ROLE OF CROP FIELD BOUNDARY VEGETATION IN POPULATION ECOLOGY OF PASSERINE BIRDS IN POTHWAR PLATEAU, PAKISTAN

MISBAH SARWAR 06-arid-555

Department of Wildlife Management Faculty of Forestry, Range Management and Wildlife Pir Mehr Ali Shah
Arid Agriculture University Rawalpindi,
Pakistan 2016

ROLE OF CROP FIELD BOUNDARY VEGETATION IN POPULATION ECOLOGY OF PASSERINE BIRDS IN POTHWAR PLATEAU, PAKISTAN

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the requirements for the degree of

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Department of Wildlife Management Faculty of Forestry, Range Management
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Pakistan 2016

CERTIFICATION

I hereby undertake that this research is an original one and no part of this
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Boundary Vegetation in Population Ecology of Passerine Birds in Pothwar
Plateau, Pakistan” submitted by Ms. Misbah Sarwar have been found
satisfactory for the requirement of degree.
To A Moment in Time!
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ABSTRACT

An agro-ecosystem demands intensive human activities related to farm operations to get optimum crop yield but such actions negatively affect local biodiversity including avifauna. Pothwar plateau of Pakistan covers an area of ~23,160 km², totally dependent on rain water. About 110,600 ha area of the plateau is under cultivation while the rest of it contains scrub forest and rangeland. The agriculture consists of two major traditional cropping systems i.e. wheat/maize/millet and wheat-groundnut. Due to its unique topography and climatic conditions the plateau is famous for hosting important floral and faunal diversity of Pakistan. Like other regions of the country the Pothwar landscape is also under tremendous pressure of urbanization and agriculture expansion. An inverse relationship between agriculture expansion and loss of wild habitat is
reducing food and shelter to its native species including avifauna. This is causing many bird species (mostly Passeriformes) to adopt croplands for nesting, feeding and breeding. Since no reliable record of passerine birds associated with field boundary vegetation in this region is available therefore, the present study was conducted to investigate anthropogenic use, diversity and abundance of the crop-field-edge vegetation, seasonal diversity and species richness of passerine birds utilizing this vegetation for feeding, nesting and breeding. The study was carried out at four isolated patches of croplands, each covering an area of 1 km$^2$. The anthropogenic practices were studied by interviews of 94 farmers and/or their workers. The farmers reported two main cropping systems i.e. wheat (intercropped with mustard) - groundnut and wheat-maize/millet. The livestock mainly consists of goats and cattle which are usually grazed on wild vegetation adjacent to the farmlands.

Animal grazing in croplands is allowed after harvest or during pre-monsoon season. The farmers plant fast growing shrubs along crop field margins for fodder browse and fuel wood. Burning of crop residues and dry vegetation is not a common practice. Inorganic fertilizers commonly urea and DAP are used to enhance crop yield. Weeds, insect and rodent pests infest the food crops. Weeds are usually removed manually with some use of surface herbicides. Chemical control of insect and rodent pests is a popular practice while the farmers lack any knowledge on beneficial roles of birds in their croplands. Vegetation analysis revealed occurrence of 51 floral species on crop field boundaries including 12 tree species among which dominant were *Acacia modesta* and *Zizyphus mauritiana*, 14 species of shrubs and 25 species of herbs/grasses. Seasonal avian densities were estimated by point counts which scored 25 species of birds including 20 resident and five migrants/winter visitorspecies. Most common and abundant bird species were house sparrow (*Passer domesticus*), common myna
(Acridotheres tristis), redvented bulbul (Pycnonotus cafer) and Himalayan bulbul (Pycnonotus leucogenys) while comparatively less common species were Indian tailor bird (Orthotomus sutorius), common lark (Alauda arvensis), ashy drongo (Dicrurus leucophaeus) and ashy prinia (Prinia socialis). Other avian species were rare and confined to specific cropping systems. The migrants/winter visitors were recorded from November to March. Bird density and diversity decreased during summer due to absence of migratory birds as well as low availability of food. More numbers and species of birds were present at sites that had wheat-maize/millet cropping system and were in close proximity to rainwater ponds which provide better living conditions to rare and infrequent birds in this arid ecosystem. Food habits of nine bird species determined by micro-histological analysis of fecal droppings revealed that red-vented bulbul and Himalayan bulbul inhabiting this agro-ecosystem were frugivores. Ashy prinia, pied bushchat (Saxicola caprata) and ashy drongo fed exclusively on insects many of which are crop pests in this agro-ecosystem while common myna, common lark, large grey babbler (Turdoides malcolmi) and Indian tailorbird were omnivorous in their dietary habits. These species fed on wheat, maize and millet during some part of the year and they also visited crops for invertebrates particularly insects pests. None of these birds have status of pest in this agro-ecosystem. The breeding ecology of ashy prinia, red-vented bulbul, Himalayan bulbul, ashydrongo and large grey babbler revealed that prinia and the bulbuls utilized shrubs bordering the crop fields for nesting while drongos and babblers used the trees. The nests were constructed at low heights and were prone to ground predators like snakes and domestic cats while humans were also observed disturbing the eggs and nestlings of these birds. Due to these predators and general disturbance low hatching, fledging and breeding success of these species was observed in this agro-ecosystem. The study suggests enhancement and
conservation of roosting, foraging and nesting sites of birds in this arid agroecosystem region which could be accomplished by maintaining heterogeneity of native natural vegetation and patches of uncultivated land that act as bird refugees as well as reduction in unwanted human activities and habitat degradation.
Chapter 1

GENERAL INTRODUCTION

Biodiversity is under pressure since the emergence of mankind because more people need more space. Thus, to match ever growing needs for food and shelter, human activity continues to encroach on natural environment, thereby destroying the habitats of countless floral and faunal species. Multiple factors are causing decline of biodiversity i.e. drastic increase in human population and associated exploitation of natural resources to carry on life and living, encroachment of wild areas, habitat degradation and pollution (Primentel et al., 1992). When the natural ecosystems are converted into agricultural landscapes, timber plantations or human settlements, the species composition and community structure is altered consequenting fall of species richness. Such decline in species richness usually negatively affects the magnitude and stability of ecosystem functioning. Thus, in addition to species loss through extinctions and species” additions through invasions, transformation of natural habitat into managed landscapes results in indiscriminate changes in ecosystems (Kale et al., 2013).

Generally, the conservation measures are directed towards natural and pristine ecosystems, viz: forests (Sampaio et al., 2003; Raman, 2003), savannahs (Thiollay, 1998) and wetlands (MacArthur et al., 1962) as they embrace high range of biodiversity and species of conservational concern. These ecologies face multitude threats in shape of deforestation, land degradation, draining, urban spread as well as harvesting of wild flora and fauna through illegal means (Sala et al., 2000). At the global scale humans utilize 30% of terrestrial primary productivity.
and it is expected to rise with the increase in the population. As a result, terrestrial ecosystems are predicted to become deficient in energy leading to further loss of biomass and biodiversity (Imhoff et al., 2004). Human dominated landscape, most importantly the land under agricultural use has traditionally received less attention and concern as it supports low level of biodiversity and hosts fewer species of conservational concern (Naidoo, 2004).

1.1 HABITAT DEGRADATION

There are three types of habitat destruction namely habitat degradation, fragmentation and its complete loss (Hunter and Gibbs, 2007). Human can alter natural habitats in a number of ways to get maximum economic benefits i.e. generation of hydroelectric power through dam-building, extraction industries, mining and logging (Wickham et al., 2007) and agriculture as well. The direct effect of these activities appears in reduction and/or complete loss of natural habitat. Whereas the indirect impacts of such interventions on habitat degradation include pesticide pollution, acid rain and leaching of fertilizers. Habitat loss has proved to be the greatest threat to wildlife (Brooks et al., 2002). It is responsible for decline of over 90% of bird species that are regarded as globally threatened (Smith and Smith, 2003). Similarly, Hopping et al. (2004) identified habitat destruction rather than hunting as principle culprit for extinction of species in recent decades.

In mountainous landscapes wildlife species become susceptible to habitat degradation because of topographical fragmentation and rugged terrain. Humanmediated changes in mountainous landscapes are generally restricted to valleys that also serve to be productive habitat for wildlife (Hobbs and Henneke, 1992).
1.2 WILDLIFE ADOPTION TO HUMAN MODIFIED HABITATS

About 95% of terrestrial biodiversity is associated with forest and agricultural systems and human settlements (Western and Pearl, 1989). Over the last 30 years it has become evident that due to loss and degradation of natural habitats much of wildlife has adopted to landscape under human use. The factors influencing the habits of wildlife for adoption to changes in their ecosystem are the size of isolated fragments and their connectivity, habitat quality as well as population density with respect to the fragmented habitats (With and Crest, 1995; Metzger and Decamps, 1997). Brawn et al. (2001) studied the role of disturbance in ecology and conservation of birds and found that many bird species such as northern bobwhite (*Colinus virginianus*), grasshopper sparrow (*Ammodramus savannarum*), and indigo bunting (*Passerina cyanea*) have become specialized into utilizing the disturbed areas for breeding. As a result of reduction of natural forests many birds have adapted to utilize shrubs and open-area habitats as shrubs provide rich sources of food (e.g. berries and invertebrate prey especially insects) and offer safe shelter to these birds (Peterjohn, 2006).

Work of Riddle and Moorman (2010) in agriculture-dominated landscapes showed that many songbirds have become adapted to human modified landscapes i.e. rangelands, pastures and croplands. It has been reported that many bird species e.g. Indian robin (*Saxicoloides fulicatus*), house sparrow (*Passer domesticus*) and common myna (*Acridotheres tristis*) are not only confined to croplands but they have adapted to both agricultural and non-agricultural lands (Kale et al., 2013). Lowe et al. (2011) also reported that human influenced ecosystems i.e. agroecosystems are predominated by small number of bird species that are pre-adapted to live in disturbed and degraded ecosystems.
The response of wildlife to habitat changes in terms of adoption is still unclear since many species do not respond instantly to these changes (Hanski, 2011). Similarly, patterns of habitat selection by many wildlife species have profoundly changed as a result of anthropogenic activities (Rogala et al., 2011). These changes have pronounced consequences on community interactions and ecology of these species. Understanding the effects of human activities on distribution and abundance of species in human mediated landscapes has great importance in areas of rugged terrain and steep topography as these factors limit the suitable habitat of many wildlife species.

1.3 CONVERSION OF WILD HABITATS TO AGRICULTURAL LANDSCAPE

At global level, the conversion of wild habitats to agriculture is considered one of the largest causes of habitat modification. Around one-third of the world’s exploitable surface is dominated by agriculture (Ormerod and Watkinson, 2000) and almost half of the terrestrial land is subject to food crop farming (Western and Pearl (1989). Ever rising human population demands intense use of existing agricultural land to meet its food and fiber needs, which is causing loss of its productivity. On the other hand about 15 million hectares of wild land is converted into farmlands annually (Primentel et al., 1992). There are forecasts that about half of all potentially suitable remaining land would be converted to agriculture in developing countries by 2050 (Tilman et al., 2001). The type and scale of agricultural land use can have a marked effect on structures and functions of the inhabiting wildlife populations (Benton et al., 2002). Nowadays there is a core incompatibility between the ever-increasing demands of agriculture and the conservation of wild flora and fauna (Firbank et al., 2008). Several complex processes govern such ecosystems and it is very difficult to trace out the causes of biodiversity responses at the local level. For
effective conservation plans, study of use patterns of different types of agricultural lands by wildlife along with the attitude of local people towards their environment is suggested for better understanding the biodiversity loss or adaptability (Hulme, 2007).

1.4 LOSS TO BIODIVERSITY

In the developing countries agriculture is expanding at an alarming rate with large scale felling of natural forests. Initially vegetation and tree debris provide nutrients for farming but after few years of cropping, the forest is allowed to reinvade. Due to this practice of short rotation agriculture, not only the farming potential of land is lost but chemical composition of nutrients and organic matter in the soil is also disturbed that ultimately leads to the loss of biodiversity in such lands (Altieri, 1990). It is well understood that agriculture intensification poses serious threats to biodiversity (Chamberlain et al., 2000; Tilman et al., 2001). The existing agricultural landscapes are also being transformed due to social, economic and technological advancements. As a result, reduced heterogeneity and resilience of such lands adds further to the loss of biodiversity (Benton et al., 2003). There are spatio-temporal variations in the impact of agriculture to biodiversity since different systems have different rates of species abundance. Firbank et al. (2003) have suggested three major dimensions of agricultural intensification viz: changes in land cover, changes in landscape structure and changes in land management, and suggested that if proper indicators are used the effects of agriculture on biodiversity can be well understood in all the farming systems. Brook et al. (2003) predicted that if present rate of anthropogenic change and habitat destruction in Southeast Asian countries continues, 13-42% of regional bird populations will be lost over the next century.
1.5 LOSS TO AVIFAUNA

The changes in land cover as well as landscape and crop management put increasing pressures on biodiversity in general and avifauna in particular to meet its food and nesting needs. The conversion of greater areas of land to agriculture has reduced the habitat heterogeneity and has led to decline in richness and diversity of bird species (Benton et al., 2003). Many bird species are associated with the early succession of the habitats and have reduced in numbers because of lack of such habitat due to natural and human mediated changes i.e. intensive agriculture and urbanization (Hunter et al., 2001). It has been estimated that as a result of all land use changes, there may have been a loss of 20-25% of pre-agricultural bird numbers (Gaston et al., 2003). Moreover, it is predicted that about 27-44% bird species could be lost to agricultural expansion from Neolithic to 2050 (Teyssedre and Couvet, 2007). In agricultural lands, bird biodiversity directly correlates with habitat diversity and can be maintained by minimizing pressure on natural habitat (Firbank et al., 2008).

Birdlife International’s World Bird Database suggests that agriculture is the main source of threat to bird species listed as threatened and it is substantially more important for species in developing than developed countries. However, there is lack of baseline data on richness of wildlife and particularly the bird species in farmlands (Green et al., 2005). When natural landscape is converted into cropland the composition of avian community of that area changes as the birds that are more sensitive to changes in vegetation structure and composition decline while those that are able to thrive in human-mediated landscapes successfully colonize the new habitat (Chace and Walsh, 2006; Van-Heezik et al., 2008). In developing countries like Pakistan few studies have been conducted to assess the impact of human
activities on ecosystems and their habitants, and such data on Pothwar plateau region of this country are scanty as well.

1.6 CHARACTERISTICS OF AGRICULTURAL LANDSCAPES

A natural habitat changed from forest, woodland or savannah to agriculture tends to result in more open areas with fewer trees and shrubs (Marsden et al., 2006) and more perennial vegetation, with increased seasonality in the availability of seed and invertebrate food (Critchley et al., 2004). Crop fields are sown and harvested on seasonal and annual basis depending upon the lifespan of the crops being cultivated. The variety of crops cultivated varies, with low crop diversity described as a monoculture is viewed as indicative of high-intensity farming (Gall and Orians, 1992). Due to preference for certain high value crops, crop diversity has also decreased (Shrubb, 2003). Agricultural land also tends to have high input of fertilizers and pesticides which alter the soil quality and its chemical make-up thus can influence vegetation and animal health (Mader et al., 2002).

The crop fields vary in size, depending on the intensity of the farming practices usually larger fields predominating on higher intensity farmland. Studies in Britain have shown that size of agricultural fields has been increased for intensive farming resulting in the loss of habitat heterogeneity in the croplands (Petitet et al., 2002). The typical characteristics of ecosystem of Pothwar plateau, Pakistan are undulating open land inter-dispersed with gullies and low hills where vegetation chiefly consists of dry sub-tropical forests. The open land is used for rain-fed agriculture (Hussain et al., 2012) and size of crop fields is mostly small because of terrain and fragmented nature of the landscape itself.
1.7 NON-CROP AREAS IN AGRICULTURAL LANDSCAPES

Some agricultural habitats offers a mosaic of different cultivated fields connected by non-cropped areas (i.e. grass margins and strips linear scrub along field boundaries, woodland, ponds, ditches and fallow land) which provide diversity of needs such as refuges, feeding areas and dispersal corridors to biodiversity and species persistence (Hinsley and Bellamy, 2000; Benton et al., 2003). Many studies have highlighted the importance of non-cropped habitat in maintaining bird biodiversity by providing them nesting and foraging opportunities (O’Connor and Shrub, 1986). In croplands of Pothwar plateau, such features naturally exist and are being maintained in order to conserve rainwater for farming and to reduce soil erosion. However, these non-cropped habitats are not intentionally managed for conservation of farmland biodiversity but probably indirectly serving this cause.

1.8 FIELD BORDERS

Smith et al. (2005a) have devised the term „field borders“ to the patches of uncultivated wild vegetation along the margins of crop fields consisting mainly of grasses and forbs and low shrubs that are especially maintained for the protection of wildlife. Field borders increase the structural diversity of vegetation due to more layers of horizontal and vertical vegetation. MacArthur and MacArthur (1961) found that trees and shrubs found along field borders are absent in croplands throughout Europe and increase space and resource partitioning for birds.

In agricultural landscapes maintained field margins properly increase habitat heterogeneity because of presence of additional layers of vegetation. This, in turn, increases avian density and diversity in such areas (Flemming and Giuliano, 1998) and the areas also provide nesting habitat to many birds (Dimmik et al., 2002).
The shape of the field borders is also important. Several studies have shown that long, even and narrow field borders have high density of birds and especially nests (Smith et al., 2005b) but these continuous and straight borders also facilitate nest predation and act as travel lanes for bird predators like snakes and raccoons (Dijak and Thompson, 2000). For this purpose, several authors have suggested the maintenance of intermittent field borders to reduce nest predation (Johnson and Temple, 1990; Riddle and Moorman, 2010). The birds that require some woody vegetation are significantly benefitted by irregular field borders of 30m or more as they reduce predator efficiency and decrease nest predation (Daria and Campbell, 2012). The heterogeneity of the field boundary vegetation is also important. If only trees are planted along the field edges but devoid of adequate proportion of shrubs and grasses, the populations of ground nesting birds and open farmland birds decline (Sanderson et al., 2013). Several authors have shown that landscape heterogeneity in agro-ecosystems particularly affects avian occurrence and abundance (Batary et al., 2011; Sanchez-Oliver et al., 2014). In Pothwar plateau, agricultural fields have invariably thick undisturbed field boundaries maintained to conserve water. Along the field boundaries, apart from wild vegetation of shrubs, fast growing trees are planted for browse and fodder purpose. Such practices need investigation to explore their impact on farmland biodiversity.

1.9 USEFUL ROLE OF BIRDS IN FARMLANDS

Birds present some important services to agro-ecosystems. Many insectivorous bird species act as biological control agents of pests by consuming harmful insects of crops. Some species also help in pollination of plants (Klein et al., 2007). The seed eating birds are also involved in dispersal of plant seeds. Raptors keep check on rodent populations while scavengers eliminate the dead animals and
thus help in environmental sanitation of agro-ecosystems (Sekercioglu, 2006; Whelan et al., 2008).

Chakravarthy et al. (2008) studied the foraging ecology of certain birds in agro-ecosystems of India and found that several birds especially drongos, owls, rollers, wagtails and warblers play an important role in pest suppression by feeding on insects that are potentially harmful to crops. In Pakistan, a study conducted on cotton-wheat based agro ecosystem of Punjab revealed that five passerine species namely common babbler (*Turdoides caudata*), jungle babbler (*Turdoides striata*), common myna (*Acridotheres tristis*), small green bee-eater (*Merops orientalis*) and ashy wren warbler (*Prinia socialis*) feed on insect pests of cotton thus contributing in suppression of arthropod pests in these croplands (Hussain and Afzal, 2005).

### 1.10 AGRI-ENVIRONMENT SCHEMES

In Europe many immaculate habitats were converted to agricultural landscapes but now several habitat restoration programs have been initiated to restore the previously converted lands and those that were abandoned because of loss of productivity (Leopold et al., 2001). The population recovery of farmland birds is achieved mainly through Agri-environment schemes (AES), an important component of which is provision of invertebrate-rich foraging habitat during their breeding season. It is considered essential in ensuring nestling growth and productivity for a range of the species (Brickle et al., 2000; Macleod et al., 2005).

### 1.11 OBJECTIVES

The objectives of the study were;

1. To determine anthropogenic use of the crop-field-edge vegetation at Pothwar plateau, Pakistan.
2. To study diversity and abundance of vegetation bordering crop fields of Pothwar plateau.

3. To study the seasonal diversity and species richness of passerine birds utilizing the field boundary vegetation.

4. To investigate the role of seasonal changes in field boundary vegetation and the field crops on bird assemblage, feeding, nesting and breeding.

1.12 STUDY AREA

1.12.1 Geographical Location

The present study was conducted in Pothwar plateau covering four administrative districts (Rawalpindi, Attock, Chakwal and Jhelum) of Punjab and some areas falling in Islamabad Capital Territory of Pakistan (Fig. 1.1). The rivers Jhelum and Indus border the plateau on the east and west boundaries, respectively. Margallah Hills are present in the north and Salt Range in the south of this plateau while Kala Chitta Range is present in the north-east (PARC, 1980; Kazmi and
Fig. 1.1: Map of the study area showing the locations of selected study sites in agroecosystem of Pothwar plateau, Pakistan.

Rasul, 2009). Pothwar plateau is located between latitudes 32° 33N and longitudes 71° 89 and 73° 37E (Ahmad, 1991) covering an area of ~ 23,160 km² which accounts to 2.9% of the total area of Pakistan (Ali, 2004), with elevation varying between 305
- 610 m above sea level (Nadeem et al., 2012). It has 31 cities (urban centers and suburbs) and 2767 villages (Ali, 2004), hosting human population of over two million (Taj et al., 2007). The plateau constitutes 23% of the total rain fed tract of Pakistan (Shah et al., 2012).

1.12.2 Climate

Climatically, Pothwar plateau is semi-arid to sub-humid (Ali, 1967). The summer temperature ranges between 15 °C and 40 °C while the range of winter temperature is between 4 °C and 25 °C and it drops below freezing point for some time in winter nights (Hussain et al., 2009a). The area receives erratic rainfall 70% of which falls during monsoon season. The mean annual rainfall varies from 250mm to 1000mm (Arif and Malik, 2009). The data regarding mean annual temperature (°C) and mean annual rainfall (mm) of Pothwar plateau over the two year study period (July 2012 to June 2014) were obtained from Pakistan Meteorological Department, Islamabad and are respectively presented in Figs. 1.2 and 1.3.

1.12.3 Topography and Soil

The word “Pothwar” means uneven, therefore, as reflected by its name, the area is a dissected region with undulating topography, gullies and rugged terrain. The farmers’ land holdings are small and fragmented (Nizami et al., 2004). The natural slope is from northeast to southeast (Ali, 2004). Traditionally four types of soil have been recognized in Pothwar plateau viz: river alluvium, piedmont
*Courtesy of Pakistan Meteorological Department, Islamabad.

**Fig. 1.2:** Mean annual temperature (°C) during July 2012 to June 2014 at the 4 selected sites of Pothwar plateau, Pakistan.
*Courtesy of Pakistan Meteorological Department, Islamabad.
Fig. 1.3: Mean annual rainfall (mm) during July 2012 to June 2014 at the 4 selected sites of Pothwar plateau, Pakistan.
alluvium, loess and residual (Muhammad, 1979) but in a recent study Khan et al.(2007) have characterized the soils as loess, alluvial, colluvial and mixed in nature. Soils of the plateau are generally considered deficient in nitrogen and phosphorus and are thus have low fertility (Kazmi and Rasul, 2009). The nitrogen content of the soil has been found to be 0.03-0.07%, organic matter less than 1% and the pH varying from 7.5 to 8.5 (Ahmad et al., 1990). Sixty percent of Pothwar area has been affected by soil and water erosion (Majeed et al., 2010) and it has been reported that sheet, gully and rill erosion have ruined around one million hectare area of the plateau (Gardner, 1996).

1.12.4 Hydrographic Features

Two rivers fringing the Pothwar plateau are river Indus in the west and river Jhelum in the east. All the streams fall in either of these rivers. There are two principal tributaries namely Soan and Haro rivers. The former emerges from Murree hills and the latter from Abbottabad. These rivers join river Indus on their way. The important man-made and natural lakes of the plateau are Ucchali, Khabbeiki, Jahlar, Kalar Kahar and Rawal lake (Ali, 2004).

1.12.5 Human Population

Humans have widespread presence in the whole of Pothwar plateau. According to Ali (2004) 5.6% of Pakistan”s population lives in this plateau and it is widely scattered throughout the area. Sixty percent of the population occupies the rural areas some of which are even inaccessible instantly. The population density has been reported to be 322 persons per km² (GOP, 2001). Taj et al. (2007) reported that Pothwar plateau hosts a population of over two million people and average family size is 8.4 persons.
1.12.6 Flora and Fauna

About 241,000 ha area of Pothwar plateau is covered by forest (GOP, 200203) which is dominated by scrub vegetation (Maan and Chaudhry, 2001). Most of the plants are annual (Zafar et al., 2006). The grasses and herbs are dominant in the wild (Shaheen et al., 2014). The important tree species of this region are lebbek or siris (Albizzia lebbek), mountain ebony or kachnar (Bauhinia variegata), eucalyptus or lachi (Eucalyptus camaldulensis), black speargrass or suriala (Heteropogon contortus), caper-berry or karir (Capparis decidua), mesquite or kikrai (Prosopis juliflora), poplar or safeda (Populus nigra), Indian plum or ber (Zizyphus mauritiana) and jumbay or ipil-ipil (Leucaena leucocephala) (Hussain et al., 2009b).

Jabeen and Ahmad (2009) have reported 10 most abundant species of grasses namely Cenchrus ciliaris, Cannabis sativa, Euphorbia helioscopia, Dodonaea viscosa, Cynodon dactylon, Ranunculuc muricatus, Parthenium hysterophorus, Carissa opaca, Otostegia limbata and Saurrurea heteromalla. Natural vegetation of the plateau is under pressure due to low rainfall, extensive deforestation, coal mining, and oil and gas exploration (Nizami et al., 2004).

The important mammals of this area include desert hare (Lepus nigricollis), jackal (Conisaureus), mongoose (Herpestes javanicus), jungle cat (Felis chaus), wild boar (Sus scrofa), Indian crested porcupine (Hystrix indica), barking deer (Muntiacus muntjak) and Punjab urial (Ovis punjabiences) (Roberts, 1992; Maan and Chaudhry, 2001). Mehmood et al. (2011) claimed that the plateau provides suitable habitat to Indian gazelle (Gazella bennettii), chukar partridge (Alectoris chukar) and yellow throated marten (Martes flavigula).

The residential avifauna of the plateau is oriental in region consisting of 25 species (Maan and Chaudhry, 2001). Many bird species that have restricted
distribution are found here i.e. blue-tailed bee-eater (*Merops philippinus*), painted sand grouse (*Pterocles indicus*), black-breasted weaver (*Ploceus benghalensis*), blossom-headed parakeet (*Psittacula roseata*) and Indian courser (*Cursorius coromandelicus*). The important summer breeding visitors are small buttonquail (*Turnix sylvaticus*), yellow-legged buttonquail (*Turnix tanki*), spotted dove (*Spilopelia chinensis*), Brahminy starling (*Sturnia pagodarum*) and pied starling (*Gracupica contra*) while the dominant wintering birds are white capped bunting (*Emberiza stewarti*), black redstart (*Phoenicurus ochruros*) and white-throated fantail (*Rhipidura albicollis*) (Qaisrani, 2006).

1.12.7 Livestock

Over 25% of the livestock population of rain fed tract of Punjab is in Pothwar plateau (Khan, 2002). Due to limited landholding, livestock is considered a supplementary income source of the farmers. Nosheen *et al.* (2011) reported that the most common livestock species reared in Pothwar region are goats followed by cattle, sheep and buffaloes. Asses, camels, horses and mules are the least kept animals in this region (Shah *et al.*, 2005; Punjab Livestock Census, 2006).

1.12.8 Agriculture, Weeds and Pests

About 25% of the total area under cultivation in Punjab lies in Pothwar plateau (Shah *et al.*, 2012) which covers about 110,600 ha (GOP, 2002-03) and contributing 10% of the total agricultural production of Pakistan (Kazmi and Rasul, 2009). Agriculture of the plateau is dominantly (96%) dependent on rain with only 4% cultivated by irrigation (Majeed *et al.*, 2010). Major cultivated crops include wheat (*Triticum aestivum*), groundnut (*Arachis hypogea*), barley (*Hordeum vulgare*), sorghum (*Sorghum bicolor*), maize (*Zea mays*), millet (*Pennisetum typhoides*), chickpea (*Cicer arietinum*), legumes (*Vigna* spp.), and lentil (*Lens culinaris*). Among these, groundnut, millet, sorghum, mash (*Vigna mungo*) and mung
beans (*Vigna radiata*) are summer (Kharif) crops whereas, the winter (Rabi) crops include wheat, chickpea, barley and mustard. Maize is grown during both the seasons.

Two types of traditional cropping systems are practiced in this region i.e. wheat-groundnut and wheat-maize/millet (Arif and Malik, 2009; Kazmi and Rasul, 2009). However, at some suitable habitats and under favorable conditions fruit plants of citrus and guava are also grown (GOP, 2002-03). Ahmad *et al.* (2006) have reported that berseem (*Trifolium alexandrinum*) and lucerne (*Medicago sativa*) are cultivated with winter crops for fodder while guar (*Cyamopsis tetragonoloba*) and sesbania (*Sesbania grandiflora*) are cultivated with summer crops for this purpose.

Several weeds infest the crops of Pothwar plateau. *Galium aparine* is a problematic weed in all the winter crops of Pakistan and it particularly affects wheat (*Triticum aestivum*) of Pothwar area. *Sorghum halepense* commonly called dadam is a weed in wheat (*Triticum aestivum*) and maize (*Zea mays*). Similarly *Amaranthus hybridus* and *Ipomea eriocarpa* typically affect maize crop (*Zea mays*) in this area (Marwat *et al*., 2010). *Parthenium hysterophorus* is also highly invasive in Pothwar plateau and is a noxious weed (Hussain *et al*., 2000). The important rodent pests in Pothwar region are *Tatera indica*, *Nesokia indica*, *Bandicoota bengalensis* and *Mus* spp. (Hussain *et al*., 2003; Khan *et al*., 2012) while common insect pests are *Rhopalosiphum maidis*, *Schizaphis graminum*, *Diuraphis noxia*, *Sitobion miscanthi*, *Chilo partellus* and *Atherigona soccata* (Nasir and Yousaf, 1995; Hafeez and Zia, 2009).

### 1.12.9 Current Knowledge of Avifauna in Pothwar Croplands

The Pothwar plateau holds rich wildlife among which the avifauna predominantly includes Passeriformes, mostly residents but some are summer
breeder visitors as well as wintering birds (Roberts, 1992; Qaisrani, 2006). No comprehensive account of passerine birds associated with field boundary vegetation in Pakistan is available, but according to Roberts (1992) more than two dozen resident and migratory passerines are associated with the farmland vegetation of Pothwar ecology. Many of these species are insectivorous, mostly in their visiting periods, thus acting as biological control agents of insect pests.

In many developing countries like India and Pakistan, pesticides are not used for low revenue crops and insectivorous birds play key roles in suppressing the insect pests in maize (Zea mays) and millet (Pennisetum typhoides) (Parasharya et al., 1994; Sivakumaran and Thiyagesan, 2003). Thus appropriate management practices are needed to enhance these important insect predators. However, no report is available on current status and population dynamics of these species in this area.

It has been reported that wild vegetation along field boundaries is a key feature of agriculture landscapes (Marshall and Moonen, 1998) and the changes in agricultural practices often lead to changes in composition of field boundary vegetation (Marshall and Moonen, 2002). In Europe, the management strategies for bird conservation on agriculture land have been linked to efforts for increasing non-crop vegetation along the fields (Gottschalk et al., 2007; Whittingham et al., 2009). Such feature naturally exists in the agro-ecosystem of Pothwar plateau although not maintained for conservation of birds but for retention of the rain water. However, there is need to explore any relationship of vegetation of crop field boundaries with existing bird species (their population, feeding, breeding etc.) that will provide baseline data for devising conservation strategies of the avifauna.

The scope of this study is restricted to investigations of those Passeriformes that are more likely to use such habitat. Need of such study is supported by
Agrienvironment schemes (AES) in Europe where the provision of non-cropped field boundaries are supporting higher invertebrate resources than the cropped fields particularly during the breeding season, and is considered essential in ensuring nestling growth and productivity for a range of bird species (Brickle et al., 2000; Macleod et al., 2005).

1.12.10 Study Sites

Four potential study sites, two in each cropping system of Potwar Plateau were selected initially through reconnaissance surveys. During the site selection due consideration was given to the composition of cropland areas for having true representation of the local cropping patterns and wild vegetation of the crop field boundaries. Cooperation of the farming communities and logistic approach was also given due weightage. At each selected site an intact area of 10 x 10 ha was selected for investigation (Table 1.1). The selected areas were regularly visited for data collection on monthly basis. One site was located in district Attock, another in district Rawalpindi and the remaining two in district Chakwal (Fig. 1.1).

Table 1.1: Description of four selected study sites in agricultural landscape of Pothwar Plateau, Pakistan.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Name and Location</th>
<th>GPS location*</th>
<th>Elevation* (m above sea level)</th>
<th>Cropping system</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Thatti Gujran (Fatehjang, Attock)</td>
<td>N 33°32.915</td>
<td>477</td>
<td>Wheat-millet/maize</td>
</tr>
<tr>
<td>II</td>
<td>Koont (Gujjar Khan, Rawalpindi)</td>
<td>N 33°07.365</td>
<td>534</td>
<td>Wheat-groundnut</td>
</tr>
<tr>
<td>III</td>
<td>Shah Syed Billu (Choa Saden Shah, Chakwal)</td>
<td>N 32°48.333</td>
<td>537</td>
<td>Wheat-groundnut</td>
</tr>
</tbody>
</table>
Chapter 2

ANTHROPOGENIC PRACTICES OF POTHWAR PLATEAU

2.1 INTRODUCTION

Continuous human intervention is required in agro-ecosystems in order to maximize production of selective crops (Birasal, 2014; Adams et al., 2015), therefore farming practices alter the landscape structure and biodiversity of these areas. There are variations in farming practices in different regimes of the world not only with respect to structure of cultivated habitat, e.g. crop diversity and size of fields, but also with respect to the structure of associated non-crop habitat, e.g. forests, ponds,
grasslands, infrastructures of roads and houses and hedgerows (Fuller et al., 1997; Firbank et al., 2008). Therefore, it is difficult to evaluate the impact of anthropogenic practices on cropland associated biodiversity as these practices change over time (Kleijn and Sutherland, 2003).

In agro-ecosystems advanced technology is used in the farming operations for high crop yield leading to the development of large-scale homogeneous farmlands. This homogeneity is because of the removal or reduction of vacant patches of wild vegetation, hedgerows, field edges, etc. However, studies have shown that all these practices leave negative impacts on the ecosystem (Warner, 1994; Philip, 2001; Smith et al., 2005b).

Human activities result in land-use changes and affect community structure of bird species in agricultural landscapes. Human intervention also alters the predator-prey interactions in birds and mammals in the croplands (Caro, 2005; Hebblewhite and Merrill, 2008; Dallimer et al., 2010a). The specific studies on birds in agro-ecosystems have reported that avian responses to changes in farming practices are species-specific since some species are able to adapt to the farming practices involving modern technological advancements while others cannot cope with such challenge (Siriwardena et al., 2000; Eggers et al., 2011).

On crop field boundaries, vegetation is usually subjected to burning, mowing and ploughing to maintain it in early successional stages. In Pothwar ecology there are patches of wild vegetation interspersed with crop fields. The agricultural potential of Pothwar plateau has decreased 2.5-7 times due to removal of wild vegetation especially shrubs for fuel wood and de-vegetation of fragile slopes (Raza and Ahmad, 1990; Ahmad et al., 2006). Similarly, due to loss of vegetation cover, water erosion
is particularly affecting agro-ecosystems of Pothwar leading to habitat degradation (Shinwari and Shinwari, 2010).

Plant diversity in agro-ecosystems can be increased by cultivation of multiple crops which not only conserve soil nutrients but they also help in water retention (Primentel et al., 1992; Power, 2010). However, agro-ecosystems of Pothwar have low crop diversity with wheat being principal winter crop having an average production of about 3000 kg per hectare (Ashraf, 2004; Shah et al., 2005). Mustard is also cultivated with wheat. Wheat straw is used for livestock feeding throughout the Pothwar plateau while mustard is used for human food and as animal fodder during winter season (Hayat, 2005; Shah et al., 2005). Groundnut is also cultivated at a large scale and about 71% of total production of this crop comes from Pothwar plateau (Ahmad, 1990; GOP, 2008; Hassnain et al., 2012). Chickpea, sorghum and maize are cultivated at small scale but large areas of farmlands are kept fallow for some seasons especially during summer in order to conserve water.

Several types of grasses and legumes in agro-ecosystems not only increase biomass, conserve natural runoff water and reduce soil erosion but also provide shelter and refuge to many wildlife species (Hartwig, 1987; Primentel et al., 1992). In this arid ecosystem crop diversity can be increased by cultivation of legumes. Hayat et al. (2008) and Hayat and Ali (2010) worked on legume-wheat rotation in Pothwar and reported that there was a significant increase in wheat yield when legumes especially mash and mung beans were cultivated in summer since due to biological nitrogen fixation by legumes, soil structure is improved and pest and disease cycles are also interrupted.

In the rain-fed areas of Pakistan (Pothwar being one of the major tracks), livestock provide economic security to people in case of crop failure (Afzal and
Naqvi, 2004), particularly during the drought spans. The overall number of livestock is increasing at an annual rate of 2% (GOP and IUCN, 1992) and twothird of the potential of Pothwar rangelands has already been lost due to over grazing since the wild areas associated with crop fields are used for open grazing in this area (Raza and Ahmad, 1990; Ahmad et al., 2006).

Adequate weed control and increased soil fertility are crucial for high crop yield. Since the soils of Pothwar are low in fertility, therefore use of fertilizers is crucial for optimum crop yield and significant increase in wheat yield has been reported in Pothwar croplands with the application of nitrogen and potassium (Khan et al., 2006). However, it is well understood that the use of fertilizers as well as tillage and weed control operations transforms the habitat of agro-ecosystems and ultimately affect biodiversity by disturbing the composition of natural flora in these patches. The use of chemical fertilizers can be reduced if livestock manure is effectively recycled and applied as it not only increases soil organic matter but reduces soil and water pollution which is evitable in case of chemical fertilizers. Ultimately productivity of land and abundance of useful arthropods increase which contribute towards a better ecosystem (Purvis and Curry, 1984; Riddle and Moorman, 2010).

In agro-ecosystems use of intensified agrochemicals is considered to be an important factor that affects birds (Mineau and Whiteside, 2013). The pesticides affect birds indirectly in a number of ways i.e. either decrease the feeding resource base of birds (i.e. seeds and invertebrates) or change the structure of vegetation which reduces the availability of refuges, roosting and nesting sites (Geiger et al., 2010). The direct effect is reported due to contamination of perching sites and/or food (Goldstein et al., 1999). It is also well understood that pesticide use in
agroecosystems disrupts the endocrine system of birds which not only suppresses their immune functions but also leads to immuno-toxicology (Lundholm, 1987; Fairbrother et al., 2004). Therefore it is crucial to understand the potential susceptibility of birds to pesticides. In the croplands carrying excessive use of pesticides (such as cotton and vegetable crops in irrigated areas of Pakistan), accumulation of pesticide residues in soil and shallow water is evident (Jabar et al., 1993). Under such circumstances, negative effect on hatching, nestling growth and survival of nestling passerines is reported worldwide (Rodenhouse and Holmes, 1992; Howe et al., 1996). In Pakistan, bird diversity has decreased in cotton based agro ecosystem of Punjab due to excessive use of pesticides (Khan, 2001). However, it has been reported that in Pothwar pesticides are used at a low scale in wheat, groundnut and millet crops (Hussain et al., 2009b; Shah et al., 2012) therefore, there is less likely effect on non-target organisms including birds.

There is inter-specific variation in birds with respect to tolerance for frequency of human disturbance. Thus, comprehensive studies are essential that predict species-specific responses to human intervention in agro-ecosystems (Blumstein, 2005). Unfortunately in Pakistan such studies on potential effects of human mediated changes in agriculture landscapes on associated biodiversity have not been conducted at vast scale. The current study was therefore carried out on anthropogenic use of crop field boundary vegetation of Pothwar agro-ecosystem in order to generate baseline data on human activities and their potential effects on avifauna in this region.

2.2 REVIEW OF LITERATURE

In agro-ecosystems avifauna is affected both at local and landscape scale due to human intervention through the use of agro-chemicals and loss of habitat
heterogeneity as a result of destruction of semi-natural habitats. As a result, population of birds in fragmented landscapes like croplands is affected by human disturbance. The foraging and breeding schedules of these birds are altered leading to decreased productivity (Batary et al., 2010; Geiger et al., 2010; Hippargi et al., 2012).

Flohre et al. (2011) investigated the effects of agricultural intensification in cereal crop fields of Estonia, France, Germany, Ireland, Netherlands, Poland, Spain and Sweden and found that both the plant and bird biodiversity decreased because of loss of diverse habitat and suggested that variety of field margins should be maintained and intensive farming practices should be minimized to conserve the floral and faunal biodiversity in agricultural landscapes. They also emphasized that arable landscapes should be interspersed with semi-natural habitat to maintain biodiversity. Oladeji et al. (2012) worked on anthropogenic activities in Nigeria and found that these activities not only have negative impacts on wildlife but biodiversity loss ultimately leads to economic loss.

Guerrero et al. (2012) studied the responses of farmland birds to agricultural intensification across Europe and found that anthropogenic practices affect the use of fields by farmland birds. They found that changes in landscape and habitat structure due to intensive farming lead to widespread decline in populations of ground-nesting specialists like skylarks (Alauda arvensis). They suggested reducing nutrient and fertilizer input and decreased mechanical disruption of soil in order to improve the populations of birds in croplands. Similarly Doxa et al. (2010) reported that low-intensity agriculture in France increases the density and diversity of several species of birds, insects and plants.
Although several studies have depicted that avian density and diversity is directly correlated with urbanization in farmlands (Smith et al., 2005b; Riffell et al., 2008) but in a recent study Adams et al. (2015) reported that avian community structure did not change with respect to species abundance and richness when infrastructure like access roads to farmlands were also planted with herbaceous and shrub vegetation on both sides. Floral diversity in croplands can be increased by planting trees and other woody vegetation along the crop fields that provide refuge to wildlife. Tree plantations in urban and agro-ecosystems render great environmental and societal services as these trees help in retention of soil and water and also help in carbon sequestration (Rey-Benayas et al., 2010). Smith et al. (2005b) studied bird density and diversity in agricultural landscape in Mississippi. They found that removal of field boundary vegetation affects the structure of wild vegetation along the field margins which results in reduction of structural complexity of this vegetation. As a result, avian density and diversity of such landscapes are affected. Bremer and Farley (2010) reported that when tree species are planted in degraded and disturbed landscapes and croplands they help to raise local biodiversity. However, in this regard care should be taken and only indigenous tree species should be planted.

Kideghesho et al. (2006) studied the factors and ecological impacts of wildlife habitat destruction in the Serengeti ecosystem of Tanzania and found that removal of wild vegetation for fuel wood and timber, mining, uncontrolled grazing, forest fires and human developments affect biodiversity negatively. The changes in the use and management of croplands by farmers at individual farm level lead to alteration of habitat structure and affect the bird communities occupying the agricultural landscapes (Firbank et al., 2008; Concepcion and Diaz, 2010). The vegetation bordering the crop fields provides shelter to many farmland birds.
Jayprakash (2014) reported that partial cutting of field boundary vegetation or its complete removal destroys the roosting and nesting sites of several species of birds i.e. red-vented bulbul (*Pycnonotus cafer*), large grey babbler (*Turdoides malcolmi*), jungle babbler (*Turdoides striata*), ashy prinia (*Prinia socialis*), Indian tailorbird (*Orthotomus sutorius*), Oriental magpie robin (*Copsychus saularis*) and Indian robin (*Saxicoloides fulicatus*) inhabiting agro-ecosystems of Maharashtra, India.

Livestock grazing in agro-ecosystems causes soil compaction, trampling as well as changes in vegetation structure. Fernandez *et al.* (2002) worked on habitat degradation and reported that are shifts in wild vegetation with respect to grazing intensity because heavy grazing removes top vegetation and due to trampling soil crust hardens that hinders the penetration of water. Thus desirable grassy vegetation does not develop. Andries *et al.* (2002) studied social impact on regime shifts in semi-arid regions of Australia and found that intensity of livestock grazing affects the vegetation structure resulting in the loss of vegetation. Pavel (2004) reported that in croplands of India high number of livestock causes trampling due to which many nests of ground nesting birds are lost. In Pothwar plateau livestock is a precious commodity to sustain livelihood of local people especially in case of accidental crop failure. It has been suggested that if grazing intensity is reduced, the habitat of agricultural landscape could be improved and the associated avian communities are benefitted (Evans *et al.*, 2005).

Gabriel *et al.* (2010) studied farmland biodiversity at different spatial scales with respect to organic farming and concluded that organic farming is environment-friendly and increases biodiversity in agricultural landscapes. The intercrops or living mulches serve purposes of weed suppression and conservation of soil and water resources. They also increase plant and animal biodiversity of agro ecosystems.
When such cover crops are inter-planted with the main crop, they also increase vegetation diversity and harbor different predators and parasites that act as biological control agents of pests. In Pothwar inter-cropping of some crops is a popular practice, e.g. wheat and mustard (*Brassica campestris*) which needs to be investigated with respect to its impact on soil, water and biodiversity.

In agro-ecosystems fertilizers and pesticides are used to increase crop yield by suppressing the growth of undesirable grassy vegetation and invertebrates that feed on cereal crops. Extensive use of fertilizers in crops not only leads to pollution but also affects the habitat structure, e.g. a study in Britain showed that nitrogen surplus leads to eutrophication of plants as a result of which few plant species become dominant while floral diversity is lost. Thus natural floral composition is altered that in turn affects associated bird biodiversity (Smart *et al.*, 2003). The seed and arthropod abundance decreases because of use of agrochemicals especially inorganic fertilizers (Newton, 2004; Kleijn *et al.*, 2009).

The soil of Pothwar plateau is poor in organic matter and consequently fertilizers are used in this region to improve crop yield. Hassnain *et al.* (2012) recommended use of gypsum in groundnut crop at the rate of 500kg/ha to improve yield in Pothwar. Iqbal and Ashraf *et al.* (2007) and Sherawat *et al.* (2012) reported that inter-cropping of *Brassica* spp. with wheat in Pothwar area provides improved habitat diversity for the natural predators of pests. It has been suggested that if crop residues e.g. stalks and stubble are left in the fields for recycling they not only help in water retention but also control soil erosion (Primentel *et al.*, 1992). Ahmad *et al.* (2012) reported that cattle and farmyard manure as well as crop residues of mustard and chickpea significantly improve growth and yield of groundnut in Pothwar area and also suppress the root rot disease.
In Pothwar plateau several weeds infest the field crops. Bhatti and Bhutta (2002) reported that most commonly occurring pathogens in wheat are *Fusarium* spp. Stripe rust caused by *Puccinia striiformis* also affects wheat yield. They also reported root rot as a major disease of groundnut. Mashwani et al. (2011) reported that maize stem borer (*Chilo partellus*) is a biotic constraint affecting maize and sorghum production. Shabbir et al. (2012) reported that *Parthenium hysterophorus* is a noxious weed in agro-ecosystems of Pakistan and has invaded Pothwar plateau as well. Field studies (Alvi et al., 2004; Jarwar et al., 2005) have suggested effective control of narrow and broad leaved weeds by application of weedicides (Affinity, Isoproturon and Sencor) in wheat crop of Pothwar area. Khan et al. (2014) found that Primextra gold and Dual gold (Active ingredient Fenvalerate) are effective herbicides for *Amaranthus viridis*, *Parthenium* spp., *Cynodon dactylon*, *Cyprus rotundus* and *Sorghum halepense*.

High input of pesticides and weedicides as well as loss of habitat heterogeneity leads to partial and/or complete loss of foraging and breeding habits of birds in agricultural landscapes (Robinson and Sutherland, 2002; Benton et al., 2003). At global scale about 2.5 billion kg of pesticides having a worth of US$ 20 billion is used every year (Primentel et al., 1992) that are toxic to wildlife. Pesticides not only alter the natural structural composition of ecosystems but are also hazardous to various non-target species. Several non-chemical control methods can be employed to minimize pesticide use. These include biological control, rotational agriculture, management of soil and water as well as promising use of genetic engineering and increases resistance of host plants (Primentel et al., 1991). A survey report of Pothwar area revealed 77% farmers consider rodents as pests (Ahmad, 1991). It has also been reported that up to 20 fold increase in groundnut production
can be achieved by controlling rodent pests using rodenticide baits (Khan et al., 1999).

Some birds are known to inflict damage to cereal crops. Ubaidullah (2004) reported that in Central Punjab foraging flocks of house sparrow (Passer domesticus) damage many cereal crops especially wheat. He also reported that migratory birds inflict serious damage to wheat and millet during the ripening stages in the rain-fed areas of Pakistan. Rais et al. (2010) reported that passeriformes like house crow (Corvus splendens) and common myna (Acridotheres tristis) act as invasive species and not only make use of domestic waste but also act as pests of crops. However, several birds inhabiting the agroecosystems have beneficial roles and are associated with wild vegetation in croplands.

2.3 MATERIALS AND METHODS

This study was based on a questionnaire survey. The information regarding the cultivation of crops by farmers was collected from the land owners and their tenants or farm workers. The farmers aged 27 to 54 years who owned or worked at farmlands of study sites were selected for gathering data on anthropogenic practices of the area. Information on the following parameters were sought from the interviewees; i) livestock owned by farmers, ii) use of crop field boundary vegetation for livestock grazing, animal feeding or as fuel wood and burning or harvesting of this vegetation for any other purpose, iii) pests, diseases, weeds, etc. which affect their crops, iv) use of chemical fertilizers and pesticides, v) record of hunting/trapping of any bird species for food, game and/or pet keeping (Annexure 1).
2.4 RESULTS

Information reported by the selected 94 farmers (through personal interviews) on anthropogenic activities at the four selected sites of Pothwar plateau is detailed in the following paragraphs.

2.4.1 Crop Types

Out of 94 farmers interviewed, 90 reported to cultivate wheat indicating it to be the most abundant crop grown in Pothwar plateau, followed by groundnut. Mustard is also cultivated by most of the farmers by intercropping with wheat and there were recorded numerous wheat mixed mustard fields in the study area. The third most important crop was maize cultivated by 64% farmers, while 57% farmers reported cultivation of millet at their farmlands. Relatively less cultivated crops included chickpea, mash and mung beans, barley, sorghum and oats (Table 2.1).

2.4.2 Livestock

Seventy six out of 94 farmers owned livestock including goats, cattle, sheep and buffaloes (Fig. 2.1.) Goat was the most popular animal reared by 70% farmers which was followed by cattle, reared by 63% farmers. Forty one percent of the farmers had sheep in their stocks while buffaloes were owned by 29% farmers. None of the interviewees reported custody of camel but a few had possession of assess and horses. The farmers who owned the farmlands had more livestock while few tenants owned livestock ($t_2 = 7.09, P = 0.001$). Only 19% farmers allowed livestock grazing in their farmlands. Majority graze the animals in wild vegetation adjacent to the farms. Grazing of animals in croplands is mostly allowed after harvest or during pre-monsoon season (mid April to mid June). The farmers reported no particular timing
of grazing and the animals are allowed to remain in the crop fields from morning till evening. The duration of grazing period depends upon farm owner’s decision, either to sow the following crop or to leave the field fallow in order to conserve rain water for the next winter crop (Fig. 2.2).

2.4.3 Cutting and Burning of Crop Field Boundary Vegetation

In response to inquiry on harvesting of crop field boundary vegetation for

**Table 2.1:** Summary of farmers report on cultivation of different food crops at four selected study sites in Pothwar area of Pakistan.

<table>
<thead>
<tr>
<th>Common name of crop</th>
<th>Scientific Name</th>
<th>Farmers reporting (n*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td><em>Triticum aestivum</em></td>
<td>90</td>
</tr>
<tr>
<td>Groundnut</td>
<td><em>Arachis hypogaea</em></td>
<td>76</td>
</tr>
<tr>
<td>Maize</td>
<td><em>Zea mays</em></td>
<td>60</td>
</tr>
<tr>
<td>Millet</td>
<td><em>Pennisetum typhoides</em></td>
<td>54</td>
</tr>
<tr>
<td>Mung</td>
<td><em>Vigna radiate</em></td>
<td>16</td>
</tr>
<tr>
<td>Mash</td>
<td><em>Vigna mungo</em></td>
<td>26</td>
</tr>
<tr>
<td>Barley</td>
<td><em>Hordeum vulgare</em></td>
<td>18</td>
</tr>
<tr>
<td>Sorghum</td>
<td><em>Sorghum bicolor</em></td>
<td>18</td>
</tr>
<tr>
<td>Oats</td>
<td><em>Avena sativa</em></td>
<td>9</td>
</tr>
<tr>
<td>Mustard</td>
<td><em>Brasicca compestris</em></td>
<td>72</td>
</tr>
<tr>
<td>Chickpea</td>
<td><em>Cicer arietinum</em></td>
<td>46</td>
</tr>
</tbody>
</table>

*Multiple responses
Fig. 2.1: Reports on various livestock animals owned by 94 farmers interviewed in the selected study areas of Pothwar plateau, Pakistan.

*Multiple responses
animal feeding, response of 58 out of 94 (61.7 %) farmers was positive. These farmers reported to plant fast growing shrubs for fodder and browse. The grasses and shrubs are cut at ground level for animal fodder. Only 17% farmers reported to use crop field boundary vegetation (mostly shrubs) for fuel wood. Generally, the cutting is subject to household demand. However majority of the farmers collect fuel wood from wild scrub forest areas adjacent to their farmlands. Only 19% farmers used to burn crop fields and associated vegetation after harvesting of crop, in order to enhance soil nutrients but this does not seem to be a common practice among the farmers of Pothwar plateau.

2.4.4 Use of Fertilizers

Seventy two percent of 94 interviewed farmers reported to use chemical fertilizers in their crops (Table 2.2). Commonly used fertilizers are urea (CO(NH$_2$)$_2$) and DAP or diammonium phosphate ((NH$_4$)$_2$HPO$_4$). These fertilizers are mostly used in wheat and groundnut crops at various growth stages. Some farmers apply DAP with sowing of crop seeds and use urea after crop germination. A small number of farmers (12 of 94) apply calcium sulfate dihydrate (CaSO.2H$_2$O) popularly called gypsum in groundnut crop while only 18 farmers reported to use cow dung as farm manure.

2.4.5 Farmers’ Report on Pests, Diseases and Weeds

Overall 70 out of 94 farmers reported to have pest/disease and weed problems in their crops (Table 2.3). Rodents (mainly rats) were reported to be top most
vertebrate pests inflicting damage to groundnut crop while some farmers also reported porcupine and wild boar damage to their crops.

![Pie chart showing percent utilization of crop field boundary vegetation by 94 farmers interviewed in the selected study areas of Pothwar plateau, Pakistan.]

**Fig. 2.2:** Percent utilization of crop field boundary vegetation by 94 farmers interviewed in the selected study areas of Pothwar plateau, Pakistan.

**Table 2.2:** Farmers’ response on use of fertilizers in their crops in agro-ecosystem
of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Farmers using fertilizer(n)*</th>
<th>Name of fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>Urea</td>
</tr>
<tr>
<td>62</td>
<td>DAP</td>
</tr>
<tr>
<td>12</td>
<td>Gypsum</td>
</tr>
<tr>
<td>18</td>
<td>Other (organic manure)</td>
</tr>
</tbody>
</table>

*Multiple responses
Table 3: Description of crop pests and diseases reported by farmers of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Pests/Diseases</th>
<th>Crops</th>
<th>Farmers reporting (n)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild boar</td>
<td>Wheat, groundnut, maize</td>
<td>8</td>
</tr>
<tr>
<td>Rodents</td>
<td>Groundnut, maize, millet</td>
<td>58</td>
</tr>
<tr>
<td>Birds</td>
<td>Wheat, millet, sorghum</td>
<td>12</td>
</tr>
<tr>
<td>Insects</td>
<td>Wheat, groundnut</td>
<td>14</td>
</tr>
<tr>
<td>Weeds</td>
<td>Wheat, groundnut, maize, millet</td>
<td>60</td>
</tr>
<tr>
<td>Diseases</td>
<td>Wheat, groundnut</td>
<td>46</td>
</tr>
</tbody>
</table>

*Multiple responses

Only 17% farmers considered birds as pests, which was attributed to flocks of house sparrow (*Passer domesticus*) feeding in wheat, millet and sorghum crops at
maturity stages. Twenty percent farmers reported insect pest problem in their crops which has been detailed in Table 2.4. Aphid species namely *Schizaphis graminum*, *Rhopalosiphum maidis* and *Sitobion miscanthi* are pests of wheat and maize. Shoot fly (*Atherigona soccata*) and maize stem borer (*Chilo partellus*) infest maize and millet. In groundnut, problem of red hairy caterpillar (*Amsacta albistriga*) was reported which devours the crop leaves.

The problem of weeds was reported by 60 out of 70 farmers in almost all crops. The list of weeds reported includes *Alternanthera pungens*, *Cannabis sativa*, *Ipomoea eriocarpa*, *Abutilon indicum*, *Cynodon dactylon*, *Cyprus rotundus*, *Convolvulus arvensis* and *Carthamus oxycantha* (Table 2.5).

Forty six farmers reported about diseases in their crops. All of these were fungal diseases namely early and late leaf spot, stalk and root rot, smut disease as well as rust (Table 2.6).

2.4.6 Pest and Disease Control

The farmers’ opinion on practices employed for management of pest and disease problems in their field crops revealed following information. Manual removal of weeds was found to be a common practice which was reported by 83% of the interviewees (Table 2.7). Manual killing of rodents was reported by only 8% farmers. Some farmers reported the use of burrow smoking method for rodent control, especially in groundnut crop. None of the farmer reported the use of scaring devices e.g. scarecrows and netting to manage the bird pests.
Common insect pests of field crops reported by farmers of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Crop being damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat aphid</td>
<td><em>Schizaphis graminum</em></td>
<td>Wheat, maize</td>
</tr>
<tr>
<td>Corn aphid</td>
<td><em>Rhopalosiphum maidis</em></td>
<td>Wheat, maize</td>
</tr>
<tr>
<td>Indian grain aphid</td>
<td><em>Sitobion miscanthi</em></td>
<td>Wheat</td>
</tr>
<tr>
<td>Maize stem borer</td>
<td><em>Chilo partellus</em></td>
<td>Maize, pearl millet</td>
</tr>
<tr>
<td>Shoot fly</td>
<td><em>Atherigona soccata</em></td>
<td>Maize</td>
</tr>
<tr>
<td>Red hairy caterpillar</td>
<td><em>Amsacta albistriga</em></td>
<td>Groundnut</td>
</tr>
</tbody>
</table>
Table 2

Table 2.5: The weed problem reported by farmers in field crops of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Local name</th>
<th>Scientific name</th>
<th>Crop being infested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessile joyweed</td>
<td>Itsit</td>
<td><em>Alternanthera pungens</em></td>
<td>Wheat</td>
</tr>
<tr>
<td>Marijuana</td>
<td>Bhang</td>
<td><em>Cannabis sativa</em></td>
<td>Wheat, maize</td>
</tr>
<tr>
<td>Purple morning glory</td>
<td>Ilra</td>
<td><em>Ipomoea eriocarpa</em></td>
<td>Maize</td>
</tr>
<tr>
<td>Indian mallow</td>
<td>Kanghi</td>
<td><em>Abutilon indicum</em></td>
<td>Groundnut</td>
</tr>
<tr>
<td>Bermuda grass</td>
<td>Khabbal</td>
<td><em>Cynodon dactylon</em></td>
<td>Wheat, groundnut, maize</td>
</tr>
<tr>
<td>Nut grass</td>
<td>Dela</td>
<td><em>Cyprus rotundus</em></td>
<td>Wheat</td>
</tr>
<tr>
<td>Creeping jenny</td>
<td>Lehli</td>
<td><em>Convolvulus arvensis</em></td>
<td>Wheat, groundnut</td>
</tr>
<tr>
<td>Wild safflower</td>
<td>Poli/kandyari</td>
<td><em>Carthamus oxycantha</em></td>
<td>Wheat, groundnut, maize</td>
</tr>
</tbody>
</table>
Table 2: Farmers’ reports on crop diseases prevalent in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Host Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early leaf spot</td>
<td><em>Cercospora arachidicola</em></td>
<td>Groundnut</td>
</tr>
<tr>
<td>Late leaf spot</td>
<td><em>Phaeoisariopsis personata</em></td>
<td>Groundnut</td>
</tr>
<tr>
<td>Stalk rot</td>
<td><em>Fusarium moniliforme</em></td>
<td>Wheat, maize</td>
</tr>
<tr>
<td>Root rot</td>
<td><em>Sclerotium rolfsii</em></td>
<td>Wheat, maize, groundnut</td>
</tr>
<tr>
<td>Loose smut</td>
<td><em>Ustilago tritic</em></td>
<td>Wheat</td>
</tr>
<tr>
<td>Rust</td>
<td><em>Puccinia striiformis</em></td>
<td>Wheat, maize</td>
</tr>
</tbody>
</table>
Table 2
Farmers’ reports on different methods and techniques employed for management of pests and diseases in agro ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Method/Technique</th>
<th>Farmers reporting (n=70)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-chemical control</td>
<td></td>
</tr>
<tr>
<td>Hand weeding</td>
<td>58</td>
</tr>
<tr>
<td>Pests chased (rodents)</td>
<td>6</td>
</tr>
<tr>
<td>Use of scaring devices (birds)</td>
<td>None</td>
</tr>
<tr>
<td>Rodent burrow smooking</td>
<td>8</td>
</tr>
<tr>
<td>Trapping (for rodents)</td>
<td>14</td>
</tr>
<tr>
<td>Chemical control</td>
<td></td>
</tr>
<tr>
<td>Use of pesticides and weedicides</td>
<td>34</td>
</tr>
<tr>
<td>Poison baiting (Zinc phosphide) for rodents</td>
<td>38</td>
</tr>
</tbody>
</table>

*Multiple responses
Among chemical control methods pesticides and weedicides were used by 49% farmers. A detail of the pesticides and weedicides used by farmers is given in Table 2.8. More than half of the interviewed farmers used poisoned baits containing zinc phosphide for killing of rodent pests in their crops.

2.4.7 Farmers’ views on Crop Field Boundary Vegetation, its Use by Birds and Bird Hunting

Eighty two out of 94 farmers admitted that crop field boundary vegetation is beneficial for their livelihood particularly used for animal feeding and fuel wood. However, only 3% farmers considered its usefulness as the birds’ habitat. Most of them believed that if bird density increased in their croplands they would become potential pests of their grain crops. Wildlife hunting is a popular sport and 43% farmers liked it. Generally, partridges in maize crop, waterfowl at rainwater ponds and quails in wheat crop are hunted in this area. However, since populations of game birds are low in agro ecosystems, therefore, bird hunting is carried out in wilder areas or wherever they are found.

2.5 DISCUSSION

This study was based on interviews of 94 farmers randomly selected around the four study sites located in three districts of Pothwar plateau. The result showed that the agriculture predominantly consists of summer (Kharif) crops of groundnut (Arachis hypogea), millet (Pennisetum typhoides), sorghum (Sorghum biclor), mash (Vigna mungo) and mung beans (Vigna radiata) whereas; the winter (Rabi) crops include wheat (Triticum aestivum), chickpea (Cicer arietinum), barley (Hordeum vulgare) and mustard (Brassica campestris). Maize (Zea mays) is grown during both
the seasons. These results are supported by Hayat (2005) and Majeed.

Table 2.8: List of weedicides and herbicides reportedly used by farmers of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Category</th>
<th>Active Ingredient</th>
<th>Crop being treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromoxynil + mcpa</td>
<td>Herbicide</td>
<td>2-methyl-4 chlorophenoxyacetic acid</td>
<td>Wheat, maize, groundnut</td>
</tr>
<tr>
<td>Pilipri pre-mixtra gold</td>
<td>Herbicide</td>
<td>Fenvalerate</td>
<td>Maize, groundnut</td>
</tr>
<tr>
<td>Furadan*</td>
<td>Insecticide</td>
<td>Carbofuran</td>
<td>Maize</td>
</tr>
<tr>
<td>Sunicidin</td>
<td>Insecticide</td>
<td>Fenvalerate</td>
<td>Wheat, maize, groundnut</td>
</tr>
<tr>
<td>Karate</td>
<td>Insecticide</td>
<td>Lambda-cyhalothrin</td>
<td>Groundnut</td>
</tr>
<tr>
<td>Daconil</td>
<td>Fungicide</td>
<td>Chlorothalonil</td>
<td>Groundnut</td>
</tr>
</tbody>
</table>

*Banned in Canada and the European Union
et al. (2010). Majority of the farmers cultivate wheat on priority, because early spring rains in this arid region are particularly useful to increase wheat yield (Kazmi and Rasul, 2009) and it is staple food of human population. In many areas of Pothwar plateau, mustard is intercropped with wheat which is not only used as human food but also as livestock fodder. Turk and Tawaha (2003) reported that *Brassica* spp. release glucosinolates that inhibit the seed germination of weeds. Quite recently, Awan et al. (2012) worked on efficacy of (*Brassica campestris*) and sunflower (*Helianthus annuus*) to control weeds in wheat crop of Pothwar plateau and found that these crop plants have allelopathic potential for weed management by restraining the growth of many weed species. Although farmers cultivate mustard for their livelihood, this indigenous practice actually saves their main crop from the weeds’ infestation.

Few farmers cultivate legumes (mash and mung beans) but wheat-fallow cropping pattern is dominant. However, many studies have highlighted the importance of wheat-legumes cropping pattern in Pothwar not only in terms of nutrient conservation (Safdar et al., 2002; Hayat and Ali, 2010) but also for substantial increase in overall crop productivity of this area (Manf and Fayyaz, 2006; Arif and Malik, 2009). Groundnut is the second most popular crop of this area (Din et al., 2009; Majeed et al., 2010). Most of the farmers from Chakwal cultivated groundnut. Ali et al. (2002) also reported that southern parts of Pothwar plateau are drier with sandy soil and are suitable for groundnut production.

The results of this study revealed that 80% farmers owned livestock with goat the most commonly reared ungulate followed by cattle. These findings are similar to those of Nosheen et al. (2011). Afzal and Naqvi (2004) found that rate of livestock rearing is high in Pothwar as they provide alternate income source in case of crop
failure. Majority of farmers did not allow livestock grazing on their farmlands because there is plenty of wild vegetation in the associated rangeland landscapes of Pothwar. These results are supported by Ahmad et al. (2006).

Cutting and harvesting and burning of field boundary vegetation is not a common practice in Pothwar plateau. Several studies have highlighted that these practices lead to habitat degradation in agricultural landscapes but in this study it was found that field boundary vegetation use is quite low. One important reason of this is that size of fields is usually small and there are large patches of uncultivated patches in the area. It could be assumed that farmers meet their requirements from these non-crop areas. Shah et al. (2012) found that most of the farmers of Pothwar plateau have less than two hectares of land for cultivation. The local people meet their demands of firewood and timber from the adjacent wild areas.

The use of chemical fertilizers is presumably at moderate level in Pothwar area, with reports of use by 72% farmers. Some international studies (Philip, 2001; Firbank et al., 2008) have depicted that these fertilizers are harmful for ecosystem. However, it has been reported that fertilizers are essential for better crop yield in this region due to low soil fertility and mineral deficiencies (Ahmad et al., 1990; Kazmi and Rasul, 2009).

Except rodent pests of groundnut, the prevalence of pests and diseases was low in the study area. Consequently, few farmers employed chemical methods of pest control. Weeds are a problem but manual weeding is popular practice, presumably for its use in animal fodder, thus a few surface herbicides are used. These findings are similar to those of Hussain et al. (2003) and Shah et al. (2012) who reported that pesticides are used at a low scale in this region due to inextensive agriculture.
The farmers had no idea if the birds inhabiting crop field boundary vegetation were beneficial or harmful to their field crops. Ahmad (1991) investigated through a farm survey that 77% farmers consider rodents as pests instead of birds in Pothwar area. This was also true in this study. Environment education and awareness of local people about biodiversity and wildlife conservation was found be lacking and hunting is a common practice. Although any reliable data on bird hunting in Pothwar plateau are not available, Mahmood et al. (2011) while studying birds” trade at pet shops of the region found that many people capture birds from wild, e.g. house sparrow (Passer domesticus), common myna (Acridotheres tristis), bank myna (Acridotheres ginginianus), baya weaver (Ploceus philippinus), common quail (Coturnix coturnix), ringed dove (Streptopelia decaocto) and partridges (Francolinus spp.) and sell them in the local bird markets to earn their livelihoods.
HABITAT ANALYSIS OF SELECTED CROPLANDS

3.1 INTRODUCTION

Vegetation cover has multiple benefits. It provides nesting and roosting sites to birds, forage to livestock and is indication of landscape health with respect to erosion (Chaudhry et al., 2010). Pakistan holds great floral diversity and harbors around 6000 species of vascular plants including 400 species of endemic plants (Stewart, 1972). Ali (2008) assigned different categories to floral composition of different areas in Pakistan viz: native flora, wild flora, agricultural flora, weeds flora and garden flora. However, sporadic information is available on agricultural flora of Pothwar plateau.

Shinwari and Shinwari (2010) studied the botanical diversity of Pakistan and reported that due to habitat loss and fragmentation some species of plants have already gone extinct while many species are continually declining in the forests, arid and semi-arid rangelands as well as wetlands of the country. They reported tree felling for fuel wood and timber to be the main culprit for deforestation while in semi-arid regions of Pothwar plateau livestock grazing is the major cause of vegetation degradation.

An outlook or framework of a landscape is a crucial factor in determining the types of field edges and field boundary vegetation (Donovan et al., 1997). Avian species richness and density as well as breeding success depends on landscape perspective and is strongly determined by neighboring land features, i.e. forests, agricultural fields and/or presence of water (Riddle and Moorman, 2010).

Vegetation cover along the field margins increases habitat heterogeneity and provides non-intensive habitat to many species (Petersen, 1998). Similarly, presence
of uncultivated wild vegetation along field margins serves as fitnessproducing habitat for avian species conservation (Smith et al., 2005b). Such concept is supported by Riddle et al. (2008) who reported increase in population density of northern bobwhite when natural vegetation at field borders were established in the croplands of USA.

The pernicious effects of agricultural expansion and intensification can be reduced by the use of agri-environment schemes where environment friendly practices at the agricultural fields help in promotion of biodiversity conservation (Concepcion and Diaz, 2010).

Native flora determines the chemical structure of soil while soil quality in turn affects the composition and structure of plant communities as well as productive potential of the land (Klinger, 1996). Therefore, diversity of native flora and soil quality are strongly determined by terrain of the landscape (Solon et al., 2007).

In Pakistan, fast growing exotic plants have been introduced in order to meet the rising demands of timber, fuel wood and fodder. Some examples of such species planted in farmlands are eucalyptus (*Eucalyptus camaldulensis*), hybrid poplar (*Populus deltoids x Populus nigra*) and paulownia (*Paulownia tomentosa*) (Shinwari and Shinwari, 2010). However, the impact of these exotics on native flora has not been yet assessed.

Pothwar plateau has sub-tropical dry scrub vegetation and has rich floral diversity (Nawaz et al., 2010). Trees and shrubs bearing specific characteristic of scrub forest are abundant here (Nawaz et al., 2012). *Acacia modesta, Olea ferruginaea* and *Tecomella undulata* are important tree species while dominant
shrubs of the region include *Dodonaea viscosa*, *Justicia adhatoda*, *Maytenus royleanus* and *Ziziphus nummularia*.

Several grass species are native to Pothwar region including the most abundant species of *Chrysopogon serrulatus*, *Heteropogon contortus*, *Dichanthium foveolatum*, *Cynodon dactylon* and *Aristida mutabilis* (Ahmad et al., 2008a). Individual trees of citrus, loquat and guava can be found near human dwellings or in small patches where soil and water support existence. These trees provide nesting sites for many species of birds (Nizami et al., 2004; Hussain et al., 2009a). The wild (non-crop) vegetation along the field boundaries comprises of *Saccharum munja*, *Cynodon dactylon*, *Eragrostis cynosuroides*, *Sorghum halepense* and *Desmostachya bipinnata* (Hussain et al., 2003).

Species richness and cover of wild vegetation bordering the crop fields is crucial to be recorded because of its potential role in providing food as well as nesting and roosting sites for birds (Bota et al., 2005; Llusia and Onate, 2005). Quine and Humphrey (2010) reported that the number of trees found in the surroundings of croplands was directly correlated with species richness. They studied the non-native trees planted along field boundary for timber procurement in Britain and found that these trees provide novel habitat to local faunal species. Since such information is lacking for Pothwar plateau. Therefore, density and cover of vegetation bordering the selected study sites were required to be studied in order to determine its role in sustaining and propagating associated avifauna.

### 3.2 REVIEW OF LITERATURE

Several studies have shown that some farmland bird species, e.g. buntings (*Emberiza* spp.) are able to get benefit from vegetation in the agro-ecosystems
especially tree plantations since these trees provide foraging and nesting sites to them (Morgado et al., 2010; Batary et al., 2012). Beside this, when native vegetation is removed for agriculture expansion, transpiration of water from soil decreases and as a result water flows through the soil causing rise of ground water table and soil salinity (Tainter, 2000). Beresford et al. (2001) worked in southwestern Australia and reported large tracts of salinized land because of continuous farming for short-term economic benefits. Farming also has an impact on soil quality leading to ultimate changes in associated flora and fauna. Many agricultural landscapes have lost production due to water logging and salinity all over the world (Walker and Meyer, 2004). Higgins et al. (2002) reported that removal of native vegetation for farming leads to abrupt changes in climate variables. As a result, ecosystem could not be restored to its original vegetation type and associated wildlife is also affected.

In agro-ecosystems bearing intensive farming local spatial heterogeneity can be increased by maintaining field borders of natural vegetation which could also benefit many bird species (DiGiacomo and de Casenave, 2010; Goijman, 2014). In North America, field borders of 9.1-36.5 m width have been established along the field margins for wildlife conservation. The vegetation planted along the field borders is primarily herbaceous (grasses/forbs) with some proportion of shrub vegetation (Burger et al., 2006).

Nezerkova and Hejcman (2006) reported that presence of woody vegetation especially trees is determined by soil type and topography in croplands of Senegal.

In lower Silesia, Orlowski and Lawniczak (2009) explored that abandoned fields were avoided by several bird species, i.e. yellow wagtail (Motacilla flava), sky lark
(Alauda arvensis), common quail (Coturnix coturnix) and yellow hammer (Emberiza citrinella). Further research showed that yellow hammer preferred arable land with trees on field boundaries (Scozzafava and DeSanctis, 2006).

Hasnain (1985) reported that grasses and forbs pre-dominate wild vegetation of Pothwar plateau. The important native species include Chrysopogon montanus, Cymbopogon schoenanthus, Heteropogon concortus, Eulaliopsis binnata, Eragrostis poaeoides, Sorghum halepense, Aristida depressa, Cenchrus ciliaris, Eriophorum comosu, Periploca aphylla, Calotropis procera, Salviamoocroftiana, Taraxacum officinalis, Oxalis corniculata and Fumaria indica.

Jabeen and Ahmad (2009) identified 44 species of grasses in Rawalpindi, including 16 abundant species consisting of Cenchrus ciliaris, Cannabis sativa, Euphorbia helioscopia, Dodonaea viscosa, Cynodon dactylon, Ranunculus muricatus, Parthenium hysterophorus, Carissa opaca, Otostegia limbata, Saussurea heteromalla, Broussonetia papyrifer, Rumex chalepensis, Polypogon monspeliensis, Nasturtium officinalis, Asparagus officinalis and Anagallis arvensis.

Shaheen et al. (2014) studied floristic diversity of Rawalpindi comprising of annual herbs (43.36%), shrubs (24.48%) and grasses (13.29%) while trees accounted for 9.79% of the flora. Herbaceous vegetation of Chakwal has been reported to be dominated by Chrysopogon serrulatus and Dodonaea viscosa while tall vegetation of the region is dominated by Acacia modesta and Justicia adhatoda (Nawaz et al., 2012). Ahmad et al. (2004) found that Cenchrus ciliaris is a perennial rhizomatic grass that prefers degraded habitats of Pothwar.
3.3 MATERIALS AND METHODS

Four study sites selected for habitat analysis have been described in Chapter 1 (section 1.12.10) and were evaluated in terms of following variables.

A) Substrate/soil type: Classified as sandy (gritty with large particles), silt (soft with medium sized particles) and/or hard (rocky soil).

B) Cropping pattern: Two major cropping patterns were classified as wheat-maize/millet and wheat-groundnut.

C) Water availability: The presence of water body i.e. small ponds and streams if any was recorded.

D) Area under cultivation (%): The percentage of area under crop cultivation within each study site was estimated.

E) Vegetation analysis: Three transects each of 200 m length were laid down randomly within each sampling site. Six quadrates were selected randomly along each transect. The size of the quadrates was 10 × 10 m for trees, 4 × 4 m for shrubs and 1 × 1 m for grasses/herbs. Density, relative density, frequency, relative frequency and dominance/cover of different plant species were estimated in each quadrate. Vegetation was analyzed by using the Importance Value Index (IVI), calculated by adding Relative density, Relative frequency and Relative cover. Following Shukla and Chandel (2008) and Kothari (2009) they were estimated as follows:

\[
\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrates}}
\]

\[
\text{Relative Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100
\]

\[
\text{Frequency} = \frac{\text{Number of quadrates in which a species occurs}}{\text{Total number of quadrates}}
\]
Relative Frequency = \( \frac{\text{Frequency value of a species}}{\text{Total frequency value of all species}} \) \times 100

Cover = \( \frac{\text{Basal area of individuals of a species}}{\text{Total basal area of all species}} \)

Relative Cover = \( \frac{\text{Total basal area of individual species}}{\text{Total basal area of all species}} \) \times 100

In addition to Importance Value Index (IVI) the Summed Dominance Ratio (SDR) was calculated for all plant species observed. Following Chul and Moody (1983) and Olorunmaiye et al. (2011) it was calculated as follows.

\[
\text{Summed Dominance Ratio (SDR)} = \frac{\text{Importance Value Index (IVI)}}{3}
\]

IVI values were used to calculate the Shannon–Wiener \((H')\) Diversity Index

\[
H' = -\sum p_i \log p_i
\]

Where \(p_i\) is the proportion of total sample belonging to the \(i\)th species.

Euitability or evenness \((J)\) was computed following Pielou (1969) while Index of Dominance \((C_d)\) was calculated according to Simpson (1949).

\[
\text{Euitability (J)} = \frac{H'}{H_{\text{max}}}
\]

and,

\[
C_d = \sum \left(\frac{n_i}{N}\right)^2
\]

Where \(n_i\) is IVI of species and \(N\) is sum of IVI for the community.

\(\beta\) diversity was calculated to measure the rate of species change across the sites as by Whittaker (1975) using the following formula.

\[
\text{Beta Diversity } (\beta) = \frac{S_c}{S}
\]
3.4 STATISTICAL ANALYSIS

The two cropping systems were compared by using 2 sample t-tests based on averages and sums within sites. The resultant 2 degrees of freedom (for t tests) implies relatively low power, so \( P \) values < 0.1 were interpreted. ANOVA was used to compare the difference in vegetation of sampling sites using sampling quadrat as replicate.

3.5 RESULTS

The habitats of all selected study sites were of mixed type harboring crop fields, associated patches of wild vegetation, human settlements as well as access roads and rainwater ponds or small dams.

3.5.1 Habitat Evaluation of Thatti Gujran (Site I)

The site-1 was located in village Thatti Gujran, tehsil Fatehjang, district Attock. The soil of the study site is silt loam type. Wheat with maize/millet was the main cropping system at this site. A large rainwater pond (150 x 70m approx.) was situated in the immediate vicinity of the site (Table 3.1). Eighty percent of the area was under cultivation and there was less human disturbance due to its location away from human dwelling/village.

3.5.1.1 Vegetation

A total of seven tree species were recorded at this site namely *Acacia modesta*, *Acacia nilotica*, *Dalbergia sissoo*, *Eucalyptus camaldulensis*, *Melia azadarach*, *Prosopis juliflora* and *Zizyphus mauritiana*. An equal number of shrubs species observed included *Calotropis procera*, *Cannabis sativa*, *Carissa opaca*, *Dodonaea viscosa*, *Lantana camara*, *Prosopis cineraria* and *Ziziphus nummularia*
The highest Summed Dominance Ratio (SDR) among trees was estimated for *Acacia modesta* followed by *Melia azadarach*, *Dalbergia sissoo*, *Zizyphus mauritiana*, *Acacia nilotica*, and *Prosopis juliflora*.

The highest Summed Dominance Ratio (SDR) among shrubs was calculated for *Dodonaea viscosa* followed by *Cannabis sativa*, while the lowest was recorded for *Lantana camara* (Fig. 3.1). Ten species of herbaceous vegetation were recorded namely *Abutilon indicum*, *Alhaji maurorum*, *Amaranthus hybridus*, *Anagalis arvensis*, *Aerva javanica*, *Cenchrus ciliaris*, *Cynodon dactylon*, *Cyperus rotundus*, *Erogrestis poroles* and *Saccharum bengalense* (Table 3.2). The highest SDR value among grasses/herbs was estimated for *Cenchrus ciliaris* and minimum for *Abutilon indicum* (Fig. 3.1).

### 3.5.2 Habitat Evaluation of Koont (Site II)

Cropping system of study site-II namely Koont, Gujjar Khan district Rawalpindi, was consisting on wheat-groundnut combination and soil of the area was hard clay (Table 3.1). No water source in shape of rain water pond, small dam or rain water stream was available on the site or in nearby areas therefore the area was completely rain-fed. There was high human activity since this area was near a village and 75% of the area of selected site was being cultivated.
Table 3.1: Description of four study sites selected in agricultural landscape of Pothwar Plateau, Pakistan.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Name and Location</th>
<th>Cropping system</th>
<th>Substrate type</th>
<th>Water resource available?</th>
<th>Area under cultivation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Thatti Gujran (Fatehjang, Attock)</td>
<td>Wheat-millet/maize</td>
<td>Silt loam</td>
<td>Rain water pond present</td>
<td>80</td>
</tr>
<tr>
<td>II</td>
<td>Koont (Gujjar Khan, Rawalpindi)</td>
<td>Wheat-groundnut</td>
<td>Hard soil</td>
<td>Absent</td>
<td>75</td>
</tr>
<tr>
<td>III</td>
<td>Shah Syed Billu (Choa Saden Shah, Chakwal)</td>
<td>Wheat-groundnut</td>
<td>Hard soil</td>
<td>Absent</td>
<td>60</td>
</tr>
<tr>
<td>IV</td>
<td>Prem Nagar Faqiran (Balkassar, Chakwal)</td>
<td>Wheat-millet/maize</td>
<td>Silt loam</td>
<td>Rain water pond present</td>
<td>75</td>
</tr>
</tbody>
</table>
Table 3.2: Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site I (Thatti Gujran) in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Density/ha</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia modesta</td>
<td>2.91</td>
<td>34.48</td>
<td>27.88</td>
<td>17.29</td>
<td>79.65</td>
</tr>
<tr>
<td>Melia azadarach</td>
<td>1.89</td>
<td>22.39</td>
<td>27.93</td>
<td>17.29</td>
<td>67.61</td>
</tr>
<tr>
<td>Dalbergia sissoo</td>
<td>0.99</td>
<td>11.73</td>
<td>19.92</td>
<td>23.46</td>
<td>55.11</td>
</tr>
<tr>
<td>Zizyphus mauritiana</td>
<td>0.97</td>
<td>11.49</td>
<td>9.37</td>
<td>24.42</td>
<td>45.28</td>
</tr>
<tr>
<td>Acacia nilotica</td>
<td>1.02</td>
<td>12.08</td>
<td>5.61</td>
<td>5.98</td>
<td>23.67</td>
</tr>
<tr>
<td>Prosopis juliflora</td>
<td>0.33</td>
<td>3.91</td>
<td>5.31</td>
<td>4.79</td>
<td>14.01</td>
</tr>
<tr>
<td>Eucalyptus camaldulensis</td>
<td>0.33</td>
<td>3.91</td>
<td>3.98</td>
<td>5.45</td>
<td>13.34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shrubs species</th>
<th>Density/4m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodonaea viscosa</td>
<td>1.55</td>
<td>30.57</td>
<td>32.27</td>
<td>22.04</td>
<td>84.88</td>
</tr>
<tr>
<td>Cannabis sativa</td>
<td>0.91</td>
<td>17.95</td>
<td>25.14</td>
<td>31.4</td>
<td>74.49</td>
</tr>
<tr>
<td>Ziziphus nummularia</td>
<td>0.67</td>
<td>13.21</td>
<td>12.43</td>
<td>43.21</td>
<td>68.85</td>
</tr>
<tr>
<td>Carissa opaca</td>
<td>0.66</td>
<td>13.02</td>
<td>18.98</td>
<td>8.34</td>
<td>40.34</td>
</tr>
<tr>
<td>Prosopis cineraria</td>
<td>0.79</td>
<td>15.58</td>
<td>4.67</td>
<td>11.75</td>
<td>32</td>
</tr>
<tr>
<td>Calotropis procera</td>
<td>0.3</td>
<td>5.92</td>
<td>3.77</td>
<td>3.29</td>
<td>12.98</td>
</tr>
<tr>
<td>Lantana camara</td>
<td>0.19</td>
<td>3.75</td>
<td>2.74</td>
<td>5.31</td>
<td>11.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herb/Grass species</th>
<th>Density/1m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenchrus ciliaris</td>
<td>2.2</td>
<td>33.74</td>
<td>22.27</td>
<td>24.43</td>
<td>80.44</td>
</tr>
<tr>
<td>Eragrostis poroles</td>
<td>0.99</td>
<td>15.18</td>
<td>9.89</td>
<td>22.75</td>
<td>47.82</td>
</tr>
<tr>
<td>Saccharum bengalense</td>
<td>0.99</td>
<td>15.18</td>
<td>10.67</td>
<td>20.75</td>
<td>46.6</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>0.14</td>
<td>2.15</td>
<td>13.61</td>
<td>29.94</td>
<td>45.7</td>
</tr>
<tr>
<td>Cyperus rotundus</td>
<td>0.8</td>
<td>12.27</td>
<td>5.14</td>
<td>14</td>
<td>31.41</td>
</tr>
<tr>
<td>Amaranthus hybridus</td>
<td>0.7</td>
<td>10.74</td>
<td>6.34</td>
<td>14</td>
<td>31.08</td>
</tr>
<tr>
<td>Aerva javanica</td>
<td>0.15</td>
<td>2.3</td>
<td>8.35</td>
<td>18.25</td>
<td>28.9</td>
</tr>
<tr>
<td>Alhagi maurorum</td>
<td>0.2</td>
<td>3.07</td>
<td>7.14</td>
<td>13.76</td>
<td>23.97</td>
</tr>
<tr>
<td>Anagalis arvensis</td>
<td>0.2</td>
<td>3.07</td>
<td>11.89</td>
<td>5.55</td>
<td>20.51</td>
</tr>
<tr>
<td>Abutilon indicum</td>
<td>0.15</td>
<td>2.3</td>
<td>4.7</td>
<td>5.15</td>
<td>12.15</td>
</tr>
</tbody>
</table>
Fig. 3.1: Summed Dominance Ratio (SDR) of the plant species observed at study Site I (Thatti Gujran) in agro-ecosystem of Pothwar plateau, Pakistan.
3.5.2.1 Vegetation

The vegetation composition of Koont is shown in Table 3.3 while Summed Dominance Ratios (SDRs) are presented in Fig. 3.2. Six species of trees comprised the tree flora, occupying field boundaries of the site. The species were *Acacia modesta*, *Acacia nilotica*, *Eucalyptus camaldulensis*, *Ficus carica*, *Tamarix aphylla* and *Zizyphus mauritiana*.

The highest Summed Dominance Ratio (SDR) at site II was estimated for *Acacia modesta* and lowest for *Tamarix aphylla*. The shrub diversity was also low at this site and only four species recorded were; *Calotropis procera*, *Capparis aphylla*, *Grewia optiva* and *Ziziphus jujube*. The highest SDR was of *Calotropis procera*, followed by *Ziziphus jujube*, *Capparis aphylla* and *Grewia optiva*.

The herbaceous flora of this site was comprised of ten species viz: *Aerva javanica*, *Chenopodium album*, *Cynodon dactylon*, *Datura stramonium*, *Setaria pumila*, *Heteropogon contortus*, *Parthenium hysterophorus*, *Saccharum bengalense*, *Tribulus terrestris* and *Withania somnifera*. Maximum SDR was calculated for *Setaria pumila* and minimum for *Withania somnifera*.

3.5.3 Habitat Evaluation of Shah Syed Billu (Site III)

Similar to site-II the substrate of this site was made of hard clay without any water access point. The site is located in area of village Shah Syed Billu, tehsil Choa Saden Shah of district Chakwal. Sixty percent of the area was under cultivation dominated by wheat-groundnut cropping system. There was high human disturbance due to human habitation in the area (Table 3.1).
Table 3.3: Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site II (Koont) in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Density/ha</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia modesta</td>
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<td>39.08</td>
<td>36.84</td>
<td>50</td>
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<tr>
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<td>24.44</td>
<td>18.44</td>
<td>21.11</td>
<td>63.99</td>
</tr>
<tr>
<td>Zizyphus mauritiana</td>
<td>1.7</td>
<td>22.22</td>
<td>24.98</td>
<td>3.21</td>
<td>50.41</td>
</tr>
<tr>
<td>Ficus carica</td>
<td>0.33</td>
<td>4.31</td>
<td>7.09</td>
<td>6.66</td>
<td>18.06</td>
</tr>
<tr>
<td>Eucalyptus camaldulensis</td>
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<td>5.09</td>
<td>6.35</td>
<td>4.93</td>
<td>16.37</td>
</tr>
<tr>
<td>Tamarix aphylla</td>
<td>0.37</td>
<td>4.84</td>
<td>5.53</td>
<td>1.21</td>
<td>11.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shrubs species</th>
<th>Density/4m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calotropis procera</td>
<td>0.72</td>
<td>22.22</td>
<td>18.46</td>
<td>45</td>
<td>85.68</td>
</tr>
<tr>
<td>Ziziphus jujube</td>
<td>1.19</td>
<td>36.73</td>
<td>37.77</td>
<td>8.3</td>
<td>82.8</td>
</tr>
<tr>
<td>Capparis aphylla</td>
<td>1</td>
<td>30.86</td>
<td>35.38</td>
<td>5.29</td>
<td>71.53</td>
</tr>
<tr>
<td>Grewia optiva</td>
<td>0.33</td>
<td>10.19</td>
<td>8.39</td>
<td>42</td>
<td>60.58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herb/Grass species</th>
<th>Density/1m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setaria pumila</td>
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<td>33.16</td>
<td>21.25</td>
<td>3.77</td>
<td>58.18</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
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<td>29.18</td>
<td>20.89</td>
<td>7.13</td>
<td>57.2</td>
</tr>
<tr>
<td>Saccharum bengalense</td>
<td>1.5</td>
<td>19.89</td>
<td>16.12</td>
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<td>49.99</td>
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<td>Parthenium hysterophorus</td>
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<td>5.97</td>
<td>10.3</td>
<td>20.25</td>
</tr>
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<td>Heteropogon concortus</td>
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<td>3.98</td>
<td>5.85</td>
<td>5.15</td>
<td>14.98</td>
</tr>
<tr>
<td>Tribulus terrestris</td>
<td>0.12</td>
<td>1.59</td>
<td>7.24</td>
<td>5.7</td>
<td>14.53</td>
</tr>
<tr>
<td>Chenopodium album</td>
<td>0.12</td>
<td>1.59</td>
<td>7.24</td>
<td>5.7</td>
<td>14.53</td>
</tr>
<tr>
<td>Aerva javanica</td>
<td>0.2</td>
<td>2.65</td>
<td>7.96</td>
<td>7.5</td>
<td>18.11</td>
</tr>
<tr>
<td>Datura stramonium</td>
<td>0.2</td>
<td>2.65</td>
<td>3.82</td>
<td>2.3</td>
<td>8.77</td>
</tr>
<tr>
<td>Withania somnifera</td>
<td>0.1</td>
<td>1.33</td>
<td>3.65</td>
<td>3</td>
<td>7.98</td>
</tr>
</tbody>
</table>
Fig. 3.2: Summed Dominance Ratio (SDR) of the plant species observed at study Site II (Koont) in agro-ecosystem of Pothwar.
plateau, Pakistan.
3.5.3.1 Vegetation

A total of seven tree species were recorded at this site, namely *Acacia modesta*, *Acacia nilotica*, *Capparis decidua*, *Dalbergia sissoo*, *Olea ferruginea*, *Tamarix aphylla* and *Zizyphus mauritiana*. Second layer of vegetation was represented by five species of shrubs comprising of *Adhatoda vasica*, *Dodonaea viscosa*, *Gymnosporia royleana*, *Justicia adhatoda* and *Ziziphus nummularia* (Table 3.4).

The herbaceous flora was consisting of eight species; *Astragalus spinosus*, *Aerva javanica*, *Cannabis sativa*, *Carthamus oxycantha*, *Chenopodium album*, *Datura stramonium*, *Fumaria indica* and *Tribulus terrestris*. The highest Summed Dominance Ratio (SDR) for trees, shrubs and grasses/herbs were calculated for *Acacia nilotica*, *Dodonaea viscosa* and *Datura stramonium* respectively and the minimum value of SDR was calculated for *Capparis deciduas* (tree), *Ziziphus nummularia* (shrub) and *Cannabis sativa* (grass) (Fig. 3.3).

3.5.4 Habitat Evaluation of Prem Nagar Faqiran (Site IV)

The study site IV was located in village Prem Nagar Faqiran, Balkassar, district Chakwal. The soil substrate of the area was silt loam with a rain-water pond (120 x 80m approx.) with water available all around the year as water access point. Seventy five percent of the area was being cultivated under wheat-maize/millet cropping system and there was moderate human disturbance in the area due to traffic (Table 3.1).
3.5.4.1 Vegetation

The tree flora of this site was comprised of *Acacia modesta*, *Morus alba*,

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Density/ha</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia nilotica</td>
<td>3.47</td>
<td>28.26</td>
<td>34.25</td>
<td>44.91</td>
<td>107.42</td>
</tr>
<tr>
<td>Zizyphus mauritiana</td>
<td>1.67</td>
<td>13.59</td>
<td>22.69</td>
<td>24.38</td>
<td>60.66</td>
</tr>
<tr>
<td>Acacia modesta</td>
<td>1.82</td>
<td>14.82</td>
<td>25.76</td>
<td>12.96</td>
<td>53.54</td>
</tr>
<tr>
<td>Olea ferruginea</td>
<td>3.96</td>
<td>32.25</td>
<td>6.47</td>
<td>7.21</td>
<td>45.93</td>
</tr>
<tr>
<td>Dalbergia sissoo</td>
<td>0.76</td>
<td>6.19</td>
<td>5.9</td>
<td>9.65</td>
<td>21.74</td>
</tr>
<tr>
<td>Tamarix aphylla</td>
<td>0.31</td>
<td>2.52</td>
<td>2.71</td>
<td>8.94</td>
<td>14.17</td>
</tr>
<tr>
<td>Capparis decidua</td>
<td>0.29</td>
<td>2.36</td>
<td>2.22</td>
<td>2.02</td>
<td>6.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shrubs species</th>
<th>Density/4m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodonaea viscosa</td>
<td>1.83</td>
<td>43.26</td>
<td>25.57</td>
<td>6.9</td>
<td>75.73</td>
</tr>
<tr>
<td>Justicia adhatoda</td>
<td>1</td>
<td>23.64</td>
<td>25.92</td>
<td>15.62</td>
<td>65.18</td>
</tr>
<tr>
<td>Adhatoda vasica</td>
<td>0.65</td>
<td>15.37</td>
<td>17.05</td>
<td>26</td>
<td>58.42</td>
</tr>
<tr>
<td>Gymnosporia royleana</td>
<td>0.5</td>
<td>11.82</td>
<td>21.31</td>
<td>5.2</td>
<td>38.33</td>
</tr>
<tr>
<td>Ziziphus nummularia</td>
<td>0.25</td>
<td>5.91</td>
<td>10.14</td>
<td>12.5</td>
<td>28.55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Herb/Grass species</th>
<th>Density/1m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datura stramonium</td>
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<td>21.95</td>
<td>18.13</td>
<td>79.99</td>
<td>120.07</td>
</tr>
<tr>
<td>Fumaria indica</td>
<td>2.1</td>
<td>20.04</td>
<td>16.29</td>
<td>66.67</td>
<td>103</td>
</tr>
<tr>
<td>Avera javanica</td>
<td>2.5</td>
<td>23.85</td>
<td>19.38</td>
<td>23.65</td>
<td>66.88</td>
</tr>
<tr>
<td>Carthamus oxycantha</td>
<td>0.72</td>
<td>6.87</td>
<td>10.86</td>
<td>27.75</td>
<td>45.48</td>
</tr>
<tr>
<td>Tribulus terrestris</td>
<td>1.5</td>
<td>14.31</td>
<td>13.63</td>
<td>17.11</td>
<td>45.05</td>
</tr>
<tr>
<td>Astragalus spinosus</td>
<td>0.66</td>
<td>6.29</td>
<td>10.86</td>
<td>16.25</td>
<td>33.4</td>
</tr>
<tr>
<td>Plant</td>
<td>Value1</td>
<td>Value2</td>
<td>Value3</td>
<td>Value4</td>
<td>Value5</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Chenopodium album</td>
<td>0.5</td>
<td>4.77</td>
<td>7.24</td>
<td>5.7</td>
<td>17.71</td>
</tr>
<tr>
<td>Cannabis sativa</td>
<td>0.2</td>
<td>1.91</td>
<td>3.62</td>
<td>3.89</td>
<td>9.42</td>
</tr>
</tbody>
</table>
Fig. 3.3: Summed Dominance Ratio (SDR) of the plant species observed at study Site III (Shah Syed Billu) in agro-ecosystem of Pothwar
plateau, Pakistan.
Capparis deciduas, Eucalyptus camaldulensis, Melia azadarach, and Zizyphus mauritiana while the six shrub species recorded included Calotropis procera, Cannabis sativa, Justicia adhatoda, Lantana camara, Saccharum griffithii and Ziziphus nummularia.A total of nine species of grasses/herbs were found at site IV namely Abutilon indicum, Amaranthus virdics, Carthamus oxyantha, Cyperus rotundus, Erogrestis poroles, Helioscopia europa, Sonchus asper, Typha latifolia and Xanthium strumarium (Table 3.5).

Fig. 3.4 shows that the highest Summed Dominance Ratio (SDR) among trees was calculated for Zizyphus mauritiana while the lowest for Morus alba. Among shrubs Justicia adhatoda was dominant with maximum SDR and least value was estimated for Lantana camara. Among grasses/herbs Carthamus oxyantha had the highest SDR value while Helioscopia europa at the bottom.

### 3.5.5 Vegetation Comparison of Four Study Sites

The sampling quadrate was used as the replicate to see if there was any difference in vegetation based on the study (Table 3.6). In total, 12 tree species were recorded. Acacia modesta and Zizyphus mauritiana were present in all the study sites. Tree density did not differ significantly across the four sites (F\(_{3, 68}\) = 1.12, \(P = 0.35\), P > 0.05).

The analysis of diversity status showed that \(\alpha\) diversity (species richness) ranged from four species of shrubs at Site II to ten species of herbs at Site I (Table 3.7). Highest \(\beta\) diversity value (\(\beta = 0.31\)) was found for trees at Site I and lowest for herbs at Site III (\(\beta = 0.05\)). The herb species had higher diversity index at all the sites.
followed by trees and shrubs. Similarly dominant species accounted 5-8% of Table 3.5: Density, relative density (RD), relative frequency (RF), relative cover (RC) and Importance Value Index (IVI) of different floral species recorded at study site IV (Prem Nagar Faqiran) in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Density/ha</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Zizyphus mauritiana</em></td>
<td>2.89</td>
<td>42</td>
<td>42.04</td>
<td>34.72</td>
<td>118.76</td>
</tr>
<tr>
<td><em>Acacia modesta</em></td>
<td>1.88</td>
<td>27.33</td>
<td>24.44</td>
<td>17.22</td>
<td>68.99</td>
</tr>
<tr>
<td><em>Melia azadarach</em></td>
<td>0.96</td>
<td>13.95</td>
<td>8.9</td>
<td>7.45</td>
<td>29.94</td>
</tr>
<tr>
<td><em>Eucalyptus camaldulensis</em></td>
<td>0.43</td>
<td>6.25</td>
<td>8.9</td>
<td>5.39</td>
<td>20.54</td>
</tr>
<tr>
<td><em>Capparis deciduas</em></td>
<td>0.43</td>
<td>6.25</td>
<td>7.93</td>
<td>3.2</td>
<td>17.38</td>
</tr>
<tr>
<td><em>Morus alba</em></td>
<td>0.29</td>
<td>4.22</td>
<td>7.78</td>
<td>3.99</td>
<td>15.99</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Shrubs species</th>
<th>Density/4m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Justicia adhatoda</em></td>
<td>0.71</td>
<td>17.93</td>
<td>6.58</td>
<td>75</td>
<td>99.51</td>
</tr>
<tr>
<td><em>Cannabis sativa</em></td>
<td>1.25</td>
<td>31.57</td>
<td>33.27</td>
<td>19.73</td>
<td>84.57</td>
</tr>
<tr>
<td><em>Saccharum griffithii</em></td>
<td>0.66</td>
<td>16.67</td>
<td>28.83</td>
<td>12.5</td>
<td>58</td>
</tr>
<tr>
<td><em>Calotropis procera</em></td>
<td>0.44</td>
<td>11.11</td>
<td>12.33</td>
<td>31.4</td>
<td>54.84</td>
</tr>
<tr>
<td><em>Ziziphus nummularia</em></td>
<td>0.65</td>
<td>16.41</td>
<td>14.77</td>
<td>20.6</td>
<td>51.78</td>
</tr>
<tr>
<td><em>Lantana camara</em></td>
<td>0.25</td>
<td>6.31</td>
<td>4.21</td>
<td>8.34</td>
<td>18.86</td>
</tr>
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<table>
<thead>
<tr>
<th>Herb/Grass species</th>
<th>Density/1m²</th>
<th>RD</th>
<th>RF</th>
<th>RC</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Carthamus oxycantha</em></td>
<td>1.5</td>
<td>17.75</td>
<td>21.29</td>
<td>50</td>
<td>89.04</td>
</tr>
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<td>21.31</td>
<td>20.06</td>
<td>47.21</td>
<td>88.58</td>
</tr>
<tr>
<td><em>Typha latifolia</em></td>
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<td>23.67</td>
<td>12.26</td>
<td>38.93</td>
<td>74.86</td>
</tr>
<tr>
<td><em>Amaranthus virdics</em></td>
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<td>18.93</td>
<td>8.95</td>
<td>37.71</td>
<td>65.59</td>
</tr>
<tr>
<td><em>Sonchus asper</em></td>
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<td>5.92</td>
<td>13.62</td>
<td>33.33</td>
<td>52.87</td>
</tr>
<tr>
<td><em>Cyperus rotundus</em></td>
<td>0.5</td>
<td>5.92</td>
<td>3.88</td>
<td>30.33</td>
<td>40.13</td>
</tr>
<tr>
<td><em>Xanthium strumarium</em></td>
<td>0.2</td>
<td>2.37</td>
<td>6.62</td>
<td>20.75</td>
<td>29.74</td>
</tr>
<tr>
<td><em>Abutilon indicum</em></td>
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<td>2.37</td>
<td>9.25</td>
<td>7.6</td>
<td>19.22</td>
</tr>
<tr>
<td><em>Helioscopia europaea</em></td>
<td>0.15</td>
<td>1.77</td>
<td>4.06</td>
<td>8.25</td>
<td>14.08</td>
</tr>
</tbody>
</table>
Fig. 3.4: Summed Dominance Ratio (SDR) of the plant species observed at study Site IV (Prem Nagar Faqiran) in agro-ecosystem of Pothwar plateau, Pakistan.
**Table 3.6**: Mean density (± SD) of trees, shrubs and grasses/herbs at 4 study sites in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Trees (D/ha)</th>
<th>Shrubs (D/4m²)</th>
<th>Herbs (D/1m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site I</td>
<td>1.21 ± 0.35ᵃ</td>
<td>0.71 ± 0.17ᵇ</td>
<td>0.65 ± 0.21ᶜ</td>
</tr>
<tr>
<td>Site II</td>
<td>1.28 ± 0.45ᵃ</td>
<td>0.81 ± 0.19ᵇ</td>
<td>0.75 ± 0.29ᵈ</td>
</tr>
<tr>
<td>Site III</td>
<td>1.75 ± 0.55ᵃ</td>
<td>0.85 ± 0.27ᵇ</td>
<td>1.31 ± 0.32ᶜ</td>
</tr>
<tr>
<td>Site IV</td>
<td>1.15 ± 0.42ᵃ</td>
<td>0.66 ± 0.14ᵇ</td>
<td>0.94 ± 0.26ᶜ</td>
</tr>
</tbody>
</table>

ANOVA* F<sub>3,68</sub> = 1.12, P=0.35  F<sub>3,68</sub> = 0.78, P=0.51  F<sub>3,68</sub> = 2.90, P=0.04

*ANOVAs were calculated using quadrate as replicate.
Mean values denoted by common letter were not significantly different from each other.

**Table 3.7**: Diversity indices of trees, shrubs and grasses/herbs observed at 4 study sites in agro-ecosystem of Pothwar plateau, Pakistan.
<table>
<thead>
<tr>
<th>Indices</th>
<th>Study Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Site I</td>
</tr>
<tr>
<td>Shannon (H')</td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>1.77</td>
</tr>
<tr>
<td>Shrubs</td>
<td>1.75</td>
</tr>
<tr>
<td>Herbs</td>
<td>2.19</td>
</tr>
<tr>
<td>Dominance (C_d)</td>
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</tr>
<tr>
<td>Trees</td>
<td>5.27</td>
</tr>
<tr>
<td>Shrubs</td>
<td>5.18</td>
</tr>
<tr>
<td>Herbs</td>
<td>8.02</td>
</tr>
<tr>
<td>Evenness (J)</td>
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<tr>
<td>Trees</td>
<td>0.91</td>
</tr>
<tr>
<td>Shrubs</td>
<td>0.90</td>
</tr>
<tr>
<td>Herbs</td>
<td>0.95</td>
</tr>
<tr>
<td>Richness (α)</td>
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<tr>
<td>Trees</td>
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</tr>
<tr>
<td>Shrubs</td>
<td>7</td>
</tr>
<tr>
<td>Herbs</td>
<td>10</td>
</tr>
<tr>
<td>Diversity (β)</td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>0.38</td>
</tr>
<tr>
<td>Shrubs</td>
<td>0.09</td>
</tr>
<tr>
<td>Herbs</td>
<td>0.15</td>
</tr>
</tbody>
</table>

the total herb species and 3-5% each of shrub and tree species. Highest dominance was recorded for herbs at site I (C_d = 8.02) and lowest for trees at Site II (C_d =
The concentration of dominance increased with the increase in evenness (J). Maximum evenness was recorded for shrubs at Site II ($C_d = 0.99$) while minimum was recorded for trees at Site II ($C_d = 0.82$).

Vegetation stratum categorized as shrubs at all the four study sites was represented by 14 species. The shrub densities did not differ significantly among study sites, when quadrat is the replicate ($F_{3, 68} = 0.78, P = 0.51, P > 0.05$).

Relatively drier sites represented by wheat-groundnut cropping system and devoid of any water source had higher ($t_2 = 4.39, P = 0.048, P < 0.05$) populations/diversity/species of shrubs as compared to the sites bearing wheatmaize/millet cropping system and having water resources (comparing mean values for these two sites to the mean values for the other two sites).

Twenty five species of grasses/herbs were recorded across the study sites. Density of these species significantly differed across the study sites ($F_{3, 68} = 2.90, P = 0.04$) and grasses/herbs present at site II were different from other sites but there was no clear association of herb/grass density with cropping practice ($t_2 = 0.71, P = 0.55$). Instead the sites in district Chakwal had fewer grasses/herbs than the other districts. In summary there appear to be more shrubs in the drier sites than the wetter ones that could be due to rain fall and soil type of the latter locations, but the difference is marginal.

### 3.6 DISCUSSION

Agricultural habitats are a mosaic of cropped and non-cropped areas. Their field margins play an important role in the biodiversity of farmland, affecting and being affected by adjacent cropland (Marshall and Moonen, 2002). Generally, the crop field vegetation in agricultural landscape is not characterized by any specific
plant but is presented by a range of vegetation communities. These communities can include segetal or ruderal plants, typical of arable land or disturbed ground. In addition, grassland communities, tall herb communities, shrub and woodland communities may be present (Marshall and Moonen, 1998).

Field borders provide habitat for many organisms that would otherwise not be found in agricultural areas, including various plants (Marshall, 1988; Jobin et al., 1997), mammals (Eldridge, 1972; Yahner, 1983) and birds (Sparks et al., 1996; Fuller, 2000). The flora of field edges can have both direct and indirect effects on adjacent agriculture. Direct effects are mediated through weed spread into the crop and by microclimatological and competition effects. Crop yields are typically less at the field edge than in the middle (Sparkes et al., 1998). The structure of field boundary also affects the distribution of pest and beneficial insects living on it (Lewis, 1969). However, the boundary may protect the adjacent crops, acting as a wind break or snow barrier (Helps, 1994). The increasing scale of agricultural activity over the past several decades has resulted in destruction of strips of vegetation bordering crop fields, variously termed „fence rows“, „shelter belts“ or „hedgerows“ (Medley et al., 1995). This loss is of concern because of the ecological benefits commonly attributed to field borders, including soil erosion control, conservation of biodiversity and pest control.

This study recorded 51 species of plants associated with crop field boundary vegetation in two different cropping systems of Pothwar plateau which shows that the plateau has flora good for birds and biodiversity. It was found that grasses and forbs pre-dominante the area. These results are in concordance with other studies conducted on wild flora in different areas of Pothwar plateau (Hasnain, 1985; Jabeen and Ahmad, 2009).
Two tree species namely *Acacia modesta* and *Zizyphus mauritiana* were common at all study sites indicating their widespread presence in the area. These results are supported by findings of Ahmed (2002) and Sher *et al.* (2012) in different valleys of this region. Hussain (2003) found that *Olea ferruginea* is also a very important dominant species of Pothwar region; however, this was not true for agro-ecosystem of Pothwar. *Acacia nilotica* and *Tamarix aphylla* were common trees at sites II and III that were generally dry. These results are in agreement with other authors, e.g. Bargali and Bargali (2009) reported that *Acacia nilotica* is widespread across the arid and semi-arid regions of the world while Joseph and Tomaso (1998) and Tellman (2002) reported that colonization of *Tamarix aphylla* is closely associated with farming.

Same was true for *Calotropis procera* and *Ziziphus nummularia* as these shrubs were found at three out of four sites. Nawaz *et al.* (2012) also found them to be the abundant species of the area. Bastin *et al.* (2003) found that *Calotropis procera* is toxic and thus unpalatable to livestock but it is symptomatic of general habitat disturbance. However, *Ziziphus nummularia* is excellent fodder for livestock and is commonly found along farmlands of the world (Hocking, 1993; Orwa *et al.*, 2009). *Cannabis sativa* and *Lantana camara* was found at sites I and IV. These species are common invasive species in agricultural landscapes and ruderal habitats (Cooper, 2009; Berry *et al.*, 2011). The presence of *Justicia adhatoda* and *Dodonaea viscosa* confirms that livestock grazing is common in agro ecosystems of this area since these are the indicator species of grazing (Ahmad *et al.*, 2008b).

Among grasses *Abutilon indicum*, *Amaranthus* spp., *Cyperus rotundus* and *Eragrostis poroles* were common at sites I and IV. *Amaranthus* spp., *Cyperus rotundus* and *Eragrostis poroles* favor the soil with moderate to high moisture and
are common in cultivated areas, disturbed landscapes and gardens (Parsons and Cuthbertson, 2001). *Amaranthushybridus* commonly called chalwera is a weed of wheat and cornfields throughout Punjab and Kyber Pakhtunkhwa (Marwat *et al.*, 2010). Selvam *et al.* (2012) reported that *Abutilon indicum* is present in both dry and wet soils and hilly areas but in this study this species was found only in sites with nearby water access points. *Chenopodium album, Datura stramonium* and *Tribulus terrestris* were common at sites II and III. Hussain *et al.* (2009b) and Nawaz *et al.* (2012) reported that these species favor dry climate and slightly acidic soils which was true in this study.

This study could not employ aerial photographs representing the physical characteristics of non-cropped vegetation due to cost and logistic constraints but future studies showing physical characteristics of field boundary vegetation, i.e. the length/width and/or shape of wild vegetation/hedgerows growing on field borders are highly desirable.

*Chapter 4*

**PASSELINE DENSITY AND DIVERSITY IN CROPLANDS OF POTHWAR PLATEAU**

**4.1 INTRODUCTION**

Human interventions have brought profound impact on majority of ecosystems leading to their transformation at varying degrees (Walker and Meyer, 2004). The agriculture intensification, being a major such factor has either completely modified the diversity of wild habitats into homogenously cultivated
crops or partially reduced their wilderness. In case of partial modification, these wild areas are interspersed with cultivations which provide food and nesting habitat to many farmland birds (Evans and Green, 2007; Vickery *et al.*, 2009). Intensive agricultural land use especially mono-culturing of food crops lead to decrease in species richness and density. Currently, advance farming practices are adopted to increase the net primary productivity of the croplands in order to sustain the ever increasing demands of food for growing human population but they ultimately lead to decreased carrying capacity of the agro ecosystems (Bhavna and Geeta, 2011).

Unlike irrigated croplands of Indus basin in Pakistan, the Pothwar plateau of Pakistan with rugged and uneven landscape is a rainfed or barani agricultural tract where intensive agriculture is not practiced due to water scarcity. The wild habitats have been partially modified in this area for crop cultivation with wheat (*Triticum aestivum*) being cultivated at priority (Majeed *et al.*, 2010). There are patches of wild vegetation within the agricultural landscape as well as terraces of thick field boundaries in order to conserve surface run-off of rain water which is a precious commodity in this arid region.

The structure of bird communities in agricultural landscapes is greatly affected by the use of resources from patches of uncultivated wild vegetation in the croplands (Robson and Percival, 2002). These patches provide fuel wood and timber as well as fodder for livestock. The diversity of local avian assemblages in croplands is governed by the interplay of landscape framework and habitat structure as well as habitat suitability (Wretenberg *et al.*, 2010). In Pothwar plateau, indigenous communities utilize the wild vegetation of croplands for livestock grazing, fuel wood
and timber as well as fodder (Ahmad et al., 1997). The removal of medicinal plants is also a common practice in this area (Nawaz et al., 2012; Shah et al., 2012).

Many bird species e.g. larks, sparrows, linnets and starlings are enforced to adapt and utilize agricultural landscapes and associated crop field boundary vegetation since their pristine habitats have been reduced and fragmented due to agriculture intensification. Pernicious effects of agricultural intensification have reduced diversity and populations of many species of farmland birds. Unfortunately such agriculture intensification is continuing to present day and have high chances in future as well, thus further degradation of the habitat is on rise. As a result, these species use croplands and field borders for their breeding and wintering (Peterjohn, 2003; Askins et al., 2007). This has been well studied in the farmlands of USA (Jones et al., 2005), Europe (Donald et al., 2006), Spain (Concepcion and Diaz, 2010) and India (Bhavna and Geeta, 2011). In Pakistan such studies have not been conducted due to lack of baseline data on farmland biodiversity and scarcity of funds and expertise.

When rainfall has an erratic pattern, time and amount of rainfall in rain-fed agro-ecosystems leads to shifts in the timing and type of crops being cultivated. In rain-fed agro-ecosystems bird habitat and food availability as well as breeding is significantly affected by rainfall that varies on seasonal and yearly basis (Kale et al., 2013).

Different agro-ecosystems affect biodiversity variably. In coffee based agro-ecosystems of Latin America the agricultural intensification has decreased the density and diversity of two faunal taxa i.e. ants and birds (Philpott et al., 2008). The study has suggested to address the conflict between biodiversity conservation and intensive farming. Similarly, research in North America has shown association of
several Passeriformes, i.e. dickcissel (*Spiza americana*), eastern meadowlark (*Sturnella magna*) and northern bobwhite (*Colinus virginianus*) with farmlands with continuous decline in their populations (Burger *et al*., 2006; Sauer *et al*., 2008). In Pothwar plateau of Pakistan, abundance of different taxa in farmlands with extensive farming practices has not yet been evaluated.

Crop field boundary vegetation is another factor considered positively contributing towards conservation of faunal diversity (Dimmik *et al*., 2002). It has been found that bird densities increase significantly if vegetation along field borders is maintained within agricultural landscapes. Smith *et al*. (2005a) observed increased density of over-wintering sparrows in the managed field borders in Mississippi. A positive correlation has been documented between wet vegetation around the water resources (as they provide rich invertebrate food) and many species of passerines in croplands of England (Dallimer *et al*. 2010b). In Pakistan, field borders are deliberately avoided to allow more space for crops where cultivation is irrigated but in Pothwar plateau, field borders naturally exist owing to topography and landscape features and are expected to harbor good biodiversity. The croplands of Pothwar with nearby water access points in the form of dams and rainwater ponds are expected to have good numbers of insectivores and granivores but no studies have so far been conducted on this aspect.

Generally granivorous bird populations in farmlands are perceived to inflict damage to field crops but Adams *et al*. (2015) found that some granivorous birds i.e. dickcissel (*Spiza americana*), red-winged Blackbird (*Agelaius phoeniceus*) and eastern Meadowlark (*Sturnella magna*) in USA do not form large flocks in agricultural landscapes and they do not cause damage to cereal crops. Several studies have demonstrated that many birds in agricultural landscapes are insectivorous and
thus are friends of farmers by acting as biological control agents of insect pests (Trembley et al., 2001; Jones et al., 2005).

The use of croplands by avifauna has been well studied in Southeast Asia. Sundar and Subramanya (2010) studied bird use of crop fields in the Indian subcontinent and found that 27% of bird species in India (n = 351) are associated with rice fields in some way. Khan (2011) reported that 30% of the birds of Bangladesh use agricultural fields. Rejashekara and Venkatesha (2014) in Bengalore, India found 38 species of insectivorous birds in agro ecosystem with multiple crops. They reported that density and diversity of insectivorous birds increases during winter due to winter migrants. In Pakistan, avian species richness and density has been studied in cotton based agro-ecosystems of Punjab (Hussain and Afzal, 2005) showing that several bird species i.e. jungle babbler (Turdoides striatus), common babbler (Turdoides caudatus), common myna (Acridotheres tristis), Indian wren warbler (Prinia subflava) and small green bee-eater (Merops orientalis) feed on insect pests of cotton crop and are threatened due to intensive farming as well as heavy use of pesticides.

In this scenario it is very important to evaluate the species composition and abundance of birds in the farmlands of Pothwar plateau of Pakistan which is contributing 10% to the national agricultural production. The baseline data about richness and density of avian communities in this arid region are required to evaluate the impact of habitat degradation on local avifauna and would be helpful to generate conservation programs for threatened bird species in this unique agroecosystem.
4.2 REVIEW OF LITERATURE

Avian communities of agro-ecosystems are comprised of frugivores, insectivores, granivores, nectarivores, omnivores as well as raptors (Birasal, 2014). Their densities can be significantly affected by a number of environmental factors, i.e. landscape structure, habitat and human disturbance in farmlands (Yuan et al., 2014).

The availability of resources in an ecosystem is significantly affected by variations in water level as well as seasonal changes in vegetation structure and human activities that affect bird populations (Zhao et al., 2013). Zhao et al. (2012) and Yuan et al. (2014) studied bird-environment relationship and found that during dry season water storage in arid regions changes the landscape variables and ultimately bird populations. They reported that bird populations declined with the decrease in water levels in agro-ecosystems of arid regions of China.

The patches of perennial crops, as well as field margins and other non-crop habitats, may act as shelters for wildlife within the matrix of less favorable annual crops (Hanski, 1999). Information on area sensitivity and effects of habitat fragmentation has come largely from forest and tall-grass prairie habitats. Research from other ecosystems is required to determine how passerine communities are being affected (Stoate et al., 2001; Bretagnolle et al., 2011). In modern agro ecosystems uncultivated patches of wild vegetation along crop fields provide suitable habitat to many birds but the composition of vegetation in field margins as well as vegetation structure is crucial for maintaining adequate avian density and diversity, so is the importance of size of field borders and landscape context (Adams et al., 2015). In a study, Smith et al. (2005b) planted 6.1m wide field borders along the crop field margins in Mississippi. They studied the density and community structure of song
sparrow (*Melopsiza melodia*) and savannah sparrow (*Passerculus sandwichensis*) in the planted and unplanted crop field margins and found higher species density of both the passerines in the crop fields associated with boundary vegetation and concluded that field boundary vegetation not only helps in increased population density of avian species but it also serves multiple benefits to the local people.

Naryana *et al.* (2013) reported that in agro-ecosystems of India more insectivorous birds are found in shrubs along field boundaries as they provide abundant insect food as well as perching sites to these birds. Brambilla *et al.* (2012) reported that many passerine species e.g. woodlark (*Lullula arborea*), skylark (*Alauda arvensis*), cirl (*Emberiza cirlus*) and corn bunting (*Emberiza calandra*) show intra and inter seasonal habitat switches depending upon environment suitability in farmlands.

Bhavna and Geeta (2011) studied avian community structure and diversity in intensive mono-cultured fields of sorghum (*Sorghum bicolor*) and pigeon pea (*Cajanus cajan*) in India and found that with the passage of time not only bird density and diversity deceased in these agricultural landscapes but few bird species became dominant and acted as functional cereal crop pests.

In the UK, 10 farmland bird species including sky lark (*Alauda arvensis*), tree sparrow (*Passer montanus*), common linnet (*Linaria cannabina*) and common starling (*Sturnus vulgaris*) have declined by 10 million breeding individuals over the past 20 years (Krebs, 1999) and there is evidence of widespread declines throughout much of the rest of the Europe (Donald *et al.*, 2001a). Fuller (1995) found that between 1970 and 1990, 86% (n=28) of farmland bird species had reduced distribution ranges and 83% (n=18) had declined in abundance.
In Florida, USA Jones et al. (2005) found that bird density in agricultural landscapes is associated with multiple culture as well as presence of field borders along the crop field margins. They also found that mixed crop plants increase the populations of ten species of insectivorous birds. Pearce-Higgins and Grant (2006) reported that some passerine species, e.g. red grouse (*Lagopus lagopus scotica*) and wren (*Troglodytes aedon*) are strictly associated to varied vegetation of tall shrubs along the field margins.

Yuan et al. (2014) studied the effects of landscape structure, habitat and human disturbance on birds in China and found that 40.95% variation in bird abundance was due to structure of landscape while habitat features accounted for 75.58% and anthropogenic were responsible for 51.97% variation in avian density. They also found that critical variables affecting bird species richness were availability of water, density of wild vegetation, area covered by sedges and grasses and distance to human settlements.

Concepcion and Diaz (2010) studied the foraging and breeding bird populations in agricultural landscapes of Spain and found that the density and diversity of foraging birds increased with respect to the length and proportion of field boundary vegetation along the crop fields while density and diversity of breeding birds was directly correlated with species richness of plants along the field borders. They also found that within the agricultural fields, weed density and cover and abundance of grasshoppers and crickets increase the species richness of foraging birds.

Ali et al. (2011) reported that in India common birds of agro-ecosystems are Indian roller (*Coracias benghalensis*), black drongo (*Dicrurus macrocercus*), common myna (*Acridotheres tristis*), small green bee-eater (*Merops orientalis*) and
white breasted kingfisher (*Halcyon smyrnensis*) and Sridhara *et al.* (1983) have reported that bird density and diversity decreased in agro-ecosystems of India during summer.

In Pakistan Roberts (1992) found that 55 species of passerines are associated with cotton based agro-ecosystem in Punjab while Hussain and Afzal (2005) recorded 32 species of birds (including 31 passeriformes) in a cotton-wheat based agro ecosystem of Multan and found majority of the species to be resident (*n* = 23) while few were migratory (*n* = 9).

Although no comprehensive account of passerine birds associated with field boundary vegetation in Pakistan is available, but according to Roberts (1992) some important resident and migratory passerines associated with such vegetation in Potwar Plateau during some part of the year are singing bush lark (*Mirafra cantillans*), red-winged lark (*Mirafra erythroptera*), rufous-tailed finch lark (*Ammomanes phoenicurus*), eastern calandra lark (*Melanocorupha bimaculata*), common lark (*Alauda arvensis*), red-vented bulbul (*Pycnonotus cafer*), Himalayan thrush (*Myiophoneus cacruleus*), grey-winged blackbird (*Turdus boulboul*), ashygrey wren warbler (*Prinia hodgsonii*), Hogson’s wren warbler (*Prinia cineveocapilla*), Indian tailor bird (*Orthotomus sutorius*), lesser whitethroat (*Sylvia curruca*), common whitethroat (*Sylvia communis*), yellow-browed leaf warbler (*Phylloscopus inornatus*), crested black tit (*Parus melanolophus*), thick-billed flower-pecker (*Dicaeum agile*), rook (*Corvus frugilegus*), common myna (*Acridootheres tristis*), willow sparrow (*Passerhispaniolensis*), yellow-throated sparrow (*Petronia xanthocellis*), Indian silver bill (*Eodice malabarica*), spotted munia (*Lonchura punctulata*), chaffinch (*Fringilla coelebs*) and white-capped bunting (*Emberiza stewarti*). However, the present status of these species and
particularly their relationship and utilization of the field boundary vegetation is unknown.

4.3 MATERIALS AND METHODS

The bird densities were estimated on monthly basis at four study sites (see Chapter 1, section 1.12.10) by employing the point count method (Bibby et al., 1992). At each study site (Table 3.1) 12 selected permanent points were marked to take the repeated observations monthly. The points were selected along the field boundary vegetation at a minimum distance of 50m to avoid overlapping. In case of falling a particular point into the crop field or any inaccessible area like deep ridge or rainwater pond a deviation of 20m was made for point relocation of the observation point to field boundary. Effective observation radius of 20 m was selected after pretesting in a pilot study in the given terrain, topography, vegetation structure.

All the 48 point count positions (4 sites x 12 points at each site) were surveyed once every month morning and evening time for 2 years (July 2012 to June 2014), adding up to a total count of 1152 points. At each point, after an initial settling time of one minute, observations were taken for 10 minutes duration. All birds viewed on the ground or in vegetation were identified and wherever possible sexed, and flock size was recorded. Bird species were identified using binoculars and field guides following Ali and Ripley (1987) and Grimmett et al. (2008). The status of species as resident or migrant was determined after Roberts (1992).

Although birds are conspicuous in ecosystems there are several possibilities that individual species are not detected due to species-specific differences, time of data collection and habitat differences (Kery and Schmid, 2004). Some bird species are readily detected on the basis of their typical behavior e.g. movements and/or
songs, some species are more cryptic and thus difficult to be detected while some species are migratory and are observed in specific season or time of the year (Goijman, 2014). The knowledge and experience of observer is also helpful in detecting birds. In order to rule out these detection possibilities, replication of observations was necessary and repeated visits to same points were made over 24 months.

The monthly record of bird abundance was categorized into five seasons namely winter (December to February), spring (March to April), summer (May to mid-July), monsoon (mid-July to August) and fall (September to November). To mark a clear distinction between summer and monsoon data, observations for July were taken after mid of the month for both the years. Monthly species diversity for each site was estimated using the Shannon–Wiener ($H'$) Diversity Index

$$H' = -\sum p_i \log p_i$$

Where $p_i$ is the proportion of total sample belonging to the $i$th species.

Species richness across the sites was calculated by Menhinick”s Index ($D$) following Magguran (2004).

$$D = \frac{s}{\sqrt{N}}$$

Where $s$ is number of species in the sample and $N$ is the number of individual organisms in the sample.

**4.4 STATISTICAL ANALYSIS**

All data were log transformed. In current study, two sites (I + IV) had water resource and wheat-maize/millet cropping system while the other two sites (II + III) were without water and had wheat-groundnut cropping system. Effect of water and
cropping system variability on bird abundance were tested statistically. Yearly difference in bird records was compared using paired t-test.

The bird abundance (unit of response variable) across the two agricultural systems was compared using 2 sample t-tests, based on averages and sums within sites in order to investigate the influence of water and cropping system across months. The resultant 2 degrees of freedom (for t tests) implies relatively low power, so $P$ values < 0.1 were interpreted. Avian species richness across the four sites was compared using chi-square test based on species counts. The chi-square test used species as the replicate. The difference in bird density across the four sites was compared by repeated measures ANOVA using month as replicate.

4.5 RESULTS

In total 25 bird species belonging to 15 families were recorded over the two year study period. Seasonal segregation of the bird records revealed that 20 species were residents (Table 4.1) while the remaining five species namely common lark (*Alauda arvensis*), eastern calandra lark (*Melanocorypha bimaculata*), yellow browed leaf warbler (*Phylloscopus humei*), common whitethroat (*Sylvia communis*) and black redstart (*Phoenicurus ochruros*) were winter visitors/migrants and were observed during November to March only (Table 4.2).

The four most common and abundant bird species included common sparrow (*Passer domesticus*), common myna (*Acridotheres tristis*), red-vented bulbul (*Pycnonotus cafer*) and Himalayan bulbul (*Pycnonotus leucogenys*). Another group of four species viz: Indian tailor bird (*Orthotomus sutorius*), common lark (*Alauda arvensis*), ashy drongo (*Dicrurcus leucophaeus*) and ashy prinia (*Prinia socialis*) were although not abundant but seen at all four sites during some part of the year. The common lark (*Alauda arvensis*) was a winter visitor seen only from November
to March while ashy drongo (*Dicrurus leucophaeus*) was resident but never observed during winter (December to February) at any of the sites.

### 4.5.1 Avian Species Richness and Abundance at Site I

In total 22 species of birds were recorded at this site during the two year study period (Table 4.3) and estimated Species Richness (Menhinick’s Index, D) was 0.63. The number of individuals counted was 1576 of which 790 were seen **Table 4.1:** Records of resident passerine species observed during July 2012 to June 2014 at the four selected sites of Pothwar Plateau, Pakistan. (Status after Roberts, 1992)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden oriole</td>
<td><em>Oriolus oriolus</em></td>
<td>Oriolidae</td>
</tr>
<tr>
<td>Ashy drongo</td>
<td><em>Dicrurus leucophaeus</em></td>
<td>Dicuridae</td>
</tr>
<tr>
<td>Indian tree magpie</td>
<td><em>Dendrocitta vagabunda</em></td>
<td>Corvidae</td>
</tr>
<tr>
<td>Singing bush lark</td>
<td><em>Mirafra cantillans</em></td>
<td>Alaudidae</td>
</tr>
<tr>
<td>Rufous tailed finch lark</td>
<td><em>Ammomanes phoenicura</em></td>
<td>Alaudidae</td>
</tr>
<tr>
<td>Grey crowned prinia</td>
<td><em>Prinia cinereocapilla</em></td>
<td>Cisticolidae</td>
</tr>
<tr>
<td>Ashy prinia</td>
<td><em>Prinia socialis</em></td>
<td>Cisticolidae</td>
</tr>
<tr>
<td>Indian tailor bird</td>
<td><em>Orthotomus sutorius</em></td>
<td>Cisticolidae</td>
</tr>
<tr>
<td>Himalayan bulbul</td>
<td><em>Pycnonotus leucogenys</em></td>
<td>Pycnonotidae</td>
</tr>
<tr>
<td>Red-vented bulbul</td>
<td><em>Pycnonotus cafer</em></td>
<td>Pycnonotidae</td>
</tr>
<tr>
<td>Large grey babbler</td>
<td><em>Turdoides malcolmi</em></td>
<td>Leiothrichidae</td>
</tr>
<tr>
<td>Common myna</td>
<td><em>Acridotheres tristis</em></td>
<td>Sturnidae</td>
</tr>
<tr>
<td>Himalayan thrush</td>
<td><em>Myophonus caeruleus</em></td>
<td>Turdidae</td>
</tr>
<tr>
<td>Pied bush chat</td>
<td><em>Saxicola caprata</em></td>
<td>Turdidae</td>
</tr>
<tr>
<td>Common sparrow</td>
<td><em>Passer domesticus</em></td>
<td>Passeridae</td>
</tr>
</tbody>
</table>
Yellow throated sparrow  *Petronia xanthocollis*  Passeridae  
Baya weaver  *Ploceus philippinus*  Ploceidae  
White wagtail  *Motacilla alba*  Motacillidae  
Common chaffinch  *Fringilla coelebs*  Fringillidae  
White capped bunting  *Emberiza stewarti*  Emberizidae

### Table 4.2: Records of migrants/winter visitor birds observed during July 2012 to June 2014 at the four selected sites of Pothwar Plateau, Pakistan. (Status after Roberts, 1992)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern calandra lark</td>
<td><em>Melanocorypha bimaculata</em></td>
<td>Alaudidae</td>
</tr>
<tr>
<td>Common lark</td>
<td><em>Alauda arvensis</em></td>
<td>Alaudidae</td>
</tr>
<tr>
<td>Yellow browed leaf warbler</td>
<td><em>Phylloscopus humei</em></td>
<td>Sylviidae</td>
</tr>
<tr>
<td>Common whitethroat</td>
<td><em>Sylvia communis</em></td>
<td>Sylviidae</td>
</tr>
<tr>
<td>Black redstart</td>
<td><em>Phoenicurus ochruros</em></td>
<td>Turdidae</td>
</tr>
</tbody>
</table>
during year I while 786 birds were recorded during year II. Apart from the eight species that were common at every site, the other resident birds observed at this site were, Indian tree magpie (*Dendrocitta vagabunda*), singing bush lark (*Mirafra cantillans*), grey crowned prinia (*Prinia cinereocapilla*), large grey babbler (*Turdoides malcolmi*), Himalayan thrush (*Myophonus caeruleus*), pied bush chat (*Saxicola caprata*), baya weaver (*Ploceus philippinus*), white wagtail (*Motacilla alba*), white capped bunting (*Emberiza stewarti*), and common chaffinch (*Fringilla coelebs*).

Except pied bush chat (*Saxicola caprata*) and common chaffinch (*Fringilla coelebs*) none of these species were found at other sites. Five passerine species found at this site namely common lark (*Alauda arvensis*), eastern calandra lark (*Melanocorypha bimaculata*), yellow browed leaf warbler (*Phylloscopus humei*), common whitethroat (*Sylvia communis*) and black redstart (*Phoenicurus ochruros*) were migrants and were observed during November to March only.

### 4.5.2 Avian Species Richness and Abundance at Site II

A total of 12 bird species were recorded at this site during both years of study period (Menhinick’s Index, $D = 0.42$). In total 1298 birds were observed (Table 4.4). During July 2012 to June 2013 the number of birds recorded was 705 while 593 birds were counted during July 2013 to June 2014. Two migratory species namely common lark (*Alauda arvensis*) and common whitethroat (*Sylvia communis*) were only observed during November to March period.
The resident avifauna at site II comprised of house sparrow (*Passer domesticus*), red-vented bulbul (*Pycnonotus cafer*), Himalayan bulbul (*Pycnonotus*
Table 4.3: Records of bird species observed during July 2012 to June 2014 at Site I (Thatti Gujran) in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Monsoon</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy drongo (Dicrurus leucophaeus)</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Indian tree magpie (Dendrocitta vagabunda)</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Singing bush lark (Mirafras cantillans)</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Eastern calandra lark (Melanocorypha bimaculata)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Common lark (Alauda arvensis)</td>
<td>11</td>
<td>8</td>
<td>5</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Grey crowned prinia (Prinia cinereocapilla)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td>11</td>
<td>4</td>
<td>16</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Indian tailor bird (Orthotomus sutotius)</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Yellow browed leaf warbler (Phylloscopus humei)</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Common whitethroat (Sylvia communis)</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Large grey babbler (Turdoides malcolmi)</td>
<td>4</td>
<td>10</td>
<td>20</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Common myna (Acridotheres tristis)</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Himalayan thrush (Myophonus caerules)</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Black redstart (Phoenicurus ochruros)</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pied bushchat (Saxicola caprata)</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Common sparrow (Passer domesticus)</td>
<td>28</td>
<td>29</td>
<td>35</td>
<td>26</td>
<td>36</td>
</tr>
<tr>
<td>Baya weaver (Ploceus philippinus)</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>White wagtail (Motacilla alba)</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Species</td>
<td>Monsoon</td>
<td>Fall</td>
<td>Winter</td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------</td>
<td>-------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>Jul</td>
<td>Aug</td>
<td>Sep</td>
<td>Oct</td>
<td>Nov</td>
</tr>
<tr>
<td>Ashy drongo (<em>Dicrurcus leucophaeus</em>)</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Rufous tailed finch lark (<em>Ammomanes phoenicura</em>)</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Common lark (<em>Alauda arvensis</em>)</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Ashy prinia (<em>Prinia socialis</em>)</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Himalayan bulbul (<em>Pycnonotus leucogenys</em>)</td>
<td>6</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Red-vented bulbul (<em>Pycnonotus cafer</em>)</td>
<td>13</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Indian tailor bird (<em>Orthotomus sutorius</em>)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Common whitethroat (<em>Sylvia communis</em>)</td>
<td></td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Common myna (<em>Acridotheres tristis</em>)</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Pied bushchat (<em>Saxicola caprata</em>)</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Common sparrow (<em>Passer domesticus</em>)</td>
<td>38</td>
<td>36</td>
<td>40</td>
<td>33</td>
<td>59</td>
</tr>
<tr>
<td>Yellow throated sparrow (<em>Petronia xanthocollis</em>)</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
leucogenys), common myna (*Acridotheres tristis*), Indian tailor bird (*Orthotomus sutorius*), ashy drongo (*Dicrulus leucophaeus*), ashy prinia (*Prinia socialis*), rufous tailed finch lark (*Ammomanes phoenicura*) and pied bush chat (*Saxicola caprata*). Among these ashy drongo (*Dicrulus leucophaeus*), Indian tailor bird (*Orthotomus sutorius*) and rufous tailed finch lark (*Ammomanes phoenicura*) were not observed during winter, although these are falling in the resident category.

### 4.5.3 Avian Species Richness and Abundance at Site III

Eight bird species comprising of 865 individuals were recorded at this site during the study period (Table 4.5). Estimated species richness was Menhinick’s Index, \( D = 0.34 \). Monthly occurrence of these species during year I made up to 418 individuals while 447 birds were recorded during year II. House sparrow (*Passer domesticus*) was dominant species at this site and a total of 336 birds were observed during the study period followed by common myna (*Acridotheres tristis*) (\( n = 97 \)).

Among bulbuls, 75 individuals of red-vented bulbul (*Pycnonotus cafer*) were counted over the entire study period while 54 Himalayan bulbuls (*Pycnonotus leucogenys*) were observed. The ashy drongo (*Dicrulus leucophaeus*) (\( n = 24 \)), ashy prinia (*Prinia socialis*) (\( n = 18 \)) and Indian tailor bird (*Orthotomus sutorius*) (\( n = 6 \)) were particularly low in numbers. Only one migrant species namely common lark (*Alauda arvensis*) (\( n = 18 \)) was observed at this site.
4.5.4 Avian Species Richness and Abundance at Site IV

A total of 1203 birds belonging to 16 species was observed at this site during a period of two years and species richness (D) was estimated to be 0.52
**Table 4.5:** Records of bird species observed during July 2012 to June 2014 at Site III (Shah Syed Billu) in agro-ecosystem of Pothwar Plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Monsoon</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jul</td>
<td>Aug</td>
<td>Sep</td>
<td>Oct</td>
<td>Nov</td>
</tr>
<tr>
<td>Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Common lark (<em>Alauda arvensis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Ashy prinia (<em>Prinia socialis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Himalayan bulbul (<em>Pycnonotus leucogenys</em>)</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Red-vented bulbul (<em>Pycnonotus cafer</em>)</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Indian tailor bird (<em>Orthotomus sutorius</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Common myna (<em>Acridotheres tristis</em>)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Common sparrow (<em>Passer domesticus</em>)</td>
<td>8</td>
<td>34</td>
<td>23</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>
(Table 4.6). Yearwise segregation of total counts resulted in to 613 counts in year I and 590 in year II. Other than the eight common species observed at every site the bird community at this site comprised of rufous tailed finch lark (*Ammomanes phoenicura*), eastern calandra lark (*Melanocorypha bimaculata*), yellow throated sparrow (*Petronia xanthocollis*), common chaffinch (*Fringilla coelebs*), golden oriole (*Oriolus oriolus*), Himalayan thrush (*Myophonus caeruleus*), pied bush chat (*Saxicola caprata*) and black redstart (*Phoenicurus ochruros*).

Common lark (*Alauda arvensis*), eastern calandra lark (*Melanocorypha bimaculata*) and black redstart (*Phoenicurus ochruros*) were migrants observed typically from November to March. Yellow throated sparrow (*Petronia xanthocollis*) and golden oriole (*Oriolus oriolus*) were exclusively observed at this site, with no record at the other sites.

### 4.5.5 Year-Wise Differences in Bird Abundance

Total number of birds recorded at all the four sites in year I was 2526 which was almost to record of 2416 in year II. There was non-significant difference between these figures (paired t-test, using month as replicate, $t_{11} = 0.43$, $P = 0.67$ $P > 0.05$).

### 4.5.6 Seasonal Differences

At all the study sites both bird numbers and species richness decreased during summer i.e. May to mid-July (Figs. 4.1 and 4.2). When avian species richness was compared with temperature data across the study period, it was found that
temperature and the number of species observed in every month were strongly negatively correlated (each month averaged across the 2 years, N = 12)
### Table 4.6: Records of bird species observed during July 2012 to June 2014 at Site IV (Prem Nagar Faqiran) in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Monsoon</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Golden oriole (Oriolus oriolus)</strong></td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Ashy drongo (Dicrurus leucophaeus)</strong></td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td><strong>Eastern calandra lark (Melanocorypha bimaculata)</strong></td>
<td>5</td>
<td>20</td>
<td>15</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td><strong>Rufous tailed finch lark (Ammomanes phoenicura)</strong></td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Common lark (Alauda arvensis)</strong></td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td><strong>Ashy prinia (Prinia socialis)</strong></td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><strong>Himalayan bulbul (Pycnonotus leucogenys)</strong></td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td><strong>Red-vented bulbul (Pycnonotus cafer)</strong></td>
<td>6</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td><strong>Indian tailor bird (Orthotomus sutorius)</strong></td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td><strong>Common myna (Acridotheres tristis)</strong></td>
<td>8</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td><strong>Himalayan thrush (Myophonus caeruleus)</strong></td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Black redstart (Phoenicurus ochruros)</strong></td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Pied bushchat (Saxicola caprata)</strong></td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Common sparrow (Passer domesticus)</strong></td>
<td>35</td>
<td>38</td>
<td>24</td>
<td>45</td>
<td>47</td>
</tr>
<tr>
<td><strong>Yellow throated sparrow (Petronia xanthocollis)</strong></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Common chaffinch (Fringilla coelebs)</strong></td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Fig. 4.1: Mean number of species (X ± SE) observed each month during July 2012 to June 2014 at the 4 selected sites of Pothwar plateau, Pakistan.
**Fig. 4.2:** The total number of birds of resident and migratory species observed during July 2012 to June 2014 at each of the 4 selected sites of Pothwar plateau, Pakistan.
months, \( r = -0.90, P < 0.001 \) indicating decline in bird species richness with rise in temperature. Bird density also decreased with rise in temperature at all sites (\( r = 0.88, P < 0.001 \)). The relationship between diversity of bird species and their numbers with rainfall was also negative, but weaker than temperature (\( r = -0.47, P = 0.12 \) and \( r = -0.19, P = 0.56 \), respectively).

### 4.5.7 Site Differences

The number of resident and migratory species observed during the study period is presented in Fig. 4.3. At Site I, 1576 birds were observed during the two year study period. These included 1397 residents and 199 migrants. The number of resident birds at Site II was 1262 while 36 birds were winter visitors. At Site III of the total birds observed, only 18 were migrants while 847 were residents and at Site IV, 102 migrants were counted while resident birds were counted to be 1101. These data show that migrants were few and the large differences were in residents, which were therefore expected to drive any patterns.

Bird density and abundance were compared across the study sites with respect to difference in cropping system and availability of water source. It was found that study sites differ in total bird numbers recorded, using month as replicate in a repeated measures ANOVA (\( P < 0.001 \)). Shannon-Weiner diversity indices were calculated separately for each year (Table 4.7). The highest diversity index was found for Site I during both the years while the lowest diversity index was recorded for Site III. The low value was accounted for dominance of house sparrow at site III (Table 4.5).

Comparison of bird abundance between combined records of sites I and
**Fig. 4.3:** Mean number of birds observed each month during July 2012 to June 2014 at the four selected sites of Pothwar plateau, Pakistan.
Table 4.7: Total number of birds of different species observed during July 2012 to June 2014 at the four selected sites of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th></th>
<th>Site I</th>
<th>Site II</th>
<th>Site III</th>
<th>Site IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of birds observed</td>
<td>1576</td>
<td>1298</td>
<td>865</td>
<td>1203</td>
</tr>
<tr>
<td>No. of species observed</td>
<td>22</td>
<td>12</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>No. of migratory species observed</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Shannon-Weiner Index (Year I)</td>
<td>2.35</td>
<td>2.08</td>
<td>1.85</td>
<td>1.95</td>
</tr>
<tr>
<td>Shannon-Weiner Index (Year II)</td>
<td>2.77</td>
<td>2.09</td>
<td>1.82</td>
<td>2.34</td>
</tr>
</tbody>
</table>

IV (by sample t-test on log transformed data of bird numbers recorded) with combined data of sites II and III ($t_2 = 1.085, P = 0.391 \ P > 0.05$) was not able to
indicate any significant difference. However, the evidently less abundance (although statistically non-significant) at sites II and III seems to be related with non availability of water source (Fig. 4.4).

Despite similarity in numbers, about 75% more species of birds were present in sites that were in close proximity to water resources viz: Site I and IV, compared to those that were not (Table 4.7). All species present at sites II and III were also recorded in the sites I and IV, but the latter sites had an additional 14 species that were not observed at the sites (II and III) without water source. A chisquare goodness of fit test comparing species richness across the four sites was significant at $P < 0.1$ ($\chi^2_3 = 6.94, P = 0.074$). There was no difference in the number of resident species between the sites that differed with respect to water availability and cropping system ($t_2 = 0.783, P = 0.515$). More migratory species were present at the sites with water sources and the difference between the sites was significant at $P = 0.1$ ($t_2 = 3.577, P = 0.07$).

**4.6 DISCUSSION**

In Pakistan, few studies exist about population status and significance of birds in agro-ecosystems. Similarly, hardly any literature is available on habitat, population status and avian species richness in the Pothwar region. Therefore, knowledge of population structure and dynamics is almost non-existent for the birds in croplands of Pothwar plateau. In that context, the present study set out some preliminary information on population status and diversity of passerine bird species utilizing the agricultural landscape of the Pothwar plateau.
Fig. 4.4: Comparison of sites I+IV vs. Sites II+III with respect to bird numbers observed during July 2012 to June 2014 in Pothwar plateau, Pakistan.

Point counts are often translated into absolute densities by fitting detection functions. These functions use observer estimated distance to individual bird sightings (Mulwa et al., 2012). Detectability is assumed to decrease exponentially
with distance. In case of community studies, a major difficulty is that detection functions differ among species making any assessment of absolute densities very difficult to compute, especially as individual species’ detection functions come with large error. In order to deal with these issues of biased detectability in using point counts, care was taken in this study to use the same methods on same sites and the authors avoided converting relative numbers into absolute densities that create extra bias.

Because of limited habitat availability to species in cropping systems, agriculturally mediated changes can have profound implications for the management and sustainability of bird populations (Laxmi et al., 2013). The results show that croplands of Pothwar plateau offer good habitat for the relatively few terrestrial bird species that are adapted to utilize this farmland. For example, the house sparrow comprised almost one-third (31.86%) of all individuals observed, probably because of food from the agriculture crops. Alongside house sparrow (Passer domesticus), red vented bulbul (Pycnonotus cafer), Himalayan bulbul (Pycnonotus leucogenys) and common myna (Acridotheres tristis) were widespread and common species occurring in all the four study sites.

The studies have shown that in agricultural systems few granivorous and omnivorous species dominate bird communities (Toor et al., 1986; Dhindsa and Saini, 1994; Tonglei and Guo, 2013). Although no baseline data are available but agriculture in Pothwar region may well have increased the total number of species in this arid region, by adding some agricultural bird species without losing natives.

More species of birds were observed in the study sites with wheatmillet/maize cropping system and water access points which also held more cultivated land (Table
1.1), but this could be a consequence of migrants (Table 4.7). It is perhaps most likely that water resources support the cropping system and consequently the birds. Ryszkouski et al. (2002) and Surmacki (2005) also reported that crops close to water access harbor rich invertebrate populations because of edge effect and thus more passerines are concentrated in such regions since foraging of farmland passerines near these edges not only reduces energy needed in food search but also decreases risk of predation.

Although trees and shrubs provide nesting and perching sites to birds, the vegetation data showed that the sites with rain water ponds (i.e. Site I and IV) had fewer shrubs. Thus the higher numbers may be attributed to the fact that the birds were attracted to crop grains and insects in the crops for feeding, and they used the nearby wild vegetation for nesting and perching that had less human intervention. Studies in agro ecosystems of India reported that shrubs attract more birds by providing food resources to them (O’Connor and Shrubb, 1986; Dhindsa and Saini, 1994) but this did not seem to be a major driver of species richness patterns in the rain-fed agro ecosystem of Pothwar plateau.

This difference may be because of different ecology of Pothwar plateau where vegetation cover is decreasing due to low rainfall, extensive deforestation, coal mining, and oil and gas exploration (Nizami et al., 2004). However, the relations between the detailed physical characteristics/structure of field margin vegetation and the occurrence of individual species or the whole bird community (primarily in the breeding season) could be further investigated in the future.

The 25 species of passerine birds reported in this study are well supported by previous records of 24 species (Roberts, 1992). Several species e.g. red-winged lark
(Mirafra erythroptera), grey-winged blackbird (Turdus boulboul), ashy-grey wren warbler (Prinia hodgsonii), Hogson’s wren warbler (Prinia cineveocapilla), lesser whitethroat (Sylvia curruca), crested black tit (Parus melanolophus), thick-billed flower-pecker (Dicaeum agile), willow sparrow (Passerhispaniolensis), Indian silver bill (Eodice malabarica) and spotted munia (Lonchura punctulata) were not recorded in this study whereas 11 new passerine species were recorded in this study. This deviation could be attributed to the fact that the rarer species were infrequent, overlooked and their habitat might have been changed (Qaisrani, 2006). In addition, this study focused only on the croplands with traditional cropping pattern and irrigated plantations or fruit orchards etc. were not studied at all.

It is evident that strategies for effective conservation vary greatly based upon the local characteristics of landscapes (Fischer et al., 2008; Ranganathan et al., 2010). In the present study, it was found that there were more species and their numbers at sites I and IV, probably because of water availability and better cropping intensity and conditions. Thus water availability was driving more birds towards these locations. Although different agriculture systems can sustain avian communities that are of very high value for biodiversity conservation, the comparison of sites on the basis of agricultural practices makes it clear that local conditions also govern the avian community structure and distribution. However, some additional studies aimed at assessing the differences in density of birds (not only passerines) between field margin vegetation and typical open habitats (crops or more natural steppe/semi-desert areas) in rural areas of Pakistan, and their use by birds are also highly desirable.
Chapter 5
FOOD HABITS OF SELECTED PASSERINES

5.1 INTRODUCTION

The analysis of foraging behavior and diet composition of avian species is crucial for their effective conservation and management. In the recent times there has been strong emphasis on investigating the food habits of economically important birds to comply with some conservation needs. Several authors have highlighted the importance of detailed studies on foraging ecology and food habits of birds in agro-ecosystems in order to assess the economic and ecological importance of farmland birds (Asokan et al., 2009, Birasal, 2014).

The changes in resource availability lead to dynamic changes in the niche of avian species (Pearman et al., 2008). Seasonal fluctuations in diet reflect the seasonal availability of food in the area. It has been found that in agro-ecosystems variation in food availability is the primary force that structures the distribution of birds in the regional ecosystems (Verhulst et al., 2004; Filloy and Bellocq, 2007).

O’Connor and Shrubb (1986) and Kale (2014) have reported that in agroecosystems bird species feed on three types of food resources viz: green parts of crops and grasses (i.e. grains, fruits, seeds and vegetative parts), insects and arthropods, and the rodents. Crop fields provide optimal foraging habitats not only to granivorous birds but also to insectivorous birds as the crops harbor large populations of insects (Adams et al., 2015).

Tscharntke et al. (2008) recorded that diet breadth of avian communities utilizing the agricultural landscapes is wide and they are able to exploit greater diversity of resources. Herrera et al. (1994) and Palita et al. (2011) have reported that
when several fruiting plant species are present, frugivore birds generally feed simultaneously on them thus distribution of fruiting plants in a habitat is influenced by birds dispersing their seeds. In agro ecosystems, plant diversity is crucial for insect diversity. Many predatory insects and spiders consume wide varieties of insects and all together these insect fauna are important for maintaining populations of insectivorous birds in croplands (Rajashekara and Venkatesha, 2014).

Croplands provide a highly foreseeable and instant source of food for birds. Although most of the birds are granivores and feed on cereal crops, many birds in agricultural landscapes feed on harmful insects (Narayana et al., 2011). Sengupta (1976) reported that many birds e.g. common myna (*Acridotheres tristis*), Indian roller (*Coracias benghalensis*), black drongo (*Dicrurus macrocercus*) increase insect uptake in food during pre-monsoon and monsoon season during which kharif crops are sown in India. These crops are vulnerable to high insect attack. He found that these birds protect the crops from serious insect damage by consuming high levels of pest insects. Parasharya et al. (1994) reported that in India white grub (*Holotricha* sp.) is an important pest that damages the root system of crops and its population is controlled by several insectivorous birds like white-breasted kingfisher (*Halcyon smyrnensis*), small green bee-eater (*Merops orientalis*) and black drongo (*Dicrurus macrocercus*). During traditional ploughing operations in agro-ecosystems, these insectivorous birds follow and pick up the insects and earthworms exposed by the ploughing operations. Other authors in India have highlighted that common and widespread species especially house sparrow (*Passer domesticus*), common myna (*Acridotheres tristis*) and black drongo (*Dicrurus macrocercus*) eat insects in the crop fields (Ali, 1949; Rajashekar and Venkatesha, 2008; Asokan et al., 2009b; Keshavan and Malavannan, 2010). Hart *et al.* (2006) estimated the arthropod populations in
cereal fields and found that one hectare of a cereal crop field is home to several million individuals of beetles, spiders and flies.

Many birds that forage in croplands act as biological control agents for insect pests (Tremblay et al., 2001; Jones et al., 2005).

Several authors have reported that field borders and patches of uncultivated wild vegetation in agricultural landscapes provide higher density and diversity of arthropods as compared to the adjacent crops and these insects are a source of food for many wildlife species (Asteraki et al., 1995; Thomas and Marshall, 1999). It has also been reported that field borders in croplands host a variety of arthropods that are absent in the interior of the fields and these arthropods serve as food source to insectivorous birds when insecticides are used in the crops to kill pest insects (Weyland and Zaccagnini, 2008; Varni, 2010). Lee et al. (2001) also found that many species of arthropods have great ability of dispersion and thus even though insecticides are used in agro-ecosystems, the total abundance of arthropods in the field boundaries are maintained at a certain level.

Irshad and Mirza (2011) observed that passerines e.g. mynas, larks and drongos are insectivores and catch the insects dislodged by livestock during grazing in riverine ecosystem of Lahore, Pakistan. They also reported that insects found in vegetation are picked up by these birds. Yard et al. (2004) and Moorman et al. (2007) have reported that bugs, beetles and weevils are most commonly eaten by all insectivorous birds. Hussain and Afzal (2005) studied foraging birds in a cotton-wheat based agro ecosystem of Punjab, Pakistan and found that 37% of the bird species were insectivorous and fed exclusively on insects belonging to two orders namely Hymenoptera and Hemiptera.
Food habits” studies also help to investigate the potential role of birds as seed dispersers especially invasive species (Spotswood et al., 2012). Buckley et al. (2006) reported that in Southeast Asia habitat fragmentation has occurred due to conversion of natural landscape to agricultural lands and in such areas many invasive plants colonize the edge habitats since they are able to tolerate more disturbance as compared to native species. The local fruit eating birds consume these species predominantly leading to an increase in dispersal of invasive species.

Fecal analysis of droppings is one of the good non-invasive techniques to determine the diet composition of birds (Hinnant and Kothmann, 1988; Kukreti et al., 2013). Many studies have highlighted a positive correlation between food and undigested fecal contents in game and wild birds (Owen, 1975; Walter and Reese, 2003; Kukreti et al., 2013) making it a reliable technique to analyze avian food habits. It has been found that soft-bodied invertebrate groups are under-represented in the fecal droppings due to quick digestion but being a non-invasive technique it is still most practicable method to determine the diet composition of birds (Moreby and Stoate, 2000; Gruar et al., 2003).

Micro-histological technique is strongly biased towards the food components that have high digestive resistance like seeds and hard leaves. Therefore, analysis of fecal samples may result in bias because of differential rate of digestion and rate of passage through the gut tract (Ralph et al., 1985; Rosenberg and Cooper, 1990) but Oliveira et al. (2002) and Khaleghizadeh et al. (2006) have suggested that micro-histology is a suitable and appropriate technique with an acceptable level of accuracy and should be used to determine the diet composition of birds.
The study of food habits and foraging ecology of birds is fundamental in order to assess their role in agro-ecosystems and such studies in and around agroecosystems of Pakistan are limited. Therefore present study was carried out to determine the diet composition of few selected passerine species inhabiting the agro-ecosystem of Pothwar plateau using micro-histological analysis of freshly collected fecal droppings.

5.2 REVIEW OF LITERATURE

Long *et al.* (1981) reported that red-vented bulbul (*Pycnonotus cafer*) and common myna (*Acridotheres tristis*) are considered as agricultural pests as significant proportion of their diet consists of fruit and berries. Palita *et al.* (2011) in India reported that common myna (*Acridotheres tristis*), red-vented bulbul (*Pycnonotus cafer*) and Himalayan bulbul (*Pycnonotus leucogenys*) are frugivores and feed on *Morus alba*.

In India, several authors have highlighted the importance of insectivorous birds in croplands as potential eliminators of pests. These birds consume different types of insects found in crop fields and play an important role in integrated pest management in agricultural landscapes (Verghese and Sriharan, 1993; Keshavan and Malavannan 2010, Rajashekara and Venkatesha, 2014). Likewise it was found that raptors like barn owl (*Tyto alba streptens*) harboring the agricultural fields of India keep a check on rodent pests in crops (Neelanarayanan, 2007).

In India Reginald *et al.* (2014) reported that bushchat (*Saxicola caprata*), green bee-eater (*Merops orientalis*), Indian roller (*Coracias benghalensis*), Indian tailorbird (*Orthotomus sutorius*), ashy prinia (*Prinia socialis*) and black drongo
(Dicrurus macrocercus) are insectivores while they found red-vented bulbul (Pycnonotus cafer) and Himalayan bulbul (Pycnonotus leucogenys) to be omnivores.

Bulbuls are widely recognized as fruit consuming generalists especially in Indo-Malayan region (Corlett, 1998). They are extremely flexible in their dietary habits and are able to consume a wide variety of fruit and plants (Sankamethawee et al., 2011). Sanitjan and Chen (2009) reported that maximum gape width of bulbul is 9.7mm and consequently they cannot consume fruit larger than one cm. Bulbuls swallow whole fruit and discharge the seeds in feces which are readily identifiable. Mandon-dalger et al. (2004) worked on red-whiskered bulbul (Pycnonotus jocosus) in Reunion Island and found 2000 seeds per dropping suggesting that these bulbuls have potential to disperse the seeds of invasive and native plants.

Many authors have worked on the foraging ecology of bulbuls and reported that certain species of bulbuls especially red-vented bulbul (Pycnonotus cafer), Chinese bulbul (Pycnonotus sinensis) and red-whiskered bulbul (Pycnonotus jocosus) consume little amounts of insects even outside the breeding season (Bhatt and Kumar, 2001; Wang et al., 2005; Leinebjerg et al., 2010). Kerdkaew et al. (2014) studied the food habits of red-eyed bulbul (Pycnonotus brunneus) and yellow-vent ed bulbul (Pycnonotus goiavier) by employing micro histological analysis of droppings in Thailand and found that 97.0% food of Pycnonotus brunneus was plant based and only 3.0% insect based. While 98.9% diet of Pycnonotus goiavier was constituted of the plant food and the insects contributed only 1.1% part. They also found seasonal fluctuations in the fruit species consumed by these bulbuls. Wang et al. (2005) worked on Chinese bulbul (Pycnonotus sinensis) in Sihuan, China and recorded uptake of insects during breeding season with 55% proportion as compared to that recorded (1.8%) in non-breeding time. A study on food composition of red-
whiskered bulbul (*Pycnonotus jocosus*) in Mauritius (Leinebjerg *et al.*, 2010) reported that major portion of their diet was consisted on invasive plants. Kerdkaew *et al.* (2014) also reported that in Thailand, red-eyed bulbul (*Pycnonotus brunneus*) and yellow-vented bulbul (*Pycnonotus goiavier*) feed on exotic invasive plants. Aravind *et al.* (2010) in India found that bulbuls feed on an invasive species *Lantana camara* and are its potential dispersers. This plant outcompetes native flora leading to reduced floral diversity and as a result insectivorous bird communities are also affected.

In a study by Bhatt and Kumar (2001) in India, 17 plant species were identified in the diet of red-vented bulbul (*Pycnonotus cafer*). They observed that these bulbuls consume mature fruits of *Azadarashta indica*, *Clerodendron infortunatum*, *Coccinia indica*, *Ficus benghalensis*, *Ficus glomerata*, *Ficus religiosa*, *Syzygium jambolanum*, *Annona squamosa*, *Lantana camara*, *Musa paradisiacal*, *Psidium guajava*, *Solanum nigrum* and *Vitis vinifera* while they also eat unripe fruit of *Solanum torvum*, leaves of *Medicago sativa* and nectar of *Bombax ceiba* and *Callistemon utilis*. They found that preferred foods of these bulbuls were unripe fruit of *Solanum torvum* followed by leaves of *Medicago sativa* and ripe fruit of *Lantana camara*. It was concluded that 55.9% diet of redvented bulbul consists of ripe fruit, 17% unripe fruit, 13.8% nectar and 13.8% leaves. The animal diet of red-vented bulbul (*Pycnonotus cafer*) in this study comprised of 56.8% flies, mosquitoes, bees and ants, 37.5% crickets, cockroaches, termites and grasshoppers and 5.7% house lizards and skinks. Hussian and Afzal (2005) reported that in cotton-wheat based agro-ecosystem of Punjab, Pakistan this bird feeds on seeds and fruit parts of several weeds, figs and grains of millet.
(Pennisetum typhoides) as well as bugs, beetles, weevils, ants, bees and thrips. In Houston, Texas Brooks (2013) found that diet of Red-vented bulbul (Pycnonotus cafer) was made of berries, fruit, flowers, buds, flying insects and bugs. Rasmussen and Anderton (2005) reported that Himalayan bulbul (Pycnonotus leucogenys) are omnivores and feed on plant matter (berries, fruit, buds, seeds and nectar) insects (especially beetles, ants and grubs) and other invertebrates. Palita et al. (2011) studied the food habits of Himalayan bulbul (Pycnonotus leucogenys) and found that this bird is predominantly frugivore and prefers fruit of Ficus palmata followed by Morus alba. Fruits of Berberis asiatica, Pyracantha crenulata and Rubus ellipticus are also consumed by this bird.

Roberts (1992) and Rasmussen and Anderton (2005) reported that ashy prinia (Prinia socialis) is an insectivorous bird. Balachandan and Lima (1992) reported that this species feeds on a wide variety of insects including aphids, coccids, earwigs, leafhoppers, caterpillars, butterflies and spiders. They found that flower nectar is also consumed by this bird. In a study of diet composition of this bird in cotton-wheat based agro-ecosystem of Punjab, Pakistan Hussain and Afzal (2005) have revealed that bugs (order Hemiptera) were preferred but thrips (order Thysanoptera), bees, ants, sawflies and wasps (order Hymenoptera), termites (order Isoptera), flies and mosquitoes (order Diptera), butterflies and moths (order Lepidoptera) and beetles and weevils (order Coleoptera) were also found in its gizzard.

Whistler (1986) recorded remains of beetles, carabid larvae as well as green vegetative matter in the gut of pied bushchat (Saxicola caprata). Ali and Ripley (1987) and Roberts (1992) have reported that this bird primarily consumes insects. Rahmani (1996) observed pied bushchat perching on Capparis bushes in India but
never observed the bird consuming seeds or other plant parts of this plant. He found that the bird picked insects in bushes. He also observed pied bushchat feeding on Camponotus ants. Birdlife International (2001) reported that this bird is solely insectivorous. Hussain and Afzal (2005) have reported that in cotton-wheat based agro-ecosystem of Punjab, Pakistan, pied bushchat feeds on mosquitoes, flies and bugs.

Drongos are insectivores and perform ariel sallies to pursue the insects by gliding. They usually do not catch insects on ground but use trees as vantage points to hunt the preys. Roberts (1991) reported that drongos consume large insects especially grasshoppers, crickets and dragonflies. Asokan et al. (2009b) have found that drongos perch on the back of livestock and pursue the insects when they are disturbed by grazing animals. They studied the foraging ecology of black drongo (*Dicrurus macrocercus*) in agro-ecosystem of Nagapattinam District, Tamil Nadu, India and found that 23.7% of their food consisted of insects belonging to order Coleoptera followed by 21.6% Hemiptera, 19.3% Orthoptera, 14.4% Hymenoptera, 7.5% Lepidoptera, 6.8% Diptera and 6.0% Odonata. Rahmani et al. (2010) worked on food habits of black drongo and found that these birds consumed bugs, beetles, grasshoppers, bees, moths and dragonflies in in Couvery Delta, Southern India. They reported that drongos use trees as vantage points but they hunt in close proximity to the ground. Naryana et al. (2014) reported that in croplands of Nalgonda district of Andhra Pradesh, India black drongo uses trees and shrubs as foraging substrates to find the insect prey.

Irshad and Mirza (2011) found that drongos are open country birds and eat flying insects disturbed by movement of livestock or when vegetation is set on fire. They determined the diet composition of black drongo (*Dicrurus macrocercus*) in
The riverine habitat of Lahore, Pakistan by crop content analysis and found that 79% of the food of this bird consisted of grasshoppers while crickets and mole crickets were also consumed.

Mathew et al. (1978) have reported that ashy drongo (Dicrurus leucophaeus) primarily feeds on beetles and weevils (order Coleoptera), bugs (order Hemiptera) and grasshoppers, crickets and cockroaches (order Orthoptera). Ali (1979) and Akhlaq (1987) reported that drongos play an important role in reducing insect pests in agro-ecosystems of India. Asokan et al. (2009a) also reported that drongos are biological control agents of pests in India. In rice agroecosystem of Pondicherry, India Nathan and Rajendran (1982) reported that black drongos (Dicrurus macrocercus) potentially consumed harmful insect pests of rice crop. Their diet included stem borer, leaf rollers and skippers. Diet of this bird in cotton-wheat based agro-ecosystem of Punjab, Pakistan was composed of bees, ants, wasps, bugs, beetles and weevils (Hussain and Afzal, 2005).

White et al. (2005) and Crisp and Lill (2006) reported that common myna (Acridotheres tristis) is highly adapted to utilize human mediated landscapes. Councilman (1974) found that the myna is an omnivore and feeds on berries, fruit and seeds of plants. It also consumes insects, other invertebrates and chicks of other birds. Ali (1979) reported that common myna forage on insects like termites, grasshoppers, beetles and bugs while plant food comprises of fruit, seeds and flower nectar. They reported that myna swallows fruit and seeds as whole. Irshad and Mirza (2011) reported that mynas are able to exploit a wide variety of habitats because of their broad ecological niche. They investigated the diet of bank myna (Acridotheres ginginianus) in the Ravi Riverine habitat of Lahore, Pakistan and found that 54% of the diet of this bird was comprised of insect larvae (especially Lepidoptera), beetles,
grasshoppers, crickets and cockroaches. However, they were not able to identify the plant based food of the bird but estimated that 29% of the food of bank myna consisted of seeds. Many authors have confirmed that the mynas are insectivores and consume the insects dispersed by grazing livestock (Ali and Ripley, 1987; Roberts, 1992; Masood, 2004).

Sengupta (1976) studied the food and foraging ecology of common myna (Acridotheres tristis) in India and found that this species consumes several insects including grasshoppers, beetles, crickets, bugs, weevils and wasps. The plant based food of common myna was found to be berries of peepal (Ficus religiosa), banyan (Ficus indica), wild fig (Ficus cunia) and fruit of neem (Azadarachta indica). He found that during pre-monsoon and monsoon season this bird increases the uptake of insects to meet their protein needs for egg laying and rearing of chicks. Hussain and Afzal (2005) studied food habits of common myna in croplands of Punjab, Pakistan and found that plant food of this bird was composed of grains of wheat, maize and millet as well as figs along with insects belonging to orders Hymenoptera, Hemiptera, Diptera, Coleoptera, Lepidoptera and Orthoptera.

It has been reported that larks are omnivores and consume seeds and green parts of plants as well as insects (Ali, 1979; Akhlaq, 1987). Whistler (1986) reported that larks are ground feeders associated with grassy areas and farmlands.

Hussain and Afzal (2005) worked on diet composition of ashy crowned finch lark (Ammomanes phoenicurus) in croplands of Punjab, Pakistan and found that these birds consumed seeds of several weeds as well as termites and thrips. Khaleghizadeh and Sehhatisabet (2006) worked on the food habits of crested lark (Galenda cristata) in Iran by analysis of crop contents and identified seeds of 30 plant
species. The most common plant species contributing to the diet of this bird were *Agrostemma githago*, *Allium* sp., *Amaranthus retroflexus*, *Anchusa* sp., *Asperugo procumbens*, *Carduus arabicus*, *Fumaria vaillantii*, *Kochia scopardia*, *Lithospermum arvense*, *Panicum* sp., *Polygonum aviculare*, *Rumex* sp., *Setaria virdis*, *Sorghum halepense*, *Spergularia* sp., *Triticum* sp. and *Vaccaria oxyodonta*. They also found that insects belonging to order Coleoptera and Orthoptera are eaten by this bird. In Pakistan, the crop content analysis of Crested lark (*Galenda cristata*) in river ecosystem of Lahore revealed that 71% diet of this bird was plant based preferably based on seeds while insect based food consisted of beetles (25%) and dragonflies (4%) (Irshad and Mirza, 2011). Roberts (1992) reported that Common lark (*Alauda arvensis*) consumes green leaf material as well as insects especially grasshoppers, cockroaches, crickets and beetles. Donald *et al.* (2001b) reported that in Britain common larks consume cereal grains, cereal leaves and broad-leaved weed leaves during winter. Rasmussen and Anderton (2005) found that these birds feed on insects and other invertebrates during summer season while during winter season seeds and green plant parts are consumed. Bruun *et al.* (1992) and Grzimek (2003) studied the food habits of common lark and found that these birds forage on the ground and consume weed seeds as well as waste grain. Among invertebrates they feed on beetles, caterpillars, millipedes, slugs and earthworms.

Khaleghizadeh *et al.* (2006) determined the diet composition of common lark in northern Iran and reported that this migratory winter visitor feeds exclusively on oilseed rape (*Brassica napus* L.) plants in Iran.

Harrop (1991) reported that babblers partly forage on ground and partly on tree trunks and branches. Stuart and Stuart (1999) reported that the babblers are arboreal in foraging habits but in arid regions some babblers are terrestrial and spend
most of their time on ground searching for food. Dhindsa et al. (1995) reported that babbler are omnivores and eat fruit, seeds and insects. They found that babbler consume many insects that are common in crops and thus act as biological control agents of pests. Roberts (1992) also recorded omnivorous habit of this bird, consuming seeds, fruit and insects. The insects belonging to order Orthoptera made major component of its diet in summer. He reported that diet of nestlings consists of only insects. Anava et al. (2000) worked on foraging ecology of Arabian babbler (Turdoides squamiceps) and reported that in arid environment these babbler consume invertebrates and fruits whose availability depends on rain which is unpredictable. Arbabi et al. (2008) reported that in Iran diet of common babbler (Turdoides caudata) was composed of insects belonging to order Orthoptera, Coleoptera and Hymenoptera. Hussain and Afzal (2005) found that in agro-ecosystem of Punjab, Pakistan common babbler feeds on grains of wheat (Triticum aestivum), rice (Oryza sativa), maize (Zea mays) and millet (Pennisetum typhoides) as well as seeds of several weeds and guava (Psidium guajava). They found insect base diet of this bird was composed of bees, wasps, ants, mosquitoes, flies, thrips, bugs, grasshoppers, crickets and cockroaches.

Cramp and Simmons (1993) reported that in India large grey babblers feed on grasshoppers, beetles, ants and spiders as well as plant matter containing berries of Lantana spp., cereal grains, seeds of various plants, leaves of grasses and nectars of Capparis spp. A study by Toor and Saini (1986) on feeding ecology of large grey babbler in agro-ecosystem of Punjab, India has revealed that the babbler is omnivore and forages on ground in close vicinity of crop fields. It was observed feeding on maize grains at different stages of maturity, and wheat grainsat harvest and sowing stages. It also feeds on leaves of Delbergia sissoo and berries of Ziziphus jujube and
Morus spp. During monsoon and fall termites were included in the diet. The bird was also observed consuming insects in pearl millet (Pennisetum typhoides) fields but did not feed on grains of this crop.

Roberts (1992) reported that Indian tailorbird (Orthotomus sutorius) is an omnivore and it consumes seeds and leaves of weeds as well as nectar from Capparis aphylla, Capparis spinosa and Salmalia spp. The bird largely fed upon beetles, weevils, bugs, ants and flies. Strange (2003) found that this species consumes adults and larvae of insects as along with small fruit, berries, tiny seeds and nectar. In agro-ecosystem of Punjab, Pakistan Hussain and Afzal (2005) recorded guava seeds (Psidium guajava) in its gut contents. Shrubb (2003) reported that Indian tailorbird feeds their juveniles on a mixture of caterpillars, winged insects and other invertebrates.

5.3 MATERIALS AND METHODS

5.3.1 Collection of Bird droppings

Bird droppings were collected arbitrarily and opportunistically at the selected study sites (Chapter 1, section 1.12.10) during each field visit. In order to rule out any possibility of misidentification of the droppings during field collection, only directly seen defecated droppings were collected from the nesting and roosting sites of the target bird species. Therefore, out of 25 bird species recorded, I was able to collect droppings of nine species over the entire study period. The microhistological technique for analyses of fecal droppings was employed to determine the diet composition of the bird species. The collected fecal samples belonged to two species of frugivores viz: red vented bulbul (Pycnonotus cafer) and Himalayan bulbul (Pycnonotus leucogenys); three species of insectivores namely ashy prinia (Prinia
socialis), bushchat (Saxicola caprata) and ashy drongo (Dicrurus leucophaeus) and four species of omnivores namely, common myna (Acridotheres tristis), common lark (Alauda arvensis), large grey babbler (Turdoides malcolmi) and Indian tailorbird (Orthotomus sutorius).

In total, 950 droppings belonging to nine bird species were collected. The individual samples were placed in plastic vials with a label containing all possible information related to a sample (i.e. name of the species, date, time, season, etc.). The samples were then brought to the laboratory at the Department of Wildlife Management, Pir Mehr Ali Shah (PMAS) Arid Agriculture University Rawalpindi and examined immediately after arrival.

5.3.2 Collection of Plant Reference Materials

Simultaneous with the collection of fecal samples, surveys of local vegetation, i.e. trees, shrubs, grasses and cultivated crops in the study areas were also conducted. On the literature based information regarding feeding habits of target bird species, all possible local floras were collected as reference material from the areas of possible foraging territory of the species under study.

Two specimens of each reference plant were collected; one for maintaining the reference record and the other for the preparation of micro-histological slides of the reference materials. The reference plants were dried by placing in newspaper folds. Help of a taxonomist was sought for the identifications. A herbarium collection was established which contained almost all prominent vegetation of the study area. Distinguishing characteristics of each part of reference plant species were recorded for comparison in order to identify the plant materials found in the fecal droppings of the birds.
5.3.3 Collection of Invertebrate Reference Materials

Special efforts were made to collect all possible insect and invertebrate fauna (as reference material) of the study sites that were possibly contributing to the diet of target bird species. The insects were collected by sweep nets and live insects were put in the cyanide killing bottle for ten minutes after which the dead specimens were preserved in insect boxes. The cyanide killing bottle was prepared by using 25g of potassium cyanide crystals and 1.5cm dry layer of plaster of Paris. It was allowed to set and dry and then covered by a disc of blotting paper to absorb moisture (Upton, 1991). Being not an expert “Entomologist”, the investigator sought help from the Department of Entomology, PMAS-Arid Agriculture University, Rawalpindi for insect identification, preservation and maintenance of the collection.

5.3.4 Processing of Bird droppings

In the laboratory, the fecal contents were segregated (first by naked eye and then by 10X hand lens) into various identical groups based on their classification as plant based and animal based materials.

For microscopic analysis, the droppings were washed gently under running tap water. The material was then transferred to a labeled test tube and 5% warm sodium hydroxide solution was added to it. The test tube was heated in boiling water for 4-6 minutes. The particles were allowed to settle before removing the supernatant dark fluid and this treatment was repeated 3-7 times until a relatively clear solution was produced. Then the material was washed four times with warm distilled water. The sample material was dehydrated through a series of 25%, 50%,
75%, and 100% alcohol treatments. Then alcohol was removed through a series of 25%, 50%, 75%, and 100% xylene and alcohol mixtures. The material was air dried by using blotting paper. It was then transferred to a microscope glass slide and evenly spread and mounted in DPX mounting medium under a cover slip. Same procedure was used for the processing of the reference materials.

The micro slides were studied in detail by recording the specific cell characteristics of different parts of the plants and wings, heads, mandibles, etc. of arthropods that survive digestion. Since it was not possible to find any organism in intact form therefore I was able to identify the insects up to Order level. The insect parts in the droppings were identified following Asokan et al. (2009b) on the basis of various insect remains in feces. According to them, Coleoptera are best identified by distinguishing mandibles, elytra and leg fragments; Hemiptera by mouthparts, H-shaped tergal parts and leg fragments; Hymenoptera by mouthparts as well as wing and length fragments; Orthoptera by mandibles and raptorial leg fragments; Diptera by antennae, wings and eyes; Odonata by head capsules as well as wing and leg fragments and Lepidoptera by proboscis and wing scales. These characteristics were used as key features for comparison and identification of the materials found in the fecal samples prepared for microscopic study.

5.4 STATISTICAL ANALYSIS

The data generated by microscopic analysis of the slides prepared from fecal matter were expressed as Food Importance Index (FII) following Beck (1952) and Bhandary et al. (1986). Since the fecal analysis approach was utilized to determine avian diet composition the FII was calculated following Hussain and Sultana (2013).

\[
\text{Food Importance Index (FII)} = \frac{\% \text{ Frequency} + \% \text{ Composition}}{2}
\]

Where,
Frequency (%) = \( \frac{\text{No. of microfield locations in which a species occurred}}{\text{Total No. of microfield locations examined and}} \times 100 \)

Composition (%) = \( \frac{\text{Occurrence of a food item in a sample}}{\text{Total occurrence of all food items}} \times 100 \)

The season-wise diet similarity between the species was calculated by Sorensen similarity index \( (S_s) \) following Magurran, 2004 and Rolecek et al. (2010).

\[ S_s = \frac{2a}{b + c} \] (a)

where,

- \( a \) = no. of food items shared by both species
- \( b \) = no. of food items eaten by species A
- \( c \) = no. of food items eaten by species B

5.5 RESULTS

5.5.1 Diet Composition of Frugivores

5.5.1.1 Red-vented bulbul (Pycnonotus cafer)

A total of 150 samples were available for fecal analysis to determine diet composition of red-vented bulbul (Pycnonotus cafer) in which 13 food items were identified (Table 5.1) including nine plant species (69.2%) and four insect species (30.8%). Plant-based food dominated the diet of this species during all seasons. The choice of fruit consumed was dependent on its availability. During winter fruit of five plant species were eaten by P. cafer namely Lantana camara, Carissa opaca, Zizyphus nummularia, Ficus carica and Zizyphus mauritiana. Among these dominant were berries of Zizyphus nummularia followed by Lantana camara. The spring samples were dominated by berries of Ficus carica popularly called wild figs followed by Zizyphus mauritiana. Since the berries of Zizyphus spp. and...
Carissa spp. were not available during summer months, the bulbul relied upon fruit of Morus alba, Ficus carica and Capparis decidua. In monsoon season, the plant based food component of this bird was consisted of berries of Ficus carica, Capparis decidua and millet grains (Pennisetum typhoides). During fall, berries of Ficus carica were preferred over those of Lantana camara. The seeds recovered from the droppings were intact. Among invertebrates, insects belonging to order Lepidoptera, Coleoptera, Hymenoptera and Isoptera were consumed by bulbuls. The insects of order Coleoptera were preferred during winter. During summer and monsoon season at least 50% of the diet was insect based while during rest of the year plant based food was dominant in the diet of this species.

5.5.1.2 Himalayan bulbul (Pycnonotus leucogenys)

Analysis of 125 fecal samples of Himalayan bulbul (Pycnonotus leucogenys) revealed occurrence of remains of nine plant species namely; Lantana camara, Carissa opaca, Zizyphus nummularia, Ficus carica, Zizyphus mauritiana, Morus alba, Capparis decidua, Capparis aphylla and Pennisetum typhoides. The Table 5.1: Food Importance Index and seasonal diet composition of Red-vented bulbul (Pycnonotus cafer) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Seasonal Food Importance Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food items</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td><strong>Plant species</strong></td>
</tr>
<tr>
<td>Lantana camara</td>
</tr>
<tr>
<td>Carissa opaca</td>
</tr>
</tbody>
</table>
animal based component was consisted of insects belonging to order Lepidoptera, Coleoptera, Hymenoptera, Homoptera and Orthoptera (Table 5.2). During winter season, berries of *Lantana camara* were consumed the most followed by *Zizyphus nummularia*. In spring season, berries of *Lantana camara* were preferred over *Ficus carica* while fruit of *Zizyphus nummularia* was least consumed. During summer, fruit of *Ficus carica, Morus alba*, and *Capparis aphylla* were consumed almost at same proportions while *Capparis decidua* was the least preferred. In monsoon season, proportion of plant based food decreased to 38% and it was replaced by invertebrates. During fall season this bulbul consumed berries of *Ficus carica, Lantana camara, Carissa opaca* and *Capparis deciduas* and seeds of *Pennisetum typhoides*. The seeds recovered from the droppings were intact.
5.5.1.3 Diet similarity between red-vented bulbul (*Pycnonotus cafer*) and Himalayan bulbul (*Pycnonotus leucogenys*)

The diet similarity between red-vented and Himalayan bulbul was calculated for each season separately and is presented in Table 5.3. The highest similarity was recorded in winter ($S_s = 0.88$) when both species were feeding exclusively on *Zizyphus nummularia* and *Lantana camara*. The lowest similarity was estimated in monsoon season ($S_s = 0.71$) when red-vented bulbul continued to feed on plant based food (fruit of *Ficus carica*) but Himalayan bulbul shifted its preference to the insect based food.

5.5.2 Diet Composition of Insectivorous Birds

5.5.2.1 Ashy prinia (*Prinia socialis*)

In total 100 samples were available to explore food selection of ashy prinia

**Table 5.2:** Food Importance Index and seasonal diet composition of Himalayan bulbul (*Pycnonotus leucogenys*) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Food items</th>
<th>Winter (n=25)</th>
<th>Spring (n=25)</th>
<th>Summer (n=25)</th>
<th>Monsoon (n=25)</th>
<th>Fall (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lantana camara</em></td>
<td>14.64</td>
<td>13.08</td>
<td>-</td>
<td>-</td>
<td>3.62</td>
</tr>
<tr>
<td><em>Carissa opaca</em></td>
<td>5.58</td>
<td>4.58</td>
<td>-</td>
<td>-</td>
<td>2.55</td>
</tr>
<tr>
<td><em>Zizyphus nummularia</em></td>
<td>12.59</td>
<td>4.07</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Ficus carica</em></td>
<td>-</td>
<td>9.15</td>
<td>8.09</td>
<td>5.09</td>
<td>7.09</td>
</tr>
<tr>
<td><em>Zizyphus mauritiana</em></td>
<td>6.59</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Species</td>
<td>Winter</td>
<td>Spring</td>
<td>Summer</td>
<td>Monsoon</td>
<td>Fall</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Morus alba</td>
<td>-</td>
<td>-</td>
<td>7.09</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Capparis deciduas</td>
<td>-</td>
<td>-</td>
<td>4.07</td>
<td>8.10</td>
<td>4.07</td>
</tr>
<tr>
<td>Capparisapylla</td>
<td>-</td>
<td>-</td>
<td>7.61</td>
<td>4.07</td>
<td>-</td>
</tr>
<tr>
<td>Pennisetum typhoides</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.58</td>
</tr>
</tbody>
</table>

**Insect Orders**

<table>
<thead>
<tr>
<th>Insect Order</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Monsoon</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepidoptera</td>
<td>5.52</td>
<td>3.02</td>
<td>2.53</td>
<td>2.05</td>
<td>3.52</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>5.04</td>
<td>2.02</td>
<td>4.03</td>
<td>4.05</td>
<td>2.03</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>2.53</td>
<td>2.53</td>
<td>4.53</td>
<td>3.57</td>
<td>2.02</td>
</tr>
<tr>
<td>Homoptera</td>
<td>4.02</td>
<td>1.02</td>
<td>2.54</td>
<td>1.05</td>
<td>3.02</td>
</tr>
<tr>
<td>Orthoptera</td>
<td>-</td>
<td>4.02</td>
<td>-</td>
<td>2.52</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 5.3:** Seasonal diet similarity between red-vented bulbul (*Pycnonotus cafer*) and Himalayan bulbul (*Pycnonotus leucogenys*) inhabiting croplands of Pothwar plateau, Pakistan.
(Prinia socialis). Based on the results of fecal analysis, the bird can be designated as full time insectivorous in feeding habits. The insects belonging to order Diptera, Isoptera, Hemiptera, Coleoptera and Homoptera were identified constituting the fecal samples (Table 5.4). During winter and spring seasons, insects belonging to order Hemiptera were preferred followed by Coleoptera and Isoptera whereas insects belonging to order Diptera were least preferred. During summer and monsoon Homoptera were also consumed by the bird. During fall highest preference was recorded for Coleoptera followed by Hemiptera while consumption of insects belonging to Diptera and Isoptera had relatively lower preference.

5.5.2.2 Pied Bushchat (Saxicola caprata)

There were collected 19 droppings of pied bushchat (Saxicola caprata) in each season making up a total of 95 droppings. The species was entirely insectivorous depending upon the insects belonging to orders Lepidoptera, Diptera, Odonata, Thsanoptera, Neuroptera and Hemiptera. Flies and mosquitoes (order Diptera) seemed to be the favorite food of the species which were preferred over all
other preys in all seasons. It was followed by butterflies and moths (order Lepidoptera). During winter and fall dragonflies and damselflies (order Odonata), and thrips (order Thysanoptera) were also consumed by this bird. In the spring season, highest consumption was of insects belonging to order Diptera followed by Hemiptera (the bugs) and Lepidoptera. Thysanopterans appeared to be least consumed in winter, spring and fall as compared to other insects while these were entirely absent from the summer and monsoon samples. In the summer and monsoon season, the favourite food was consisted of insect species belonging to orders Diptera, Hemiptera and Lepidoptera (Table 5.5).

Table 5.4: Food Importance Index and seasonal diet composition of ashy prinia

*(Prinia socialis)* inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Insect Orders</th>
<th>Winter (n=20)</th>
<th>Spring (n=20)</th>
<th>Summer (n=20)</th>
<th>Monsoon (n=20)</th>
<th>Fall (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diptera</td>
<td>2.55</td>
<td>2.58</td>
<td>2.56</td>
<td>2.11</td>
<td>2.06</td>
</tr>
<tr>
<td>Isoptera</td>
<td>4.14</td>
<td>3.12</td>
<td>3.09</td>
<td>2.06</td>
<td>2.12</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>4.59</td>
<td>4.15</td>
<td>3.11</td>
<td>3.60</td>
<td>3.62</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>4.23</td>
<td>3.65</td>
<td>3.7</td>
<td>3.68</td>
<td>4.71</td>
</tr>
<tr>
<td>Homoptera</td>
<td>-</td>
<td>-</td>
<td>2.04</td>
<td>3.55</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 5.5: Food Importance Index and seasonal diet composition of pied bushchat

*(Saxicola caprata)* inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Insect Orders</th>
<th>Winter (n=19)</th>
<th>Spring (n=19)</th>
<th>Summer (n=19)</th>
<th>Monsoon (n=19)</th>
<th>Fall (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepidoptera</td>
<td>3.63</td>
<td>3.11</td>
<td>4.11</td>
<td>3.87</td>
<td>4.63</td>
</tr>
<tr>
<td>Diptera</td>
<td>4.17</td>
<td>4.64</td>
<td>7.99</td>
<td>9.21</td>
<td>8.56</td>
</tr>
<tr>
<td>Odonata</td>
<td>3.6</td>
<td>2.06</td>
<td>1.22</td>
<td>1.88</td>
<td>2.52</td>
</tr>
<tr>
<td>Thysanoptera</td>
<td>1.6</td>
<td>1.02</td>
<td>-</td>
<td>-</td>
<td>1.13</td>
</tr>
<tr>
<td>Neuroptera</td>
<td>-</td>
<td>2.08</td>
<td>2.56</td>
<td>1.09</td>
<td>-</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>-</td>
<td>4.09</td>
<td>4.04</td>
<td>3.99</td>
<td>-</td>
</tr>
</tbody>
</table>
5.5.2.3 Ashy drongo (*Dicrurus leucophaeus*)

Sixty samples were procured for diet composition analysis of ashy drongo (*Dicrurus leucophaeus*). The bird was an insectivore and food was made up by insects belonging to orders Orthoptera, Hymenoptera, Hemiptera, Homoptera, Thysanoptera, Neuroptera and Dermaptera (Table 5.6). Based on entire study data, the highest Food Importance Index values were estimated for Orthoptera (grasshoppers, crickets and cockroaches) showing highest frequency and highest percent composition of this insect order, followed by Hymenoptera (bees, wasps, ants, sawflies) and Hemiptera (bugs) while Neuroptera (alderflies, lacewings, dobsonflies) were least preferred. The insects of order Dermaptera (earwigs) were not found in any sample of spring and summer while they were present in adequate amount in the fecal collection of monsoon and fall. No samples were available during winter because the bird seemed to be absent from the study area over this period.

5.5.2.4 Diet similarity among three insectivore species

Sorensen similarity index was calculated on the basis of seasonal availability of droppings of selected species (Table 5.7). Highest diet similarity was recorded between ashy prinia (*Prinia socialis*) and pied bushchat (*Saxicola caprata*) in the monsoon season when 67% food items were shared by these two insectivores ($S_s = 0.67$). Lowest Sorensen similarity index ($S_s = 0.18$) was recorded in the fall season
between pied bushchat (*Saxicola caprata*) and ashy drongo (*Dicrurus leucophaeus*) and, between ashy prinia (*Prinia socialis*) and ashy drongo (*Dicrurus leucophaeus*).

**Table 5.6:** Food Importance Index and seasonal diet composition of ashy drongo (*Dicrurus leucophaeus*) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Insect Orders</th>
<th>Spring (n=15)</th>
<th>Summer (n=15)</th>
<th>Monsoon (n=15)</th>
<th>Fall (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoptera</td>
<td>6.11</td>
<td>7.15</td>
<td>6.09</td>
<td>6.13</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>4.61</td>
<td>4.61</td>
<td>3.62</td>
<td>3.10</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>4.11</td>
<td>2.59</td>
<td>3.65</td>
<td>3.60</td>
</tr>
<tr>
<td>Homoptera</td>
<td>2.09</td>
<td>1.57</td>
<td>2.56</td>
<td>5.06</td>
</tr>
<tr>
<td>Thysanoptera</td>
<td>5.05</td>
<td>3.57</td>
<td>1.56</td>
<td>1.04</td>
</tr>
<tr>
<td>Neuroptera</td>
<td>1.02</td>
<td>3.02</td>
<td>-</td>
<td>1.04</td>
</tr>
<tr>
<td>Dermaptera</td>
<td>-</td>
<td>-</td>
<td>3.53</td>
<td>3.54</td>
</tr>
</tbody>
</table>
Table 5.7: Seasonal diet similarity among ashy prinia (*Prinia socialis*), pied bushchat (*Saxicola caprata*) and ashy drongo (*Dicrurus leucophaeus*) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Season</th>
<th>Species</th>
<th>Sorensen Similarity Index ($S_s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Pied bushchat (<em>Saxicola caprata</em>)</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Pied bushchat (<em>Saxicola caprata</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.20</td>
</tr>
<tr>
<td>Spring</td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Pied bushchat (<em>Saxicola caprata</em>)</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Pied bushchat (<em>Saxicola caprata</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.20</td>
</tr>
<tr>
<td>Summer</td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Pied bushchat (<em>Saxicola caprata</em>)</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Pied bushchat (<em>Saxicola caprata</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.36</td>
</tr>
<tr>
<td>Monsoon</td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Pied bushchat (<em>Saxicola caprata</em>)</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Pied bushchat (<em>Saxicola caprata</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.36</td>
</tr>
<tr>
<td>Fall</td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Pied bushchat (<em>Saxicola caprata</em>)</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>Pied bushchat (<em>Saxicola caprata</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Ashy prinia (<em>Prinia socialis</em>) and Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>0.18</td>
</tr>
</tbody>
</table>
5.5.3 Diet Composition of Omnivorous Birds

5.5.3.1 Common myna (*Acridotheres tristis*)

A total of 150 fecal samples of common myna (*Acridotheres tristis*) were collected for its food habit analysis and overall results helped to designate it an omnivorous bird (Table 5.8). Thiry fecal sample collected in winter season showed presence of only two food items i.e. wheat and kanzala (*Carthamus oxycantha*) leaves, with highest Food Importance Index was estimated for wheat.

Analysis of the entire set of 150 fecal samples showed occurrence of several insects that varied among the seasonal samples. These included insects belonging to orders Diptera, Lepidoptera, Orthoptera, Homoptera, Hymenoptera, Hemiptera and Coleoptera but showed highest preference for the Dipterans.

In spring, wheat was still consumed in preference by common myna with supplementation of *Carthamus oxycantha* and *Ficus carica* and rest of the food was comprised of insects of order Lepidoptera. The summer diet was dominantly composed of *Ficus carica*, with supplementation of *Carthamus oxycantha* and *Lantana camara*. The insects based food contents of this season were consisted on Orthoptera, Homoptera and Coleoptera. The feces collected in monsoon consisted of only *Ficus carica*, maize (*Zea mays*) and insects belonging to three orders (Orthoptera, Homoptera and Coleoptera). In fall, again insect based food became dominant which belonged to orders Orthoptera, Homoptera, Hymenoptera, Hemiptera and Coleoptera whereas plant based food was made up by *Carthamus oxycantha*, *Zea mays*, *Pennisetum typhoides* and *Setaria pumila*. 
Table 5.8: Food Importance Index and seasonal diet composition of common myna

(Acridotheres tristis) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th></th>
<th>Winter (n=30)</th>
<th>Spring (n=30)</th>
<th>Summer (n=30)</th>
<th>Monsoon (n=30)</th>
<th>Fall (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Triticum aestivum</em></td>
<td>12.56</td>
<td>11.57</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Carthamus oxyacantha</em></td>
<td>5.11</td>
<td>6.61</td>
<td>6.1</td>
<td>-</td>
<td>4.07</td>
</tr>
<tr>
<td><em>Ficus carica</em></td>
<td>-</td>
<td>6.57</td>
<td>14.13</td>
<td>15.11</td>
<td>-</td>
</tr>
<tr>
<td><em>Lantana camara</em></td>
<td>-</td>
<td>-</td>
<td>4.13</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Zea mays</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.65</td>
<td>6.05</td>
</tr>
<tr>
<td><em>Pennisetum typhoides</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.55</td>
</tr>
<tr>
<td><em>Setaria pumila</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8.57</td>
</tr>
<tr>
<td><strong>Insect Orders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diptera</td>
<td>7.05</td>
<td>2.51</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lepidoptera</td>
<td>4.04</td>
<td>5.51</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Orthoptera</td>
<td>5.59</td>
<td>3.10</td>
<td>6.58</td>
<td>5.15</td>
<td>5.1</td>
</tr>
<tr>
<td>Homoptera</td>
<td>6.06</td>
<td>4.56</td>
<td>2.55</td>
<td>4.57</td>
<td>3.05</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td>2.03</td>
<td>3.05</td>
<td>-</td>
<td>-</td>
<td>3.55</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>4.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.03</td>
</tr>
<tr>
<td>Coleoptera</td>
<td>2.53</td>
<td>1.52</td>
<td>3.03</td>
<td>5.02</td>
<td>3.03</td>
</tr>
</tbody>
</table>
5.5.3.2 Common lark (*Alauda arvensis*)

Diet analysis of common lark (*Alauda arvensis*) was based on only 120 fecal samples collected during the entire study period. Since it is a winter visitor thus 40 samples per season were available in winter, spring, and fall. The bird relied on plant-based food during winter (Table 5.9).

It showed high preference for seeds and leaves of *Brassica campestris* and *Heteropogon contortus*. The diet was also supplemented with leaves of *Triticum aestivum* and *Capparis deciduas* and, seeds and leaves of *Ipomea eriocarpa*. The insects recovered from the droppings of this bird belonged to orders Coleoptera and Hemiptera. During spring season, *Brassica campestris* continued to be consumed in large amounts along with some proportions of *Gymnosporia royleana, Triticum aestivum, Heteropogon contortus* and *Sonchus asper*. The insect-based food was comprised of beetles and weevils (Order Coleoptera). In fall samples highest Food Importance Index was recorded for leaves of *Chenopodium album* while other plants eaten by species were *Brassica campestris, Sonchus asper, Setaria pumila* and *Xanthium strumarium*. The insects of order Coleoptera and Hemiptera were also found in the droppings.

5.5.3.3 Large grey babbler (*Turdoides malcolmi*)

A total of 100 droppings of large grey babbler (*Turdoides malcolmi*) were collected (20 per season) to determine the food composition of this species. The bird diet was based on 13 food items identified in the droppings (Table 5.10). The plant parts belonging to eight species were identified. Of these, wheat (*Triticum aestivum*)
was consumed during winter and spring both at sowing and harvest, Table 5.9: Food Importance Index and seasonal diet composition of common lark (Alauda arvensis) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Seasonal Food Importance Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food items</strong></td>
</tr>
<tr>
<td><strong>Plant species</strong></td>
</tr>
<tr>
<td>Ipomea eriocarpa</td>
</tr>
<tr>
<td>Triticum aestivum</td>
</tr>
<tr>
<td>Brassica campestris</td>
</tr>
<tr>
<td>Heteropogon contortus</td>
</tr>
<tr>
<td>Capparis deciduas</td>
</tr>
<tr>
<td>Gymnosporia roylaena</td>
</tr>
<tr>
<td>Sonchus asper</td>
</tr>
<tr>
<td>Chenopodium album</td>
</tr>
<tr>
<td>Setaria pumila</td>
</tr>
<tr>
<td>Xanthium strumarium</td>
</tr>
<tr>
<td><strong>Insect Orders</strong></td>
</tr>
<tr>
<td>Coleoptera</td>
</tr>
<tr>
<td>Hemiptera</td>
</tr>
</tbody>
</table>
Table 5

Table 5.10: Food Importance Index and seasonal diet composition of large grey babbler (*Turdoides malcolmi*) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Food items</th>
<th>Winter (n=20)</th>
<th>Spring (n=20)</th>
<th>Summer (n=20)</th>
<th>Monsoon (n=20)</th>
<th>Fall (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Triticum aestivum</em></td>
<td>6.06</td>
<td>5.06</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Pennisetum typhoides</em></td>
<td>4.54</td>
<td>-</td>
<td>-</td>
<td>9.55</td>
<td>11.07</td>
</tr>
<tr>
<td><em>Zea mays</em></td>
<td>5.56</td>
<td>-</td>
<td>7.99</td>
<td>7.05</td>
<td>5.64</td>
</tr>
<tr>
<td><em>Morus alba</em></td>
<td>-</td>
<td>3.58</td>
<td>3.22</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Melia azadarach</em></td>
<td>-</td>
<td>5.10</td>
<td>-</td>
<td>3.05</td>
<td>-</td>
</tr>
<tr>
<td><em>Ziziphus nummularia</em></td>
<td>-</td>
<td>3.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Sorghum bicolor</em></td>
<td>-</td>
<td>-</td>
<td>6.54</td>
<td>8.05</td>
<td>-</td>
</tr>
<tr>
<td><em>Saccharum bengalense</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.05</td>
<td>1.57</td>
</tr>
<tr>
<td><strong>Insect Orders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hymenoptera</em></td>
<td>4.63</td>
<td>4.54</td>
<td>6.73</td>
<td>5.60</td>
<td>3.57</td>
</tr>
<tr>
<td><em>Thysanoptera</em></td>
<td>2.06</td>
<td>1.54</td>
<td>-</td>
<td>1.05</td>
<td>1.07</td>
</tr>
<tr>
<td><em>Hemiptera</em></td>
<td>2.06</td>
<td>2.06</td>
<td>2.55</td>
<td>2.05</td>
<td>1.07</td>
</tr>
<tr>
<td><em>Lepidoptera</em></td>
<td>3.06</td>
<td>1.02</td>
<td>-</td>
<td>2.57</td>
<td>-</td>
</tr>
<tr>
<td><em>Orthoptera</em></td>
<td>5.04</td>
<td>2.01</td>
<td>2.76</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
while maize (*Zea mays*) and millet (*Pennisetum typhoides*) were consumed in monsoon, fall and winter. *Morus alba, Melia azadarach* and *Ziziphus nummularia* were consumed in addition to wheat during spring while in monsoon *Sorghum bicolor* and *Saccharum bengalense* were eaten along with *Zea mays,* *Pennisetum typhoides* and *Melia azadarach.* Only *Zea mays,* *Morus alba* and *Sorghum bicolor* were identified in summer samples while *Zea mays,* *Pennisetum typhoides* and *Saccharum bengalense* were recovered from fall samples. The insect based food was comprised of insects belonging to orders Hymenoptera, Hemiptera, Thysanoptera, Lepidoptera and Orthoptera with preference for Hymenoptera in all seasons.

### 5.5.3.4 Indian tailorbird (*Orthotomus sutorius*)

Only 50 samples were obtained from Indian tailorbird (*Orthotomus sutorius*) for analysis. A total of nine food items were identified. These included plant parts from six plant species namely *Sonchus asper,* *Erogrestis poroles,* *Gymnosporia roylaena,* *Grewia optiva,* *Heteropogon contortus* and *Setaria pumila* while insects belonging to orders Coleoptera, Hemiptera and Homoptera were found in the samples suggesting that the bird is omnivorous (Table 5.11). In winter season plant based diet component was comprised of *Gymnosporia roylaena* and *Heteropogon contortus.* In spring dropping analysis showed highest preference for *Gymnosporia roylaena* followed by *Sonchus asper* among plant based food while rest of plant species were not found in the samples.

Among insects Hemiptera were consumed the most with Food Importance
Table 5
Index value of 3.1. The analysis of summer samples showed presence of leaves of .11: Food Importance Index and seasonal diet composition of Indian tailorbird (*Orthotomus sutorius*) inhabiting croplands of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Winter (n=10)</th>
<th>Spring (n=10)</th>
<th>Summer (n=10)</th>
<th>Monsoon (n=10)</th>
<th>Fall (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Sonchus asper</em></td>
<td>-</td>
<td>3.65</td>
<td>-</td>
<td>-</td>
<td>3.55</td>
</tr>
<tr>
<td><em>Erogrestis poroles</em></td>
<td>-</td>
<td>-</td>
<td>5.5</td>
<td>3.07</td>
<td>5.55</td>
</tr>
<tr>
<td><em>Gymnosporia roylaena</em></td>
<td>6.33</td>
<td>4.63</td>
<td>3.94</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Grewia optiva</em></td>
<td>-</td>
<td>-</td>
<td>2.83</td>
<td>5.57</td>
<td>4.11</td>
</tr>
<tr>
<td><em>Heteropogon contortus</em></td>
<td>3.48</td>
<td>1.77</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Setaria pumila</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insect Orders</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coleoptera</td>
<td>3.76</td>
<td>2.08</td>
<td>2.46</td>
<td>3.14</td>
<td>1.17</td>
</tr>
<tr>
<td>Hemiptera</td>
<td>1.09</td>
<td>3.1</td>
<td>-</td>
<td>1.71</td>
<td>-</td>
</tr>
<tr>
<td>Homoptera</td>
<td>-</td>
<td>2.05</td>
<td>2.22</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Erogrestis poroles, Grewia optiva* and *Gymnosporia roylaena* while in monsoon leaves of only *Grewia optiva* and *Erogrestis poroles* were consumed.
Among insects, Coleoptera and Hemiptera were consumed. In fall, leaves of four species of plants were identified in the fecal samples namely *Erosogrestis poroles*, *Grewia optiva*, *Sonchus asper* and *Setaria pumila*. The insects eaten in this season were beetles and weevils (order Coleoptera).

### 5.5.3.5 Diet similarity among four omnivore species

Comparison of similarities in food selection by the selected four bird species is presented in Table 5.12. The winter data showed maximum food similarity between common myna (*A. tristris*) and common lark (*Alauda arvensis*) and between common lark (*Alauda arvensis*) and Indian tailorbird (*O. sutorius*) ($S_s = 0.38$) while this index was minimum between common myna (*A. tristris*) and Indian tailorbird (*O. sutorius*) ($S_s = 0.14$) (Table 5.12). In the spring season, common lark (*Alauda arvensis*) and Indian tailorbird (*O. sutorius*) showed the highest value of similarity index ($S_s = 0.55$) while the index value between common myna (*A. tristris*) and common lark (*Alauda arvensis*) was the lowest ($S_s = 0.27$). In the summer season, common myna (*A. tristris*) and Indian tailorbird (*O. sutorius*) had 17% ($S_s = 0.17$) similarity. No dietary items were shared between common myna (*A. tristris*) and Indian tailorbird (*O. sutorius*) as well as between large grey babbler (*T. malcolmi*) and Indian tailorbird (*O. sutorius*) during this season. During rainy months of monsoon, highest value for similarity index was estimated for common myna (*A. tristris*) and Indian tailorbird (*O. sutorius*) ($S_s = 0.22$). Fecal analysis in fall season showed the food similarity index between common myna (*A. tristris*) and large grey babbler (*T. malcolmi*) as $S_s = 0.53$ while .12: Seasonal diet similarity among the selected omnivore bird species inhabiting croplands of Pothwar plateau, Pakistan.
<table>
<thead>
<tr>
<th>Season</th>
<th>Species</th>
<th>Sorensen Similarity Index (S&lt;sub&gt;s&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td><em>Acridotheres tristis</em> and <em>Alauda arvensis</em></td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Turdoides malcolmi</em></td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Orthotomus sutorius</em></td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Turdoides malcolmi</em></td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Orthotomus sutorius</em></td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td><em>Turdoides malcolmi</em> and <em>Orthotomus sutorius</em></td>
<td>0.20</td>
</tr>
<tr>
<td>Spring</td>
<td><em>Acridotheres tristis</em> and <em>Alauda arvensis</em></td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Turdoides malcolmi</em></td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Orthotomus sutorius</em></td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Turdoides malcolmi</em></td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Orthotomus sutorius</em></td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td><em>Turdoides malcolmi</em> and <em>Orthotomus sutorius</em></td>
<td>0.29</td>
</tr>
<tr>
<td>Summer</td>
<td><em>Acridotheres tristis</em> and <em>Turdoides malcolmi</em></td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Orthotomus sutorius</em></td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td><em>Turdoides malcolmi</em> and <em>Orthotomus sutorius</em></td>
<td>0.00</td>
</tr>
<tr>
<td>Monsoon</td>
<td><em>Acridotheres tristis</em> and <em>Turdoides malcolmi</em></td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Orthotomus sutorius</em></td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td><em>Turdoides malcolmi</em> and <em>Orthotomus sutorius</em></td>
<td>0.15</td>
</tr>
<tr>
<td>Fall</td>
<td><em>Acridotheres tristis</em> and <em>Alauda arvensis</em></td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Turdoides malcolmi</em></td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td><em>Acridotheres tristis</em> and <em>Orthotomus sutorius</em></td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Turdoides malcolmi</em></td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td><em>Alauda arvensis</em> and <em>Orthotomus sutorius</em></td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td><em>Turdoides malcolmi</em> and <em>Orthotomus sutorius</em></td>
<td>0.00</td>
</tr>
</tbody>
</table>

no food item was shared between large grey babbler (*T. malcolmi*) and (*O. sutorius*) (S<sub>s</sub> = 0.00).
5.6 DISCUSSION

Determination of diet composition by micro-histology of fecal matter is a challenging procedure. It demands ample skills and expertise to identify variety of food taken by species on the basis of undigested fecal remains. In this study diet composition of nine bird species namely red vented bulbul (Pycnonotus cafer), Himalayan bulbul (Pycnonotus leucogenys), ashy prinia (Prinia socialis), pied bushchat (Saxicola caprata), ashy drongo (Dicrurus leucophaeus), common myna (Acridotheres tristis), common lark (Alauda arvensis), large grey babbler (Turdoides malcolmi) and Indian tailorbird (Orthotomus sutorius) was determined from their droppings collected at the roosting and nesting sites. However, it was not possible to draw any conclusion on relative prey selection of any of these bird species from the results of their fecal analysis because of differential digestion rates of different food materials. Further detailed studies focused on the identification of insect prey to species/family level based on fecal analysis should be carried out in future.

Red-vented bulbul (Pycnonotus cafer) was found to be a generalist and opportunistic feeder with ability to rely on different types of fruits and insects. These findings are supported by reports of Sankamethawee et al. (2011) in Thailand. The diet of P. cafer contained 69% plant based food and 31% insect. Unlike it Kerdkaew et al. (2014) investigated diet composition of two bulbul species in wild habitat of Thailand and reported that P. brunneus and P. goiavier derived 97% and 98.9% food from plant sources and only 3% and 1.1% from
insects respectively. Such high intake of insects in this study could be attributed to insect abundance in croplands as compared to the natural habitat of Thailand. In this study *P. cafer* preferred berries of *Zizyphus nummularia*, *Ficus carica* and *Zizyphus mauritiana* all of which constitute native flora of Pothwar plateau and are generally planted along the crop field boundaries. Feeding of *P. cafer* on ripened fruit of these plants has also been reported (Bhatt and Kumar, 2001). The berries of *Lantana camara* were also consumed by this species in large amounts. *Lantana camara* is a common invasive species in agricultural landscapes and rural habitats (Cooper, 2009; Berry *et al.*, 2011). This species is dietary part of various bulbul species in India, Mauritius and Thailand (Aravind *et al.*, 2010; Leinebjerg *et al.*, 2010; Kerdkaew *et al.*, 2014). In the Pothwar cropland, *P. cafer* was found to feed on millet seeds during monsoon and fall season which is supported by food habits records of it reported from cotton based agro-ecosystem of south Punjab, Pakisan (Hussain and Afzal, 2005).

Analysis of summer and monsoon fecal samples revealed occurrence of more than 50% insect remains while during other three seasons (fall, winter and spring) plant based food (leaves and grains) dominated the dietary components of *P. cafer*. This feeding pattern is supported by feeding habits of Chinese bulbul (*Pycnonotus sinensis*) of same genus (Wang *et al.*, 2005) that increases intake of insect food up to 55% of total dietary components during breeding season. The current records of butterflies, moths, bees, ants, termites, beetles and weevils in the fecal samples of *P. cafer* are conferred by by findings of Bhatt and Kumar (2001) and Brooks (2013) who reported flies, mosquitoes, bees, ants, crickets, cockroaches, termites and grasshoppers as food constituents of this bulbul.
The diertay analysis of Himalayan bulbul (*Pycnonotus leucogenys*) revealed occurrence of fruit and seeds of nine plant species i.e. *Lantana camara*, *Carissa opaca*, *Zizyphus nummularia*, *Ficus carica*, *Zizyphus mauritiana*, *Morus alba*, *Capparis decidua*, *Capparis aphylla* and *Pennisetum typhoides*. Among these, *Lantana camara* is an invasive species and its berries are also preferred by other bulbuls i.e. *P. cafer*, *P. brunneus* and *P. goiavier* (Aravind et al., 2010; Leinebjerg et al., 2010; Kerdkaew et al., 2014). Although millet (seeds) was the only cultivated crop consumed by Himalayan bulbul (*P. leucogenys*) during fall season but the bird was observed spending most of its time in feeding on berries and fruit of wild plants. These results are supported by findings of Rasmussen and Anderton (2005) and Palita et al. (2011) on food habits of *P. leucogenys* in India. Year round heavy reliance of *P. leucogenys* on butterflies, moths, beetles, weevils, bees, ants, wasps, aphids, crickets, grasshoppers and cockroaches is partially similar with findings of Wang *et al.* (2005) in China and Palita *et al.* (2011) in India. The high intake of insects could be attributed to support of cropping systems in hosting high populations of beetles, spiders and flies (Tischler, 1980; Jones *et al*., 2005). In all seasons Himalayan bulbul (*P. leucogenys*) appeared to be more insectivorous as compared to red-vented bulbul (*P. cafer*).

The outcome of current study has designated ashy prinia (*Prinia socialis*) as a full time insectivorous species which is supported by the observations of Roberts (1992) and Rasmussen and Anderton (2005) but this outcome is not in agreement with the findings of Balachandan and Lima (1992) who observed this species feeding on flower nectar as well. It could be expected that micro-histological technique employed in current study might not be able to detect remains of delicate nectars in the fecal samples or their presumable disappearance during the digestion process.
The insect based food of this bird was comprised of order Diptera, Isoptera, Hemiptera, Coleoptera and Homoptera with preference for bugs during winter and spring and beetles and weevils for rest of the period. However, termites were least consumed insect. Hussain and Afzal (2005) have reported similar feeding habits of this bird inhabiting cotton and wheat croplands of Punjab, Pakistan.

The pied bushchat (*Saxicola caprata*) was found to prefer flies and mosquitoes (order Diptera) followed by butterflies and moths (order Lepidoptera) and damselflies and dragonflies (order Odonata). Unlike, this full time insectivorous status, Whistler (1986) found green vegetative matter in the stomach of this bird. However, Birdlife International (2001) also reported exclusive feeding of *S. caprata* on insects only. Ali and Ripley (1987), Roberts (1992) and Hussain and Afzal (2005) have also reported that this bird primarily consumes flies and mosquitoes. Report of *S. caprata* feeding on ants (Rahmani, 1996) is not supported by the current findings.

The diet of ashy drongo (*Dicrurus leucophaeus*) was mainly based on grasshoppers, crickets and cockroaches with supplements of bees, wasps, ants, sawflies and bugs. Such high insectivory of this bird has also been documented in literature (Mathew *et al.*, 1978; Roberts, 1991; Irshad and Mirza, 2011). However, dragonflies (order Odonata) reported as favourite prey of *D. leucophaeus* was not evident in the fecal samples of this study.

The diet of the omnivorous common myna (*Acridotheres tristis*) was relying on a variety of food comprised of wheat, maize and millet grains, berries and fruit of wild plants (*Carthamus oxycantha, Ficus carica, Lantana camara* and *Setaria pumila*) and variety of insects, particularly flies and mosquitoes (order Diptera) and
butterflies and moths (order Lepidoptera). These are supported by report of Sengupta (1976), Roberts (1992), Masood (2004), Hussain and Afzal (2005) and Irshad and Mirza (2011). There was no evidence of termites’ remains as reported by Ali (1979) in the food of this myna.

The fecal material of winter visitor, common lark (*Alauda arvensis*), was available during fall, winter and spring seasons. The results of this study revealed that winter diet of this species was dominated by plant matter mainly seeds and leaves (83%) and insects were consumed in less quantity. Irshad and Mirza (2011) have also reported that in river ecosystem of Lahore 71% diet of Crested lark (*Galenda cristata*) was plant based and seeds were preferred. The seeds and green plant parts of *Brassica campestris* were preferred by Common lark (*Alauda arvensis*) followed by *Heteropogon contortus*. This is in concordance with findings of Khaleghizadeh et al. (2006). The leaves of *Triticum aestivum* and *Capparis decidua* were also eaten. In addition seeds and leaves *Ipomea eriocarpa*, *Gymnosporia royleana*, *Heteropogon contortus*, *Setaria pumila*, *Sonchus asper* and *Xanthium strumarium* were also consumed by this species. Akhlaq (1987), Roberts (1992) and Donald et al. (2001b) also reported that seeds and green parts of plants constitute winter diet of this bird. Similarly, Hussain and Afzal (2005) also found that weed seeds are consumed by larks in agro-ecosystem of Punjab, Pakistan. Beetles, weevils and bugs constitute the insect based diet of Common lark (*Alauda arvensis*). This is similar to the findings of Bruun et al. (1992), Grzimek (2003) and Khaleghizadeh et al. (2006).

The fecal content analysis of large grey babbler (*Turdoides malcolmi*) revealed that this species consumed four crops grown in the agro-ecosystem of Pothwar plateau namely wheat, maize, millet and *Sorghum bicolor*. These findings
are partially similar to those reported by Cramp and Simmons (1993) and Toor and Saini (1986) in agro-ecosystem of Punjab, India where they also found this species to be eating cereal grains especially wheat and maize. They found that *T. malcolmi* does not consume millet (*Pennisetum typhoides*) but in this study millet grains were recovered from the droppings of *T. malcolmi*. Hussain and Afzal (2005) also observed grains of wheat, maize, millet and rice and seeds of weeds in the diet of babblers inhabiting cotton-wheat based agro-ecosystem of Punjab, Pakistan. Cramp and Simmons (1993) observed large grey babbler feeding on berries of *Lantana* spp. while Rana (1974) saw them feeding on nectar of *Capparis* spp. but this was not true in this study. Among wild plants *T. malcolmi* consumed *Morus alba*, *Ziziphus nummularia*, *Melia azadarach*, and *Saccharum bengalense*. Dhindsa et al. (1995) also had the same results in rainfed agro-ecosystems of India. Among insects bees, wasps and ants were favored by this species. The other insects consumed were bugs, thrips, butterflies, moths, crickets, cockroaches and grasshoppers. Arbabi *et al.* (2008) also reported that bees, wasps and ants are preferred food of babblers in semi-arid regions of Iran. Toor and Saini (1986) in irrigated agroecosystem of India also observed this species feeding on termites but no termite remains were recovered from the fecal droppings of this bird in this study.

Seeds and leaves of several weed species were found in the droppings of Indian tailorbird (*Orthotomus sutorius*). These included leaves from six plant species namely *Sonchus asper*, *Erogerstis poroles*, *Gymnosporia roylaena*, *Grewia optiva*, *Heteropogon contortus* and *Setaria pumila*. These results are in disagreement to those of Roberts (1992) who observed this species feeding on *Capparis aphylla* and *Salmalia* spp. in wild habitats of Pothwar and Hussain and Afzal (2005) who observed Indian tailorbird (*Orthotomus sutorius*) feeding on guava
seeds (Psidium guajava) in cotton-wheat based agro-ecosystem of Punjab, Pakistan. The insect based food of this bird was comprised of beetles, bugs, aphids and leafhoppers. These findings are similar to those of Roberts (1992).

On the basis of study of food habits of selected passerine species in the croplands of Pothwar plateau by micro-histological analysis of fecal droppings it was found that these passerine species feed on variety of plant based and animal based foods. Among plants these species consume seeds, grains and leaves of crops cultivated in the area but also consume weeds and wild plants and none of the species has pest status in this agro-ecosystem. Similarly the invertebrate component of food is largely derived from insects many of which could be crop pests and thus by consuming them these birds keep a check on insect populations in this agroecosystem.
6.1 INTRODUCTION

Survey of breeding birds in a particular habitat or ecosystem is used to monitor the status and trends of bird populations. The results are valuable in evaluating the increasing and decreasing fashion of bird population which can be indicator of habitat characteristics and carrying capacity in hosting the populations and key point of their conservations. The presence and success of breeding birds in croplands is strongly determined by the characteristics of field boundary vegetation and the adjacent land-use (Sparks et al., 1996). Agricultural intensification and reduction in grassland patches leads to decreased nest success of birds (Jeffery et al., 2006) and consequently the breeding bird populations (Persson et al., 2010).

The availability of suitable nesting sites and nesting materials is crucial to determine the breeding period of species. The breeding success of many bird species is influenced by micro-habitat and vegetation composition around the nesting tree because in addition to food and nesting space, the material needed for nest construction, i.e. fibers, twigs and grasses are also obtained from micro-habitat and vegetation accompanying the nesting trees (Parajapati et al., 2011).

Different types of field edges have multiple effects on breeding ecology of associated farmland birds (Adams et al., 2015). The sites for nesting in agricultural landscapes are selected by a particular species depending upon the imminent cues of viability of the habitat for breeding, e.g. nest predation, human disturbance, etc.

It is also important to note that clutch size in birds is affected by several factors, e.g. diet availability, habitat quality and age of the parents-young parents lay
small number of eggs (Klomp, 1970; Hustler and Howells, 1978; Ndithia et al., 2007).

The nest density of passerines increases on farmlands when habitat is improved by creating intermittent patches of wild vegetation along the crop fields (Marcus et al., 2000; Smith et al., 2005b). Conovoer (2005) studied avian responses to field borders and found that nest density was positively correlated with the width of field margin but nest success was independent of this habitat variable.

Bergin et al. (2000) found that the nest success of breeding birds in field boundary vegetation depends on the habitat features and presence of predators. Dale et al. (1997) studied breeding of songbirds in the agricultural fields of Saskatchewan, Canada and recorded a decrease in nesting success with the removal of field margin vegetation.

Many farmland bird species do not prefer the wooded field edges (Walk et al., 2010). In Vermont, USA Keyel et al. (2013) worked on the edge-effects on nest site selection and reproductive success of birds and found that two passerine species namely bobolink (*Dolichonyx oryzivorus*) and savannah sparrow (*Passerculus sandwichensis*) prefer open and unwooded areas for nesting in agricultural landscapes.

Smith et al. (2005b) suggested that in order to improve the breeding success of birds inhabiting agricultural landscapes, field borders should be well established along the field margins instead of establishing them adjacent to patches of forests or grasslands. The establishment of field borders is crucial part of conservation buffer practices in agricultural landscapes and should consist of diversity of trees, shrubs and herbaceous vegetation. For breeding populations of birds the structure of
vegetation in field boundaries is also very important (Adams et al., 2015). For management purposes, grasses and early-successional herbaceous vegetation should be planted along field margins in order to enhance the breeding success of birds in farmlands.

Physical condition of nestlings and their resilience to parasites is strongly determined by the availability of food (Searchy et al., 2004; Cichon et al., 2006). It has been found that in agro-ecosystems, nesting and breeding success as well as nestling survival are strongly affected by the human activities leading to reduced habitat quality and decreased availability of food (Gilroy et al., 2009).

Several authors have indicated that electric wires are used for perching by birds and many birds construct nests close to electric wires in agro-ecosystems since in most agro-ecosystems predominant habitat underneath electric wires are grasses (Ali, 2003; Asokan et al., 2010).

A limiting factor in nest success of breeding birds that breed in agricultural landscapes is nest parasitism and nest predation. Two species namely brownheaded cowbirds (Molothrus ater) and American crows (Corvus brachyrhynchos) destroy the nests of birds in farmlands of North America (Winter, 1999). Domestic cats are a major cause of bird mortality in India and they easily attack the nests that are constructed at low height. Consequently several species e.g. ashy prinia (Prinia socialis), common tailorbird (Orthotomus sutorius), red-vented bulbul (Pycnonotus cafer), red-whiskered bulbul (Pycnonotus jocosus) and purple-rumped sunbird (Leptocoma zeylonica) have changed their nesting habits. Although these species are known to nest at low heights they now construct nests in upper branches of trees in order to avoid and reduce nest predation (Pachlore and Pachlore, 2012).
For effective avian conservation strategies in agro-ecosystems the studies on
nest-site characteristics, material used for nest construction, nest morphology and
related nesting and territorial behavior are important (Hanazak, 1971; Ali and Ripley,
1987; Manju and Sharma, 2014). There have been no studies highlighting the
importance of conservation of field boundary vegetation for breeding birds in any
agro-ecosystem of Pakistan including Pothwar plateau. This study recorded 25
species of passerine birds in agro-ecosystem of Pothwar plateau of which five were
winter migrants. In this study breeding biology of only five passerine species namely
ashy prinia (Prinia socialis), red-vented bulbul (Pycnonotus cafer), Himalayan
bulbul (Pycnonotus leucogenys), ashy drongo (Dicrurus leucophaeus) and large grey
babbler (Turdoides malcolmi) was studied. These species were observed breeding in
the crop field boundaries while other species utilize the patches of wild vegetation
interspersed in the croplands.

6.2 REVIEW OF LITERATURE

Field borders play an important role in providing shelter and nesting sites to
breeding birds in croplands. Smith et al. (2005b) studied the density and diversity of
breeding populations of six species namely indigo bunting (Passerina cyanea),
mourning dove (Zenaida macroura), dickcissel (Spiza ameicana), northern cardinal
(Cardinalis cardinalis), common grackle (Quiscalus quiscula) and red-winged
blackbird (Agelaius phoeniceus) to see effect of 6.1 m wide experimental field
borders on their breeding. It was found that both the density and diversity of these
breeding species increased in the fields with planted field borders.

Bakker et al. (2002) found that field edges with trees were not favored by
some passerines, e.g. savannah sparrow (Passerculus sandwichensis), western
meadow lark (*Sturnella neglecta*) and grasshopper sparrow (*Ammodramus savannarum*). Batary and Baldi (2004) studied the nest success of birds in field edges and found that trees provide suitable habitat to bird predators and thus reduce nest success and survival of fledglings. Winter *et al.* (2000) reported that nests in the field edges with trees are prone to increased nest parasitism i.e. brood parasitism by brown headed cowbird (*Molothrus ater*). Adams *et al.* (2013) observed that in agricultural landscapes of USA the trees provide habitat and shelter to snakes, birds, mammals and fire ants that affect the breeding of birds in croplands as they are nest predators.

Vickery *et al.* (2009) studied breeding of farmland birds in Sweden and found that agricultural intensification leads to the simplification of ecosystems with monoculture. As a result of reduced crop diversity, food resources for breeding birds are particularly reduced in agro ecosystems of Sweden.

George (1962) reported that ashy prinia (*Prinia socialis*) made nests at a height of 65cm from ground on *Lantana camara*. He reported that the species breeds from March to September and also observed nest shifting behavior. Balachandaran and Lima(1992) reported breeding season to be June to September in north India while Reginald *et al.* (2014) observed the breeding of ashy prinia during August to September and found that the nests (n = 4) of this bird were located in the bushes of *Cenchrus ciliaris*. Pachlore and Pachlore (2012) have reported that in India breeding season of ashy prinia starts soon after onset of monsoon but it ranges from March to September. The clutch size of ashy prinia is three and eggs are orange red in color. The species makes nest at a height of three feet. Jairamdas (1977) and Ramanan (1995) reported that ashy prinia (*Prinia socialis*) constructs small nests of 8.5 x 5cm (length x breadth) in India. According to Ali and Ripley (1987) and Ramanan (1995) ashy prinia lays 3-5 eggs. The incubation and nestling period of this species has been
found to be 12 days (Chakravarthy et al., 1980; Subramanya and Veeresh, 1998; Ali, 2002; Rasmussen and Anderton, 2005). George (1962) and Pachlore and Pachlore (2012) found that when clutch or nestlings of this bird are destroyed, the birds dismantle the nest and use the nest material to construct another nest in the nearby bushes. They further anticipated that nest shifting is an act of mitigating the predatory threats. Jones et al. (2007) have reported that in warblers nest destruction behavior exists and they steal nest material of other birds thus saving time and energy in nest construction.

Fazili et al. (2013) have reported that breeding season of Himalayan bulbul (Pycnonotus leucogenys) is April to July in India while Bates and Louther (1969) found it to be April to June and Rasmussen and Anderton (2005) found it to be March to August. The studies in India have shown that this species nests in bushes (Bates and Louther, 1969; Fazili et al., 2013) while Hsu and Lin (1997) reported that this bulbul prefers dense vegetation for nesting in Taiwan. Rasmussen and Anderton (2005) reported that this species constructs nests at a height of 2m and average clutch size is three while incubation and nestling period is 12 days and 911 days respectively. Palita et al. (2011) have observed a nest of P. leucogenys in Hibiscus spp. Fazili et al. (2013) found that eggs of P. leucogenys are white and have red spots. They reported incubation period of 12 days and nestling period of 14 days and also reported that these bulbuls throw the egg shells after hatching. According to Fazili et al. (2013) hatching success of Himalayan bulbul (Pycnonotus leucogenys) was 80% and fledgling success was 86% while overall breeding success was 69%. Hsu and Lin (1997) have found that cats and house crows are major predators of this bird.
Many bird species especially drongos favor trees close to water resources, roads, human habitation and agricultural lands for nesting (Ali et al., 2010). Shukkur and Joseph (1978) reported that breeding season of black drongo (*Dicrurus macrocercus*) is April to June in India but Ali *et al.* (2010) found that in agro-ecosystems insect availability increases during March to June due to agricultural operations. They found that availability of insect prey influences the breeding pattern of black drongo. Frey *et al.* (2000) found that breeding season of ashy drongo (*Dicrurus leucophaeus*) is April to August on Java islands. In Pakistan Awais and Bibi (2014) found that breeding season of black drongo (*D. macrocercus*) is April to July and is affected by rainfall, temperature as well as predation and human disturbance.

Shukkur and Joseph (1978) reported that drongos construct nests at height of 2.5-13m. According to a study by Ali *et al.* (2010) on *D. macrocercus* in India the average length of nest was 14.6 ± 2.02cm, average circumference was 35.0 ± 3.72cm and average depth was 4.4 ± 0.44cm. They reported that *D. macrocercus* favor *Enterolobium saman* followed by *Acacia nilotica* for nesting and construct nests at an average height of 8.9 ± 2.19m. They construct cup-shaped nests in forks of trees using grass, dry fibers and twigs. Radhakrishnan (2006) also found that Acacia species provide suitable nesting sites to drongos. Clutch size of black drongo ranges from 3-4 eggs. Average egg size was 26.0 ± 0.14mm x 20.0 ± 0.07 (Length x width). The incubation period ranges from 13-16days and eggs are incubated by only one of the parents (Ali *et al.*, 2010). In a study by Nijman (2004) it was found that incubation period of ashy drongo (*D. leucophaeus*) is 16-17days and the nestling period is 17-18days on Java islands. Awais and Bibi (2014) have found that in Mansehra, Pakistan
clutch size of *D. macrocercus* is 3.3 with a range of 2-4. They found mean egg length and breadth of drongo eggs to be 24.5 ± 2.6mm and 20.3 ± 1.7mm respectively. Mean egg shape index of black drongo was 1.20 ± 0.02. They reported hatching and fledgling success as 71.1% and 64.7% respectively. In agro-ecosystem of India hatching success of drongo was found to be 79.10% while fledging success was 75.5% (Ali *et al.*, 2010). Santisteban *et al.* (2002) reported that the nests of drongos at elevated height are prone to predation by visually-oriented nest predators. Nijman (2004) also reported that raptors particularly eagles are predators of drongo.

Li *et al.* (2009) in China have reported nest dismantling behavior in haircrested drongo (*D. hottentottus*) in which it seemed to be a common practice as 12 out of 13 nests were dismantled after fledgling. They proposed this behavior as adaptive in terms of increased fitness by reducing nest site competition for the following breeding season. Root (1969) and Sedgwick and Knopf (1988) have reported that many birds dismantle their old and abandoned nests and use the nest material from these nests in order to construct new nests. However, Li *et al.* (2009) found that drongo dismantle nests after fledgling of young and the nest materials are not used for construction of other nests. Several authors have suggested that population status of drongos should be monitored in agro-ecosystems and threats to species should be minimized since they are biological control agents of insect pests and contribute to lessen the use of chemical insecticides which are harmful for nontarget species as well (Santisteban *et al.*, 2002; Ali *et al.*, 2010).

Babblers have been reported to inhabit scrub of up to 3m height in Delhi, India and they prefer *Ziziphus nummularia*, *Carica spinarum* and *Capparis decidua* but during summer they prefer *Acacia* and *Prosopis* which may be up to 20m high
(Gaston, 1978). In India Manju and Sharma (2014) have reported that common babbler (*Turdoides caudata*) constructs nests at a height of 1.5 to 5.3m and grasses and twigs are used for nest construction. Gaston (1978) reported that in India large grey babblers (*Turdoides malcolmi*) prefer agricultural landscape with scattered trees for nesting. The nests are constructed at a height of 3-20m in terminal twigs of Acacia or Prosopis. In Pakistan babblers inhabit thorny Acacia bordering the agro-ecosystem at Chinji and Dhok Pathan. Cramps and Simmons (1993) have reported that in India peak breeding season of *T. malcolmi* is March to May.

Arbabi *et al.* (2008) reported that in southern Iran Common babbler *T. caudata* prefer Tamarix trees and dense thorny bushes for nesting. They found that this species breeds from March to April and builds nests at an average height of 152cm above ground. They reported that outer and inner diameter of nest was 14.5cm and 8.3cm respectively while the depth of nest was 7.6cm. The average egg diameter measured 22.5 x 16.8mm. However, Moosavi *et al.* (2011) found that *T. caudata* in Iran prefer *Ziziphus nummularia* for nesting as 37 out of 38 nests were found on this plant and the clutch size is 4.18. They reported that the average length of egg is 23.52 ± 0.99mm while width is 17.25 ± 0.55mm. Average incubation and nestling period in their study was 14.90 ± 1.57days and 12.77 ± 2.25days respectively. They found the hatching, nesting and overall breeding success to be 39%, 22% and 28% respectively. Hume (2014) found that *T. malcolmi* builds nests at a height of 4-10feet and four is the normal clutch size in India. He reported egg dimensions of *T. malcolmi* as 0.88 to 1.1inch in length and 0.73 to 0.85inch in breadth. Gupta and Midha (1997) have reported that in large grey babbler all adult family members contribute towards nest construction. Marshall (2011) also reported that cooperative breeding exists in babblers and helpers help feed the chicks.
The clutch size varies from 1-3 but usually two eggs are laid. During rainy season more four-egg clutches are found while in spring three eggs are commonly laid. Cramp and Simmons (1993) reported that average clutch size of common babbler in India is 3.4 while Arbabi et al. (2008) have reported a clutch size of 5. In India a study on common babbler has reported the hatching, fledgling and breeding success to be 54%, 40% and 57% respectively (Gatson, 1978). The predators of babbler have been known to be snakes as well as raptors (Gatson, 1978). Arbabi et al. (2008) found that mammalian predators of T. caudata are fox (Vulpes vulpes), sand fox (Vulpes rueppelli), small Indian mongoose (Herpestes javanicus) and golden jackal (Canis aurens) in Iran. Moosavi et al. (2011) found that predation due to two snake species namely Echis carinatus and Platyceps rhodorachis is main reason of low breeding success of T. caudata in Iran overall leading to 66% mortality while 20.6% is caused by rodents and birds. Ostreiher (1999) reported that food division in babbler is not uniform and last-hatched nestling usually die because the older nestlings are aggressive and do not let the younger ones feed. Nestling competition and siblicide are common in babbler. Communal nest feeding in babbler has been reported by several authors (Bates, 1959; Manju and Sharma, 2014). The communal defense of the fledglings has also been reported in large grey babbler (T. malcolmi) by Dharmakumarsinhji (1961).

6.3 MATERIALS AND METHODS

The nests were sought in all the study sites during breeding season by following the birds carrying nesting material and by behavior observations and cues of nest construction. Seventy six active nests were located in the four study sites over a period of two years. These nests were visited after every two days in order to collect data about the following breeding parameters.
Out of 25 passerine species recorded over the entire study period, breeding parameters of five passerine species namely ashy prinia (*Prinia socialis*) redvented bulbul (*Pycnonotus cafer*), Himalayan bulbul (*Pycnonotus leucogenys*), ashy drongo (*Dicrurus leucophaeus*) and large grey babbler (*Turdoides malcolmi*) were studied.

### 6.3.1 Characteristics of Nest Location and Nest Materials

Each nest was studied for following characteristics.

i. Identification of vegetation hosting the nest.

ii. Height of the nest from the ground.

iii. Identification of vegetation material used for nest construction.

iv. Outer and inner diameter of nest.

v. Depth of nest.

### 6.3.2 Egg and Incubation Record

The data about clutch size, egg laying intervals and incubation period were collected for the selected passerine species. The date of first egg laying was noted by direct observation whenever possible. In case of spotting a nest with eggs already laid, the clutch initiation date was calculated through back dating by subtracting the hatching date from the mean incubation period following Fazili *et al*. (2013). During observation, care was taken to minimize bird and nest disturbance (Martin and Guepel, 1993). The incubation period was calculated as the time interval (in days) between the laying and hatching of first egg. The dimensions (length and width) of freshly laid eggs were measured (mm) with Vernier Calipers whenever possible. The egg shape index was calculated by the following formula (Dolenec, 2006),

\[
\text{Egg shape index (ESI)} = \frac{\text{Length of egg (L)}}{\text{Width of egg (W)}}
\]
6.3.3 Hatching, Fledging and Breeding Success

Hatching, fledging and breeding success was calculated by the following formulae described by Ali et al. (2010) and Fazili et al. (2013).

Hatching success = \( \frac{\text{No. of eggs hatched}}{\text{Total No. of eggs laid}} \times 100 \)

Fledging success = \( \frac{\text{No. of nestlings fledged}}{\text{Total No. of eggs hatched}} \times 100 \)

Breeding success = \( \frac{\text{No. of nestlings fledged}}{\text{Total No. of eggs laid}} \times 100 \)

Egg survival during incubation and nestling survival during nestling period were estimated on the basis of daily survival rate of eggs and nestlings following Mayfield (1975).

Egg/Nestling survival = \( (\text{Egg/Nestling DSR})^d \)

Where,

DSR = daily survival rate  
\( d = \) Average Incubation/Nestling Period

Daily survival rates were calculated as follows.

\[ \text{Daily Survival Rate (DSR)} = 1 - \frac{\text{No. of failed eggs during incubation/nestling}}{\text{No. of exposure days when nest is at risk}} \]
6.4 RESULTS

6.4.1 Breeding Season and Nest Locations

The breeding activities of ashy prinia (*Prinia socialis*) were found during months May to September (Table 6.1) with July being the peak nesting month. In total 15 active nests of this prinia were located. Among these two nests were found in May, one in June, six in July, four in August and two in September. Both the sexes were observed participating in nest building. The nests were recorded at a mean height of 1.74 m ± 0.21(SD) from ground level in shrubs. Distribution of the nests with respect to the shrub species revealed presence of seven nests in *Cenchrus ciliaris* and four each in *Prosopis juliflora* and *Lantana camara*. Soft twigs, dry herbs and grasses were used for nest construction. The nests were cupshaped and finely built with the inner lining of root hair of plants.

The measurements of nests showed average outer diameter of 10.29 cm ± 0.58SD (range 9.7 - 11.3, n = 15), average inner diameter 6.45cm ± 0.44SD (range 5.9 - 7.1, n = 15) and the average depth of 4.44cm ± 0.53SD (range 3.6 - 5.3, n = 15) (Table 6.2). Nest shifting behavior was also observed in four cases. Whenever the nest was spotted during nest building stage, the parent birds dismantled the nest and used the material for constructing another nest in close vicinity of the abandon location.

The breeding period of red-vented bulbul (*Pycnonotus cafer*) was found to be spreading from April to September (Table 6.1) and maximum numbers of nests were in the month of May. A total of 23 nests were found at the four study sites. Of these five nests were found in April, seven in May, four in June, two each in July and August and, three in September. Both sexes participated in nest building activities.
Various shrubs and young trees used for nesting included *Ziziphus nummularia* (n = 7), *Ziziphus mauritiana* (n = 6), *Capparis decidua* (n = 7) and *Dodonea viscosa* (n = 3). Mean height of nest from ground was 1.91 ± 0.37 m. The nests of red-vented bulbul were cup-shaped and loosely attached to the tree/shrub branches. The nests were made up of a variety of grasses, herbs, dead leaves, twigs and other fine materials. Mean outer and inner diameters of the nests were 12.43 cm ± 1.24 (range 10.4 - 13.9, n = 23) and 8.66 cm ± 0.73 (range 7.7 - 9.9, n = 23), respectively. Mean depth of the nests was estimated to 5.83 cm ± 0.63 (range 4.8 - 6.9, n = 23).

The breeding activities of Himalayan bulbul (*Pycnonotus leucogenys*) were observed during April through July (Table 6.1). In total 17 active nests were found. May was the peak nest building month when seven nests were found while two nests were located in April and four each in June and July. The nests were constructed in *Ziziphus nummularia* (n = 5), *Capparis decidua* (n = 6), *Lantana camara* (n = 4) and *Dodonea viscosa* (n = 2). Nests construction activities were shared by both the sexes by using dry twigs, herbs and grasses. One nest was found exclusively made up of leaves of pearl millet (*Pennisetum typhoides*). The nests were cup-shaped, quite neatly woven and firmly attached to the host vegetation at an average height of 1.23 ± 0.66 m. The recorded nests had mean outer diameter of 15.39 cm ± 0.64 (range 14.9 - 16.3, n = 17) and mean inner diameter of 7.48 cm ± 0.51 (range 6.8 - 8.4, n = 17). Mean depth of nest depression was estimated to 5.57 cm ± 0.50 (range 4.8 - 6.3, n = 17) (Table 6.2).

The nests of ashy drongo (*Dicrurus leucophaeus*) were found only during three months i.e. March through May (Table 6.1). In total, 13 nests were found with almost equal monthly distribution i.e. four in March, five in April and four in May.
The nests were loosely woven and flimsy, constructed from dry grasses, fibers and twigs. The trees used for nest construction were: *Acacia nilotica* (n = 7), *Acacia modesta* (n = 4) and *Melia azadarach* (n = 2). Mean height of nest from the ground was estimated to 4.7 ± 1.1 m. The nest measurements of *D. leucophaeus* (Table 6.2) showed mean outer diameter of 11.6 cm ± 0.69 (range 10.8 - 12.5, n = 13), mean inner diameter of 7.21 cm ± 0.64 (range 6.9 - 8.6, n = 13) and mean depth of 4.79 cm ± 0.79 (range 3.9 - 6.1, n = 13).

Breeding activities of large grey babbler (*Turdoides malcolmi*), initiated by pair formation and nest construction) were observed from March to May and in August (Table 6.1). Only eight nests were found in the four study sites. Three nests were found in March, two in April, one in May and two in August with no records during June and July. Six nests were found on *Acacia nilotica* while one nest was located each in *Delbergia sissoo* and *Ziziphus nummularia*. Acacia twigs and grasses were used in nest building. The mean height of nest from ground was 6.5 ± Table 6.1: Breeding season of five passerine species recorded in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific name</th>
<th>Breeding season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy prinia</td>
<td><em>Prinia socialis</em></td>
<td>May to September</td>
</tr>
<tr>
<td>Red-vented bulbul</td>
<td><em>Pycnonotus cafer</em></td>
<td>April to September</td>
</tr>
<tr>
<td>Himalayan bulbul</td>
<td><em>Pycnonotus leucogenys</em></td>
<td>April to July</td>
</tr>
<tr>
<td>Ashy drongo</td>
<td><em>Dicrurus leucophaeus</em></td>
<td>March to May</td>
</tr>
<tr>
<td>Large grey babbler</td>
<td><em>Turdoides malcolmi</em></td>
<td>March to May, August</td>
</tr>
</tbody>
</table>
Table 6.2: Nest dimensions of five passerine species recorded in agro-ecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sample size</th>
<th>Parameters (Mean (cm) ± SD) (n)</th>
<th>Outer diameter (Range)</th>
<th>Inner diameter (Range)</th>
<th>Depth of nest depression (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td>15</td>
<td>10.29 ± 0.58</td>
<td>6.45 ± 0.44</td>
<td>4.44 ± 0.53</td>
<td>(9.7-11.3)</td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>23</td>
<td>12.43 ± 1.24</td>
<td>8.66 ± 0.73</td>
<td>5.83 ± 0.63</td>
<td>(10.4-13.9)</td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>17</td>
<td>15.39 ± 0.64</td>
<td>7.48 ± 0.51</td>
<td>5.57 ± 0.50</td>
<td>(14.9-16.3)</td>
</tr>
<tr>
<td>Ashy drongo (Dicrurus leucophaeus)</td>
<td>13</td>
<td>11.6 ± 0.69</td>
<td>7.21 ± 0.64</td>
<td>4.79 ± 0.79</td>
<td>(10.8-12.5)</td>
</tr>
<tr>
<td>Large grey babbler (Turdoides malcolmi)</td>
<td>8</td>
<td>18.25 ± 0.99</td>
<td>11.85 ± 0.52</td>
<td>6.8 ± 0.69</td>
<td>(16.3-19)</td>
</tr>
</tbody>
</table>
The nests were cup-shaped but open and loosely built. The species was found to be gregarious even in the breeding season. The nest measurement of *T. malcolmi* showed mean outer diameter of $18.25cm \pm 0.99$ (range 16.3 - 19, $n = 8$), mean inner diameter of $11.85cm \pm 0.52$ (range 10.9 - 12.5, $n = 8$) and the mean depth of $6.8cm \pm 0.69$ (range 5.5 - 7.6, $n = 8$).

### 6.4.2 Egg Morphology of Five Passerine Species

The egg dimensions of the five passerine species, available for observation in agro-ecosystem of Pothwar plateau are given in Table 6.3. In 15 nests of ashy prinia (*Prinia socialis*) 56 eggs were recorded in total. Among these, seven nests had 3 eggs, five nests had 4 eggs while three nests had 5 eggs. The eggs were crimson red in color with mean length of $15.71mm \pm 0.48$ and average breadth of $11.48mm \pm 0.60$.

In 23 nests of red-vented bulbul (*Pycnonotus cafer*), 64 eggs were laid in total. The nest-wise distribution revealed three nests with one egg, four nests with two eggs, 11 nests with three eggs and four nests with four eggs. The eggs were pinkish white in color with few crimson spots. Mean length of the eggs was estimated to $23.46mm \pm 0.58$ and mean breadth of $16.06mm \pm 0.66$.

I was able to locate only 17 nests of Himalayan bulbul (*Pycnonotus leucogenys*) at four selected study sites in the agro-ecosystem of Pothwar. In total 51 eggs were observed with distribution score of one nest with single egg, three nests with two eggs, eight nests with three eggs and five nests with four eggs. The eggs were white in color with brown spots. Mean length and width of the eggs were $22.35mm \pm 0.50$ and $15.5mm \pm 0.55$, respectively.
Table 6: Egg dimensions of five passerine species observed breeding in agroecosystem of Pothwar plateau, Pakistan.

<table>
<thead>
<tr>
<th>Species</th>
<th>Egg Length (Range)</th>
<th>Egg Breadth (Range)</th>
<th>Egg index shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td>56</td>
<td>15.71 ± 0.48 (14.9-16.5)</td>
<td>11.48 ± 0.60 (10.7-12.8)</td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>64</td>
<td>23.46 ± 0.58 (22.7-24.6)</td>
<td>16.06 ± 0.66 (15-16.9)</td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>51</td>
<td>22.35 ± 0.50 (21.1-23.2)</td>
<td>15.5 ± 0.55 (14.9-16.5)</td>
</tr>
<tr>
<td>Ashy drongo (Dicrurus leucophaeus)</td>
<td>42</td>
<td>26.39 ± 0.75 (25.1-27.9)</td>
<td>21.2 ± 0.84 (20.1-22.7)</td>
</tr>
<tr>
<td>Large grey babbler (Turdoides malcolmi)</td>
<td>38</td>
<td>25.68 ± 1.22 (23.3-27.1)</td>
<td>19.77 ± 0.84 (19.2-21.6)</td>
</tr>
</tbody>
</table>
Forty two eggs were found in 13 nests of ashy drongo (*Dicrurus leucophaeus*) with occurrence of three eggs each in ten nests and four eggs each in three nests. Due to aggressive behavior of the parent birds, I was not able to measure
Table 6
the total clutch. The eggs were observed to be off-white in color with crimson-red spottings. Mean length and breadth of the ova were 26.39mm ± 0.75 and 21.2mm ± 0.84, respectively.

Only eight nests of large grey babbler (*Turdoides malcolmi*) were found over the entire study period. The total record observed was of 38 eggs. Among the eight nests, six had four eggs while two had five eggs. Due to aggressive behavior of these birds, access to nests was difficult at many times and therefore, I was not able to measure all eggs. The eggs were turquoise blue in color. Mean egg length was 25.68mm ± 1.22 and mean breadth was 19.77mm ± 0.84.

6.4.3 Breeding Success of Five Passerine Species

Mean clutch size of ashy prinia (*Prinia socialis*) was 3.73 ± 0.79 and incubation period was 11.65 ± 0.52 days (range 11-12 days, n = 29) (Table 6.4). Among the 15 active nests, fledging took place in eight only (53.33%) while seven nests failed completely to produce viable chicks (three nests failed during incubation and four nests failed during nestling). Of the seven nests that failed, six were predated and one lost its occupants due to harsh weather. In all these nests, complete loss of eggs and/or nestlings was recorded. The predators were domestic cats, rodents, snakes. The humans were also poachers of this bird. The nests that succeeded to contribute in the population had 29 eggs in total, among which 18 hatched and 11 failed with hatching success of 62.06% and egg survival rate during incubation was 0.53 (Table 6.5). Mean nestling period was estimated to 11.89 ± 0.4: Clutch size, incubation and nestling period of the selected passerine species observed breeding in agro-ecosystem of Pothwar plateau, Pakistan.
<table>
<thead>
<tr>
<th>Species</th>
<th>Study Parameters (Mean ± SD)</th>
<th>Clutch size (n=nests)</th>
<th>Incubation period (n=eggs)</th>
<th>Nestling period (n=hatchlings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td>3.73 ± 0.79 (15)</td>
<td>11.65 ± 0.52 (29)</td>
<td>11.89 ± 0.68 (18)</td>
<td></td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>2.78 ± 0.95 (23)</td>
<td>13.94 ± 0.66 (48)</td>
<td>13.91 ± 0.59 (37)</td>
<td></td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>3.00 ± 0.87 (17)</td>
<td>11.75 ± 0.62 (36)</td>
<td>12.07 ± 0.74 (26)</td>
<td></td>
</tr>
<tr>
<td>Ashy drongo (Dicrurus leucophaeus)</td>
<td>3.23 ± 0.44 (13)</td>
<td>14.6 ± 0.71 (28)</td>
<td>20.9 ± 0.85 (20)</td>
<td></td>
</tr>
<tr>
<td>Large grey babbler (Turdoides malcolmi)</td>
<td>4.00 ± 0.46 (8)</td>
<td>13.4 ± 0.55 (25)</td>
<td>11.5 ± 0.52 (12)</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.5: Mayfield survival probability for selected passerine species during incubation and nestling stages.

<table>
<thead>
<tr>
<th>Species</th>
<th>Exposure days</th>
<th>Total no. of eggs or nestlings observed</th>
<th>Daily survival rate</th>
<th>Success rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td></td>
<td>Incubation stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>209</td>
<td>29</td>
<td>0.95</td>
<td>0.53</td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>332</td>
<td>48</td>
<td>0.96</td>
<td>0.63</td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>240</td>
<td>36</td>
<td>0.96</td>
<td>0.60</td>
</tr>
<tr>
<td>Ashy drongo (Dicrurus leucophaeus)</td>
<td>180</td>
<td>28</td>
<td>0.96</td>
<td>0.52</td>
</tr>
<tr>
<td>Large grey babbler (Turdoides malcolmi)</td>
<td>108</td>
<td>25</td>
<td>0.88</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Nestling stage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ashy prinia (Prinia socialis)</td>
<td>269</td>
<td>37</td>
<td>0.97</td>
<td>0.65</td>
</tr>
<tr>
<td>Red-vented bulbul (Pycnonotus cafer)</td>
<td>188</td>
<td>26</td>
<td>0.96</td>
<td>0.63</td>
</tr>
<tr>
<td>Himalayan bulbul (Pycnonotus leucogenys)</td>
<td>159</td>
<td>18</td>
<td>0.94</td>
<td>0.49</td>
</tr>
<tr>
<td>Bird Species</td>
<td>Quantity</td>
<td>Sex</td>
<td>Age</td>
<td>Maturity</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------</td>
<td>-----</td>
<td>-----</td>
<td>----------</td>
</tr>
<tr>
<td>Ashy drongo (<em>Dicrurus leucophaeus</em>)</td>
<td>135</td>
<td>20</td>
<td>7</td>
<td>0.95</td>
</tr>
<tr>
<td>Large grey babbler (<em>Turdoides malcolmi</em>)</td>
<td>89</td>
<td>12</td>
<td>7</td>
<td>0.92</td>
</tr>
</tbody>
</table>
0.68 days (range 11-13 days, n = 18). The fledging success was 50% (with nine fledged out of 18 hatched). Nestling survival during nestling period was 0.49. Overall breeding success of this species was found to be 31.03%.

Mean clutch size estimated from field data of red-vented bulbul (*Pycnonotus cafer*) was 2.78 ± 0.95 (range 1-4, n = 23) with incubation period of 13.94 ± 0.66 days (range 13-14 days, n = 48). Out of total 23 active nests, fledging took place in 17 nests (73.91%). Among the failed six nests, the mortality in three occurred at incubation stage and in other three at nestling stage. Cause of mortality in four nests was predation by cats and rodents while in two nests the progenies were destroyed by heavy rain. The successful nests had 48 eggs in total, among which 37 hatched and 11 failed with hatching success 77.08%. The egg survival during incubation was 0.63 (Table 6.5). Mean nestling period was 13.91 ± 0.59 days (range 13-15 days, n = 37). The fledging success was 78.38% since 29 fledged out of 37 hatched. Nestling survival during nestling period was 0.65. Overall breeding success of red-vented bulbul was found to be 60.42%.

Among the 17 active nests of Himalayan bulbul (*Pycnonotus leucogenys*) the mean clutch size was 3.00 ± 0.87 (range 1-4, n = 17) (Table 6.4). Five nests failed completely (four during incubation and one during nestling phase). The failure was due to snake predation in one nest, raptors’ predation in two nests and destruction of two nests by human activities. Fledging took place in 12 out of 17 nests, with 70.6% success rate. The nests that survived had 36 eggs, among which 26 hatched and 10 failed. The average incubation period was 11.75 ± 0.62 days (range 11-13 days, n = 36). The hatching success was 72.2% and egg survival during incubation was 0.60 (Table 6.5). The average nestling period was 12.07 ±
0.74 days (range 11-13 days, n = 26). Out of 26 hatched 19 fledged with fledging success of 73.07%. Nestling survival during nestling period was 0.63 and overall breeding success of the species was estimated to 52.77%.

The average clutch size of ashy drongo (*Dicrurus leucophaeus*) was 3.23 ± 0.44 (range 3-4, n = 13) (Table 6.4). The average incubation period was 14.6 ± 0.71 days (range 14-16 days, n = 28). Among the 13 active nests fledging took place in 9 nests only (69.23%) while four nests failed completely (two nests failed during incubation and two nests failed during nestling). The nests that failed were predated by raptors particularly eagles and owls. The nests that succeeded had 28 eggs in total, among which 20 hatched and 8 failed. The hatching success was 71.4% and egg survival during incubation was 0.52 (Table 6.5). The average nestling period was 20.9 ± 0.85 days (range 20-21 days, n = 20). The fledging success was 65% since 13 fledged out of 20 hatched. Nestling survival during nestling period was 0.33. After fledging of nestlings five out of 13 nests were dismantled by the female birds. Overall breeding success of Ashy drongo (*Dicrurus leucophaeus*) was found to be 46% in this agro-ecosystem.

The average clutch size of large grey babbler (*Turdoides malcolmi*) was 4.00 ± 0.46 (range 4-5, n = 8). The average incubation period was 13.4 ± 0.55 days (range 14-15 days, n = 25) (Table 6.4). Among the eight active nests fledging took place in five nests only (62.5%) while three nests failed completely (two nests failed during incubation and one failed during nestling). Among the three nests that failed, one was predated by raptors while the reason of nest failure for other two could not be found. The nests that succeeded had 25 eggs in total, among which 12 hatched and 13 failed to hatch. The hatching success was 48% and egg survival during incubation was 0.17 (Table 6.5).
It was also found that after hatching shells of eggs were completely consumed by the parents and helpers. The average nestling period was 11.5 ± 0.52 days (range 11-12 days, n = 12). The fledging success was 41.6% since five fledged out of 12 hatched. Nestling survival during nestling period was 0.38. Siblicide was also observed and older nestlings killed the newly hatched ones. Overall breeding success of this species was found to be 20%.

6.5 DISCUSSION

Earlier part of current study (Chapter 3) has revealed existence of 20 resident and five migratory species. Against prevalence of such as big number of avian species, I was able to locate nests of only five birds (*Prinia socialis, P. cafer, P. leucogena*, *D. leucophaeus* and *T. malcolmi*). It is presumed that since the bird breeding surveys were restricted to four selected study areas exclusively pertaining to croplands, therefore, species adopted to wild habitats might had missed in observation. Unlike, contiguous cropland areas of irrigated agroecosystems of Pakistan, the agroecology of Pothwar is intermitted with wild patches of subtropical scrub forest, patches of rangelands and rain water gullies. It is possible majority of species recorded in population and foraging studies were using wild areas for breeding. However, these assumptions demand detailed investigation for evidential support.

George (1962) and Pachlore and Pachlore (2012) have reported the breeding season of ashy prinia (*Prinia socialis*) from March to September in southern India while Balachandaran and Lima (1992) recorded its breeding period from June to September in north India. Since no nests of this prinia were recorded in the months of March-April therefore, it seems in agreement with the finding of the later study.
However, ending of the breeding season is supported by the aforementioned investigation in India. Such small variation within a wide span of seasonal breeders could be attributed to latitudinal variations of the study locations and local climatic factors.

The prinia nests were found in *Cenchrus ciliaris*, *Prosopis juliflora* and *Lantana camara* whereas George (1962) and Reginald et al. (2014) have reported its association with *Cenchrus ciliaris* and *Lantana camara* only. The nests height from ground level (1.74 m) recorded in this study is much higher as compared to observations of George (1962) and Pachlore and Pachlore (2012) who reported the height in the range of 0.65-0.91 m. The nest dimensions recorded in this study are similar to those reported by Ali and Ripley (1987) but somewhat larger than those reported by Jairamdas (1977) and Ramanan (1995). The clutch size of 3-5 eggs is in agreement with earlier reports of Ali and Ripley (1987) and Ramanan (1995).

Similarly, the egg dimensions are in support of an old study of Oates (1905) in Britain. The average incubation period of *P. socialis* was found to be 11.65 ± 0.52 days. Chakravarty et al. (1980) and Ali (2002) have also reported that eggs of this bird hatch in about 12 days. The estimated nestling period of 11.89 ± 0.68 days is also supported by the records of Subramanya and Veeresh (1998) and Rasmussen (2005) in India. The nest predation by cats and rodents and destruction by human activities and harsh weather condition is also evident by the records Roberts (1992) and Pachlore and Pachlore (2012). The self nest dismantling behaviour by this species in response to spotting any predator and/or invader (human) has also been documented by Pachlore and Pachlore (2012) and Jones et al. (2007) who found the bird dismantling its own nest and using the same materials to reconstruct it at nearby safe place to mitigate the predatory threats.
The breeding season of red-vented bulbul (*Pycnonotus cafer*) was found to be April to September in the study area. These findings are similar to Roberts (1992) and Zia *et al.* (2014) in different areas of Pakistan. However, Watling (1983) found that breeding season of this species lasts from February through September in Fiji. Dhondt (1977) found that *P. cafer* at most has three successive broods and its breeding season mostly coincides with monsoon in India. The nests were found in low trees and shrubs particularly *Zizyphus* spp., *Capparis decidua* and *Dodonea viscosa*. Zia *et al.* (2014) also recorded nests of this species on *Zizyphus nummularia, Psidium guajava, Dalbergia sissoo, Dodonea viscosa* and *Phoenix dactylifera* in Rawalpindi and Islamabad but Watling (1983) found the nests of *P. cafer* in *Samanea saman, Albizzia lebbek* and *Delonix regia* in Fiji. Ali and Ripley (1987) reported that average height of nest of red-vented bulbul is 3.6m above ground while Zia *et al.* (2014) found it to be 0.97m. In this study nests were found at a height of 1.91 ± 0.37m. These findings disagree with those of Ali and Ripley (1987) and Zia *et al.* (2014) but are in agreement with Watling (1983) who reported a height of 1.5m above ground. The nest dimensions of the species were found to be similar to those reported by Ali and Ripley (1987), Parajapati *et al.* (2011) and Zia *et al.* (2014) but dissimilar to Dhondt (1977) who found the nests to be much shallower as compared to this study. The clutch size of *P. cafer* was 14 eggs in this study. Although Ali and Ripley (1987) and Fishpool and Tobias (2005) reported that usual clutch of red-vented bulbul has two eggs but in this study 11 out of 23 nests observed had three eggs. These findings are similar to those of Zia *et al.* (2014) who also found that 51% clutches had three eggs. The egg dimensions are similar to those recorded by Ali and Ripley (1987).

The incubation period was found to be 13-14 days while nestling period was
13-15 days but these results are partially similar to Vijayan (1980), Fishpool and Tobias (2005) and Zia et al. (2014) who reported that incubation and nestling period of this species is 11-13 days. The hatching fledgling and overall breeding success of the species in agro-ecosystem of Pothwar was 77.08%, 73.38% and 60.42% respectively. These results are close to those of Parajapati et al. (2011) and Zia et al. (2014) but other authors have recorded low success (Vijayan, 1980; Balakrishnan, 2007). In this study nest predators of *P. cafer* were found to be rodents and cats. Humans and harsh weather conditions also had an impact on breeding of the species. These were also reported by Vijayan, (1980) and Balakrishnan (2007) in India. Zia et al. (2014) found that in addition to house mouse (*Rattus rattus*), crested eagle (*Morphnus guianensis*) and barn owl (*Tyto alba*) were important raptors that predated on this species in Rawalpindi/Islamabad area but in this study no raptors were seen to be involved in nest predation of this bird.

The breeding season of Himalayan bulbul (*Pycnonotus leucogenys*) was found to be April to July in this study. This has also been reported by Fazili et al. (2013) in India. However, Bates and Louther (1969) found it to be April to June. Vijayan (1980) and Hsu and Lin (1997) reported that this bulbul prefers dense vegetation for nesting but in this study the nests of this bulbul were found at *Zizyphus nummularia*, *Capparis deciduas*, *Lantana camara* and *Dodonea viscosa*. Bates and Louther, (1969) and Fazili et al. (2013) also reported that this species nests in bushes. The average height of nest from ground was $1.23 \pm 0.66$ m which is similar to Watling (1983) who reported a height of 1.5 m above ground. The nest dimensions recorded in this study are similar to findings of Vijayan (1980) and Fishpool and Tobias (2005). The clutch size was in the range of 1-4 eggs. This finding is dissimilar to findings of Bates and Louther (1969) and Fazili et al. (2013) who reported that
usual clutch size is 3-4 eggs with five eggs being rare but in this study clutches having a single egg or two eggs were also found. The average length and breadth of eggs was $22.35 \pm 0.50$mm and $15.5 \pm 0.55$mm respectively and this is in concordance with Fazili et al. (2013) in India.

The incubation and nestling period was 11-13 days which is similar to Ali and Ripley (1987) and Fishpool and Tobias (2005). However, Fazili et al. (2013) reported incubation period of 12 days and nestling period of 14 days and also reported that these bulbuls throw the egg shells after hatching. The hatching fledgling and overall breeding success of the species in agro-ecosystem of Pothwar was 72.22%, 73.07% and 52.77% respectively which is lower than reported by Fazili et al. (2013) in India. In this study nest predators of *P. leucogenys* were found to be raptors and snakes. This finding is in disagreement to those of Hsu and Lin (1997) and Fazili et al. (2013) who reported that cats and house crows are major predators of this bird.

The breeding season of ashy drongo (*Dicrurus leucophaeus*) was found to be March to May in Pothwar. Ali et al. (2010) also reported that the breeding season of drongo in agro-ecosystem of Southern India is March to June. However, Awais and Bibi (2014) found that breeding season of black drongo (*Dicrurus macrocercus*) is April to July in Pakistan but no nests of *D. leucophaeus* were found during June and July in this study. The Acacia trees were chiefly used by drongos for nesting and this is in concordance with Radhakrishnan (2006) and Ali et al. (2010). The average height of drongo nest from the ground was $4.7 \pm 1.1$m. This is contrary to Ali et al. (2010) who reported average nest height to be $8.9 \pm 2.19$m in India. However Shukkur and Joseph (1978) reported that drongos construct nests at height of 2.5-13m. The nest dimensions recorded in this study were similar to those of Ali et al. (2010). In this study three or four eggs per clutch were recorded. These results are
similar to Ali et al. (2010) in India. In Pakistan clutch size of *D. leucophaeus* has been reported to be 2-4 eggs (Roberts, 1992; Awais and Bibi, 2014) but in this study no clutch with two eggs was observed. Egg length and breadth as well as egg shape index recorded in this study were similar to those to Ali et al. (2010) and Awais and Bibi (2014). The incubation and nestling period was found to be 14-16 days and 20-21 days respectively. These results were similar to Ali et al. (2010) and Awais and Bibi (2014) but Nijman (2004) reported a relatively long incubation period of (16-17 days) and short nestling period (1718 days) on Java islands. The hatching, fledgling and overall breeding success of *D. leucophaeus* in Pothwar is almost similar to findings of Awais and Bibi (2014) for *D. macrocercus* in Pakistan but Ali et al. (2010) have reported a slightly increased success of drongo in agro-ecosystem of India. In the present study nest predators of ashy drongo were found to be eagles and owls. Santisteban et al. (2002) and Nijman (2004) also found that eagles are predators of drongos. Nest dismantling after fledgling of nestlings was observed in five out of 13 nests. Although this behavior has not been reported for *D. macrocercus* or *D. leucophaeus* but Li et al. (2009) in China have reported nest dismantling behavior in hair-crested drongo (*D. hottentottus*).

The breeding season of large grey babbler (*Turdoides malcolmi*) was found to be March to August in agro-ecosystem of Pothwar. This is in concordance with Ali and Ripley (1987) and Rasmussen and Anderton (2005) who reported that this species breeds from March to August. The babblers preferred *Acacia nilotica* for nesting as six out of eight nests were found on *Acacia nilotica* while two other tree species used for nesting were *Delbergia sissoo* and *Ziziphus nummularia*. Gatson (1978) reported that in Pakistan common babbler (*T. caudata*) prefers to nest on *Acacia* or *Prosopis* species while Moosavi et al. (2011) observed all nests in
Ziziphus nummularia in Iran except one which was located in Lycium shawii. Gupta and Midha (1997) reported that in India T. malcolmi prefer Ziziphus nummularia, Carica spinarum, Acacia nilotica, and Capparis decidua. Moosavi et al. (2011) has reported that nesting site of babblers differs with respect to habitat. The nests were observed at an average height of 6.5 ± 2.3m. This is contrary to the findings of Hume (2014) who found that T. malcolmi build nests at a height of 1.23m in India. However, the results are somewhat similar to findings of Manju and Sharma (2014) who reported that these babblers construct nests at a height of 1.5 to 5.3m in India. The clutch size was 4-5 eggs in this study. Gatson (1978) reported that in T. caudata the clutch size varies from 1-3 but usually two eggs are laid while Moosavi et al. (2011) have found it to be 4-6 eggs. However, Gupta and Midha (1997) also found that four is the normal clutch size in India. The eggs were 25.68mm ± 1.22 x 19.77mm ± 0.84 (length x breadth). This is similar to the findings of Gatson (1978) and Moosavi et al. (2011) for T. caudata.

The incubation period was 14-15 days while nestling period was 11-12 days in this study. This is contrary to the findings of Moosavi et al. (2011) who reported much shorter incubation and nestling period for T. caudata in Iran. The hatching, fledgling and overall breeding success of T. malcolmi in Pothwar was found to be 48.00%, 41.65% and 20.00% respectively which is slightly low than that reported for common babbler in India i.e. 54%, 40% and 57% respectively (Gatson, 1978). However, Moosavi et al. (2011) in Iran has reported the hatching, fledgling and overall breeding success of T. caudata to be 39%, 22% and 27.7% respectively which is quite similar to the findings of T. malcolmi in this study.
Traditionally agro-ecosystems were used to consider degraded landscapes having poor habitat quality, high human intervention and low species diversity (Chamberlain et al., 2001) but now they are treated as dynamic unique ecological systems harboring characteristic biodiversity (Birasal, 2014). There are about 10,000
species of birds in the world which inhabit all the continents and interface with agricultural landscapes. Less than 1% of the global avifauna prefers agroecosystems whereas one third of all bird species occasionally use farmlands (Sekercioglu, 2012; Abdar, 2014).

Birds play important role in agro-ecosystems and are quick responsive to habitat disturbance and landscape changes. Due to conspicuity; they are considered good indicators of health of any ecological system including farmlands. Birds also have an intrinsic value and provide many ecosystem services of human interest (Goijman, 2014). Since it is evident from global research that farmland avifauna contributes significantly towards total biodiversity of a region but such information on agro-biodiversity of Pothwar plateau of Pakistan is wanted in literature. To fulfill this gap there is need to collect data on scientific basis supported with statistical analysis. Therefore, detailed ecological studies and economic status of birds of this agro-ecosystem are crucial for proper management of avifauna with emphasis on conservation of beneficial species and management of harmful ones.

Merely expansion in agricultural area is no longer the answer to meet everincreasing food demands of growing human population. Therefore, now the focus is to close the yield gap of crops in under-performing areas so that more food can be produced from the existing farmlands (Foley et al., 2011; Cunningham et al., 2013). In Pothwar plateau of Pakistan, natural landscapes are under pressure due to continuous clearing of wild habitats for cultivation to expand agricultural area (Ali, 2004). Generally, changing of agricultural landscape to wild is an irreversible process therefore many authors are of opinion that avian density and diversity in croplands
can not be promoted unless area specific research is carried out to investigate the impact of agricultural practices on the avifauna (Peterjohn, 2003; Adams et al., 2015).

The result of current study supported by existing literature (Hayat, 2005; Shah et al., 2005; Hassnain et al., 2012) reveals that major crops of this region are wheat (intercropped with mustard), groundnut and maize. However, in many areas wheat-fallow cropping pattern is practiced for conservation of rain water. Although numerous studies have highlighted importance of wheat-legume cropping pattern for nutrient conservation to increase crop productivity of Pothwar plateau (Safdar et al., 2002; Manf and Fayyaz, 2006; Hayat and Ali, 2010) but only 17% of our interviewed farmers replied for cultivation leguminous crops.

Since habitat factors are key variables affecting all biodiversity including avian species therefore, management of an agricultural landscape should be carried out by integrating biodiversity as its vital component. In agro-ecosystem of Pothwar, vegetation of crop field boundaries is maintained for conservation of rain water and prevention of soil erosion. It could be assumed that propagation of wild vegetation at crop borders could lead to some reduction in crop yield but with integrated management, it would lead to acceptable tradeoff as not only birds would be benefitted and natural invertebrate enemies reduced but water and soil would also be conserved. The spatial and temporal heterogeneity within this agroecosystem could be increased by simply maintaining small patches of vegetation which not only directly benefit the birds and other organisms but also provide corridors for their dispersal.
Current study scored 51 species of wild vegetation (12 trees, 14 shrubs and 26 herbs/grasses) on crop field boundaries. Such diversity leads to assume that wild vegetation along the field boundaries provide suitable habitat to many ubiquitous and generalist bird species and help to raise local avian species richness in this arid agro-ecosystem. Such assumptions are supported by the findings that many birds are benefitted with the increase in number of native trees in field borders combined with herb and shrub coverage (Lee et al., 2001; Stamps et al. 2008; Sanchez-Oliver et al., 2014) since woody habitats are best suitable for increasing local avian richness in croplands (Jones et al., 2005; Puckett et al., 2009). It has also been suggested that land use systems where cover canopy of native trees is maintained can hold good avifaunal communities (Subasinghe et al., 2014). Thus for ecological restoration of Pothwar plateau, its native vegetation should be planted and propagated for providing food and shelter to its faunal diversity including birds.

In this agro-ecosystem several factors affect the activity pattern of birds which include types of cultivated crops, structure of non-crop vegetation and human influence. The farmers’ interviews revealed a low impact of anthropogenic practices on habitat degradation of Pothwar area. Livestock grazing is common practice in the rangelands of Pothwar plateau; but due to abundance of wild vegetation, majority of farmers do not carry out livestock grazing on their farmlands. The use of vegetation bordering the crop fields is quite low in terms of harvesting for fuel wood and animal feed. It could be assumed that farmers do not utilize this vegetation owing to large patches of scrub forests intermittently distributed within croplands that meet their requirements. In Pothwar plateau, mineral deficient soils are low in fertility and consequently chemical fertilizers are generally used (with a limited use of organic
fertilizers) to increase crop yield. These agro-chemicals not only cause pollution but also disturb the habitat.

Due to low prevalence of pests and diseases than the irrigated agriculture of Indus basin, few farmers employ chemical methods of pest control in the Pothwar area. Similarly, a few surface herbicides are used since manual weeding is popular practice, presumably for their use in animal fodder. Hunting is a popular sport in Pothwar plateau, although no reliable hunting record data are available for this region. However, it could be assumed that the species being hunted would certainly be at risk owing to uncontrolled hunting. Overall environment education and awareness of local people about biodiversity and wildlife conservation is lacking which should be promoted for effective bird conservation in this agroecosystem. Furthermore, for protection of avian diversity eco-friendly measures should be taken right from preparation/ seeding of crop fields till the harvesting of the crops.

In an agro-ecosystem, avifauna can be affected by human intervention i.e. disturbance by farm operations, use of pesticides as well as amount of rainfall and cropping pattern (Kale et al., 2013). Many developing countries in Europe have long-term monitoring programs to generate data on population, distribution and movement of bird species. Such research is also needed in Pakistan to see impacts of farming practices on local and migratory avifauna. The data of current study could serve as a baseline for monitoring the impacts of agricultural practices as well as an input in conservation decision making process. This could generate farmer friendly management recommendations for the reconciliation of agriculture with avian conservation. For example, many birds of this agro-ecosystem are partially or completely insectivorous and could contribute towards the biological control of
insect pests but they are certainly at risk with the use of agrochemicals. Thus judicial use of agrochemicals could be advised.

It has been well documented that conservation practices that promote multiple economic and environmental benefits to indigenous communities (including wildlife conservation) are readily acceptable by the local people and are implemented in true sense (Allen and Vanderer, 2003; Smith et al., 2005b; Daria and Campbell, 2012). Thus, plans for bird conservation in the Pothwar agroecosystem need to be developed on regional basis considering intensification of agriculture, type of landscape use and its use by the avifauna.

In Pakistan, few studies exist on population status and significance of birds for any agro-ecosystem. Similarly, literature on habitat, population status and avian species richness in the Pothwar region is scanty. The present study provides baseline data on population status and diversity of passerine bird species utilizing the agricultural landscape of the Pothwar plateau. Apparently there is no change in number of passerine bird species from previous report of 24 species (Roberts (1992) to the current record of 25 species. However, the composition of the Passeriformes indicates some change over this two decade period. Contrary to the reports of Roberts (1992) ten species namely red-winged lark (Mirafra erythroptera), grey-winged blackbird (Turdus boulboul), ashy-grey wren warbler (Prinia hodgsonii), Hogson’s wren warbler (Prinia cineveocapilla), lesser whitethroat (Sylvia curruca), crested black tit (Parus melanolophus), thick-billed flower-pecker (Dicaeum agile), willow sparrow (Passerhispaniolensis), Indian silver bill (Eodice malabarica) and spotted munia (Lonchura punctulata) were not recorded in this study whereas 11 new passerine species including golden oriole
(Oriolus oriolus), ashy drongo (Dicrurcus leucophaeus), India tree magpie (Dendrocitta vagabunda), grey-crowned prinia (Prinia cinereocapilla), Indian tailorbird (Orthotomus sutorius), large grey babbler (Turdoides malcolmi), pied bushchat (Saxicola caprata), baya weaver (Ploceus philippinus), white wagtail (Motacilla alba), yellow browed leaf warbler (Phylloscopus humei) and black redstart (Phoenicurus ochruros) were recorded.

This change could be attributed to expansion in agricultural area, alteration of cropping system, reduction of wild vegetation (rangelands and forests) and adaptation or immigration of some species versus vanishing/emigration of the others. In addition, the scope of current study was limited to croplands excluding any irrigated plantations or fruit orchards etc. which might not had been able to fully score the avian diversity. These assumptions, however, require further investigations to provide evidence support on habitat adaptation or migration of the indigenous bird species related to different ecologies of the Pothwar plateau.

Impact of agricultural intensification on biodiversity has been intensively investigated at global scale. But since each ecosystem is unique with respect to its landscape history, climate, habitat use, biodiversity (i.e. vegetation and wildlife) as well as technological advances therefore, it is imperative to study each region individually to see any impact of local ecological conditions and farming practices on the biodiversity. Although such impacts of landscape changes on biodiversity of Pothwar plateau have not studied but the research conducted elsewhere (Goijman, 2014) has shown that in agro-ecosystems avian species associated with human dominated landscapes increase in number while those associated with natural grasslands decline. In my study avian richness was high at the study sites with rain water ponds as compared to those not having any open water resource, indicating
that presence of water in this arid agro-ecosystem is crucial to support the crops that host rich invertebrate populations, thus attracting more passerines. This is also supported by findings of Ryszkouski *et al.* (2002) and Surmacki (2005) in similar agro-ecosystems of India.

Bird density and species richness decreased with rise in temperature at all the study sites of Pothwar area. This could be related with low food availability to the birds during summer in this arid region. Seasonal crop phenology and diversity might be another factor influencing the bird abundance. It is evident that wheat seeds were available during winter (sowing) and spring (ripening), while maize and millet seeds were available during monsoon, fall and winter seasons. During the summer season many fields were left fallow after harvest of wheat in order to conserve water for next winter crop and thus grain availability was low. Moreover, the groundnut during summer did not provide any attractive grain food source to small Passeriformes; consequently food availability for birds was reduced during the summer season. The decline in bird richness can also be attributed to the absence of migratory species that were winter visitors in this region.

The determination of food habits of selected passerine species in the croplands of Pothwar plateau by micro-histological analysis of fecal droppings revealed that these species derive their food from vegetation and animal sources of Pothwar croplands. The birds feed on seeds and leaves of cultivated crops but also supplement their diet with leaves and seeds of weeds. Since the bird population is low therefore they do not act as crop pests in this agro-ecosystem. Similarly, the invertebrate component of food is largely derived from insects, many of which could be crop pests, thus by consuming the insects the birds keep a check on insect populations in this agro-ecosystem.
Out of 25 passerine bird species, I was able to study breeding ecology of only five passerine species (*Prinia socialis, Pycnonotus cafer, Pycnonotus leucogenys, Dicrurus leucophaeus* and *Turdoides malcolmi*) that were exclusively utilizing the crop field boundary vegetation for nesting. These species are already known to be adaptable to human disturbance and usually breed in farmlands and urban environments (Smith *et al.*, 2005b; Ali *et al.*, 2010; Adams *et al.*, 2015). Non-existance of breeding activities of remaining resident passerine birds within the croplands helps to speculate that they were using wild patches of sub-tropical scrub forest, rangelands and rain water gullies for their breeding activities, probably due to lower level of human disturbance. However, detailed studies are required to support this assumption. Several authors have suggested that landscape context should be considered for effective biodiversity management (Piha *et al.*, 2007; Batary *et al.*, 2010). Wretenberg *et al.* (2010) and Batary *et al.* (2010) have reported that in forest dominated ecosystems food resources are more limited for the birds as compared to cropland dominated ecosystems. Relatively low breeding success of the birds in Pothwar croplands indicate that bird species are probably facing limitation of nesting sites in this region. Therefore, propagation and conservation of trees and bushes that provide nesting sites to the birds are crucial in such landscapes for bird conservation.

Although numerous threats to avifauna of agro-ecosystems are global scale but each ecology has specific impact on local bird biodiversity, thus specific management options are driven for every ecosystem. The agricultural landscape of Pothwar plateau is continuously and rapidly undergoing changes and impact of these changes on associated biodiversity especially avifauna need to be addressed in order to provide management recommendations which are an absolute necessity to reduce the pressure on natural resources and to prevent habitat degradation as well as to
conserve biodiversity. The tradeoffs between optimal farming outputs and minimal habitat loss should be focused not only for the well being of ecosystem as a whole but for socio-economic and sustainable benefits to indigenous communities. The management of field boundary vegetation is crucial in order to develop an Agri-environment scheme (AES) for agro-ecosystem of Pothwar to mitigate the impacts of agriculture on biodiversity in general and avifauna in particular.

**SUGGESTED CONSERVATION MEASURES**

In order to maintain profitable agriculture while retaining faunal biodiversity, bird friendly agricultural practices should be employed. Some of the suggestions are;

- At local level, spatial and temporal heterogeneity of natural vegetation should be maintained at the crop field borders.

- Patches of uncultivated land should be kept as bird refuges. Such areas provide cover and nesting sites to the local avifauna.

- Native plant species that provide roosting and nesting sites should be propagated and re-established (where necessary) in this agro-ecosystem for effective conservation of birds.

- Multiple cropping should be promoted to increase the floral diversity of this agro-ecosystem which in turn would not only provide food variety to local people but would also promote arthropod diversity needed for avian breeding and their nestling growth.

- Habitat fragmentation should be minimized to the possible extent. Conservation buffer practices should be introduced in the agricultural landscapes for the enhancement of habitat to promote bird diversity.

- Climate of Pothwar plateau is arid in nature where rain is the only source of water. It is proposed that
appropriate measures for rain water conservation should be encouraged to support agriculture, livestock as well natural flora and fauna.

- Unwanted human activities (i.e. illegal hunting, poaching fuel wood collection and livestock grazing) should be minimized to a possible extent in wild areas through effective management and effective implementation of existing laws.

- Instead of expanding the area under agriculture, improved crop varieties should be introduced to achieve optimum crop yield from the existing cultivable land.

- Use of agrochemicals should be rationalized to the possible extent for reducing their negative impact on soil, water, flora and fauna.

- Environment education and awareness of local communities is a crucial component of conservation. It shall be made integral part of formal education at primary and high school level. Whereas, local folks can be reached through print and electronic media.

- Further research on bird-environment relationships is essential for devising effective conservation strategies in this less studied ecosystem of Pothwar plateau.
SUMMARY

Agro-ecosystems are dynamic ecological systems due to continuous human intervention for optimum production of food and fiber crops and harbor characteristic wildlife. Due to extensive and prolonged farming practices, the associated biodiversity of such areas is continuously subjected to changes in habitat and landscape structure that usually are unfavorable to wild flora and fauna. Pothwar plateau of Pakistan is rain-fed region covering an area of \( \approx 23,160 \) km\(^2\) which accounts to 2.9\% of the total area of Pakistan. Around 110,600 ha area of the plateau is under cultivation and it contributes 10\% of the total agricultural production of the country. Agriculture of the plateau is dominantly (96\%) dependent on rain with only 4\% cultivated by irrigation. Two types of traditional cropping patterns are practiced in this region i.e. wheat-groundnut and wheatmaize/millet. The plateau is dissected with undulating topography, gullies and rugged terrain and hosts important floral and faunal diversity of Pakistan.
Fast expansion of urbanization and agriculture are putting wild habitat and associated avifauna of Pothwar under pressure for need of food and shelter. Consequently many bird species especially Passeriformes are being forced to utilize croplands for feeding, roosting and breeding. Since no comprehensive account of passerine birds associated with field boundary vegetation in Pothwar is available, so the present study was carried out to provide baseline data on the anthropogenic use, diversity and abundance of the crop-field-edge vegetation, seasonal diversity and species richness of passerine birds utilizing this vegetation for feeding, nesting and breeding. After initial reconnaissance surveys four study sites (two in each cropping system) in agro-ecosystem of Pothwar plateau were selected. At each site an intact area of 1 km² was selected to record the study parameters.

The anthropogenic data is based on interviews of 94 farmers and/or workers aged 27 to 54 years. The results revealed that principal crop cultivated in this region is wheat, followed by groundnut and maize. Mustard is generally intercropped with wheat. Farmers of this area rear livestock, commonly goats and cattle, in order to generate revenue especially in drought years when low crop yields are expected in this rain dependent ecology. Livestock is usually grazed in wild vegetation adjacent to the farms but animal grazing in croplands is allowed after harvest or during pre-monsoon season. The farmers plant fast growing shrubs along crop field margins for fodder and browse as well as for fuel wood and only few of them burn crop fields and associated vegetation after harvesting of crop, in order to enhance soil nutrients. Due to mineral deficiencies and low fertility of soil inorganic fertilizers are used at various growth stages to enhance yield of wheat and groundnut crops. Commonly used fertilizers are urea and DAP while organic fertilizers are scarcely used. Weeds,
insect and rodent pests infest the host crops. Weeds as source of animal fodder are usually removed manually and few surface herbicides are used. For insect control, insecticides are used while rodents are poisoned with zinc phosphide baits. The farmers’ knowledge of beneficial roles of birds in their croplands is poor.

For vegetation analysis transects of 200 m length were laid down and density, frequency and percent cover of plant species were measured within quadrates of 10 m × 10 m for trees, 4 m × 4 m for shrubs, and 1 m × 1 m for grasses and herbs. Importance Value Index (IVI) and Summed Dominance Ratio (SDR) were calculated for all plant species observed. In total 51 species of plants associated with crop field boundary vegetation were recorded which included 12 tree species (with dominance of *Acacia modesta* and *Zizyphus mauritiana*), 14 species of shrubs and 25 species of herbs/grasses. Many of herbs/grasses were weeds or symptomatic of general habitat disturbance.

Avian densities were estimated by establishing 48 permanent point count locations (12 at each site), on monthly basis and data were categorized into five seasons namely; monsoon, fall, winter, spring and summer. Twenty five species of birds were recorded among which 20 were resident and five were migrants/winter visitors. Most common and abundant bird species inhabiting the croplands of Pothwar were house sparrow (*Passer domesticus*), common myna (*Acridotheres tristis*), red-vented bulbul (*Pycnonotus cafer*) and Himalayan bulbul (*Pycnonotus leucogenys*) while comparatively less common species were Indian tailor bird (*Orthotomus sutorius*), common lark (*Alauda arvensis*), ashy drongo (*Dicrurus leucophaeus*) and ashy prinia (*Prinia socialis*). Other species were rare and confined to specific cropping systems. The migrants/winter visitors were observed only from November to March. Avian density and diversity decreased during summer due to
absence of migratory birds and decreased availability of food since during summer
groundnut crop did not provide attractive sources of food to birds. More numbers
and species of birds were present at sites that had wheatmaize/millet cropping system
and were in close proximity to rain water ponds since these areas provided better
living conditions to rare and infrequent birds in this arid ecosystem.

Diet composition of nine bird species was determined through micro-
histological analysis of fecal droppings. In total, 950 droppings were collected over a
period of two years. The analysis showed that red-vented bulbul and Himalayan
bulbul inhabiting this agro-ecosystem are frugivores and consume berries and fruit
of wild plants as well as insects. Insect uptake increases during breeding season.
They do not prefer cultivated crops. Three species of passerines utilizing the
croplands of Pothwar were full time insectivorous in feeding habits. These included
ashy prinia, pied bushchat (*Saxicola caprata*) and ashy drongo. These birds feed
exclusively on insects including crop pests and thus are the potential biological
control agents of insect pests in this agro-ecosystem. Common myna, common lark,
large grey babbler (*Turdoides malcolmi*) and Indian tailorbird were omnivorous in
their dietary habits. Among the cultivated crops these species feed on wheat, maize
and millet during some part of the year but they also visit crops for invertebrates
particularly insects that are pests of these crops. Since majority of the bird species
are low in populations and also consume wild plant parts therefore, they do not carry
thresholds of crop pests in this area.

The breeding ecology of only five passerine bird species (ashy prinia,
redvented bulbul, Himalayan bulbul, ashy drongo and large grey babbler) was
studied that were found exclusively utilizing field boundary vegetation for nesting.
The study parameters included; nest characteristics, egg morphometry, incubation
and nestling period and hatching, fledging and breeding success and threats. The smaller passerines (prinia and the bulbuls) utilized shrubs bordering the crop fields for nesting while drongos and babblers used trees. The nests were constructed at low height probably to avoid aerial nest predators but that made them susceptible to ground predators like snakes and domestic cats while humans were also observed disturbing the eggs and nestlings of these species. Although these birds are well adapted to farmlands for nesting but this study showed that these species had low hatching, fledging and breeding success in this agro-ecosystem as compared to other studies elsewhere suggesting that roosting, foraging and nesting sites of avifauna need to be enhanced and conserved in this region.

In order to maintain profitable agriculture with retaining avian biodiversity in Pothwar plateau it is important to provide heterogeneity of native natural wild vegetation by maintaining existing forest and range areas as bird refuge. Conversion of wild area to agriculture landscape should be limited by improving crop varieties to meet food and fiber needs. Multiple cropping with improved crop varieties can also be favourable for avifauna. Use of agrochemicals should be reduced as much as possible. Appropriate measures for rain water conservation are crucial in this arid region to support agriculture, livestock, natural flora and fauna. Habitat degradation and unwanted human activities should be minimized to the possible extent. Environment education and awareness of local communities and further research on bird-ecosystem relationships are required to provide a base for devising effective bird conservation strategies in this region.
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Annexure-1

Interview Performa for Anthropogenic practices

Form No. _______________

Date: ________________

Study site (location): ________________

Farmer’s name: ________________

Farmer’s status: a. Land owner b. Tenant c. Other

1. Which livestock do you own?
   i) Cows ii) Buffaloes iii) Goat/sheep iv) Other

2. Do you graze animals on your fields for their feeding?
   i) Yes ii) No

   If yes,
   a. During which season or crop growth stage do you graze the animals?
   b. What are the timings of grazing?
   c. What is approximate duration of grazing?

3. Do you cut the crop field boundary vegetation for animal feeding?
   i) Yes ii) No

   If yes,
   a. What is the season of cutting?
b. Which type of vegetation (grasses, shrubs) and what portion is cut?

4. Do you cut field boundary vegetation for fire-wood?
   i) Yes       ii) No

5. If yes,
   a. What is the season of cutting?
   b. Which type of vegetation (grasses, shrubs) and what portion is cut?

6. Do you use chemical fertilizers in your crop?
   i) Yes       ii) No

If yes,
   a. What type of chemical fertilizer do you use?
      (i) Urea     (ii) DAP     (iii) Any other
   b. In which crop you use chemical fertilizer?
   c. What is rate of application of the chemical fertilizer i.e. weight per Kanal?
   d. At what crop growth stage do you apply the chemical fertilizer?

7. What type of pests and diseases do you observe in your crops?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Weeds</th>
<th>Diseases</th>
<th>Insects</th>
<th>Rodents</th>
<th>Birds</th>
<th>Wild boar</th>
<th>Porcupine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
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<td>Groundnut</td>
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<td>Any other</td>
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</tr>
</tbody>
</table>

8. Do you do anything to prevent and control diseases and pests damaging crops?
i) Yes       ii) No

If yes,

a. What do you do?
   (i) Non-chemical control   (ii) Chemical/pesticide control

b. What is the name of pesticide that you buy?

c. To which crops do you apply pesticide?

d. How much pesticide do you buy per year?

9. Do you burn field boundary vegetation?

   i) Yes       ii) No

   If yes,

   a. In which season do you burn field boundary vegetation?
   b. How often do you burn field boundary vegetation?

10. Do you feel that crop field boundary vegetation is beneficial or harmful to your field crops or your livelihood? i) Yes   ii) No

11. Do you feel that small birds inhabiting crop field boundary vegetation are beneficial or harmful to your field crops? i) Yes   ii) No

12. Do you hunt any bird species inhabiting crop field boundary vegetation?

   i) Yes       ii) No

   If yes,

   a. In what season do you hunt those birds?
   b. Which Species of birds do you hunt?