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Jordan Journal of Natural History

Editorial Preface

It is a pleasure to present issue 2 of volume (12) of Jordan Journal of Natural History (JJNH), a journal published by the Conservation Monitoring Centre, The Royal Society for the Conservation of Nature (RSCN). The Jordan Journal of Natural History (JJNH) is an open access international scientific journal publishing original research and reviews in nature history in its broadest sense. This is taken to include conservation biology, botany, geology, paleontology, zoology, and ecology, including a broad range of systematics papers encompassing traditional taxonomic revisions and descriptions, cladistics analyses and molecular phylogenetic. The editorial policy of JJNH will follow the lines of most international journals. All manuscripts received by the editor will be examined by referees, who will be instructed to judge the papers by the significance and novelty of the results reported and to favour briefness of presentation.

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At the end of this preface, would like to thank our readers and authors for their continuing interest in JJNH, and each member of our editorial and review boards for their continued hard work, support and dedication, which made it possible to bring another new issue of JJNH to the multidisciplinary international audience. We very much appreciate your support as we strive to make JJNH one of the most leading and authoritative journals in the field of Natural History Sciences.

December, 2025

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Hamidan, NA, Geiger, MF and Freyhof, J. 2014. *Garra jordanica*, a new species from the Dead Sea basin with remarks on the relationship of *G. ghorensis, G. tibanica* and *G. rufa* (Teleostei: Cyprinidae). *Ichthyological Exploration of Freshwaters*, **25** (3): 223-236.

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Assessment of Flora and Butterflies in Al-Arqoub Valleys in Palestine: Value in Conservation Plans

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Received: February 17, 2025; Revised: April 23, 2025; Accepted: April 28, 2025

Abstract:

Habitat destruction and fragmentation, climate change, pollution, invasive species, and overexploitation are global causes of biodiversity loss. Area-based conservation measures that consider connectivity are critical. It is extremely challenging to conserve isolated or fragmented areas. The area of the South Jerusalem Hills (9.1 km^2) includes several villages collectively called the Al-Arqoub area (Al-Khader, Battir, Husan, Al-Walaja, and Wadi Fukin) with several valleys that were proposed in 2023 as a new protected area by EQA. The area is rich in cultural and natural heritage. The challenges reported in the conservation of the area warranted serious consideration of how to implement effective conservation measures. Two groups (vascular plants and butterflies/Lepidoptera) were selected to identify key challenges resulting from urbanization and habitat destruction. 387 floral species belonging to 79 families were identified, of which 53 are rare, while 54 are considered very rare. We recorded 63 medicinal and herbal plants, 5 parasitic plants, and 10 introduced invasive species. 44 butterfly species were demonstrated within the targeted region. Their distribution within four poorly connected areas comprising the four valleys in the study areas suggests isolated populations, making protection difficult for the whole area. We suggest that despite the near impossibility of ensuring a connected eco corridor in the area, key plants and associated key butterflies in each of the four areas (like small reserves) ought to be protected. Such studies can be implemented in other fragmented areas of the State of Palestine.

* Corresponding author info@palestinenature.org

Keywords:

Protected areas, biodiversity loss, conservation measures, natural habitat, invasive species, urbanization, butterflies

Introduction

Protected Areas (PAs) cover 15% of land and inland freshwater globally (UNEP-WCMC and IUCN, 2020). However, within and outside PAs, biodiversity loss is inevitable globally. For example, over one third of PAs have suffered from increasing anthropogenic activities (Jones *et al.*, 2018). Further, only half of the protected areas globally show connectivity (Saura *et al.,* 2018; Ward *et al.,* 2020). While protected areas and other effective area-based conservation measures (OECMs) are critical, they are no longer considered sufficient in many places (IUCN World Commission on Protected Areas (WCPA), 2019). Thus, active measures must be implemented to maintain, enhance, or restore ecological connectivity among and between protected areas and key biodiversity areas (KBAs) (Tabor, 2018; Cohen, 2002). Ecological corridors are passages on land or in water that enable the movement of wildlife and dispersal of plant species and facilitate seasonal migration, reproduction, feeding, and adaptation to environmental change (Hilty *et al.,* 2020). The disruption and lack of ecological connectivity occur because of human-induced 'fragmentation' of habitats and ecosystems into smaller, dispersed parcels (Venter *et al.*, 2016; Scheffers *et al.,* 2016). Habitat loss and fragmentation are among the primary causes of biodiversity loss and ecosystem degradation worldwide. Even

though some habitats are naturally disjointed in terms of abiotic and biotic conditions (Wu and Loucks, 1995), anthropogenic effects have the highest effect upon the fragmentation of habitats (Haddad *et al*., 2015), altering the quality and connectivity of habitats. Hence, comprehending the cause and effect of habitat fragmentation is critical to preserving biodiversity and ecosystem functioning.

Historic Palestine (now the Occupied Palestinian Territories) has rich floral and faunal biodiversity due to its geography, diverse biogeographical zones, and various topographical features (Al Sheikh and Qumsiyeh, 2021b; Al Sheikh, 2019; Gedeon and Qumsiyeh, 2023; Gedeon and Khalilieh, 2024). It is in the eastern part of the Mediterranean Basin hotspot within the Orontes Valley and Levantine Mountains corridor hotspot (CEPF, 2017; Gedeon and Khalilieh, 2024; Médail and Quézel, 1997; Myers et al., 2000). Recently a reevaluation of the network of Palestinian protected areas (PAN) was performed (Qumsiyeh et al. 2023a). Amid these newly designated PAs is the Al-Arqoub area, it was designated based on extensive field surveys and substantial research (Qumsiyeh et al., 2023b). The Al-Arqoub PA, along with the broader PAN, was officially endorsed by the Palestinian cabinet and proposed for recognition as a biosphere reserve in June 2023.While rich in biodiversity, this PA is the most unusual in its map-geographic structure (Fig. 1). While the Al-Arqoub PA includes several valleys with somewhat disjointed geospatial features, they are ecologically interlinked and historically considered as one cultural and natural unit—the Al-Arqoub villages. The potential designation of this area as either a biosphere or a Hema offers appropriate conservation framework. Our study seeks to understand how ecological corridors—both natural and semi-managed—may enhance

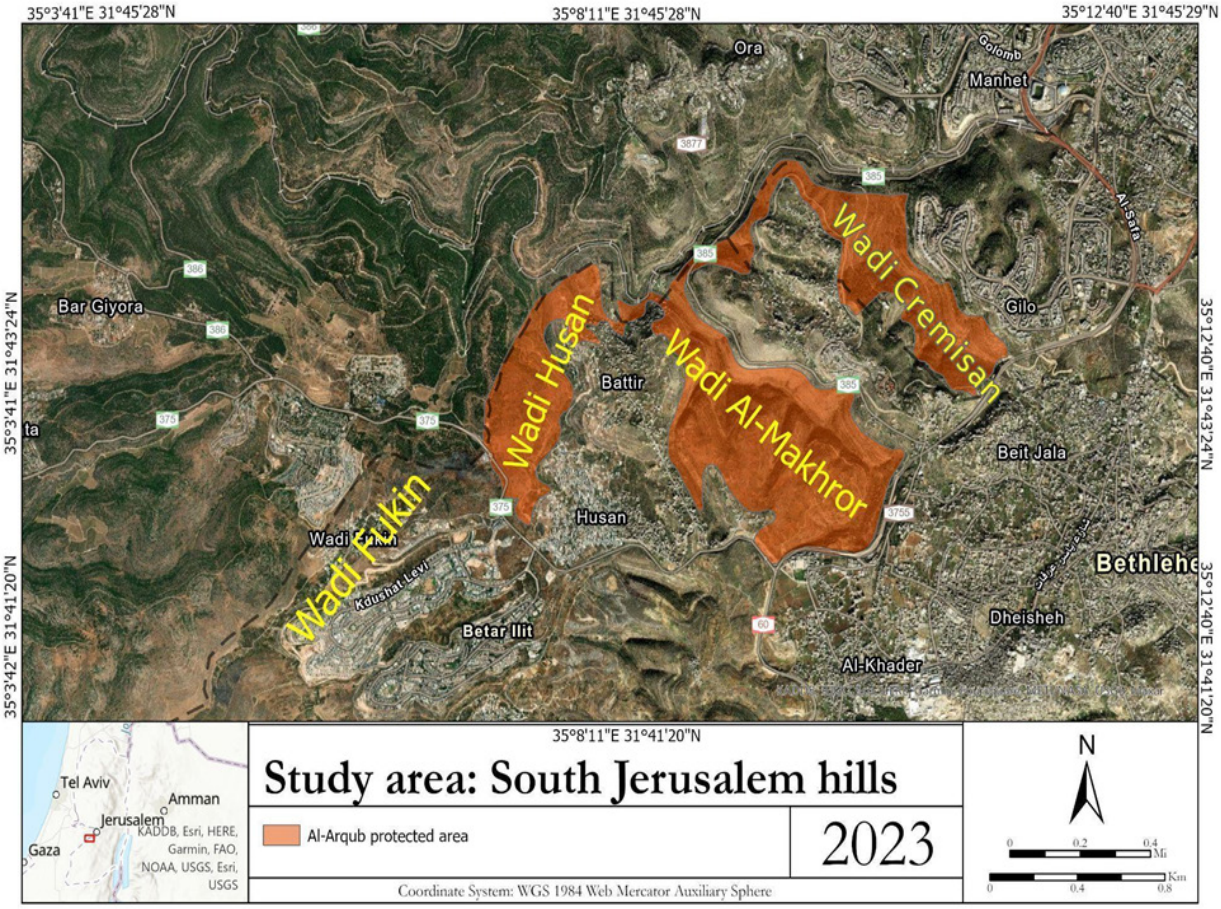

Figure 1. Map of the study area which include the three valleys designated a new protected area (Qumsiyeh et al., 2023a, 2023b) plus Wadi Fukin to the West.

conservation within this mosaic landscape, particularly under ongoing threats from rapid urbanization. In this context, we examined four key valleys, including one additional area to the southwest (Wadi Fukin), to evaluate potential connectivity and conservation value. We chose to focus our efforts on vascular plants and butterflies (Lepidoptera) because they are dependent upon each other (biological community) and could give us an idea of the relative fragmentation of habitats in the four valleys. The choice of the butterfly's larva regarding which plant to devour, as well as the adult butterfly choice on which plant to lay eggs, play an important role in food plant relationships.

To implement conservation measures on earth, it is critical to understand plant distribution. Plants are unique due to being primary producers and dominating elements in terrestrial ecosystems. Using plants to study habitat fragmentation is most important in understanding and mitigating the challenge (Rosati *et al*., 2010; Mutke et al., 2011; Heinken and Weber, 2013; Püttker *et al*., 2020). Butterflies are also particularly vulnerable to shrinkage and fragmentation of habitats (Kormann *et al*, 2019; Schlegel and Hofstetter, 2021). Thus, we decided to look at the distribution of butterflies and plants in the four recently identified valleys as part of an important new protected area called Al-Arqoub (Qumsiyeh *et al.*, 2023b) to better understand the threats to local biodiversity and how we may conserve any of the endangered species. This would also help with future conservation efforts for both flora and fauna.

Materials and Methods

Study area:

The South Jerusalem hills and valleys (9.1 km^2) in the Occupied Palestinian Territories comprise a natural and cultural landscape consisting of old Canaanitic agricultural terraces, water springs, ancient irrigation systems, and forested areas. Human-settlement remains (Canaanitic, Roman, Byzantine, and Islamic) are evident in many areas: agricultural watchtowers (manatir), old buildings of stone called "qusoor" locally, ancient terraces, and olive presses. The area was evaluated by the Palestinian Ministry of Tourism and Antiquities (MOTA) and submitted for emergency consideration as a UNESCO World Heritage Site (WHS) (MOTA, 2015). The Al-Arqoub area is a cluster of villages surrounding four biodiversity-rich valleys and associated hills: Wadi Cremisan, Al-Makhrour, Wadi Husan, and Wadi Fukin (Figure 1). This significant area is among the 13 most Important Bird Areas in Palestine as well as part of the listed Al-Quds Key Biodiversity Area (KBA) (BirdLife International, 2019). Most of the land of the seven Palestinian communities in the area (Husan, Al-Walaja, Battir, Wadi Fukin, Al-Khader, Artas, Beit Jala) lies within area C of the West Bank, which is under Israeli military and civilian control, which adds further pressure upon conservation measures. The area endures numerous difficulties, including habitat loss and fragmentation, land separation, as well as challenging economic and political circumstances (Qumsiyeh and Amr, 2016; AlHirsh, 2016; ARIJ, 2016; Husein and Qumsiyeh, 2022).

In a revelation of protected area networks in Palestine, three of the four valleys were designated as a new protected area named Al-Arqoub (Figure 1; Qumsiyeh *et al*., 2023a, 2023b). Additional studies by our team suggested the need for further evaluation of the four valley systems and associated hills, including Cremisan, Al-Makhrour Valley, Husan Valley, and Wadi Fukin. This study aims to evaluate the connectivity and value of conservation of these critical areas south of Jerusalem and West of Bethlehem and retain intact ecosystems, in a fast-changing world (Scheffers *et al.,* 2016). Our previous study generated a biodiversity strategy and management plan for Al-Makhrour, which was amended to the UNESCO World Heritage Site management plan and benefitted four marginalized communities (Al-Walaja, Battir, Husan, and Beit Jala) via enhanced ecosystem services (ecotourism, eco-friendly agriculture, and women empowerment) (Qumsiyeh *et al.,* 2023a).

Field Data:

Field trips were conducted over three years to survey the floral species and butterflies. The field trips were conducted to cover all four seasons within the four communities of Makhrour, Battir, Husan, and Wadi Fukin. A previously developed ecosystem management plan covering Husan and Battir was thus expanded not merely geographically to include Cremisan and Wadi Fukin but also by looking more in detail at threats to the four-valley ecosystem and its connectivity. Important flora were also documented within the area (Gedeon and Qumsiyeh, 2023). A desktop study was made to build on existing data collected by the PMNH/PIBS team and expand it to ensure the conservation of a fragmented habitat. Based on that study and earlier work, it was decided to focus on plants and butterflies as good indicator species for area connectivity and assessment of threats by direct observation on the ground. Butterflies were collected and identified per Abusarhan *et al.* (2016). Pictures of plants were taken in the field, and some samples were collected and inserted as plant voucher specimens kept in the herbarium of the Palestine Museum of Natural History. Data was also collected relating to the preservation of endangered species by ex-situ conservation within our botanical garden.

Results

Major butterfly species detected: A total of 44 butterfly species were recorded across the four targeted valleys, representing five families: Papilionidae, Pieridae, Lycaenidae, Hesperiidae, and Nymphalidae (Table 1). These valleys—Cremisan, Al-Makhrour, Wadi Husan, and Wadi Fukin—are situated within close geographic proximity in a very small area, historically considered a single ecological and cultural unit. The distances between them are minimal, making separation insignificant from a conservation planning perspective. The entire area is composed of privately owned lands managed by local communities from adjacent municipalities, with no portion classified as state land.

All four valleys fall within the Mediterranean biogeographical zone and are characterized by maquis habitat, a habitat type that is already represented in several other protected areas. Given their ecological cohesion and socio-cultural context, it is more appropriate to manage the site as a unified biosphere or Hema.

Butterfly distribution showed notable overlap among the valleys. For example, the same species were recorded in both Cremisan and Al-Makhrour Valleys, including *Kretania sephirus* (Frivaldszky, 1835) and *Thymelicus acteon phoenix*, both of which are listed as Near Threatened in Europe and Least Concern in the Mediterranean by the IUCN Red List. Rarely observed species such as *Spialia orbifer hilaris*, *Apharitis acamas*, and *Anthocharis cardamines phoenissa* were also minimally detected.

Importantly, *Archon apollonius* (Figure 2A), a globally rare and Near Threatened species according to the IUCN, was recorded in three of the four valleys. This species typically inhabits olive groves, orchards, roadsides, and mountain slopes, and visits flowers like *Crocus hyemalis* Boiss. & Blanche. Additionally, *Gonepteryx cleopatra taurica* was detected exclusively in Wadi Al-Makhrour; its larvae primarily feed on *Rhamnus spp.*, though its presence was less frequent compared to other species. *Hipparchia fatua sichaea* was rarely observed and only in two sites; it prefers dry, low-altitude areas and is associated with grasses, rocky slopes, and open pine forests.

Table 1. 44 species of butterflies observed within the study area. In this table Cremisan and Al-Makhrour are grouped together as we found no difference except for *Gonepteryx cleopatra taurica* which we found only in Al-Makhrour Valley.

Family	Scientific name	IUCN Status	Local Status	In Makhrour and Cremisan	In Husan	In Wadi Fukin
Hesperiidae	*Carcharodus alceae alceae*	*LC Mediterranean, Europe*	*Very Common*	X	X	X
	Gegenes gambica	-	*Uncommon*	X		
	Spialia orbifer hilaris	*LC Mediterranean, Europe*	*Rare*	X	X	X
	Syrichtus proto hieromax	-	*Uncommon*			X
	Thymelicus acteon phoenix	LC Mediterranean/ NT Europe	*Uncommon*		X	X
	Thymelicus hyrax hyrax	LC Mediterranean, Europe	*Uncommon*		X	
	Thymelicus sylvestris syriaca	LC Mediterranean	*Common*	X		
Lycaenidae	*Apharitis acamas*	NA Mediterranean, Europe	Rare	X		X
	Aricia agestis agestis	LC Mediterranean, Europe	*Very common*	X		
	Chilades galba	LC Mediterranean	*Common*	X	X	X
	Freyeria trochylus	LC Global, Mediterranean, Europe	*Common*	X		
	Lampides boeticus	LC Global, Mediterranean, Europe	*Common*	X	X	X
	Leptotes pirithous	LC Global, Mediterranean, Europe	*Common*	X		
	Lycaena phlaeas	LC Mediterranean, Europe	*Uncommon*	X		
	Lycaena thersamon	LC Mediterranean, Europe	*Common*	X	X	X
	Plebejus pylaon Kretania sephirus	*LC Mediterranean/ NT Europe*	*Common*	X	X	X
	Polyommatus icarus	*LC Mediterranean, Europe*	*Common*	X	X	X
	Zizeeria karsandra	*LC Mediterranean*	*Uncommon*	X	X	

Family	Scientific name	IUCN Status	Local Status	In Makhrour and Cremisan	In Husan	In Wadi Fukin
Nymphalidae	*Hipparchia fatua sichaea*	*LC Mediterranean, Europe*	*Very Rare*		X	X
	Lasiommata maera	*LC Mediterranean, Europe*	*Very common*	X	X	X
	Lasiommata megera emilyssa	*LC Mediterranean, Europe*	*Common*	X	X	X
	Maniola telmessia	*LC Mediterranean, Europe*	*Common*	X	X	X
	Melanargia titea	*LC Global, Mediterranean*	*Very Common*	X	X	X
	Melitaea telona	*LC Global, Mediterranean*	*Uncommon*	X		
	Melitaea trivia syriaca	*LC Global, Mediterranean*	*Common*	X	X	X
	Polygonia egea	*LC Global, Mediterranean*	*Uncommon*	X		
	Pseudochazara telephassa	-	*Common*	X		
	Vanessa atalanta	*LC Global*	*Common*	X		X
	Vanessa cardui cardui	*LC Global, Mediterranean, Europe*	*Very common*	X	X	X
	Ypthima asterope	*LC Global, Mediterranean*	*Uncommon*	X		
Papilionidae	*Archon apollonius*	*NT Global*	*Rare*	X		X
	Papilio machaon syriacus	*LC Global, Mediterranean, Europe*	*Common*	X	X	X
Pieridae	*Anthocharis cardamines phoenissa*	*LC Mediterranean, Europe*	*Rare*	X	X	
	Aporia crataegi augustior	-	*Common*	X	X	X
	Belenois aurota Anaphaeis aurota	*LC Global/ NA Mediterranean*	*Common*	X	X	X
	Colias croceus	-	*Common*	X		
	Colias fausta fausta	-	*Very common*	X	X	X
	Euchloe ausonia melisande	*LC Mediterranean, Europe*	*Common*	X	X	X
	Euchloe belemia belemia	*LC Mediterranean, Europe*	*Common*	X		

Family	Scientific name	IUCN Status	Local Status	In Makhrour and Cremisan	In Husan	In Wadi Fukin
Pieridae	*Gonepteryx cleopatra taurica*	*LC Mediterranean, Europe*	*Rare*	X (Makhrour only)		
	Pieris brassicae	*LC Mediterranean, Europe*	*Common*	X		
	Pieris rapae leucosoma	*LC Mediterranean, Europe*	*Very common*	X	X	X
	Pontia daplidice	*LC Global, Mediterranean, Europe*	*Common*	X	X	X
	Ponita glauconome glauconome	*ND*	*Common*	X		

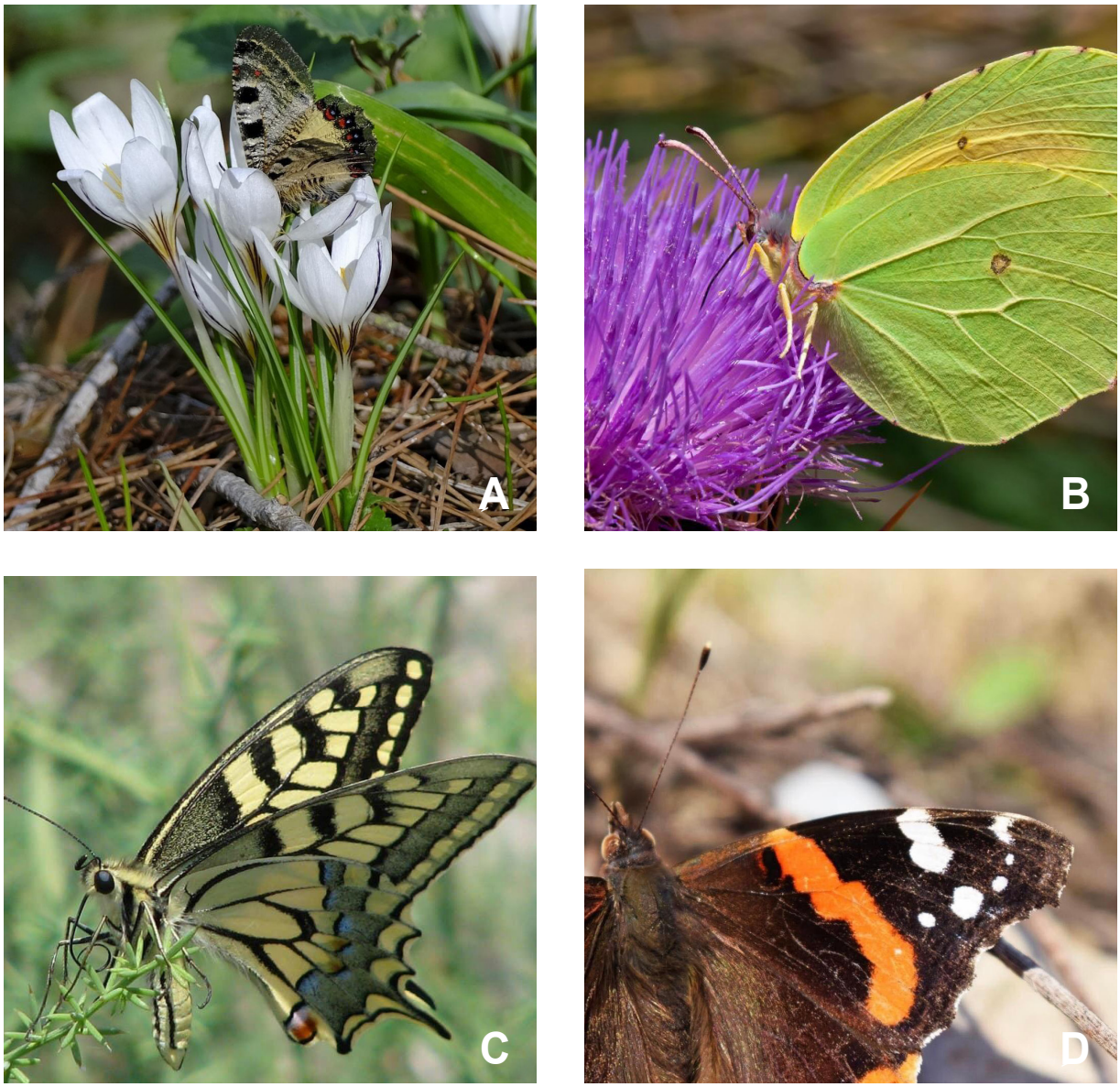

Figure 2. A) *Archon apollinus* on *Crocus hyemalis* plant**, B)** *Gonepteryx cleopatra* on *Onopordum spp*.**, C)** *Papilio machaon syriacus* on *Asparagus aphyllus* L., **D)** *Vanessa atalanta*

Flora:

387 flora species belonging to 79 plant families are hereby recorded in the area (list archived at https://www.palestinenature.org/flora/AlArqoub-Flora.pdf). This is a very rich floral biodiversity for such an area. Among these species, there are 53 species that are considered rare, while 54 species are considered very rare, and there are seven species that are scarce (see Figure 3 for examples of species). Amid these 387 flora species, there are 167 species that are decreasing due to habitat fragmentation due to urbanization and infrastructure development. Moreover, among these species, there are 27 subshrubs as well as 21 trees. The presence of five parasite species was detected: *Cuscuta campestris* Yuncker, *Orobanche aegyptiaca* Pers., *Parentucellia latifolia* (L.) Caruel, *Osyris alba* L. *(hemiparasitic),* and *Thesium humile Vahl*. As well as demonstrating the presence of many invasive species, such as: *Ambrosia confertiflora* DC., *Erigeron bonariensis* L., *Erigeron sumatrensis* Retz., *Amaranthus viridis* L., *Ailanthus altissima* (Mill.) Swingle, *Nicotiana glauca* Graham, *Ricinus communis* L., and *Oxalis pes-caprae* L. Amid the 79 plant families within the studied region, the family that has the richest biodiversity of species is the Papilionaceae (Fabaceae) family, which has 48 species, tagged along with the Compositae (Asteraceae) family, which has 46 species, trailed around by the Labiatae (Lamiaceae) family with 29 species and the Gramineae (Poaceae) family with 28 species, followed by both the Cruciferae and Umbelliferae families, which each have 12 and 11 species, respectively.

Noteworthy, there are 63 medicinal (see table 2) as well as herbal plant species, of which 10 species among them belong to the Compositae family alone, such as *Chiliadenus iphionoides* (Boiss. & Blanche) Brullo, *Dittrichia viscosa* (L.) Greuter, *Lactuca serriola* L., *Matricaria aurea* (Loefl.) Sch.Bip., *Silybum marianum* (L.) Gaertn., and *Sonchus oleraceus* L. Also, the Labiatae family has 16 species that have medicinal properties as well as herbal characteristics, such as Ajuga *chia* (L.) Schreber, *Origanum syriacum* L., *Marrubium vulgare* L., *Micromeria fruticosa* (L.) Druce, *Micromeria nervosa* Desf., *Salvia fruticosa* Mill., *Salvia hierosolymitana* Boiss., *Salvia palaestina* Benth., *Salvia viridis* L., *Satureja thymbra* L., *Teucrium divaricatum* Heldr., *Teucrium capitatum* L., *Thymbra spicata* L., and *Coridothymus capitatus* (L.) Rchb.f. As well as the *Asparagus aphyllus L.* that belongs to the Liliaceae family. This richness is due to diverse habitats, which form a supporting environment for the growth of diverse plant species. New records were documented for the first time within this studied area, such as *Sambucus ebulus* L., *Fumana scoparia* Pomel, *Crepis reuteriana* Boiss., *Glaucium flavum* Crantz, and *Coronilla cretica* L. (Gedeon and Qumsiyeh, 2023).

The flowering time is highly affected by seasonal weather and by the altitude; it was recorded that *Asphodelus ramosus* L. blooms in the low-elevated Wadi Fukin by October two weeks earlier than in the high-elevated Al-Makhrour, where it blossoms in November. Therefore, based upon the altitude of the region, spring starts from early February to May and often later upon higher mountains, and it starts nearly two weeks earlier in the eastern regions than the Western Mediterranean regions. It was observed within the last three years that spring started earlier than usual, which is an adaptation to cope with the new environmental conditions due to climate change, where rain seasons are shorter, the mean temperature is increasing, and the summer season is becoming longer, which leads to earlier blooming (Zittis *et al.*, 2022).

Table 2. List of medicinal and herbal plant species within the study area including local arabic names.

Family	Scientific name	Arabic name
Adiantaceae	*Adiantum capillus-veneris*	كزبرة البئر
Anacardiaceae	*Pistacia atlantica*	بطم أطلسي
	Pistacia lentiscus	بطم او سريس
Asphodelaceae	*Asphodelus ramsous*	قيصلان
Cactaceae	*Opuntia ficus-indica*	التين الشوكى أو الصبر
Capparaceae	*Capparis spinosa*	كبار
Caesalpiniaceae	*Ceratonia siliqua*	خروب
Compositae (Asteraceae)	*Anthemis pseudocotula*	قَحْوان كاذِب
	Calendula arvensis	أزريون
	Chiliadenus iphionoides	الضفائر الصفراء
	Inula viscosa	طيون
	Lactuca serriola	خس بري
	Matricaria aura	بابونج
	Silybum marianum	شوك الجمل
Convolvulaceae	*Convolvulus arvensis*	لبلاب الحقول أو مديدة
Cruciferae (Brassicaceae)	*Eruca sativa*	جرجير
	Nasturtium officinale	جرجير الماء/ حويرنة
	Sinapis alba	خردل ابيض
Cucurbitaceae	*Ecballium elaterium*	فقوس الحمار
Cupressaceae	*Cupressus sempervirens*	سرو اخضر
Euphorbiaceae	*Mercurialis annua*	عشبة الجرح أو مغيص
	Ricinus communis	خروع
Fumariaceae	*Fumaria capreolata*	رز الدجاج الجنوبي
	Fumaria parviflora	رز الدجاج صغير الزهر
Geraniaceae	*Erodium cicutarium*	رقمة شوكرانية
	Geranium robertianum	عطريه
Labiatae (Lamiaceae)	*Ajuga chia*	عشبة الدم
	Marrubium vulgare	عشبةالكلب / فراسيون شائع
	Mentha longifolia	نعنع طويل
	Mentha spicata	نعنع اخضر
	Micromeria fruticosa	زعتر بلاط
	Micromeria nervosa	شاي اعراق / زوفا
	Rosmarinus officinalis	اكليل الجبل / حصلبان
	Salvia fruticosa	مريمية / مريمية لبنان
	Salvia hierosolymitana	لسينة / السينة
	Satureja thymbra	ندغ
	Teucrium divaricatum	مشط العروس، ريحية
	Teucrium polium	جعدة
	Thymbra spicata	زعتر فارسي، زعيتمانِ
	Coridothymus capitatus	زحيف
	Vitex agnus-castus	غار

Family	Scientific name	Arabic name
Liliaceae	*Aloe vera*	الوفيرا
	Smilax aspera	جربيح / لجيم
Malvaceae	*Malva parviflora*	خبيزة
Moraceae	*Ficus carica*	تين
	Morus alba	توت أبيض
Oleaceae	*Olea europaea*	زيتون
Papaveraceae	*Papaver subpiriforme*	خشخاش
Papilionaceae	*Coronilla scorpioides*	خويتمة / حويذان
	Vicia sativa	بيقة شائعة
Pinaceae	*Pinus halepensis*	صنوبر
Plantaginaceae	*Plantago afra*	لسان الحمل الإفريقي
Portulacaceae	*Portulaca oleracea*	بقلة او فرفحينا
Ranunculaceae	*Clematis cirrhosa*	غاشية / نويعمة
	Nigella sativa	حبة البركة
Rosaceae	*Amygdalus communis*	لوز
	Crataegus aronia	زعرور
Rubiaceae	*Rubia tinctorum*	فُوّة
Scrophulariaceae	*Verbascum sinuatum*	عورور
Solanaceae	*Hyoscyamus aureus*	البنج المصري
Umbelliferae	*Ammi majus*	خلة شيطاني
	Daucus carota	جزر بري
	Foeniculum vulgare	شومر
	Pimpinella anisum	يانسون
Urticaceae	*Urtica pilulifera*	قريص جاج
	Urtica urens	قريص

Discussion

The four studied valleys in South Jerusalem/ West Bethlehem—historically known collectively as the Al-Arqoub villages—form a distinct and ecologically rich landscape within the Mediterranean biogeographical zone, characterized primarily by maquis vegetation and perennial water springs. While some variation in species composition of butterflies and plants was observed among the valleys, these differences likely reflect localized habitat preferences rather than strong evidence of significant ecological fragmentation. The valleys lie within a very small geographic area and retain a degree of ecological connectivity through both natural and cultivated landscapes, reinforcing the view that they should be managed as a unified conservation unit.

Three of the four valleys have already been designated as part of the newly established Al-Arqoub Protected Area (Qumsiyeh et al 2023a, b; Figure 4), which has been proposed by the Palestinian cabinet for declaration as a biosphere or hema. Several species of conservation concern were identified in specific sites within the study area. For example, *Arum hygrophilum* Boiss. — listed as Near Threatened by the IUCN—is currently restricted to the Al-Makhrour site. Similarly, the endemic *Iris vartanii* Foster and *Limodorum abortivum* (L.), both rare in the West Bank, were documented only in the Cremisan Valley, while *Iris palaestina* was confined to Wadi Fukin. These findings underscore the ecological uniqueness of each

Figure 3. A) *Fumana scoparia* Pomel, **B)** *Antirrhinum majus* L., **C)** *Salvia indica* L., **D)** *Glaucium flavum* Crantz.

valley, but they do not contradict the unified nature of the area. Rather, they highlight the value of site-specific conservation actions within a broader, integrated management framework.

The study area also plays an important hydrological role, contributing to the recharge of the western aquifer of the West Bank. It is designated as one of Palestine's thirteen Important Bird Areas (BirdLife International, 2019), as well as an Important Plant Area (Catullo *et al*., 2011). Considering its ecological, hydrological, and cultural significance, the site is best managed as a protected area, consistent with the recent recommendations of the Palestinian cabinet. This would allow for the protection of rare and localized species while also supporting sustainable development initiatives for the benefit of local communities.

While the area does exhibit some habitat discontinuities due to urbanization and land use pressures, these do not render the valleys ecologically isolated. Existing connectivity, supported by landscape features such as agricultural terraces, groves, and cultural corridors, provide steppingstones that facilitate species movement. Maintaining and enhancing this connectivity through in

situ conservation is essential for ensuring long-term biodiversity resilience, especially under the pressures of climate change and increasing human development (Foden & Young, 2016; Gross *et al.*, 2016).

Dudley *et al.* (2024) emphasizes the conservation value of small reserves, particularly for range-restricted and relict species—criteria that clearly apply to elements of the Al-Arqoub landscape, such as *Lycaena phlaeas, Iris vartanii,* and *Arum hygrophilum*. The Mediterranean biodiversity hotspot to which this area belongs includes critical microhabitats, water springs, and a diversity of fungi (Thaler *et al*., 2020), all of which add further justification for its preservation. Furthermore, recognition of the region as a "cultural landscape" enhances its value under global conservation frameworks and strengthens the case for its biosphere or Hema designation (Kormann *et al.*, 2019)..

Ultimately, this study contributes important baseline data to ongoing conservation planning in Palestine. By analyzing the distribution of vascular plants and butterflies—two ecologically linked taxonomic groups—we offer insight into localized habitat use and community composition, which can guide targeted conservation and education strategies. These efforts, integrated within the framework of a unified biosphere reserve, will help mitigate further habitat degradation and ensure that both biodiversity and local livelihoods are sustained.

The study area falls into an area in which there are significant habitat changes associated with climate change documented over the past few decades (Qumsiyeh *et al.,* 2014) with the intrusion of elements from other phytogeographic zones into the Mediterranean zone. Threats include not only climate change and desertification but also habitat destruction and fragmentation, pollution, invasive species, and overexploitation from both locals and Israeli settlers (Qumsiyeh *et al*., 2023a; Al Sheikh and Qumsiyeh, 2021a). In addition to the urban expansion at the expense of both agricultural and natural areas, the area is affected by the uncontrolled number of visitors and hikers, consecutively leading to habitat destruction via accidental bushfire, excessive foraging for medicinal and herbal plants, noise disturbance to animals, solid and liquid waste, overgrazing, cutting trees, the use of chemical pesticides, feral dogs, and cats. For instance, the *Gonepteryx cleopatra taurica* and *Hipparchia fatua sichaea* species are declining; because of degradation of forests and wooded regions due to infrastructure development, urbanization, and agricultural measures (Katbeh-Bader *et al.,* 2003; Van Swaay *et al.*, 2011). This stands true as both Battir and Husan have an expansion of urbanized areas towards maquis forested habitats, resulting in the fragmentation and loss of natural floral and faunal species habitats (Wilson *et al*., 2016).

Another major threat is the devastating spread of major invasive species within the area, which are *Ambrosia confertiflora* (most aggressive and rapid in spreading), *Ailanthus altissima*, *Nicotiana glauca, Ricinus communis*, and *Oxalis pes-caprae.* In November 2021, a wide spread of *Ricinus communis* was recorded in Wadi Fukin, and within two years, *Ricinus* had displaced a site full of native *Ranunculus asiaticus* species. The spread of invasive species has a direct correlation with urbanization and transport infrastructure development; for instance, *Nicotiana glauca* was the least detected within Makhrour, unlike Wadi Fukin, where the Israeli settlement of Beitar-Illit is being expanded. Urbanization expansion and infrastructure development lead to the disturbance and destruction of natural habitat where invasive species often thrive and outcompete native species. In addition, it aided in the spread of the worst invasive species, which is *Ambrosia confertiflora,* which outcompetes native species and leads to respiratory health disorders near urbanized sites. The Beitar-Illit settlement, built in the 1980s, is separating Wadi Husan from

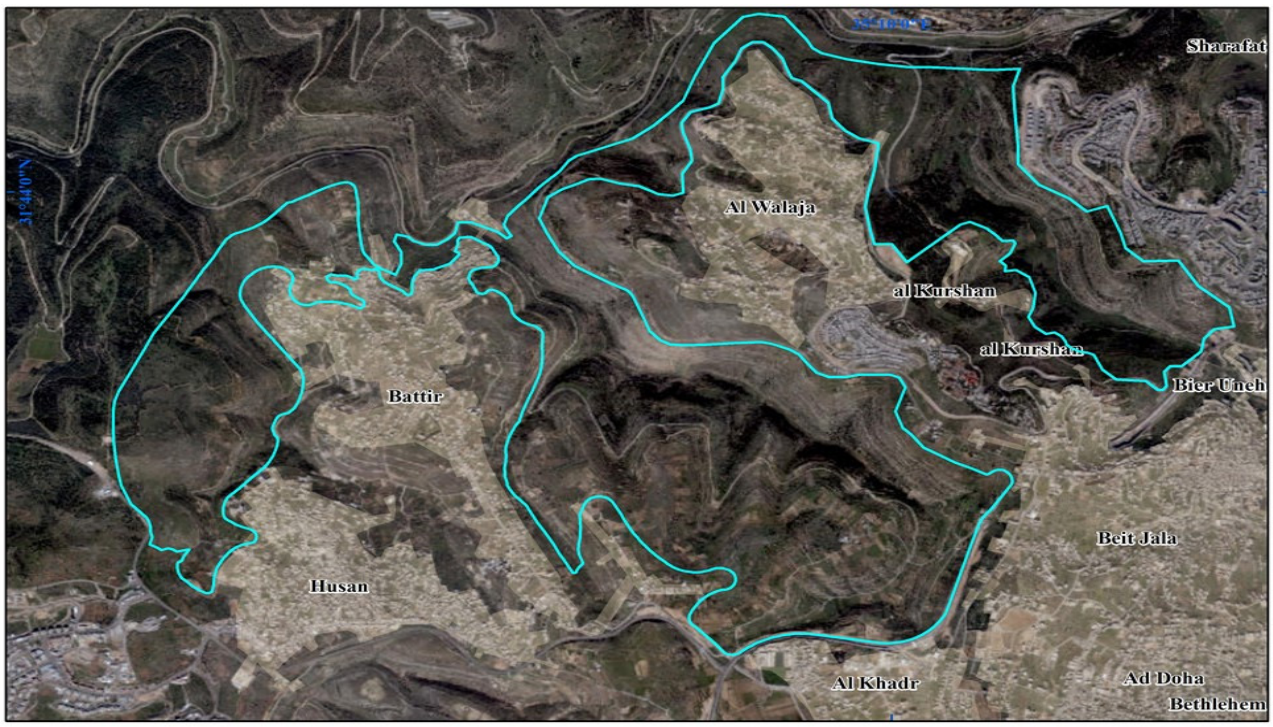

Fig. 4. Map of newly designated protected area. Note that the three valleys are connected by narrow corridors (Qumsiyeh et al. 2023a, 2023b). We studied these plus Wadi Fukin to the west also separated by a narrow corridor (see Figure 1)

Wadi Fukin village and fragmenting natural habitats, which may contribute to the decline of biodiversity. In addition, the settlement is dumping their raw sewage water upon the local agricultural lands.

The newly established protected area network for the State of Palestine has recommended the development of biosphere reserves in areas such as Wadi Al-Quff and the current study site (Qumsiyeh *et al*., 2023a, b). This approach emphasizes the importance of involving local communities in environmental protection. A recent study in the region highlighted the effectiveness of engaging farmers, women, and other community members in efforts to enhance ecosystem services (Qumsiyeh *et al*., 2024). Agriculture remains a primary source of livelihood for local inhabitants, who have demonstrated a strong commitment to conservation (Qumsiyeh *et al.*, 2023a, 2024). In addition, our research documented numerous medicinal and herbal plants in the area (Table 2), many of which are actively cultivated. However, traditional knowledge related to the use of these plants is increasingly being lost among communities surrounding the valleys (Mourad Hanna *et al.*, 2021). This study contributes valuable new data to the growing body of research on the fauna, flora, and local populations of the South Jerusalem hills and valleys. We underscore the urgent need for conservation strategies that promote sustainable human-nature interactions. In this context, our institute is actively collaborating with the Environment Quality Authority, the Ministry of Agriculture, the Ministry of Local Government, and stakeholders from the eight communities adjacent to these four valleys to develop and implement effective conservation and community engagement programs. This is a concept of Hema, an ancient system of conservation from our region (Serhal and Saidi 2005).

In conclusion, the four valleys comprise a relatively small area but are historically and ecologically significant, collectively known as the Al-Arqoub villages. These valleys lie within the Mediterranean biogeographical zone and represent a mosaic of maquis habitat, forest remnants, water springs, and agricultural lands. The whole PA system harbors rare, endemic, and threatened species, underscoring their

value as biodiversity refugia. While not the only habitat where such species persist, the ecological, cultural, and hydrological importance of this landscape makes it a prime candidate for enhanced conservation. Therefore, it is strongly recommended to follow the decision of the Palestinian cabinet to designate the area as a protected area. This would not only align with the scientific findings presented here but would also ensure the long-term preservation of biodiversity, the maintenance of ecosystem services, and the inclusion of local communities in sustainable development and conservation efforts.

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Supplementary Data:

Listing of plant species in the four valleys studied may be found here: https://www.palestinenature.org/flora/AlArqoub-Flora.pdf

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Diversity and Distribution of Rodents in Northern Jordan

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Abstract:

Despite the comprehensive literature on the mammals of Jordan published in the last two decades, the rodent fauna in northern Jordan remains largely unknown. This study aims to study rodents' diversity and distribution in northern Jordan. The survey was conducted during July 2020-April 2021 using Sherman folding live traps for 360 trap nights from 18 different locations along the northern borders of Jordan with Syria extending from Saham to Um el Quttein. A total of 102 individuals representing six species of rodents representing two families (Muridae: The eastern spiny mouse, *Acomys dimidiatus*; broad-toothed field mouse, *Apodemus mystacinus*; Wagner's gerbil, *Gerbillus dasyurus*; Tristram's jird, *Meriones tristrami*; and the house mouse, *Mus musculus*; Cricetidae: Günther's vole, *Microtus guentheri*) were identified. In this study, no new records for the rodents of Jordan were added. However, the present study adds new localities for the rodent fauna of Jordan and extends the distribution range for some species. Surveys on rodents and other small mammals should be carried out every two or three years to estimate their population size and monitor changes in their composition.

Keywords:

Rodentia, Northern Jordan, Diversity, Distribution.

Introduction

Rodents make up one of the most diverse groups of mammals on the planet, accounting for nearly half of all recognized mammalian species. Rodents are divided into 33 families with over 2,287 species representing a wide range of appearance and behavior (Wilson and Reeder, 2005).

Amr (2012) reported that 26 rodent species representing seven families (Spalacidae, Hystricidae, Sciuridae, Dipodidae, Gliridae, Cricetidae, and Muridae) were recorded during the study of Jordanian mammals. The study showed that rodents are the most diverse group of mammals in Jordan. Amr *et al.* (2018) gave details on the distribution and ecology data to all rodents of Jordan as well as identification keys for families and species. Habitat preference and zoogeographic affinities of rodents in Jordan were analyzed. The authors reported 28 species of rodents with 20 genera in eight families (Cricetidae, Dipodidae, Gliridae, Hystricidae, Muridae, Myocastoridae, Sciuridae, and Spalacidae) were recorded in Jordan.

This study is the first attempt to study the rodents of northern Jordan.

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Materials and Methods
Area of study:

1. Sama as Sirhan, Raba'a Al Sarhan, Hawija, Al Kawm al Aḥmar and Um el Quttein

These regions located within the Irano-Turanian area, and they meet the Syrian border. The vegetation is dominated by *Anabasis articulata, Artemesia herba-alba, Astragulus spinosum, Retama raetam, Urginea maritima, Ziziphus lotus, Zygophyllum dumosum,* and scattered *Pistacia atlantica* trees. The altitude of these regions ranges from 400 to 700 m asl, with an average annual rainfall of 50-100 mm. Surface soil layers are thin or non-existent in certain situations, and surface rockiness is quite high. Chains of basalt rocks scattered throughout the region, as well as spots of wheat fields (Amr, 2012, Ababsa, 2013) (Figure 1).

2. Ar Ramtha, As Sarih, Ash Shajarah, Elhusn, Balad ash Shaykh, Foara, Saham, and Zubiah

These localities lie within the Mediterranean region, which is defined by mountain ranges that stretch from Irbid in the north to Ra's Al Naqb in the south. The elevation of these regions ranges from 700 to 1500 m asl, with an annual rainfall of 400-600 mm (Amr, 2012, Ababsa, 2013) (Figure 1).

A total of 18 locations along the northern borders of Jordan with Syria extending from Saham to Umm Al Quttain were visited. The sites in which the traps were set up, coordinates and number of traps are recorded (Table 1).

Table 1. List of trapping localities.

Location	N	E	Number of Traps
1. Al Hammah	32° 41' 45.43''	35° 41' 26.68''	20
2. Al-Kawm al Aḥmar	32°22'26.79"	36°23'59.00"	20
3. Ar Ramtha	32° 34' 0.82''	36° 3' 2.74''	20
4. As Sarih 1	32°29'21.90"	35°55'15.18"	20
5. As Sarih 2	32°28'49.05"	35°57'46.97"	20
6. Ash-Shajara 1	32° 39' 22.97''	35° 58' 4.89''	40
7. Ash-Shajara 2	32° 39' 55.20''	35° 57' 20.36''	25
8. Ash-Shajara 3	32° 38' 20.63''	35° 56' 5.88''	19
9. Balad ash Shaykh	32° 40' 6.82''	35° 43' 18.74''	20
10. Elhusn	32°28'3.07"	35°56'20.34"	10
11. El-kherba	32° 39' 18.89''	35° 55' 47.72''	20
12. Fo'ara	32° 37' 9.62''	35° 46' 10.60''	20
13. Hawija	32° 25' 52.29''	36° 16' 50.80''	20
14. Raba'a Al Sarhan	32° 26' 59.65''	36° 17' 6.19''	20
15. Saham	32° 42' 45.45''	35° 45' 55.03''	16
16. Sama as-sirhan	32° 27' 54.68''	36° 15' 47.16''	20
17. Um el Quttein	32° 19' 46.31''	36° 37' 47.28''	20
18. Zubiah	32° 26' 36.07''	35° 46' 27.66''	10

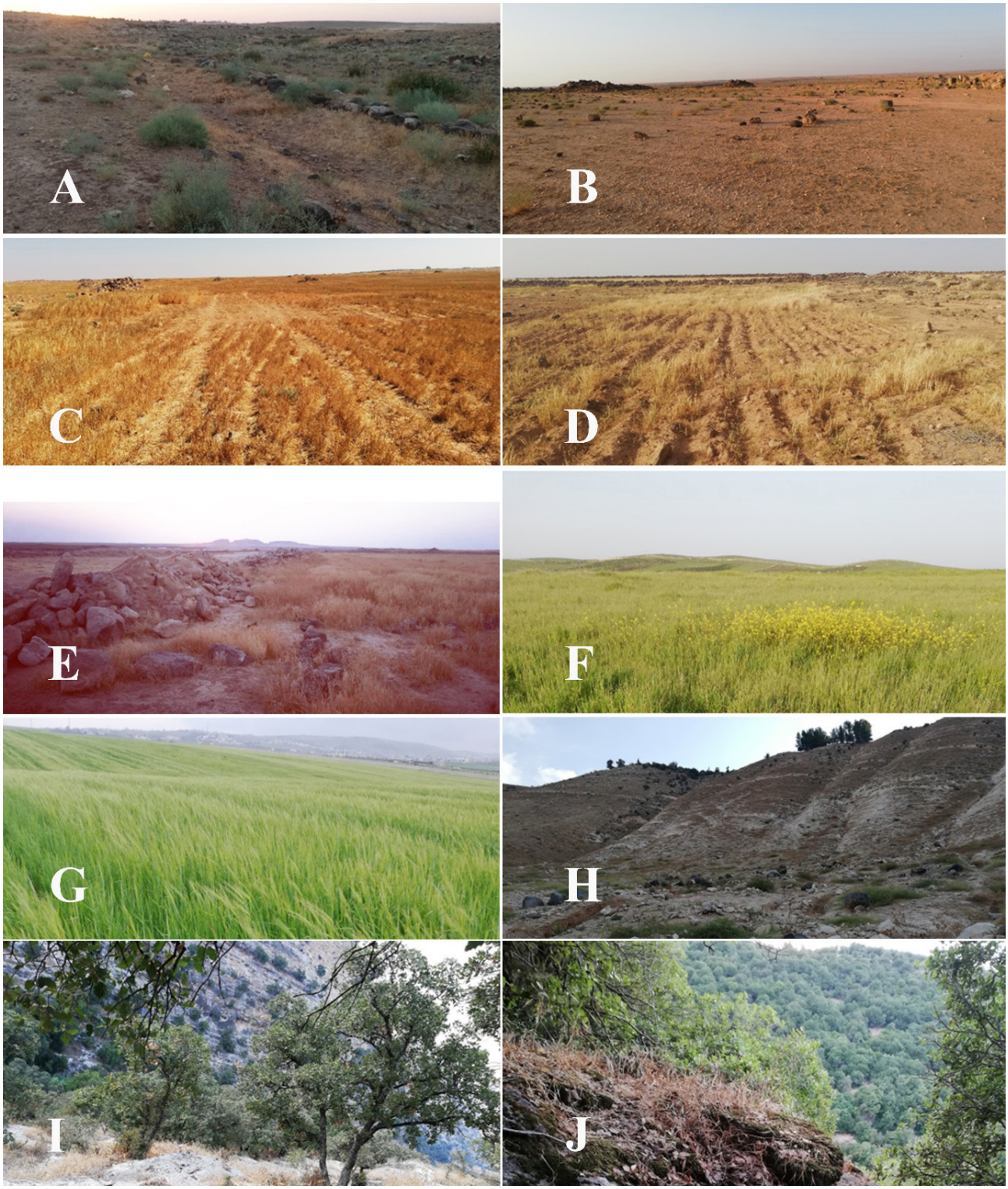

Figure 1. A. Habitat of Sama As-Sirhan area, near the Syrian border. B. Raba'a area showing desert plains with thorny plants and basalt rocks. C. Hawija area showing wheat fields and rocky accumulations. D. A wheat field with basalt rock chains in the Al Kawm al Aḥmar area. E. Habitat of Um el Quttein area, near the Syrian border. F. Wheat fields on the border with southern Syria in the Ar Ramtha area. G. Wide plains of wheat in the As Sarih area. H. Habitat of Wadi Ash Shajarah area. I. Saham area showing rocky cliffs with an abundance of oak trees. J. Dense oak forests of *Quercus calliprinos* in the Zubiah area.

Sherman folding live-traps

The survey was conducted during July 2020-April 2021. Rodents were trapped using Sherman folding live-traps (23 × 9 × 9 cm). Number of traps per location is shown in table (1). Traps were baited with mixed oatmeal and peanut butter. The traps were set in the late afternoon and checked in the early morning at sunrise the following day. Traps were aligned in longitudinal transects 20 meters apart from each other.
By using a nylon bag, the rodent species was tentatively identified based on morphological characteristics. and identified according to Amr (2012). Traps are cleaned, ventilated, and prepared for the next field trip.

Results

The 360 trap nights yielded 102 rodents' specimens belonging to six rodent species in two families (Muridae: *Acomys dimidiatus*, *Apodemus mystacinus*, *Gerbillus dasyurus*, *Meriones tristrami*, and *Mus musculus*, Cricetidae: *Microtus guentheri*) (Table 2 and 3, Figure 2 and 3).

Table 2. Relative abundance (%) of rodent species collected from 18 sites in northern Jordan.

Family	**Species**	Relative abundance (%)
Cricetidae	*Microtus guentheri*	0.06
Muridae	*Acomys dimidiatus*	0.1
	Apodemus mystacinus	0.04
	Gerbillus dasyurus	0.13
	Mus musculus	0.53
	Meriones tristrami	0.14

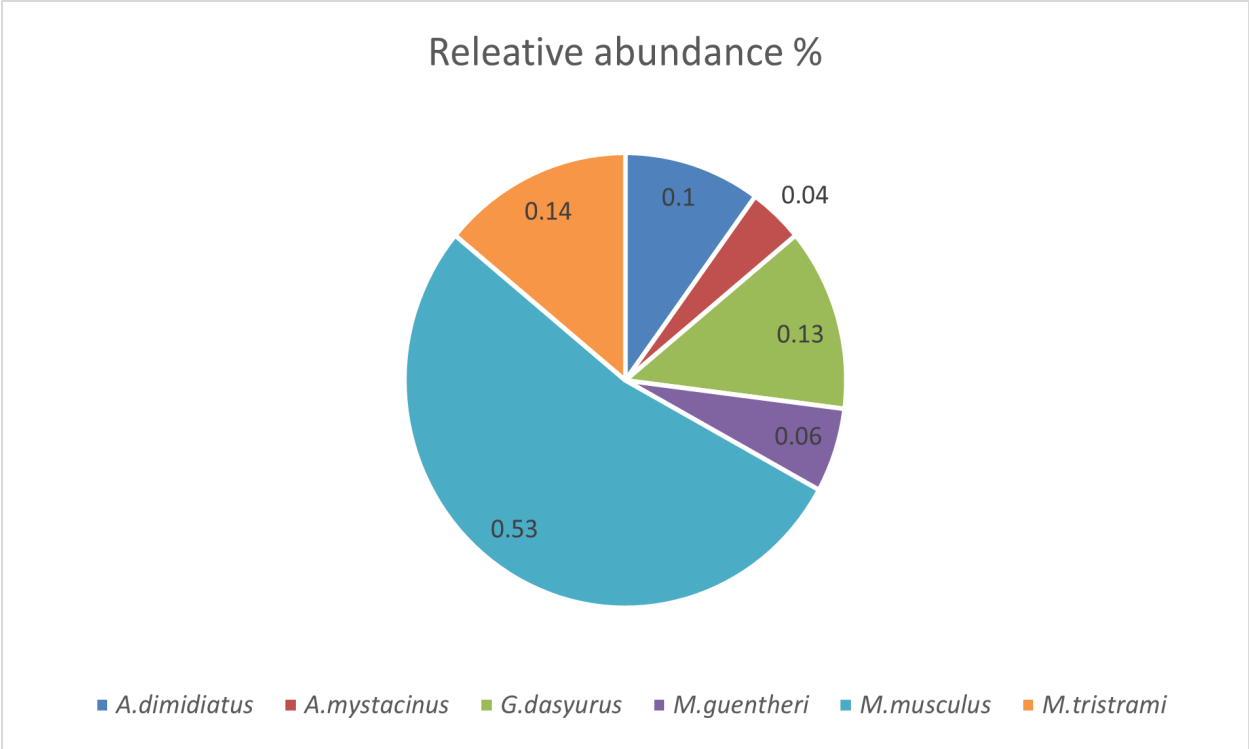

Figure 2. The relative abundance for the rodents' species that recorded at northern Jordan.

By far, *M. musculus* was the most abundant species, followed by *G. dasyurus* and *M. tristrami*. Both *A. dimidiatus* and *A. mystacinus* were the least abundant species (Figure 2).

Figure 3. Diversity of rodents in northern Jordan. A. The eastern spiny mouse (*Acomys dimidiatus*). B. Broad- toothed field mouse (*Apodemus mystacinus*). C. Wagner's gerbil (*Gerbillus dasyurus*). D. Tristram's jird (*Meriones tristrami*). E. The house mouse (*Mus musculus*). F. Günther's vole (*Microtus guentheri*).

Table 3. Number of rodents trapped per site.

Location	*A. mystacinus*	*A. dimidiatus*	*M. musculus*	*G. dasyurus*	*M. tristrami*	*M. guentheri*
Al Hammah	0	6	0	1	2	0
Al-Kawm al Aḥmar	0	0	1	0	2	0
Ar Ramtha	0	0	1	0	1	0
As Sarih	0	0	2	0	0	0
Ash-Shajara	0	3	26	0	1	6
Balad ash Shaykh	1	3	0	1	1	0
Elhusn	0	0	1	1	0	0
El-kherba	0	0	0	2	0	0
Saham	1	0	0		0	0
Sama as-sirhan	0	0	17	8	1	0
Um el Quttein	0	0	9	1	1	0
Zubiah	2	0	0	0	0	0

Family Muridae

***Acomys dimidiatus* (Cretzschmar, 1826)**
Arabian spiny mouse, Eastern spiny mouse**.**
Material Examined. 3 specimens, Ash-Shajara, 24 July 2020. 6 specimens, Al Hammah, 14 October 2020. 3 specimens, Balad ash Shaykh, 25 January 2021.

Remarks: This species was found among rocky areas in Al Hammah and Ash-shajara areas. *Acomys dimidiatus* lives in mesic and xeric biotopes and is a rock-dwelling rodent. It can be found in Jordan's entire mountain ranges, which reach from Aqaba to Al Hammah in the far north. It also encroached on Mediterranean forest ecosystems in northern Jordan, such as the Jarash and Malka forests, which have thick pine and deciduous oak vegetation, respectively. This species has never been found in rocky areas in the eastern desert of Jordan (Amr, 2012; Amr *et al.,* 2018).

***Apodemus mystacinus* (Danford and Alston, 1877)** Broad- toothed field mouse**.**
Material Examined. 2 specimens, Zubiah, 12 August 2020. 1 specimen, Balad ash Shaykh, 25 January 2021. 1 specimen, Saham, 1 September 2021.

Remarks: This species was found among forested areas in Zubiah and Saham. It was discovered that *Apodemus mystacinus* prefers thick, humid oak forests with or without pistachio trees or pines (Amr *et al*., 2018). This species' burrows were found under small rocky boulders or piles of rocks, with empty oak acorns often pointed their entrances (Abu Baker and Amr, 2008; Amr *et al.,* 2018).

***Gerbillus dasyurus* (Wagner, 1842)**
Wagner's gerbil.
Material Examined. 5 specimens, Sama Al-Sarhan1, 16 August 2020. 3 specimens, Sama as-sirhan 2, 18 August 2020. 1 specimen, Um el Quttein, 23 September 2020. 2 specimens, Sama as-sirhan 3, 1 October 2020. 1 specimen, Al Hammah, 14 October 2020. 1 specimen, Balad ash Shaykh, 25 January 2021.

Remarks: This species was found among chains of basalt rocks and scattered wheat fields in Sama Al-Sarhan and Um el Quttein. Gerbillus dasyurus can be found in a variety of environments, including basalt deserts, sandstone mountains, hammada deserts, and temperate areas of the Mediterranean mountains. The Jordanian Desert is home to a large population of this gerbil. Wagner's gerbil was discovered to share burrows with Psammomys obesus (Amr and Saliba, 1986). The burrows of *Gerbillus dasyurus* were simple but deep, with one or two unplugged

emergency exits (Hatough-Bouran, 1990). According to Amr *et al.* (2018), Wagner's Gerbil is also found in sand dunes, dry wadi beds, flat gravel plains, limestone cliffs, and narrow wadis and hills. *Anabasis articulata, Atriplex halimus,* and *Artemisia sieberi* were among the stored plants in the burrows (Abu Baker and Amr, 2003a).

***Meriones tristrami* (Thomas, 1892)**
Tristram's jird.
Material Examined. 1 specimen, Ash-Shajara, 24 July 2020. 1 specimen, Elhusn, 5 Augest 2020. 2 specimens, Al Hammah, 14 October 2020. 2 specimens, El-Kherba, 10 September 2020. 1 specimen, Um el Quttein, 23 September 2020. 1 specimen, Sama as-sirhan, 1 October 2020. 1 specimen, Balad ash Shaykh, 25 January 2021. 4 specimens, Ar Ramtha, 10 Mar 2021. 2 specimens, Al Kawm al Aḥmar, 8 April 2021.

Remarks: This species was found among the steppe of scattered thorny vegetation in Sama Al-Sarhan and Um el Quttein. *Meriones tristrami* lives in the Mediterranean and steppe regions of Jordan, mostly in the humid and dry Mediterranean regions (Amr, 2012). Peter (1961) investigated Tristram Jird's burrow system, which could be small (50 cm long) or large reaching several meters in length.

***Mus musculus* (Linnaeus, 1758)** The house mouse.
Material Examined. 13 specimens, Ash-Shajara (1), 23 July 2020. 2 specimens, Ash-Shajara (2), 24 July 2020. 11 specimens, Ash-Shajara (3), 24 July 2020. 1 specimen, Elhusn, 5 Augest 2020. 9 specimens, Um el Quttein, 23 September 2020. 1 specimen, Sama as-sirhan (1), 16 August 2020. 5 specimens, Sama as-sirhan (2), 18 August 2020. 11 specimens, Sama as-sirhan (3), 1 October 2020. 1 specimen, Ar Ramtha, 10 Mar 2021. 2 specimens, As Sarih, 21 Mars 2021. 1 specimen, Al Kawm al Aḥmar, 8 April 2021.

Remarks: This species was found in all regions of this research. Mus musculus is a common species that can be found in a wide range of environments, including deserts. It can be found in both new and old homes, restaurants, hotels, and farms. Because of its close connection with humans, it has spread across much of the world. In some areas, it is confined to human dwellings and ecosystems preserved by human activity, and when introduced, it may become feral. (Amr, 2012; Amr *et al.*, 2018).

Family Cricetidae
***Microtus guentheri* (Danford & Alston, 1880)** Levant vole.
Material Examined. 6 specimens, Ash-Shajara, 23 July 2020.

Remarks: This species was found only among the wheat plains in the Al-Shajara area on the border with Syria. According to Amr (2012), *Microtus guentheri* is only found in the Mediterranean biome. In the areas between Irbid and Al Mafraq, some colonies were discovered. This is a colonial species, with colonies ranging from 40 to 100 burrow systems per 1000 m^2. Gray hamster (*Cricetulus migratorius*) and Tristram's jird (*Meriones tristrami*) share burrows with it. *Microtus guentheri* is a favorite of the Barn owl, *Tyto alba* (Rifai *et al.*, 1998).

Discussion

The rodent fauna of northern Jordan follows two patterns: those found near plains and rocky valleys in the Ash-Shajarah, as well as Mediterranean forests in the Zubiah and Saham areas, have Palearctic affinities (*Apodemus mystacinus*, and *Microtus guentheri*), while those found in arid regions have mesic affinities (*Meriones tristrami* and *Gerbillus dasyrus*).

New sites within the distribution range for each species of rodents were recorded in northern Jordan, which are as follows: *Acomys dimidiatus* (Ash-Shajara), *Apodemus mystacinus* (Saham), *Gerbillus dasyurus*

(Sama as Sirhan, Al Hammah, and Balad ash-Shaykh), *Meriones tristrami* (Al Kawm al Aḥmar, Sama as Sirhan, Al Hammah, Harta, Amrawah, and Balad ash-Shaykh), *Microtus guentheri* (Ash-Shajara).

The Balad ash-Shaykh mountains, covered in deciduous oak and punctuated by narrow valleys, have the highest diversity, whereas four species were collected: *Meriones tristrami*, *Acomys dimidiatus*, *Apodemus mystacinus*, and *Gerbillus dasyurus*). The lowest diversity was recorded in several localities with different habitats where only one species was recorded as follow: Zubiah (*Apodemus mystacinus*), El-kherba (*Meriones tristrami*), and As Sarih (*Mus musculus*). In addition, the highest trappbility (0.59) was recorded in the Um el Quttein and Ash Shajarah areas.

The most frequently trapped species was the house mouse (*Mus musculus*), accounting for 0.53 % of all traps (Figure 2). This species is a common species of northern Jordan, as was recorded in almost all regions, especially wherever there are human habitations. It is a common species found around plantations and inhabited areas. *Mus musculus* populations are increasing in northern Jordan due to their ability to adapt to a variety of conditions and ability to construct nests everywhere. Moreover, the growing human presence for grazing and farming in many places led to the introduction and extensive reproduction of this species.

Despite intensive trapping in northern Jordan, particularly in the Sama as Sirhan and Ash-Shajarah areas, the gray hamster (*Cricetulus migratorius cinerascens*) was neither captured nor recovered from owl pellets. Rifai *et al.* (1998) found this species in Barn owl pellets collected in the As Sarih region.

The distribution range of *Acomys dimidiatus* fits very well with its current distribution that extending from northern parts of Jordan until its most southern edges (Amr *et al.,* 2018). This species was only found near the northern border of Jordan with Syria in the Ash-Shajarah and the Al Hammah areas, where it inhabited rockslides and the pilling up of large basalt rocks in wadis.

According to Amr (2012), the habitat of northern Jordan is appropriate for *Apodemus mystacinus*, it has a rocky Mediterranean habitat with an abundance of evergreen oak forests. *Apodemus mystacinus* is a widespread and abundant species in the forested areas within its distribution range in Jordan and still fits very well with its current distribution (Amr, 2012). In current study, *Apodemus mystacinus* was only found in the Zubiah and Saham areas with the same habitats. On the other hand, Wagner's gerbil (*Gerbillus dasyurus*) was only found in rocky areas. Hatough-Ouran (1990) stated that *Gerbillus dasyurus* prefers the runoff wadis rather than another habitat. This gerbil prefers rocky areas with little vegetation and avoids sandy soil (Amr, 2012). In this study, *Gerbillus dasyurus* was collected from different localities within the arid Mediterranean such as Al Kawm al Amar, Um el Quttein, and Sama as-sirhan.

Microtus guentheri was found in the Mediterranean biotope, with colonies located between Irbid and Al Mafraq (Amr, 2012). In this study, this species was only trapped near Jordan's northern border with Syria, in the Ash-Shajarah region, where intensive agriculture is widespread (Shehab *et al.*, 2018).

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Unifying Sixty-Five Years of Ornithological Records in Azraq Wetland Reserve, Jordan: A Comprehensive Checklist and Conservation Evaluation

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Abstract:

The Azraq Wetland Reserve, located in eastern Jordan, is the only permanent wetland in the hyper-arid northern Arabian Desert and an essential habitat along the Eastern Palearctic-African flyway. The reserve encompasses a mudflat habitat covering approximately 62 square kilometers, representing the lowest topographic point in the region. receiving surface runoff and inflows from all surrounding wadis. Due to its hydrological significance and habitat characteristics, it supports high densities of waterbirds and has been designated as a Ramsar Site of International Importance. This study presents a unified and annotated checklist of bird species recorded in the Azraq Wetland Reserve between 1960 and 2025, based on historical expeditions, published literature, institutional monitoring programs, and recent field surveys. A total of 328 species are documented, each classified by scientific name, common names in English and Arabic, IUCN Red List status, and seasonal presence in the Azraq region. Among these, fourteen species are Near Threatened, eight Vulnerable, four Endangered, and two Critically Endangered. Despite the loss of natural spring discharge since the early 1990s, artificial water pumping has maintained limited wetland functions, enabling the site to continue supporting wetland-dependent biodiversity. This checklist provides a comprehensive baseline for ongoing ecological monitoring and conservation planning in the Azraq Wetland Reserve.

Keywords:

Flyway migration; Habitat fragmentation; Avian hotspots; Ecological functionality, Wetland restoration

Introduction

Azraq Oasis is the only permanent wetland within the hyper-arid northern Arabian Desert, located approximately 85 km east of Amman, Jordan (31˚50'N, 36˚50'E) (Scates, 1966). It lies at the junction of basaltic formations to the north and limestone-flint geology to the south, occupying the center of the Azraq Basin—a closed inland catchment spanning 12,710 km², of which 94% lies within Jordan, with minor portions in Syria and Saudi Arabia (Bender, 1975; Nelson, 1973). The basin is a gently sloping plateau, with elevations ranging from 1,576 m above sea level in southern Syria to 500 m at the Qa of Azraq, the lowest point of the depression (Al-Kharabsheh, 2000).

The hydrology of Azraq is primarily driven by a basalt aquifer system extending from Jabal al-Arab to the center of the basin, where it historically surfaced via artesian springs, creating the oasis. Secondary sources include deep paleo water from the Tulul al-Ashaqif highlands and thermal flows through fault systems, while shallow aquifers are intermittently recharged by seasonal runoff (Abu-Jaber *et al*., 1998). These inputs sustained a diverse wetland system comprising permanent freshwater marshes, pools, and a large seasonally flooded Qa (Scates, 1966). Historically, the permanent wetland area—excluding the Qa—covered approximately 26 km².

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The Mudflat (Qa'a Al-Azraq) covers an area of approximately 62 km² and represents the lowest point within the Azraq region, with its lowest elevation reaching 480 meters above sea level. It serves as the collection point for all surface runoff from surrounding wadis and constitutes an important habitat for migratory and resident waterbirds. Since the mudflat was fenced in 2017, vegetation has significantly increased due to the cessation of grazing, enhancing the habitat's ecological value by providing food resources for migratory and resident birds.

From earliest times, Azraq was a vital freshwater refuge, shaping human settlement and economy. Bedouin tribes relied on the marshes for grazing and water, while later waves of Druze and Chechen migrants established villages in the early 20th century. The wetlands supported duck hunting, fishing, salt extraction, and water buffalo grazing (Nelson, 1973; UNDP, 1993, 1995). Conservation initiatives began in the 1960s, with early ecological surveys and a proposed national park (Hemsley and George, 1966). Azraq was declared a Ramsar site in 1977 and later a protected wetland reserve under the management of the Royal Society for the Conservation of Nature (RSCN), with the first formal management plan issued in 1980 (Conder, 1980). Groundwater abstraction for urban supply began in the early 1980s, drastically reducing spring discharge—from 14–16 million m³/year in the 1960s to near zero by 1992 (Scott, 1995). A national restoration initiative was developed in the early 1990s, with support from the Global Environment Facility (GEF), aiming to restore 10% of the former wetland through artificial recharging. Currently, water is supplied through two plastic pipelines, delivering only 750,000 m³/year—half the target volume. This supports a fragmented system of three surface pools, reed-covered canals, and seasonal flood zones (RSCN, internal data). The site continues to provide partial ecological functionality, sustaining limited wetland-dependent biodiversity and maintaining its symbolic conservation value in Jordan.

As part of the habitat restoration plan approved in 2005, a new pool was established in the northern area of the reserve in 2016 (Swiss Pool), covering an area of approximately 25 dunums. This pool constitutes approximately 50% of the total area of permanent pools within the reserve. A hydraulic infrastructure, consisting of a network of pipes connected to the internal pumping station, was implemented to ensure a continuous and controlled water supply, thereby maintaining the ecological functionality of this water body.

For migratory birds, the Azraq Wetland Reserve functions as an ecological "island" of wetland habitat within the otherwise barren Eastern Desert (Ellis, 2017). Its geographic position along the Eastern Palearctic-African flyway makes it a site of critical importance for refueling and resting during long-distance migration (Melling, 1999). As a result, the site has received considerable ornithological attention, with surveys conducted in 1999, 2000, 2004, 2006, 2009, 2011, 2014, 2017, and 2023. These efforts, alongside published works such as Azraq: Desert Oasis by Bryan Nelson and The Birds of the Hashemite Kingdom of Jordan by Ian Andrews, have documented a rich avian community composed of both migratory and resident species.

Despite this body of work, the avifaunal data on Azraq remain fragmented and dispersed across unpublished reports, short-term studies, and isolated publications. No unified, annotated checklist currently exists that consolidates all known records or assesses the status of each species in the context of the Azraq region. This lack of synthesis presents a critical gap in knowledge that limits the capacity for evidence-based conservation planning, ecological monitoring, and habitat management. In response, the present study aims to compile a comprehensive and standardized checklist of bird species recorded in Azraq Oasis and its surrounding basin. The checklist integrates historical and contemporary sources to clarify species

taxonomy, residency status, and conservation relevance, and provides a scientific baseline to support future biodiversity assessments and wetland protection initiatives.

Materials and Methods

Extensive ornithological surveys took place in the Azraq Wetland Reserve date back to the early 1960s, with significant foundational work led by D.I.M. (Ian) Wallace, James Ferguson-Lees, Guy Mountfort, and other members of the British conservation delegation. Between 1963 and 1967, Wallace participated in multiple expeditions that documented the scale of spring bird migration through Azraq, estimating that hundreds of thousands of passerines passed through the oasis during peak periods—a magnitude that exceeded contemporaneous records from Habbaniya (Wallace, 1982; 1983a). These early studies not only provided the first quantified estimates of migration patterns but also laid the groundwork for Azraq's eventual designation as a Ramsar site. Additional historical insights were offered in Azraq: Desert Oasis by Bryan Nelson (1973), who directed the International Biological Programme research station in 1967.

Building upon this historical foundation, our study consolidates six decades of avifaunal records from Wallace's expeditions, Nelson's fieldwork, the Royal Society for the Conservation of Nature (RSCN), and modern bird monitoring conducted in 1999, 2000, 2004, 2006, 2009, 2011, 2017, and 2023. These more recent surveys—primarily led by RSCN and implemented by Pete Ellis, Tim Melling, and Tim Strudwick in cooperation with the RSPB and Jordanian ornithologists—were further supplemented by verified records from Jordan Birdwatch and the Jordan Bird Records Committee (JBRC). This effort culminates in the first unified, annotated checklist of bird species recorded in Azraq. In addition to the National Waterbird Census, coordinated in Jordan for over 25 years, has provided consistent annual winter count data from Azraq Wetland Reserve. This census forms a core component of long-term population monitoring and was integrated into our broader data synthesis, allowing comparison of interannual population trends for key waterbird species. Status assessments were derived from historical literature, expert consultations, and our own field observations. Additionally, avian hotspots were georeferenced using handheld GPS devices and processed through RSCN's GIS unit to generate an updated spatial distribution map across the Azraq Basin.

Fieldwork was conducted during peak migration seasons—spring (March–May) and autumn (September–November)—as well as in the breeding season (April–July) and winter (December–February). Each survey varied in duration, ranging from single-day observations to week-long intensive campaigns. Standard birdwatching methods were employed, including point counts, transect walks, and opportunistic observation. Breeding status assessments followed internationally recognized criteria, such as nest building, feeding of young, and confirmed presence of fledglings.

All rare or new species records were subjected to a multi-step verification process. This included photographic documentation, detailed field notes, and review by experienced ornithologists. Species of high interest or first records for Jordan were submitted to the Jordan Bird Records Committee (JBRC) for formal validation. Only verified records were included in the annotated checklist and spatial database.

Results

This article presents a checklist of bird species recorded in the Azraq Wetland Reserve, Jordan, spanning the period from 1960 to 2025. A total of 329 species have been compiled based on data from historical expeditions, published literature, institutional monitoring programs, and recent field observations. Each species entry

includes the English and Arabic common names, scientific name, IUCN Red List category, and recorded status in the Azraq region using standardized codes for seasonal presence and breeding status. These codes distinguish between resident breeders (R), passage migrants (PM), winter visitors (WV), occasional breeders (ob), non-breeding summer visitor (SV), vagrants (V), summer breeder (SB), former breeder (fb) transient (t), and other relevant categories, based on multi-source verification.

According to the IUCN Red List, the documented avifauna includes 14 Near Threatened (NT) species, eight Vulnerable (VU), four Endangered (EN), and two Critically Endangered (CR). Notable threatened species include the Sociable Lapwing (*Vanellus gregarius*, CR), Yellow-breasted Bunting (*Emberiza aureola*, CR), Steppe Eagle (*Aquila nipalensis*, EN), and Saker Falcon (*Falco cherrug*, EN). Several wetland-dependent species of conservation concern have also been recorded, such as the Marbled Duck (*Marmaronetta angustirostris*, NT), Ferruginous Duck (*Aythya nyroca,* NT), and Black-tailed Godwit (*Limosa limosa*, NT). In addition, the checklist includes a wide range of passage migrants and wintering species, such as the Common Teal (*Anas crecca*), Common Redshank (*Tringa totanus*), and Black-headed Gull (*Chroicocephalus ridibundus*), as well as breeding residents like the Graceful Prinia (*Prinia gracilis*), the introduced White-spectacled Bulbul (*Pycnonotus xanthopygos*).

The spatial distribution of bird observation records within the Azraq Wetland Reserve was mapped using georeferenced field data collected between 1999 and 2025. The resulting Bird Distribution Map (Figure 1)

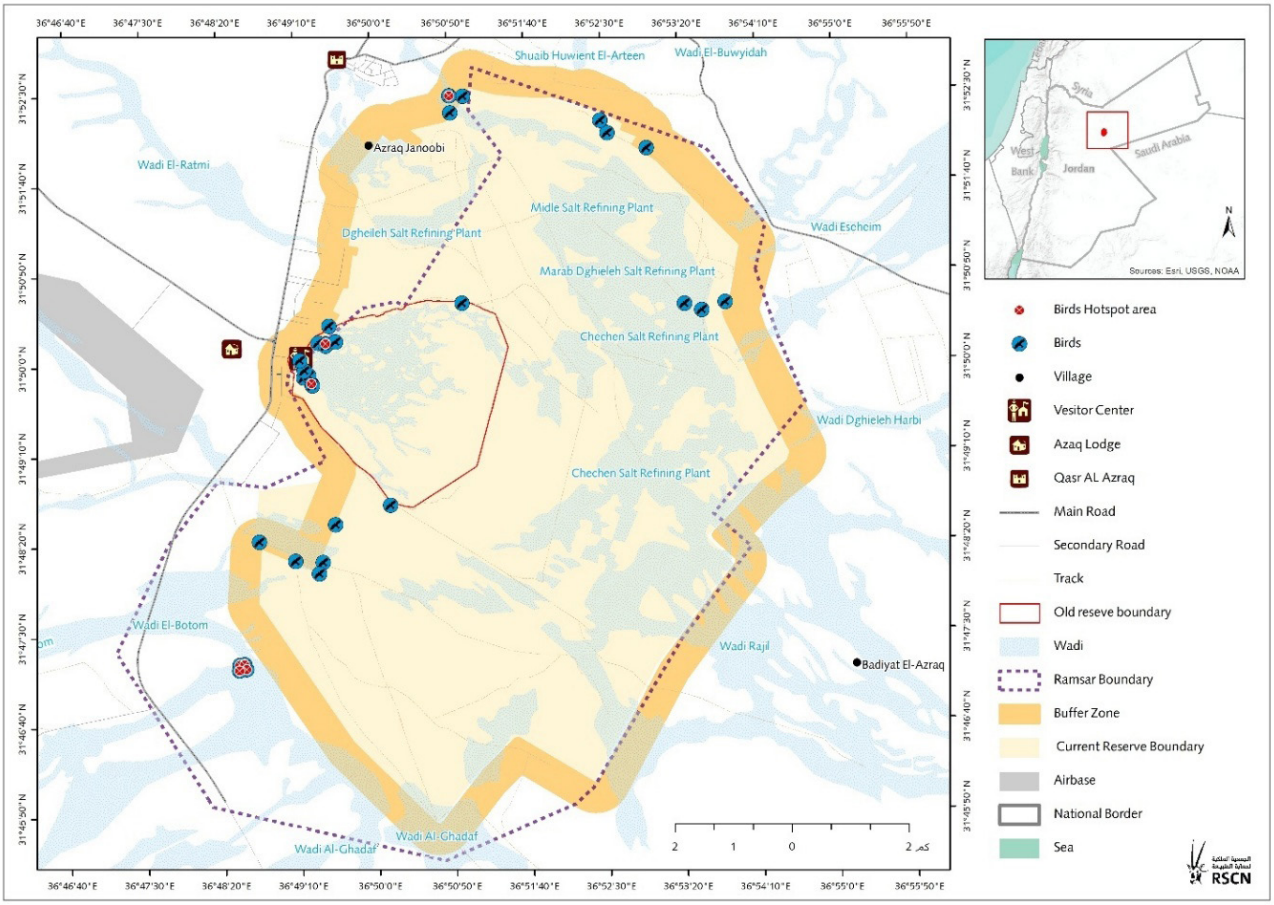

Figure 1. Bird Distribution Map.

identifies specific locations of repeated bird observations within and around the reserve. Concentration points are located primarily in the central-western part of the Ramsar site, particularly near the Visitor Center, Qasr Al Azraq, and Azraq Lodge. Additional hotspots are recorded in the southern and eastern areas, including sites near Wadi El-Botom and Wadi Rajil. Further observation clusters appear adjacent to salt refining plants such as Dgheich, Marab Dgheich, and Chechen Salt Refining Plant.

The checklist (Table 1) constitutes the primary output of the study and is intended to provide a verified reference dataset for ongoing ecological assessments, avian monitoring programs, and conservation planning in the Azraq Basin.

Figure 1 (Bird Distribution Map) illustrates the bird distribution areas within the Azraq Wetland Reserve and its buffer zone and Ramsar boundary in Jordan, identified based on species richness and population density. The map was created using data collected through intensive field studies, seasonal bird monitoring programs, and daily observations conducted across the reserve. The highlighted areas represent zones of high ornithological importance, providing critical habitats for both resident and migratory bird species. The map also includes relevant features such as the reserve boundaries, salt refining plants, roads, wadis, and the locations of the Azraq Lodge and Visitor Center.

Table 1. Checklist of bird species recorded in Azraq Wetland Reserve, Jordan, from 1960 to 2025, including scientific and common names, IUCN Red List status, and seasonal presence in the Azraq region.

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
1	Mute Swan	*Cygnus olor*	تم اخرس	LC	V
2	Greater White-fronted Goose	*Anser albifrons*	إِوَزَّةٌ غَرّاءُ كَبِيرةٌ	LC	V
3	Grey Lag Goose	*Anser anser*	الوزة الربداء	LC	V
4	Mallard	*Anas platyrhynchos*	ابو حشيش/الخضاري	LC	R, WV
5	Common Shelduck	*Tadorna tadorna*	شَهْرَمَانَةٌ	LC	ob,PM,WV
6	Ruddy Shelduck	*Tadorna ferruginea*	البط الأحمر	LC	WV
7	Gadwall	*Mareca strepera*	السماري	LC	WV
8	Falcated Duck	*Mareca falcata*	حذف منجلي	NT	V
9	Northern Pintail	*Anas acuta*	البلبول	LC	PM,WV
10	Northern Shoveler	*Spatula clypeata*	أبو مجرف	LC	ob,PM
11	Marbled Duck	*Marmaronetta angustirostris*	الحذف المرقط	NT	V
12	Common Teal	*Anas crecca*	الشرشير الشتوي	LC	PM,WV
13	Garganey	*Anas querquedula*	الشرشير الصيفي	LC	PM
14	Common Pochard	*Aythya ferina*	بَطَّةٌ حَمْرَاءُ رَأْسٍ	VU	PM,WV
15	Red-crested Pochard	*Netta rufina*	الكوشرة	LC	PM,WV
16	Ferruginous Duck	*Aythya nyroca*	الحمراوي أبيض العين	NT	PM,ob
17	Tufted Duck	*Aythya fuligula*	ابو خصلة	LC	PM,WV
18	Common Goldeneye	*Bucephala clangula*	ذهبية العين الشائعة	LC	V
19	SMEW	*Mergellus albellus*	بلقشة بيضاء	LC	V
20	Red-breasted Merganser	*Mergus serrator*	بلقشة حمراء الصدر	LC	V
21	Chukar	*Alectoris chukar*	الشنار	LC	R
22	Sand Partridge	*Ammoperdix heyi*	الحجل	LC	R

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
23	Common Quail	*Coturnix coturnix*	السمان	LC	PM,(SB?)
24	Corncrake	*Crex crex*	سَلْوَى	LC	PM
25	Little Grebe	*Tachybaptus ruficollis*	الغطاس الصغير	LC	SB ,WV ,R
26	Great Crested Grebe	*Podiceps cristatus*	غطاس متوج	LC	PM,WV
27	Black Necked Grebe	*Podiceps nigricollis*	غطاس أسود الرقبة	LC	PM
28	Great White Pelican	*Pelecanus onocrotalus*	البجع الأبيض	LC	PM
29	Great Cormorant	*Phalacrocorax carbo*	غراب البحر الأسود	LC	PM
30	Great Bittern	*Botaurus stellaris*	الواق الكبير	LC	WV
31	Little Bittern	*Ixobrychus minutus*	الواق الصغير	LC	SB,PM,(R?)
32	Black-crowned Night Heron	*Nycticorax nycticorax*	بلشون الليل اسود التاج	LC	t,PM,WV
33	Striated Heron	*Butorides striata*	البلشون المخطط	LC	V
34	Cattle Egret	*Bubulcus*	بلشون ابيض كبير	LC	PM,WV
35	Squacco Heron	*Ardeola ralloides*	الواق الأبيض	LC	PM
36	Little Egret	*Egretta garzetta*	البلشون الصغير	LC	t,PM,WV
37	Western Reef-Heron	*Egretta gularis*	بلشون البحر	LC	t
38	Great White Egret	*Ardea alba*	البلشون الأبيض الكبير	LC	PM,WV
39	Grey Heron	*Ardea cinerea*	مالك الحزين الرمادي	LC	t,PM,WV
40	Purple Heron	*Ardea purpurea*	مالك الحزين الأرجواني	LC	PM,fb
41	Goliath heron	*Ardea goliath*	مالك الحزين الكبير	LC	V
42	White Stork	*Ciconia ciconia*	اللقلق الأبيض	LC	PM,SV
43	Black Stork	*Ciconia nigra*	لقلق اسود	LC	PM
44	Glossy Ibis	*Plegadis falcinellus*	أبو منجل الأسود	LC	PM,SV
45	Eurasian Spoonbill	*Platalea leucorodia*	أبو ملعقة	LC	PM
46	Greater Flamingo	*Phoenicopterus roseus*	النحام	LC	WV
47	Black Vulture	*Aegypius monachus*	نسر اسود	NT	V
48	Egyptian Vulture	*Neophron percnopterus*	الرخمة المصرية	EN	PM
49	Osprey	*Pandion haliaetus*	العقاب النساري	LC	PM
50	Golden Eagle	*Aquila chrysaetos*	العقاب الذهبي	LC	R
51	Imperial Eagle	*Aquila heliaca*	ملك العقبان	VU	PM,WV
52	Lesser Spotted Eagle	*Clanga pomarina*	العقاب الأسفع الصغير	LC	PM
53	Spotted Eagle	*Clanga clanga*	العقاب الأسفع الكبير	VU	PM
54	Steppe Eagle	*Aquila nipalensis*	عقاب السهول(بوحقب)	EN	PM,WV
55	Short-toed Eagle	*Circaetus gallicus*	عقاب الحيات	LC	PM
56	Booted Eagle	*Hieraaetus pennatus*	عُقَابٌ مُسَيَّرَةٌ	LC	PM
57	Black Kite	*Milvus migrans*	حداة سوداء	LC	PM
58	Western Marsh Harrier	*Circus aeruginosus*	مرزة البطائح	LC	fb,PM,WV
59	Hen Harrier	*Circus cyaneus*	مرزة الدجاج	LC	PM,WV
60	Montagu's Harrier	*Circus pygargus*	مرزة مونتاكو	LC	PM
61	Pallid Harrier	*Circus macrourus*	المرزة الباهتة	NT	PM,WV
62	Long-legged Buzzard	*Buteo rufinus*	الحميق	LC	WV
63	Steppe(common) buzzard	*Buteo buteo vulpinus*	الصقر الحوام	LC	PM
64	Rough-Legged Buzzard	*Buteo lagopus*	الصقر الحوام المسرول	LC	V

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
65	European Honey-buzzard	*Pernis apivorus*	صقر العسل	LC	PM
66	Crested Honey Buzzard	*Pernis ptilorhynchus*	صقر العسل المتوج	LC	V
67	Eurasian Sparrowhawk	*Accipiter nisus*	الباشق	LC	PM,WV
68	Goshawk	*Accipiter gentilis*	الباز الأوراسي	LC	V
69	Levant Sparrowhawk	*Accipiter brevipes*	بيدق مشرقي	LC	PM
70	Black-winged Kite	*Elanus caeruleus*	حداة سوداء الكتف	LC	R
71	Common Kestrel	*Falco tinnunculus*	عوسق شائع	LC	R,PM
72	lesser kestrel	*Falco naumanni*	العويسق	LC	PM
73	Red-footed Falcon	*Falco vespertinus*	اللزيق	VU	PM
74	Eurasian Hobby	*Falco subbuteo*	شُوَيهِينٌ أَوْرَاسِيٌّ	LC	PM
75	Eleonora's Falcon	*Falco eleonorae*	صقر اليونورا	LC	V
76	Peregrine Falcon	*Falco peregrinus*	الشاهين	LC	PM,WV
77	Merlin	*Falco columbarius*	اليؤيؤ	LC	WV
78	Saker Falcon	*Falco cherrug*	صقر الغزال	EN	PM,WV
79	Lanner	*Falco biarmicus*	صقر وكري	LC	V
80	Water Rail	*Rallus aquaticus*	مرعة الماء	LC	fb,PM,WV
81	Spotted Crake	*Porzana porzana*	المرعة المنقطة	LC	PM
82	Baillon's Crake	*Zapornia pusilla*	مرعة صغيرة	LC	fb,PM
83	Little Crake	*Zapornia parva*	المرعة الصغيرة	LC	PM
84	Common Moorhen	*Gallinula chloropus*	فُرْفُرٌ شَائِعٌ	LC	R,PM,WV
85	Eurasian Coot	*Fulica atra*	غَرَّاءٌ أَوْرَاسِيَّةٌ	LC	R,WV
86	Common Crane	*Grus grus*	الكركي الشائع	LC	PM,WV
87	Macqueen Bustard	*Chlamydotis macqueenii*	الحبارى	VU	fb
88	Pied Avocet	*Recurvirostra avosetta*	النكات	LC	ob,PM
89	Black-winged Stilt	*Himantopus himantopus*	كرسوع أبو المغازل	LC	SB,PM
90	Eurasian stone-curlew	*Burhinus oedicnemus*	الكروان الصحراوي	LC	R
91	Cream-coloured Courser	*Cursorius cursor*	دُرَّاجٌ شَائِعٌ	LC	SB
92	Collared Pratincole	*Glareola pratincola*	يُسْرٌ مُطَوَّقٌ	LC	ob,PM
93	Black-winged Pratincole	*Glareola nordmanni*	ابو اليسر اسود الجناح	NT	V
94	Little Ringed Plover	*Charadrius dubius*	الزقزاق المطوق الصغير	LC	SB,PM
95	Common Ringed Plover	*Charadrius hiaticula*	زُقْزَاقٌ مُطَوَّقٌ شَائِعٌ	LC	PM,WV
96	Kentish Plover	*Charadrius alexandrinus*	الزقزاق الاسكندراني	LC	R,PM,WV
97	Greater Sand Plover	*Charadrius leschenaultii*	قطقاط الرمل الكبير	LC	SB,PM
98	Grey Plover	*Pluvialis squatarola*	قطقاط رمادي	LC	PM
99	Eurasian Dotterel	*Charadrius morinellus*	القطقاط الأغبر	LC	WV
100	Caspian Plover	*Charadrius asiaticus*	زقزاق قزويني	LC	V
101	Northern Lapwing	*Vanellus vanellus*	زقزاق شامي	NT	PM,WV
102	Spur-winged Lapwing	*Vanellus spinosus*	الزقزاق ابو ظفر	LC	R

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
103	Sociable Lapwing	*Vanellus gregarius*	قطقاط اجتماعي	CR	V
104	White-tailed Lapwing	*Vanellus leucurus*	قطقاط ابيض الذيل	LC	ob,PM
105	(Red) Knot	*Calidris canutus*	دريجة الشمال	NT	V
106	Sanderling	*Calidris alba*	المدروان	LC	V
107	Dunlin	*Calidris alpina*	طِيْطَوَى كَبْدَاءُ	LC	PM,WV
108	Curlew Sandpiper	*Calidris ferruginea*	طيطوي مقوس المنقار	NT	PM
109	Temminck's Stint	*Calidris temminckii*	دريجة تمنك	LC	PM
110	Little Stint	*Calidris minuta*	فطيرة صغيرة	LC	PM,WV
111	Wood Sandpiper	*Tringa glareola*	طيطوي الغاب	LC	PM
112	Green Sandpiper	*Tringa ochropus*	الطيطوي الأخضر	LC	PM,WV,SV
113	Common Sandpiper	*Actitis hypoleucos*	طِيْطَوَى شَائِعةٌ	LC	PM,WV
114	Common Redshank	*Tringa totanus*	حَمْرَاءُ سَاقٍ	LC	PM,WV
115	Spotted Redshank	*Tringa erythropus*	الطيطوي الداكن	LC	PM
116	Common Greenshank	*Tringa nebularia*	طيطوي أخضر الساق	LC	PM,WV
117	Marsh Sandpiper	*Tringa stagnatilis*	طيطوي البطائح	LC	PM
118	Broad-billed Sandpiper	*Calidris falcinellus*	طيطوي شدقاء	VU	PM
119	Terek Sandpiper	*Xenus cinereus*	طيطوي نكات	LC	V
120	Black-tailed Godwit	*Limosa limosa*	البقويقة السلطانية سوداء الذيل	NT	PM , WV
121	Eurasian Curlew	*Numenius arquata*	كروان الماء أو الكروان الأوراسي	LC	PM
122	Eurasian whimbrel	*Numenius phaeopus*	كروان الماء الصغير	LC	PM
123	Common Snipe	*Gallinago gallinago*	شُنْقُبٌ شَائِعٌ	LC	PM,WV
124	Red-necked phalarope	*Phalaropus lobatus*	طيطوي الماء	LC	PM
125	Ruff	*Calidris pugnax*	الحجوالة	LC	PM,WV
126	Black-headed Gull	*Chroicocephalus ridibundus*	نورس اسود الراس	LC	PM,WV,SV
127	Slender-billed Gull	*Chroicocephalus genei*	النورس مستدق المنقار	LC	PM,WV,SV
128	Pallas's Gull	*Ichthyaetus ichthyaetus*	نورس السمك	LC	PM,WV
129	Common Gull	*Larus Canus*	النورس	LC	WV
130	Caspian Gull	*Larus cachinnans*	نورس قزوين	LC	V
131	Lesser Black-backed Gull	*Larus fuscus*	النورس اسود الظهر الصغير	LC	PM,WV
132	Little Gull	*Hydrocoloeus Minutus*	النورس الصغير	LC	PM
133	Little Tern	*Sternula albifrons*	الخطاف الصغير	LC	SB/ob,PM
134	Sandwich Tern	*Sterna sandvicensis*	خرشنة الساندويش	LC	V
135	Gull-billed Tern	*Gelochelidon nilotica*	الخطاف النيلي	LC	ob,PM
136	Common Tern	*Sterna hirundo*	خَرْشَنَةٌ شَائِعةٌ	LC	PM
137	Arctic tern	*Sterna paradisaea*	الخطاف القطبي	LC	V
138	Caspian Tern	*Hydroprogne caspia*	الخطاف القزويني	LC	V
139	Black Tern	*Chlidonias niger*	خرشنة سوداء	LC	PM
140	White-winged Tern	*Chlidonias leucopterus*	خطاف مستنقعات ابيض الجناح	LC	PM,WV
141	Whiskered Tern	*Chlidonias hybrida*	الخطاف الملتحي	LC	PM
142	Black bellied sandgrouse	*Pterocles orientalis*	القطا الكدّري	LC	WV
143	Pin-tailed sandgrouse	*Pterocles alchata*	القطا العراقي	LC	fb(R?)

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
144	Spotted Sandgrouse	*Pterocles senegallus*	القطا المرقط	LC	R
145	Chestnut-bellied Sandgrouse	*Pterocles exustus*	قطا كستنائي البطن	LC	V
146	Turnstone	*Arenaria interpres*	أو قنبرة الماء	NT	V
147	Rock Dove	*Columba livia*	الحمام الأزرق	LC	R
148	Stock dove	*Columba oenas*	الحمام الأزرق الشمالي	LC	WV
149	Common Woodpigeon	*Columba palumbus*	وَرَشَانٌ	LC	WV
150	Namaqua Dove	*Oena capensis*	الحمامة طويلة الذنب	LC	R,SB,PM
151	Collared Dove	*Streptopelia decaocto*	اليمامة المطوقة	LC	R
152	European Turtle Dove	*Streptopelia turtur*	الحمامة الرقطية	VU	PM
153	Laughing Dove	*Spilopelia senegalensis*	اليمام الضاحك	LC	R
154	Common Cuckoo	*Cuculus canorus*	وقواق شائع	LC	PM
155	Great spotted cuckoo	*Clamator glandarius*	الوقواق المنقط الكبير	LC	PM
156	Pharaoh Eagle Owl	*Bubo ascalaphus*	بومة صحراوية(الفرعونية)	LC	R
157	Eurasian Eagle Owl	*Bubo bubo*	البومة النسارية	LC	R
158	Long-eared Owl	*Asio otus*	البومة الأذناء	LC	PM
159	Short-eared Owl	*Asio flammeus*	البومة الصمعاء	LC	PM,WV
160	Barn Owl	*Tyto alba*	الهَامَة/بومة المخازن	LC	R
161	Little Owl	*Athene noctua*	البومة الصغيرة	LC	R
162	Eurasian Scops Owl	*Otus scops*	الثبج الأوروبي	LC	PM
163	Pallid Scops-owl	*Otus brucei*	الثبج المخطط	LC	R
164	European Nightjar	*Caprimulgus europaeus*	سُبَدٌ أَوْرُوبِيٌّ	LC	PM
165	Egyptian Nightjar	*Caprimulgus aegyptius*	سُبَدٌ مِصْرِيٌّ	LC	(SB?),PM
166	Nubian nightjar	*Caprimulgus nubicus*	السبد النوبي	LC	R
167	Common Swift	*Apus apus*	سمامة شائعة	LC	PM
168	Pallid Swift	*Apus pallidus*	السمامة الباهتة	LC	PM
169	Alpine swift	*Tachymarptis melba*	السمامة الجبلية	LC	PM
170	Little Swift	*Apus affinis*	السمامة الصغيرة	LC	R
171	Eurasian Hoopoe	*Upupa epops*	هُدْهُدٌ أَوْرَاسِيٌّ	LC	R,PM
172	Common Kingfisher	*Alcedo atthis*	رَفْرَافٌ شَائِعٌ	LC	PM,WV
173	White-throated Kingfisher	*Halcyon smyrnensis*	السمّاك أبيض الصدر	LC	R
174	Pied Kingfisher	*Ceryle rudis*	السمّاك الأبقع	LC	V
175	European Bee-eater	*Merops apiaster*	الوروار	LC	PM
176	Blue-cheeked Bee-eater	*Merops persicus*	الوروار أزرق الخدين	LC	SB,PM
177	European Roller	*Coracias garrulus*	الشقراق	LC	PM
178	Wryneck	*Jynx torquilla*	لَوَّاء أوراسي	LC	PM
179	Eurasian Skylark	*Alauda arvensis*	الزرعي	LC	WV
180	Oriental Skylark	*Alauda gulgula*	قبرة حقلية شرقية	LC	WV
181	Crested Lark	*Galerida cristata*	قبرة متوجة	LC	R

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
182	Greater Short-toed Lark	*Calandrella brachydactyla*	قبرة السهوب	LC	fb,PM
183	Mediterranean Short-toed Lark	*Alaudala rufescens*	قبرة السهوب الصغيرة	LC	SB,PM
184	Desert Lark	*Ammomanes deserti*	القبرة الصحراوية	LC	R
185	Bar-tailed Desert Lark	*Ammomanes cincturus*	قبرة سوداء الرأس	LC	R
186	Dunn's Lark	*Eremalauda dunni*	قبرة الرمال	LC	R
187	Calandra Lark	*Melanocorypha calandra*	قبرة كلاندرا	LC	WV
188	Thick billed Lark	*Ramphocoris clotbey*	عصفور قبرة سميكة المنقار	LC	R
189	Temminck's Horned lark	*Eremophila bilopha*	قبرة مقرنة	LC	R
190	Hoopoe lark	*Alaemon alaudipes*	القبرة الهدهدية	LC	R
191	Bimaculated Lark	*Melanocorypha bimaculata*	قبرة مرقطة	LC	V
192	Sand Martin	*Riparia riparia*	خطاف الشواطئ	LC	PM
193	Eurasian Crag Martin	*Ptyonoprogne rupestris*	عَوْهَقٌ جُرُفِيٌّ أَوْرَاسِيٌّ	LC	PM,WV
194	Rock Martin	*Ptyonoprogne fuligula*	خطاف الصخور	LC	R
195	Barn Swallow	*Hirundo rustica*	خُطَّافُ المخازن	LC	R,PM
196	Red- rumped swallow	*Cecropis daurica*	السنونو أحمر العجز	LC	PM
197	Common House Martin	*Delichon urbicum*	خطاف المدن الشائع	LC	PM
198	Tawny Pipit	*Anthus campestris*	ابو تمرة الأصفر	LC	PM
199	Long-billed Pipit	*Anthus similis*	ابو تمرة طويل المنقار	LC	PM
200	Richard's Pipit	*Anthus richardi*	جشنة ريتشاردية	LC	PM
201	Water Pipit	*Anthus spinoletta*	ابو تمرة الماء	LC	WV
202	Meadow Pipit	*Anthus pratensis*	ابو تمرة الحقول	LC	PM,WV
203	Tree Pipit	*Anthus trivialis*	ابو تمرة الشجر	LC	PM,WV
204	Red- throated pipit	*Anthus cervinus*	ابو تمرة أحمر الزور	LC	PM,WV
205	White wagtail	*Motacilla alba*	الذُّعَرّة البيضاء	LC	PM,WV
206	Western Yellow Wagtail	*Motacilla flava*	ذُعَرَة الربيع	LC	fb,PM
207	Citrine Wagtail	*Motacilla citreola*	ذعرة ليمونية	LC	PM
208	Grey Wagtail	*Motacilla cinerea*	الذعرة الرمادية	LC	PM
209	Dunnock	*Prunella modularis*	عصفور الشوك الاوروبي	LC	V
210	European Robin	*Erithacus rubecula*	ابو الحناء	LC	WV
211	White-throated Robin	*Irania gutturalis*	ابو الحن ابيض الزور	LC	PM
212	Common Nightingale	*Luscinia megarhynchos*	هَزَارٌ شَائِعٌ	LC	PM
213	Thrush Nightingale	*Luscinia luscinia*	الهزاز	LC	PM
214	Rufous-tailed Scrub-Robin\bush	*Cercotrichas galactotes*	ابو الحناء الأحراش الأحمر	LC	SB,PM
215	Bluethroat	*Luscinia svecica*	ازرق الزور	LC	PM,WV
216	Common Redstart	*Phoenicurus phoenicurus*	حُمَيْرَاءُ شَائِعَةٌ	LC	PM

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
217	Black Redstart	*Phoenicurus ochruros*	أبو الحناء أبيض الزور	LC	PM,WV
218	Isabelline Wheatear	*Oenanthe isabellina*	الأبلق الأشهب	LC	PM
219	Northern Wheatear	*Oenanthe oenanthe*	الأبلق	LC	PM
220	Black- eared wheatear	*Oenanthe hispanica*	أبلق أسود الاذن	LC	PM
221	Cyprus Wheatear	*Oenanthe cypriaca*	الأبلق القبرصي	LC	PM
222	Finsch's Wheatear	*Oenanthe finschii*	الأبلق العربي	LC	WV
223	Mourning Wheatear	*Oenanthe lugens*	الأبلق الحزين	LC	R
224	Hooded Wheatear	*Oenanthe monacha*	الأبلق ابو قلنسوة	LC	R
225	White-crowned Wheatear	*Oenanthe leucopyga*	الأبلق ابيض القنة	LC	R
226	Blackstart	*Oenanthe melanura*	قليعي اسود الذيل	LC	R
227	Desert Wheatear	*Oenanthe deserti*	أبلق صحراوي	LC	R
228	Kurdish Wheatear	*Oenanthe xanthoprymna*	أبلق أحمر الذيل	LC	V
229	Red-rumped Wheatear	*Oenanthe moesta*	الأبلق أحمر العجز	LC	R
230	Basalt Wheatear	*Oenanthe warriae*	أبلق البازلت		R,?
231	Whinchat	*Saxicola rubetra*	القليعي الأحمر	LC	PM
232	European Stonechat	*Saxicola rubicola*	القليعي المطوق	LC	PM,WV
233	Eastern Stonechat	*Saxicola maurus*	قليعي سيبيري		PM,WV
234	Song Thrush	*Turdus philomelos*	السمنة المطربة	LC	WV
235	Redwing	*Turdus iliacus*	حمراء الجناح	NT	V
236	Mistle Thrush	*Turdus viscivorus*	سمنة الدبق	LC	WV
237	Fieldfare	*Turdus pilaris*	سمنة حقلية	LC	WV
238	Eurasian Blackbird	*Turdus merula*	شحرور	LC	R, WV
239	Blue Rock Thrush	*Monticola solitarius*	سمنة الصخور الزرقاء	LC	PM
240	Common Rock Thrush	*Monticola saxatilis*	سمنة صخرية	LC	PM
241	Barred Warbler	*Curruca nisoria*	هازجة (دخلة) عربية	LC	PM
242	Garden Warbler	*Sylvia borin*	دخلة البساتين	LC	PM
243	Eurasian Blackcap	*Sylvia atricapilla*	هازجة مقلنسة اوراسية	LC	PM
244	Lesser Whitethroat	*Curruca curruca*	زريقة فيرانية صغرى	LC	PM
245	Arabian Warbler	*Curruca leucomelaena*	الهاجزة العربية	LC	R
246	Sardinian Warbler	*Curruca melanocephala*	هازجة سردينا	LC	WV
247	Menetries's Warbler	*Curruca mystacea*	هازجة الطرفاء	LC	PM
248	Rüppell's Warbler	*Curruca ruppeli*	دخلة روبيل	LC	PM
249	Common Whitethroat	*Curruca communis*	زَوْرَاءُ شَائِعَةٌ	LC	PM
250	Spectacled Warbler	*Curruca conspicillata*	الدخلة ذات النظارة	LC	R,WV
251	Orphean Warbler	*Curruca crassirostris*	الدخلة المغنية	LC	PM
252	Subalpine Warbler	*Curruca cantillans*	دخلة الصرود	LC	PM
253	Asian Desert Warbler	*Curruca nana*	دخلة الصحراء	LC	PM,WV
254	Graceful Prinia	*Prinia gracilis*	الهازجة طويلة الذنب	LC	R
255	Scrub Warbler	*Scotocerca inquieta*	هازجة الشجيرات	LC	R
256	Sedge Warbler	*Acrocephalus schoenobaenus*	هازجة السعد	LC	PM

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257	Aquatic Warbler	*Acrocephalus paludicola*	هازجة الماء	VU	V
258	Moustached Warbler	*Acrocephalus melanopogon*	الهازجة ذات الشارب	LC	fb,WV
259	Zitting Cisticola	*Cisticola juncidis*	الهازجة مروحية الذنب	LC	R
260	Common Grasshopper-warbler	*Locustella naevia*	دخلة جندبية شائعة	LC	PM
261	River Warbler	*Locustella fluviatilis*	دخلة نهرية	LC	PM
262	Savi's Warbler	*Locustella luscinioides*	هازجة الغاب	LC	fb,PM
263	Cetti's Warbler	*Cettia cetti*	بلشون البقر ابو قردان	LC	PM
264	Eurasian Reed Warbler	*Acrocephalus scirpaceus*	هازجة القصب	LC	SB,PM,WV
265	Marsh Warbler	*Acrocephalus palustris*	دخناء مستنقعية	LC	PM
266	Blyth's Reed Warbler	*Acrocephalus dumetorum*	دَخْنَاءُ إِبْلاِيثِيَّةٌ	LC	V
267	Paddyfield Warbler	*Acrocephalus agricola*	هازجة الأرز	LC	V
268	Great Reed Warbler	*Acrocephalus arundinaceus*	هازجة القصب الكبيرة	LC	fb,PM
269	Clamorous Reed-warbler	*Acrocephalus stentoreus*	دخناء صخباء	LC	fb
270	Basra Reed-warbler	*Acrocephalus griseldis*	هازجة قصب البصرة	EN	V
271	Icterine Warbler	*Hippolais icterina*	دخناء ليمونية	LC	V
272	Olive-tree Warbler	*Hippolais olivetorum*	دخناء شجر الزيتون	LC	PM
273	Upcher's Warbler	*Hippolais languida*	الخنشع الشجري	LC	PM
274	Eastern Olivaceous Warbler	*Iduna pallida*	دخناء زيتونية	LC	SB,PM
275	Booted Warbler	*Iduna caligata*	هازجة منتعلة	LC	PM
276	Willow Warbler	*Phylloscopus trochilus*	نقشارة الصفصاف	LC	PM
277	Wood Warbler	*Phylloscopus sibilatrix*	نقشارة الغابة	LC	PM
278	Eastern Bonelli's Warbler	*Phylloscopus orientalis*	دخلة بونلية شرقية	LC	PM
279	Common Chiffchaff	*Phylloscopus collybita*	ذعرة شائعة	LC	PM,WV
280	Spotted Flycatcher	*Muscicapa striata*	خطاف الذباب المنقط	LC	PM
281	Red-breasted Flycatcher	*Ficedula parva*	خطاف الذباب احمر الصدر	LC	PM
282	European Pied Flycatcher	*Ficedula hypoleuca*	خطاف الذباب الأبقع	LC	PM
283	Semicollared Flycatcher	*Ficedula semitorquata*	خطاف الذباب شبه المطوق	LC	PM
284	Collared Flycatcher	*Ficedula albicollis*	خاطف الذباب المطوق	LC	PM
285	Eurasian Penduline Tit	*Remiz pendulinus*	قَرْقَفَنَّةٌ أَوْرَاسِيَّةٌ	LC	PM, WV
286	Ring-necked parakeet	*Psittacula krameri*	الببغاء المطوقة	LC	R (introduced)
287	Great Grey Shrike	*Lanius excubitor*	الصرد الرمادي الكبير	LC	R
288	Lesser Grey Shrike	*Lanius minor*	الصرد الرمادي الصغير	LC	PM
289	Red-backed Shrike	*Lanius collurio*	الصرد أحمر الظهر	LC	PM
290	Isabelline Shrike	*Lanius isabellinus*	الصرد الأشهب	LC	WV

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
291	Turkestan Shrike	*Lanius phoenicuroides*	الصرد التركستاني	LC	PM
292	Woodchat Shrike	*Lanius senator*	الصرد أحمر القنة	NT	PM
293	Masked Shrike	*Lanius nubicus*	الصرد المقنع	LC	PM
294	White-spectacled Bulbul	*Pycnonotus xanthopygos*	كعيت	LC	R
295	White-eared Bulbul	*Pycnonotus leucotis*	البلبل ابيض الخد	LC	R (introduced)
296	Palestine Sunbird	*Cinnyris osea*	التميرالفلسطيني	LC	R
297	Arabian babbler	*Argya squamiceps*	الثرثار العربي	LC	R
298	Jackdaw	*Corvus monedula*	غراب زرعي	LC	V
299	Rook	*Corvus frugilegus*	غراب القيظ	LC	V
300	Brown-necked Raven	*Corvus ruficollis*	غراب احيمر العنق	LC	R
301	Common Starling	*Sturnus vulgaris*	زَرْزُورٌ شَائِعٌ	LC	WV
302	Rosy Starling	*Pastor roseus*	الزرزور الوردي	LC	PM
303	Eurasian Golden Oriole	*Oriolus oriolus*	صفير ذهبي	NT	PM
304	House Sparrow	*Passer domesticus*	عصفور دوري	LC	R
305	Spanish Sparrow	*Passer hispaniolensis*	العصفور الأسباني	LC	R, WV
306	Pale Sparrow	*Carpospiza brachydactyla*	عصفور صخري شاحب	LC	PM
307	Common Chaffinch	*Fringilla coelebs*	شرشور ظالم	LC	WV
308	Brambling	*Fringilla montifringilla*	شرشور جبلي	LC	PM
309	Common Linnet	*Linaria cannabina*	حَسُّونٌ ثُفَاحِيٌّ	LC	R,WV
310	Goldfinch	*Carduelis carduelis*	حسون مذهب	LC	R,WV
311	Syrian serin	*Serinus syriacus*	نعار سوري	VU	PM
312	Common Rosefinch	*Carpodacus erythrinus*	حسون ورد شائع	LC	V
313	Trumpeter Finch	*Bucanetes githagineus*	الزمّير الوردي	LC	R
314	Desert Finch	*Rhodospiza obsoleta*	الحسون الصحراوي	LC	R
315	Common Reed Bunting	*Emberiza Schoeniclus*	درسة قصبية	LC	WV
316	Ortolan Bunting	*Emberiza hortulana*	درسة الشعير	LC	PM
317	Cretzschmar’s Bunting	*Emberiza caesia*	درسة زرقاء الرأس	LC	PM
318	Cinereous Bunting	*Emberiza cineracea*	درسة أورتلان (درسة الشعير)	NT	PM
319	Yellow-breasted bunting	*Emberiza aureola*	درسة صفراء الصدر	CR	V
320	Corn Bunting	*Emberiza calandra*	دُرْسَةٌ قَمْحِيَّةٌ	LC	WV
321	Rock Bunting	*Emberiza cia*	درسة صخرية	LC	V
322	Striolated Bunting	*Emberiza*	درسة منزلية	LC	V
323	Black-headed Bunting	*Emberiza melanocephala*	درسة رأساء	LC	PM
324	Little Bunting	*Emberiza pusilla*	درسة صغيرة	LC	V
325	Syrian Ostrich	*Struthio camelus syriacus*	النعام السوري	LC	E
326	Eurasian Wigeon	*Mareca penelope*	المصوة	LC	PM,WV
327	Indian Silverbill	*Euodice malabarica*	الحبّاك الهندي	LC	R (introduced)

No	Common Name	Scientific Name	Arabic Name	IUCN Red List	Status in Azraq
328	Common Myna	*Acridotheres tristis*	ماينا شائعة	LC	R (introduced)
329	Eurasian Siskin	*Spinus spinus*	حسون شوكي	LC	WV

The new and rare documentations in the Azraq Wetland Reserve (2018-2025).

A total of 26 new, rare, or locally significant avian records were documented in the Azraq Wetland Reserve between 2018 and 2025 (Table 2). First national breeding records were confirmed for **Ferruginous Duck (***Aythya nyroca***)** in 2020 and 2021, and for **Northern Shoveler (***Spatula clypeata***)** in 2020. In 2025, **Paddyfield Warbler (***Acrocephalus agricola***)** was recorded for the second time in Jordan, with both observations originating from Azraq. The **Basra Reed Warbler (***Acrocephalus griseldis***)** was documented for the first time in Jordan in 2024 at the Swiss Pool. Additional first records for Azraq include **Caspian Gull (***Larus cachinnans***)**, **Crested Honey Buzzard (***Pernis ptilorhynchus***)**, **Cinereous Vulture (***Aegypius monachus***)**, **Rook (***Corvus frugilegus***)**, and **Pallid Scops Owl (***Otus brucei***)**, with the latter representing only the third national record. Rare migrants and winter visitors included **Asian Desert Warbler (***Sylvia nana***)**, **Isabelline Shrike (***Lanius isabellinus***)**, **Short-eared Owl (***Asio flammeus***)**, and **Rose-coloured Starling (***Pastor roseus***)**, last recorded in Azraq in 1976. Large aggregations were recorded for **Ruff (***Calidris pugnax***)**, exceeding 5,000 individuals in May 2025, and for **Purple Heron (***Ardea purpurea***)**, with a flock of 55 individuals—both the highest counts documented in Jordan to date. Regular nesting of **Mallard (***Anas platyrhynchos***)** has been confirmed annually since 2018. The first breeding record of **Northern Pintail (***Anas acuta***)** in Jordan and Palestine occurred in 2020 in Azraq. **Red-crested Pochard (***Netta rufina***)** was recorded five times in the Azraq region between 1969 and 2018. A second record of **Common Wood Pigeon (***Columba palumbus***)** was made in 2020, following the only previous sighvting in 1966. An albino individual of **Eurasian Coot (***Fulica atra***)** was also observed in 2021. These records provide updated documentation of breeding activity, species occurrence, and seasonal dynamics in the Azraq Wetland Reserve (Table 2).

Table 2. New, rare, and notable bird records documented in Azraq Wetland Reserve between 2018 and 2025, including first national and local occurrences, confirmed breeding events, and rare migratory observations, with corresponding dates and documentation sites.

No	Species	Record Date	Location	Status
1	Caspian Gull	17\10\2023	Azraq Wetland Reserve	First record in Azraq
2	Hybrid Turkestan Shrike	5\10\2023	Azraq Wetland Reserve/Mudflat	First record in Jordan
3	Striated Heron	15\9\2023	Azraq Wetland Reserve	Second record since 2011
4	Ferruginous Duck	4\6\2020 2021	Azraq Wetland Reserve	The first documentation of a breeding case in Jordan and the second breeding documentation near threatened (population decreasing)

No	Species	Record Date	Location	Status
5	Northern Shoveler	11\6\2020	Azraq Wetland Reserve	The first breeding record in Jordan
6	Crested Honey Buzzard	10\5\2023	Azraq Wetland Reserve	first verified observation in the Azraq Wetland Reserve
7	Stone Curlew	5\5\2020	Azraq Wetland Reserve	The second nesting case in Azraq since 2006
8	Eurasian Curlew	1\10\2023	Azraq Wetland Reserve/Mudflat	A rare migrant to Azraq and it Classified according to the Red List as a Near Threatened species (NT).
9	Pallid Scops Owl	14\7\2023	Azraq Wetland Reserve/Mudflat	The first record in Azraq and the third in Jordan.
10	Cinerous Vulture	8\11\2023	Azraq Wetland Reserve	one of the rarest species of vultures in the world and first documentation in Azraq.
11	Mallard		Azraq Wetland Reserve	breeding continuously since 2018 in the Azraq Wetland Reserve.
12	Leucistic coot	12\12\2021	Azraq Wetland Reserve	(Coot) Leucism is a wide variety of conditions that result in partial loss of pigmentation in an animal—causing white, pale, or patchy coloration of the skin, hair, feathers, scales, or cuticles, but not the eyes. It is occasionally spelled leukism. Some genetic conditions that result in a "leucistic".
13	Common Wood Pigeon	14\10\2020	Azraq Wetland Reserve	The second record of the common wood pigeon in Azraq after 27/4/1966.
14	Rose Coloured Starling	3\5\2020	Azraq Wetland Reserve/Mudflat	recorded as one of the rarest bird species in Jordan, where its last record in Azraq region dates back to 5/28/1976 by (Ian Andrews).
15	Flamingo	17\6\2020	Azraq Wetland Reserve/Mudflat	The first photographic documentation in Azraq and it is considered rare migrant.
16	Asian Desert Warbler	November 2021	Azraq Wetland Reserve/Mudflat	Rare winter visitor.
17	Northern Pintail	16\6 2020	Azraq Wetland Reserve	First breeding case in Jordan and Palestine.
18	Common Pochard	18\10\2019	Azraq Wetland Reserve	(Vulnerable) due to IUCN Red List
19	Red Crested Pochard	2\11\2018 15\4\1988 20\4\1984 12\1\1979 29\9\1969	Azraq Wetland Reserve	Very rare winter visitor to Azraq 5 records in Azraq Wetland Reserve
20	Short Eared Owl	24\4\2022	Azraq Wetland Reserve	Rare migrant to Azraq Wetland Reserve

No	Species	Record Date	Location	Status
21	Isabelline Shrike	6\1\2021	Azraq Wetland Reserve	Rare winter visitor to Azraq Wetland Reserve and Jordan
22	Macqueen Bustard	10\5\2022	Azraq Wetland Reserve	Vulnerable (population decreasing)
24	Basra Reed Warbler	June/2024	Azraq Wetland Reserve	First Record in Jordan
25	Rook	2024	Azraq Wetland Reserve	First Record to Azraq and second to Jordan
26	Paddyfield Warbler	8/May/2025	Azraq Wetland Reserve	The second record in Jordan since 2003, and both records are in Azraq.

Discussion

This study documents a total of 329 bird species recorded in the Azraq Wetland Reserve between 1960 and 2025, confirming the site's long-term significance for avian diversity in arid regions of the Levant. Between 2018 and 2025. A total of 26 species were recorded with status updates, new locality records, or verified breeding confirmations. These findings expand the existing ornithological baseline and provide direct evidence of recent changes in species occurrence and reproductive behaviour within the reserve (Table 2).

Confirmed breeding was recorded for Ferruginous Duck (Aythya nyroca) in 2021 5 Youngs seen in A pool and for Northern Shoveler (Spatula clypeata) in 2020 2 Youngs seen in pool near mudflat, representing a verified breeding cases for these species in Jordan. Northern Pintail (Anas acuta) was also confirmed as a breeder in 2020 a 9 young seen in Swiss pool 16/6/2020 , marking the first such case for both Jordan and Palestine. Repeated breeding of Mallard (Anas platyrhynchos) from 2018 to 2025, previously classified only as a potential breeder (Nelson, 1973), reflects a shift in local population establishment, likely influenced by managed water input.

High-density observations included a remarkable aggregation of over 5,000 Ruff (Calidris pugnax) and 55 Purple Herons (Ardea purpurea), the latter representing the largest known aggregation of this species ever recorded in Jordan. In comparison, data from the study Monitoring of Breeding and Migrant Birds – Azraq Wetland Reserve and Qa' al Azraq, Jordan (2017) documented only 6 individuals of Purple Heron and 3,295 Ruff during the same migratory period. These aggregation events confirm that managed water bodies in Azraq continue to function as critical staging and foraging habitats during migration periods. The Common Wood Pigeon (*Columba palumbus*) was recorded again in 2020 for the first time since its initial documentation in Azraq in 1966, indicating either under-detection or episodic presence. Likewise, Red-crested Pochard (*Netta rufina*) was recorded five times between 1969 and 2018, confirming its status as a scarce but recurring winter visitor to the site. The Hybrid Turkestan shrike was recorded in 2023 for the first time in Jordan and considered a hybrid between the Turkestan Shrike and unknown shrike species that keep the opportunity open for further research. This record has been confirmed by the Jordan Bird Records Committee (JBRC), batch number (27/28) as a recognized hybrid observation.

The documentation of Leucistic Eurasian Coot (*Fulica atra*) in 2021 represents a rare genetic anomaly rather than a population-level indicator, but further reflects the breadth of observation in the reserve. Records of Stone Curlew (*Burhinus oedicnemus*)

breeding in 2020—the first since 2006—provide additional support for continued reproductive use of the reserve's peripheral habitats.

While the natural discharge from Azraq's artesian springs ceased in the early 1990s due to over-extraction (Scott, 1995), the artificial maintenance of wetland pools through managed water pumping has facilitated the continued presence of numerous breeding and migratory species. Nonetheless, the reduced water volume (currently 750,000 m³/year) falls short of the planned 1.5–2.5 million m³/year (RSCN internal data), potentially limiting broader habitat recovery. These results support the designation of Azraq as a site of national and international importance for avian conservation and highlight the need for continuous, standardized long-term monitoring. Particular attention should be given to the breeding status of formerly rare or vagrant species, migratory population fluctuations, and habitat-dependent species vulnerable to hydrological variability.

Furthermore, this research highlights the value of long-term, standardized monitoring for detecting shifts in species composition, distribution, and reproductive behavior. The repeated confirmation of breeding in species previously considered vagrants or rare breeders, along with the discovery of hybrid individuals and the reappearance of birds after decades, illustrates the dynamic nature of the ecosystem and the need for continued surveillance. Such monitoring serves as a foundation for adaptive management strategies, particularly in ecosystems where water availability is tightly linked to species survival.

these findings emphasize that Azraq Wetland Reserve not only retains national conservation value but also serves as a regional model for wetland management in arid environments. They support the continued justification of its Ramsar designation and underscore the urgent need for increased technical and financial investment to ensure the long-term resilience of this ecosystem.

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Annex

Notable Records

1. Hybrid Turkestan Shrike`
Location:Azraq wetland reserve mudflat
Photographer: Tamir Aqili
Date: 4/10/2023

2. Paddyfield Warbler
Location:Azraq wetland reserve mudflat
Photographer: Fares Khoury
Date: 8/5/2025

3. Rook
Location:Azraq wetland reserve mudflat
Photographer: Tamir Aqili
Date: 31/10/2024

4. Leucistic coot
Location:Azraq wetland reserve
Photographer: Hazem Alhreisha

5. Greater Flamingo
Location:Azraq wetland reserve mudflat

6. Young Northern Shoveler
Location:Azraq wetland reserve
Photographer: Hazem Alhreisha
Date: 11/6/2020

7. Young Ferruginous duck
Location:Azraq wetland reserve
Photographer: Hazem Alhreisha
Date: 4/6/2020

8. Northern Pintail
Location:Azraq wetland reserve
Photographer: Hazem Alhreisha
Date: 16/6/2020

Floristic Composition, Vegetation Structure, and Regeneration Dynamics of Aleppo Pine Forest in Dibeen Forest Reserve, Jordan

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Abstract

Dibeen Forest Reserve in northern Jordan represents one of the last remaining natural forests of *Pinus halepensis*, playing a vital role in conserving Mediterranean forest biodiversity in the country. This study provides an assessment of the reserve's floristic composition, vegetation structure, and regeneration dynamics, based on fieldwork conducted across 30 systematically selected plots and 11 random route transects. A total of 513 vascular plant species were recorded, representing 50 families and 254 genera. Conservation assessments revealed the presence of 74 nationally threatened species and 7 globally threatened taxa, including orchids listed under CITES. The tree layer was dominated by *P. halepensis* and *Quercus coccifera*, which exhibited the highest Importance Value Index (IVI) values. The shrub layer was characterized by high abundance of *Cistus creticus*, while the herbaceous layer was dominated by annual grasses such as *Aegilops peregrina, Brachypodium pinnatum,* and *Bromus sterilis.* Regeneration surveys indicated strong recruitment of *P. halepensis*, with an estimated density of 653 seedlings/ha and a seedling-to-mature-tree ratio of 7.1:1. In contrast, other native tree species exhibited limited regeneration, and species such as *Pistacia atlantica* and *Quercus infectoria* were either absent or rare in the regeneration layer. Vegetation mapping delineated three main forest types: Aleppo pine forest, evergreen oak forest, and deciduous oak forest, each distributed along distinct environmental gradients. These findings highlight the ecological importance of Dibeen Forest Reserve as a refuge for threatened and endemic Mediterranean species and underscore the need for habitat specific monitoring and targeted conservation efforts, especially in areas with limited recruitment or high human disturbance.

Keywords:

Mediterranean forest, Vegetation structure, Natural regeneration, Threatened species, Habitat mapping.

Introduction

Jordan's geographical position is located at the intersection of Africa, Asia, and Europe, provides it with diverse climatic, geological, and topographic conditions that contribute to its rich biodiversity (Aburjai *et al.,* 2007; Al-Eisawi, 1996; 1998). Despite its small area (89,287 km²), Jordan encompasses four major biogeographical regions; Mediterranean, Irano-Turanian, Saharo-Arabian, and Sudanian (sub-Tropical), comprising 13 distinct vegetation types (Al-Eisawi, 1996).

Forest ecosystems occupy a very limited area in Jordan, as approximately 80% of the country is classified as arid or semi-arid, receiving less than 150 mm of rainfall annually. However, the Mediterranean region, particularly in the highlands, supports forested areas where annual precipitation ranges from 400 to 900 mm. These regions contain the most fertile soils compared to other parts of the country (Al-Eisawi, 1985; Alrababah and Alhamad, 2006). The forests

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include natural and man-made forests; classified into six different types; Pine Forest, Evergreen Oak Forest, Deciduous Oak Forest, mixed forest, Juniper Forest, and man-made forest (Al-Eisawi, 2012; Al-Eisawi and Oran, 2015), all these forest types are under significant threats, making them highly vulnerable to degradation from logging, overgrazing, fires, habitat fragmentation, and urban expansion (Khresat *et al.,* 2008). To address these threats, the Royal Society for the Conservation of Nature (RSCN) has established a national network of protected areas, including Dibeen Forest Reserve, primarily aimed at conserving the last remaining natural Aleppo pine forest. The Dibeen Forest, dominated by *Pinus halepensis* and associated species such as *Quercus coccifera*, *Arbutus andrachne*, and *Cistus criticus*, constitutes an important habitat for Mediterranean biodiversity in Jordan (Al-Eisawi, 1996; Nawash *et al.,* 2014). Earlier, Al-Shgair (2005) conducted a comprehensive vegetation study in Dibbin National Park, documenting 177 plant species belonging to 38 families. His results highlighted the dominance of *Pinus halepensis* as the primary canopy species, co-dominated by *Quercus coccifera*, and recognized four distinct vegetation strata ranging from tall trees to herbaceous layers. The study emphasized the climax status of the Aleppo pine community, providing one of the earliest detailed ecological baselines for Dibeen forest.

In terms of stand density, Al-Shgair (2005) estimated a total of approximately 1,119 trees/ha, with *P. halepensis* exhibiting the highest density followed by *Q. coccifera*. This quantitative baseline further emphasized the structural dominance of Aleppo pine within the forest.

Beyond its floristic value, Dibeen has recently gained attention as a refuge for rare and threatened species. For instance, Othman *et al.* (2023) evaluated habitat suitability for *Iris bismarckiana*, a rare and vulnerable species, and identified parts of Dibeen Forest Reserve as ecologically suitable for potential reintroduction efforts. Their findings emphasize the microhabitat diversity and relative ecological stability of the reserve, further supporting its conservation importance.

While the study by Othman *et al.* (2023) focused on a single rare and representative species, highlighting Dibeen's ecological potential, the present study builds upon that by examining a broader spectrum of rare and endemic plant species.

In the broader Eastern Mediterranean region, *P. halepensis* has been widely studied for its ability to regenerate naturally under various environmental conditions. Several studies have reported particularly high regeneration following disturbances such as fire. For instance, Pausas *et al.* (2004) observed post-fire seedling densities reaching up to 12,400 individuals per hectare in eastern Spain, while Thanos *et al.* (1996) and Kazanis (2005) reported 50,000–60,000 seedlings/ha in fire-affected areas in central Greece. Similarly, Spanos *et al.* (2010) found that regeneration was significantly higher in unmanaged than in disturbed stands in northern Greece. These findings highlight the species strong capacity to regenerate under favorable ecological conditions, especially when disturbance reduces competition and enhances light availability.

In contrast, the regeneration dynamics of *P. halepensis* in Jordan appear more limited. Triepke *et al.* (2012) conducted a detailed assessment of the species communities in Dibeen Forest Reserve and reported sparse to moderate levels of natural regeneration across most sites. Factors such as dense litter layers, insufficient canopy gaps, and grazing pressure were identified as key ecological barriers. While their study offered valuable insights into forest composition and structure, detailed quantification of regeneration metrics (e.g., seedling densities, number of seedlings, and comparison of the regeneration of associated species) was lacking.

These observations are further supported by forest health evaluations. Alananbeh *et al.* (2023) assessed regeneration status in four Jordanian forest reserves, including Dibeen, and recorded seedling densities ranging

from 25 to over 200 individuals per 1000 m². Regenerating species included *P. halepensis, Q. coccifera,* and *A. andrachne*. However, the study noted that human activity—especially along tourist trails was associated with decreased regeneration, suggesting the need for stricter conservation measures in sensitive zone

This contrast between the high regeneration reported in other Mediterranean countries and the more limited patterns observed in Jordan underscores the importance of site-specific ecological assessments. It also highlights important questions about the local factors affecting regeneration in Dibeen, particularly under continued anthropogenic pressures. Therefore, the present study aims to provide a comprehensive analysis of floristic composition, vegetation structure, and regeneration status across different habitat types within Dibeen Forest Reserve, filling a critical gap in current ecological knowledge and supporting future conservation strategies

Materials and Methods

Study Area

Dibeen Forest Reserve (Figure1), located in northern Jordan, which encompasses a diverse range of Mediterranean habitats. The reserve has a Mediterranean climate with an annual rainfall ranging from 400 to 900 mm, particularly concentrated during the winter months. Its elevation ranges between 500 and 900 meters above sea level. The reserve has varied topography includes hills, slopes, and wadies, and its diverse soil types; calcareous, Terra Rosa, and limestone support multiple distinct plant communities (Al-Eisawi, 1996; Al Omary, 2011).

Sampling Design and Data Collection

A systematic sampling design was employed to ensure representative coverage of the habitat types within the reserve. The methodology consisted of two integrated approaches: random route surveys and systematic plot-based sampling (Figure1).

Random Route Surveys

Eleven random routes were selected to cover the major habitat types within the reserve, with priority given to areas containing key vegetation features such as water springs and wadi systems (Figure 1). The distance and path of each transect varied depending on the density of the vegetation cover. In some cases, the end of the transect was determined by the physical boundaries of the reserve. Along these routes, all vascular plant species were recorded, and voucher specimens were collected for the herbarium. Transitions between vegetation types, particularly changes in dominant tree species, were georeferenced using handheld GPS units to facilitate later spatial analysis and mapping of vegetation distribution.

Systematic Plot Sampling

A grid system was applied across the entire reserve, dividing it into 500 × 500 m grid cells, resulting in 44 potential sampling units (Figure1). From these, 30 plots were randomly selected, covering approximately 75% of the total number of grid cells, to ensure representative sampling of the reserve's various habitat types. Within each selected grid cell, a 20 × 20 m plot was established for the assessment of floristic composition, trees, and shrubs. All individual trees and shrubs within each plot were identified to species level, and their counts were recorded to calculate abundance, density, and regeneration status. Regeneration was assessed by recording seedlings and saplings within the plots as indicators of natural recruitment and forest sustainability. Additionally, for herbaceous vegetation (annuals and perennials), a 50 m line transect was established from the center of each plot. Along these transects, all herbaceous species intersecting the line were identified and recorded.

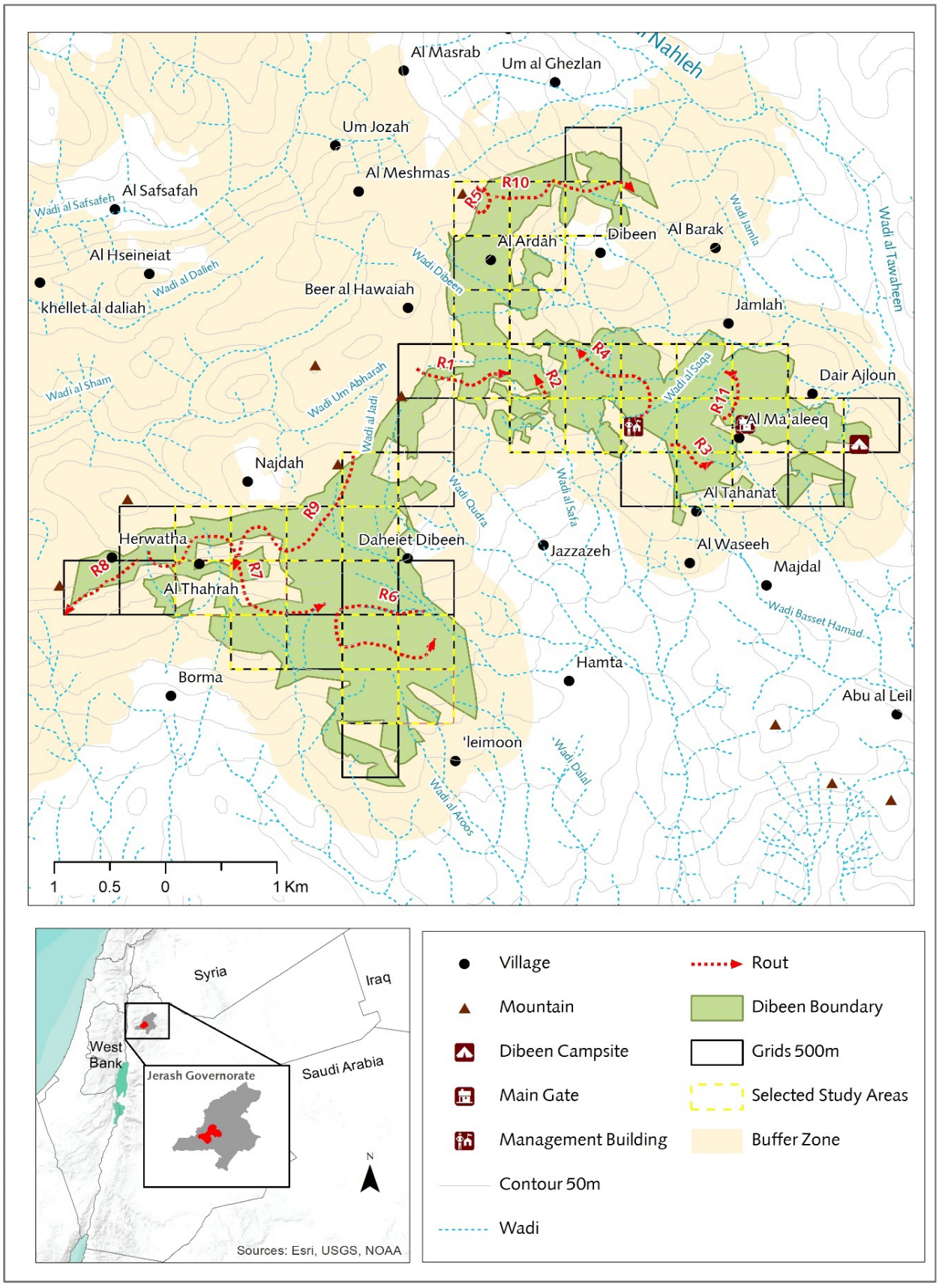

Figure 1. Location of Dibeen Forest Reserve in Jordan Showing Random Transects and Selected Plots

Vegetation Analysis Parameters

The results of the systematic sampling (Quadrats) were used following Ludwig and Reynolds (1988) to analyze the vegetation data. The following quantitative parameters were calculated:

Abundance: Refers to number of individuals of each species recorded across all plots or line transects. The total count of individuals for each species was summed across all sampling units**.**

Density and Relative Density: Density indicates the numerical strength of a species, calculated by dividing the total number of individuals of a species by the number of quadrats studied. Relative density represents the proportion of individuals of a given species relative to the total number of individuals of all species combined.

Frequency and Relative Frequency: Frequency refers to the number of sampling units (plots or transects) in which a species occurs, expressed as a percentage of the total number of units. In this measure, only the presence or absence of a species is recorded—not the number of individuals—giving insight into species distribution across the study area. Relative frequency represents the frequency of a species relative to the cumulative frequency of all recorded species.

Relative Dominance: Refers to the coverage (or basal area) of a species in relation to the total coverage of all species in the area. It provides a measure of the spatial influence of a species within the community.

Importance Value Index (IVI): Assesses the overall ecological significance of a species by integrating its relative frequency, relative dominance, and relative density. It provides a comprehensive view of a species' role in the plant community.

To calculate IVI = Relative Frequency + Relative Density + Relative Dominance

Herbarium specimens' collection

All collected specimens were pressed and dried and then were poisoned chemically using a mixture of 150 g mercuric chloride (HgCl) and 350 g ammonium chloride (NH_4Cl) dissolved in a minimal volume of distilled water sufficient to dissolve the salts, combined with 10 L of 96% ethanol. After processing, the specimens were identified, labeled, and mounted. Voucher specimen of each species was deposited at the herbarium of the Royal Society for the Conservation of Nature (RSCN).

Results

Floristic Composition

A total of 512 plant species were identified within Dibeen Forest Reserve, representing 50 families and 254 genera (Table 1). The most dominant families in terms of species richness were Fabaceae, Poaceae, Asteraceae, and Brassicaceae.

Table 1. List of vascular plant species recorded in Dibeen Forest Reserve during this study.

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
AMARANTHACEAE			
Atriplex	*halimus* L.	Common	Least Concern
ANACARDIACEAE			
Pistacia	*atlantica* Desf.	Near Threatened	Near Threatened

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Pistacia	*palaestina* Boiss.	Least Concern	Not Evaluated
Rhus	*coriaria* L.	Not Evaluated	Least Concern
APIACEAE			
Ainsworthia	*carmelii* Boiss.	Not Evaluated	Not Evaluated
Ainsworthia	*trachycarpa* Boiss.	Not Evaluated	Not Evaluated
Artedia	*squamata* L.	Not Evaluated	Not Evaluated
Astomaea	*seselifolia* (A.DC.) Rauschert	Least Concern	Not Evaluated
Chaetosciadium	*trichospermum* (L.) Boiss.	Least Concern	Not Evaluated
Daucus	*carota* L.	Least Concern	Least Concern
Daucus	*jordanicus* Post	Least Concern	Least Concern
Daucus	*subsessilis* Boiss.	Not Evaluated	Least Concern
Eryngium	*creticum* Lam.	Least Concern	Not Evaluated
Eryngium	*glomeratum* Lam.	Least Concern	Not Evaluated
Foeniculum	*vulgare* Mill.	Not Evaluated	Least Concern
Heptaptera	*anisoptera* (DC.) Tutin	Vulnerable	Not Evaluated
Lagoecia	*cuminoides* L.	Least Concern	Not Evaluated
Lecokia	*cretica* (Lam.) DC.	Least Concern	Not Evaluated
Orlaya	*grandiflora* (L.) Hoffm.	Least Concern	Not Evaluated
Pimpinella	*cretica* Poir.	Least Concern	Not Evaluated
Scandix	*iberica* M.Bieb.	Not Evaluated	Not Evaluated
Scandix	*stellata* Banks & Sol.	Least Concern	Not Evaluated
Tordylium	*carmeli (Labill.) Al-Eisawi*	Not Evaluated	Not Evaluated
Tordylium	*trachycarpum* (Boiss.) Al-Eisawi	Least Concern	Not Evaluated
Torilis	*arvensis* (Huds.) Link	Least Concern	Not Evaluated
Torilis	*japonica* (Houtt.) DC.	Least Concern	Not Evaluated
Torilis	*leptophylla* (L.) Rchb.f.	Least Concern	Not Evaluated
Torilis	*nodosa* (L.) Gaertn.	Least Concern	Not Evaluated
Torilis	*tenella* (Delile) Rchb.f.	Least Concern	Not Evaluated
Turgenia	*latifolia* (L.) Hoffm.	Least Concern	Not Evaluated
ARACEAE			
Arum	*dioscoridis* Sm.	Endangered	Not Evaluated
Arum	*hygrophilum* Boiss.	Endangered	Near Threatened
Arum	*palaestinum* Boiss.	Endangered	Least Concern
Bupleurum	*nodiflorum* Sibth. & Sm.	Least Concern	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
ASPARAGACEAE			
Muscari	*commutatum* Guss.	Least Concern	Not Evaluated
Ornithogalum	*arabicum* L.	Not Evaluated	Not Evaluated
Ornithogalum	*montanum* Cirillo	Least Concern	Not Evaluated
Ornithogalum	*narbonense* L.	Least Concern	Not Evaluated
Ornithogalum	*neurostegium* Boiss. & Blanche	Least Concern	Not Evaluated
Ornithogalum	*neurostegium* subsp. *eigii* (Feinbrun) Feinbrun	Least Concern	Not Evaluated
Ornithogalum	*trichophyllum* Boiss.	Least Concern	Not Evaluated
ASPLENIACEAE			
Asplenium	*ceterach L.*	Not Evaluated	Not Evaluated
ASTERACEAE			
Achillea	*aleppica* DC.	Not Evaluated	Not Evaluated
Achillea	*arabica* Kotschy	Least Concern	Not Evaluated
Anthemis	*bornmuelleri* Stoj. & Acht.	Not Evaluated	Not Evaluated
Anthemis	*brachycarpa* Eig	Critically Endangered	Not Evaluated
Anthemis	*maris-mortui* Eig	Endangered	Not Evaluated
Anthemis	*nabataea* Eig	Vulnerable	Not Evaluated
Anthemis	*pseudocotula* Boiss.	Least Concern	Not Evaluated
Anthemis	sp	Not Evaluated	Not Evaluated
Symphyotrichum	*subulatum* (Michx.) G.L.Nesom	Introduced	Least Concern
Asteriscus	*graveolens* (Forssk.) Less.	Least Concern	Not Evaluated
Atractylis	*cancellata* L.	Least Concern	Not Evaluated
Calendula	*arvensis* M.Bieb.	Least Concern	Not Evaluated
Carduus	*argentatus* L.	Least Concern	Not Evaluated
Carduus	*getulus* Pomel	(LC)Least Concern	Not Evaluated
Carduus	*nigrescens* subsp. *australis* (Nyman) Greuter	Endangered	Not Evaluated
Carlina	*hispanica* Lam.	Least Concern	Not Evaluated
Carthamus	*nitidus* Boiss.	Least Concern	Not Evaluated
Carthamus	*tenuis* (Boiss. & Blanche) Bornm.	Least Concern	Not Evaluated
Catananche	*lutea* L.	Least Concern	Not Evaluated
Centaurea	*hyalolepis* Boiss.	Least Concern	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Centaurea	*iberica* Trevir. ex Spreng.	Least Concern	Not Evaluated
Centaurea	*rigida* Banks & Sol.	Least Concern	Not Evaluated
Centaurea	sp	Not Evaluated	Not Evaluated
Chiliadenus	*iphionoides* (Boiss. & Blanche) Brullo	Least Concern	Not Evaluated
Cichorium	*pumilum* Jacq.	Least Concern	Least Concern
Cota	*palaestina* Reut. ex Unger & Kotschy	Least Concern	Not Evaluated
Crepis	*aspera* L.	Least Concern	Not Evaluated
Crepis	*hierosolymitana* Boiss.	Least Concern	Not Evaluated
Crepis	*kotschyana* (Boiss.) Boiss.	Not Evaluated	Not Evaluated
Crepis	*micrantha* Czerep.	Least Concern	Not Evaluated
Crepis	*palaestina* (Boiss.) Bornm.	Least Concern	Not Evaluated
Crepis	*sancta* (L.) Bornm.	Least Concern	Not Evaluated
Crepis	*syriaca* (Bornm.) Babc. & Navashin	Least Concern	Not Evaluated
Crupina	*crupinastrum* (Moris) Vis.	Least Concern	Not Evaluated
Dittrichia	*viscosa* (L.) Greuter	Least Concern	Not Evaluated
Echinops	*pungens* Trautv.	Least Concern	Not Evaluated
Filago	*contracta* (Boiss.) Chrtek & Holub	Least Concern	Not Evaluated
Filago	*eriocephala* Guss.	Least Concern	Not Evaluated
Filago	*gallica* (L.) L.	Endangered	Not Evaluated
Filago	*inexpectata* Wagenitz	Least Concern	Not Evaluated
Filago	*pyramidata* L.	Least Concern	Not Evaluated
Geropogon	*hybridus* (L.) Sch.Bip.	Least Concern	Not Evaluated
Hedypnois	*rhagadioloides* (L.) F.W.Schmidt	Least Concern	Not Evaluated
Helichrysum	*sanguineum* (L.) Kostel.	Least Concern	Not Evaluated
Hyoseris	*scabra* L.	Not Evaluated	Not Evaluated
Hypochaeris	*achyrophorus* L.	Not Evaluated	Not Evaluated
Klasea	*pusilla* (Labill.) Greuter & Wagenitz	Least Concern	Not Evaluated
Lactuca	*tuberosa* Jacq.	Least Concern	Least Concern
Lactuca	*viminea* (L.) J.Presl & C.Presl	Not Evaluated	Least Concern
Leontodon	*tuberosus* L.	Least Concern	Not Evaluated
Micropus	*supinus* L.	Endangered	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Notobasis	*syriaca* (L.) Cass.	Least Concern	Not Evaluated
Onopordum	*carduiforme* Boiss.	Least Concern	Not Evaluated
Onopordum	*cynarocephalum* Boiss. & Blanche	Least Concern	Not Evaluated
Onopordum	*jordanicola* Eig	Endangered	Not Evaluated
Phagnalon	*rupestre* (L.) DC.	Least Concern	Not Evaluated
Picnomon	*acarna* (L.) Cass.	Least Concern	Not Evaluated
Picris	*amalecitana* (Boiss.) Eig	Least Concern	Not Evaluated
Picris	*cyanocarpa* Boiss.	Least Concern	Not Evaluated
Picris	*galilaea* (Boiss.) Eig	Least Concern	Not Evaluated
Picris	*longirostris* Sch.Bip.	Least Concern	Not Evaluated
Rhagadiolus	*edulis* Gaertn.	Not Evaluated	Not Evaluated
Rhagadiolus	*stellatus* (L.) Gaertn.	Not Evaluated	Not Evaluated
Scolymus	*maculatus* L.	Least Concern	Not Evaluated
Senecio	*vernalis* Waldst. & Kit.	Least Concern	Not Evaluated
Silybum	*marianum* (L.) Gaertn.	Least Concern	Least Concern
Sonchus	*oleraceus* (L.) L.	Least Concern	Not Evaluated
Tragopogon	*porrifolius* subsp. *longirostris* (Sch.Bip.) Greuter	Least Concern	Not Evaluated
Urospermum	*picroides* (L.) Scop. Ex F. W. Schmidt	Least Concern	Not Evaluated
BORAGINACEAE			
Alkanna	*strigosa* Boiss. & Hohen.	Least Concern	Not Evaluated
Alkanna	*tinctoria* (L.) Tausch	Least Concern	Least Concern
Anchusa	*aegyptiaca* (L.) A.DC.	Least Concern	Not Evaluated
Anchusa	*arvensis* subsp. *orientalis* (L.) Nordh.	Not Evaluated	Not Evaluated
Anchusa	*strigosa* Banks & Sol.	Least Concern	Not Evaluated
Buglossoides	*arvensis* (L.) I.M.Johnst.	Least Concern	Not Evaluated
Buglossoides	*tenuiflora* (L.f.) I.M.Johnst.	Least Concern	Not Evaluated
Echium	*judaeum* Lacaita	Least Concern	Not Evaluated
Heliotropium	*hirsutissimum* Grauer	Endangered	Not Evaluated
Myosotis	*ramosissima* Rochel	Endangered	Not Evaluated
Myosotis	*uncata* Boiss. & Balansa	Endangered	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Nonea	*echioides* (L.) Roem. & Schult.	Not Evaluated	Not Evaluated
Nonea	*melanocarpa* Boiss.	Not Evaluated	Not Evaluated
Nonea	*obtusifolia* (Willd.) DC.	Not Evaluated	Not Evaluated
Nonea	*philistaea* Boiss.	Not Evaluated	Not Evaluated
Symphytum	*prachycalyx* Boiss.	Not Evaluated	Not Evaluated
	BRASSICACEAE		
Alyssum	*damascenum* Boiss. & Gaill.	Least Concern	Not Evaluated
Arabis	*aucheri* Boiss.	Least Concern	Not Evaluated
Arabis	*turrita* L.	Not Evaluated	Not Evaluated
Arabis	*verna* (L.) R.Br.	Least Concern	Not Evaluated
Bifora	*testiculata* (L.) Roth	Least Concern	Not Evaluated
Biscutella	*didyma* L.	Least Concern	Not Evaluated
Brassica	*aucheri* Boiss.	Not Evaluated	Not Evaluated
Brassica	*nigra* (L.) K.Koch	Least Concern	Least Concern
Calepina	*irregularis* (Asso) Thell	Least Concern	Not Evaluated
Capsella	*bursa-pastoris* (L.) Medik.	Least Concern	Least Concern
Carrichtera	*annua* (L.) DC.	Least Concern	Least Concern
Clypeola	*jonthlaspi* L.	Least Concern	Not Evaluated
Crambe	*hispanica* L.	Least Concern	Least Concern
Crambe	*orientalis* L.	Least Concern	Not Evaluated
Draba	*verna* L.	Not Evaluated	Not Evaluated
Eruca	*vesicaria* (L.) Cav.	Least Concern	Least Concern
Erucaria	*rostrata* (Boiss.) A.W.Hill ex Greuter & Burdet	Least Concern	Not Evaluated
Fibigia	*clypeata* (L.) Medik.	Not Evaluated	Not Evaluated
Hirschfeldia	*incana* (L.) Lagr.-Foss.	Least Concern	Not Evaluated
Lepidium	*draba* L.	Least Concern	Not Evaluated
Malcolmia	*chia* (L.) DC.	Least Concern	Not Evaluated
Matthiola	*arabica* Boiss.	Least Concern	Not Evaluated
Matthiola	*longipetala* (Vent.) DC.	Least Concern	Not Evaluated
Neslia	*paniculata* subsp. *thracica* (Velen.) Bornm.	Least Concern	Not Evaluated
Raphanus	*raphanistrum* L.	Near Threatened	Not Evaluated
Sinapis	*alba* L.	Least Concern	Least Concern
Sinapis	*arvensis* L.	Least Concern	Least Concern

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Sisymbrium	*orientale* L.	Least Concern	Not Evaluated
Thlaspi	*perfoliatum* L.	Least Concern	Not Evaluated
CAMPANULACEAE			
Campanula	*erinus* L.	Least Concern	Not Evaluated
Campanula	*hierosolymitana* Boiss.	Least Concern	Not Evaluated
Campanula	*rapunculus* L.	Least Concern	Not Evaluated
Campanula	*strigosa* Banks & Sol.	Least Concern	Not Evaluated
Legousia	*falcata* (Ten.) Fritsch ex Janch.	Least Concern	Not Evaluated
CAPPARACEAE			
Capparis	*spinosa* L.	Least Concern	Least Concern
CAPRIFOLIACEAE			
Cephalaria	*syriaca* (L.) Schrad. ex Roem. & Schult.	Least Concern	Not Evaluated
Gypsophila	*pilosa* Huds.	Least Concern	Not Evaluated
Lomelosia	*palaestina* (L.) Raf.	Not Evaluated	Not Evaluated
Lonicera	*etrusca* Santi	Vulnerable	Not Evaluated
Pterocephalus	*brevis* Coult.	Not Applicable	Not Evaluated
Pterocephalus	*papposus* (L.) Coult.	Not Evaluated	Not Evaluated
Lomelosia	*prolifera* (L.) Greuter & Burdet	Not Evaluated	Not Evaluated
Valerianella	*coronata* (L.) DC.	Least Concern	Not Evaluated
Valerianella	*muricata* (Steven ex M.Bieb.) W.H.Baxter	Least Concern	Not Evaluated
Valerianella	*sclerocarpa* Fisch. & C.A.Mey.	Least Concern	Not Evaluated
Valerianella	*vesicaria* (L.) Moench	(LC)Least Concern	Not Evaluated
CARYOPHYLACEAE			
Arenaria	*serpyllifolia* subsp. *leptoclados* (Rchb.) Nyman	Least Concern	Not Evaluated
Cerastium	*dichotomum* L.	Least Concern	Not Evaluated
Cerastium	*glomeratum* Thuill.	Not Evaluated	Not Evaluated
Herniaria	*hirsuta* L.	Least Concern	Not Evaluated
Minuartia	*decipiens* Bornm.	Not Applicable	Not Evaluated
Minuartia	*globulosa* (Labill.) Schinz & Thell.	Critically Endangered	Not Evaluated
Minuartia	*hybrida* (Vill.) Schischk.	Least Concern	Not Evaluated
Minuartia	*mediterranea* (Ledeb. ex Link) K.Malý	Least Concern	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Minuartia	*meyeri* (Boiss.) Bornm.	Least Concern	Not Evaluated
Paronychia	*argentea* Lam.	Least Concern	Not Evaluated
Silene	*aegyptiaca* (L.) L.f.	Least Concern	Not Evaluated
Silene	*apetala* Willd.	Not Evaluated	Not Evaluated
Silene	*behen* L.	Least Concern	Not Evaluated
Silene	*colorata* Poir.	Least Concern	Not Evaluated
Silene	*conoidea* L.	Least Concern	Not Evaluated
Silene	*italica* (L.) Pers.	Critically Endangered	Not Evaluated
Silene	*linearis* Decne.	Not Applicable	Not Evaluated
Silene	*macrodonta* Boiss.	Critically Endangered	Not Evaluated
Silene	*nocturna* L.	Least Concern	Not Evaluated
Silene	*palaestina* Boiss.	Not Applicable	Not Evaluated
Silene	*telavivensis* Zohary & Plitmann	Not Evaluated	Not Evaluated
Silene	*vivianii* Steud.	Not Evaluated	Not Evaluated
Silene	*vulgaris* (Moench) Garcke	Least Concern	Least Concern
Spergularia	*hybrida* Hausskn.	Not Evaluated	Not Evaluated
Stellaria	*media* (L.) Vill.	Least Concern	Not Evaluated
Velezia	*rigida* L.	Least Concern	Not Evaluated
CHENOPODIACEAE			
Chenopodium	*album* L.	Least Concern	Not Evaluated
Chenopodium	*murale* L.	Least Concern	Least Concern
CISTACEAE			
Cistus	*creticus* L.	Least Concern	Not Evaluated
Cistus	*salviifolius* L.	Least Concern	Not Evaluated
Fumana	*arabica* (L.) Spach	Vulnerable	Not Evaluated
Fumana	*thymifolia* (L.) Spach	Least Concern	Not Evaluated
Helianthemum	*aegyptiacum* (L.) Mill.	Least Concern	Not Evaluated
Helianthemum	*ledifolium* subsp. *lasiocarpum* (Desf. ex Jacques & Hérincq) Nyman	Least Concern	Not Evaluated
Helianthemum	*salicifolium* (L.) Mill.	Least Concern	Not Evaluated
Helianthemum	*syriacum* (Jacq.) Dum. Cours.	Least Concern	Not Evaluated
CONVOLVULACEAE			
Convolvulus	*pentapetaloides* L.	Not Applicable	Not Evaluated
Convolvulus	*scammonia* L.	Not Applicable	Not Evaluated

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Convolvulus	*siculus* L.	Not Applicable	Not Evaluated
CRASSULACEAE			
Sedum	*cespitosum* (Cav.) DC.	Least Concern	Not Evaluated
Sedum	*microcarpum* (Sm.) Schönland	Endangered	Not Evaluated
Sedum	*pallidum M.Bieb.*	Endangered	Not Evaluated
Sedum	*rubens* L.	Least Concern	Not Evaluated
Umbilicus	*intermedius* Boiss.	Least Concern	Not Evaluated
CUCURBITACEAE			
Bryonia	*cretica* L.	Least Concern	Not Evaluated
EPHEDRACEAE			
Ephedra	*aphylla* Forssk.	Least Concern	Least Concern
Ephedra	sp	Not Evaluated	Not Evaluated
ERICACEAE			
Arbutus	*andrachne* L.	Vulnerable	Not Evaluated
EUPHORBIACEAE			
Euphorbia	*aleppica* L.	Least Concern	Not Evaluated
Euphorbia	*aulacosperma* Boiss.	Least Concern	Not Evaluated
Euphorbia	*densa* Schrenk	Vulnerable	Not Evaluated
Euphorbia	*helioscopia* L.	Least Concern	Not Evaluated
Euphorbia	*oxyodonta* Boiss.	Endangered	Not Evaluated
Euphorbia	*peplus* L.	Least Concern	Not Evaluated
Euphorbia	*reuteriana* Boiss.	Vulnerable	Not Evaluated
Mercurialis	*annua* L.	(LC)Least Concern	Not Evaluated
FABACEAE			
Astragalus	*oleifolius* DC.	Not Evaluated	Not Evaluated
Astragalus	*corrugatus* Bertol.	Not Evaluated	Not Evaluated
Astragalus	*epiglottis* L.	Least Concern	Not Evaluated
Astragalus	*hamosus* L.	Least Concern	Not Evaluated
Astragalus	*palaestinus* var. *jordanensis* (Eig) Podl.	Not Evaluated	Not Evaluated
Astragalus	*pelecinus* (L.) Barneby	Not Evaluated	Not Evaluated
Astragalus	*schimperi* Boiss.	Least Concern	Not Evaluated
Astragalus	trimestris L.	Least Concern	Not Evaluated
Bituminaria	*flaccida* (Nábělek) Greuter	Least Concern	Not Evaluated
Calicotome	*villosa* (Poir.) Link	Least Concern	Not Evaluated
Ceratonia	*siliqua* L.	Least Concern	Not Evaluated

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Coronilla	*scorpiodes* K. Koch	Least Concern	Not Evaluated
Hippocrepis	*unisiliquosa* L.	Least Concern	Not Evaluated
Hymenocarpos	*circinnatus* (L.) Savi	Least Concern	Not Evaluated
Lathyrus	*aphaca* L.	Least Concern	Least Concern
Lathyrus	*blepharicarpus* Boiss.	Least Concern	Least Concern
Lathyrus	*cicera* L.	Endangered	Least Concern
Lathyrus	*gloeosperma* Warb. & Eig	Critically Endangered	Critically Endangered
Lathyrus	*hierosolymitanus* Boiss.	Least Concern	Least Concern
Lathyrus	*gorgoni* Parl.	Not Evaluated	Least Concern
Vicia	*orientalis* (Boiss.) Bég. & Diratz.	Least Concern	Not Evaluated
Vicia	*lenticula* (Hoppe) Janka	Endangered	Not Evaluated
Vicia	sp	Not Evaluated	Not Evaluated
Lotus	*conimbricensis* Brot.	Critically Endangered	Not Evaluated
Lotus	*edulis* L.	Least Concern	Least Concern
Lotus	*longesiliquosus* R.Roem.	Not Evaluated	Not Evaluated
Lotus	*ornithopodioides* L.	Least Concern	Not Evaluated
Lotus	*peregrinus* L.	Least Concern	Not Evaluated
Lysimachia	*linum-stellatum* L.	Least Concern	Not Evaluated
Medicago	*astroites* (Fisch. & C.A.Mey.) Trautv.	Least Concern	Least Concern
Medicago	*coronata* (L.) Bartal.	Least Concern	Least Concern
Medicago	*doliata* Carmign.	Not Evaluated	Least Concern
Medicago	*granadensis* Willd.	Least Concern	Not Applicable
Medicago	*laciniata* (L.) Mill.	Least Concern	Least Concern
Medicago	*littoralis* Loisel.	Least Concern	Least Concern
Medicago	*minima* (L.) L.	Least Concern	Least Concern
Medicago	*orbicularis* (L.) Bartal.	Least Concern	Least Concern
Medicago	*polymorpha* L.	Least Concern	Least Concern
Medicago	*radiata* L.	Least Concern	Not Evaluated
Medicago	*rotata* Boiss.	Least Concern	Least Concern
Medicago	*rugosa* Desr.	Least Concern	Least Concern
Medicago	*truncatula* Gaertn.	Least Concern	Least Concern
Medicago	*turbinata* (L.) All.	Not Evaluated	Least Concern
Melilotus	*messanensis* (L.) All.	Least Concern	Not Evaluated
Onobrychis	*caput-galli* (L.) Lam.	Least Concern	Not Evaluated
Onobrychis	*crista-galli* (L.) Lam.	Least Concern	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Onobrychis	*kotschyana* Fenzl	Least Concern	Not Evaluated
Onobrychis	*squarrosa* Viv.	Not Evaluated	Not Evaluated
Ononis	*alopecuroides* L.	Critically Endangered	Not Evaluated
Ononis	*natrix* L.	Least Concern	Least Concern
Ononis	*ornithopodioides* L.	Least Concern	Not Evaluated
Ononis	*pubescens* L.	Least Concern	Not Evaluated
Ononis	*reclinata* L.	Least Concern	Not Evaluated
Ononis	*spinosa* L.	Least Concern	Least Concern
Ononis	*spinosa* subsp. *antiquorum* (L.) Briq.	Least Concern	Least Concern
Ononis	*variegata* L.	Endangered	Not Evaluated
Ononis	*viscosa* L.	Least Concern	Not Evaluated
Ononis	*sicula* Guss.	Not Evaluated	Not Evaluated
Ononis	*ornithopodioides* L.	Least Concern	Not Evaluated
Pisum	*fulvum* Sibth. & Sm.	Least Concern	Near Threatened
Lathyrus	*oleraceus* Lam.	Not Evaluated	Least Concern
Pisum	*syriacum* (A.Berger) C.O.Lehm.	Not Evaluated	Not Evaluated
Scorpiurus	*muricatus* L.	Least Concern	Not Evaluated
Trifolium	*campestre* Schreb.	Least Concern	Not Evaluated
Trifolium	*clusii* Godr. & Gren.	Least Concern	Least Concern
Trifolium	*clypeatum* L.	Least Concern	Not Evaluated
Trifolium	*dasyurum* C.Presl	Least Concern	Not Evaluated
Trifolium	*erubescens* Fenzl	Endangered	Not Evaluated
Trifolium	*nigrescens* Viv.	(Least Concern	Not Evaluated
Trifolium	*palaestinum* Boiss.	Not Evaluated	Not Evaluated
Trifolium	*physodes* M.Bieb.	Least Concern	Not Evaluated
Trifolium	*pilulare* Boiss.	Least Concern	Not Evaluated
Trifolium	*purpureum* Loisel.	Least Concern	Not Evaluated
Trifolium	*repens* L.	Least Concern	Least Concern
Trifolium	*resupinatum* L.	Least Concern	Least Concern
Trifolium	*scabrum* L.	Least Concern	Least Concern
Trifolium	*stellatum* L.	Least Concern	Not Evaluated
Trifolium	*tomentosum* L.	Least Concern	Not Evaluated
Trigonella	*filipes* Boiss.	Least Concern	Not Evaluated
Trigonella	*foenum-graecum* L.	Least Concern	Not Evaluated
Trigonella	*kotschyi* Benth.	Not Evaluated	Not Evaluated
Tripodion	*tetraphyllum* (L.) Fourr.	Least Concern	Not Evaluated

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Vicia	*galilaea* Plitmann & Zohary	Least Concern	Not Evaluated
Vicia	*hybrida* L.	Least Concern	Least Concern
Vicia	*lutea* L.	Least Concern	Least Concern
Vicia	*narbonensis* L.	Least Concern	Not Evaluated
Vicia	*palaestina* Boiss.	Least Concern	Not Evaluated
Vicia	*peregrina* L.	Least Concern	Least Concern
Vicia	*sativa* L.	Least Concern	Least Concern
Vicia	*sericocarpa* Fenzl	Least Concern	Least Concern
FAGACEAE			
Quercus	*coccifera* L.	Vulnerable	Least Concern
Quercus	*infectoria* G.Olivier	Not Evaluated	Least Concern
Quercus	*ithaburensis* Decne.	Vulnerable	Least Concern
GERANIACEAE			
Erodium	*acaule* (L.) Bech. & Thell	Least Concern	Not Evaluated
Erodium	*alnifolium* Guss.	Not Evaluated	Not Evaluated
Erodium	*ciconium* (L.) L'Hér.	Least Concern	Not Evaluated
Erodium	*cicutarium* (L.) L'Hér.	Least Concern	Not Evaluated
Erodium	*gruinum* (L.) L' Hér.	Least Concern	Not Evaluated
Erodium	*laciniatum* (Cav.) Willd.	Least Concern	Not Evaluated
Erodium	*pulverulentum* (Cav.) Willd.	Not Evaluated	Not Evaluated
Erodium	*malacoides* (L.) L'Hér.	Least Concern	Not Evaluated
Erodium	*moschatum* (L.) L'Hér.	Least Concern	Not Evaluated
Erodium	*subintegrifolium* Eig	Endangered (EN)	Not Evaluated
Erodium	*touchyanum* Delile ex Godr.	Least Concern	Not Evaluated
Erodium	*trifolium* (Cav.) Guitt.	Not Evaluated	Not Evaluated
Geranium	*molle* L.	Least Concern	Not Evaluated
Geranium	*rotundifolium* L.	Least Concern	Not Evaluated
IRIDACEAE			
Gynandriris	*sisyrinchium* (L.) Parl.	Not Evaluated	Not Evaluated
Iris	*atrofusca* Baker	Endangered	Vulnerable
Iris	*bismarckiana* Damman & Sprenger	Critically Endangered	Endangered
LAMIACEAE			
Ajuga	*chamaepitys* subsp. *chia* (Schreb.) Arcang.	Least Concern	Least Concern

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Ballota	*saxatilis* Sieber ex C.Presl	Least Concern	Not Evaluated
Ballota	*undulata* (Sieber ex Fresen.) Benth.	Least Concern	Not Evaluated
Lamium	*amplexicaule* L.	Least Concern	Not Evaluated
Lamium	*moschatum* Mill.	Least Concern	Not Evaluated
Micromeria	*myrtifolia* Boiss. & Hohen.	Least Concern	Not Evaluated
Micromeria	*nervosa* (Desf.) Benth.	Least Concern	Not Evaluated
Phlomis	*viscosa* Poir.	Least Concern	Not Evaluated
Prasium	*majus* L.	Least Concern	Not Evaluated
Salvia	*dominica* L.	Least Concern	Not Evaluated
Salvia	*verbenaca L.*	Least Concern	Not Evaluated
Salvia	*hierosolymitana* Boiss.	Least Concern	Not Evaluated
Salvia	*indica* L.	Critically Endangered	Not Evaluated
Scutellaria	*brevibracteata* subsp. *subvelutina* (Rech.f.) Greuter & Burdet	Not Evaluated	Not Evaluated
Sideritis	*perfoliata* L.	Least Concern	Not Evaluated
Sideritis	*romana* subsp. *curvidens* (Stapf) Holmboe	Not Evaluated	Not Evaluated
Stachys	*neurocalycina* Boiss.	Least Concern	Not Evaluated
Teucrium	*polium* L.	Not Evaluated	Not Evaluated
Thymbra	*spicata* L.	Not Evaluated	Not Evaluated
Ziziphora	*capitata* L.	Not Evaluated	Not Evaluated
LILIACEAE			
Allium	*albotunicatum* O.Schwarz	Not Evaluated	Endangered
Allium	*decaisnei* C.Presl	Not Evaluated	Not Evaluated
Allium	*neapolitanum* Cirillo	Least Concern	Not Evaluated
Asparagus	*aphyllus* L.	Least Concern	Not Evaluated
Asphodeline	*lutea* (L.) Rchb.	Least Concern	Not Evaluated
Asphodelus	*aestivus* Brot.	Not Evaluated	Not Evaluated
Bellevalia	*flexuosa* Boiss.	Least Concern	Not Evaluated
Bellevalia	*trifoliata* (Ten.) Kunth	Least Concern	Not Evaluated
Drimia	*maritima* (L.) Stearn	Least Concern	Not Evaluated
Gagea	*villosa* (M.Bieb.) Sweet	Endangered (EN)	Not Evaluated
Tulipa	*agenensis* DC.	Least Concern	Least Concern
LINACEAE			

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Linum	*nodiflorum* L.	Least Concern	Not Evaluated
Linum	*pubescens* Banks & Sol.	Least Concern	Not Evaluated
Linum	*strictum* L.	Least Concern	Not Evaluated
MALVACEAE			
Alcea	*acaulis* (Cav.) Alef.	Least Concern	Not Evaluated
Alcea	*digitata* Alef.	Least Concern	Not Evaluated
Alcea	*setosa* (Boiss.) Alef.	Least Concern	Not Evaluated
Althaea	*ludwigii* L.	Least Concern	Not Evaluated
Malva	*multiflora* (Cav.) Soldano, Banfi & Galasso	Vulnerable	Not Evaluated
Malva	*nicaeensis* All.	Least Concern	Not Evaluated
Malva	*parviflora* L.	Least Concern	Not Evaluated
OLEACEAE			
Olea	*europaea* L.	Vulnerable	Data Deficient
ORCHIDACEAE			
Anacamptis	*collina* (Banks & Sol. ex Russell) R.M.Bateman, Pridgeon & M.W.Chase	Endangered	Least Concern
Anacamptis	*papilionacea* (L.) R.M.Bateman, Pridgeon & M.W.Chase	Endangered (EN)	Least Concern
Anacamptis	*pyramidalis* (L.) Rich.	Critically Endangered	Least Concern
Cephalanthera	*longifolia* (L.) Fritsch	Endangered	Least Concern
Limodorum	*abortivum* (L.) Sw.	Critically Endangered	Least Concern
Ophrys	*sphegodes* subsp. *taurica* (Aggeenko) Soó ex Niketić & Djordjevic	Critically Endangered	Not Evaluated
Orchis	*anatolica* Boiss.	Endangered	Least Concern
Orchis	*galilaea* (Bornm. & M.Schulze) Schltr.	Endangered	Least Concern
Neotinea	*tridentata* (Scop.) R.M.Bateman, Pridgeon & M.W.Chase	Endangered	Least Concern
OROBANCHACEAE			
Orobanche	*aegyptiaca* Pers.	Least Concern	Not Evaluated
Orobanche	sp	Not Evaluated	Not Evaluated
Parentucellia	*flaviflora* (Boiss.) Nevski	Not Evaluated	Not Evaluated
PAPAVERACEAE			
Ceratocapnos	*turbinata* (DC.) Lidén	Endangered	Not Evaluated

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Fumaria	*densiflora* DC.	Not Evaluated	Not Evaluated
Hypecoum	*imberbe* Sm.	Not Evaluated	Not Evaluated
Papaver	*argemone* L.	Least Concern	Not Evaluated
Papaver	*carmeli* Feinbrun	Least Concern	Not Evaluated
PINACEAE			
Pinus	*halepensis* Mill.	Vulnerable	Least Concern
PLANTAGINACEAE			
Kickxia	*aegyptiaca* (L.) Nábělek	(LC)Least Concern	Not Evaluated
Linaria	*albifrons* Spreng.	Not Applicable	Not Evaluated
Linaria	*micrantha* (Cav.) Hoffmanns. & Link	Not Applicable	Not Evaluated
Misopates	*orontium* (L.) Raf.	Least Concern	Not Evaluated
Plantago	*bellardii* All.	Not Applicable	Not Evaluated
Plantago	*cretica* L.	Not Applicable	Not Evaluated
Plantago	*indica* L.	Not Evaluated	Least Concern
Plantago	*lagopus* L.	Not Evaluated	Not Evaluated
Veronica	*cymbalaria* Bodard	Not Applicable	Not Evaluated
Veronica	*persica* Poir.	Least Concern	Not Evaluated
Veronica	*polita* Fr.	Least Concern	Not Evaluated
Veronica	*syriaca* Roem. & Schult.	Not Evaluated	Not Evaluated
POACEAE			
Aegilops	*geniculata* Roth	Least Concern	Least Concern
Aegilops	*peregrina* (Hack.) Maire & Weiller	Least Concern	Least Concern
Alopecurus	*arundinaceus* Poir.	Endangered	Least Concern
Alopecurus	*myosuroides* Huds.	Endangered	Least Concern
Avena	*barbata* Pott ex Link	Least Concern	Least Concern
Avena	*clauda* Durieu	Endangered	Least Concern
Avena	*eriantha* Durieu	Critically Endangered	Least Concern
Avena	*longiglumis* Durieu	Least Concern	Data Deficient
Avena	*sterilis* L.	Least Concern	Least Concern
Avena	*wiestii* Steudel	Not Evaluated	Least Concern
Brachypodium	*distachyon* (L.) P.Beauv.	Least Concern	Not Evaluated
Bromus	*alopecuros* Poir.	Not Evaluated	Not Evaluated
Bromus	*alopecuros* subsp. *caroli-henrici* (Greuter) P.M.Sm.	Not Evaluated	Not Evaluated
Bromus	*fasciculatus* C.Presl	Least Concern	Least Concern

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Bromus	*japonicus* Thunb.	Not Evaluated	Data Deficient
Bromus	*lanceolatus* Roth	Least Concern	Not Evaluated
Bromus	*madritensis* L. subsp. *Madritensis*	Least Concern	Least Concern
Bromus	*rigidus* Roth	Not Evaluated	Not Evaluated
Bromus	*rubens* L.	Least Concern	Least Concern
Bromus	*scoparius* L.	Least Concern	Not Evaluated
Bromus	*sterilis* L.	Least Concern	Not Evaluated
Bromus	*tectorum* L.	Least Concern	Not Evaluated
Catapodium	*rigidum* (L.) C.E.Hubb.	Least Concern	Least Concern
Crithopsis	*delileana* (Schult.) Roshev.	Least Concern	Not Evaluated
Cynosurus	*echinatus* L.	Least Concern	Not Evaluated
Cynosurus	*elegans* Desf.	Not Evaluated	Not Evaluated
Dactylis	*glomerata* L.	Least Concern	Not Evaluated
Gastridium	*ventricosum* (Gouan) Schinz & Thell.	Critically Endangered	Not Evaluated
Hordeum	*bulbosum* L.	Least Concern	Least Concern
Hordeum	*murinum* subsp. *glaucum* (Steud.) Tzvelev	Least Concern	Least Concern
Hordeum	*spontaneum* K.Koch	Least Concern	Least Concern
Hordeum	*vulgare* L.	Not Evaluated	Least Concern
Hyparrhenia	*hirta* (L.) Stapf	Least Concern	Not Evaluated
Lamarckia	*aurea* (L.) Moench	Least Concern	Not Evaluated
Lolium	*rigidum* Gaudin	Least Concern	Least Concern
Phalaris	*brachystachys* Link	Least Concern	Least Concern
Phalaris	*minor* Retz.	Least Concern	Not Evaluated
Phragmites	*australis* (Cav.) Trin. ex Steud.	Least Concern	Not Evaluated
Piptatherum	*blancheanum* Desv. ex Boiss.	Not Evaluated	Not Evaluated
Piptatherum	*holciforme* (M.Bieb.) Roem. & Schult.	Not Evaluated	Not Evaluated
Piptatherum	*miliaceum* (L.) Coss.	Not Evaluated	Not Evaluated
Poa	*bulbosa* L.	Least Concern	Not Evaluated
Poa	*sinaica* Steud.	Least Concern	Not Evaluated
Psilurus	*incurvus* (Gouan) Schinz & Thell.	Least Concern	Not Evaluated
Rostraria	*berythea* (Boiss. & Blanche) Holub	Not Evaluated	Not Evaluated

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Stipa	*bromoides* (L.) Dörfl.	Least Concern	Least Concern
Stipa	*capensis* Thunb.	Least Concern	Not Evaluated
Stipa	*hohenackeriana* Trin. & Rupr.	Least Concern	Not Evaluated
Trisetaria	*koelerioides* (Bornm. & Hack.) Melderis	Not Evaluated	Not Evaluated
Trisetaria	*glumacea* (Boiss.) Maire	Least Concern	Not Evaluated
Vulpia	*ciliata* Dumort.	Least Concern	Not Evaluated
Vulpia	*fasciculata* (Forssk.) Samp.	Least Concern	Not Evaluated
Vulpia	*myuros* (L.) C.C.Gmel.	Least Concern	Not Evaluated
Vulpia	*unilateralis* (L.) Stace	Least Concern	Not Evaluated
POLYGALACEAE			
Polygala	*monspeliaca* L.	Least Concern	Not Evaluated
POLYGONACEAE			
Polygonum	*equisetiforme* Sm.	Least Concern	Not Evaluated
Emex	*spinosa* (L.) Campd.	Least Concern	Not Evaluated
Rumex	sp	Not Evaluated	Not Evaluated
PRIMULACEAE			
Anagallis	*arvensis* L.	Least Concern	Not Evaluated
Cyclamen	*persicum* Mill.	Endangered	Not Evaluated
PTERIDACEAE			
Cheilanthes	*pteridioides* C. Chr.	Not Evaluated	Least Concern
RANUNCULACEAE			
Adonis	*aestivalis* L.	Least Concern	Not Evaluated
Adonis	*dentata* Delile	Least Concern	Not Evaluated
Adonis	*palaestina* Boiss.	Not Evaluated	Not Evaluated
Anemone	*coronaria* L.	Least Concern	Not Evaluated
Clematis	*cirrhosa* L.	Least Concern	Not Evaluated
Delphinium	*ithaburense* Boiss.	Not Applicable	Not Evaluated
Nigella	*ciliaris* DC.	Not Applicable	Not Evaluated
Ranunculus	*asiaticus* L.	Least Concern	Not Evaluated
Ranunculus	*marginatus* d'Urv.	Not Evaluated	Not Evaluated
RESEDACEAE			
Reseda	*lutea* L.	Not Evaluated	Not Evaluated
RHAMNACEAE			
Rhamnus	*palaestina* Boiss.	Not Evaluated	Not Evaluated
ROSACEAE			

Genus Name	Species Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Crataegus	*azarolus* var. *aronia* L.	Least Concern	Least Concern
Prunus	*dulcis* (Mill.) D.A.Webb	Not Evaluated	Not Evaluated
Pyrus	*syriaca* Boiss.	Least Concern	Least Concern
Sanguisorba	*minor* Scop.	Least Concern	Not Evaluated
Sarcopoterium	*spinosum* (L.) Spach	Not Evaluated	Not Evaluated
RUBIACEAE			
Crucianella	*macrostachya* Boiss.	Least Concern	Not Evaluated
Crucianella	*transjordanica* Rech.f.	Endangered	Least Concern
Cruciata	*articulata* (L.) Ehrend.	Least Concern	Not Evaluated
Galium	*aparine* L.	Least Concern	Not Evaluated
Galium	*cassium* Boiss.	Vulnerable (VU)	Not Evaluated
Galium	*hierochuntinum* Bornm.	Least Concern	Not Evaluated
Galium	*judaicum* Boiss.	Least Concern	Not Evaluated
Galium	*murale* (L.) All.	Least Concern	Not Evaluated
Galium	*setaceum* Lam.	Least Concern	Not Evaluated
Rubia	*tenuifolia* d'Urv.	Least Concern	Not Evaluated
Theligonum	*cynocrambe* L.	Not Evaluated	Not Evaluated
Valantia	*hispida* L.	Least Concern	Not Evaluated
SANTALACEAE			
Osyris	*alba* L.	Least Concern	Not Evaluated
Thesium	*bergeri* Zucc.	Least Concern	Not Evaluated
Thesium	*humile* Vahl	Least Concern	Not Evaluated
SCROPHULARIACEAE			
Scrophularia	*rubricaulis* Boiss.	Not Evaluated	Not Evaluated
Scrophularia	*xanthoglossa* Boiss.	Not Evaluated	Not Evaluated
Verbascum	*sinuatum* L.	Least Concern	Not Evaluated
SOLANACEAE			
Mandragora	*officinalis* Mill.	Not Evaluated	Not Evaluated
STYRACACEAE			
Styrax	*officinalis* L.	Vulnerable	Least Concern
URTICACEAE			
Parietaria	*alsinifolia* Delile	Least Concern	Not Evaluated
Parietaria	*judaica* subsp. *judaica*	Least Concern	Not Evaluated
Parietaria	*lusitanica* L.	Least Concern	Not Evaluated
Urtica	*urens* L.	Least Concern	Least Concern

Conservation assessments were conducted based on the IUCN Red List (2024) and the Jordan Plant Red List (Volumes 1 and 2) (Taifour and El-Oqlah, 2014; Taifour, 2022). A total of seven species are classified globally as threatened: *Lathyrus gloeosperma* (Critically Endangered), *Iris bismarckiana* and *Allium albotunicatum* (Endangered), *Iris atrofusca* (Vulnerable), and *Pistacia atlantica, Arum hygrophilum,* and *Pisum fulvum* (Near Threatened).

At the national level, 65 species were categorized as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), or Near Threatened (NT). These include numerous orchid species listed under CITES, such as *Anacamptis pyramidalis, Orchis galilaea, Anacamptis papilionacea,* and *Limodorum abortivum* (Figure 2).

Figure 2. Some nationally threatened orchid species from Dibeen Forest Reserve: (A) *Anacamptis pyramidalis,* (B) *Orchis galilaea*, (C)*Anacamptis papilionacea*, and (D) *Limodorum abortivum*), all listed under CITES

Several species were notably frequent among the Critically Endangered group, such as *Anthemis brachycarpa, Silene italica, Avena eriantha,* and *Salvia indica*, indicating local rarity and high conservation priority. Vulnerable taxa included ecologically and structurally significant species such as *Pinus halepensis, Quercus coccifera, Olea europaea,* and *Arbutus andrachne.*

This highlights Dibeen Forest Reserve not only as a biodiversity hotspot but also as a critical refuge for many threatened and endemic species within Jordan, reinforcing the importance of site-specific monitoring and conservation planning. A full list of conservation concern species is presented in (Table 2).

Table 2. List of threatened and endemic plant species recorded in Dibeen Forest Reserve, including their national and global conservation status.

Scientific Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Allium albotunicatum	Not Evaluated	Endangered
Alopecurus arundinaceus	Endangered	Least Concern
Alopecurus myosuroides	Endangered	Least Concern
Anacamptis collina	Endangered	Least Concern
Anacamptis papilionacea	Endangered	Least Concern
Anacamptis pyramidalis	Critically Endangered	Least Concern
Anthemis brachycarpa	Critically Endangered	Not Evaluated
Anthemis maris-mortui	Endangered	Not Evaluated
Anthemis nabataea	Vulnerable	Not Evaluated
Arbutus andrachne	Vulnerable	Not Evaluated
Arum dioscoridis	Endangered	Not Evaluated
Arum hygrophilum	Endangered	Near Threatened
Arum palaestinum	Endangered	Least Concern
Avena clauda	Endangered	Least Concern
Avena eriantha	Critically Endangered	Least Concern
Carduus nigrescens subsp. australis	Endangered	Not Evaluated
Cephalanthera longifolia	Endangered	Least Concern
Ceratocapnos turbinata	Endangered	Not Evaluated
Crucianella transjordanica	Endangered	Least Concern

Scientific Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Cyclamen persicum	Endangered	Not Evaluated
Erodium subintegrifolium	Endangered	Not Evaluated
Euphorbia densa	Vulnerable	Not Evaluated
Euphorbia oxyodonta	Endangered	Not Evaluated
Euphorbia reuteriana	Vulnerable	Not Evaluated
Filago gallica	Endangered	Not Evaluated
Fumana arabica	Vulnerable	Not Evaluated
Gagea villosa	Endangered	Not Evaluated
Galium cassium	Vulnerable	Not Evaluated
Gastridium ventricosum	Critically Endangered	Not Evaluated
Heliotropium hirsutissimum	Endangered	Not Evaluated
Heptaptera anisoptera	Vulnerable	Not Evaluated
Iris atrofusca	Endangered	Vulnerable
Iris bismarckiana	Critically Endangered	Endangered
Lathyrus cicera	Endangered	Least Concern
Lathyrus gloeosperma	Critically Endangered	Critically Endangered
Limodorum abortivum	Critically Endangered	Least Concern
Limodorum abortivum	Critically Endangered	Least Concern
Lonicera etrusca	Vulnerable	Not Evaluated
Lotus conimbricensis	Critically Endangered	Not Evaluated
Malva multiflora	Vulnerable	Not Evaluated
Micropus supinus	Endangered	Not Evaluated
Minuartia globulosa	Critically Endangered	Not Evaluated
Myosotis ramosissima	Endangered	Not Evaluated
Myosotis uncata	Endangered	Not Evaluated
Neotinea tridentata	Endangered	Least Concern

Scientific Name	National Conservation Status (Jordan Red List)	Global Conservation Status (IUCN Red List)
Olea europaea	Vulnerable	Data Deficient
Ononis alopecuroides	Critically Endangered	Not Evaluated
Ononis variegata	Endangered	Not Evaluated
Onopordum jordanicola	Endangered	Not Evaluated
Ophrys sphegodes subsp. taurica	Critically Endangered	Not Evaluated
Orchis anatolica	Endangered	Least Concern
Orchis galilaea	Endangered	Least Concern
Pinus halepensis	Vulnerable	Least Concern
Pistacia atlantica	Near Threatened	Near Threatened
Pisum fulvum	Least Concern	Near Threatened
Quercus coccifera	Vulnerable	Least Concern
Quercus ithaburensis	Vulnerable	Least Concern
Raphanus raphanistrum	Near Threatened	Not Evaluated
Salvia indica	Critically Endangered	Not Evaluated
Sedum microcarpum	Endangered	Not Evaluated
Sedum pallidum	Endangered	Not Evaluated
Silene italica	Critically Endangered	Not Evaluated
Silene macrodonta	Critically Endangered	Not Evaluated
Styrax officinalis	Vulnerable	Least Concern
Trifolium erubescens	Endangered	Not Evaluated
Vicia lenticula	Endangered	Not Evaluated

Vegetation Structure

– Tree Layer: *Pinus halepensis* was the most dominant tree species, exhibiting the highest Importance Value Index (IVI) of 1.82, followed by *Quercus coccifera* with an IVI of 1.75, indicating a strong co-dominance pattern between these two species across the sampled plots. Additional tree species recorded included *Arbutus andrachne, Pistacia palaestina,* and *Quercus ithaburensis*, though with lower frequencies and densities (Table 3).

Pistacia atlantica was not recorded in any of the 30 systematic plots; however, it was documented during the random route surveys. A total of 10 tree species were recorded, with varying dominance and frequencies across the 30 plots. *Arbutus andrachne* appeared in 30% of plots, while other species such as *Pistacia palaestina, Calicotome villosa, Rhamnus palaestina, Quercus ithaburensis, Quercus infectoria,* and *Pyrus syriaca* occurred in fewer than 10% of the plots.

Table 3. Total number of each Regeneration species in 30 plots, along with the relative parameters of each tree Regeneration in Dibeen forest reserve.

Species name	Total number of individuals of each species	Abundance	Frequency %	Relative Frequency	Density	Relative Density	Relative dominance	Importance of Index value
Pinus halepensis	392	17.8	73.3	0.449	13.07	0.726	0.733	1.91
Quercus coccifera	71	4.2	56.7	0.347	2.37	0.132	0.567	1.05
Rhamnus palaestina	3	1.0	10.0	0.061	0.10	0.006	0.100	0.17
Calicotome villosa	3	1.5	6.7	0.041	0.10	0.006	0.067	0.11
Crataegus azarolus	2	1.0	6.7	0.041	0.07	0.004	0.067	0.11
Arbutus andrachne	1	1.0	3.3	0.020	0.03	0.002	0.033	0.06
Pistacia palaestina	1	1.0	3.3	0.020	0.03	0.002	0.033	0.06
Quercus ithaburensis	1	1.0	3.3	0.020	0.03	0.002	0.033	0.06
Quercus infectoria	0	0.0	0.0	0.000	0.00	0.000	0.000	0.00
Pistacia atlantica	0	0.0	0.0	0.000	0.00	0.000	0.000	0.00

Regeneration

A total of 392 *Pinus halepensis* seedlings were recorded across the 30 sampled plots (20 × 20 m each), that is equivalent to an estimated density of 653 seedlings per hectare. *Quercus coccifera* followed with 71 seedlings, corresponding to around 118 seedlings per hectare. Other species such as *Rhamnus palaestina, Calicotome villosa,* and *Arbutus andrachne* were represented by very few regenerating individuals, while species like *Pistacia atlantica* and *Quercus infectoria* showed no seedlings in the systematic plots (Table 4).

The seedling-to-mature-tree ratio for *P. halepensis* was approximately 7.1:1. For *Q. coccifera*, the ratio was approximately 1.07:1.

In terms of regeneration percentage, *P. halepensis* seedlings represented approximately 87.7% of the total regeneration recorded, while *Q. coccifera* contributed around 15.9%. These results highlight the ecological dominance of *P. halepensis* in the regeneration layer of the forest, whereas other native tree species exhibited minimal or no recruitment within the systematic plots.

Table 4. Total number of each Regeneration species in 30 plots, along with the relative parameters of each tree Regeneration in Dibeen forest reserve.

Species name	Total number of individuals of each species	Abundance	Frequency %	Relative Frequency	Density	Relative Density	Relative dominance	Importance of Index value
Pinus halepensis	55	2.62	70	0.333	1.8	0.385	1.1	1.819
Quercus coccifera	66	2.54	86.67	0.413	2.2	0.471	0.9	1.750
Arbutus andrachne	9	1	30	0.143	0.3	0.064	0.3	0.507
Pistacia palaestina	3	1.5	6.67	0.032	0.1	0.021	0.1	0.120
Calicotome villosa	2	2	3.33	0.016	0.07	0.015	0.0	0.064
Rhamnus palaestina	2	2	3.33	0.016	0.07	0.015	0.0	0.064
Quercus ithaburensis	2	2	3.33	0.499	0.07	0.015	0.0	0.064
Quercus infectoria	1	1	3.33	0.016	0.03	0.006	0.0	0.056
Quercus infectoria	0	0.0	0.0	0.000	0.00	0.000	0.000	0.00
Pistacia atlantica	0	0.0	0.0	0.000	0.00	0.000	0.000	0.00

-Shrub Layer: The shrub layer was dominated by *Cistus creticus*, which exhibited the highest values in terms of frequency, density, and Importance Value Index (IVI = 1.91). *Cistus salviifolius* and *Sarcopoterium spinosum* were also recorded as prominent shrubs within the sampled plots, but with lower relative densities and frequencies (Table 5). These species together form the core structure of the shrub layer in Dibeen Forest Reserve.

Table 5. Total number of each species in 30 plots, along with the relative parameters of each shrub species in Dibeen forest reserve.

Species name	Total number of individuals of each species	Abundance	Frequency %	Relative Frequency	Density	Relative Density	Relative dominance	Importance of Index value
Cistus creticus	367	19.1	63.3	0.576	12.23	0.706	0.633	1.91
Cistus salviifolius	134	12.2	36.7	0.333	4.47	0.258	0.367	0.96
Sarcopoterium spinosum	18	9.0	6.7	0.061	0.60	0.035	0.067	0.16

-Herbaceous Layer: The herbaceous layer was dominated by species belonging to the Poaceae family, particularly *Aegilops peregrina, Brachypodium pinnatum, Bromus sterilis,* and *Hordeum murinum* subsp. *glaucum* (Table 6). *Aegilops peregrina* was the most abundant annual species, with a total of 2,312 individuals recorded across the line transects and an Importance Value Index (IVI) of 0.83. *Brachypodium pinnatum* and *Bromus sterilis* also showed high abundance and frequency values, indicating their wide distribution within the reserve. Notably, *Urospermum picroides* exhibited a high relative dominance despite its moderate abundance, reflecting its strong local competitiveness. These results highlight the ecological significance of annual grasses and forbs in the herbaceous layer of Dibeen Forest Reserve.

Table 6. Total number of each species in 30 line transects, along with the relative parameters (abundance, density, relative density, frequency, relative frequency, relative dominance, and the importance value index) of each annual or perennial species in Dibeen Forest Reserve.

Plant name	Total number of individuals of each species	Abundance	Frequency %	Relative Frequency	Density	Relative Density	Relative dominance	Importance of Index value
Aegilops peregrina	2312	136	56.67	0.023	77.07	0.241	0.567	0.830
Brachypodium pinnatum	1758	117.2	50	0.02	58.60	0.183	0.500	0.703
Hordeum murinum subsp. glaucum	598	199.33	10	0.004	19.93	0.062	0.100	0.166
Bromus sterilis	572	31.78	60	0.024	19.07	0.06	0.600	0.684
Catapodium pinnatum	420	420	3.33	0.001	14.00	0.044	0.033	0.078
Trifolium stellatum	327	23.36	46.67	0.019	10.90	0.034	0.467	0.520
Avena longiglumis	227	20.64	36.67	0.015	7.57	0.024	0.367	0.405
Lolium rigidum	226	25.11	30	0.012	7.53	0.024	0.300	0.336
Crithopsis delileana	219	43.8	16.67	0.007	7.30	0.023	0.167	0.196
Trifolium resupinatum	195	39	16.67	0.007	6.50	0.02	0.167	0.194
Bromus scoparius	175	35	16.67	0.007	5.83	0.018	0.167	0.192
Urospermum picroides	175	7	38.33	0.015	5.83	0.018	0.833	0.867
Lagoecia cuminoides	147	14.7	33.33	0.013	4.90	0.015	0.333	0.362

Vegetation Types

Based on species composition, dominance, and spatial distribution, three primary vegetation types were delineated within Dibeen Forest Reserve (Figure 3):

Aleppo Pine Forest: Typical naturally pine forest forms the best representation of Aleppo Pine in Jordan, with the dominant tree of *Pinus halepensis* can reach 20 meters in height and grows in the reserve at altitudes ranges from 500m to 700m above sea level. As well as association with low trees are

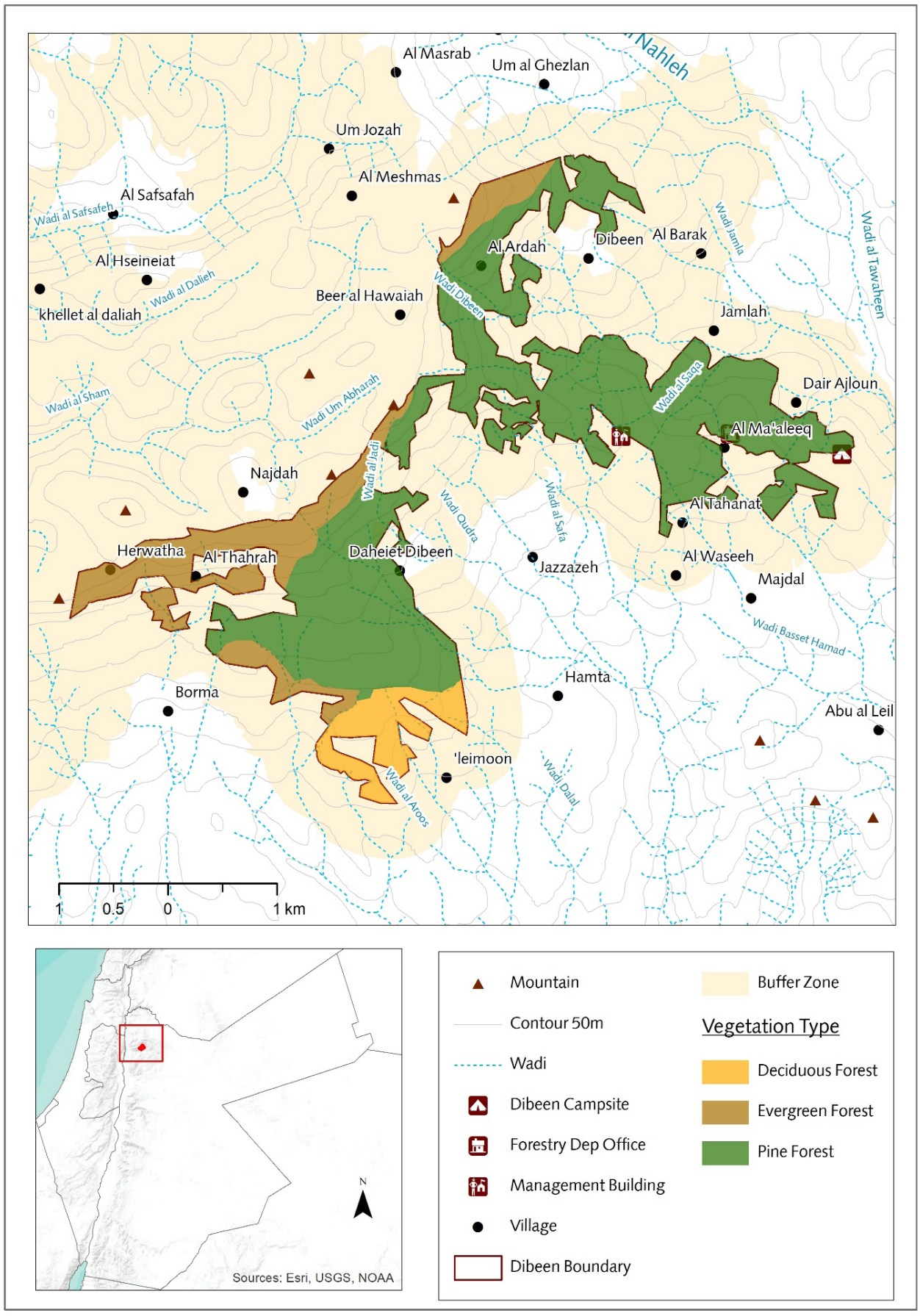

Figure 3. Vegetation Communities in Dibeen Forest Reserve.

Quercus coccifera, Arbutus andrachne and *Pistacia palaestina* and low shrubs are such as *Cistus creticus* and *Cistus salvifolius*. This vegetation covers the most area of the reserve in the east-west part, where calcareous soil is more dominant in this area.

Evergreen Oak Forest: This vegetation is mostly restricted to the western part of reserve at altitudes usually more than 700m, where red soil (Terra rosa) is more dominant in this area. The Major vegetation components are evergreen oak (*Quercus coccifera*) in association with *Quercus ithaburensis*, *Ceratonia siliqua* and *Crataegus aronea*.

Deciduous Oak Forest: This type of forest association is smallest area of the reserve, where occur at lower altitude than all other vegetation usually less than 500m and grow on brown soil of hard limestone parental rock. The dominance tree species is *Quercus ithaburensis* and associated with *Pistacia atlantica* and *Ceratonia siliqua*.

Discussion

The establishment of Dibeen Forest Reserve by the Royal Society for the Conservation of Nature (RSCN) represents effort to conserve the last remaining natural Aleppo pine (*Pinus halepensis*) forests in Jordan. The present study provides analysis of floristic composition, vegetation structure, and regeneration patterns, contributing insights into the current ecological condition of this unique Mediterranean ecosystem.

The results confirmed the ecological dominance of *P. halepensis* alongside *Quercus coccifera* in the arboreal layer, supported by their high Importance Value Index (IVI) values. This pattern is consistent with the findings of Triepke *et al.* (2012), who also reported the prevalence of these species in Dibeen. The ecological interaction between them is shaped in part by disturbance regimes, particularly fire. *Q. coccifera* exhibits strong vegetative regeneration and thick bark that confer fire resistance, whereas *P. halepensis* relies entirely on post-fire seed germination, triggered by the serotinous nature of its cones (Daskalakou and Thanos, 2004; Pascual *et al.,* 2002; Baker, 2020).

The regeneration survey documented a seedling density of approximately 653 seedlings/ha for *P. halepensis*, representing 87.7% of all seedlings recorded, and a seedling-to-mature-tree ratio of 7.1:1. Although lower than post-fire regeneration figures in the Mediterranean Basin (e.g., 12,400–60,000 seedlings/ha in Greece and Spain; Thanos *et al.,* 1996; Pausas *et al.,* 2004), the observed density indicates relatively healthy recruitment, especially in areas less affected by grazing pressure, where increased light availability, favorable soil alkalinity, and reduced human disturbance support regeneration. Compared to earlier assessments reporting sparse to moderate regeneration (Triepke *et al.,* 2012), these results suggest improvement, likely driven by increased light availability in canopy gaps, favorable soil alkalinity, and reduced human disturbance in select areas (Moya *et al.,* 2008; Al Omary, 2011).

The results also align with the findings of Alananbeh *et al.* (2023), who evaluated regeneration across four Jordanian forest reserves, including Dibeen. Their study recorded seedling densities ranging between 25 and 200 individuals per 1000 m² and identified *P. halepensis, Q. coccifera,* and *Arbutus andrachne* among the regenerating taxa. However, they reported regeneration declines near heavily disturbed areas, especially tourist trails. The current study, which recorded higher regeneration densities, reinforces the role of microhabitat variation and human impact gradients in shaping regeneration success. These observations underscore the importance of site-specific conservation interventions, particularly in high-pressure zones.

The findings of this study also expand upon the earlier assessment by Al-Shgair (2005), who reported *P. halepensis* as the dominant canopy species with *Q. coccifera* as co-dominant, supported by high importance

values. Al-Shgair further noted stable regeneration patterns and interpreted the forest as a climax *P. halepensis* community. While our results similarly confirm the dominance of *P. halepensis* and the co-dominance of *Q. coccifera*, they also indicate spatial variability in regeneration success, particularly under grazing and tourism pressures, which were not explicitly addressed in the 2005 study. This contrast underscores the dynamic nature of regeneration processes in Dibeen and highlights the importance of long-term monitoring to detect shifts in forest stability over time.

Despite the strong regeneration of *P. halepensis*, recruitment of other native tree species remains limited. *Q. coccifera* exhibited moderate regeneration, while *A. andrachne, Pistacia palaestina,* and *Quercus ithaburensis* showed low seedling numbers. Notably, *Pistacia atlantica*, although classified as Near Threatened, was absent from the systematic plots and recorded only during random route surveys. This pattern may reflect species-specific ecological traits rather than regeneration failure, as many Mediterranean broadleaved species are slow-growing, long-lived, and often rely on vegetative resprouting or require specialised microhabitats for successful recruitment (Pausas and Keeley, 2014). Their seedlings may therefore be underrepresented in short-term surveys. Additionally, the absence of *P. atlantica* in systematic plots, in systematic plots, despite its presence along random routes, may be attributed to sampling limitations. These findings highlight the need for long-term, species specific monitoring and habitat-based assessments to better understand the regeneration dynamics and conservation requirements of less dominant native tree species.

The shrub layer was dominated by *Cistus creticus*, which is characteristic of early post-disturbance succession in Mediterranean pine ecosystems. This species tends to dominate recently disturbed habitats but gradually declines as canopy cover increases (Tavşanoğlu and Gürkan, 2005; Spanos *et al.,* 2000). Its high IVI values and widespread presence in the reserve support the interpretation of recent disturbances or early successional phases in many plots. The presence of *Cistus salviifolius* and *Sarcopoterium spinosum* adds structural and compositional diversity, reflecting a typical Mediterranean shrubland assemblage.

The herbaceous layer was primarily composed of annual grasses and forbs, with species such as *Aegilops peregrina, Brachypodium pinnatum,* and *Bromus sterilis* dominating across the transects. These species contribute significantly to ground cover, prevent soil erosion, and provide forage resources (Aboulaich *et al*., 2009). The high IVI of *A. peregrina* indicates its adaptation to semi-open habitats and its competitiveness in early successional stages. Moreover, the documentation of nine orchid taxa, including *Ophrys sphegodes* subsp. *taurica* and *Orchis galilaea*, highlights the floristic significance of the reserve. These orchids are indicators of habitat quality and are commonly associated with calcareous soils beneath Aleppo pine canopies, where decomposing pine litter interacts with alkaline substrates to create favorable microhabitats (Al-Eisawi, 1996; Triepke *et al.,* 2012).

Vegetation mapping revealed three distinct forest types within the reserve: Aleppo pine, evergreen oak, and deciduous oak forests. These types are distributed along gradients of elevation, soil type, and moisture availability. Aleppo pine forests are widespread in mid-elevation zones on calcareous soils; evergreen oak forests dominate higher elevations on Terra Rosa soils, while the fragmented deciduous oak communities occur at lower elevations on hard limestone substrates.

In contrast to Triepke *et al.* (2012), who categorized some stands in Dibeen as mixed pine-oak forests, the current study classified these areas as Aleppo pine communities, based on the clear dominance of *P. halepensis*

which consistently exceeded 60% of the canopy composition. This classification follows the vegetation typology proposed by Al-Eisawi (1996), who described natural Aleppo pine forests as frequently containing evergreen oak components yet maintaining pine as the dominant canopy species. This refinement in classification provides a more consistent interpretation of the forest structure and emphasizes the importance of dominance thresholds in defining vegetation types. The diversity of vegetation types reflects Dibeen's role in preserving multiple successional stages and edaphic niches, consistent with earlier classifications of Jordan's Mediterranean forests (Amer *et al.,* 2004).

In summary, the results of this study reaffirm the ecological importance of Dibeen Forest Reserve as a critical refuge for Mediterranean flora in Jordan. The forest supports active regeneration of key tree species, harbors numerous threatened and endemic taxa, and sustains diverse vegetation types. Nevertheless, the observed spatial variability in regeneration and species distribution indicates that ongoing management efforts should prioritize habitat-specific monitoring, restoration of poorly regenerating species, and stricter regulation of anthropogenic activities in ecologically sensitive areas.

Conclusion

Dibeen Forest Reserve plays a vital role in conserving one of Jordan's last natural stands of *Pinus halepensis*, which remains ecologically dominant and demonstrates strong natural regeneration across the reserve. While species such as *Quercus coccifera* and *Cistus creticus* increase following disturbance events, particularly fire or canopy openings, they are eventually outcompeted by regenerating pines, indicating their role as early successional, disturbance-favoured species. The limited persistence of mature *C. creticus* in established stands further supports this dynamic. These findings highlight the need to integrate fire ecology into management practices to maintain pine dominance, regulate shrub encroachment, and support natural succession. Ongoing monitoring and targeted interventions in areas with weak regeneration will be critical for sustaining the ecological integrity and biodiversity of the Dibeen Forest ecosystem.

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Spatial Modeling of Critical Habitats to Guide Conservation and Research Priorities for Nubian Ibex *Capra nubiana* in Mujib Biosphere Reserve, Jordan

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Abstract

The Mujib Biosphere Reserve in Jordan provides vital habitats for the endangered Nubian ibex (*Capra nubiana*), yet knowledge of its ecological distribution remains limited. This study used species distribution modeling (SDM) via the MaxEnt algorithm to predict habitat suitability based on presence-only data collected between 2005 and 2013 and a range of environmental variables collected from related literature and expert judgment. The final model performed well (mean AUC = 0.88), identifying approximately 17–18% of the reserve—mainly steep escarpments and perennial wadis—as suitable habitat. Slope and annual precipitation were the most influential predictors. Crucially, field-based ground-truth validation confirmed that over 80% of independent occurrence records fell within high-suitability zones, directly reinforcing the model's accuracy and credibility. This integration of field verification added substantial confidence to the predictions, demonstrating how on-the-ground data can correct for spatial bias and validate remote modeling outputs. The findings offer a scientifically grounded tool to guide targeted monitoring, patrolling, and habitat management programmes, and provide essential input for adaptive conservation strategies in arid and mountainous landscapes.

Keywords:
MaxEnt algorithm, suitability, ground truth verification, mountainous landscapes

Introduction

Jordan was among the first Middle Eastern countries that has established conservation initiatives in the region. As early as 1963, the government of Jordan, under the direction of the late King Hussein bin Talal, recognized the urgency of addressing the degradation of the country's natural resources. In coordination with the British Museum (Natural History), a team of experts conducted a nationwide survey, which revealed alarming declines in habitat quality and biodiversity (Evans, 1994). This work led to the initial identification of key areas for conservation, although political and social circumstances delayed formal protection. In parallel with this foundation, the Royal Society for the Conservation of Nature (RSCN) was established in 1966 as the first NGO in the Arab world mandated with the establishment and management of protected areas. The RSCN played a critical role in developing Jordan's network of reserves, with the recommendations of the 1978 Clark Expedition forming the roadmap for protected area designation (Child and Grainger, 1990).

Among the first areas protected under this framework was the Mujib Nature Reserve, established in 1985. Located at the intersection of Mediterranean, Irano-Turanian, and Sudanian biogeographical zones, declared as a Man and Biosphere Reserve in 2011 (UNESCO, 2011). Mujib represents a unique assemblage of biodiversity within the Jordan Rift Valley, Particularly the presence of the Nubian ibex (*Capra nubiana*), a flagship species

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emblematic of Jordan's rugged mountain ecosystems and historically depicted in local rock art and cultural traditions (Shackleton, 1997).

Initial conservation efforts at Mujib focused on captive breeding of *C. nubiana*. In 1989, twenty individuals were imported from the San Diego Zoo's conservation breeding program, all sourced from Middle Eastern genetic stock (Hammond *et al.,* 2001). An additional local male, named *Fareed* ("Unique"), confiscated from illegal hunting was added to the herd to enhance the genetic diversity. Over a decade, breeding success in captivity culminated in the phased release of 85 individuals into the wild between 1997 and 2000. While post-release survival was challenged by disease outbreaks such as foot-and-mouth disease, adaptive interventions including vaccination protocols maintained population viability (Reintroduction Unit, RSCN, 1999).

Despite these early successes, detailed ecological studies on the Nubian ibex in Jordan have been limited. Early faunal surveys provided baseline presence data (Harrison and Bates, 1991; Qumsiyeh, 1999; Amr, 2000), but systematic population assessments have been sporadic. A landmark survey in Mujib Reserve in 1996 indicated healthy breeding populations but underscored threats from hunting and livestock competition (Boef *et al.,* 1996). Simultaneously, advances in remote monitoring technologies, such as camera trapping (Burton *et al.,* 2015) and species distribution modeling (SDMs) (Elith and Leathwick, 2009), have transformed ecological research, enabling non-invasive, large-scale habitat assessments. Such tools offer new opportunities to bridge the persistent information gaps regarding the distribution and habitat preferences of *C. nubiana* within the reserve.

The current study aims to model the habitat suitability and predict the potential distribution of the Nubian ibex within the Mujib Biosphere Reserve using species distribution modeling (SDM) techniques, specifically the MaxEnt algorithm. By integrating occurrence records with key environmental variables, the research seeks to (i) identify critical habitat areas, (ii) determine the most influential environmental factors shaping the species' distribution, (iii) guide the optimal placement of research and monitoring efforts to enhance population assessments, and (iv) provide a scientifically grounded baseline to inform conservation strategies, habitat management, and targeted patrolling for the effective protection of *C. nubiana*.

Materials and Methods

Study Area

Mujib Biosphere Reserve (Figure 1) is situated in west-central Jordan, extending from the highlands east of the Dead Sea at an elevation of approximately 800 meters above sea level to the shoreline of the Dead Sea at around 400 meters below sea level, making it the world's lowest Biosphere reserve.

The reserve encompasses an area of about 212 km² and features an exceptionally rugged topography composed of sandstone escarpments, steep cliffs, and deeply incised wadis. Three major perennial watercourses — Wadi Mujib, Wadi Hidan, and Wadi Zarqa Ma'in provide critical water resources for the reserve's biodiversity. The climate of Mujib is arid to semi-arid, with pronounced altitudinal and spatial gradients. Annual rainfall ranges from 50 mm in the lowlands to about 300 mm in the highlands, with temperatures fluctuating from mild winters (~15°C) to extremely hot summers, where temperatures can exceed 45°C (Al-Eisawi, 2014). These variations create a diverse array of microhabitats within a relatively small geographic area.

The vegetation is categorized into five primary vegetation types: steppe, sub-tropical, saline, aquatic, and non-forested habitats (Al-Eisawi, 2014). This study focuses on the western part of the reserve, where sub-tropical and saline vegetation are dominated, and characterized by species such as *Tamarix* spp., *Ziziphus spina-christi*, and *Acacia tortilis*. These habitats are critical

for the Nubian ibex, offering both foraging resources and rugged escape terrain. Key physical features of the study area include Wadi Mujib — the main river through the reserve — and Al-Marrah, a flatter expanse providing seasonal grazing grounds.

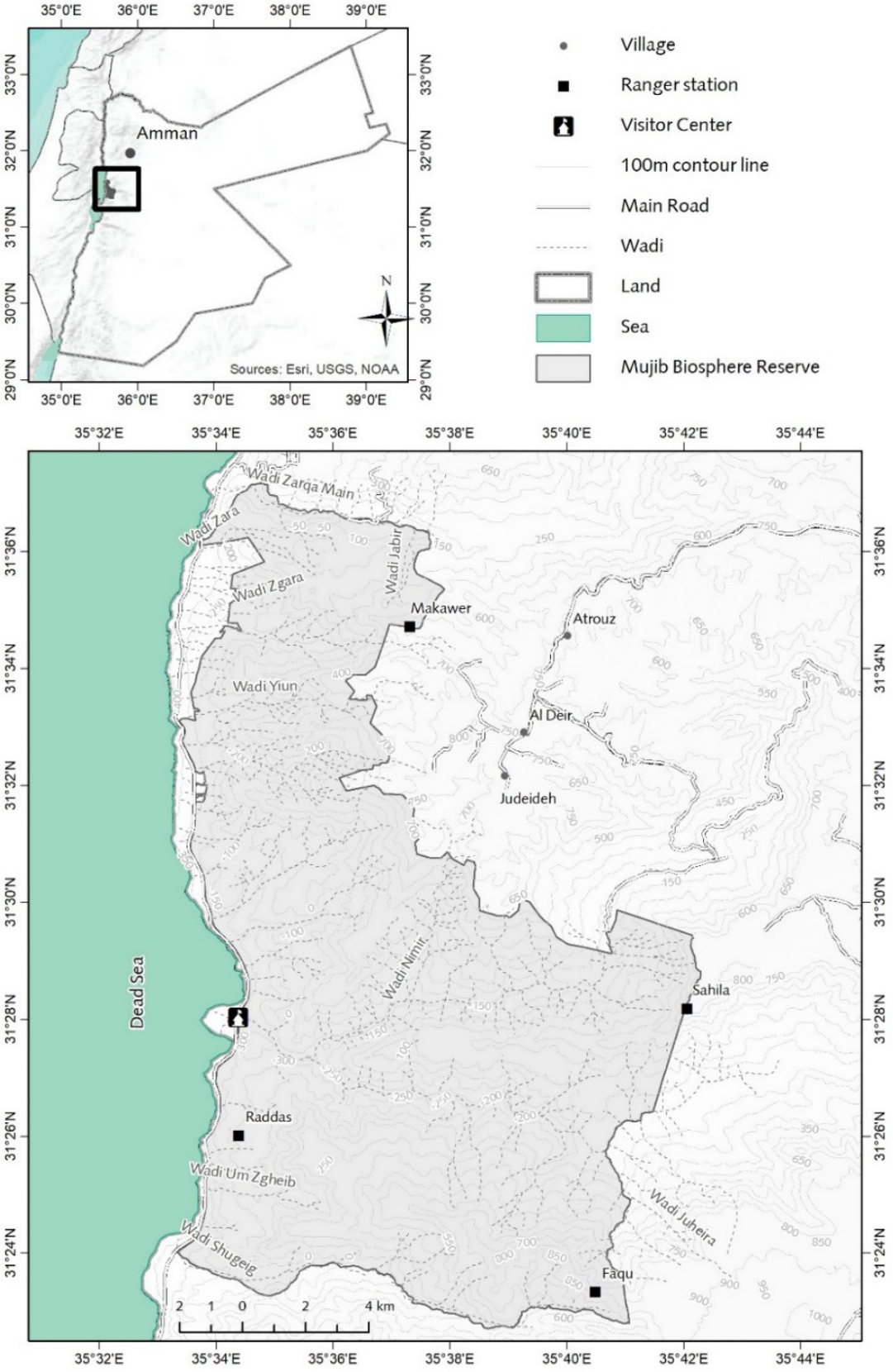

Figure 1. Location map of Mujib Biosphere Reserve within Jordan**.**

Species Occurrence Data: Occurrence records for *C. nubiana* were compiled based on historical and current observations collected between 2005 and 2013. These data were gathered systematically by reserve rangers during their daily patrolling activities, and supplemented by verified historical accounts from published literature (Habibi, 1994; IUCN SSC Caprinae Specialist Group, 2000). Each observation was georeferenced and verified to ensure spatial accuracy (Figure 2).

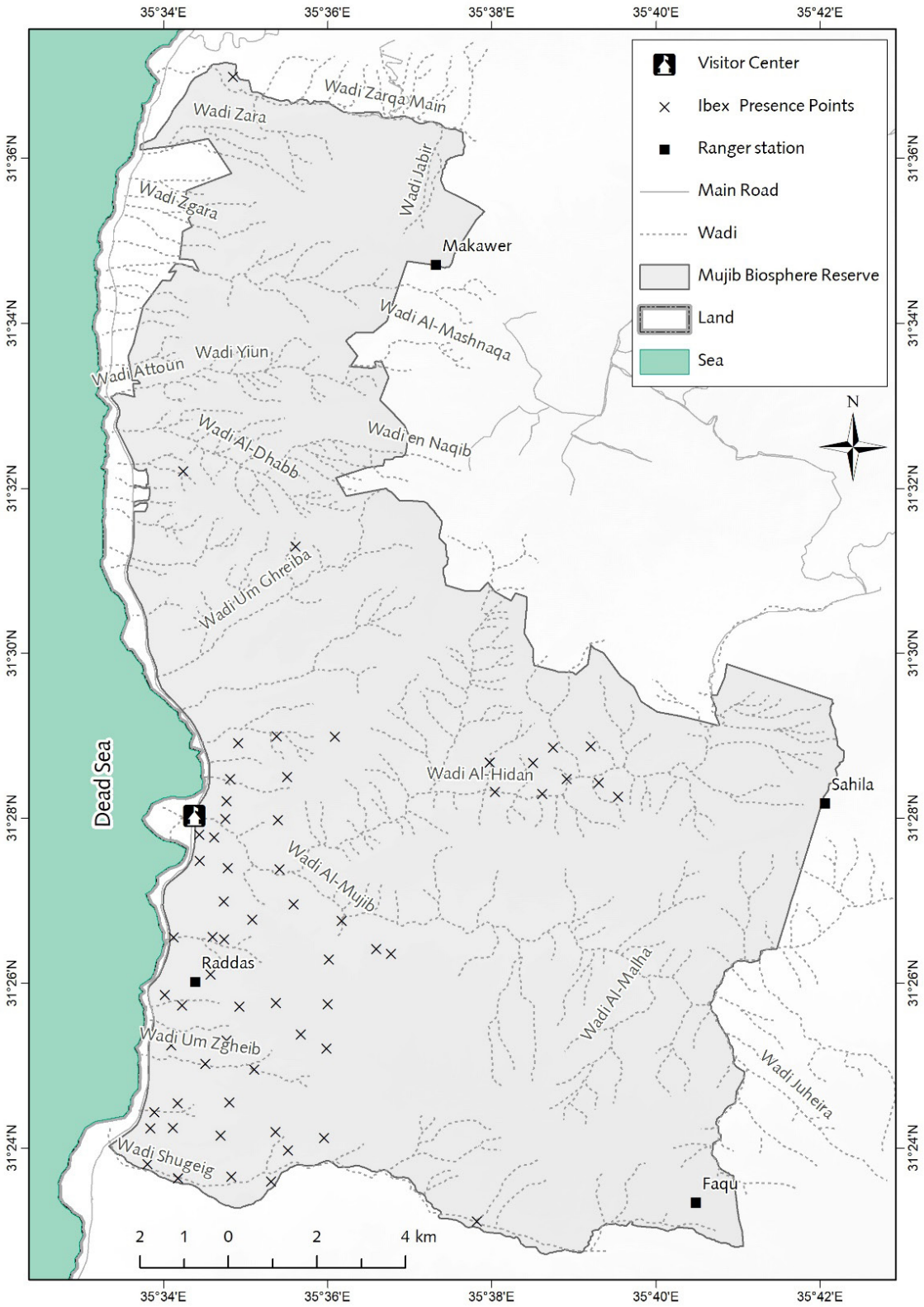

Figure 2. The distribution of the ibex occurrence records in Mujib Biosphere Reserve

Environmental Variables:

A set of environmental predictors was selected based on the species' known ecological preferences and consultations with biodiversity experts. Variables were selected to represent key ecological gradients and potential habitat constraints and were processed at a 30-meter resolution in raster format, as summarized in Table 1.

Table 1. Environmental Variables and Data Sources

Environmental Variable	Source	Year
Digital Elevation Model (DEM)	ASTER Global DEM (NASA, 2011)	
Slope	Derived from DEM (via ArcGIS Spatial Analyst)	
Geology	Natural Resources Authority of Jordan (Geological Map, 1988)	1988
Vegetation Types	Eisawi (2014)	2014
Annual Precipitation	Jordan Meteorological Department (climatological averages)	
Distance to Springs	Royal Jordanian Geographic Center (Spring Locations, 2009)	
Distance to Mujib Valley	Royal Jordanian Geographic Center (Hydrology Layers, 2009)	2009
Distance to Main Roads	Google Earth Digitized Road Network	2009
Distance to Springs	Jordan Meteorological Department (climatological averages)	2013

Environmental layers were pre-processed using ArcGIS 10.8 (ESRI, 2020) following standard protocols (Elith and Leathwick, 2009). The slope layer was derived from the DEM, and Euclidean distances to springs, valleys, and roads were computed. A composite map of the environmental variables used is shown in Figure 3.

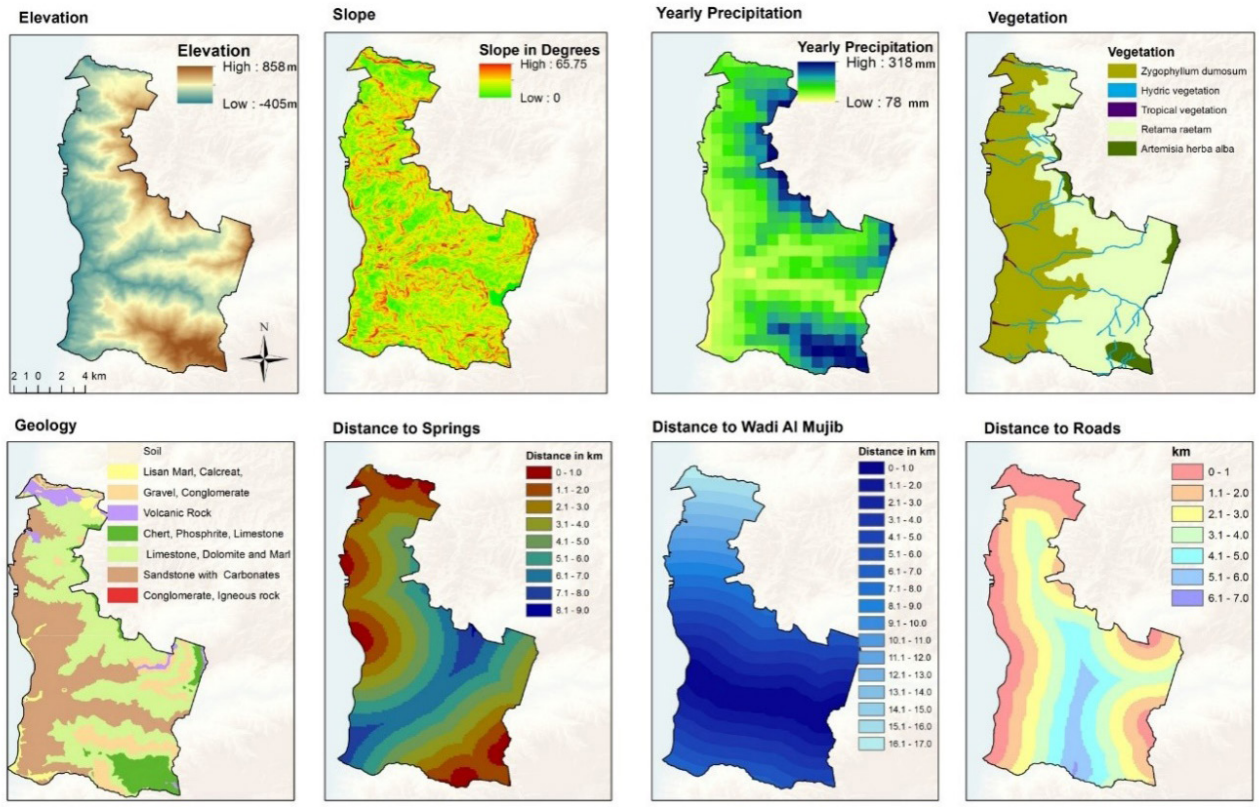

Figure 3. Environmental layers prepared for the species distribution modeling analysis.

Species Distribution Modeling Approach:
Species distribution modeling (SDM) was conducted using the Maximum Entropy algorithm implemented in MaxEnt version 3.4.1 (Phillips *et al.,* 2006). MaxEnt is particularly suitable for presence-only data and has been demonstrated to outperform other modeling approaches (Elith *et al.,* 2011). Model settings included 10 replicates with a cross-validation scheme, randomly splitting occurrence data into 70% training and 30% testing sets. Default regularization parameters were used to minimize overfitting. Predictive performance was evaluated across the ensemble of 10 replicate models.

Model Calibration and Threshold Selection:
Continuous habitat suitability maps generated by MaxEnt were thresholded to create binary habitat maps. The threshold used was the Equal Training Sensitivity and Specificity (ETSS), recognized for balancing omission and commission errors and widely used in conservation applications (Liu *et al*., 2013). The ETSS threshold was calculated for each replicate, and the mean threshold was applied to the averaged prediction map (Figure 4).

Model Evaluation:
Model predictive performance was assessed using the Area Under the Receiver Operating Characteristic Curve (AUC). Mean AUC values were computed over the 10 replicates. AUC values were interpreted following standard thresholds (Swets, 1988): values >0.9 indicate excellent, 0.8–0.9 good, and 0.7–0.8 fair discrimination. Mean AUC for the final model ensemble was 0.88, indicating good predictive performance.

Variable Importance Analysis:
A Jackknife test was conducted in MaxEnt to assess the importance of individual environmental predictors. This method measures the model's training gain with each variable individually and when each variable is excluded (Phillips *et al*., 2006).

Results Post-Processing:
Habitat suitability predictions were averaged across all replicates, and a final binary map of predicted suitable habitat was generated. The extent of suitable habitat was quantified and compared to the total area of the reserve to assess habitat availability for *C. nubiana*.

Results

The MaxEnt model produced habitat suitability maps highlighting the spatial distribution patterns of *C. nubiana* within Mujib Biosphere Reserve (Figure 5). The continuous logistic output values ranged from 0 (unsuitable) to 1 (highly suitable), with the highest predicted suitability concentrated in areas characterized by steep slopes and moderate proximity to water sources. Approximately 18% of the reserve was identified as suitable habitat based on the model outputs. The predicted high suitability zones were located along the western escarpments of the reserve. The spatial predictions showed that areas near perennial watercourses exhibited consistently higher habitat suitability compared to the surrounding plateau and desert zones. The areas classified as having high suitability were primarily composed of rugged cliffs and narrow valleys — typical habitats for *C. nubiana*.

Binary Habitat Classification

Applying the Equal Training Sensitivity and Specificity (ETSS) threshold yielded a binary classification map (Figure 4). Areas exceeding the ETSS threshold were classified as suitable habitat, whereas areas below the threshold were considered unsuitable. Using this approach, approximately 17% of the total area of Mujib Reserve was categorized as suitable habitat for the Nubian ibex. The binary map indicated habitat fragmentation, with suitable areas often isolated and aligned with major wadis.

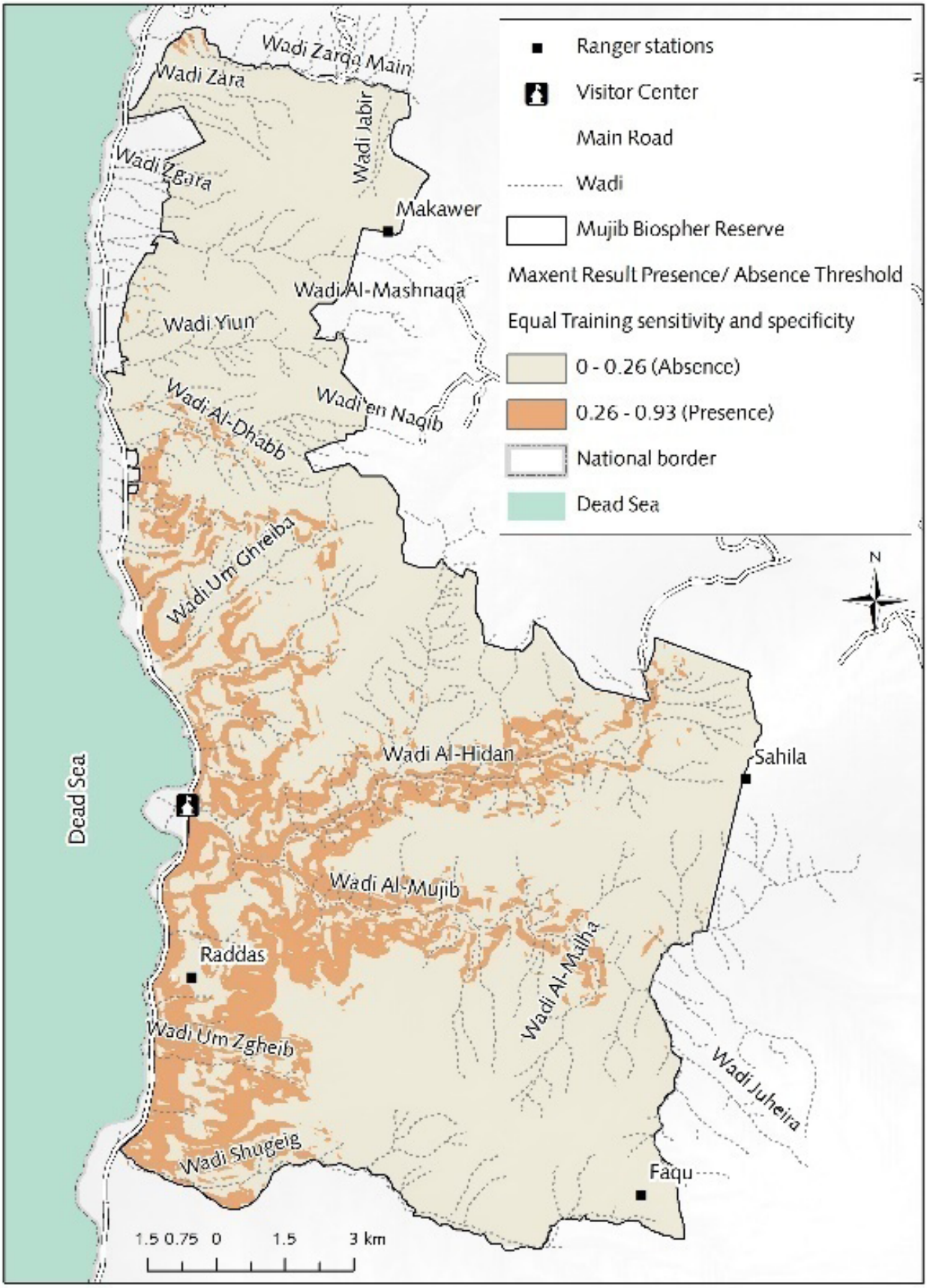

Figure 4. Threshold-dependent binary classification based on ETSS.

Model Performance Evaluation

The mean Area Under the Curve (AUC) across the 10 model replicates was 0.88 (±0.02), the omission rates were consistent across the training and testing datasets, further supporting the stability of the model and suggesting minimal overfitting and indicating good model performance and reliable discriminatory capacity between suitable and unsuitable habitats. According to standard AUC interpretation thresholds, values between 0.8 and 0.9 reflect robust predictive capability, supporting the credibility of the generated distribution model.

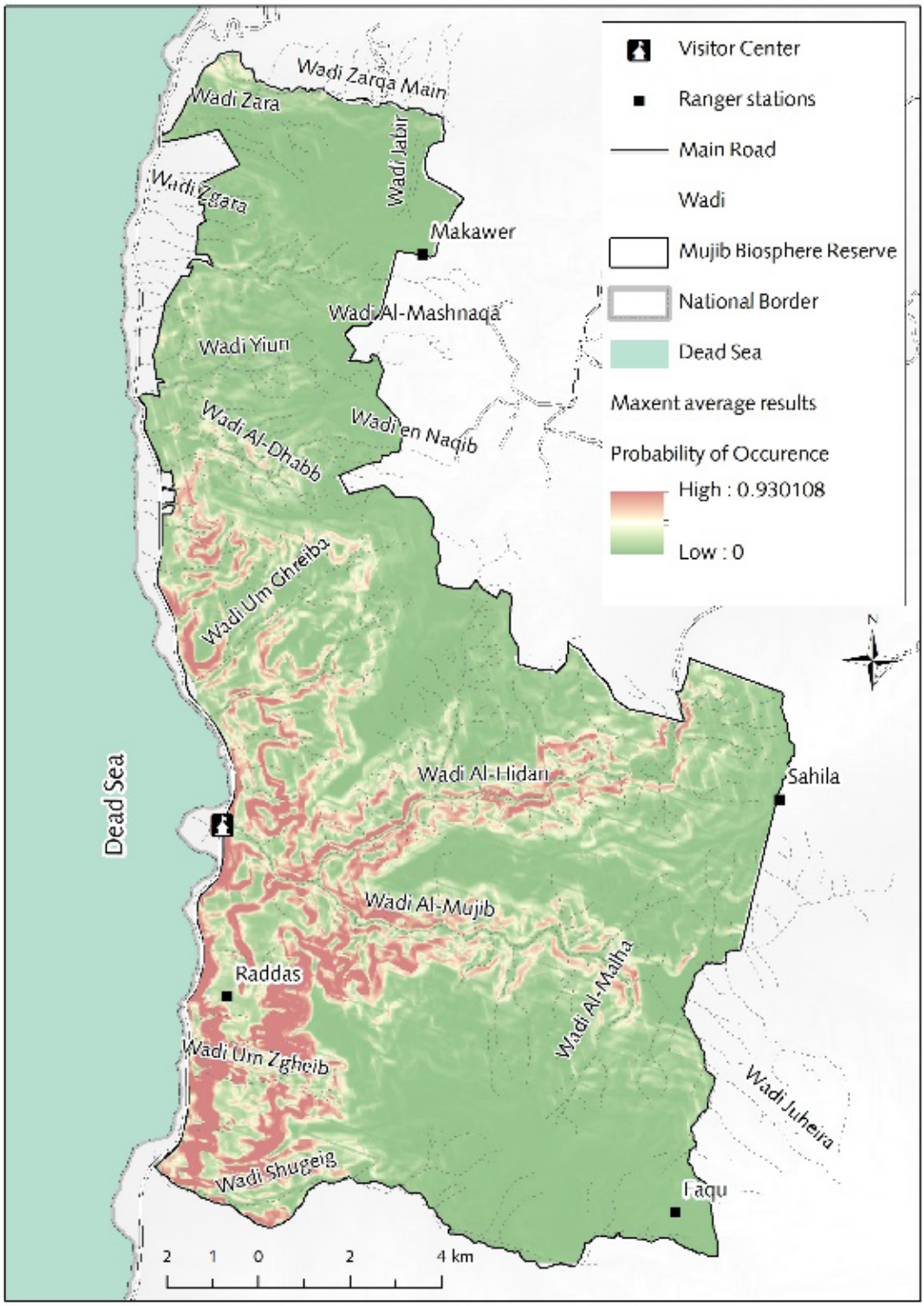

Figure 5. Average Probability of occurrence for Nubian Ibex western Mujib Biosphere Reserve

Variable Importance and Response

The Jackknife analysis of regularized training gain (Figure 6) demonstrated that slope was the most influential environmental variable, achieving a training gain of 0.75 when used in isolation. This was notably higher than all other variables evaluated. Yearly precipitation was the second most important predictor, with a training gain of 0.55. Elevation and geology followed, with training gains of 0.35 and 0.32, respectively. Vegetation type had a moderate influence with a gain of 0.28. In contrast, other environmental variables, including distance to roads, distance to springs, and distance to Wadi Mujib, exhibited very low individual contributions, each with training gains below 0.1.

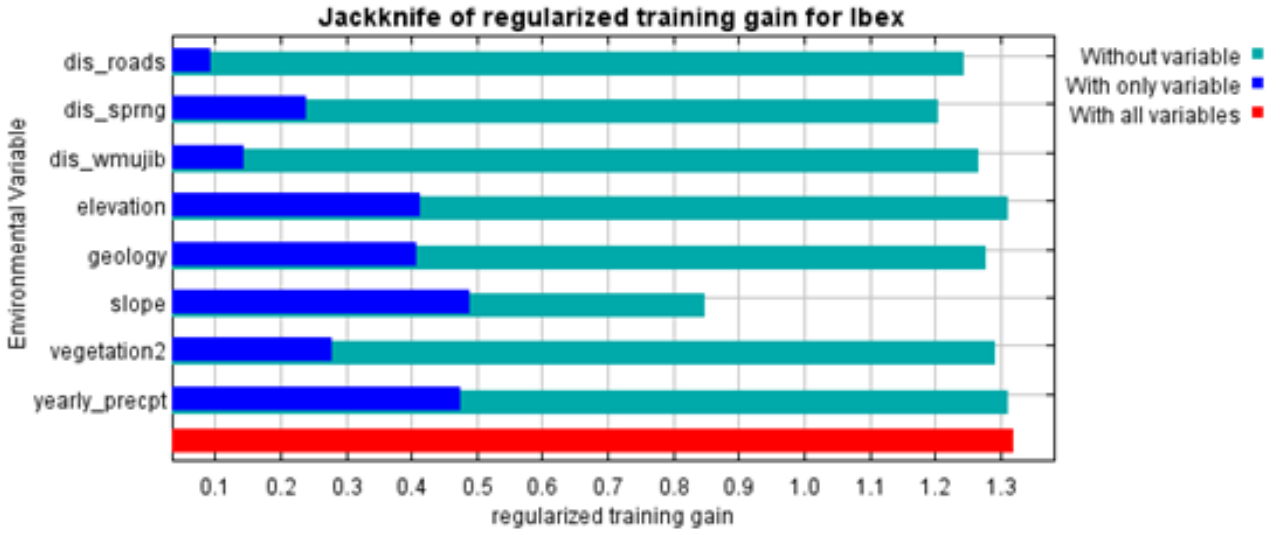

Figure 6. Results of the Jackknife test of variable importance.

The pattern of variable importance was further confirmed by the drop in training gain observed when slope was omitted from the model, indicating that slope provided unique information not compensated for by other variables. Similar, although less pronounced, reductions in training gain were observed with the removal of yearly precipitation, elevation, and geology. These results collectively highlight the primary role of topographic and climatic factors in determining the habitat suitability for *C. nubiana* within the study area, as opposed to proximity to anthropogenic features or specific vegetation types.

Ground-Truth Validation

A total of 82% independent records were located within the areas predicted by the MaxEnt model as high-suitability zones, based on the applied ETSS threshold. The spatial distribution of the validation records showed a clear overlap with the predicted high-suitability areas, primarily concentrated along the western cliffs of the Mujib Biosphere Reserve and the Mujib and Hidan wadis. Validation presence points consistently aligned with regions where the logistic output values exceeded the threshold, indicating consistency between the model's predicted suitable habitats and the independent occurrence data. A validation map was generated, illustrating the correspondence between the independent sightings and the modeled high-suitability areas (Figures 5 and 6). The overlay analysis indicated that the majority of validation points fell within zones classified as suitable, reinforcing the spatial agreement between predicted habitat suitability and field observations.

Discussion

Strengths of Using MaxEnt for *Capra nubiana* Modeling

The choice of MaxEnt was critical for achieving reliable predictions given the presence-only nature of *C. nubiana* occurrence data in Mujib Biosphere Reserve. MaxEnt has consistently demonstrated clear performance in similar arid and mountainous contexts globally, offering strong resistance to overfitting even with small sample sizes (Elith *et al*., 2011; Merow *et al.,* 2013). In the Middle East, recent applications for Scimitar-horned Oryx in Tunisia *Oryx dammah* (Louhichi *et al.,* 2024) revealed MaxEnt's robustness under rugged terrain conditions, confirming its appropriateness for species with niche specialization in harsh environments. The model's AUC of 0.88 is consistent with these studies and exceeds thresholds set in broader biodiversity modeling benchmarks (Franklin, 2010), demonstrating discrimination capacity. Notably, MaxEnt's capacity to integrate complex environmental relationships was instrumental in identifying the non-linear effects of slope and precipitation — two factors that emerged as primary habitat determinants.

Comparative Insights with National and Regional Studies

In Jordan, species distribution modeling remains limited for mountain ungulates. Previous expert-based suitability mapping for *C. nubiana* (RSCN, 2012) highlighted general habitat zones but lacked the resolution and statistical background presented in this study. The findings of this study also come in agreement with regional studies on mountain goats (*Oreamnos americanus*) in North America, where terrain ruggedness and water proximity are similarly critical (Gross *et al.,* 2002). This reinforces the ecological principle that mountainous ungulates, regardless of geographic location, exhibit convergent habitat preferences shaped by predator avoidance strategies and hydration requirements. Locally, the current work acknowledged the spatial resolution and ecological depth of earlier habitat classifications within Mujib Biosphere Reserve (Al-Eisawi, 1996 and 2014), which were based primarily on vegetation and geomorphological mapping without species-specific validation. The integration of ground-truthing in this study further strengthens the credibility of the model outcomes.

While alternatives such as Random Forest and Boosted Regression Trees (BRT) have gained traction for distribution modeling, studies in comparable environments suggest MaxEnt maintains better performance with limited and biased occurrence datasets (Wisz *et al.,* 2008). Random Forest models require large, balanced datasets, often unavailable for elusive and endangered species like *C. nubiana* (Breiner *et al.,* 2015). The use of MaxEnt, validated by strong AUC performance and low omission rates, supports its continued recommendation for species with sparse datasets. Furthermore, MaxEnt's internal Jackknife test allows for variable contribution analysis, a feature not inherently available in other machine learning approaches. Identifying slope and precipitation as critical variables supports the species' known eco-physiological constraints (Habibi, 1994).

Advancements Over Traditional Suitability Mapping

Habitat suitability assessments in Jordan have traditionally relied on expert-based evaluations and land-cover associations (Child and Grainger, 1990). Although these approaches have contributed foundational knowledge, they are inherently subjective and sometimes fail to capture the full complexity of multi-scalar environmental determinants influencing species distributions. In contrast, species distribution models (SDMs), particularly MaxEnt, provide a statistically robust, quantitative, and replicable framework for habitat prediction. These models account for non-linear relationships among environmental variables and are capable of projecting future scenarios under changing climatic and

land-use regimes, thereby offering enhanced utility for conservation planning (Araújo and Peterson, 2012).

The present model, operating at a spatial resolution of approximately 30 meters, facilitates the translation of results into actionable field-level management interventions. High-suitability areas delineated by the model can inform the spatial allocation of critical resources such as artificial water supplementation sites and optimized patrolling efforts. These applications have the potential to increase operational efficiency and conservation efficacy. For instance, camera trap deployment guided by SDM outputs has been shown to improve detection probabilities and reduce monitoring costs, particularly in the context of ungulate population studies (Burton *et al*., 2015). Similarly, the strategic concentration of patrolling efforts in high-probability areas has demonstrated significant gains in conservation outcomes, as evidenced by the improved protection of *Diceros bicornis* in Etosha National Park, Namibia (Leader-Williams *et al*., 2011).

Furthermore, the spatial outputs generated by the SDM offer valuable insights for habitat management and restoration planning. Fragmented habitat patches identified through the model underscore the necessity of maintaining or enhancing landscape connectivity to mitigate the adverse effects of habitat isolation. The development of wildlife corridors between suitable yet disjointed habitats may reduce the risk of genetic bottlenecks and promote metapopulation dynamics.

Limitations and Future Directions

Despite the strengths, limitations exist. The presence-only data may be biased towards areas accessible to patrols. Future models should incorporate systematic survey designs and, where possible, presence-absence data to improve model robustness. Additionally, while slope and precipitation were key predictors, microhabitat variables like forage quality and predation risk could refine model precision if integrated into future analyses. Expanding environmental layers to include dynamic variables such as Normalized Difference Vegetation Index (NDVI) could also enhance temporal modeling capabilities and can be incorporated to anticipate range shifts, a practice increasingly recommended in SDM applications for arid-land ungulates (Reside *et al.,* 2012).

In conclusion, the application of species distribution modelling in this study provides a clear spatial framework to inform conservation strategies for *C. nubiana* in Mujib Biosphere Reserve. Beyond identifying suitable habitat, the integration of field validation and expert judgment enhances the ecological credibility of the results and demonstrates the practical utility of SDMs in challenging arid landscapes. These findings underline the importance of aligning predictive tools with on-the-ground knowledge to improve reserve-level decision-making. As environmental pressures intensify, such evidence-based spatial analyses will be increasingly vital for adaptive management, long-term monitoring, and the development of targeted interventions that support the persistence of vulnerable mountain ungulate populations.

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Short Communication

Short Note on the Observation of Leucistic Colour Aberration in Indian Rock Pigeon in Chennai, Tamil Nadu, India

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Leucism is a pigment abnormality in birds which causes partial or complete loss of melanin in their feathers. Initially defined as all-white plumage with normal eyes, its use has broadened to include diluted pigments or isolated white feathers (Davis, 2007). Unlike albinism, where the lack of the enzyme tyrosinase leads to complete melanin absence, leucism retains normal eye colouration (Konter, 2015). This observation records a case of partial leucism in the Indian Rock Pigeon (*Columba livia*) on 10 November 2024 in Perungalathur (12.84868° N, 80.06402° E), Chennai, Tamil Nadu (Figure 1).

(Figure 1. Leucistic *C. livia* feeding on grains in Chennai, Tamil Nadu)

The pigeon displayed a white morph plumage, with symmetrical depigmentation patches across its wings, tail and head, yet retained its usual flock behaviour. This phenomenon is categorized by its distinct developmental anomaly affecting the melanoblast migration from the neural crest during early embryonic stages (Oisoe *et al.* 2013). This results in pigment-free feathers and skin, although carotenoids, if present, remain unaffected

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(van Grouw, 2021). The persistence of symmetrical white patches, as noted in this pigeon, aligns with prior findings that leucistic patterns are static and unaffected by age (van Grouw, 2022). Documenting such rare pigmentation anomalies is essential for understanding their genetic underpinnings and ecological implications (Samson *et al*. 2016). In this observation's context, an urban environment like Chennai is known for its highly disturbed habitat due to high anthropogenic activities. This, in turn, may amplify such anomalies due to genetic bottlenecks or environmental stressors. While these leucistic individuals can suffer from increased predation or social exclusion (Reis *et al.* 2019). However, this pigeon's integration from this observation suggests its adaptability hence the social factors might play a less critical role in survival. Additionally, the feather pigmentation in birds is often linked to mate selection (Jawor & Breitwisch, 2003) therefore raising questions on how leucistic birds influence or are influenced by these dynamics in their populations (Roulin, 2004). Here the leucistic plumage in *C. livia* indicates the need for standardizing terminology to accurately describe avian colour aberrations. Moreover, leucism is often confused with conditions like progressive greying or dilution, which have distinct genetic and phenotypic characteristics (van Grouw, 2021). In conclusion, documenting such occurrences can greatly enhance our understanding of the evolution and genetic basis of avian pigment disorders. It also sheds light on their ecological relevance, especially in urban areas where anthropogenic pressures influence wildlife genetics. By enhancing public awareness and encouraging citizen science platforms, more extensive datasets on such anomalies can be collected. These datasets can be studied to support avian biodiversity conservation efforts. This observation also contributes to the understanding of avian colour aberrations and nuances of urban wildlife.

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Short Communication

Arid-System Carnivore at Low Detectability: Evidence of Mellivora capensis Persistence Near Zaranik

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Abstract

We report a contemporary, georeferenced record of the honey badger (*Mellivora capensis*) from North Sinai, Egypt: an adult skull found on 13 March 2023 in psammophytic shrubland ~5 km from Zaranik Protected Area. Diagnostic cranial and dental traits confirm identity. The shrub-dominated dune–sabkha–wadi mosaic typifies the species' arid-land ecology and low detectability, indicating patchy occupancy along the northeastern Sinai margin. Although based on a single specimen, this spatially referenced record provides contemporary evidence of persistence and motivates targeted, non-invasive monitoring to refine occurrence mapping. To our knowledge, it constitutes the first georeferenced, post-2014 physical evidence of *M. capensis* in northeastern Sinai and aligns with habitat features predicted to support arid-carnivore occurrence.

Keywords:

honey badger; Mellivora capensis; North Sinai; Egypt; Zaranik Protected Area.

Introduction

The honey badger (*Mellivora capensis*, Mustelidae) is a wide-ranging omnivore occurring across Afro-Arabian drylands and adjacent steppes (Begg *et al., 2013;* Do Linh San *et al., 2016*). Despite its broad extent, encounter rates are generally low due to nocturnal and fossorial habits and naturally low densities (*Begg et al., 2003*). In Egypt and the Arabian Peninsula, records are scattered, with few or no verified records from the Nile Valley and use of habitats offering vegetative cover and denning opportunities (*Basuony et al., 2010; Vanderhaar & Hwang, 2003*). In northeastern Sinai, the species was reported just south of Ain (Ein) el-Qudeirat (*Saleh & Basuony, 2014*). Here, we report a 2023 North Sinai record (approximately 5 km from Zaranik Protected Area) and contextualize it alongside prior published occurrences from northeastern Sinai near Ain (Ein) el-Qudeirat in Egypt, the Negev system in Palestine, Burqu Nature Reserve in northeastern Jordan, and Tabuk Province in Saudi Arabia, underscoring the species' regional rarity and conservation relevance (*Saleh & Basuony, 2014; Hamidan, 2023; Aloufi & Amr, 2018; Werner, 2012*). To our knowledge, this is the first georeferenced, physical record post-2014 confirming persistence of *M. capensis* in northeastern Sinai and it aligns spatially with habitat features predicted to support arid-carnivore occupancy (dune–sabkha–wadi mosaics).

Materials and Methods

The site lies on the North Sinai coastal plain, approximately 5 km from the boundary of Zaranik Protected Area. Substrates comprise calcareous sands and semi-fixed dunes intergrading with halophytic depressions (sabkha margins) and low gravelly plains (*El-Bana, 2006; El-Bastawisy, 2006; Galal, 1999*). Vegetation is a psammophytic–halophytic mosaic dominated by perennial

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shrublands and grass–forb patches—principally *Convolvulus lanatus, Echiochilon fruticosum, Pancratium sickenbergeri*, and *Centropodia forsskaolii*, with scattered Tamarix—underlain by an ephemeral winter–spring annual layer (notably *Erodium crassifolium, Senecio glaucus coronopifolius, Ononis serrata, Polycarpon succulentum*) that flourishes after winter precipitation (*Attum et al., 2021*). This habitat matrix offers potential den sites via reused fox burrows—especially those of red fox (*Vulpes vulpes*) and fennec fox (*Vulpes zerda*)—and within large rodent burrow systems *(jirds, gerbils, jerboas*), and it provides foraging opportunities for *Mellivora* through invertebrate nests, small vertebrates, and carrion (*Hoath, 2009; Soliman & Mohallal, 2016*).

Field observation and identification

The opportunistic field observation was georeferenced in situ with a handheld GPS under the WGS84 datum (EPSG:4326); device-reported horizontal error was <10 m, provided alongside the coordinates. Species identity was determined from diagnostic cranial and dental characters consistent with regional treatments of the honey badger *Mellivora capensis* and contemporary distribution syntheses for the Levant and adjoining Arabia.

To situate our record in its regional biogeographic context, we collated published occurrences from three peer-reviewed sources: a 30-year synthesis of small-carnivore records from Palestine (*Werner, 2012*), a faunal account from Tabuk Province, northwestern Saudi Arabia (*Aloufi & Amr, 2018*), and a locality report from Burqu, eastern Jordan (*Hamidan, 2023*). For records reporting explicit coordinates, we transcribed values verbatim. Where publications provided only toponyms (e.g., checklist entries or distribution maps), we derived coordinates via gazetteer-based point–radius georeferencing (WGS84) at the smallest unambiguous spatial unit and retained the resulting coordinate uncertainty for interpretation rather than analytical weighting. Spatial comparisons used great-circle (haversine) distances, expressed in kilometers, between the Sinai observation and the nearest verifiable locality within the Negev system in Palestine; additional distances were calculated to the Tabuk and Burqu localities to summarize regional context. No live animals were handled, and the skeletal remains were documented under the field authorization framework of the Nature Conservation Sector.

Results

Egypt — North Sinai (31.024090°, 33.343820°). On 13 March 2023, skeletal remains consistent with an adult *Mellivora capensis* were located within psammophytic shrubland on the northern Sinai coastal plain (≈5 km from Zaranik Protected Area). The skull exhibits the robust cranium, broad rostrum, and dentition characteristic of *Mellivora* (Figure 1).

For spatial context, distances from the North Sinai site to three literature-based localities are as follows, ordered by proximity:

(i) Palestine — Negev system; coordinates taken directly from the cited locality description cited in (*Werner, 2012*): ≈137 km.

(ii) Jordan — Burqu Nature Reserve (32.669095°, 37.835977°); observation on 2 July 2022 (*Hamidan, 2023*): ≈462 km.

(iii) Saudi Arabia — Tabuk Province (27.648889°, 38.615833°); coordinates as published (*Aloufi & Amr, 2018*): ≈635 km.

Discussion

The North Sinai record is consistent with post-2014 evidence for honey badger in northeastern Sinai—specifically the report from just south of Ain (Ein) el-Qudeirat—while earlier national syntheses listed no verified Egyptian records at the time

Figure 1. Skull of Mellivora capensis recovered from psammophytic shrubland on the North Sinai coastal plain, Egypt, 13 March 2023 (31.02409° N, 33.34382° E). Photographs by the author.

(*Saleh & Basuony, 2014; Basuony et al., 2010*). To our knowledge, this is the first georeferenced, post-2014 physical record confirming persistence of *Mellivora capensis* in northeastern Sinai, refining spatial context relative to Zaranik Protected Area. Persistence inference remains probabilistic; however, temporal proximity to recent records (2014–2023) strengthens the case for local continuity.

Interpreted against localities in southern Palestine (Negev) and additional points in Jordan and northwestern Saudi Arabia, the distributional pattern suggests patchy occupancy along shrub-dominated dunes, sabkha margins, and wadi systems rather than continuous distribution across the corridor (*Werner, 2012; Hamidan, 2023; Aloufi & Amr, 2018*). This accords with the species' arid-land ecology—low densities, nocturnal and fossorial habits, and reliance on cover and denning opportunities—which collectively reduce detectability even where the species persists (*Begg et al., 2003; Vanderhaar & Hwang, 2003; Begg et al., 2013*).

The regional dune–sabkha–wadi mosaic also supports small carnivores such as red fox (*Vulpes vulpes*) and fennec fox (*Vulpes zerda*), indicating ecological continuity that likely facilitates *Mellivora* persistence despite detection scarcity. Carcasses and skeletal remains provide valuable evidence for such low-density species, though spatial inference should remain restricted to the immediate discovery context. Targeted non-invasive monitoring around Zaranik—camera trapping, track-and-sign surveys, and documentation of opportunistic remains—would enhance detectability and refine occurrence mapping without assuming continuity between widely spaced observations.

Conclusion

This study provides contemporary, georeferenced confirmation of the honey badger (*Mellivora capensis*) in North Sinai, representing the first post-2014 physical evidence of persistence in northeastern Egypt. The record supports a pattern of patchy occupancy within arid dune–sabkha–wadi mosaics that typify the species' ecology across the Afro-Arabian corridor. Focused, non-invasive monitoring around Zaranik Protected Area—such as camera trapping and track-and-sign surveys—should help verify continuity, improve detectability, and inform conservation strategies for low-density carnivores in desert ecosystems.

Author Contributions

B.R. conceived the study, conducted fieldwork, analyzed data, and wrote the manuscript.

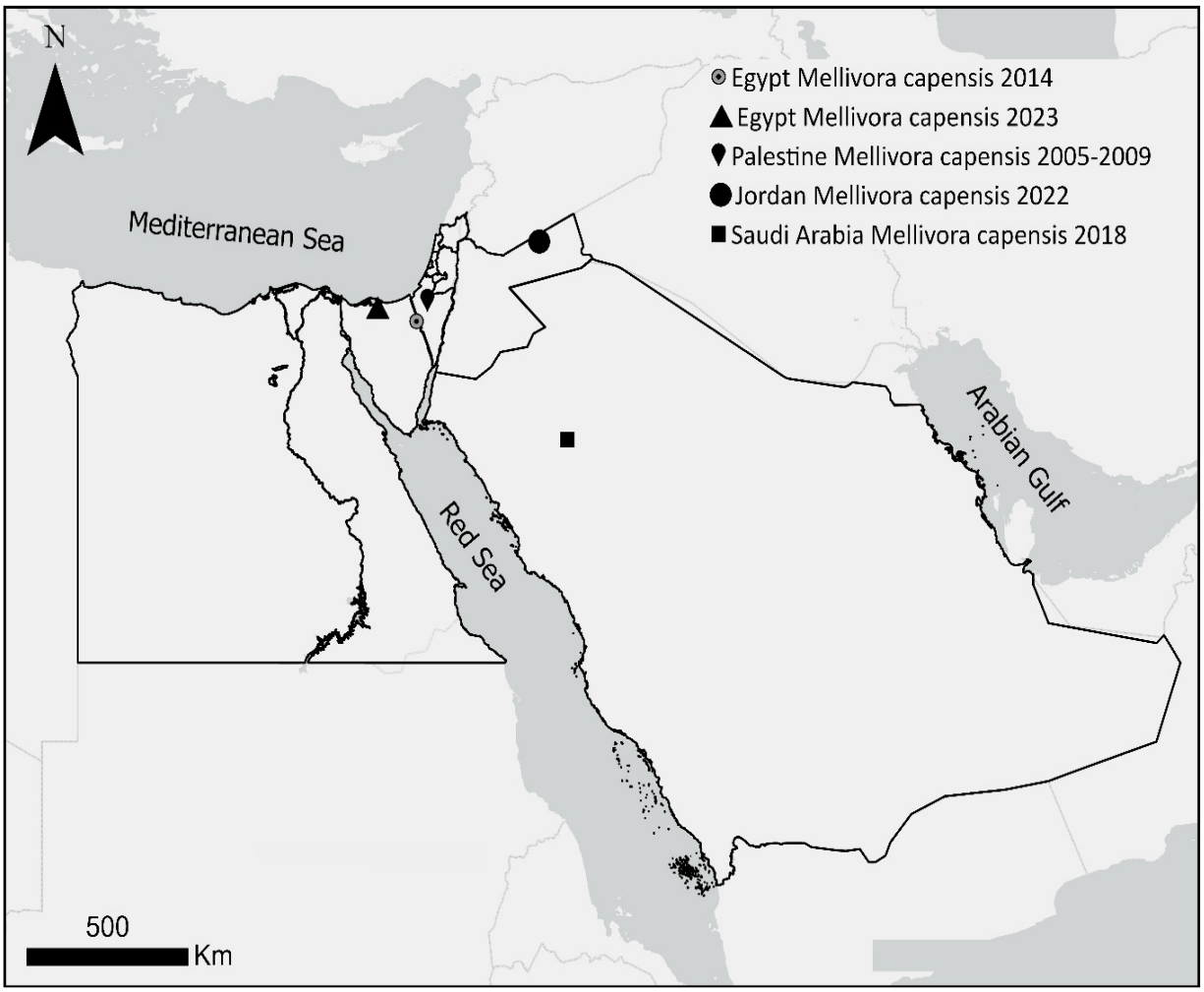

Figure 2. Contemporary *Mellivora capensis* records used for spatial context: North Sinai (this study), a locality in southern P (Negev), Burqu Nature Reserve (Jordan), and a locality in Tabuk Province (Saudi Arabia).

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The Royal Society for the Conservation of Nature

Is a national organization devoted to the conservation of Jordan's wildlife. It was founded in 1966 under the patronage of His Majesty the late King Hussein and has been given responsibility by the government to establish and manage protected areas and enforce environmental laws. As such, it is one of the few non-governmental organizations in the Middle East to be granted such a public service mandate.

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