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First data on bird species composition of Djebel Aïssa National Park, Southwestern Algeria

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Abstract Algeria has a diverse bird fauna, yet data from arid and semi-arid regions are scarce. To fill this knowledge gap, we conducted a study on the composition and conservation status of bird species of Djebel Aïssa National Park in the Naama province of Southwestern Algeria between September 2021 and September 2023. We collected data by using progressive frequency sampling (PFS) and line transects, which allowed us to systematically assess bird species across different habitats within the park. We recorded 94 species of birds belonging to 11 orders and 27 families. Passeriformes was the most abundant order, comprising 16 families and 67 species. The bird species detected were predominantly sedentary (50%) or wintering (39%), and some were visiting (8%) or migratory (3%). Most species were insectivores (45%), followed by granivores/insectivores (24%), carnivores (13%), omnivores (7%), granivores (6%), and carnivores/insectivores (5%). Most bird species were classified as "Least Concern" by the IUCN Red List, two species were "Near Threatened", and one was "Vulnerable". In addition, 29 species are protected under Executive Fiat 12–235 of 24 May 2012. Our study provides a baseline for future monitoring efforts and a basis for the development and implementation of conservation strategies in Djebel Aïssa National Park and the surrounding regions.

Keywords: birds, monitoring, species composition, conservation, Djebel Aïssa National Park

Összefoglalás Algéria változatos madárfaunával rendelkezik, azonban a száraz és félszáraz területekről kevés adat áll rendelkezésre. Ennek a tudáshiánynak a pótlására felmértük a délnyugat-algériai Naama tartományban, a Djebel Aïssa Nemzeti Parkban élő madárvilág összetételét és természetvédelmi helyzetét egy kétéves időszakban, 2021 szeptembere és 2023 szeptembere között. Az adatokat progresszív gyakoriságú mintavétel (PFS) és vonalas transzektek mentén gyűjtöttük, mely lehetővé tette a madárfajok szisztematikus felmérését a park különböző élőhelyein. A vizsgálat során 94 madárfajt rögzítettünk, amelyek 11 rendbe és 27 családba tartoztak. A verébalakúak (Passeriformes) volt a legnagyobb számban képviselt rend, mely 16 családot és 64 fajt foglalt magába. Az észlelt madárfajok túlnyomó része állandó (50%) vagy telelő (39%) faj volt, néhány kóborló (8%) vagy vonuló (3%) fajjal. A legtöbb faj rovarevő volt (45%), ezt követték a magevők/rovarevők (24%), ragadozók (13%), mindenevők (7%), kizárólag magevők (6%) és ragadozók/rovarevők (5%). A madárfajok többsége az IUCN Vörös Lista szerint nem fenyegetett státuszú, két faj mérsékelten fenyegetett, egy faj pedig közel veszélyeztetett helyzetű volt. A 2012. május 24-i 12-235. számú végrehajtási utasítás értelmében 29 faj részesül védelemben. Tanulmányunk viszonyítási alapot szolgáltat a jövőbeli monitorozási erőfeszítésekhez, valamint a természetvédelmi stratégiák kidolgozásához és végrehajtásához a Djebel Aïssa Nemzeti Parkban és a környező régiókban.

Kulcsszavak: madarak, monitorozás, fajösszetétel, természetvédelem, Djebel Aïssa Nemzeti Park

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Introduction

Protected areas play a vital role in the conservation of biodiversity (Oldekop *et al.* 2016, Feng *et al.* 2021, Pulido-Chadid *et al.* 2023). National Parks and biosphere reserves have long been regarded as key sites for research on the environment, biodiversity, conservation and sustainable development (Yoccoz *et al*. 2001). Therefore, biodiversity monitoring is an essential component of protected area management (Mandeville *et al.* 2023). This process involves a continuous and systematic study of various elements of biodiversity to assess their current status, identify potential threats, and detect patterns of change (Hochkirch *et al.* 2021). Effective biodiversity monitoring is crucial for evaluating the success of conservation efforts and guiding management decisions in protected areas (Rodrigues & Cazalis 2020).

Studies on animal community diversity offer a direct approach to assessing species richness and composition, as well as the relative abundance of individual species (Robinson 1999, Magurran 2004, Sigel *et al*. 2006, Laurance *et al.* 2008). Such data are particularly relevant in protected areas, where they inform the development of effective conservation and management programs. In these contexts, human activities should focus on the sustainable use of natural resources while ensuring the protection of biodiversity (Sigel *et al.* 2006, Negrões *et al.* 2011).

Avifaunal diversity is an important component of biodiversity and serves as a vital environmental indicator due to birds' essential ecological roles, such as pollination, pest control, predation and seed and propagule dispersal (Sekercioglu 2006). Avifaunal biodiversity has faced severe declines, mainly due to habitat fragmentation, human activities and the proliferation of non-native species (Stanton *et al.* 2018). Unfortunately, the current availability of accurate and publicly accessible information regarding bird diversity in numerous regions is limited, potentially leading to a significant underestimation of losses occurring in various areas (Politi *et al.* 2021).

Algeria is renowned for its remarkable climatic diversity, spanning from humid to Saharan climates (Stevenson *et al.* 1988). Arid and semi-arid landscapes are pivotal ecosystems that provide breeding and foraging grounds for many avian species, including those facing endangerment (Ogendi & Ondieki 2020). Studies on bird diversity and composition in Southwestern Algeria are scarce, with few historical investigations primarily focused on this region. Research on bird diversity and ecology in this region includes significant studies such as those by Blondel (1962), Heim de Balsac (1979), Ledant *et al.* (1981), Isenmann and Moali (2000), Mostefai and Grenot (2006), as well as recent work on the trophic ecology of the Royal Eagle by Djilali *et al.* (2023). The most recent update on bird diversity in Naama province (Southwestern Algeria) is provided by the checklist compiled by Youcefi and Marouf (2022).

The aim of this study was to gain knowledge on the composition and diversity of bird species in Djebel Aïssa National Park, a newly established park located in the Naama province of Southwestern Algeria. To date, no information has been available on the faunal diversity of the park, particularly concerning avian species, which should be the foundation for effective conservation efforts.

Material and Methods

Study area

Djebel Aïssa National Park is located in the Ksour Mountains, in the commune of Ain Sefra in the province of Naama of Southwestern Algeria *(Figure 1)*. Djebel Aïssa was classified as a national park under Executive Decree No. 03-148 of the General Forest Direction (DGF) on 29 March 2003. The park spans 24,500 hectares, and it features the highest peak in the region at 2,236 meters and supports a rich biodiversity of flora and fauna *(Figure 1)*.

The climate of the region can be moderate when it's cold during the day and hot at night. The average temperature is between 2 °C and 36 °C throughout the year, and the annual precipitation is between 189 mm and 483 mm. The vegetation in Djebel Aïssa is diverse and comprises pre-forest formations, psammophyte vegetation and sub-desertic flora, harboring a variety of plant types adapted to the unique climatic and geological conditions (Bouallala 2006, Gordo 2014, Benaradj 2017, Boucherit 2018, Benaradj *et al.* 2021, Boucherit *et al*. 2024). Djebel Aïssa National Park is subdivided into 11 zones *(Figure 1)*. We surveyed 12 sites in the national park *(Table 1)*.

Methodology

To gain an in-depth knowledge of the bird species in Djebel Aïssa National Park, we carried out extensive bird surveys from September 2021 to August 2023. These surveys covered the park during the four seasons of each year. Observations took place from 6:00 am to 12:00 pm and from 4:00 pm to sunset, capturing the times of day when bird activity is highest (Robbins 1981).

We used Progressive Frequency Sampling (PFS) for our surveys, which can be conducted at any time of day and throughout the year, including outside the reproduction season. Briefly, it consists of recording, on a presence/absence scale, all the species, both seen or heard, from a point, during a 20-minute session. This method is cost-effective and straightforward to implement, though it does not estimate population density but rather provides a bird inventory (Blondel 1975). We established 54 georeferenced listening points *(Figure 1)*, distributed across various habitats and plant formations along the northern and southern slope of Djebel Aissa National Park. To ensure the reliability of our survey, each point was visited twice a month, with a listening duration of 10 to 20 minutes per point (Prodon 1987).

In addition to the PFS methodology, we used the "random transect method" to ensure the reliability of the species observations, particularly for the raptors. This approach involved

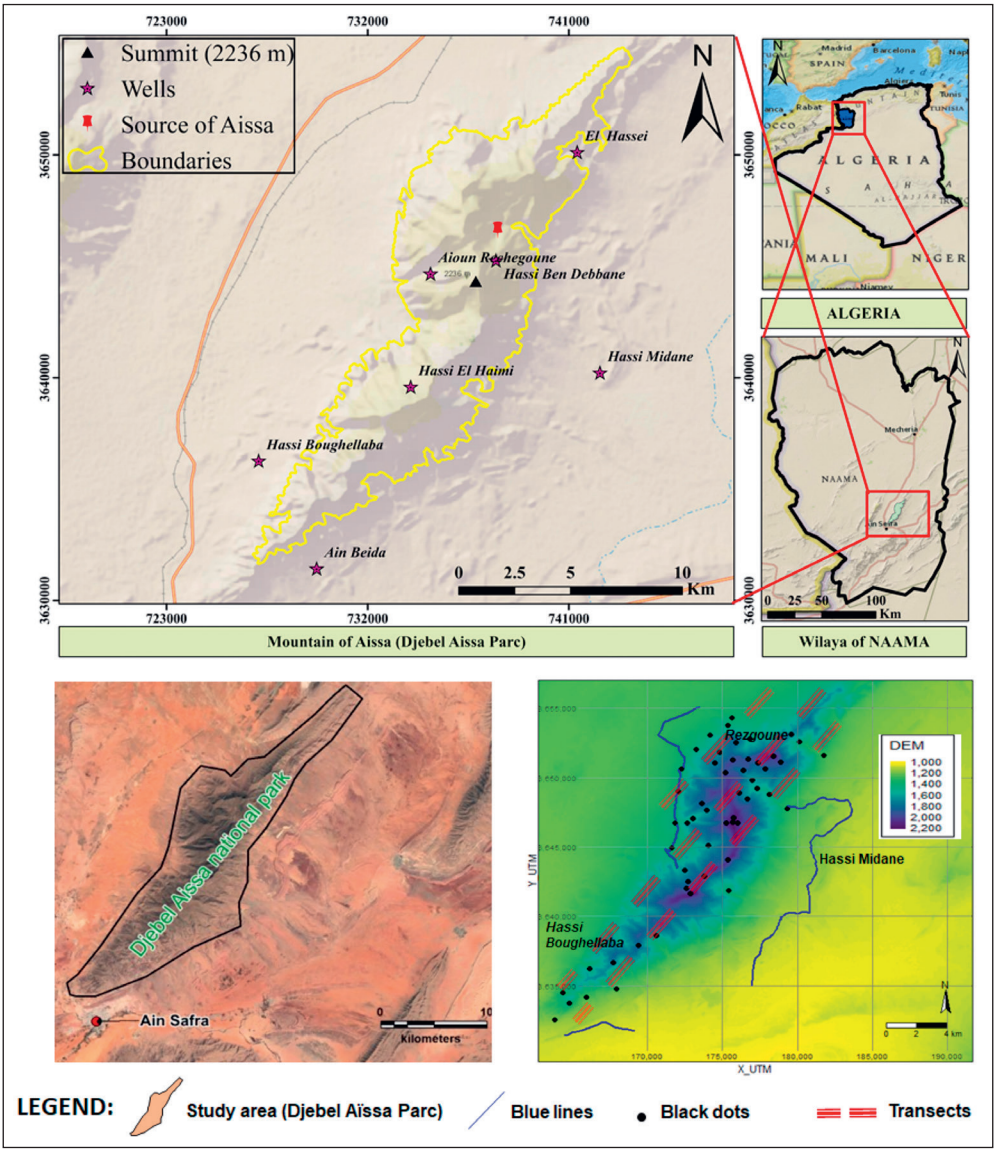

Figure 1. Map of the study area and location of transects (blue lines) and listening points (black dots).
1. ábra A vizsgálati terület és a felmérési pontok térképe

establishing three transects: the first one was located in the northern slope of Djebel Aïssa Mountain (16 km), while the second and third transect in its southern side, with 22 and 5 km, respectively *(Figure 1)*. We surveyed each transect from a vehicle moving at moderate speed (30 km/h) four times during the autumn season (September to December 2022) and spring-summer season (March to July 2023). These surveys enhanced the probability of detecting raptors across various habitats and ensured that no significant observations were missed (Fuller & Mosher 1981, Benmammar-Hasnaoui & Bounaceur 2019).

Table 1. Main characteristics of the 12 sites surveyed for birds in Djebel Aïssa National Park
1. táblázat A Djebel Aïssa Nemzeti Parkban kijelölt 12 madárfelmérési pont fő jellemzői

Sites	Coordinates	Characteristics
Hassi Rechegoun	0°29′45.37″O 32°54′47.08″N	Semi-open habitat dominated by *Stipa tenacissima* and *Artemisia herba alba*, with some trees of *Pinus halepensis, Ziziphus lotus, Quercus ilex, Juniperus phoenicea,* near the well (Hassi Rechegoun)
Hassi Ben Himmi	0°29′55.50″O 32°52′2.93″N	Semi-open habitat corresponding the well of Ben-Himmi, covered by a mix between *Q. ilex*, *J. phoenicea* and *J. oxycedrus* with some trees of *P. halepensis*
Hassi Boudjenib	0°47′35.76″O 32°97′41.88″N	An open gravel habitat with a relatively sparse vegetation cover, dominated by *S. tenacissima* and *A. herba alba*, with some trees of *P. halepensis, Z. lotus, Q. ilex, J. phoenicea,* near the well (Hassi Boudjenib)
Ain Aghlal	0°27′2.90″O 32°56′1.70″N	Semi-open habitat near the water point of Ain Aghlal, covered with a mix of *P. halepensis, Z. lotus, Q. ilex, J. phoenicea J. oxycedrus, Pistacia atlantica* and some trees of *Ceratonia silique*
Ain Aissa	0°27′17.56″O 32°56′21.16″N	Dense habitat with diverse vegetation cover (*P. halepensis Q. ilex, J. phoenicea*, *P. atlantica, Ceratonia siliqua*) especially near the water point of Ain Aissa
Pinus halepensis Forest	0°27′64.36″O 32°56′23.16″N	Dense habitat of *P. halepensis* associated with some trees of *Juniperus* spp. and *Q. ilex* with the presence of herbaceous plants such as *Ferula communis*
Tifkert Mont	0°26′24.79″O 32°57′18.78″N	Open barren habitat featuring cliffs and massive rock
Maita Mont	0°28′19.66″O 32°54′38.07″N	Semi-open habitat with cliffs including some trees of *P. halepensis* and *Q. ilex*
Mekalis	0°28′42.05″O 32°57′22.37″N	Urban area, open habitat with a water point and presence of *S. tenacissima, A. herba alba, Z. lotus*
Hassi Ouled-Ziad	0°25′19.80″O 32°57′52.52″N	Semi-open habitat dominated by *Atractylis, Hammada scoparia* especially in the border of well (Hassi Ouled-ziad)
Ain El-Baydha	0°32′56.23″O 32°49′3.53″N	Open habitat, *H. scoparia*, *A. herba alba* and some trees of *P. altantica*, *Q. ilex* and *Juniperus* spp.
Steppe	0°34′1.92″O 32°47′41.41″N	Open habitat dominated by herbaceous plants such as *Atractylis cancellata, H. scoparia, Ferula communis*

Regular monitoring was carried out through monthly surveys, supplemented by additional surveys in various biotopes, especially during the primary postnuptial and prenuptial bird migration seasons (Chedad *et al.* 2021, Benaradj 2023).

Listening points were determined based on the distribution of habitats and vegetation cover, as well as water sources in the study area (Arendt *et al.*1999, Bibby *et al.* 2000), especially during the nesting, breeding and migration seasons (Gregory 2000, Laiolo 2005, Ehnes *et al.* 2018, Morelli *et al.* 2022). The sampling process was conducted monthly over the large size of the massif (24,400 hectares) with very rugged terrain (Rahmani *et al.* 2017, Habibi *et al.* 2024). Birds were counted at each of the points at least twice per month. As for transects along the paths, surveys were carried out four times per month. All observed

species, either seen, heard, or detected indirectly through signs such as footprints, droppings, nests, or feathers, were recorded.

To record the presence of species by visual observations, we used binoculars Tasko 10×32 Black Roof, while Nikon P900, Canon 7D Mark II and 5D Mark III cameras, equipped with a 150–600 mm lens, were employed for photographing. To identify birds, we used ornithology guidebook (Svensson 2012). We also recorded the presence of bird species by recording songs and voices, bird droppings and footprints.

The phenological and feeding habits (granivorous, insectivorous, Carnivorous, Omnivorous) of the bird species detected were determined based on data from Heim de Balsac (1928), Ledant *et al*. (1981), Blondel (1982), Isenmann and Moali (2000). To determine foraging behaviour, we conducted direct observations of the birds and used the website oiseaux.net (https://www.oiseaux.net/). The final list of birds is organized according to the classification system established by Heinzel *et al*. (1988).

To assess the conservation status of the bird species observed during our study, we used Executive Decree 12-235 of May 24, 2012, which lists protected non-domestic animal species in Algeria. We also consulted Ordinance 06–05 of July 15, 2006, which focuses on the protection and conservation of endangered species. Additionally, we used the IUCN Red List 2022 to evaluate the global conservation status of the species.

Results

Species composition

We found that the checklist of bird species for Djebel Aïssa National Park currently holds 94 species *(Table 2)*, which could be classified into 11 orders and 27 families. The order Passeriformes was the most abundant, comprising 71% of the species, with 16 families and 67 species. Within this order, the Muscicapidae family was the most prevalent, with 18 species. Additionally, 15 species of raptors belonging to three orders were documented: Accipitriformes (7 species), Strigiformes (4 species), and Falconiformes (4 species).

Phenological patterns

The bird species of Djebel Aïssa National Park show high variability in seasonal phenology. The park's bird fauna includes seven visiting species (8%), 50 breeding species, of which 47 are sedentary (50%), three migratory (3%), and 37 wintering species (39%). This variability highlights the complex interactions of seasonal movements and ecological niches within the park.

Trophic status and feeding habits

The insectivorous category dominated, which made up 45% of the total bird species richness. This was followed by granivorous species at 6% and by carnivorous species at

Table 2. The checklist of bird species in Djebel Aïssa National Park (September 2021 – August 2023)
2. táblázat A Djebel Aïssa Nemzeti Park madár fajlistája (2021. szeptember – 2023. augusztus)

Order	Family	Common name	Scientific name	Phenological status	Feeding habits	Protection status	
						Nationally (Algeria)	UICN
Galliformes	Phasianidae	Barbary Partridge	*Alectoris barbara*	S	O		LC
Caprimulgiformes	Caprimulgidae	Eurasian Nightjar	*Caprimulgus europaeus*	V	I	P	LC
Cuculiformes	Cuculidae	Common Cuckoo	*Cuculus canorus*	V	I	P	LC
Columbiformes	Columbidae	Common Wood-Pigeon	*Columba palumbus*	S	O		LC
		Rock Pigeon	*Columba livia*	S	G		LC
		European Turtle-Dove	*Streptopelia turtur*	M	G		VU
		Eurasian Collared-Dove	*Streptopelia decaocto*	S	G.I		LC
		Laughing Dove	*Spilopelia senegalensis*	S	G.I		LC
Accipitriformes	Accipitridae	Booted Eagle	*Aquila pennatus*	W	C	P	LC
		Eurasian Sparrowhawk	*Accipiter nisus*	W	C	P	LC
		Long-legged Buzzard	*Buteo rufinus*	S	C	P	LC
		Short-toed Snake-Eagle	*Circaetus gallicus*	S	C		LC
		Golden Eagle	*Aquila chrysaetos*	S	C	P	LC
		Bonelli's Eagle	*Aquila fasciata*	S	C	P	LC
		Black Kite	*Milvus migrans*	V	C	P	LC
Strigiformes	Strigidae	Little Owl	*Athene noctua*	S	C.I	P	LC
		Eurasian Scops-Owl	*Otus scops*	V	C.I	P	NE
		Pharaoh Eagle-Owl	*Bubo ascalaphus*	S	C	P	LC
		Long-eared Owl	*Asio otus*	S	C	P	LC
Bucerotiformes	Upupidae	Eurasian Hoopoe	*Upupa epops*	S	I	P	LC
Coraciiformes	Coraciidae	European Roller	*Coracias garrulus*	V	I	P	LC
	Méropidae	European Bee-eater	*Merops apiaster*	V	I	P	LC
Piciformes	Picidae	Eurasian Wryneck	*Jynx torquilla*	W	I	P	LC

Order	Family	Common name	Scientific name	Phenological status	Feeding habits	Protection status	
						Nationally (Algeria)	UICN
Falconiformes	Falconidae	Lesser Kestrel	*Falco naumanni*	S	C.I	P	LC
		Peregrine Falcon	*Falco peregrinus*	S	C		LC
		Lanner Falcon	*Falco biarmicus*	S	C	P	LC
		Peregrine Falcon	*Falco peregrinus pelegrinoides*	S	C	P	LC
Passeriformes	Alaudidae	Desert Lark	*Ammomanes deserti*	S	G		LC
		Crested or Maghreb Lark	*Galerida cristata*	S	G		LC
		Thekla Lark	*Galerida theklae*	S	G.I		LC
		Thick-billed Lark	*Ramphocoris clotbey*	S	G.I		LC
	Emberizidae	House Bunting	*Emberiza sahari*	S	G.I		LC
		Corn Bunting	*Emberiza calandra*	S	G.I		LC
		Rock Bunting	*Emberiza cia*	S	G.I		LC
	Muscicapidae	Moussier's Redstart	*Phoenicurus moussieri*	S	I	P	LC
		Common Redstart	*Phoenicurus phoenicurus*	W	I	P	LC
		Black Redstart	*Phoenicurus ochruros*	W	I	P	LC
		Spotted Flycatcher	*Muscicapa striata*	W	I		LC
		Collared Flycatcher	*Ficedula albicollis*	W	I		LC
		Atlas Flycatcher	*Ficedula speculigera*	W	I		NE
		Blue Rock-Thrush	*Monticola solitarius*	S	O		LC
		Rufous-tailed Rock-Thrush	*Monticola saxatilis*	W	I	P	LC
		Western Black-eared Wheatear	*Oenanthe hispania*	W	I		LC
		Black Wheatear	*Oenanthe leucura*	S	I		LC
		Desert Wheatear	*Oenanthe deserti*	M	I		LC
		Red-rumped Wheatear	*Oenanthe moesta*	S	I		LC
		White-tailed Wheatear	*Oenanthe leucopyga*	S	I		LC

Order	Family	Common name	Scientific name	Phenological status	Feeding habits	Protection status	
						Nationally (Algeria)	UICN
Passeriformes	Muscicapidae	Northern Wheatear	*Oenanthe oenanthe*	W	I		LC
		European Robin	*Erithacus rubecula*	W	G.I		LC
		Whinchat	*Saxicola rubetra*	W	I		LC
		European Stonechat	*Saxicola rubicola*	W	I		NE
		Rufous-tailed Scrub-Robin	*Cercotrichas galactotes*	M	I		LC
	Turdidae	Common Blackbird	*Turdus merula*	S	I		LC
		Ring Ouzel	*Turdus torquatus*	W	G.I		LC
		Mistle Thrush	*Turdus viscivorus*	W	G.I		LC
		Song Thrush	*Turdus philomelos*	W	G.I		LC
		Redwing	*Turdus iliacus*	W	G.I		NT
		Fieldfare	*Turdus pilaris*	W	G.I		LC
	Paridae	Tenerife Blue Tit	*Cyanistes teneriffae*	S	G.I		LC
	Fringillidae	Common Chaffinch	*Fringilla coelebs*	S	O		LC
		Brambling	*Fringilla montifringilla*	W	G.I		LC
		Trumpeter Finch	*Bucanetes githagineus*	S	G		LC
		European Greenfinch	*Chloris chloris*	S	G.I		LC
		Eurasian Linnet	*Linaria cannabina*	S	G.I		LC
		Eurasian Siskin	*Spinus spinus*	W	G.I		LC
		Red Crossbill	*Loxia curvirostra*	S	G	P	LC
		European Serin	*Serinus serinus*	S	G	P	LC
	Laniidae	Great Grey Shrike	*Lanius excubitor*	S	C.I		LC
		Woodchat Shrike	*Lanius senator*	W	I		LC
	Sylviidae	Tristram's Warbler	*Curruca deserticola*	S	I		LC
		Dartford Warbler	*Curruca undata*	W	I		NT
		Eurasian Blackcap	*Sylvia atricapilla*	W	I		LC

Order	Family	Common name	Scientific name	Phenological status	Feeding habits	Protection status	
						Nationally (Algeria)	UICN
Passeriformes	Sylviidae	Common Whitethroat	*Curruca communis*	W	I		LC
		Western Orphean Warbler	*Curruca hortensis*	S	I		LC
		Western Subalpine Warbler	*Curruca iberiae*	W	I		LC
	Corvidae	Eurasian Jay	*Garrulus glandarius*	S	O	P	LC
		Brown-necked Raven	*Corvus ruficollis*	S	O		LC
		Red-billed Chough	*Pyrrhocorax pyrrhocorax*	W	G.I	P	LC
	Oriolidae	Eurasian Golden Oriole	*Oriolus oriolus*	V	I	P	LC
	Hirundinidae	Barn Swallow	*Hirundo rustica*	S	I		LC
		Eurasian Crag Martin	*Ptyonoprogne rupestris*	S	I		LC
		Northern House-Martin	*Delichon urbicum*	W	I		LC
		Sand Martin	*Riparia riparia*	W	I		LC
	Passeridae	Rock Sparrow	*Petronia petronia*	S	G.I		LC
		Spanish Sparrow	*Passer hispaniolensis*	S	G.I		LC
		House Sparrow	*Passer domesticus*	S	O		LC
	Motacillidae	White Wagtail	*Motacilla alba*	W	I		LC
		Tree Pipit	*Anthus trivialis*	W	I		LC
		Western Yellow Wagtail	*Motacilla flava*	W	I		LC
	Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	W	I		LC
		Willow Warbler	*Phylloscopus trochilus*	W	I		LC
		Wood Warbler	*Phylloscopus sibilatrix*	W	I		LC
	Prunellidae	Alpine Accentor	*Prunella collaris*	W	G.I	P	LC
	Acrocephalidae	Melodious Warbler	*Hippolais polyglotta*	W	I		LC

Phenological status: S – sedentary, W – wintering, M – migratory, V – Visiting; Feeding habits: G – Granivorous, I – insectivorous, C – Carnivorous, O – Omnivorous, G.I – Granivorous + insectivorous, C.I – Carnivorous + insectivorous; Protection status (Nationally): P – protected by the Executive Fiat 12–235 of 24 May 2012; (UICN): LC- least concern, NE – not evaluated, VU – vulnerable, NT – near threatened.

13%. Omnivorous birds accounted for 7% of the observed feeding habits. Additionally, species classified as granivorous + insectivorous represented 24% of the feeding guilds, while those classified as carnivorous + insectivorous made up 4%.

Conservation status

Of the 94 species recorded in the survey, 29 species (31%) are protected according to Executive Fiat 12-235 of 24 May 2012, which establishes the list of protected non-domestic animal species in Algeria. Notably, 13 of these protected species are raptors. This highlights Algeria's commitment to safeguarding its biodiversity *(Table 2)*.

In addition, 89 or 94.7% of the species recorded in the surveys are listed as "Least Concern" according to the IUCN Red List, which is reassuring because this indicates that these species currently are not facing a high risk of extinction. However, two species (Dartford Warbler *Curruca undata,* Redwing *Turdus iliacus)* are listed as "Near Threatened", indicating that they could become vulnerable if specific threats are not addressed. One species (European Turtle Dove *Streptopelia turtur*) has a "Vulnerable"" status, indicating a higher risk of extinction in the wild *(Table 2)*. Two species (Atlas Flycatcher *Ficedula speculigera*, European Stonechat *Saxicola rubicola*) remain unassessed, which poses a significant challenge to conservation due to the absence of essential data.

Discussion

Species composition

This study investigated bird species composition in Djebel Aïssa National Park of Southwestern Algeria (Northern Sahara Atlas Mountains). These data are valuable because they fill the gap in the information on the avifauna in Algeria, especially in semi-arid and arid protected regions. In addition, until now, no data were available for Djebel Aïssa National Park because previous studies investigated larger regions such as the Ksour Mountains or Naama Province, where the national park is located. The number of species detected (94) suggests relatively high diversity, which can probably be related to the location of the park in the northern part of the Atlas Mountains of the Sahara, the various climatic conditions and vegetation types (Benaradj *et al.* 2021). This number of species corresponds to 28% of the 336 species documented across Algeria by Ledant *et al.* (1981) and 23.2% of the species reported to occur in Algeria by Isenmann and Moali (2000).

This study shows that the species richness of Djebel Aïssa National Park is high compared to other regions. Blondel (1962) reported 58 bird species in the Ksour Mountains of Naama Province. Mostefai and Grenot (2006) recorded 100 bird species for the whole of Naama Province. More recently, Youcefi and Marouf (2022) noted a total of 179 species for Naama province, with only 20 species from the forest and mountain regions of the province. In the pre-Saharan steppes of the Zibans, Farhi *et al*. (2016) recorded 42 species and in Boussada, Chiheb *et al.* (2021) reported 53 species. Moreover,

Guezoul *et al.* (2013) recorded 59 species from a much larger area covering three different localities of the Northern Algerian Sahara (Biskra: 47, Oued Souf: 33 and Ouargla: 44). A more comprehensive recent study of the M'Zab region in the Northern Algerian Sahara reported 203 species, which corresponds to more than 50% of the Algerian avifauna. The highest richness of arid land birds in Algeria was recorded in the Timimoun region in Southwestern Algeria, where 100 species belonging to 59 genera, 28 families and 12 orders were observed (Boukhemza 1990). The richness found in this study was also higher than that reported for southern Tunisia, i.e. 86 species in 13 families and orders (Selmi 2002).

The order Passeriformes is prominently represented in all avian communities that are present in the oasis (69% of the assessed species). This is in line with previous studies on pre-desertic birds of Algeria (Farhi & Belhamra 2012, Guezoul *et al.* 2013).

The diversity of birds in this study area indicates the abundance of food resources (Sommerfeld & Hennicke 2010, Barger *et al.* 2016), and the differences found in species richness among the surveyed regions are certainly due to altitudinal, microclimatic, floristic and faunal differences (Habibi *et al.* unpublished data).

Studies into recent changes in the distribution range of some species, show that the range of avian species with a Saharan distribution have shifted north in Algeria (Heim de Balsac 1979). There are multiple factors that contribute to the simultaneous movement of species ranges such as climate change, drought, urban development, fires, overexploitation of natural resources, different types of pollution and agricultural expansion. Generally, habitat fragmentation (Brotons & Herrando 2001, Santos *et al.* 2002) and land abandonment following the rural exodus, timber harvesting, and overgrazing are the main reasons for biodiversity losses in the Mediterranean (Suárez-Seoane *et al.* 2002, Sirami *et al.* 2008).

In a comparable region in North Sahara, Farhi & Belhamra (2012) have recorded a total of 136 bird species that represent 33.5% of the Algerian avifauna, which has a total of 406 species (164 passerines, 242 non-passerines) (Isenmann & Moali 2000). The importance of passerine birds (67 species) in Djebel Aïssa agrees with other data originating from a semi-arid and arid region, namely the Ziban region in Southeastern Algeria, where 14 families with 63 bird species were found, which corresponds to 46.3% of the total bird fauna of Algeria (Isenmann & Moali 2000). In the Ziban region, Turdidae and Sylvidae were the most frequent families, with 18 and 13 species, respectively. However, for the other families, this number varied between 1 and 10 species (Farhi & Belmhamra 2012). Nevertheless, it seems that the dominance of these two families of passerines is likely related to their high species richness on a Palearctic scale.

Our data are relatively similar to those obtained from neighboring countries. In natural ecosystems in the High Atlas region of Morocco, Wakass *et al.* (2023) reported the dominance of Passeriformes, with 68 species grouped in 16 families, and Accipitriformes, with 13 species in one family. The families Muscicapidae, Accipitridae, Fringillidae, and Alaudidae were the most prevalent. These results agree with those of Mansouri *et al.* (2021) from the Eastern High Atlas and those of Mounir *et al.* (2022) from the Central High Atlas. These authors also reported Passeriformes and Accipitriformes orders and Accipitridae and Muscicapidae families as dominant. In this context, we agree that the

ecosystems of those investigated regions are favorable to a diverse avifauna dominated by Passeriformes, which likely reflects their global importance. They are globally represented by 5,700 species and 96 families, or ~60% of all avian species (Blondel & Mourer-Chauvier 1998, Aliabadian *et al.* 2005).

Trophic status and feeding habits

The findings of our study indicate that insectivorous birds are the most prevalent dietary group within the park. We hypothesize that the geographic isolation of the bird populations, the characteristics of the habitats within the park, and the structural features of the habitats are primary contributors to this dominance, which should be tested in future researches. Despite the degradation, the vegetation cover in the park supports a diverse plant life that attracts a significant bird population. Pine forests and open steppe areas, identified as critical habitats by Maire (1916) and Thiollay and Mostefai (2004), remain particularly important for avian species. In contrast, *Juniperus* forests attracted birds only during the flowering season; however, this should not restrict conservation efforts to restore this typical local habitat type. For the three "Vulnerable" or "Near Threatened" species, sub-forest habitats, water sources and open areas were the most important. It is generally recognized that insectivorous bird populations decline following environmental disturbances. However, it is crucial to note that broad classifications such as 'insectivorous' obscure significant variation among species in terms of habitat preferences, behaviour, and ecological roles (Gray *et al.* 2007, Boucif *et al*. 2022).

Species categorized as granivorous and insectivorous accounted for 24.5% of all observed species, while carnivorous and insectivorous species contributed 4.3%. Such intricate dietary patterns underscore the adaptive strategies employed by avian populations to exploit the diverse resources available within this park.

Conservation status

The executive decree 12-235 of May 24, 2012, established the list of protected non-domestic animal species. It lists 29 species as protected, which accounts for 23.2% of the protected Algerian avifauna. Notably, 13 of these protected species belong to the raptor group.

At the international level, 94.7% of the recorded species have the status of "Least Concern", according to the IUCN Red List. Dartford Warbler (according to criteria A2bc+3bc+4bc) and Redwing (according to criteria A2b+3b+4b) are listed as "Near threatened", meaning their populations might decline and become more vulnerable in the future. European Turtle-Dove is also classified as "Vulnerable" (according to criteria A2bcd+3bcd+4bcd), highlighting a higher threat level. These statuses are determined according to the criteria based on different biological factors that are associated with the extinction risk: population size, rate of decline, geographical range, degree of settlement, and fragmentation of the distribution (IUCN 2023).

Compared to Blondel's (1962) work entitled "The Ecology of Birds in the Ksours Mountains", we found noteworthy absences during our research period. We did not

detect several species reported by Blondel (1962), such as Egyptian Vulture *(Neophron percnopterus),* Great Tit *(Parus major),* Western Bonelli's Warbler *(Phylloscopus bonelli),* and Eurasian Wren *(Troglodytes troglodytes)*. The potential local extinction of these species possibly reflects habitat alterations induced by recent climate shifts, which may have blocked the adaptability of these species.

Furthermore, Blondel's (1962) report on the abundance of Northern Raven *(Corvus corax)* contrasts with our findings, because we did not detect this species at all. Instead, we found that Brown-necked Raven *(C. ruficollis)* pervaded numerous habitats throughout the park, which may have resulted from potential competition between the two species.

Finally, it should be noted that Blondel's (1962) mention of Blue Tit *(Cyanistes caeruleus)*, can be problematic because this species is absent from Africa, whereas we found African Blue Tit *(Cyanistes teneriffae),* which was not recorded by Blondel. Similarly, Rock Bunting *(Emberiza cia)* was a resident species in our observations, whereas Striolated Bunting *(E. striolata)*, reported by Blondel (1962), is currently absent from the region. These discrepancies underscore the need to revise bird species records and to document observations with techniques for enhanced accuracy beyond past methodologies. Differences between past and current observations can also indicate the evolving nature of avian populations and the necessity for up-to-date assessments to inform conservation strategies effectively.

Conclusion

We found that Djebel Aïssa National Park supports many resident and migratory bird species. We detected 94 species of bird in the area, belonging to 11 orders and 27 families, which represent a substantial proportion of the avifauna of Algeria. One species is classified as "Vulnerable" and two species are "Near Threatened" based on the IUCN Red List, which supports the role of Djebel Aïssa National Park in their conservation.

Our bird species inventory of Djebel Aïssa National Park serves as a valuable baseline for future monitoring and for the development of management strategies. Moreover, the high diversity of bird species within these national parks underscores their critical role as bastions of biodiversity in the face of mounting anthropogenic pressures and habitat degradation and calls for continued efforts at biodiversity conservation within the landscapes of Djebel Aïssa and beyond.

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