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

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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.

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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 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

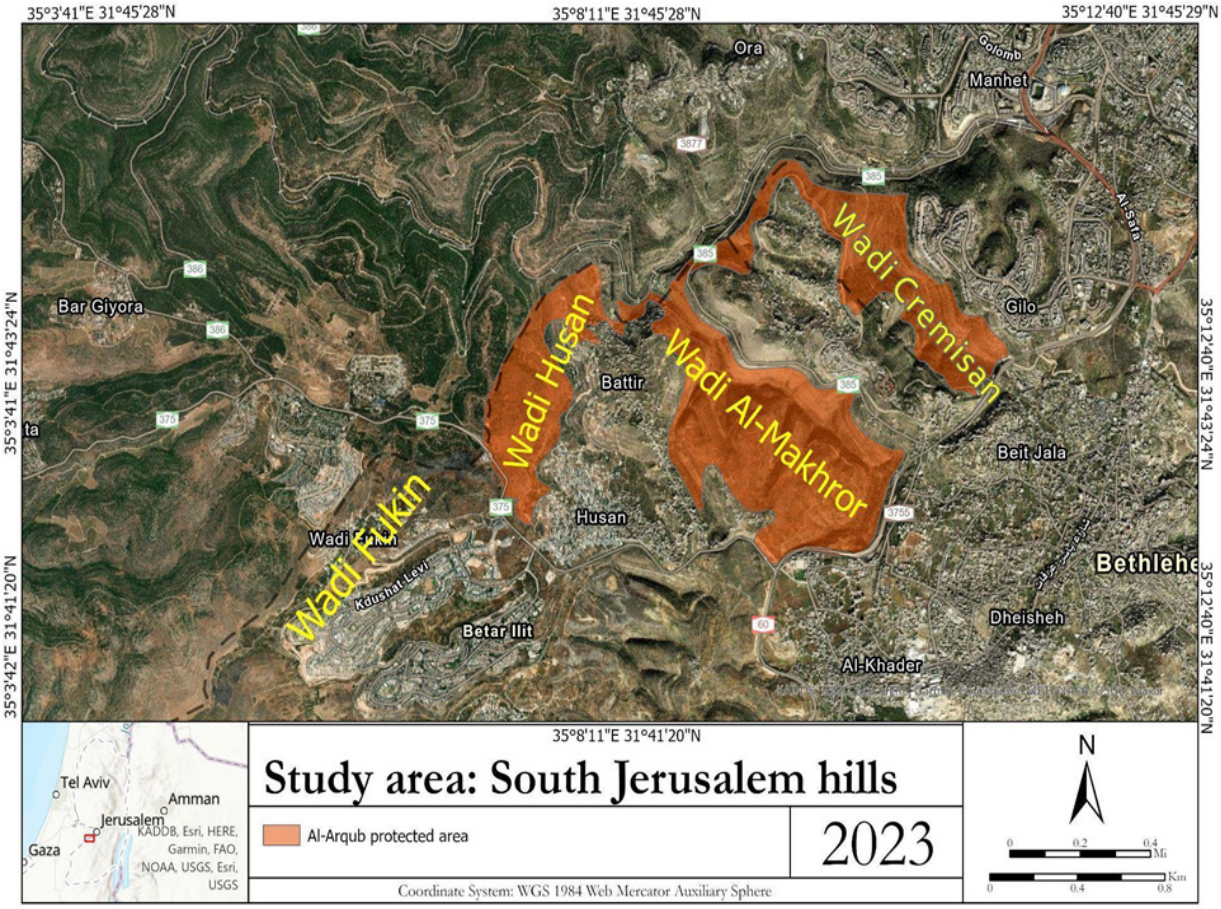

Figure 1. Map of the study area which include the three valleys designated a new protected area (Qumsiyeh et al., 2023a, 2023b) plus Wadi Fukin to the West.

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.

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

Table 1. A total of 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		

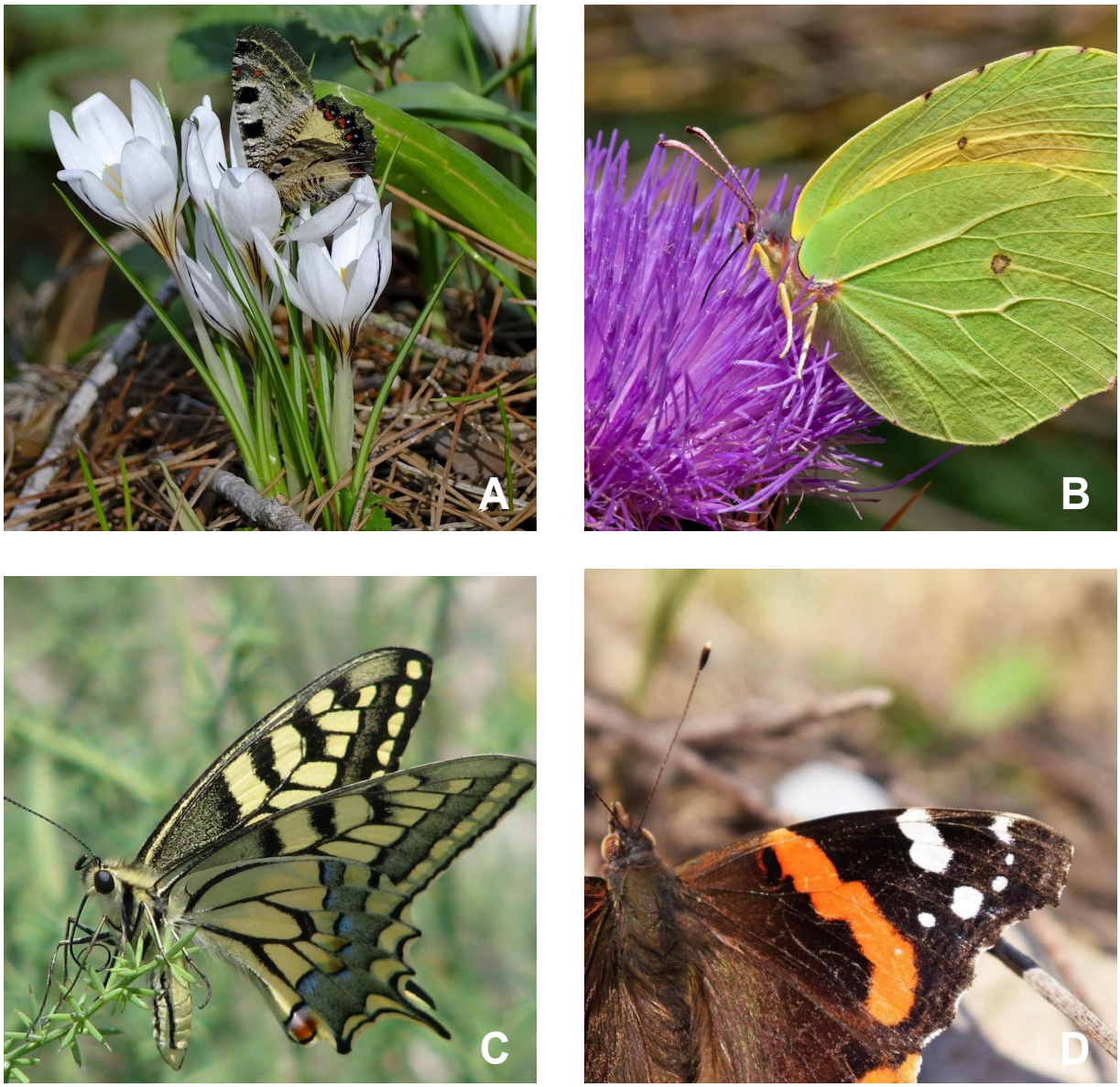

Figure 2. A) *Archon apollinus* on *Crocus hyemalis* plant**, B)** *Gonepteryx cleopatra* on *Onopordum spp*.**, C)** *Papilio machaon syriacus* on *Asparagus aphyllus* L., **D)** *Vanessa atalanta*

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).

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.

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

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 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.

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

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 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

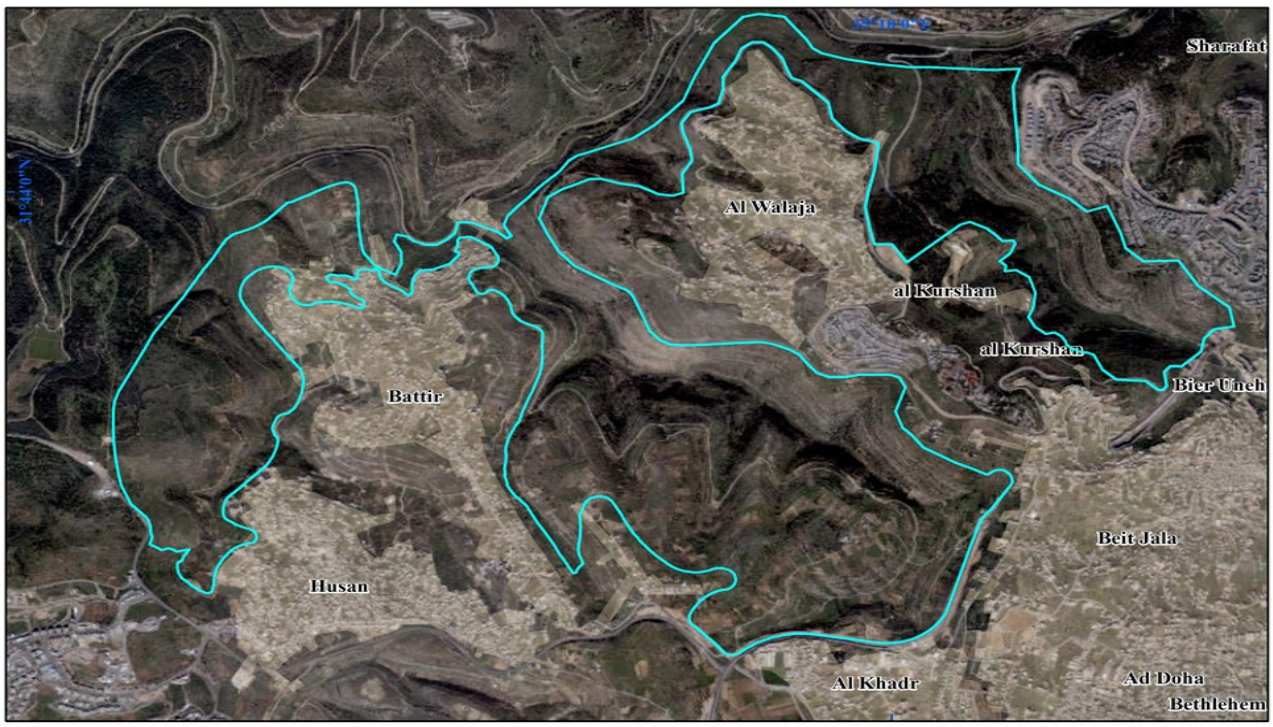

Fig. 4. Map of newly designated protected area. Note that the three valleys are connected by narrow corridors (Qumsiyeh et al. 2023a, 2023b). We studied these plus Wadi Fukin to the west also separated by a narrow corridor (see Figure 1)

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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