Distribution of Breeding Wheatears and Rock Nuthatches According to Elevation and Habitat at Peramagroon Mountain in Kurdistan, Northern Iraq

by

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Thesis presented in part-fulfillment of the degree of Master of Science in accordance with the regulations of the University of East Anglia

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August, 2012

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Abstract

The influence of altitude and habitat structure on three breeding wheatears and two rock nuthatches was studied at Peramagroon Mountain in Kurdistan, northern Iraq. These studied birds were distributed differently in various vegetation zones and habitats at c. 850-2600 m asl. Ecological segregation between the wheatears was also observed. Depending on the methodology implied, the logistic regression analysis revealed that density and distribution of the Kurdistan Wheatear *O. xanthoprymna* is only and significantly (*P* < 0.001) related to altitude, whereas the occurrence of the Eastern Black-eared Wheatear *O. melanoleuca* is negatively associated with stone and grass cover (*P* < 0.005), but its abundance increases with increase of tree densities (*P* < 0.001). Contrary, Finsch’s Wheatear *O. finschii* were found in areas where the stone (*P* < 0.005) and grass (*P* < 0.05) were dominant and these are strongly related. However, in rock nuthatches, the Western Rock Nuthatch *S. neumayer* and Eastern Rock Nuthatch *S. tephronota*, altitude and habitat preferences were not significant factors in their distribution (*P* > 0.05). It seems that interspecific interaction play an important role and caused ecological release in these birds, especially in the Western Rock Nuthatch *S. neumayer*. 
Acknowledgement

First and foremost I would like to express my deepest gratitude to my supervisor, Dr. Paul Dolman, who has guided and supported me during my study and without him I would never have been able to finish or write my dissertation.

Also I would like to thank Dr. Nigel Collar (BirdLife International) for his effort and encouragement.

My sincere thanks goes to my adviser, Dr. Alan Bond, who advised and helped me throughout my study.

My warm thanks are due to my friend Richard Porter (BirdLife International adviser for the Middle East), who was very supportive of this thesis in many ways.

I am indebted to my many of my good friends especially Nabaz Rashid, Saman Abdulrahman and Christina Ieronmidou, Mariwan Qadir, Hana Raza, Shoxan Baba and Ara Raza.

I take this opportunity to sincerely acknowledge the Kurdistan Regional Government (KRG), for providing financial support.

I would like to thank my best friend, Lizan Araz, who supported, encouraged and motivated me during my study.

The last not least, my sincerest thanks to my family “especially my father”, without their help I was not able to finish my study.
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Introduction

The Irano-Anatolian Hotspot consists of complex topography, elevations range from 300 m asl (in the foothills of the western Zagros Mountains and Kopet Dagh) up to more than 5,000 m asl. Mountain Ararat in Turkey and Damavan in Iran reach 5,165 m asl and 5,671 m asl respectively. Seven eco-regions are located within this area including; Central Anatolian steppe, Central Anatolian deciduous forests, Eastern Anatolian deciduous forests, Eastern Anatolian montane steppe, Elburz Range forest steppe, Kopet Dag woodlands and forest steppe and Zagros Mountains forest steppe. The Irano-Anatolian Hotspot encompasses 89,977.3 ha, comprising most parts of central and eastern Turkey, north eastern Iraq, western and northern Iran, southern Georgia, a small part of Azerbaijan, a major part of Armenia, and western Turkmenistan (Northern Kopet Dagh Range) (Fig. 1). The Irano-Anatolian Hotspot has continental climate, characterised by hot summers and very cold winters; and annual rainfall ranges from 100 to 1,000 mm. The main habitat of this area is mountainous forest steppe; favouring deciduous oak (*Quercus* spp.) forests in the west (Anatolia) and south (Zagros mountains) and juniper (*Juniperus* spp.) forests in the east (Elburz mountains and Kopet Dagh). Sub-alpine and alpine vegetation zone covers mountains above the timberline. In addition, thorn-cushion vegetation exists in the sub-alpine zone (Conservation International, 2012).

Peramagroon Mountain is located in the south of the Irano-Anatolian Hostspot, 27 km northwest of the city of Sulaimani, in the Sulaimani Governorate of Kurdistan, Northern Iraq (map 1). The entire area, which is approximately 11,000 ha, lies within the Irano-Tauranian biome/ Zagros Mountain Forest Steppe, which is a critically threatened habitat and eco-region. The mountain peak is c. 2,613 m asl. It is the highest peak in the Sulaimani Governorate. Geologically it locates on the southwest of the Zagros Thrust Belt, which is formed from the basin fill of the Neo-Tethys Sea and colliding of Iranian and Arabian plates; within the High Folded Zone (Buday and Jassim, 1987; Goff and Jassim, 2006). It includes the mountain ridge and most of the Mergapan valley to the Northeast (which includes areas near the villages of Homer Qawm and Shadala), and it is one of the potential proposed protected areas in the Kurdistan Region, Northern Iraq.
This mountain is one of the most diverse and rich in bird species in the Middle East (R.F. Porter, pers comm.). Between 2007 and 2012, Key Biodiversity Areas (KBA) surveys observed 134 bird species (Ararat, 2009; Ararat et al., 2009; Nature Iraq, in prep). This site is considered as one of the potential Important Bird Areas, as it meets two of the global criteria, namely: the A1 criteria (holding considerable number of globally endangered Neophron percnopterus (4-6 pairs)) and the A3 criteria (BirdLife International, 2012).
A significant species number including eleven breeding species restricted to the Irano-Tauranian were found breeding, including the following: Ammoperdix griseogularis, the Plain Leaf Warbler Phylloscopus neglectus (which is the only known breeding population in the western Palearctic region) (Cramp, 1992), Upcher’s Warbler Hippolais languida, Menetries’s Warbler Sylvia mystacea, the Eastern Rock Nuthatch Sitta tephronota, the White-throated Robin Irania gutturalis, the Kurdistan Wheatear Oenanthe xanthoprymna, Finsch’s Wheatear Oenanthe finschii, the Grey-necked Bunting Emberiza buchanani, the Eastern Cinerous Bunting Emberiza semenowi, and the Pale Rock Sparrow Carpospiza brachydactyla. Five breeding species, which are restricted to the Mediterranean biome were also found; the Masked Shrike Lanius nubicus, the Sombre Tit Poecile lugubris, the Western Rock Nuthatch Sitta neumayer, the Eastern Black-eared Wheatear Oenanthe melanoleuca, the Black-headed Bunting Emberiza melanocephala. Furthermore, three Eurasian High-Montane biome restricted species; Pyrrhocorax graculus, Montifringilla nivalis and Serinus pusillus are also breeding in this area.
Chapter Two

Literature review

2.1. Mountain bird diversity and richness:

Bird species existence is determined by vegetation structure (Roth 1976; Finch 1991; Waterhouse et al. 2002). However, vegetation and several other interacting factors (abiotic and biotic) affect species distribution, for example productivity and temperature change along the environmental strata related to elevation (Udvardy 1969; MacArthur 1972, Able and Noon 1976, Rahbek 1997, Hofer et al. 1999, Waterhouse et al. 2002).

The pioneer naturalists including Linnaeus, Willdenow, Darwin, Wallace and van Humboldt were the first people to record the change of the natural world with elevation (Lomolino, 2001; McCain, 2009, McCain and Grytnes, 2010). In their journeys around the globe, they observed a number of species and types of habitats predictably vary with increase in latitude and elevation. In addition, these obvious changes over short distances helped ecologists to generate various essential ecological concepts (McCain, 2010), including niche theory (Grinnel, 1917), life zones (Merriam and Stejneger, 1890), community assembly (Whittaker, 1960) and insular biogeography (Brown, 1971). As the physical condition and types and amounts of resources required for breeding and foraging activities are affected by elevation, the structure and composition may vary along elevation gradients (Able and Noon 1976; Cody 1981, Stevens 1992). For some birds an increase in elevation adversely affects their existence and diminishes the resources. This is due to factors such as change in forest stand structure, vegetation cover and composition, productivity of the site, secondary biotic interactions, and available spaces (Able and Noon, 1976; Sabo, 1980; Karr, 1983; McCoy, 1990; Rahbeck, 1995; Hofer et al., 1999). Species richness on mountains divide into four categories according to altitudinal patterns: decreasing, low plateau, low plateau with a mid-elevational peak, and mid-elevational peak. In decreasing richness patterns, species numbers decline monotonically with increasing elevation. In low plateau patterns species richness is higher at the lower area of the gradient (> 300 m) than decreasing species richness.
In the low plateau with a mid-elevational peak patterns there is high species richness at low elevations (> 300 m) and the diversity peaks at more than 300 m from the base. Unimodal peak in diversity appears at the mid-elevation peaks where the elevations are intermediate (> 300 m) with more species richness (≥ 25%) than at the base and top of the mountain.

2.2. Factors affecting bird distributions:

The species distribution and its range are determined by the interactions between two main factors: the species characteristics and adaptability which reflect the environmental circumstances in which it can survive; and the surrounding biotic and abiotic factors (Cornwallis, 1975). These include climate, space, evolutionary history and biotic processes and they are the main biodiversity drivers (Pianka, 1966; Gaston, 2000; McCain, 2007; McCain and Grytnes, 2010). In addition, different biological processes affect richness patterns studies, including competition (Terborgh and Weske, 1975), source-sink dynamics and ecotone effects (Lomolino, 2001), and habitat complexity and heterogeneity (Terborgh, 1977). Regarding ecotones, areas on the major gradient transitions between habitats appear to have been occupied by more species because of source-sink dynamics or overlapping range limits (Terborgh, 1985; Lomolino, 2001). So, the highest diversity can be observed at the dominant ecotones, whereas areas with minor diversity are predicted at minor ecotones (McCain and Grytnes, 2010). Therefore, a species will be found only within the range of its dispersal ability, where it tolerates the environmental conditions and its minimum requirements are available, and where it is not excluded by disease, predation or competition. Moreover, the concept of competition exclusion implies that in a mature community, where the individual species are in dynamic balance between themselves and the other environmental variables, each of these species will be better adapted to use its own habitat and range than any competitor.
2.3. Ecological Isolation and coexistence of closely related species within the same area

There are many avifauna species that are differentiated to subspecies or geographical races, and in some cases these are very obvious. When these geographical forms occupy the same region, species can either interbreed and merge or become very distinctive. A species may remain separate and will be considered as a separate species (Lack, 1943). Closely related species occasionally inhabit different geographical areas, known as allopatry (Wilson and Brown, 1955; Grant, 1972). If they exist in the same region they usually inhabit different habitats; but if they exist in the same region and habitat they usually have different feeding behaviour and/or differ distinctively in size; this is known as sympatric species (Wilson and Brown, 1955). Species that vary distinctively in size mainly consume a different diet (Lack, 1933). Furthermore, according to Gause (1934), two animal species cannot occupy the same area with the same ecological requirements, unless they are ecologically segregated (or isolated). Therefore, there are different patterns of ecological isolation in birds (Lack, 1971; Diamond, 1972; Cody, 1974). these may be spatial segregation and/or habitat segregation. In spatial segregation, species have similar ecological requirements exist away from competition by living and occupying different areas. Whereas in habitat segregation, species that coexist together within the same habitat have different food requirements (Lack, 1966); they also differ in size at least at certain periods of the year (Cornwallis, 1975).

Moreover, interactions between nearly related species influence the diversity of both fauna and fauna within the ecosystem (Darwin, 1854; Clatworthy et al., 1961). Species can exist together when they do not merge by hybridization to form an interbreeding population. Species that are closely related systematically may occur in geographic isolation (allopatric speciation) or in coexistence (sympatric speciation), which mean these species diverge in each other’s occurrence; or they diverged in isolation and then migrate to each other’s breeding area. In some cases geographical isolation is significant for the evolving distinct races (Mayr, 1947; Ford, 1954). While in wheatears, as most of them overlap in their distribution, morphological variations seem to be mainly linked to their foraging and migratory habitats, rather than the degree of sympatry (Kaboli, 2007).
2.4. Character displacement

Character displacement is the phenomenon of alterations of a species' morphological character state under natural selection, evolving from presence, as the consequences of the presence of one or more species similar to it ecologically and/or reproductively within the same environment. Many biologists have succeeded in proving the character displacement in animals, particularly birds (Hutchinson, 1959; Ripley, 1959; Parkes, 1965; Ficken et al., 1968; Bock, 1970), and also other taxa, including lizards, mammals and insects (Hutchinson, 1959; Schaffer, 1968; Shoener, 1970). This also ruled out the Gausian principle of competitive exclusion (Hardin, 1960) and raised a question of how two or more similar species avoid one of the species competitively excluding the other (Shoener, 1965; Grant, 1966; MacArthur and Levins, 1967; Lack, 1971; Grant, 1972; Schluter and McPhail, 1992). Rock nuthatches (Sitta neumayer and Sitta tephronota), which are partly sympatric and overlap their habitat in the Zagroz ranges; differ from each other in bill size and also facial patterns (Grant, 1972). While in areas where there is allopatry they have almost identical or intermediate size and morphology (Kear, 1962; Hespenheide, 1966; Grant, 1972). This results from the change in ranges of two allopatric species and becomes sympatric with their feeding strategies, which is called divergent displacement or selection. As a result the two species can coexist stably, minimizing interspecific competition for food.

2.5. Congener Breeding Bird Species Observed at Peramagroon Mountain:

There are different bird species that share their habitats in the southwest region of Asia especially along the Zagrozian Ranges (Cornwallis, 1975). Including wheatears and rock nuthatches. These were observed at Peramagroon Mountain as resident and/or summer breeder and winter visitor:
2.5.1. Wheatears:

Wheatears, which are birds belong to the genus Oenanthe, are small chat-like birds (thrushes) belong to family Muscicapidae (Cornwallis, 1975). Twenty-one species with 45-47 races (Cramp, 1988; Sibley & Monroe, 1990; Keith et al., 1992; Dickinson, 2003; Kaboli et al., 2007) have been identified of which seventeen largely breed in the Palearctic region, while the rest are resident in Africa (Cornwallis, 1975; Panov, 2005; Porter and Aspinall, 2011; BirdLife International, 2012). They have similar morphology and size and some of them are alike in plumage, also generally their behaviour and ecology are similar. Mostly they occupy open, stony barren plains, hillsides and rock outcrops. They are hole-nesting birds, nesting in rock crevices, under boulders or in ground holes. Most of the Palearctic wheatears are confined to arid zones as their suitable habitat is found there. However, some of them differ in the altitudinal and latitudinal ranges and/or their habitats. But the majority of these species are in contact or overlap in their ranges, especially in the Middle East and northern Africa, where several wheatear species exist. Seven wheatear species were recorded at Peramagroon Mountain. Two of them are winter visitors and passage migrants, namely the Northern Wheatear Oenanthe oenanthe (possibly breeds) and the Pied Wheatear Oenanthe pleschanka. While the other five species are breeding summer visitors to the area, including:

2.5.1.1. The Isabelline Wheatear *O. isabellina*

This species is (fig. 3 a) widely distributed and breeds in lower, middle and middle continental latitudes on plains and plateau with different altitudinal ranges (from 1200 m to 3500 m), in warm arid climates, and in open rocky or sandy areas with level or gently sloping terrains. It exists in forest steppe in Russia and on screes in the Caucasus. In addition, it breeds in hilly areas in Kurdistan, northern Iraq, and is a common winter visitor and passage migrant in Mesopotamia (Allouse, 1962). In Pakistan (Baluchistan), the species is recorded at c. 1200-2200 m near roadsides and houses irrigating banks and excavations. In Jordan, it inhabits wadis of limestone areas (Cramp, 1988). It breeds at altitudes up to 3000 m in open plain regions of Afghanistan, in fertile valleys, away from mountains, and usually at the
margins of cultivations. Cornwallis (1975) studied this species in the southwest of Iran and observed it on flat ground and gentle slopes, but preferring steep areas. O. isabellina commonly favors undeveloped steppe areas, but infrequently it found in abandoned fields or at the edge of cultivations, primarily on wide open plains with silt surfaces and scattered shrublets. In addition, the bird occupies rocky and steep terrains in areas like the Caucasus where there is no competition (Cramp, 1988). During their winter migration, this species reaches up to the northern edge of the Sahel zone. It is found at different altitudes from coastal flats up to 2500 m, predominantly in drier and barren habitats and also among short grasses at 1500 m in East Africa. While in West Africa, it prefers burnt ground: In Senegal its habitat overlaps with the Northern Wheatear O. oenanthe, and the Black-eared Wheatear O. hispanica; in Chad it is common on flat sandy bare ground. Moreover, in spring it found along the seashore of the Red Sea province of Egypt, in gardens and under palm trees and bushes (Cramp, 1988).

2.5.1.2. The Kurdistan Wheatear O. xanthprymna

The Kurdistan Wheatear Oenanathe xanthoprymna is one of the biome-restricted (Irano-Tauranian biome) species. The xanthoprymna, the nominate species, has a distribution range as summer breeder in SE Turkey to SW Iran, and as non-breeding in E Egypt S to E Sudan and Eritrea, Arabian Peninsula and NE Somalia (Fig. 3 b & c). Also breeding evidence was observed on five semi-arid bared rock mountains north-east of Iraq (Ararat et al., 2011; Porter and Aspinall, 2011). Whereas the split species Oenanthe chrysopygia is distributed across North-East Turkey, Armenia and North Iran, East to South Tajikistan, Afghanistan and extreme West Pakistan; and non-breeding in the Arabian Peninsula, South Iraq, South Iran, East Afghanistan, Pakistan and NW India. In Russia, it occupies scree and bare often rocky slopes at c. 1200- 3100 m. While in Afghanistan, during breeding season it is found mainly on rocky mountain slopes, and in fallow fields in barren valleys at c. 2000- 2700 m. Also in south-west Iran it breeds at c. 2500- 4000 m, on steep stony and boulder-strewn hillsides, terrains with gentle slopes and even plains (Cornwallis, 1975, Cramp, 1988). In addition, O. cummingi, which is the hybrid of O. xanthoprymna and O. chrysopygia (McCarthy, 2006) breeds in the Zagrozian ranges in the western part of
Iran (Chamani et al, 2010). In the southwest of Iran *O. xanthoprymna* (probably nominate *chrysopygia*) is found at high altitude at c. 2500-4000 m. While on the other hand, the same area distribution range of *O. finschii* is c. 1900-2200 m in winter. In addition antagonism behaviour between these two species was observed, and socially *O. finschii* is dominant to *O. xanthoprymna* and all other species of wheatears (Cornwallis, 1975).

![Figure 2. Distribution range of *Oenanthe xanthoprymna*, *Oenanthe chrysopygia* and *Oenanthe cummingi* (Chamani et al, 2010).](image)

### 2.5.1.3. The Eastern Black-eared Wheatear *O. melanoleuca*

*O. hispanica* was split into *O. hispanica* and *O. melanoleuca* (fig. #) by Sangster *et al.* (1999) and they interbreed and intergrade between each other. *O. melanoleuca* breeds at lower latitudes in warm continental Mediterranean and steppe areas. It replaces *O. oenanthe* in areas below c. 600 m (Cramp, 1988). While in the Caucasus it reaches higher altitude (2000-2300 m), also occupying steppes with rock outcrops or stony hills and slopes. It occurs more commonly in open or lightly wooded arid area (Peterson *et al.*, 1983), also on stony grounds and warm rocky plains, dry river valleys, limestone hills, dry stony fields, Mediterranean heaths with oak (*Quercus* spp.), and dry cultivations (Cramp, 1988). Moreover, in southwest Iran it breeds in different habitats at altitude c. 1700-2500 m with annual precipitation of more than 400 mm, with richer vegetation cover than those areas occupied by other
Oenanthe, including shrublets, ample flush of spring herbage, bushes and often trees; in particular Quercus and Juniperus (Cornwallis, 1975). During their wintering the birds inhabit areas with Acacia and thorn-bush steppe, rocky gills, semi-desert area, and gardens.

2.5.1.4. The Finsch's Wheatear O. finschii

This species occurs in continental lower-middle latitude of the southeast portion of the west Palearctic, in steppe and dry warm temperate zones. It is resident in the northern foothills of Iraq (Allouse, 1962) and in Russia it breeds on bare clay sands, steppes with rock outcrops, and stony ravines in low mountains, at altitude c. 1400-1600. On the east coast of the Caspian, it inhabits plains and rocky foothills, nesting in rodent holes. It occurs locally in northern Afghanistan, in foothills at c. 700-950 m, predominantly within canyons with barred rock outcrops. In Pakistan, it is found frequently from mid-August by roadsides on high upland steppe-like terrain up to c. 2000 m, coexisting in this season with the Isabelline Wheatear O. isabellina. In Lebanon, it inhabits stony and rock outcrops in ravines of mountains or hillsides, particularly rock-rims in arid region (Cramp, 1988). In Turkey it is restricted to rocky hillsides and perches on prominent rocks (Wadley, 1951). In its eastern range, it has been observed breeding up to 2400 m on bare rock outcrops or large boulder screes and less frequently in ravines among scattered bushes (Gaston, 1968). On the other hand, in southwest Iran, it is found breeding on bare ground, rocky areas, and more often areas with gently slope or flat terrain overlapping with the habitat of the Mourning Wheatear O. lugens (Cornwallis, 1975). O. finschii is partially migratory, their altitudinal distribution may vary occur during their migration. Wintering observation range across Turkmenistan, Transcaucasia, and Kazakhstan; but their main wintering ranges of west Palearctic extend from southern Turkey and northern Iraq south to northeast Egypt and northern Saudi Arabia.
2.5.1.5. The Mourning Wheatear *O. lugens*

This species breeds in lower middle latitude in warm arid Mediterranean and subtropical desert climates, commonly found on rocky areas, clay hill-slopes and wadis banks (Heim de Balsac and Mayaud, 1962). It is local resident and summer visitor in foothills in north and central Iraq (Ararat et al., 2011). In Egypt, it occupies major desolate wadis and rocky gorges, often side by side with Hooded Wheatear *O. monacha*. Its breeding territories in the southwest of Iran are found at c. 1700-2700 m on steep, rocky, boulder-strewn hillsides with broken rock outcrops used as song posts, searching for food and protection from predator or unfavourable weather, nesting, and provider of shade; less frequently in areas with gentle slopes. Their habitat requirements are similar to those of Finsch’s Wheatear *O. finschii*, and where these two species coexist, the latter usually inhabits areas with gentle slopes, while *O. lugens* becomes restricted to steep hillsides. However, cases of interspecific interaction are usually ruled out by geographical separation. In Egypt, during their winter migration they move from dry wadis in mountains between the Nile and Red Sea to lower spurs of the mountains (Hartley, 1949), and rarely pass through cultivations.
Figure 3. Breeding wheatears observed at Piramagroon Mountain: (a) Adult ♀ of *O. isabellina* was feeding its young, (b & c) adult ♀ & ♂ of *O. xanthopyrma*, (d & e) adult ♀ & ♂ of *O. melanoleuca*, (f & g) adult ♀ & ♂ of *O. finschii*, and (h) a breeding pair of *O. lugens*. 
2.5.2. Rock Nuthatches:

Nuthatches are small passerines belonging to genus Sitta and family Sittidae. They recognised by their large heads, short tails, strong bills and feet. They are also characterised by greyish or bluish upperparts and a black eye stripe. There are approximately 25 species of nuthatches, the majority of which breed in temperate or montane forests of the Northern Hemisphere. However two species in the warmer drier areas of Eurasia have adapted to the rocky habitat of the eastern Mediterranean, from the Balkans to mountains of Tien-Shan (Harrap and Quinn, 1995). They coexist in northern Iraq and southwest of Iran, and are discussed below:

2.5.2.1. The Western Rock Nuthatch \textit{Sitta neumayer}

This species breeds in warm Mediterranean lower middle latitudes of dry continental climate in and near the west Palearctic region, restricted to the Mediterranean biome. It inhabits sunny, commonly calcareous rocky slopes and steep faces with vegetation. In Iraq, the species breeds in mountains and hills with rocky boulders, and open woodland with scattered rocks. It is predominantly a rock and ground bird, but in winter is frequently found in roadside shrubs and trees. Additionally, its breeding is isolated to low levels, mainly on uplands and mountains up to c. 1000 m (Cramp, 1988). In Turkey, the species is a common inhabitant of mountains and hills with rock outcrops and scrubby rocky slopes at c. 2100 m in the Taurus ranges. Less commonly it appears in woodland with scattered rocks. Furthermore, in Anatolia it is found mainly on limestone at below 1300 m to 3300 m, but rarely above 2650 m (Cramp, 1988). In Russia, it occupies rocky terrain up to 2000 m during its breeding season and in winter it moves down to valleys with trees where it forages.

2.5.2.2. The Eastern Rock Nuthatch \textit{Sitta tephronota}

This species is restricted to the Irano-tauranian biome. It breeds in Asian dry montane in lower middle latitudes, and reaches up to c. 2600 m on steep and ravines in Russia. It is a common breeding resident on rocky hillsides with open oak Quercus woodlands. It Inhabits the boulder-strewn slopes of mountains in Afghahanistan at c. 1070- 3000 m, and also rock walls in canyons.
It is more arboreal and less confined to rock-living than the Western Rock Nuthatch S. neumayer. In Pakistan (Baluchistan), this species occupies the crevices of valleys with jumbles of boulders, especially areas near to streams; dispersing down to c. 300 m during winter. Also in this region, this species has been found restricted to small areas of gorge with small rocks at c. 2000 m. S. tephronota has been observed nesting in rocky oak Quercus wood. In Russia, after the breeding season, it moves down to mountain forests and orchards, there it also inhabits trees, pecking trunks and fruits of pistachio Pistachia orchards (Cramp, 1988).

Figure 4.1. Western Rock Nuthatch S. neumayer feeding its young.

Figure 4.2. Eastern Rock Nuthatch S. tephronota.
Chapter Three

Aim of this Study

The aims of this study are first to understand the density, distribution and elevation gradients patterns of wheatears and rock nuthatches species at Peramagroon Mountain during their breeding season. The next aim is to determine to what extent these species share their habitats and/or coexist together, or whether they are ecologically isolated. The main variables that affect the wheatears and rock nuthatches ranges and habitat distributions are also to be investigated. The final aim is to estimate the degree of correlation between the studied birds and their surrounding habitats, especially the globally vulnerable ecosystem deciduous montane oak forest. Since scientific studies have not yet been conducted on birds of Peramagroon Mountain, this study will be a foundation for further studies at the site, as it is one of the important areas from conservation, scientific and economic points of view.
Chapter Four

Material and Method

Bird surveys were conducted along 78 line transects at Peramagroon Mountain (Fig 6) away from road and residential areas, between 28 April and 16 April 2012. These transects were visited more than once, and were not intersected or overlapped. This was done to eliminate the migrant bird species (Porter & Aspinall, 2011) and seasonal differences. Sampling was stratified by elevations and divided into four ranges. Also, land cover percentages of rocky, grassland, herb and shrubland were estimated and woodland density was measured using the point quadrat method. Most areas of the mountain were accessible by good roads and tracks.

Fig. 5: Map showing surveyed sites within the studied area
4.1. Bird and habitat surveys:

Line transects were implied because of the fine-scale habitat heterogeneity. A straight 500 m line transect was walked through the area, with a minimum distance between two transects of 100 m. Geographical coordinates and altitude of transect start and end points were obtained using a handheld GPS (Garmin 60) receiver. Additionally, binoculars (MINOX BL 8X33) and a digital camera (Canon 7D) with lens (Canon EF 400mm f/5.6 L USM) were used to observe and record birds. The surveys have been conducted from 45 min to 4 h after sunrise, recording wheatears and rock nuthatches seen or heard and allocating them to perpendicular distance bands 30m within 40 min (SD= ±10, n=78). A laser rangefinder (≥ 10 m), tape measure (< 10 m) and compass were used to measure distance and angle respectively of the observed birds from the line transect. All field work and surveys were carried out by a single observer (K.M.), experienced in identifying the studied birds. During two months of field surveys, five breeding wheatear species; Isabelline O. isabellina, Kurdistan Wheatear O. xanthopyrna, Eastern Black-eared Wheatear O. melanoleuca, Finsch’s Wheatear O. finschii, and Mourning Wheatear O. lugens were found. Also the two congener rock nuthatches, Western Rock Nuthatch S. neumayer and Eastern Rock Nuthatch S. tephronota, recorded with the wheatears at different elevations and habitats.

The study area is approximately 11,000 ha, located on the south-west edge of the Zagros ranges, geologically the mountain composed of sedimentary rocks with different geomorphology. These transects were taken at different locations with different elevations ranging between c. 870-2613 m at the south and north faces of the mountain (Fig. 6.1 & 6.2). Four major vegetation zones occur in the study area along the elevational gradients (Saman Abdulrahman, pers comm). Grasslands, occupy the bottom of the mountain (Fig. 8) and the common species are Horidium spp. and Bromus spp. Then there is Mountain riverine forest, mostly at the north faces of the mountain near Mergapan Stream, which is dominated by Popilus alba and Salix aegyptiaca. Deciduous mountain oak forest, which is mainly composed of four species and their richness, vary according to elevation. The two oak species Quercus aegilops and Quercus infectoria as well as Pistacia eurycarpa and Pistacia
khinjuk occupy the lower region of the mountain (c. 1200-1600 m asl). Then *Quercus infectoria* with *Q. libani* and small patches of *Juglans regia* dominate the area at altitude c. 1600-1800 m asl. The timberline starts where the elevation is c. 1800 m asl. After that the thorn-cushion (sub-alpine) habitat begins, where the most abundant plants are *Ferulago* spp., *Astragalus* spp., *Acantholimon* spp. and *Pragnos pabularia* (Saman Abdulrahman, pers comm).

Figure 6.1. North face of Peramagroon Mountain.

Figure 6.2. South face of Peramagroon Mountain.
Habitat features, slope, aspect and land cover percentages were measured along the surveyed transects, at the start and end points at 100 m intervals within a radius of 30 m. So each line transect was divided into 5 sections. A representative sampling method has been used to measure the vegetation land cover and the common plant species were identified at these sections. Tree density was measured using the point-quarter method (Cottam & Curtis 1956), which is widely used as it is accurate and reliable in measuring the density.

4.2. Data Analysis methods:

4.2.1. Estimation of bird density per stratum

As a part of this study the ArcGIS10Digital and Shuttle Radar Topography Mission (SRTM) Elevation Model (DEM: Jarvis et al., 2012) ranged from 850 to 2400 m were used to create digital maps, measuring the elevation gradients and area of the mountain, which were divided into four bands depending on the vegetation zones of the mountain. In addition, DISTANCE software (version 6) was used to estimate the density and abundance of the studied birds.

In this study, data were collected on seven species of wheatears and rock nuthatches. Despite covering a large area, Isabelline Wheatear *O. isabellina* and *O. lugens* were excluded from the data analysis because the sample sizes were small (Buckland et al., 2001). Next, the data of the other five species were run, and according to Kolmogrov-Smirnov goodness fit test, the models provide a good fit to the data when $P > 0.05$ and confidence interval (CI) is 95%, as has been implemented in this study. The models with lowest Akaike’s Information Criterion (AIC) have been chosen (Buckland, 2001). The Hazard Rate model was used for the Kurdistan Wheatear *O. xanthopyrmyrna* ($P= 0.0780$, CI= 95%) and Eastern Black-eared Wheatear *O. melanoleuca* ($P= 0.04$); and Negative Exponential option for Finsch’s Wheatear *O. finschii* ($P= 0.20$), the Western Rock Nuthatch *S. neumayer* ($P= 0.16$) and the Eastern Rock Nuthatch *S. tephronota* ($P= 0.23$). Their AIC are: 281.65, 407.81, 259.52, 288.83 and 297.34 respectively. For all species Cosines and no size bias adjustments function, and average cluster size were used. In addition, the cluster size was not stratified.
4.2.2 Habitat as a determinant of bird distribution

General Linear Modeling (GLM) was tested using PASW (version 18.0) to determine the co-linearity between the density of the wheatears and rock nuthatches, with different variables including elevations, vegetation and land cover of the area and to what extent they are significant (CI= 95%). But herb % was excluded as it has been inter-related with elevation (r > 0.6). Their densities were measured at each of the surveyed transects using models with high AIC and Cosines no and size bias adjustments function with no cluster stratification as mentioned in previous section. Moreover, one way ANOVA test implied to see to obtain the differences between the percentage of vegetation cover, tree density and rock cover at different aspects (south and north face) of the mountain.
5.1. Habitats at different elevation gradients

The response of vegetation structure to elevation is shown in (Fig. 7.1, 7.2 and 7.4) First, grassland habitat mostly occurred at the bottom of the mountain; where Hordeum spp. and Bromus spp. are the dominant plant species, and with increasing altitude grass cover declined ($r = 0.51$). The shrubs, mainly Prunus spp., are the minor habitat at the area it mainly found at c. 1000- 1850 m; however one small population of shrubs, which belong to family Rosaceae, were found at elevation at c. 2250 m. On the other hands, the herbs were widely distributed at different altitudes ($r = 0.02$, Fig. 7.2) and with greater cover at alpine region at c. 1800- 2500; where Ferulago spp. and Astragalus spp. were common plant species. The elevation and herb density were strongly correlated ($r = 0.65$, $P < 0.01$), with percentage cover of herbs greater at higher altitude (Fig. 7.1), while other variables were not affected by the change in altitude and there were no strong correlation between them ($r < 0.06$). Moreover, according to the ANOVA test rock cover at the south face of the mountain is more than the north face ($P < 0.001$); while the rest of the other variables their coverage were not affected by the aspect of the mountain ($P > 0.05$).

The tree density was measured in the area at c. 1100-1800 m. Deciduous oak trees, especially Quercus aegilops make up the majority of the tree species in this area. The tree density seems very scattered (Fig. 7.4), with the highest (450/ ha) recorded in the north face. This might be due to the aspects of the surveyed sites and the sample size, and because it was measured at a small scale (500 m X 30 m/ transect), i.e. the habitat was not monotonic at that scale. In addition, there was pressure on oak trees during the 1990s, largely due to people using oak wood as fuel. This might have affected the density of the oak trees in the region.
Figure 7.1. Linear correlation between the two variables elevation (X) and herb cover (Y). Pearson’s $r = 0.65$, $P < 0.001$; $R^2 = 0.4271$.

Figure 7.2. Percentage cover of shrub at different altitude ($r < 0.6$).
Figure 7.3. Percentage cover of rock/ bare ground at different altitude ($r < 0.6$).

Figure 7.4. Tree density/ ha at the surveys sites at different elevation ($r < 0.6$)

Note: In the previous four figures each point marker represents habitat land cover at each distance transect (~ 0.15 km² or 15 ha).
5.2. Bird species density:

During two months of field surveys, three coexisted breeding wheatear species; the Kurdistan Wheatear *O. xanthoprymna*, the Eastern Black-eared Wheatear *O. melanoleuca*, Finsch’s Wheatear *O. finschii*, and the Mourning Wheatear *O. lugens* were found; with registrations of 47, 51 and 43 for each of these species respectively. Beside these wheatears, eight pairs of the ground-dwelling Isabelline Wheatear *O. isabellina* was observed, but it has been excluded due to their small sample size. Also the two congener rock nuthatches, Western Rock Nuthatch *S. neumayer* (47 observations) and Eastern Rock Nuthatch *S. tephronota* (45 observations), were recorded with the wheatears at different elevations and habitats.

Then density of each species at different elevation bands and surveyed transects was obtained using Distance, and the model with the lowest Akaike’s Information Criterion AIC has been chosen (Table 1). Also their cluster size were not stratified, according to the ANOVA test, the means of bird species at different elevation bands were not significant for all of the studied species, which were as follows: *O. xanthoprymna* ($F_{2, 46}= 0.954, P= 0.393$), *O. melanoleuca* ($F_{3, 62}= 0.374, P= 0.158$), *O. finschii* ($F_{1, 41}= 2.067, P= 0.158$), *S. neumayer* ($F_{3, 43}= 0.070, P= 0.976$) and *S. tephronota* ($F_{2, 43}= 0.143, P= 0.867$).

Table 1. This Figure presents a Distance analysis, with non size biased pooled detection function and encounter rate / density stratified by vegetation zone. ESW: effective strip width, E(S): estimate of expected value of cluster size; P: Kolmogrov-Smirnov goodness test.

<table>
<thead>
<tr>
<th>Species</th>
<th>Detection Model</th>
<th>ESW</th>
<th>E(S)</th>
<th>Observations</th>
<th>P</th>
<th>Cluster Size (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. xanthoprymna</em></td>
<td>Hazard Rate + Cosine</td>
<td>17.2</td>
<td>1.50</td>
<td>47</td>
<td>0.08</td>
<td>1.47</td>
</tr>
<tr>
<td><em>O. melanoleuca</em></td>
<td>Hazard Rate + Cosine</td>
<td>19.1</td>
<td>1.39</td>
<td>51</td>
<td>0.04</td>
<td>1.35</td>
</tr>
<tr>
<td><em>O. finschii</em></td>
<td>Negative Exponential + Cosine</td>
<td>12.7</td>
<td>1.34</td>
<td>43</td>
<td>0.20</td>
<td>1.40</td>
</tr>
<tr>
<td><em>S. neumayer</em></td>
<td>Negative Exponential + Cosine</td>
<td>14.8</td>
<td>1.86</td>
<td>47</td>
<td>0.16</td>
<td>1.80</td>
</tr>
<tr>
<td><em>S. tephronota</em></td>
<td>Negative Exponential + Cosine</td>
<td>16.4</td>
<td>1.96</td>
<td>45</td>
<td>0.23</td>
<td>1.93</td>
</tr>
</tbody>
</table>
5.2.1. Elevation patterns of wheatears and rock nuthatches:

According to the result of this survey, the density of the wheatears and rock nuthatches varies with change in vegetation zones or elevation gradients as shown in Fig. 12 and 13. For the wheatears; the highest density (D) of *O. xanthoprymna* is in the alpine zone (AL), which is 2.23/ha (SE= ±0.51). Then at the timberline zone (TL) it declines to 0.66/ha (SE= ±0.55). The lowest density is in the deciduous oak forest zone (OW), where this species was observed only on the north face of the mountain, where it becomes 0.37/ha (SE= ±0.15). On the other hand, *O. melanoleuca*, mainly occupies deciduous oak forest (D= 1.2/ha, SE= ±0.22) and timberline (D= 0.91/ha, SE=± 0.36) zones, and is less common in grassland (D= 0.08/ha, SE= ±0.06) and alpine (D= 0.13/ha, SE= ±0.13) zones. In addition, *O. finschii* exists only in grassland (D= 0.8/ha, S= ±0.35) and oak forest (D= 0.72/ha, S= ±0.32) zones.

![Figure 8.1. Densities of adults of Kurdistan Wheatear O. xanthoprymna, Eastern Black-eared Wheatear O. Melanoleuca and Finsch’s Wheatear O. finschii at different vegetation zones of the mountain: Montane Steppe zone( GS, c.850- 1100 m asl), deciduous oak forest zone (OW, c. 1100- 1600 m asl), timberline zone (TL, c. 1600- 1800 m asl) and alpine zone (AL, c.1800-2600 m asl).](image-url)
Additionally, *S. neumayer* occupies grassland (D= 0.04/ha, SE= ±0.04), oak forest (D= 0.73/ha, SE= ±0.29), timberline (D= 2.21/ha, SE= ±1.03), and alpine zones (D= 1.61/ha, SE= ±0.06). Also, *S. tephronota* coexists with *S. neumayer* in grassland, oak forest and timberline zones, and its density increases simultaneously with the latter species from bottom till alpine area, where it does not occur. The densities of this species at these zones are; 0.37/ha (SE= ±0.19), 0.96/ha (SE= ± 0.38), and 1.64/ha (SE= ± 0.75).

Figure 8.2. Densities of Western Rock Nuthatch *S. neumayer* and Eastern Rock Nuthatch *S. tephronota* at different vegetation zones of the mountain: Montane Steppe zone (GS, c.850-1100 m asl), deciduous oak forest zone (OW, c. 1100- 1600 m asl), timberline zone (TL, c. 1600-1800 m asl) and alpine zone (AL, c.1800- 2600 m asl).
5.2.2. Factors related to bird density:

Furthermore, to obtain the collinearity between bird density, vegetation structure and altitude of the area as environmental factors, herb vegetation (%) was excluded from the statistic analysis because it is inter-related with altitude ($r=0.65$). According to the General Linear Modelling (GLM) output, the density transect, which obtained from Distance software analysis, of each of these species, which relates in different ways to the environmental factors as they can be seen in the table below:

Table 1: GLM models analysing the influence of altitude, rock, grass and shrub cover, and tree abundance on the density of the studied. SS: sums of squares, beta: standardized regression coefficient

<table>
<thead>
<tr>
<th>Species</th>
<th>SS</th>
<th>Beta</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. xanthopyrmina</em></td>
<td>61</td>
<td>0.026</td>
<td>0.795</td>
</tr>
<tr>
<td>Rocky/bare ground</td>
<td></td>
<td>-0.104</td>
<td>0.339</td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td>-0.103</td>
<td>0.287</td>
</tr>
<tr>
<td>Shrub</td>
<td></td>
<td>-0.035</td>
<td>0.695</td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td>0.015</td>
<td>&lt;0.001****</td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. melanoleuca</em></td>
<td>25.38</td>
<td>-0.407</td>
<td>0.001****</td>
</tr>
<tr>
<td>Rocky/bare ground</td>
<td></td>
<td>-0.371</td>
<td>0.004</td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td>0.002</td>
<td>0.987</td>
</tr>
<tr>
<td>Shrub</td>
<td></td>
<td>0.390</td>
<td>&lt;0.001****</td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td>0.009</td>
<td>0.430</td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. finschii</em></td>
<td>22.13</td>
<td>0.366</td>
<td>0.004***</td>
</tr>
<tr>
<td>Rocky/bare ground</td>
<td></td>
<td>0.281</td>
<td>0.033</td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td>0.024</td>
<td>0.935</td>
</tr>
<tr>
<td>Shrub</td>
<td></td>
<td>0.190</td>
<td>0.075</td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td>0.009</td>
<td>0.430</td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. neumayer</em></td>
<td>61.64</td>
<td>0.038</td>
<td>0.769</td>
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<tr>
<td>Rocky/bare ground</td>
<td></td>
<td>-0.158</td>
<td>0.256</td>
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<tr>
<td>Grass</td>
<td></td>
<td>0.204</td>
<td>0.102</td>
</tr>
<tr>
<td>Shrub</td>
<td></td>
<td>-0.049</td>
<td>0.666</td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td>0.213</td>
<td>0.099</td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. tephronota</em></td>
<td>11.579</td>
<td>-0.151</td>
<td>0.263</td>
</tr>
<tr>
<td>Rocky/bare ground</td>
<td></td>
<td>-0.187</td>
<td>0.193</td>
</tr>
<tr>
<td>Grass</td>
<td></td>
<td>0.178</td>
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</tr>
<tr>
<td>Shrub</td>
<td></td>
<td>-0.055</td>
<td>0.635</td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td>-0.142</td>
<td>0.284</td>
</tr>
</tbody>
</table>

$P < 0.05^*, P < 0.01^{**}, P < 0.005^{***}, P < 0.001^{****}$
First, density of Kurdistan Wheatear *O. xanthopyrmina* was only and most strongly related to the altitude, which is inter-related to herb cover, \(F_{5, 72} = 13.29, P < 0.001; R^2 = 44.4\%\); Table 1). While the density of Eastern Black-eared Wheatear *O. melanoleuca* most significantly associated to tree density \(F_{5, 72} = 6.713, P < 0.001; R^2 = 27.1\%\); Table 1), conversely related to grass and rock cover \(P < 0.005\), and altitude did not affect its distribution. However, the model was used did not fit the data of this species \(P < 0.05\) might be the presence of the observer affected the detection of this bird (Buckland *et. al.*, 2001).

Furthermore, Finsch’s Wheatear *O. finschii* occupied areas stony ground with grasses and rock outcrops, screes below c. 1100 m, this might be because this species is socially dominant to other species of wheatears. Also, as it is shown (Table 2) altitude is not limiting factor of its distribution. But, presence of rock and grasses (%), were the important variables \(F_{5, 72} = 4.89, P < 0.05; R^2 = 31.8\%\) in determining the density of this species and they are positively related. This may reflect the morphological adaptation of this rock-dwelling bird as it is tolerated to perch on firm objects and flimsy vegetation (Cornwallis, 1975).

On the other hands, the two rock nuthatches; Western Rock Nuthatch *S. neumayer* \(F_{5, 72} = 2.49, P > 0.05; R^2 = 8.8\%\) and Eastern Rock Nuthatch *S. tephronota* \(F_{5, 72} = 1.53, P > 0.05; R^2 = 9.6\%\), their occurrence was not affected by these environmental variables. However, they were widely distributed in the area; but at alpine area only Western Rock Nuthatch *S. neumayer* was found.
Chapter Six  
Discussion

In general wheatears have similar food preferences (Cornwallis, 1975), however they were observed at different elevation gradients and vegetation cover. Each of them might reflecting the ecomorpholgy of this species, as the habitat needs of a bird species depend on its biological characteristics, such as adaptations for coloration, thermoregulation, foraging, and hiding and escaping from predators, the and it will exist whenever its minimum needs are available in habitats.

Kurdistan Wheatear *O. xanthopyrmyrma*, however is socially dominant to other wheatears except *O. finschii*, which they found together on their wintering grounds; but it is mostly restricted to high altitude (*P* < 0.001). This maybe species unable to thermoregulate efficiently in a moist air, it has long tarsi, short tail, and relatively heavy weight (Cornwallis, 1975; Kaboli *et al.*., 2007), therefore; it needs enough strong objects to perch on it. However, most of the *O. xanthopyrmyrma* nearby the flimsy herb *Ferulago* spp., which is also its abundance, was increased with increasing altitude and it was found mainly above c. 1750m asl. But seven pairs of them were seen at the steep rocky areas of deciduous oak forest and timberline zone at c. 1500-1900 m, where there were snow patches. Also, since this species is not restricted to high altitude and during its winter migration found in low lands (Cramp, 1988), this might indicate that temperature is contribute in determining the occurrence of this species; i.e. it breeds at areas with high elevation as altitude inversely related with ambient temperature (Kalder and King, 1974). In contrast, Eastern Black-eared Wheatear *O. melnaoleuca* which considered as vegetation tolerant species (Cornwallis, 1975; Kaboli *et al.*., 2007), it found at rocky deciduous oak forest zone and rocky slopes at timberline zones. Also its interactions with other species might play an important role in determining its distribution (Fig. 9)

Since Eastern Black-eared Wheatear *O. melnaoleuca* is the lightest among the studied wheatears, it has short tarsi, high lift, elliptical wings and long tail, which help this bird to perch on the flimsy vegetation and ease the above foraging strategy. Also it can thermoregulate efficiently in moist air (Cornwallis, 1975; Kaboli *et al.*., 2007). In addition, it is found at c. 1100-1900 m may be as a result of the competition from
Kurdistan Wheatear *O. xanthoprymna* above and Finsch’s Wheatear *O. finschii* below its range, because *O. melanoleuca* is socially subordinate to these wheatears. Moreover, a pair of Mourning Wheatear *O. lugens*, was found breeding in a hole of a bare slope at c. 1850 at timberline zone approximately 25 m below a breeding pair of Eastern Black-eared Wheatear *O. melanoleuca* where there was scattered shrublets with rocks and dense vegetation and this might be because temperature declines when elevation increases.

Moreover, Finsch’s Wheatear *O. finschii* strongly associated with stone cover (*P* < 0.005); also with grass cover (*P* < 0.05). However, grass cover might be is not crucial, since regarding the aspects there is no differences in grass coverage at the south face and north face of the mountain (*P* > 0.05). Only one pair of Finsch’s Wheatear *O. finschii* was recorded at the north face. It may use grass areas during its foraging as its tarsi relatively short, which is morphologically adapted to catch preys in grassy vegetations (Cornwallis, 1975; Kaboli et al., 2007). Finsch’s Wheatear *O. finschii* was not influenced by altitude variable (*P* > 0.05) and two breeding pairs have been observed at up to 2300 m in 2009 on a bare rocky mountain north west of Peramagroon Mountain (Ararat et al., 2009). Additionally, Isabelline Wheatear *O. isabellina* is observed only at ten localities at the south face region of the mountain, where there is an open rocky flat or gently slope terrains. They were sharing habitats with Finsch’s Wheatear *O. finschii* at two transects. Their small population size in comparison with the rest of the wheatears, except Mourning Wheatear *O. lugens*, in this area. This can be because of the presence of other wheatear species in particular Finsch’s Wheatear *O. finschii* and Mourning Wheatear *O. lugens* as they are socially dominant and prevent Isabelline Wheatear *O.isabellina* to inhabit the rocky hillsides, also as this species prefers undeveloped rocky steppe, because they are morphologically adapted to this type of habitat (Cornwallis, 1975; Cramo, 1988), but the majority of the area is converted to agriculture and cleaned from the rocks. So, this might have implications on the abundance and distribution of Isabelline Wheatear *O. isabellina*.
Figure 9. Interspecific interactions between rock nuthatches and other species found at the studied sites; (a) Western Rock Nuthatch *S. neumayer* encounters a snake at c.1900 m asl, (b) a nest of Eastern Rock Nuthatch *S. tephronota* invaded by the Rock Sparrow *Petronia petronia* at c. 1100m asl, (c) antagonistic behaviour between a male of Kurdistan Wheatear *O. xanthoprymna* and Western Rock Nuthatch *S. neumayer* at c.2300 m asl.

Lastly, the occurrence of the two rock nuthatches, the Western Rock Nuthatch *S. neumayer* (*F*5, 72= 2.49, *P* > 0.05; *R*2= 8.8 %) and the Eastern Rock Nuthatch *S. tephronota* (*F*5, 72= 1.53, *P* > 0.05; *R*2= 9.6 %), was not affected by these environmental variables. Rather, they were widely distributed in the area; but in the alpine area only the Western Rock Nuthatch *S. neumayer* was found. This may be due to “ecological release” phenomenon, whereby a species expands its altitudinal
range, foraging strategy or habitat distribution in the absence of one or more closely related species. This suggests indirect evidence of interspecific competition implications on distribution of these birds, where these rock nuthatches are sympatric. Evidence of the interspecific competition of these rock nuthatches was observed (Fig. 9) from the bottom to the top of the mountain, which may play an important role in determining the distribution of both rock nuthatches and wheatears.
Chapter Seven

Conclusion and future prospectives

However, patterns of coexistence between different species of wheatears and rock nuthatches are not simple, but their distributions are affected differently by variables such as topography, vegetation structure and rock cover. The GLM models analysis shows that the Kurdistan Wheatear *O. xanthopyrmana* is the only species whose occurrence is affected by altitude. Whereas the occurrence of the other wheatears is related to vegetation structure and stone cover. Wheatears are seemed to be segregated depending on their ecomorphological adaptation. Also some related species show partial segregation as their habitat and/ or territory are overlapped. Moreover, there might be other variables influencing the abundance of these species. Such as species interaction also anthropogenic implications needs to be considered, so further study of these perspectives is required. In addition, it is important to investigate the influence of climate on species like the Kurdistan Wheatear *O. xanthopyrmana*, since this area is the southern limit of this species, and according to this study its distribution might be related to temperature.


