

Research Article

Avifauna Diversity in the Gate between Humid Atlas and Saharan Desert: Midelt Province, Morocco

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The analysis of biological diversity at a regional scale is the first step to understand and classify the biological importance of a specific region and therefore the adoption of implementing conservation strategies. We conducted weekly bird counts by using the point count method from January 2015 to December 2017 in Midelt province, Morocco. A total of 130 bird species were observed, among breeding, migrant, and wintering species belonging to 42 families. Accipitridae (15 species), Muscicapidae (9 species), and Alaudidae (9 species) were the most observed families. Order of Passeriformes was the dominant order represented with 16 families and 68 species. Moreover, five species of conservation concern were recorded such as the vulnerable European turtle dove, houbara bustard, and Dupont's lark; the near threatened ferruginous duck and bearded vulture; and the endangered Egyptian vulture. On the other hand, the results of the diversity analysis (Margalef index, Shannon–Wiener index, and Simpson index) showed the highest diversity in wetlands, forests, steppes, and farmlands, while cliff, landfills, and urban areas were the least diversified habitats. Finally, with its geographic situation between humid Atlas and Sahara desert, as well as the diversity of habitats and avifauna, Midelt region needs advanced analysis in terms of biodiversity and environmental characteristics, in order to provide effective conservation management.

1. Introduction

The study of biological diversity in a regional pattern is an important step in conservation management [1]. Patterns of geographic distribution, species boundaries, and differentiation taxonomy must be studied and defined for each species [2, 3]. Site inventories must be conducted to determine regional levels of diversity and integrated into a regional view of spatial variation in diversity and endemism [4]. Then, these patterns can be associated with physical and biological features of the environment to produce a synthetic understanding of determinants of biological diversity patterns [5]. However, this process is difficult in time and field, but the completion of such syntheses, particularly patterns of biological diversity, is crucial for both conservation

measures and scientific knowledge regarding the process of biological diversification [6, 7].

Morocco is situated in the Mediterranean Basin hotspot, one of Earth's biologically richest and most endangered terrestrial ecoregions [8, 9]. Consequently, it hosts the second greatest concentration of animal and vegetation diversity in the Mediterranean Basin and the greatest marine biodiversity [10, 11]. Morocco has a significant species diversity of more than 31,000 species of which about 11 % are endemic [12, 13]. Morocco shelters approximately 500 bird species among them were breeders, migrants, and wintering species [5–7]. This species richness is the result of the diversity of Moroccan habitats [8, 9], climate conditions [14], and geographical localisation. In fact, Morocco has 10 national/natural parks, including three that have marine areas

within their boundaries, 38 RAMSAR wetlands, and 160 Sites of Biological and Ecological Interest (SBEI) [15] in addition to the Atlantic Ocean, the Mediterranean Sea, and the Sahara influence on the climate [16]. Morocco is the gate between Europe and Africa for many migrant bird species [17]. However, despite this richness and diversity, Moroccan ecosystems are less studied; several of them are under pressure and most are moderately-to-severely degraded. On the other hand, Midelt province was chosen due to its localisation between the humid Atlas considered as castle Morocco and Eastern Saharan Oasis installed in the Daraa-Tafilalet. Furthermore, Midelt houses the Isli, Tislit, and Agoulmame Sidi Ali RAMSAR wetlands [18, 19], which are the least wetlands that can be used as a stopover site by migrant species before crossing the Sahara desert.

The present contribution thus has two main objectives: (1) we present an inventory of the birds frequenting Midelt province in the high Moulouya plain and (2) we compare the richness and diversity of different habitats dominating this zone. Therefore, the understanding of biological diversity in this unique area will be a first step to consolidate conservation strategies.

2. Methods

2.1. Study Area. This study was carried out in the Midelt province, located in the Daraa-Tafilalet region between the Middle and High Atlas Mountains in the North of Morocco (32°40'47.57"N and 4°44'16.28"W), on an elevated plain with altitude ranging between 1300 m and 1500 m on sea level [20, 21] (Figure 1). This area contains the last forests and lakes before the Saharan oasis of the desert. Moreover, the province is dominated by the high plain of Moulouya in the east and mountains in the Northwest and the South. The main irrigated crops are fruit trees (mainly apple trees Starking Delicious and Golden Delicious), fodder crops, and vegetables, while the main crops in rainfed farming are barley and wheat (Table 1).

The Midelt area is characterized by a cold arid climate (the annual average temperature and precipitations being about 29°C and 89 mm successively) with a mountainous tendency and the rainfall regime is marked by extremely variable and irregular low rainfall; stormy precipitation brings eroded products upstream. Sometimes the region receives snowfall.

2.2. Bird Surveys. The study area was divided into seven habitats (Table 2), including wetlands (12 sites), forests (9 sites), farmlands (11 sites), steppes (8 sites), cliffs (8 sites), landfills (9 sites), and urban areas (9 sites) as defined by the landscape scale (Figure 1).

In each site, we collected a number of data associated with the species richness and relative abundance of bird species. From January 2015 to December 2017, birds were surveyed and recorded during the breeding and wintering seasons by using the "point-counts" method with unlimited distance due to the wide area explored [22]. This is an effective method for sampling bird species [23] because it

permits an extensive surveying of sample areas and the neighbouring landscape [24, 25]. In addition, this method enables collecting a wide range of ecological data on species with cost-effectiveness [26]. During every single visit, which took around 12 hours to walk, from 06.00 to 18.00 hours, the numbers of species, as well as abundance seen and/or heard singing (mainly during the breeding phase), were recorded.

2.3. Data Analysis. Species diversity indexes were calculated to compare the species diversity among habitat types. Various types of total species diversity indexes, including Margalef species richness index (D), Shannon–Wiener species diversity index (H), and Simpson index (D), were calculated.

Margalef index: $D = S - 1 / \ln N$ [27]

Shannon–Wiener index: $H' = \sum p_i \ln p_i$ [28]

Simpson index: $\lambda = \sum \{i=1\}^R p_i^2$, where S is the total number of species; N is the total number of individuals; p_i represents the number of birds for species, i represents the total number of bird species. Moreover, the index of abundance was estimated as the relative size of an animal population calculated from counts of the number of individuals recorded in each habitat. In parallel, birds were divided into three groups including passerines, water birds, and raptors.

The diversity indexes (Shannon–Wiener index, Margalef index, and abundance index) were calculated and compared for all habitats. Similarly, the species richness, families, and relative abundance for habitats and orders were calculated and compared by means of ANOVA (after assessing normality of variances, all data were parametric). Also, species were grouped in passerines, water birds, and raptors and compared via ANOVA during three years. All analyses were performed using SPSS 18 (SPSS IBM, 2009).

3. Results

3.1. Avifauna Diversity. Table 3 illustrates bird species diversity for the prospected habitats in Midelt province. A total of 130 bird species were recorded, including passerines (92 species), water birds (23 species), and raptors (15 species). These species were belonging to 42 families. The most important families are Accipitridae (15 species), Muscicapidae (9 species), and Alaudidae (9 species), while Upupidae, Alcedinidae, Coraciidae, and Otidae are the less represented with 1 species for each (Figure 2). On the other hand, Fringillidae are the abundant family with 280520 individuals. Similarly, the European serin represented by 105000 birds and Common Linnet with 81000 birds were the most abundant species, while the Egyptian vulture and bearded vulture were the less observed species. In addition, passerines were the most dominant species (Table 4) in comparison with water birds and raptors.

In terms of presence status at Midelt, we recorded 98 breeding species, 24 wintering birds, and 57 migrants. In parallel, five species have been categorized by the IUCN as a species of conservation concern, including the vulnerable

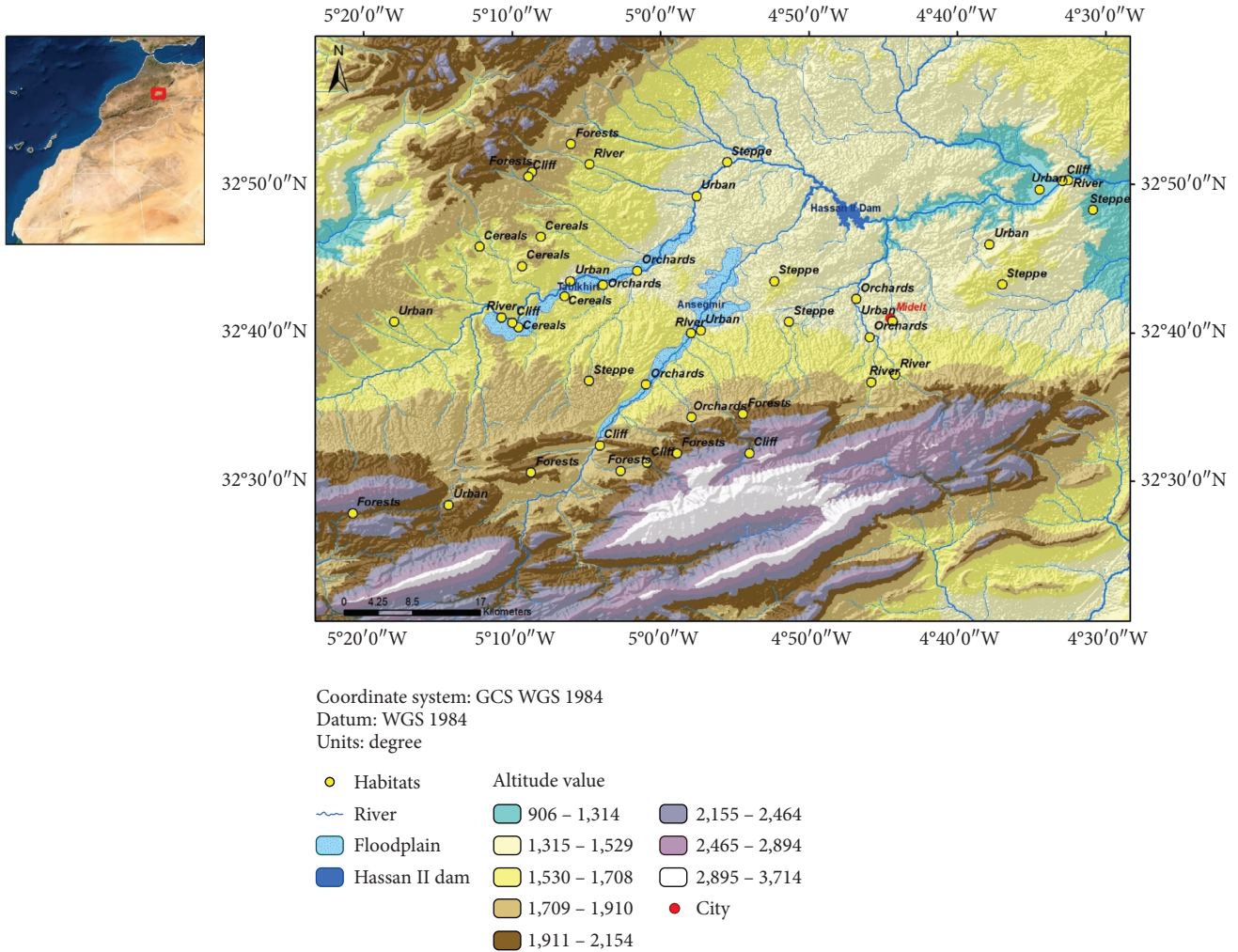


FIGURE 1: Studied habitats in Midelt province between 2015 and 2018.

TABLE 1: Principal agricultural plantations in Midelt province.

Plantation	Species	Surfaces (Ha)
Cereals	Durum wheat	2330
	Soft wheat	217
	Barley	172
	Maize	200
Farming	Alfalfa	548
	Bean	10
Fruit trees	Apple tree	1 503
	Peach tree	13
	Pear tree	54

European turtle dove, houbara bustard, and Dupont’s lark, the near threatened ferruginous duck and bearded vulture, and the endangered Egyptian vulture. The other birds (125) were a species of less concern conservation status.

3.2. *Habitats and Distribution.* The results of diversity analysis (Margalef index, Shannon–Wiener index, and Simpson index) and compositional parameters (species

richness) are shown in Table 5. Wetlands, forests, steppes, and farmlands were the highest diversity habitats in terms of species, while cliff, dumps, and urban were fewer divers’ habitats (Figure 3) ($DF = 6, F = 2378.58, p < 0.001$). On the other hand, farmlands and steppes were the highest abundant sites in terms of observed birds, followed by wetlands and forests. On the contrary, birds were less abundant in cliff, urban, and dump sites.

4. Discussion

Total species richness and habitat specific-birds-diversity (recorded in each habitat) showed that Midelt province avifauna diversity is important. Among the 42 families, Accipitridae, Muscipidae, and Alaudidae represent 34% of recorded bird species. In an opposite pattern, Upupidae, Ciconiidae, and Oriolidae represent only 3% of recorded bird species. On the other hand, Passeriformes (with 16 families and 68 species) are the most dominant order (in terms of field abundance, species, and family levels) in Mountainous province, followed by Accipitriformes (one family and 13 species) and Charadriiformes (4 families and 6 species) (Table 3). Similar results were reported by [29] and

TABLE 2: Type and localisation of studied habitats in the Midelt region, Morocco.

Habitat	Type	Local name	GPS	
Wetlands	Dum	Hassan II	32°48'9.00"N	4°47'36.16"W
		Tamaloute	32°31'8.83"N	5° 4'55.23"W
		Ansguemir	32°39'59.81"N	4°57'56.21"W
	River	Tabelkhirte	32°41'3.05"N	5°10'42.04"W
		Tatteouine	32°36'41.46"N	4°45'49.22"W
		Tissouite	32°37'12.54"N	4°44'12.68"W
		Aguersif	32°51'22.25"N	5° 4'47.88"W
		Moulouya	32°50'18.35"N	4°32'32.86"W
		Ziz	32°17'27.72"N	4°32'1.99"W
		Tislit	32°11'39.94"N	5°38'4.82"W
	Lake	Isli	32°13'4.51"N	5°32'25.83"W
		Agoulmame Sidi Ali	33° 4'15.97"N	4°59'53.59"W
Forests (Atlas cedar, holm oak, juniper oxyhedron)	Sidi Yahya Ou Youssef	Imtchimne	32°30'44.11"N	5° 2'40.66"W
		Jaafar	32°34'32.79"N	4°54'27.40"W
		Tounfite	32°30'36.23"N	5° 8'43.97"W
		Ait Brahim	32°27'52.21"N	5°20'44.71"W
		Mi Tqan	32°31'53.78"N	4°58'53.45"W
		Itzer	32°52'43.15"N	5° 6'2.86"W
		Farmlands	Orchards	Ait Ayach
Ait Mouli	32°44'11.53"N			5° 1'34.51"W
Taddamoute	32°42'17.46"N			4°46'49.57"W
Ait Izdeg	32°39'43.73"N			4°45'55.10"W
Taouraoute	32°34'20.79"N			4°57'54.12"W
Tamouajjat	32°43'15.57"N			5° 3'52.44"W
Cereals	Boulbzouz		32°40'22.02"N	5° 9'34.02"W
	Boumia		32°42'27.62"N	5° 6'28.39"W
	Ighesdiss		32°44'30.52"N	5° 9'18.20"W
	Tanourdi		32°46'28.72"N	5° 8'3.15"W
	Boutkhoubay		32°45'49.65"N	5°12'11.58"W
	Steppe		<i>Stipa tenacissima</i>	Mibladen
Aouli		32°48'17.40"N		4°30'51.31"W
Ghalban		32°40'45.55"N		4°51'20.12"W
<i>Artemisia herba-alba</i>		Toughach	32°43'30.07"N	4°52'19.99"W
		Aaride	32°36'47.46"N	5° 4'49.12"W
		Zaida	32°51'30.30"N	4°55'30.78"W
Urban	Cities	Midelt	32°40'47.47"N	4°44'22.77"W
		Zaida	32°49'12.86"N	4°57'34.53"W
		Boumia	32°43'30.04"N	5° 6'3.62"W
		Tounfite	32°28'25.81"N	5°14'15.37"W
		Aghbalou	32°40'45.24"N	5°17'56.80"W
		Ait Oumghar	32°40'11.36"N	4°57'17.47"W
		Mibladen	32°45'58.08"N	4°37'50.31"W
		Aouli	32°49'40.26"N	4°34'27.32"W
Cliff		Rich	32°15'31.09"N	4°30'0.06"W
		Abouazam	32°32'25.96"N	5° 4'5.06"W
		Jaafar	32°31'54.47"N	4°53'59.91"W
		Ait Brahim	32°50'32.57"N	5° 8'53.83"W
		Aouli	32°50'15.34"N	4°32'56.06"W
		Tabelkhirt	32°40'42.07"N	5° 9'58.49"W
		Ait Ouchen	32°31'16.65"N	5° 0'54.67"W
Imilchile	32°12'55.61"N	5°41'52.55"W		

support the importance of this arid zone [30], particularly for migratory birds. In reality, [21, 31, 32] have reported the breeding case of migrant turtle doves (*Streptopelia turtur*) in Midelt. Moreover, this study highlights the presence of 24 wintering-migrants and 6 migrant species, beside 98 breeding species. In parallel, five species of conservation

concern, including the vulnerable European turtle dove (*Streptopelia turtur*) [33], houbara bustard (*Chlamydotis undulata*) [34], and Dupont's lark (*Chersophilus duponti*) [35]; the near threatened ferruginous duck (*Aythya nyroca*) [36] and bearded vulture (*Gypaetus barbatus*) [37]; and the endangered Egyptian vulture (*Neophron percnopterus*) [38]

TABLE 3: Relative abundance, bird phenology status (b: breeding, m: migration, and w: wintering), and IUCN Red List status 2017 (E: endangered, LC: least concern, NT: near threatened, and VU: vulnerable) [34] of recorded species in Midelt region.

Order	Family	Species	Status	Conservation status	Relative abundance observed and heard	
Passeriformes	Passeridae	<i>Passer domesticus</i>	b	LC	35000–75000	
		<i>Passer hispaniolensis</i>	b	LC	3500–7500	
Columbiformes	Columbidae	<i>Streptopelia turtur</i>	b	VU	16000–18000	
		<i>Streptopelia decaocto</i>	b	LC	10000–12000	
		<i>Columba palumbus</i>	b	LC	8500–10200	
		<i>Columba livia</i>	b	LC	45000–55000	
Passeriformes	Corvidae	<i>Garrulus glandarius</i>	b	LC	1200–1900	
		<i>Pica mauritanica</i>	b	LC	850–855	
		<i>Corvus corax</i>	b	LC	642–750	
		<i>Pyrrhocorax pyrrhocorax</i>	b	LC	600–800	
Passeriformes	Sturnidae	<i>Sturnus unicolor</i>	b	LC	2600v3200	
Piciformes	Picidae	<i>Dendrocopos major</i>	w	LC	130–170	
		<i>Picus vaillantii</i>	w	LC	17–19	
Passeriformes	Turdidae	<i>Turdus merula</i>	b	LC	22000–30000	
		<i>Turdus viscivorus</i>	w	LC	1200–1300	
		<i>Monticola saxatilis</i>	b	LC	120–150	
		<i>Monticola solitarius</i>	b	LC	120–130	
		<i>Erithacus rubecula</i>	b	LC	460–520	
		<i>Serinus serinus</i>	b	LC	80000–105000	
		<i>Fringilla coelebs</i>	b	LC	60000–73000	
		<i>Linaria cannabina</i>	b	LC	67000–81000	
	Fringillidae	<i>Carduelis carduelis</i>	b	LC	15000–15500	
		<i>Bucanetes githagineus</i>	b	LC	1800–3600	
		<i>Chloris chloris</i>	b	LC	1500–2100	
		<i>Coccothraustes coccothraustes</i>	w	LC	250–320	
		<i>Hirundo rustica</i>	b	LC	1700–2100	
		<i>Delichon urbicum</i>	b	LC	5700–6500	
		Hirundinidae	<i>Ptyonoprogne rupestris</i>	b	LC	840–1020
<i>Riparia riparia</i>	b		LC	260–310		
<i>Cecropis daurica</i>	m		LC	340–350		
Apodiformes	Apodidae		<i>Apus apus</i>	b	LC	28000–30000
			<i>Tachymarptis melba</i>	m	LC	3500–3700
Passeriformes	Sylviidae	<i>Sylvia melanocephala</i>	b	LC	12000–12500	
		<i>Sylvia undata</i>	b	LC	740–750	
		<i>Sylvia atricapilla</i>	b	LC	380–430	
		<i>Sylvia deserti</i>	b	LC	120–160	
	Acrocephalidae	<i>Sylvia deserticola</i>	b	LC	135–168	
		<i>Hippolais polyglotta</i>	b	LC	2500–2700	
		<i>Phylloscopus bonelli</i>	b	LC	3400–3500	
	Phylloscopidae	<i>Phylloscopus sibilatrix</i>	b	LC	1200–1600	
		<i>Phylloscopus collybita</i>	w	LC	1400–1650	
		<i>Phylloscopus trochilus</i>	b	LC	690–720	
		<i>Cyanistes teneriffae ultramarinus</i>	b	LC	18000–18500	
	Paridae	<i>Periparus ater</i>	w	LC	380–420	
		<i>Parus major</i>	b	LC	8000–8500	
<i>Muscicapidae</i>		<i>Luscinia megarhynchos</i>	b	LC	7500–7700	
Galliformes	Phasianidae	<i>Coturnix coturnix</i>	b	LC	1600–1900	
		<i>Alectoris barbara</i>	b	LC	1250–1300	
Pterocliiformes	Pteroclididae	<i>Pterocles orientalis</i>	b	LC	3100–3300	
		<i>Pterocles alchata</i>	b	LC	1260–1270	
		<i>Pterocles coronatus</i>	b	LC	1200–1300	
Charadriiformes	Glareolidae	<i>Cursorius cursor</i>	b	LC	600–650	
	Burhinidae	<i>Burhinus oedicephalus</i>	b	LC	180–200	
Otidiformes	Otididae	<i>Chlamydotis undulata sensu stricto</i>	b	VU	8–12	

TABLE 3: Continued.

Order	Family	Species	Status	Conservation status	Relative abundance observed and heard	
Passeriformes	Muscicapidae	<i>Muscicapa striata</i>	b	LC	1100–1250	
		<i>Ficedula hypoleuca</i>	b	LC	360–410	
		<i>Phoenicurus moussieri</i>	b	LC	1300–1600	
		<i>Oenanthe moesta</i>	b	LC	320–325	
		<i>Oenanthe leucopyga</i>	b	LC	300–310	
		<i>Oenanthe leucura</i>	b	LC	1860–1910	
		<i>Oenanthe hispanica</i>	b	LC	1200–1250	
		<i>Oenanthe oenanthe</i>	b	LC	320–411	
		<i>Oenanthe deserti</i>	b	LC	2100–2500	
		<i>Eremophila alpestris</i>	w	LC	840–890	
		<i>Eremophila bilopha</i>	b	LC	1200–1430	
		<i>Ammomanes cinctura</i>	b	LC	620–640	
		<i>Ammomanes deserti</i>	b	LC	380–395	
		Alaudidae	<i>Calandrella brachydactyla</i>	b	LC	1600–1740
			<i>Galerida cristata</i>	b	LC	19000–20500
			<i>Melanocorypha calandra</i>	b	LC	800–850
<i>Alaudala rufescens</i>	b		LC	14000–16000		
		<i>Chersophilus duponti</i>	b	V	129–141	
Bucerotiformes	Upupidae	<i>Upupa epops</i>	b	LC	580–591	
Passeriformes	Laniidae	<i>Lanius senator</i>	b	LC	3400–3550	
		<i>Lanius excubitor</i>	b	LC	640–659	
Coraciiformes	Méropidae	<i>Merops apiaster</i>	b	LC	1450–1500	
Coraciiformes	Coraciidae	<i>Coracias garrulus</i>	w	LC	460–480	
	Alcedinidae	<i>Alcedo atthis</i>	w	LC	12–12	
Passeriformes	Motacillidae	<i>Motacilla alba</i>	b	LC	1900–1950	
		<i>Motacilla cinerea</i>	b	LC	3200–3400	
		<i>Motacilla flava</i>	b	LC	880–950	
		<i>Anthus pratensis</i>	w	LC	1500–1560	
		<i>Anthus spinoletta</i>	w	LC	640–850	
		<i>Anthus campestris</i>	w	LC	210–220	
		<i>Emberiza calandra</i>	b	LC	8550–8640	
		Emberizidae	<i>Emberiza cia</i>	b	LC	1200–1240
			<i>Emberiza cirulus</i>	b	LC	439–478
			<i>Emberiza sahari</i>	b	LC	800–840
			<i>Prunella collaris</i>	w	LC	340–360
Caprimulgiformes	Caprimulgidae	<i>Caprimulgus europaeus</i>	b	LC	320–340	
Passeriformes	Troglodytidae	<i>Troglodytes troglodytes</i>	b	LC	700–900	
	Oriolidae	<i>Oriolus oriolus</i>	w	LC	180–190	
Anseriformes	Anatidae	<i>Anas platyrhynchos</i>	b	LC	830–837	
		<i>Mareca penelope</i>	w	LC	8–12	
		<i>Anas crecca</i>	w	LC	170–176	
		<i>Spatula querquedula</i>	w	LC	180–190	
		<i>Tadorna ferruginea</i>	b	LC	640–689	
		<i>Anas clypeata</i>	w	LC	220–260	
		<i>Aythya nyroca</i>	w	NT	180–190	
Suliformes	Phalacrocoracidae	<i>Phalacrocorax carbo</i>	w	LC	88–98	
Podicipediformes	Podicipédidae	<i>Podiceps cristatus</i>	w	LC	38–42	
		<i>Tachybaptus ruficollis</i>	w	LC	58–67	
		<i>Podiceps nigricollis</i>	w	LC	34–47	
Pelecaniformes	Ardéidae	<i>Egretta garzetta</i>	w	LC	16	
		<i>Bubulcus ibis</i>	b	LC	4600–4670	
		<i>Ardea cinerea</i>	w	LC	46–52	
Ciconiiformes	Ciconiidae	<i>Ciconia ciconia</i>	b	LC	760–780	

TABLE 3: Continued.

Order	Family	Species	Status	Conservation status	Relative abundance observed and heard
Gruiformes	Rallidae	<i>Gallinula chloropus</i>	b	LC	6
		<i>Fulica atra</i>	b	LC	430-479
		<i>Fulica cristata</i>	b	LC	340-389
		<i>Rallus aquaticus</i>	b	LC	22
Charadriiformes	Charadriidae	<i>Charadrius dubius</i>	b	LC	121-123
		<i>Charadrius hiaticula</i>	b	LC	15-17
	Scolopacidae	<i>Actitis hypoleucos</i>	b	LC	22-28
		<i>Tringa ochropus</i>	b	LC	24-30
Falconiformes	Falconidae	<i>Falco tinnunculus</i>	b	LC	650-678
		<i>Falco naumanni</i>	b	LC	860-880
		<i>Falco peregrinus</i>	b	LC	164-179
Accipitriformes	Accipitridae	<i>Buteo rufinus cirtensis</i>	b	LC	60-66
		<i>Pernis apivorus</i>	m		320-330
		<i>Circaetus gallicus</i>	m	LC	6
		<i>Circus aeruginosus</i>	b	LC	80-110
		<i>Accipiter nisus</i>	b	LC	42-44
		<i>Milvus migrans</i>	m	LC	22
		<i>Hieraetus pennatus</i>	b	LC	18
		<i>Aquila fasciata</i>	b	LC	6
		<i>Aquila chrysaetos</i>	b	LC	3
		<i>Elanus caeruleus</i>	b	LC	18-19
		<i>Gyps fulvus</i>	m	LC	18
		<i>Neophron percnopterus</i>	m	E	2
		<i>Gypaetus barbatus</i>	b	NT	2
Strigiformes	Strigidae	<i>Bubo bubo</i>	b	LC	8-10
		<i>Athene noctua</i>	b	L C	800-820

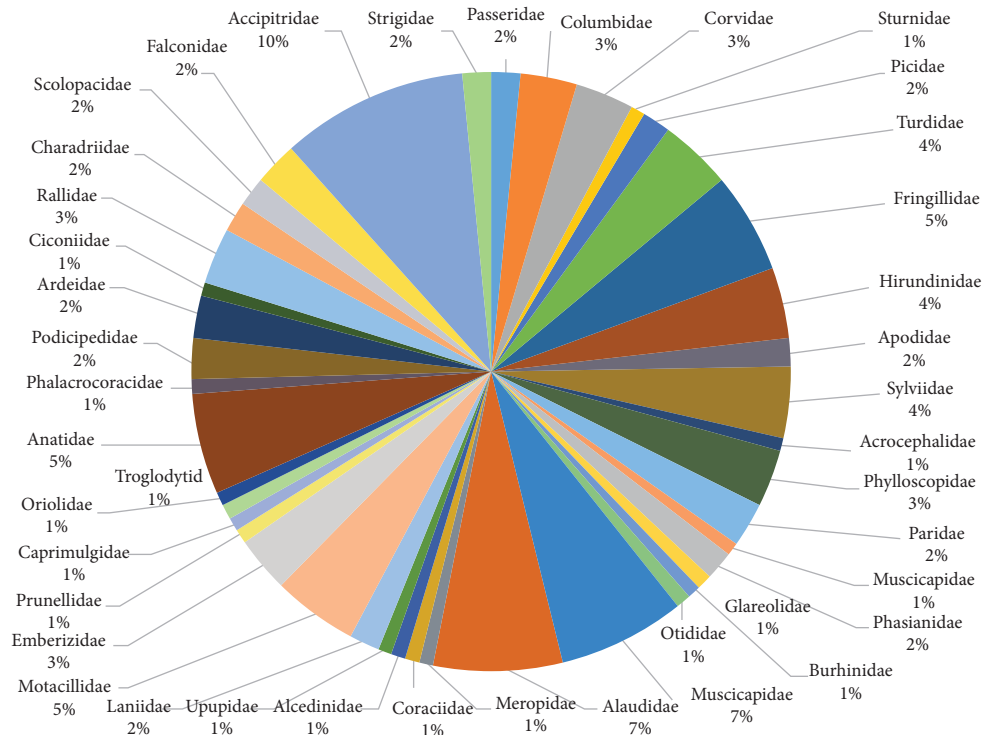


FIGURE 2: Species richness and percentage of avian families recorded in Midelt province.

TABLE 4: Comparison of the bird' groups recorded in Midelt province with ANOVA one-way test.

	Passerines	Water birds	Raptors	F	P value
Abundance	645041	53378	44558	14.485	≤ 0.001
Species	92	23	18	149.822	≤ 0.001
Families	32	8	3	25.571	≤ 0.001

TABLE 5: Avian diversity among studied habitats in Midelt province.

	Forest	Wetland	Steppe	Farmland	Urban	Cliff	Landfills
Taxa_S	69	91	61	60	20	16	13
Dominance_D	0.01449	0.01099	0.01639	0.01667	0.05	0.0625	0.07692
Shannon_H	4.234	4.511	4.111	4.094	2.996	2.773	2.565
Simpson_1-D	0.9855	0.989	0.9836	0.9833	0.95	0.9375	0.9231
Margalef	16.06	19.95	14.6	14.41	6.342	5.41	4.678

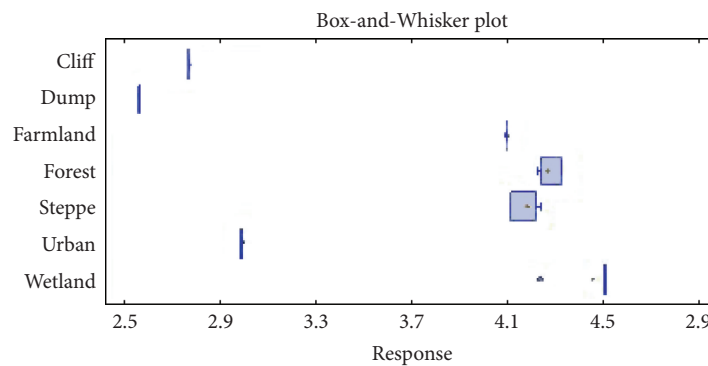


FIGURE 3: Comparison (graphical ANOVA) of avifauna diversity among studied habitats at Midelt province.

were observed regularly, which necessitate important and urgent research to characterise their habitats for effective conservation measures [39].

In wetlands, forests, steppe, and farmlands, the number of species, families, and abundance were higher in comparison to urban, dump, and cliff, which is in agreement with results reported by [40–42] and support the diversity of avifauna in forest, farmlands, and wetlands. The abundance of food resources, including water and nutrients in farmlands [31, 43] and nesting-trees in forests [44–46], are the main reasons behind this diversity. In fact, the water availability (rivers, lakes, and dams) and feeding sources (cereals, wild seeds, and invertebrates) in wetlands, farmlands, and forests at the studied zone confirm this suggestion. The low avifauna diversity in urban and dumps sites is supposed to be controlled by human disturbance. In this point, it is known that bird diversity decreases with the urban gradient [47–49] due to increasing human disturbance in cities and buildings that reduce breeding opportunities and resources for bird species [50] which is in agreement with results reported in our study.

5. Conclusion

The Midelt province presents a variety of natural habitats, agroecosystems, and urban zones, which makes it a gate between the humid world and Saharan desert in Morocco. Midelt province needs a deep analysis in terms of

biodiversity and habitat characterisation in order to orient and adopt effective conservation measures at least for the vulnerable habitats and threatened species.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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