites, white grub and leaf feeding caterpillars (*Helicoverva aremigera* and *Spodoptera litura*) attack sporadically but they are minor pests (Table 24).

Table 23. Distribution of different insect species in 20 districts of Bangladesh

Sl. No.	Common name	Scientific name	Order : Family	Present Status	District wise distribution of insect pests
Field insect pests					
01.	Grasshopper	*Melanoplus* spp.	Orthoptera: Acrididae	Minor	All 20 Districts under study
02.	Termite	*Odontotermes obesus*, *Microtermes obesi*	Isoptera: Termitidae	Minor and sporadic	All 20 Districts under study
03.	Wheat aphid	*Rhopalosiphum maidis*, *Rhopalosiphum padi*, *Schizaphis graminum*	Homoptera: Aphididae	Major	All 20 Districts under study
04.	Wireworms	*Melanotus* spp., *Agriotes* spp.	Coleoptera: Elateridae	Minor	Comilla, Lakshmipur, Noakhali, Dinajpur, Bogra, Gaibandha, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal
05.	Cereal leaf beetle	*Oulema melanopus*	Colepoptera: Chrysomelidae	Minor	Comilla, Thakurgaon, Sirajganj, Rajshahi, Naogaon, Sherpur, Pabna,
06.	Flea beetle	*Phyllotreta* spp.	Colepoptera: Chrysomelidae	Minor	Jhenaidah, Kishoreganj, Sherpur
07.	White grub	*Phyllophaga* spp.	Coleoptera: Scarabaeidae	Minor and sporadic	Comilla, Lakshmipur, Noakhali, Dinajpur, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal
08.	Cutworm	*Agrotis ipsilon*	Lepidoptera: Noctuidae	Minor	All 20 Districts under study
09.	Pink borer	*Sesamia inferens*	Lepidoptera: Noctuidae	Minor	All 20 Districts under study
10.	Leaf eating caterpillar	*Helicoverpa armigera*, *Spodoptera litura*	Lepidoptera: Noctuidae	Minor and sporadic	All 20 Districts under study
11.	Shoot fly	*Atherigona naqvii*	Diptera: Muscidae	Minor	Gaibandha, Jhenaidah, Naogaon,

					Mymensingh, Pabna, Barisal
Storage insect pests					
1.	Khapra beetle	*Trogoderma granarium*	Coleoptera: Dermestidae	Major	All 20 Districts under study
2.	Rice weevil	*Sitophilus oryzae*	Coleoptera: Curculionidae	Major	All 20 Districts under study
3.	Rust-red flour beetle	*Tribolium castaneum*	Coleoptera: Tenebrionidae	Major	All 20 Districts under study
4.	Lesser grain borer	*Rhyzopertha dominica*	Coleoptera: Bostrichidae	Minor	Bogra, Rangpur, Jhenaidah, Naogaon, Kishoreganj, Sherpur, Barisal
5.	Sawtoothed grain beetle	*Oryzaephilus surinamensis*	Coleoptera: Silvanidae	Minor	Comilla, Dinajpur, Thakurgaon, Gaibandha, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal
6.	Rice moth	*Sitotroga cerealella*	Lepidoptera: Gelichiidae	Minor in wheat	Dinajpur
7.	Rice meal moth	*Corcyra cephalonica*	Lepidoptera: Pyralidae	Minor in wheat	Lakshmipur, Noakhali, Naogaon, Pabna

4.3 Distribution, infestation and severity of wheat insect pests

Different insect pest of wheat at field level and storage condition was recorded with their infestation status and damage severity from 20 major wheat growing districts of Bangladesh (Comilla, Lakshmipur, Noakhali, Dinajpur, Thakurgaon, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal) with their distribution, infestation, severity and pest status are discussed below-

4.3.1 Field insect pests

Twenty districts were selected for recording data on percent damage, status and severity for wheat production in Bangladesh. Infestation status and damage severity of all insect pest were not same. Some of them were marked as major pest and some of them were minor pest determined by their severity of infestation.

Results indicated that infestation of grasshopper, termite, wheat aphid, cutworm, pink borer and leaf eating caterpillar was exist in all 20 district (Table 23) where the lowest existence was for Shoot fly only in 6 districts (Gaibandha, Jhenaidah, Naogaon, Mymensingh, Pabna, Barisal) and thereafter for cereal leaf beetle was only in 7 districts (Comilla, Thakurgaon, Sirajganj, Rajshahi, Naogaon, Sherpur, Pabna).

The infestation of wireworms was found in 18 districts (Comilla, Lakshmipur, Noakhali, Dinajpur, Bogra, Gaibandha, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal) and white grub was in 19 districts (Comilla, Lakshmipur, Noakhali, Dinajpur, Bogra, Gaibandha, Rangpur, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Naogaon, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal) under the present study.

Eleven field insect pests have been identified but there was variation in infestation percent, severity and distribution (Table 24). Some of them are major and cause heavy damage but some are minor pests. Among the entire field insect, wheat aphid is the major insect pests of wheat in Bangladesh and cause heavy damage

and other field insect pests were minor pests in Bangladesh. Wheat aphid was recorded as major pest of wheat with high level of infestation (farmer's information 11.95 ± 3.30 percent and field survey data 10.23 ± 3.42 percent of infestation) and severity (Table 24). Among all minor field insect pests, comparatively higher infestation from pink borer was recorded with low level of infestation (farmer's information 3.93 ± 0.52 percent and field survey data 3.13 ± 1.08 percent of infestation) and severity. The lowest infestation, was found from cereal leaf beetle with low level of infestation (farmer's information 1.21 ± 0.34 percent and field survey data 1.29 ± 0.15 percent of infestation) and severity followed by Flea beetle (farmer's information 1.50 ± 0.26 percent and field survey data 1.50 ± 0.28 percent of infestation), wireworms (farmer's information 1.83 ± 0.75 percent and field survey data 1.64 ± 0.25 percent of infestation) and shoot fly (farmer's information 1.25 ± 0.16 percent and field survey data 0.92 ± 0.12percent of infestation). Freier *et al*. (2007) observed that wheat productivity is seriously affected by different wheat insects. Annonymous (2010) reported that aphids can cause damage to plants in several ways. They can reduce plant growth directly as they remove plant sap. Some aphids inject a toxin with their saliva that injures the plant host. Russian wheat aphid (*Diuraphis noxia*) is another important aphid pest of winter wheat.

4.3.2 Storage insect pests

Selected same twenty districts were also considered for recording data of storage insect pests on percent damage, status and severity for wheat storage in Bangladesh (Table 3). Only 7 storage insect pests were observed as harmful pest. Infestation status and damage severity of all insect pest were not same. Some of them were marked as major pest and some of them were minor pest determined by their severity of infestation. Results showed that infestation of khapra beetle, rice weevil and rust-red flour beetle were existed in all 20 districts (Table 3) where the lowest existence was for rice moth only in 1 district (Dinajpur). Lesser grain borer,

sawtoothed grain beetle and rice meal moth were not also found in all 20 districts (Table 3). Lesser grain borer was found in 7 districts (Bogra, Rangpur, Jhenaidah, Naogaon, Kishoreganj, Sherpur, Barisal), sawtoothed grain beetle was found in 15 districts (Comilla, Dinajpur, Thakurgaon, Gaibandha, Kushtia, Jhenaidah, Jessore, Sirajganj, Rajshahi, Kishoreganj, Mymensingh, Sherpur, Pabna, Faridpur, Barisal) and rice meal moth was found in 4 districts (Lakshmipur, Noakhali, Naogaon, Pabna).

Seven storage insect pests have been identified but there was variation in infestation percent, severity and distribution (Table 24). Some of them are major and cause heavy damage but some are minor pests. Under the present study, all storage insect pests were minor insect with low level of infestation. Among the entire storage insect, rice weevil is the top storage insect pests of wheat in Bangladesh and cause heavy damage. Rice weevil was recorded as minor storage pest of wheat with medium level of infestation (farmer's information 7.78 ± 0.68 percent and field survey data 6.43 ± 1.70 percent of infestation) and severity followed by khapra beetle was recorded with low level of infestation (farmer's information 3.53 ± 0.74 percent and field survey data 2.95 ± 0.84 percent of infestation) and rust-red flour beetle (farmer's information 4.08 ± 0.78 percent and field survey data 3.65 ± 1.12 percent of infestation). The lowest infestation, was found from Rice meal moth with low level of infestation (farmer's information 1.00 ± 0.16 percent and field survey data 1.13 ± 0.14 percent of infestation) and severity followed by Sawtoothed grain beetle (farmer's information 1.57 ± 0.18 percent and field survey data 1.03 ± 0.18 percent of infestation) and Lesser grain borer (farmer's information 1.67 ± 0.22 percent and field survey data 1.33 ± 0.48 percent of infestation) (Table 24). David *et al*. (2005) revealed that losses of grain in storage due to insects were the final components of the struggle to limit insect losses in agricultural production. Insect do not only hamper the yield but also induce fungus attack. Worldwide losses in stored products, caused by insects have been estimated to between 5-10%. Heavy insect pest infestation caused about 30%

damage in the tropics. FAO's estimation as cited by Sing (1972) also revealed similar reviews that is the damage and loss in stored grains in temperate and developed countries ranged from 5-10% of world's production. Gentile and Trematerra (2004) stated that grain moth, *Sitotroga cerealella* was the major insect pests of wheat in storage while Baloch (1992) reported that Rice weevil (*Sitophilus oryzae* L.) is one of the severe pests of cereal grains and their products. Baloch *et al*. (1994) revealed that the major biotic factors influencing wheat loss during storage are insects, moulds, birds and rats. Yildirim *et al.* (2012) revealed that (*Sitophilus granaries*) is a well-known pest causing economically significant yield lost in stored products in Turkey and many other countries.

Table 24. Infestation, severity and pest status of insect and pests wheat at field level and storage condition in Bangladesh

Sl. No.	Common name	% Infestation (Mean ± SD)		Severity	Status
		Farmers information	Field survey		
Field insect pests					
01.	Grasshopper	2.75 ± 0.68	2.05 ± 0.50	Minor	Low
02.	Termite	2.30 ± 0.50	1.63 ± 0.36	Minor	Low
03.	Wheat aphid	11.95 ± 3.30	10.23 ± 3.42	Major	High
04.	Wireworms	1.83 ± 0.75	1.64 ± 0.25	Minor	Low
05.	Cereal leaf beetle	1.21 ± 0.34	1.29 ± 0.15	Minor	Low
06.	Flea beetle	1.50 ± 0.26	1.50 ± 0.28	Minor	Low
07.	White grub	2.24 ± 0.41	1.68 ± 0.27	Minor	Low
08.	Cutworm	2.11 ± 0.48	1.95 ± 0.65	Minor	Low
09.	Pink borer	3.93 ± 0.52	3.13 ± 1.08	Minor	Low
10.	Leaf eating caterpillar	2.10 ± 0.35	2.05 ± 0.74	Minor	Low
11.	Shoot fly	1.25 ± 0.16	0.92 ± 0.12	Minor	Low
Storage insect pests					
01.	Khapra beetle	3.53 ± 0.74	2.95 ± 0.84	Minor	Low
02.	Rice weevil	7.78 ± 0.68	6.43 ± 1.70	Minor	Medium
03.	Rust-red flour beetle	4.08 ± 0.78	3.65 ± 1.12	Minor	Low
04.	Lesser grain borer	1.67 ± 0.22	1.33 ± 0.48	Minor	Low
05.	Sawtoothed grain beetle	1.57 ± 0.18	1.03 ± 0.18	Minor	Low
06.	Rice moth	2.00 ± 0.00	1.00 ± 0.00	Minor	Low
07.	Rice meal moth	1.00 ± 0.16	1.13 ± 0.14	Minor	Low

Data are the average of 20 districts.

CHAPTER V
SUMMARY AND CONCLUSION

The present research work on diversity and damage severity of insect pests of wheat were undertaken in 60 upazilas of 20 major wheat growing districts of Bangladesh. Insect pests of wheat were recorded from the farmer's information and field survey data during November 2014 to February 2015.

Data were recorded from both farmer's information and field survey. Data collection was divided into two category viz. field insect and storage insect pests of wheat. From both farmer's information and field survey data, 11 field insects and 7 storage insects were found in Bangladesh.

The recorded field insects were grasshopper, termite, wheat aphid, wireworms, cereal leaf beetle, flea beetle, white grub, cutworm, pink borer, leaf eating caterpillar, and shoot fly and storage insects were khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer, sawtoothed grain beetle, rice moth and rice meal moth.

Under the present study, 9 field insect pests were recorded in Comilla, Gaibandha, Sirajganj, Rajshahi, Kishoreganj, Mymensingh and Barisal districts, 10 in Jhenaidah, Naogaon, Sherpur and Pabna, 8 in Lakshmipur, Noakhali, Dinajpur, Bogra, Kushtia, Jessore and Faridpur, 7 in Thakurgaon and Rangpur were recorded with variable infestation levels and severity. Again, 4 storage insect pests pests were found in Comilla, Lakshmipur, Noakhali, Thakurgaon, Bogra, Gaibandha, Rangpur, Kushtia, Jessore, Sirajganj, Rajshahi, Mymensingh and Faridpur, 5 in Dinajpur, Jhenaidah, Naogaon, Kishoreganj, Sherpur, Pabna and Barisal were recorded with variable infestation levels and severity.

Among all the surveyed field insects only one insect was considered as major insect with high level of severity in all the districts of Bangladesh. Results showed that wheat aphid was recorded as major pest with high level of infestation (farmer's information 11.95 ± 3.30 percent and field survey data 10.23 ± 3.42

percent of infestation) and severity. All other field insects (grasshopper, termite, wireworms, cereal leaf beetle, flea beetle, white grub, cutworm, pink borer, leaf eating caterpillar and shoot fly) were observed as minor pest with low level of infestation. Pink borer was also a field insect, considered as minor pest but comparatively higher infestation was found compared to other minor field insect.

Again, in terms of storage grain insects (khapra beetle, rice weevil, rust-red flour beetle, lesser grain borer, sawtoothed grain beetle, rice moth, rice meal moth), all insects were observed as minor pest with low level of severity except rice weevil, which weevil was recorded as major storage pest of wheat with medium level of infestation (farmer's information 7.78 ± 0.68 percent and field survey data 6.43 ± 1.70 percent of infestation) and severity. Khapra beetle and rust-red flour beetle were also considered as minor insect pests but comparatively higher infestation was found than the others.

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

1. Among the entire field insects, wheat aphid was the major pest of wheat and management practices are needed for this pest and thereafter pink borer.
2. In terms of storage insects, management practices are needed for Rice weevil, khapra beetle and rust-red flour beetle.
3. Seasonal abundance of major insect pests of wheat in Bangladesh may be studied in relation to environmental factors.

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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 /Female: Male: ……. Female: ……. (Put √)
3. Age: ……..
4. Education: …… (Write score)

   (No education=1, Primary=2, Secondary=3, Higher secondary/above=4)
5. Agricultural Farming Experience (No. of years.): ……
6. Which wheat crop generally you cultivate? ……..
7. Area of wheat crop cultivated by you? (In decimal): ……
8. Name of wheat 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 wheat crops

    (Yes-1, No-2): ……

    If yes, where and on which wheat crops? (Name the variety): ……..
11. Did any insect pests attack your wheat 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. Which variety of wheat crops generally grown in your upazila/district?
2. Total area under wheat crops in your upazila/district
3. How many farmers cultivate wheat in your upazila/district?
4. Recorded name of pests of wheat 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 wheat

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

……
Signature and name of data collector