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Jordan Journal of Natural History

Editorial Preface

It is a pleasure to present issue 2 of volume (11) 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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We would like to reaffirm that the success of the journal depends on the quality of reviewing and, equally, the quality of the research papers published. In addition to being a hard-copy journal, JJNH is an open access journal which means that all contents are freely available for the users and their institutions free of charge. Users are allowed to read, download, copy, distribute, print, search, or link to the full texts of the articles in this journal without asking for prior permission from the publisher or the author. This is in accordance with the BOAI definition of open access.

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, 2024

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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 Jordan Journal of Natural History is published by the Conservation Monitoring Centre at the Royal Society for the Conservation of Nature, Jordan.

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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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Table of Contents

Jordan Journal of Natural History, 11 (2), 2024 Pages: 82-86

Oecobius putus O. Pickard-Cambridge, 1876 (Araneae: Oecobiidae) in Jordan

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Received: October 3, 2024; Revised: October 24, 2024; Accepted: November 3, 2024

Abstract: *Oecobius putus* O. Pickard-Cambridge, 1876, a spider of the family Oecobiidae is recorded from the Dead Sea region in Jordan for the first time. One adult male and one adult female were collected in April 2024 in a resort at the Dead Sea region, Jordan at the lowest place on Earth (altitude -381 m). Its illustrations and measurements are presented below.

Keywords: Araneae, Oecobiidae, *Oecobius putus*, Jordan.

Introduction

Oecobiidae Blackwall, 1862 is a small family of 129 spider species in seven genera with the largest genus being *Oecobius* Lucas, 1846 which includes ninety-three species worldwide (World Spider Catalog, 2024).

Oecobius spiders are commonly known as the "dwarf round-headed" or "star-legged" spiders. These small sized cribellate araneomorph spiders are characterized by large anal tubercle, that consists of two segments with a double fringe of curved setae. They are usually found under small star-shaped mesh-webs, and some species are synanthropic (Jocqué and Dippenaar-Schoeman, 2006).

Oecobius putus O. Pickard-Cambridge, 1876 is mainly distributed across Africa and Asia in addition to North America (World Spider Catalog, 2024). It is a "synanthropic" spider that lives in close association with people and benefits from their surroundings, especially small insects.

Until now, oecobiid spiders are represented in Jordan only by two species of two genera, namely,*Oecobius cellariorum* (Dugès, 1836) and *Uroctea hashemitorum* Bosselaers, 1999. This record increases the confirmed number of the known spider species from Jordan to thirty-eight species of thirty-one genera and seventeen families (El-Hennawy, 2020, 2023, 2024).

Material and Methods

One adult male and one adult female were found together inside a small star-shaped mesh-web on a wall in April 2024 in a resort at the Dead Sea area in Jordan. Both specimens were preserved in 75% ethanol and deposited at the Arachnid Collection of Egypt (ACE).

The abbreviations used include: AL = abdomen length, CL = carapace length, CW = carapace width, TL = total length. All measurements are in millimeters (mm).

Results

Family **Oecobiidae** Blackwall, 1862

Genus ***Oecobius*** Lucas, 1846

Oecobius putus O. Pickard-Cambridge, 1876 Figures 1-9.

Material examined. 1♂, 1♀, Mövenpick Resort at the Dead Sea, Jordan (31°43'1.44" N, 35°35'14.73" E, elevation -381 m), 28 April 2024, inside a star-shaped mesh-web on a wall, *leg*. H.K. El-Hennawy [ACE.2024.04.28.AR.001-002.JOR].

Description

Octavius Pickard-Cambridge collected males and females of *Oecobius putus* from upper Egypt in 1864 and desribed all these spiders as a new species in 1876 saying:

The legs have on the metatarsi and tarsi (of

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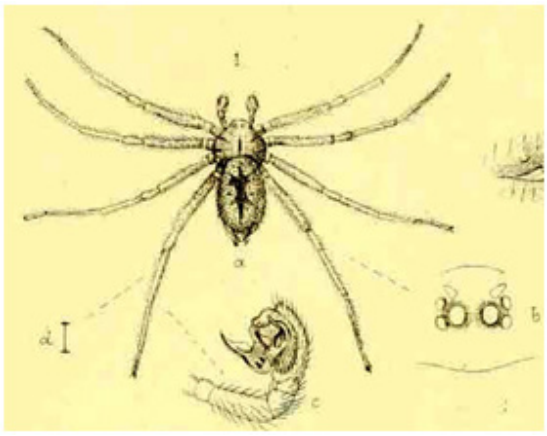


Figure 1. *Oecobius putus* O. Pickard-Cambridge, 1876 ♂ after (Pickard-Cambridge,1876: Plate LVIII, fig.1.).

Figure 2. *Oecobius putus* O. Pickard-Cambridge, 1876 habitus, dorsal view (♂).

Figures 3. *Oecobius putus* O. Pickard-Cambridge, 1876 habitus, dorsal view (♀).

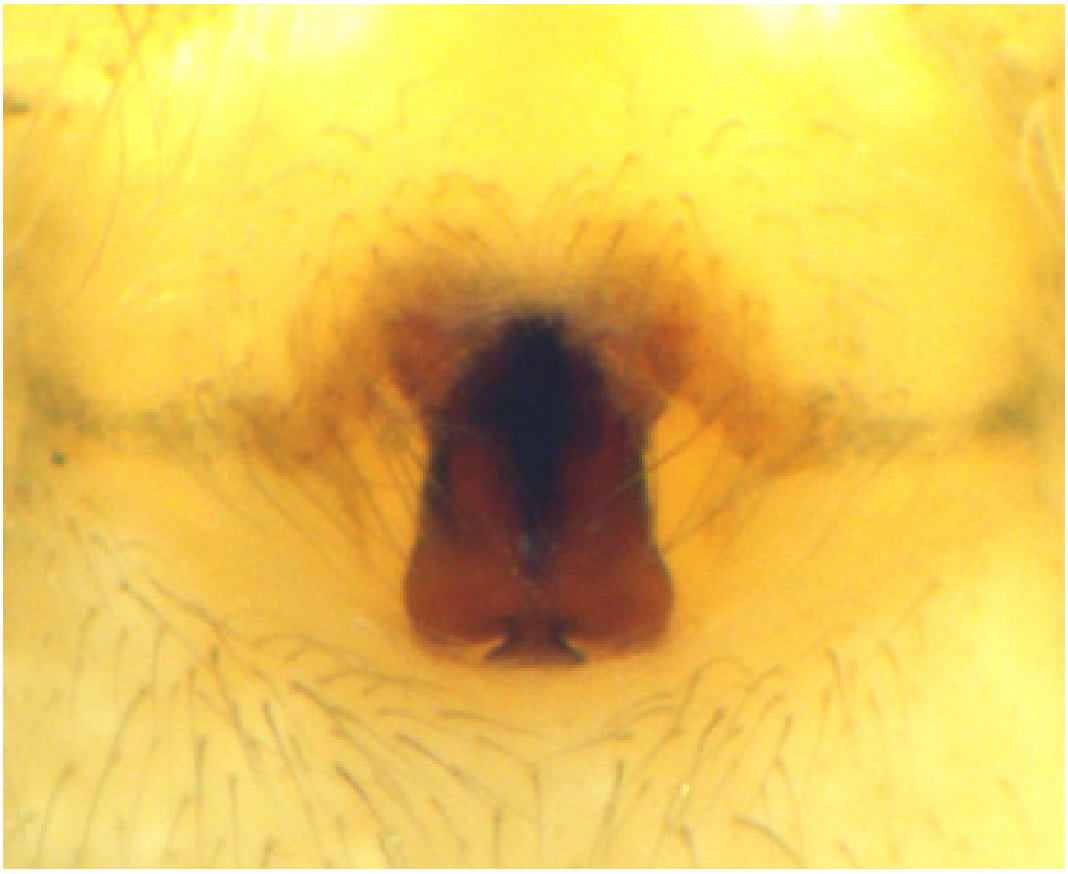
Figures 4. *Oecobius putus* O. Pickard-Cambridge, 1876. ♂, cephalothorax, dorsal view.

Figures 5. *Oecobius putus* O. Pickard-Cambridge, 1876. ♀, anal tubercle, ventral view.

Figures 6. *Oecobius putus* O. Pickard-Cambridge, 1876 ♂, Pedipalp. prolateral view.

Figures 7. *Oecobius putus* O. Pickard-Cambridge, 1876 ♂, Pedipalp. retrolateral view.

Figures 8. Oecobius putus O. Pickard-Cambridge, 1876 ♀. Abdomen, ventral view.



Figures 9. *Oecobius putus* O. Pickard-Cambridge, 1876 ♀. Epigynum, ventral view.

the fourth pair at least) several distinct and tolerably strong prominent spines. The eyes are not so large. The interval between those of the central pair (which are the largest of the eight) is equal to an eye's diameter; and the two posterior flattened angular eyes are much smaller. The armature also of all the femora is of a much more spinous character. The abdomen is more thickly covered with white cretaceous spots; and the cruciform marking on the upper side is better defined, though of a similar character. The palpi are thickly furnished with fine pale hairs. (Pickard-Cambridge, 1876) He also illustrated the male of this species in addition to its palpal organ (Figure 1).

For the description of *Oecobius putus* and the illustrations of both the male and female genitalia see (Pickard-Cambridge, 1876; Hassan, 1953; Kritscher, 1966; Shear, 1970; Baum, 1972; Wunderlich, 1995; Zamani *et al.*, 2016; Dippenaar-Schoeman *et al.*, 2022; Dippenaar-Schoeman *et al.*, 2021; Marusik and Zonstein, 2024).

Measurements: ♂ TL 2.4, CL 0.9, CW 1.0, AL 1.7; ♀ TL 3.1, CL 1.0, CW 1.0, AL 2.2.

Habitus: Male (Figure 2) and female (Figure 3).

Male cephalothorax and eyes (Figure 4). Female anal tubercle (Figure 5).

Genitalia: Male Pedipalp (Figures 6-7). Female Epigynum (Figures 8-9).

The studied spiders were found at an area of a low elevation "altitude -381 m" at the lowest place on Earth, on the contrary of *Euophrys everestensis* Wanless, 1975 and *Euophrys omnisuperstes* Wanless, 1975, of the family Salticidae, which inhabit areas of high altitudes in the Himalayas (Wanless, 1975) at elevations ranging between 16,500 and 19,500 ft. A survey of the spiders living in this region is recommended to identify the spider species living at the same conditions.

Acknowledgment

The author is grateful to Dr. Khaldoon Qumei who invited him to a tour of the Dead Sea region where the studied specimens were found.

References

Baum, S. 1972. Zum „Cribellaten-Problem": Die Genitalstrukturen der Oecobiinae und Urocteinae (Arach.: Aran: Oecobiidae). Abhandlungen und Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg (NF), 16: 101-153.

Dippenaar-Schoeman, AS, Steenkamp, R and Booysen, R. 2022. New records of Oecobius putus O. Pickard-Cambridge, 1876 from South Africa (Araneae: Oecobiidae). SANSA Newsletter, 41: 21-22.

Dippenaar-Schoeman, AS, Haddad, CR, Foord, SH and Lotz, LN. 2021. The Oecobiidae of South Africa. Version 1. South African National Survey of Arachnida Photo Identification Guide, Irene, 19 pp.

El-Hennawy, HK. 2020. *Segestria florentina* (Rossi, 1790) in Jordan (Araneae: Segestriidae), with a list of the known records of spiders from Jordan. Serket, 17(3): 314-323.

El-Hennawy, HK. 2023. *Loxosceles rufescens* (Dufour, 1820) in Jordan (Araneae: Sicariidae), with updated list of the known records of spiders from Jordan. Serket, 19(4): 419-426.

El-Hennawy, HK. 2024. *Steatoda paykulliana* (Walckenaer, 1806) in Jordan (Araneae: Theridiidae). Serket, 20(2): 200-203.

Hassan, AI. 1953. The Oecobiidae of Egypt. Bulletin - Zoological Society of Egypt, 11: 14-28.

Kritscher, E. 1966. Die paläarktischen Arten der Gattung *Oecobius* (Aran., Oecobiidae). Annalen des Naturhistorischen Museums in Wien, 69: 285-295.

Marusik, YM and Zonstein, S. 2024. The spider genus *Oecobius* (Araneae: Oecobiidae) in Israel, with description of a new species and new synonymies. Israel Journal of Entomology, 53: 49-62.

Pickard-Cambridge, O. 1876. Catalogue of a collection of spiders made in

Egypt, with descriptions of new species and characters of a new genus. Proceedings of the Zoological Society of London, 44(3): 541-630, pl. 58-60.

Shear, WA. 1970. The spider family Oecobiidae in North America, Mexico, and the West Indies. Bulletin of the Museum of Comparative Zoology, 140(4): 129-164.

Wanless, FR. 1975. Spiders of the family Salticidae from the upper slopes of Everest and Makalu. Bulletin of the British Arachnological Society, 3(5): 132-136.

World Spider Catalog 2024. World Spider Catalog. Version 25.5. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on 29.09.2024.

Wunderlich, J. 1995. Zu Taxonomie und Biogeographie der Arten der Gattung *Oecobius* Lucas 1846, mit Neubeschreibungen aus der Mediterraneis und von der Arabischen Halbinsel (Arachnida: Araneae: Oecobiidae). Beiträge zur Araneologie, 4(1994): 585-608.

Zamani, A, Mirshamsi, O, Rashidi, P, Marusik, YM, Moradmand, M and Bolzern, A. 2016. New data on the spider fauna of Iran (Arachnida: Aranei), part III. Arthropoda Selecta, 25(1): 99-114.

Jordan Journal of Natural History, 11 (2), 2024 87-89

A lone Wolf *Canis lupus* (Linnaeus,1758) Coalition with Feral Dogs in the Kaj Village, Kodinar, Gujarat, India

Dhruv Parajapati [1], Aurobindo Samal [2] and Shreya Pandey [2,3*]

[1] Web of Nature (WON) Research Foundation, Ahmedabad, Gujarat 380058; [2] Earth Crusaders Organisation, Bhubaneswar – 751019, Odisha, India; [3] Ecology and Genetics Unit, University of Oulu, 90014, Finland

Received: September 10, 2024; Revised: October 30, 2024; Accepted: November 9, 2024

Abestract: This article presents the first conclusive photographic evidence of a wolf (*Canis lupus*) in India successfully adapting to coexist with a pack of feral dogs (*Canis lupus familiaris*). Three photographs were captured in a specific area documenting the wolf's interactions and behaviors within this unconventional social structure. This observation raises important questions about the adaptability of wolves in changing environments and their potential to form unique associations with domestic species. The findings contribute to the understanding of interspecies dynamics and the ecological implications of such relationships in the wild. Further research is necessary to explore the impact of this adaptation on both the wolf population and the local ecosystem.

Introduction

In the past, the wolf *Canis lupus* (Linnaeus,1758) was the most widely dispersed terrestrial mammal after humans (Mech 1970). However, it has almost completely vanished from a third of this broad range over the recent years. While the International Union for the Conservation of Nature's Red List classifies several local populations as endangered, the wolf *Canis lupus* is categorized as least concern (Mech and Boitani 2010). The wolf is listed in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 3.3.1973), excluding the populations in Bhutan, Pakistan, India, and Nepal, which are listed in Appendix I (species in danger of extinction). The subspecies of the Indian wolf (*Canis lupus pallipes*) is listed in Schedule I of the Wildlife Protection Act, 1972.

The Canidae family is one of the most geographically diverse carnivore families, with at least one wild species present on every continent except Antarctica. There are currently thirty-five species of dogs, wolves, coyotes, jackals, and foxes in the Canidae family (Zubiri *et al*. 2004). The Canidae family, which includes dogs and foxes, has a wide range of habits and geographical distribution. Canidae are opportunistic organisms. Adaptability and non-specialization are the factors that have allowed Canidae members to survive and even thrive. This has had a significant impact on their behavioural repertoire, insuring that social behaviour and its expression through postures and movements remain consistent across the family, despite significant ecological differences. Most existing behavioural differences are of degree rather than kind. Many of the larger canids have adaptations that allow them to travel over great distances while hunting, pursuing prey, and during seasonal migrations.

In addition to zoologists and naturalists, psychologists interested in the formation of social bonds as well as anthropologists curious about the biological roots of human group behaviour have all taken an interest in the evolution of social behaviour and the mechanisms through which it develops and can be maintained. A highly social species that has been studied in the wild (Mech, 1966), in semi-natural conditions of confinement (Woolpy, and Ginsburg, 1967), and in domesticated conditions (Rabb, *et al.,* 1967), the wolf is a great example (Fentress, 1967).

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The differential social behaviour development of various members of the Family Canidae is one feature that sets them apart from one another. The wolf is the most social among the close relatives of the domestic dog. It is because of this trait that we can say with a high degree of certainty that dogs most likely descended from wolves rather than other species including coyotes and jackals, which typically form no group larger than a mating pair which lasts only for a short period of time, until the litter are born to this pair. The Canidae's social-behavior patterns seem to have evolved as conservative traits. Wolves have an incredibly intricate social structure; they cooperatively breed, hunt, and maintain sizable territories. A similarly intricate and sophisticated communication system would be anticipated to maintain such a complex system.

Methods

Based on information from locals, it was found that there used to be several packs of wolves inhabiting this area back in 2010, and suddenly they disappeared. Only one wolf was repeatedly sighted amidst the pack of dogs, and a strange behavior was noted that it coexisted with a pack of dogs. Camera traps were installed for a period of over five months in the area in random selected sampling units. White flash Cuddeback camera traps were used. The installation of camera traps was done based on the natural trails used by the species as previously observed by local men.

Results and Discussion

During the regular field surveys over a period of five months in the Kodinar district of Gujarat 24°43'49.01"N, 70°48'06.09"E, the authors had an unusual encounter of a lone wolf *Canis lupus* (Figure 1) (Linnaeus,1758) amidst a pack of feral dogs. It could be predicted that the individual might have migrated locally from a distant population and joined this pack of dogs. However, there is no evidence to prove this. This is a

Figure 1. A lone wolf Canis lupus found in the Kaj village, Kodinar, Gujarat 24°43'49.01"N, 70°48'06.09"E

unique social adaptation through which two different species are interacting and showing inter-specific dependency.

This is a unique adaptive behavior of an individual who has strategically adapted to living in a social networking system of dogs amidst their hierarchy and close-knit structure and coexisted with them. It was seen performing regular activities such as feeding and resting with the other dogs. Although, this cannot be a deterministic behavior of

the entire species and can't be generalized. It is an individualistic adaptive phenomenon based on the behavior of the individual and the dominance pattern of the other.

Ecology and evolutionary biology have long placed a high priority on comprehending the relationship between individual behaviour and population organization and functioning (Sueur *et al.* 2011; Kurvers *et al.* 2014). Individual state, ecological factors, and social interactions are just a few examples of the intrinsic and extrinsic factors that influence behaviour. The ecology and evolution of populations, and species can be significantly impacted by the network's structure.

Acknowledgement

The authors would like to acknowledge and extend warm gratitude to the Forest Department of Gujarat. They also acknowledge the local community for being cooperative and welcoming, sharing their valuable information with the authors.

References

Fentress, J C. 1967. Observations on the behavioral development of a hand-reared male timber wolf. American Zoologist, 7(2): 339-351.

Kurvers, R H, Krause, J, Croft, D P, Wilson, A D and Wolf, M. 2014. The evolutionary and ecological consequences of animal social networks: emerging issues. Trends in Ecology and Evolution, 29(6): 326-335.

Murie, A. 1944. The wolves of mount McKinley (No. 5). US Government Printing Office.

Mech, L D. 1966. The Wolves of isle royale (No. 7). US Government Printing Office.

Rabb, G B, Woolpy, J H and Ginsburg, B E. 1967. Social relationships in a group of captive wolves. American zoologist, 7(2): 305-311.

Sillero-Zubiri, C, Hoffmann, M and Macdonald, D W. (Eds.) 2004. Canids: Foxes, Wolves, Jackals, and Dogs: Status Survey and Conservation Action Plan (Vol. 95). Gland, Switzerland: IUCN.

Sueur, C, Petit, O, De Marco, A, Jacobs, A T, Watanabe, K and Thierry, B. 2011. A comparative network analysis of social style in macaques. Animal Behaviour, 82(4): 845-852.

Confirmation of the Presence of the Berthold's Bush Anole (*Polychrus gutturosus*) on the Nicoya Peninsula, Costa Rica.

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Abstract: The Berthold's Bush Anole, *Polychrus gutturosus* (Polychridae), is a rare lizard distributed from Honduras to Colombia and Ecuador, where it inhabits rainforests up to 800 m above sea level. In northwestern Costa Rica, it is found in the Guanacaste and Tilarán mountain ranges, with a single report from the Nicoya Peninsula in 2016. However, this locality was not included in the recent description of its distribution. The authors confirm the presence of the Berthold's Bush Anole in the Nicoya Peninsula with a juvenile found in Hojancha, Guanacaste, 8 km away from the former 2016 observation. This area is located within the Tropical Moist Forest, which means that the Berthold's Bush Anole has not yet been observed in the Tropical Dry Forest as previously reported. The area of the finding has various anthropogenic uses, with only small patches of vegetation remaining, mainly thorny scrubs.

Key words: Distribution, Lizards, Tropical dry forest, Tropical moist forest, Polychridae

Introduction

Polychrotidae is a small family of canopy lizards primarily found in South America, consisting of eight species within the single genus *Polychrus* (Uetz *et al.,* 2024). These lizards are characterized by a laterally compressed body, a very long tail, and green or grey dorsal coloration (Murphy *et al.,* 2017). These morphological traits and their ecology make them difficult to spot in the wild, resulting in limited knowledge about most species (Barquero *et al.,* 2024). Only one species, the Berthold's Bush Anole, *Polychrus gutturosus*, is found in Costa Rica (Savage, 2002; Uetz, 2024), and most of its biological information comes from sporadic observations (Barquero *et al.,* 2024).

The most conspicuous characteristic of the Berthold's Bush Anole is its long, round tail, which is more than three times the length of its head and body (Savage, 2002). This tail is used for balance and stabilization during arboreal movements (Leenders, 2019). The total length of this lizard is about 700 mm, with the females being significantly larger, measuring 125 to 170 mm in snout-vent length (SVL), compared to males which reach 83 to 135 mm (Savage, 2002). The limbs of the Berthold's Bush Anole are moderately long, and the upper head scales are smooth (Savage, 2002). Additionally, it lacks toe pads, as well as nuchal, dorsal, and caudal crests, a large subtympanic scale, and tail spines (Savage, 2002). The Berthold's Bush Anole is usually bright green in coloration, but it can change to a dull brown depending on its mood or other factors (Leenders, 2019). Most individuals have a distinct large light spot below the posterior margin of the orbit (Savage, 2002).

The Berthold's Bush Anole is a strictly diurnal and arboreal lizard, typically found in humid forests. It uses its hands and feet to grasp small branches and twigs, moving slowly and deliberately with alternating limb movements (Savage, 2002). These lizards can remain completely still for extended periods, often hanging in awkward or bizarre positions using one or more limbs and the tail (Savage, 2002; Leenders, 2019).

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As a sit-and-wait predator, it slowly advances on prey once spotted, feeding primarily on relatively large arthropods but also consuming leaves, flowers, fruits, and seeds (Savage, 2002).

The Berthold's Bush Anole is found at low and moderate elevations on the Atlantic slope, ranging from northwestern Honduras to northwestern Colombia, and from west-central Costa Rica to western Ecuador on the Pacific slope (McCranie, 2018). It is also marginally present on the Pacific slope in northwestern Costa Rica (McCranie, 2018), but not in the northwest Pacific slope's subhumid area (Savage, 2002). It is found from 6 to 800 m above sea level (Sasa *et al.,* 2010). Generally, the species has been reported from various localities across its range, although it is rarely seen (Savage, 2002; Abarca Alvarado, 2012). Despite its rarity, it can thrive in some disturbed areas, like roads and gardens near the forest edge (Savage, 2002).

In northwestern Costa Rica, the Berthold's Bush Anole has been recorded in the Cordillera de Guanacaste and the Cordillera de Tilarán (Savage, 2002), but it was not known to inhabit the Tropical Dry Forest (Bringsøe *et al.,* 2016). However, two males were observed fighting in a low scrub vegetation in Hojancha, Guanacaste, Costa Rica in 2016 (Bringsøe *et al.,* 2016). This locality was incorporated in the "Reptiles of Costa Rica" guide (Leenders 2019), but it was not included in Leenders' later guide to the "Amphibians and Reptiles of Costa Rica" (Leenders, 2023). Herein, the authors report the presence of this species on the Nicoya Peninsula based on another observation in Hojancha, Costa Rica.

Materials and Methods

As part of a herpetological inventory in Hojancha in the Nicoya Peninsula, northwestern Costa Rica, the researchers found a juvenile Berthold's Bush Anole in an open area. The general habitat of the site consists of dry cultivated land and pastures with scattered human settlements, among which are patches of xerophytic scrub vegetation (Figure 1).

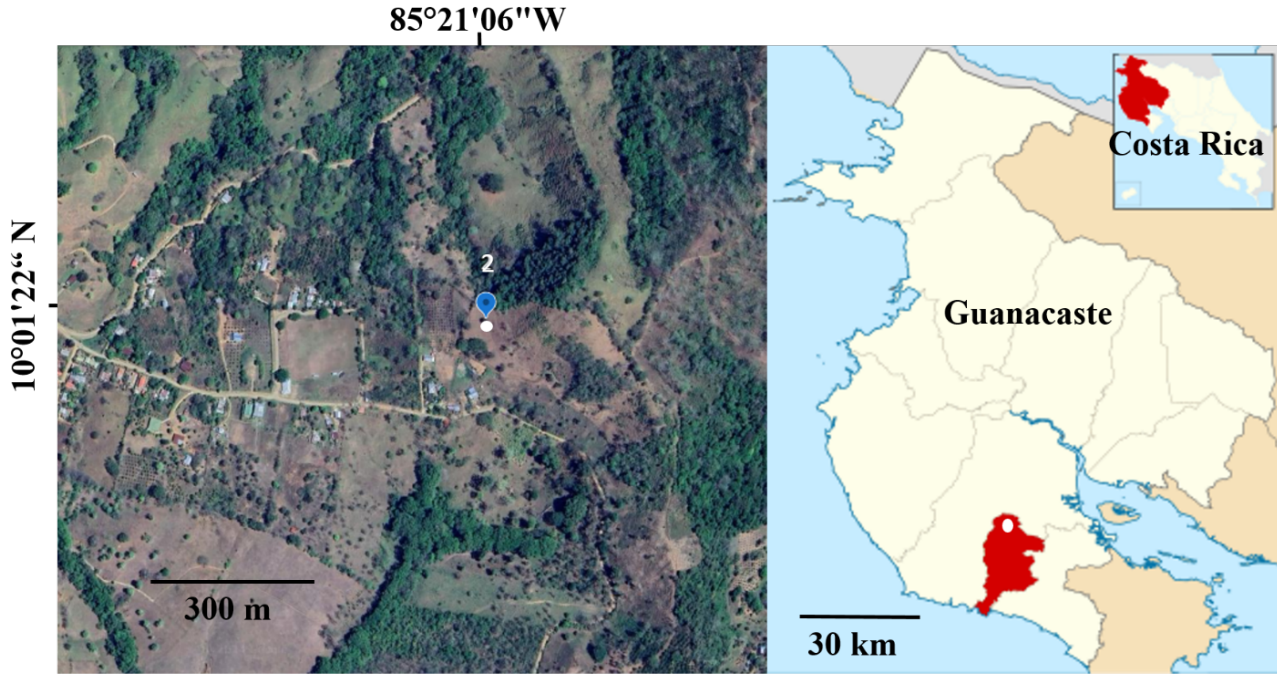

Figure 1. General habitat conditions (left) and the observation site (white dot under the blue marker) of a Berthold's Bush Anole, *Polychrus gutturosus*, in the Hojancha county (highlighted in red) in the Guanacaste province (outlined in white but shown in red on the map of Costa Rica). Figure prepared by José Manuel Mora based on Google Earth (left section) and Wikipedia under the Creative Commons Attribution-ShareAlike 3.0 license (right section).

The original forest of this area belongs to the Tropical Moist Forest, with annual precipitation ranging from 1800 to 4000 mm. It is characterized by high temperatures and a dry period lasting from zero to two months (Hartshorn, 1983). It is an evergreen or semi-deciduous forest with very high density and is characterized by the presence of four to five different strata (Bolaños *et al.,* 2005). The understory is abundant, predominantly with evergreen species (Hartshorn, 1983). The average height of the canopy can reach between 30 and 40 m, but some trees reach up to 50 m, with broad and elevated crowns, unbranched up to 25 or 35 m, having tall, slender, and smooth trunks with usually colored bark (Hartshorn, 1983). The sub-canopy has trees of 30 m in height, with narrow crowns, and palms that are abundant, except in the cold transition area (Bolaños *et al.,* 2005). The lower stratum is between 8 and 20 m in height, with round or conical crowns; the leaves often have elongated tips or apices (Hartshorn, 1983). The shrub layer consists of broad-leaved species, dwarf palms, and an abundance of lianas or vines, as well as epiphytes such as bromeliads, mosses, lichens, orchids, and vines (Bolaños *et al.,* 2005).

The authors reviewed data on Costa Rica in the GBIF database, looking for any specimens reported from the Nicoya Peninsula. The authors also reviewed the localities of the voucher specimens deposited at the Zoology Museum of the University of Costa Rica (MZ-UCR).

Results

On 5 July 2024 at 11:15 a.m., the researchers observed a Berthold's Bush Anole (Figure 2) near a small forest patch and a small belt of a dense scrub vegetation, about 80 m away from two small springs (10°01'22"N, 85°21'06"W, WGS84; 580 m elevation; Figure 1). The lizard was climbing a Kassod tree, *Senna siamea* (Caesalpinioideae), which is an introduced species native to southeastern Asia (Nsonde Ntandou *et al.,* 2010). This tree was planted and located in isolation within a pastureland (Figure 3).

Figure 2. A Juvenile individual of the Berthold's Bush Anole, *Polychrus gutturosus*, observed in Hojancha, Guanacaste, Costa Rica. Photo by Gustavo Aguilera Castro.

Figure 3. The Kassod tree, *Senna siamea*, in the foreground on a pastureland where a Berthold's Bush Anole *Polychrus gutturosus* was found in Hojancha, Guanacaste, Costa Rica. Gustavo Aguilera Castro.

The authors found ninety-eight records of the Berthold's Bush Anole in the GBIF database; however, none were from the Nicoya Peninsula. Additionally, no specimens of this species from this Costa Rican region were deposited in the MZ-UCR collection.

Discussion

This study reports the second individual of the Berthold's Bush Anole from the Nicoya Peninsula in northwestern Costa Rica. Two points are particularly noteworthy in this report. First, the confirmation of the extension of the distribution range of the Berthold's Bush Anole to the Nicoya Peninsula. Second, the information presented on the type of habitat in which this species has been observed on the Nicoya Peninsula.

Bringsøe *et al.* (2016) pointed out that the riparian habitat in Nicoya, although limited in extent during the dry season, is crucial for the survival of the Berthold's Bush Anole. They pointed out that populations of this species may most likely occur in other riparian areas of the peninsula. It is noteworthy that most of the Nicoya Peninsula is Tropical Moist Forest, not Dry Forest (Rodríguez-Ramírez and Mora, 2022). However, the authors agree that the riparian forests along rivers and streams in the peninsula constitute a more suitable habitat for the Berthold's Bush Anole because these areas are even more humid (Bringsøe *et al.,* 2016). There are some records of this species in riparian forests within the pine savannah ecosystems in Honduras (McCranie *et al.,* 2006).

Supposedly, the Berthold's Bush Anole is a diurnal and arboreal species, inhabiting mainly the forest canopy (Savage, 2002). The Dry Forest characteristics would constrain perch availability and the selection of potential sleeping sites because deciduous trees leave individuals more exposed to predators during the dry season. Consequently, lizards are obliged to increase their search for proper sleeping sites or use unsafe perches (Barquero *et al.,* 2024). Therefore, the moist forest may be somewhat more favorable for the Berthold's Bush Anole in this regard. The thermal environment is also important when choosing a sleeping site, especially for ectothermic animals (Mohanty *et al.,* 2022; Barquero *et al.,* 2024).

However, the survival of this species in the Nicoya Peninsula may not be the issue, but rather its secretive habits. The Berthold's Bush Anole is a slow-moving, completely arboreal lizard usually found at night trying to select a sleeping spot in low shrubs or trees (Leenders, 2019). The rarity of this species may be due to the height above ground at which it lives (Roberts 1997; McCranie *et al.,* 2006). During the day, it is generally active in the tops of trees, including the crowns of emergent canopy trees more than 35 m above the forest floor (Leenders, 2019). Additionally, most herpetologists conduct their research in protected areas or pristine habitats and not in the disturbed areas that are now more extensive (Mora *et al.,* 2019). Degraded and secondary forests constitute about 50% of the remaining tropical forest (Latta *et al.,* 2017).

Although the presence of the Berthold's Bush Anole in the Nicoya Peninsula extends its distribution range in Costa Rica, it is important to note that most of the original forest in the Nicoya Peninsula has been cut, which decreases the chances of the Berthold's Bush Anole to survive in the region. Nevertheless, this species is listed under the Least Concern of the IUCN Red List (Acosta Chaves *et al.,* 2017). However, the status of its population is unknown (Acosta Chaves *et al.,* 2017). This is an uncommonly seen species, and although it occurs in a relatively large number of localities, the Berthold's Bush Anole is found in isolated populations and has a discontinuous distribution (Acosta Chaves *et al.,* 2017). As a result, the conservation status of the Berthold's Bush Anole is potentially inaccurate or with limited data (Antúnez-Fonseca *et al.,* 2022). Moreover, using the Environmental Vulnerability Score (EVS), this species presents a score of twelve, which signifies medium vulnerability (Antúnez-Fonseca *et al.,* 2022).

There is yet a relatively favorable spot for this species. Although the Berthold's Bush

Anole is supposedly restricted to primary lowland humid forests and marginally along stream courses (Savage, 2002), it also inhabits disturbed areas in some regions (McCranie *et al.,* 2006; Acosta Chaves *et al.,* 2017). Furthermore, this species is not utilized or traded to any significant degree (Acosta Chaves *et al.,* 2017). As a result, the main localized threat is deforestation (Acosta Chaves *et al.,* 2017).

The Berthold's Bush Anole may be more tolerant to habitat alteration than is currently thought. Due to its secretive behavior and excellent camouflage, this species is difficult to detect and is most likely underreported. The Berthold's Bush Anole is capable of considerable color change and can match its coloration with that of its backdrop (Savage, 2002). Its behavioral traits can further camouflage the species, as individuals mask their presence by superimposing a rocking motion on their forward movement to mimic wind-blown vegetation (Leenders, 2019).

Information on natural history, including perch height in the Berthold's Bush Anole, is scarce (Antúnez-Fonseca *et al.,* 2022). Some anecdotal data and basic information have been published recently by Antúnez-Fonseca *et al.* (2022) and Barquero *et al.* (2024). However, the record presented in this study helps understand the use of somewhat marginal habitats for this lizard and confirms its presence in the moist forest of the Nicoya Peninsula.

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References

Abarca Alvarado, JG. 2012. Historia natural de la herpetofauna de El Rodeo y el oeste del Valle Central, Costa Rica. Brenesia 77: 229-250.

Acosta Chaves, V, Ballestero, E, Batista, A, Chaves, G, Ibáñez, R, Ines Hladki, A, Jaramillo, C, Lamar, W, Ramírez Pinilla, M, Renjifo, J, Solórzano A, Urbina, N. 2017. *Polychrus gutturosus*. The IUCN Red List of Threatened Species 2017: e.T203161A2761248.

Antúnez-Fonseca, CA, Martínez, M, King, TW, Ordoñez-Mazier, DI, Wilson LD, Turcios-Casco, MA. 2022. Filling a gap in the distribution of the Berthold's Bush Anole, *Polychrus gutturosus* (Squamata, Polychrotidae), in Honduras. *Herpetozoa* **35**: 219-223.

Barquero, MD, Arguedas, V, Ovares, L, Vargas, R, Arguedas, R. 2024. Sexual dimorphism and ecomorphology of the Berthold's bush anole (*Polychrus gutturosus*) in Costa Rica. *Amphibia-Reptilia* **45(1)**: 73-84.

Bolaños, R, Watson, V, Tosi, J. 2005. **Mapa ecológico de Costa Rica (Zonas de Vida), según el sistema de clasificación de zonas de vida del mundo de L. R. Holdridge, Scale 1:750 000**. Centro Científico Tropical. San José, Costa Rica.

Bringsøe, H, Alfaro Sánchez, O, Hansen, HO. 2016. First record and distributional extension for *Polychrus gutturosus* Berthold, 1845 (Squamata: Polychrotidae) in the Península de Nicoya of northwestern Costa Rica, with a new record from Provincia de San José. *Mesoamerican Herpetology* **3(4)**: 1091-1094.

Hartshorn, GS. 1983. Plants. *In*: Janzen DH. (Ed), **Costa Rican Natural History.** University of Chicago Press, Chicago, USA, pp. 136-141

Latta, SC, Brouwer, NL, Olivieri, A, Girard-Woolley, J, Richardson, JE. 2017. Long-term monitoring reveals an

avian species credit in secondary forest patches of Costa Rica. Peer J, 5: e3539.

Leenders, T. 2019. **Reptiles of Costa Rica: a field guide**. Zona Tropical Publications, Ithaca, New York, USA. 640 pp.

Leenders, T. 2023. **Pocket guide to the amphibians and reptiles of Costa Rica**. Zona Tropical Publications, Ithaca, New York, USA. 322 pp.

McCranie, JR. 2018. **The lizards, crocodiles, and turtles of Honduras. Systematics, distribution, and conservation**. *Bulletin of the Museum of Comparative Zoology* **15**:1-129.

McCranie, JR, Townsend, JH, Wilson, L.D. 2006. **The Amphibians and Reptiles of the Honduran Mosquitia**. Krieger Publishing Company, Malabar, Florida, USA. 291 pp.

Mohanty, NP, Wagener, C, Herrel, A, Thaker, M. 2022. The ecology of sleep in non-avian reptiles. *Biological Reviews* **97(2)**: 505-526.

Mora, JM, Espinal, MR, Chaves, G, López, LI. 2019. Distributional records for *Loxopholis rugiceps* Cope, 1869 (Squamata, Gymnophthalmidae) in Central America. *Check List* **15(3)**: 363-368.

Murphy, JC, Lehtinen, RM, Charles, SP, Wasserman, D, Anton, T, Brennan, PJ. 2017. Cryptic multicolored lizards in the *Polychrus marmoratus* group (Squamata: Sauria: Polychrotidae) and the status of *Leiolepis auduboni* Hallowell. *Amphibian & Reptile Conservation* **11(8)**: 1-16.

Nsonde Ntandou, GF, Banzouzi, JT, Mbatchi, B, Elion-Itou, RD, Etou-Ossibi, AW, Ramos, S, Benoit-Vical, F, Abena AA, Ouamba, JM. 2010. Analgesic and Anti-Inflammatory Effects of *Cassia siamea* Lam. Stem Bark Extracts. *Journal of Ethnopharmacology* **127(1)**: 108-111.

Roberts, WE. 1997. Behavioural observations of *Polychrus gutturosus*, a sister taxon of anoles. *Herpetological Review* **28(4)**: 184-185

Rodríguez-Ramírez, M, Mora, JM. 2022. Analysis of the male annual antler cycle, reproductive behavior and spotted fawn presence in the tropical white-tailed deer. *Therya* **13(2)**: 143-151.

Sasa, M, Chaves, G, Porras, LW. 2010. The Costa Rican herpetofauna: conservation status and future perspectives. *In*: Wilson, LD, Townsend, JH, Johnson, JD. (Eds), **Conservation of Mesoamerican Amphibians and Reptiles**. Eagle Mountain. Eagle Mountain Publishing, LC. Eagle Mountain, Utah, USA, pp. 509-560.

Savage, JM. 2002. **The Amphibians and Reptiles of Costa Rica a Herpetofauna between two continents, between two seas**. The University of Chicago Press, Chicago, Illinois, USA. 954 pp.

Uetz, P, Freed, P, Aguilar, R, Reyes, F, Kudera, J, Hošek, J. (Eds). 2023. **The Reptile Database**. http://www.reptile-database.org. Accessed 22 July 2024.

Checklist and Distribution of Coccinellid Aphid Predators in Tunisia

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Abstract: An extensive survey of aphid predatory coccinellid beetles (Coleoptera: Coccinellidae) was conducted in twenty-seven sites in Tunisia over fourteen years from 2005 to 2019. In total, thirteen ladybird beetles (*Adalia decempunctata*, *Chilocorus bipustilatus, Coccinella algerica*, *Coccinella undecimpunctata*, *Coccinella novemnotata*, *Harmonia axyridis*, *Hippodamia tredecimpunctata, Hippodamia variegata, Oenopia doublieri*, *Oenopia lyncea*, *Myrrha octodecimguttata* Linnaeus, *Scymnus fulvicollis*, S*cymnus nubilus*) were identified as predators of aphid. Among them, *C. algerica* was the most abundant predator observed preying on twenty-two aphid species found in twenty-seven sites. The second most abundant predator was *H. variegata* observed feeding on ten aphid species. Four species (*H. axyridis*, *O. doublieri*, *O. lyncea, S. nubilus*) were the least abundant and were observed only in one site.

Key words: Coccinellid beetles, aphid, geographical distribution, Tunisia.

Introduction

Coccinellidae (Lady beetles, ladybirds) comprise one of the largest and most abundant families of the super family Coccinelloidea with over 6.000 nominal species described throughout the world (Canepari, 2011, Robertson *et al.,* 2015). Most of them, including larva and adults, are entomophagous, predators of a wide range of hosts from hemipteran pests such as aphids, mealybugs and scale insects, to thrips (Thysanoptera) and mites (Acarina) all over the world (Raimundo *et al.,* 2008). Predaceous groups have a great economic importance and are used today to control the populations of many arthropod pests, particularly aphid species and mealybugs (Agarwala and Dixon, 1992, Mdellel and Ben Halima Kamel, 2012). Some adult ladybirds visit flowers and feed on pollen and nectar, usually as supplement to their predatory diet (Biranvand *et al.,* 2017). In addition to predation, some other species of ladybirds are phytophagous and feed on leaves of cultivated plant species (Cucurbitaceae, Fabaceae) and are considered pests (Koren *et al.,* 2012). Some other species are mycophagous feeding mainly on powdery mildew fungi. Ladybirds are considered to be good indicator species because they are very sensitive to changes in the environment and can offer a better overall picture about the health of ecosystems. The degree of their adaptation as well as their efficiency in controlling aphid populations varies with the species and the environmental conditions (Dixon 2000). The ability of natural enemies to track their hosts will depend on their tolerance to environmental extremes relative to their herbivore hosts as well as their movement rates. Under climate change, the effectiveness of some biological control agents may change. Stireman *et al.* (2005) predicted that the frequency and intensity of pest outbreaks will increase as climate becomes more variable and disrupts the stability of existing biological control systems. Only few publications on the Coccinellidae in Tunisia exist providing little information about Coccinellidae fauna.

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The majority of studies record the ladybird species as predators of pests especially aphids, but so far no comprehensive checklist exists (Mdellel *et al.,* 2015, Ben Halima Kamel *et al.,* 2018). The main goal of this paper is to contribute to our knowledge of diversity and geographical distribution of ladybirds in Tunisia and to present the first preliminary checklist of species recorded until now from Tunisia.

Materials and Methods

Study sites

The survey was carried out over the period from 2005 to 2019 in different agroecosystems in Tunisia. Localities, site/ zone-name, geographic coordinates and the date of sampling are given in Table 1.

Sampling methods

Ladybugs or the larvae of ladybugs and aphids were collected every two weeks from host plants. Ladybugs were collected weekly from a wide variety of habitats (agricultural land, gardens and parks, both on herbaceous and woody plants) using sweep nets, yellow traps and by hand picking. Captured adult insects were killed immediately with diethyl ether and were soon preserved in a ratio of 90% of ethyl alcohol (Eastop and Van Emden, 1972, Blackman and Eastop, 2000) for identification. The larvae of the ladybirds were taken to the laboratory, where they were reared on aphid colonies until adult emergence and were then preserved as described above.

Aphid and ladybird identification

Alate and apterous adult aphids were removed from the samples and were preserved and mounted on microscope slides (Blackman and Eastop, 2000); they were identified using Leclant (1978) and Blackman and Eastop (1984) keys. The collected ladybirds were carefully studied under a binocular microscope to determine the scientific name of the species using Iablokoff- Khnzorian (1982) keys. They were then sent to Dr Sahraoui L. (Department of Agricultural and Forestry Zoology, ENSA El Harrach/ Algeria) for confirmation.

Climate characteristic and ladybird distribution relationship

The relationship between the climate characteristics of the survey sites (Figure 1) and the ladybird beetle diversity was studied. Several species from sites having the same climate were registered and compared.

Results

Ladybird species

The ladybird species collected over the period of fourteen years belong to thirteen species in three tribes. One species of the Chilicorini was collected, *Chilochorus bipustalitus* Linnaeus. The Coccinellini included ten species: *Adalia decempunctata* Linnaeus, *Coccinella algerica* Kovar, *Coccinella novemnotata* Herbst, *Coccinella undecimpunctata Linnaeus*, *Hippodamia variegata* Goeze, *Hippodamia tredecimpunctata Linnaeus*, *Harmonia axyridis* Pallas, *Oenopia doublieri Mulsant, Oenopia lyncea Olivier,* and *Myrrha octodecimguttata* Linnaeus. Two species of the Scymnini were collected, *Scymnus fulvicollis Mulsant* and *Scymnus nubilus* Mulsant (Figure 2).

Abundance of ladybird species

Thirteen ladybird species were identified. Among these, the most frequent species in time and sites was *C. algerica*, observed over the period between2005 and 2019 across twenty-seven sites in the north, middle, and south of Tunisia. *C. algerica* (eggs, larva, and adult) was observed feeding on twenty-two aphid species, found on the leaves and trunks of twenty host plants belonging to eight families (*Poaceae*, *Rosaceae, Rutaceae, Asteraceae, Solanaceae, Lythceae, Fabacea,* and *Pinaceae*). The second abundant species

Table 1. Sites, climates, and crops of the survey.

Province	Site/Zone	Climate	Sampling period	Crops
Bizerte	Tinja	Sub-Humid	2017 - 2019 December to June	Cereal, Rape (Colza)
Beja	Hammem-Sayala	Sub-Humid	2017- 2018 December to June	Cereal, Vetch
	Tarhouna			
	Ghozzia			
	Tebaba			
Kef	Eddir	Semiarid	2017- 2018 December to June	Cereal, Vetch
	Boulifa			
	Sers			
	El-Houdth			
	Sidi-Khiar			
Siliana	Krib	Semi-arid	2017- 2019 December to June	Cereal, Faba
Ariana	Sidi-Thabet		2000 -2014 December to May	Peach, Potato
Ben-Arous	Mornag		2007- 2008 April to May	Peach, Apple
Zaghouane	Ras-El Gassaa		2007- 2008 April to May	Alfah grass
Nabeul	Takelsa		2007- 2008 April to May	Peach, Citrus
	Korbous			Citrus
Sousse	Chott Mariem	S uperior arid	2007 – 2016 December to June	Peach, almond, artichoke Citrus, cucumber, melon, pomegranate, pepper.
	Sidi-Bouali		2000 – 2005 February to April	Citrus
	Hergla		2008 – 2014 December	Cereal
	Kalaa Kebira		2015 – 2016 May	Apple
	Akouda		2007 – 2016 December to May	Peaches, almond, apricot, Citrus
	Msaken		2007 – 2011 December to February	Potato
Monastir	Jammel	Superior arid	2008 – 2014 April to May	Peaches, almond, apricot, apple, plum
	El-Werdanine		2014 December	Potato
Mahdia	Sidi-Alouane	Superior arid	2008 – 2014 December to April	Cereal, almond, faba
Kairouan	Chebika	Superior arid	2015 – 2019 December to April	Citrus, cereal
Sfax	Manzel-Chaker	Inferior arid	2008 – 2015 April to May	Peaches, almond

was *H. variegata,* recorded from six sites feeding on nine aphid species, found on seven infested host plants belonging to seven families (*Poaceae*, *Rosaceae, Rutaceae, Asteraceae, Solanaceae, Lythceae,* and *Pinaceae*) (Table 2). Five species (*C. indecimpunctata, C. novemnotata, H. tredecimpunctata*, *M. octodecimguttata,* S. *nubilus*) were observed, each at one site, feeding on one aphid species (Table 2). One species, *H. axyridis*, is an introduced species observed for the first time by Ben Halima Kamel et *al.*, (2018) (Table 3).

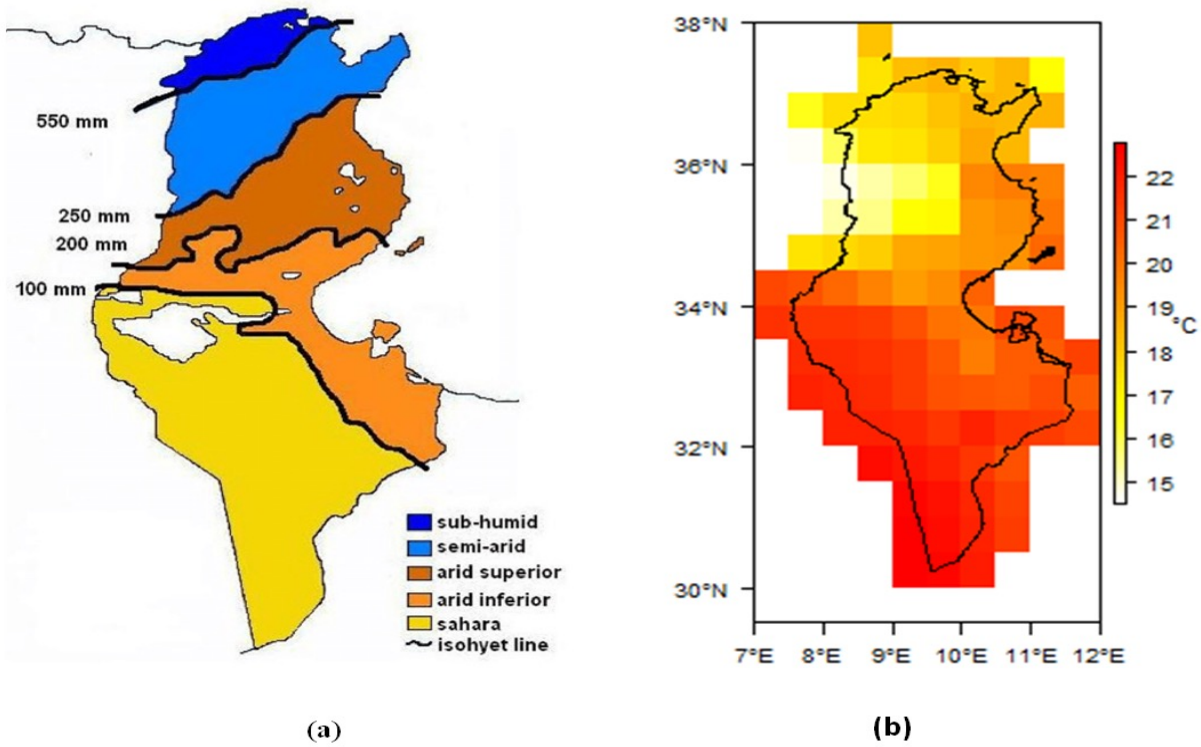

Figure 1. Tunisia climate map based to Koppen climate classification. **(a)**: Average annual precipitation, **(b)** average annual temperature

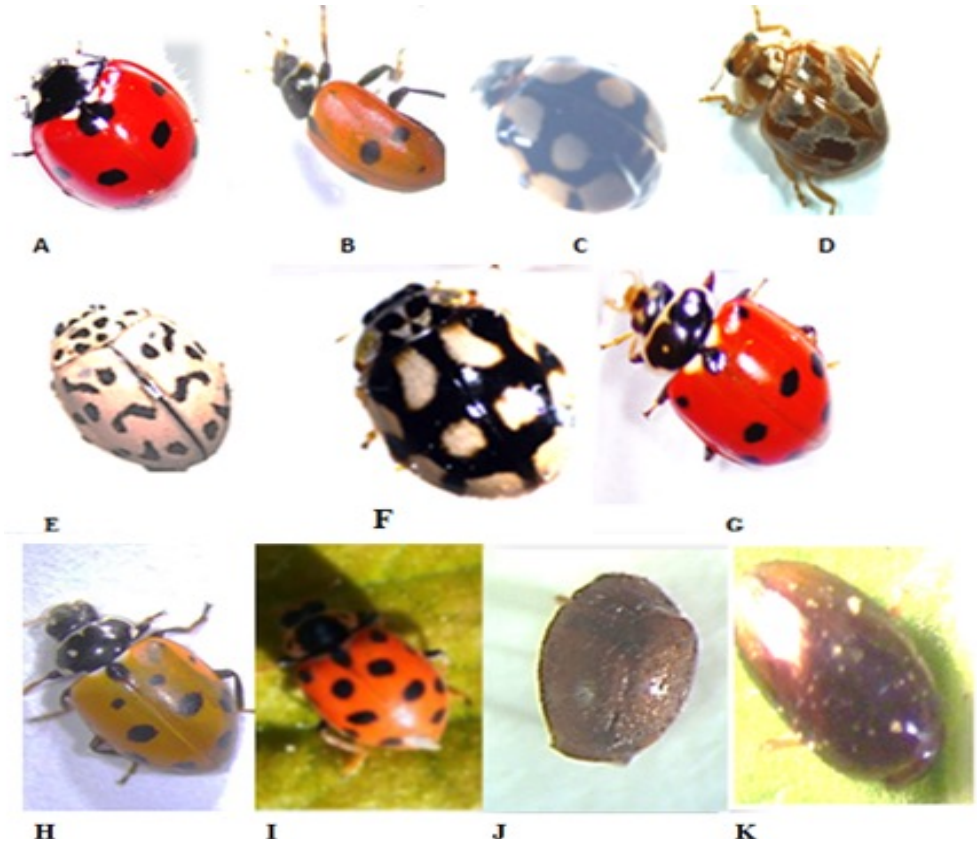

Figure 2. Ladybird species recorded in Tunisia. **A***: Coccinella algerica*, **B**: *Hippodamia variegata*, **C**: *Adalia decempunctata*, **D**: *Myrrha octodecimguttata* , **E***: Oenopia doublieri,* **F**: *Oenopia lyncea,* **G***: Coccinella novemnotata* **H***: Coccinella undecimpunctata***, I***: Hippodamia tredecimpunctata,* **J***: Scymnus fulvicollis,* **K***: Scymnus nubilus*.

Table 2. Ladybird species and aphid hosts.

Ladybird species	Aphid species prey
Chilochorus bipustalitus Linnaeus	*Aphis spiraecola* Patch
Adalia decempunctata L.	*Cinara magrebica* Mimeur, *Eulachnus agillis* Kaltenbach
Coccinella algerica Kovar	*Aphis gossypii* Glover, *Aphis fabae* Scopoli, *Aphis punicae* Passerini, *Aphis pomi* De Geer, *A. spiraecola*, Brachycaudus schwartzi Börner, *Capitophorus eleagnus* Olivier, *C. magrebica*, *Diuraphis noxia* Kurdjumov, *Dysaphis plantaginea Passerini*, *E. agillis*, *Hyalopterus pruni* Geoffroy, *Hyalopterus amygdali* Blanchard, *Hyalopterus persikonus* Miller, *Myzus persicae* Sulzer, *Macrosiphum rosae* L., *Pterochloroides persicae* Cholodkovsky, *Rhopalosiphum padi* L., *Sitobion avenae* Fabricius, *Sitobion fragariae* Wolke, *Schizaphis graminum* Rondani, *Taxoptera aurantii* Boyer de Fonscolombe.
Coccinella novemnotata Herbst	*R. padi*
Coccinella undecimpunctata Linnaeus	*R. padi*
Harmonia axyridis Pallas	*C. magrebica*, *E. agillis*.
Hippodamia variegata Goeze	*A. gossypii, H. pruni, H. amygdali, M. persicae, P. persicae, A. punicae, Aphis neeri* Fonscolombe, *C. eleagnus, R. padi*, *S. avenae.*
Hippodamia tredecimpunctata L	*C. eleagnus*
Oenopia doublieri Mulsant	*H. pruni, H. amygdali, C. magrebica*, *E. agillis.*
Myrrha octodecimguttata Linnaeus	*E. agillis*
Oenopia lyncea Olivier	*C. magrebica*, *E. agillis.*
Scymnus fulvicollis Mulsant	*H. pruni, H. amygdali, M. persicae, A. punicae, Aphis pomi, A. spiraecola.*

Table 3. Ladybird species and geographical distribution.

Ladybird species	Site/Zone
Chilochorus bipustalitus Linnaeus	Chott Mariem, Sidi Bouali, Akouda, Takelsa
Adalia decempunctata L.	Chott Mariem, Boulifa
Coccinella algerica Kovar	Tinja, Hammem-Sayala, Tarhouna, Ghozzia, Tebaba, Eddir, Boulifa, Sers, El-Houdth, Sidi-Khiar, Krib, Sidi-Thabet, Utique, Mornag, Ras-El Gassaa, Takelsa, Korbous, Chott Mariem, Sidi-Bouali, Hergla, Kalaa-Kebira, Akouda, Msaken, Jammel, El Ouerdanine, Sidi-Alouane, Chebika, Manzel-Chaker.
Coccinella novemnotata Herbst	Boulifa
Coccinella undecimpunctata Linnaeus	Boulifa
Harmonia axyridis Pallas	Chott Mariem
Hippodamia variegata Goeze	Sidi Thabet, Akouda, Chott Mariem, Jammel, El Ouerdanine, Chebika, Tinja, Hammem Sayala, Tarhouna, Ghozzia, Tebaba, Eddir, Boulifa, Sers, El-Houdth, Sidi Khiar, Krib
Hippodamia tredecimpunctata L.	Utique
Oenopia doublieri Mulsant	Chott Mariem
Oenopia lyncea Olivier	Chott Mariem
Myrrha octodecimguttata Linnaeus	Chott Mariem
Scymnus fulvicollis Mulsant	Chott Mariem, Jammel, Chebika.
Scymnus nubulis Mulsant	Jammel

Climate and ladybird distribution

The survey of the ladybird distribution demonstrated that certain species can live in sites with different climates (Table 4 and 5), while others were observed only at sites with a specific climate (Table 4).
C. algerica can be said to have the widest distribution and was found in all studied areas in which the annual average temperature ranges between 15 and 22 °C. *H. variegata* (second frequent species) and *A. decempunctata* were observed in sites belonging to two climates (semi-arid, superior arid climates) with the average annual temperature ranging between 19 and 21°C. *O. doublieri, O. lyncea, S. fulvicollis* and *S. nubulis* were less distributed and were recorded only at sites belonging to superior arid climates where the average annual temperature ranges between 19 and 20°C. *H. tredecimpunctata* at Utique and *C. novemnotata* and *C. undecimpunctata* at Boulifa were found in semiarid climates in which the average annual temperature is 18°C. The subfamily Coccinellini is found in all climate areas of Tunisia (Table 5).

Table 4. Ladybird species distribution and function of climate.

Species	**Climate zone**			
	Inferior arid	**Superior arid**	**Semiarid**	**Subhumid**
Chilochorus bipustalitus L.		+	+	
Adalia decempunctata		+	+	
Coccinella algerica	+	+	+	+
Coccinella novemnotata			+	
Coccinella undecimpuntata			+	
Harmonia axyridis		+		
Hippodamia variegata		+	+	
Hippodamia tredecimpunctata			+	
Oenopia doublieri		+		
Oenopia lyncea		+		
Myrrha octodecimguttata		+		
Scymnus fulvicollis		+		
Scymnus nubulis		+		

Table 5. Ladybird subfamily distribution and function of climate.

Subfamily	**Climate zone**			
	Inferior arid	**Superior arid**	**Semiarid**	**Subhumid**
Chilicorini		+	+	
Coccinellini	+	+	+	+
Scymnini		+		

Discussion

Over the last decade, climate changes and agricultural practices (intensive agriculture and use of chemical pesticides) affected the insect's fauna and all living organisms. In this context, the current research aimed to highlight the species of *Coccinellidae* fauna present in different habitats and crops in Tunisia. Thirteen ladybird species were identified and *C. algerica* was found to be the most abundant species. This coccinellid is known as a generalist predator and was described based on small morphological differences with the North African populations. It was originally thought to be *Coccinella septumpunctata* L. (Sahraoui *et al.,* 2014; Sahraoui and Gourreau, 2000). Marin *et al.* (2010) demonstrated that these two species were genetically similar.

Previous studies in Tunisia, described *C. algerica*, as larva and as adult, near a population of several aphid species on different host plants (Ben Halima Kamel and Ben Hammouda, 2005; Mdellel and Ben Halima Kamel, 2012; Ben Halima Kamel *et al.,* 2013; Mdellel and Ben Halima Kamel; 2015). *H. variegata,* the second abundant species, recorded at six sites, was defined as an efficient predator of *C. eleagnus* on artichoke in Tunisia (Guesmi *et al.,* 2011). It was also defined as an efficient predator of *A. gossypii* and other aphid species (Rondoni *et al.,* 2014; Hodek and Honek 1996; Obrycki *et al.,* 2009). In Australia, the lady beetle was recorded preying on twelve aphid species; one psyllid species was found to be feeding on various crops, weeds, and ornamental plants (Franzmann, 2002). The other identified species (*A. decempunctata, C. undecimpunctata, C. novemnotata, H. axyridis, O. doublieri, O. lyncea* and *S. fulvicollis*) were less abundant and have a small number of aphid species preys. Distribution and abundance of some species can be affected by the agroecosystem and the climate. All identified species were recorded in superior arid climates where temperature ranges between19 and 20°C. Mattias *et al.,* (2014) showed that complex landscapes generally harbor higher abundance and richness of beneficial natural enemies than simple landscapes. In complex landscapes, the use of predator ladybirds or parasitoids is more efficient compared to simple landscapes and intensive agriculture (Landis *et al*., 2008). In addition, climate can impact the host plants, aphid population and their natural enemies. Indeed, aphids are sensitive to climatic conditions, with extreme rainfall and drought events or low winter temperatures directly causing mortality or reducing the population growth (Hulle *et al.*, 2010). Narayandas and Alyokhin (2006) proved that rain can increase the predation risk by dislodging aphids from plants and forcing them to move between plants. However, temperature may facilitate predator effects when aphids are often more sensitive to extreme temperature fluctuations than their predators (Bale *et al.*, 2002). Extreme temperatures are stronger on aphids than predators when development rate and population density are affected (Bannerman and Roitberg, 2011). Thus, the small abundance of the ladybird species can be explained in relation to the cultural practices in some sites principally in the north of Tunisia (cereals) where a small number of aphid species was recorded, and major ladybird species were identified. Therefore, it is recommended that the impact of cultural practices, aphid diversity, and specificity of some ladybird species should be studied further in the future. Also, the mass rearing of some abundant species of ladybirds and their use in the biological control of aphids can be implemented.

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References

Agarwala, BK and Dixon, AFG. 1992. Laboratory study of cannibalism and interspecific predation in ladybirds. *Ecological Entomology*, **17**: 303-309.

Bale, JS, Masters, GJ, Hodkinson, ID, Awmack, C, Bezemer, TM, Brown, VK, Butterfield, J,

Bannerman, JA, Gillespie, DR and Roitberg, BD. 2011. The impacts of extreme and fluctuating temperatures on trait-mediated indirect aphid-parasitoid interactions. *Ecological Entomology*, **36**, 490–498.

Ben Halima Kamel, M and Ben Hamouda MH. 2005. A propos des pucerons des arbres fruitiers en Tunisie. *Notes fauniques de Gembloux*. **58**: 11-16.

Ben Halima Kamel, M, Mdellel, L, Karboul, H and Zouari, S. 2013. Les ennemis naturels du complexe d'espèces de Hyalopterus pruni en Tunisie.

Tunisian Journal of Plant Protection, **8**: 119-126.

Ben Halima Kamel, M, Mdellel, L, Zouari, S and Adouani, R. 2018. Occurrence of Harmonia axyridis in Tunisia. *Bulletin OEPP/EPPO Bulletin*, **48** (2): 307-308.

Biranvand, A, Tomaszewska, W, Nedvěd, O, Zare Khormizi, M, Nicolas, V, Canepari, C, Shakarami, J, Fekrat, L and Fürsch, H. 2017. Review of the tribe Hyperaspidini Mulsant (Coleoptera: Coccinellidae) from Iran. *Zootaxa*, **6** (2): 311-326.

Blackman, RL and Eastop, VF. 2000. **Aphids on the World's Crops. An Identification and Information Guide.** 2nd ed. John Wiley & Sons, Chichester, 414 pp.

Canepari, C. 2011. Contribution to the knowledge of the Coccinellidae of Sardinia (Coleoptera). *Conservazione Habitat Invertebrati*, **5** : 501-516.

Dixon, AFG. 2000. I**nsect predator-prey dynamics: Ladybird Beetles and Biological Control**. New York: Cambridge University Press, 257 pp.

Eastop, VF and Van Emden, HF. 1972. The insect material. In: van Emden, H. F. ed., **Aphid Technology**. London and New York, Academic Press, 45 p.

Franzman, BA. 2002. Hippodamia variegata predacious ladybird new in Australia. *Australian Journal of Entomology*, **41** (4): 375-377.

Guesmi, J, Ben Halima Kamel, M and Al Mohandes Dridi, B. 2011. Diversity of natural enemy associated to aphid's artichoke in different area of production in Tunisia. ACTA Horticulturae, 215-219.

Hodek, I and Honek, A. 1996. **Ecology of Coccinellidae**. Kluwer Academic Publishers, Boston, Massachusetts, USA, 464 pp.

Hulle, M, Coeur d'Acier, A, Bankhead Dronnet, S and Harrington R. 2010. Aphids in the face of global changes. *Comptes Rendus Biologies*, **333**: 497–503.

Iablokoff Khnzorian, SM. 1982. Les Coccinelles, **Coléoptères-Coccinellidae, tribu Coccinellini des Régions Paléarctiques et Orientale**. Société Nouvelle des Éditions Boubée, Paris, 568 pp.

Koren, T, Hlavati, D, Rojko, I, and Zadravec, M. 2012. First checklist of ladybirds (Coleoptera: Coccinellidae) of Croatia. *Acta Entomologica Serbica*, **17** (1/2): 107-122.

Landis, DA, Gardiner, MM, Van Der Werf, W and Swinton, SM. 2008. Increasing corn for biofuel production reduces biocontrol services in agricultural landscapes. Proceedings of the National Academy of Sciences, 105: 20552–20557.

Leclant, F. 1978. **Etude biocologique des aphides de la région méditeranneene : implications agronomiques**. Thése de Doctorat. Montpellier/ Université des Sciences et Techniques du Languedoc (France), 318 pp.

Marin J, Crouau-Roy, B, Hemptinne, JL, Le Compte, E and Magro, A. 2010. Coccinella septempunctata (Coleoptera, Coccinellidae): a species complex? *Zoologica Scripta*, **39**: 591-602.

Mattias, J, Riccardo, B, Barbara, E, Henrik, GS, Jan, B, Berta, CL, Camilla, W and Ola, O. 2014. Ecological production functions for biological control services in agricultural landscapes. *Methods in Ecology and Evolution*, **5**: 243 – 252.

Mdellel, L and Ben Halima Kamel M. 2012. Prey consumption efficiency and fecundity of the ladybird beetle, Coccinella algerica Kovàr (Coleoptera, Coccinellidae) feeding on the giant brown bark aphid, Pterochloroides persicae Cholodkovsky (Hemiptera, Lachninae). *Africain Entomology*, **20**: 292-299.

Mdellel, L and Ben Halima Kamel, M. 2015. Prospection and identification of natural enemies of Pterochloroides

persicae Cholodovsky (Hemiptera, Aphididae) in Tunisia. J*ournal of Entomology and Zoology Studies*, **3**: 278-282.

Narayandas, G.K and Alyokhin, AV. 2006. Interplant movement of potato aphid (Homoptera: Aphididae) in response to environmental stimuli. *Environmental Entomology*, **35**: 733–739.

Obrycki, JJ, Harwood, JD, Kring, TJ and O'neil, RJ. 2009. Aphidophagy by coccinellids; application of biological control in agroecosystems. *Biological Control*, **51**: 244-254.

Raimundo, AC, Fürsch, H and Van Harten, A. 2008. Order Coleoptera, family Coccinellidae. *Arthropod fauna of the UAE*, **1**: 217-239.

Robertson, JA, Ślipiński, A, Moulton, M, Shockley, FW, Giorgi, A, Lord, NP, McKenna, DD, Tomaszewska, W, Forrester, J, Miller, KB, Whiting, MF and McHugh, JV. 2015. Phylogeny and classification of Cucujoidea and the recognition of a new superfamily Coccinelloidea (Coleoptera: Cucujiformia). *Systematic Entomology*, **40**: 745–78.

Rondoni, G, Fulvio I, Carlo, R and Eric, C. 2014. Intraguild predation responses in two aphidophagous coccinellids identify differences among juvenile stages and aphid densities. *Insects*, **5**: 974-983.

Saharaoui, L, Hemptinne, JL and Magro, A. 2014. Biogéographie des coccinelles (Coleoptera: Coccinellidae) d'Algérie. Entomologie Faunistique. *Faunistic Entomology*, **67**: 147–164.

Saharaoui, L and Gourreau, JM. 2000. Les Coccinelles d'Algérie: Inventaire et régime alimentaire (Coleoptera, Coccinellidae). *Recherche Agronomique*, **6**: 1-27.

Stireman, JO, Dyer, LA and Matlock, RM. 2005. Top-down forces in managed versus unmanaged habitats. In: Barbosa P, Castellanos I. Editors **Ecology of Predator-Prey Interactions**. Oxford University Press.

Assessment of the Flora and Vegetation of the Shaumari Wildlife Reserve, Jordan

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Abstract: The Shaumari Wildlife Reserve, located 120 km east of Amman, is a natural protection site for dry ecosystems. It serves as a complete biodiversity station, with native animals and natural vegetation away from human disturbance. Several Field surveys were conducted in the reserve to collect plant specimens and data on habitat types and plant communities for the sake of mapping them. During this survey, random routes and quadrat analysis were used, and GPS records were taken. A geological map was prepared and modified. The reserve lies across three main formations: Azraq formation (AQ), Fluviatile deposits and gravel of Pleistocene (Pl/ Plg), and Holocene to recent alluvial sediments (Al). Four habitats were identified based on topography, soil type, and the distribution of dominant plant species as follows: Gravel plains with dwarf shrub vegetation habitats, Wadis wih sandy or gravel floors, and drainage channels habitat, Wadis with dike wall, and drainae channels and Urban areas.Two main vegetation types were determined in this reserve including Gravel Hammada and Saline vegetation. The reserve has thirteen different plant communities, primarily distributed within the Run-off hamada vegetation. A checklist of 197 recorded species belonging to 125 genera and 35 families has been prepared. Amongst the checklist species, two are globally endangered according to IUCN red list, (IUCN, 2024),namely *Bellevalia warburgii* and *Euphorbia grossheimii*. At the national level, seventeen rare species were recorded, and eleven species were endemic to Jordan. In addition, there were two species that are considered invasive plant species; *Xanthium spinosum* and *Xanthium strumarium* and are distributed in the northwest of the reserve. A total number of seventy-five plant species were collected and recorded from twenty-one quadrats. The analysis showed that *Anabasis articulata* scored the highest frequency value among the perennial species, while the highest density was recorded for *Atriplex halimus*, and the highest abundance was for *Halogeton alopecuroides*. Specimens of the collected plant species have been deposited in the Royal Society for the Conservation of Nature RSCN/NCMC Herbarium.

Keywords: Biodiversity, Plant species, Protected Areas, Habitat, NE Desert, Mapping, RSCN.

Introduction

The Shaumari Wildlife Reserve is located in the eastern desert of Jordan with a total area of 22 km² surrounded by a fence. The reserve is located about 120 km east of Amman, and 12 km southwest of the Azraq village. The Shaumari Wildlife Reserve is the oldest national reserve in Jordan established as a center and international biological station for the protection and rehabilitation of the locally extinct Arabian Oryx and endangered gazelles at the global level. It is considered an important example of natural protection as well as a living area for the protection of dry ecosystems. Moreover, it can be used as a complete biodiversity station since it has both native animals and natural vegetation that are away from human interference (Al-Eisaw, 1996).

The Shaumari Wildlife Reserve is situated after Tethys Sea regression and migration in the Hammada Plains, which is one of the regional geomorphological provinces in the Azraq area. The reserve consists of extensive

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flat or gently sloping plains with a distinctive ferret-dendritic drainage pattern (Abed *et al.* 2008). The plains are strewn with partially weathered fragments of limestone and flint or chert.

The oldest formation exposed in the reserve is the Azraq formation (AQ) dating to the middle Pleistocene age (Abed *et. al*, 2008; Abed and Hamidan, 2021). It is dominated by mud plains, unconformably covers of the Chert- Limestone and Chalk formations (Ibrahim, 1996). The overlying AQ consists of Fluviatile deposits and gravel of Pleistocene (Pl/ Plg) characterized by poorly sorted deposits of limestone and gravel mostly black chert lithology and is usually cemented by gypsum (Ibrahim *et al.* 2001). The Pl/ Plg is overlain by the most recent deposits from Holocene to Recent sediments (Al) (Figure 1); the sediments include alluvial and wadi sediments, alluvial mudflats, and siltflats (Fadda, 1996).

Soil parent materials in the reserve include limestone, chalk, calcareous sands, gypsum, marls, and Tertiary cherts. These soils, when occurring with dense flint pavement, are named "Hammada" by Gruneberg and Dajani (1964).

Hydrologically, occasional runoff in the reserve occurs during the wet season and is caused by short and heavy thunderstorms, which may lead to large floods. Three wadis drain into the reserve, including Wadi Al-Shaumari, Wadi Al-Dab'i, and Wadi Al-Ghadaf (Fadda, 1996 and Ibrahim *et al.* 2001).

The Shaumari Wildlife Reserve is located within the Saharo-Arabian biogeographical region (Figure 2) (Al-Eisawi, 1996). The reserve extends over flat land and consists of two main landscapes: the Gravel Hammada and the Runoff Hammada. The Gravel Hammada is the flat part of the reserve and is confined to the south and southwestern parts. This area is comprised of clayey loam covered by gravel with sparse vegetation. The Runoff Hammada represents wadi beds, including three main wadis: Al-Ghaddaf, Al-Dab'i, and Al-Shaumari wadis, which constitute the largest part of the reserve.

The Shaumari Wildlife Reserve in Jordan is a unique ecosystem with a sparsely vegetated area, dominated by shrubs and subshrubs with a low density of individuals. The reserve has been the subject of several environmental studies and field surveys, with the first survey conducted by John Clark in 1975-1979. These surveys documented 170 plant species belonging to thirty-five families, which were collected and deposited at the Herbarium of the Royal Society for the Conservation of Nature (RSCN).

The reserve is surrounded by a fence, which protects it against all threats such as overgrazing and contributes to increasing the vegetation cover inside the reserve two to three times compared to the outside of the reserve (Hatough *et al.* 1986). This protection from grazing has allowed the development of a structurally complex and species-rich plant ecosystem which supports a more diverse community of mammals, reptiles, and birds compared to the outside of the reserve (Al- Eisawi and Hatough, 1987). The vegetation analysis revealed a mean vegetation cover of 23% in the reserve and a plant height reaching 84.1 cm, while there is only 5% outside the reserve with a height of <20 cm. This indicates that the reserve contributes to the prevention of desertification and serves as a good example for the rehabilitation of degraded desert areas, such as reducing runoff, increasing soil fertility, and enhancing seed banks. Al-Eisawi (1996) indicated that Hammada vegetation is dominant in the reserve and four main subdivisions are recognized; (i) Gravel Hammada, (ii) Runoff Hammada, (iii) Mud flats vegetation restricted to small areas with a poor vegetation except on the margins, and (iv) Saline vegetation. RSCN (2002) conducted an ecological baseline survey at the reserve recording 193 plant species with two species classified as endemic: *Salsola jordanicola* and *Rheum palaestinum* and seven as rare species (Al- Eisawi *et al*., 2000). In 2015, Al-Eisawi and Abu Yahia documented a total of eighty-three plant species belonging to twenty-two families and sixty-four genera; two of which are classified as endemic species; *Rheum palaestinum*

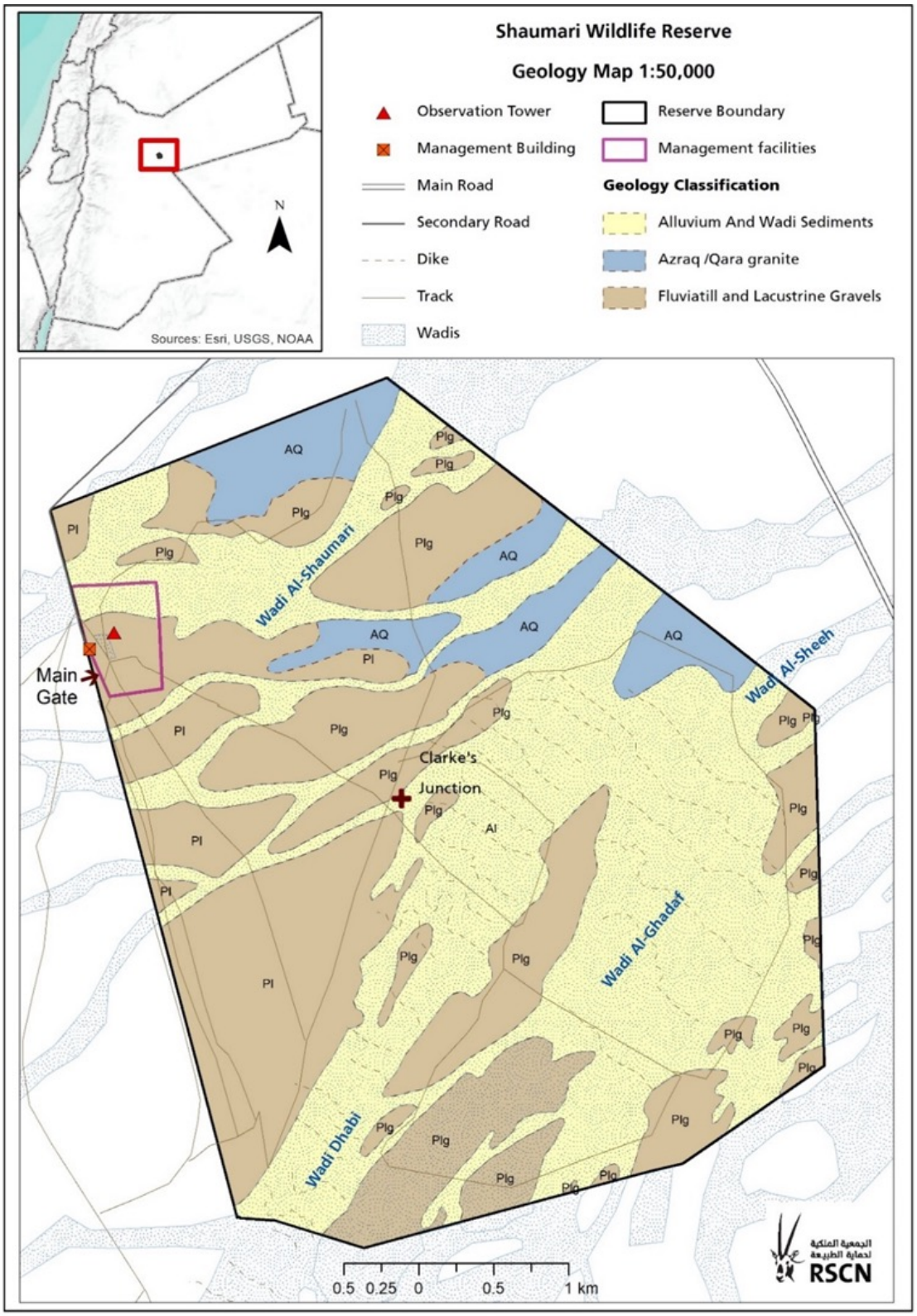

Figure 1. A modified geological map of the Shaumari Wildlife Reserve.

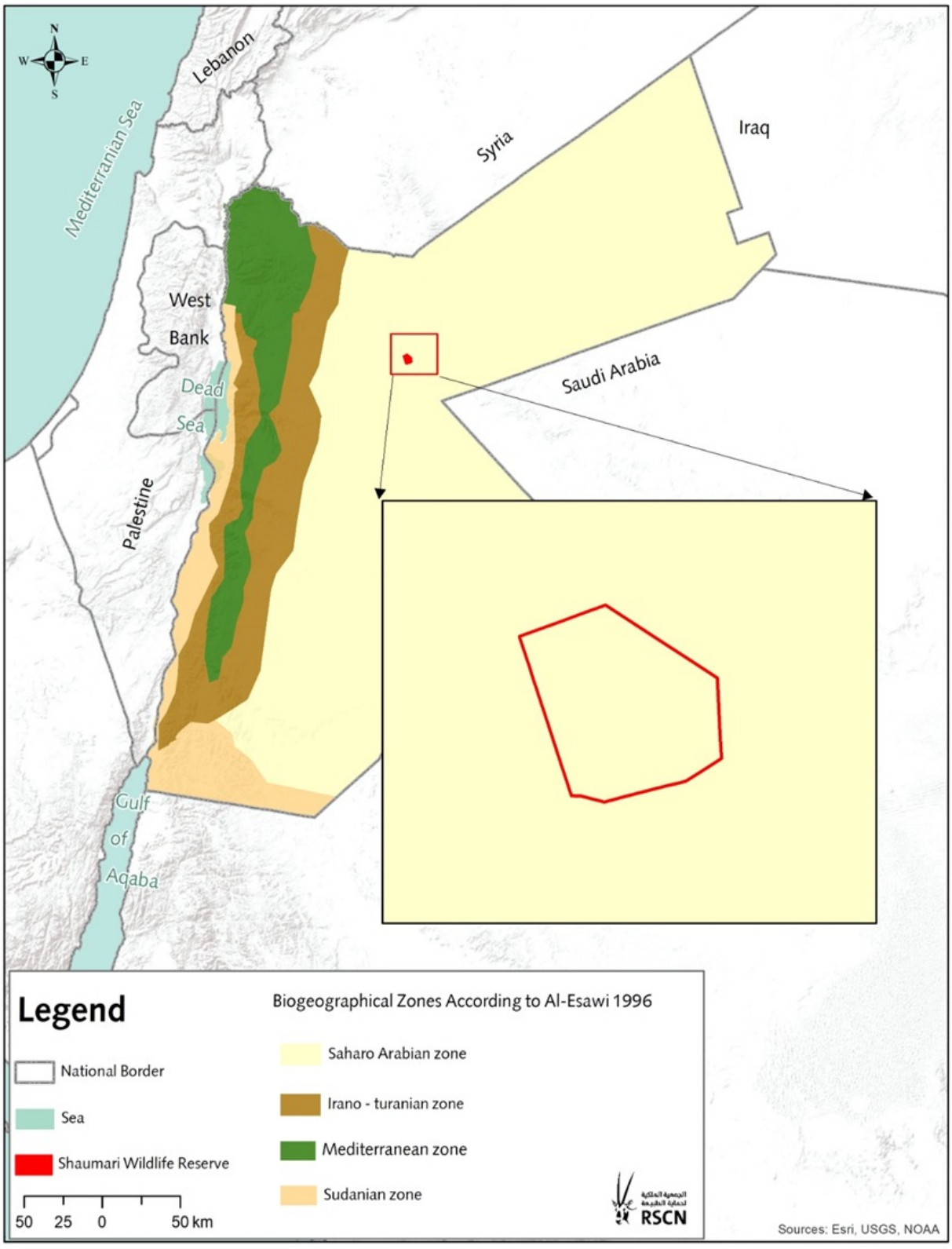

Figure 2. The biogeographical zone to which belongs the Shaumari Wildlife Reserve according to Al-Eisawi, 1996.

and *Salsola jordanicola,* and four as rare species at the national level; *Girgensohnia oppositiflora, Halocnemum strobilaceum, Suaeda fruticosa*, and *Pseuderucaria clavata*. The most recent study of flora and vegetation cover in the reserve was conducted in 2023. The vegetation cover in the reserve was assessed using satellite sensor data from the period between 1991 and 2022 (Majed, and Othman, 2023). The NDVI-Landsat showed that 70% to 94% of the reserve is classified as bare soil across the growing seasons (March to July) and over the study period. Additionally, in July-August (1991-2022), the percentage of reduction in vegetation cover area (compared to March) ranged from 1% (1994) to 20% (2004). The study concluded that a moderate and significant relationship between vegetation cover density and rainfall was found during the growing season in the reserve.

Despite all these studies conducted in the reserve, no plant specimens were collected except for Clark's in 1976. The study aims to evaluate the vegetation cover, including plant species and vegetation communities, and provide recommendations for supporting the management and conserving ecosystems of the reserve. Additionally, it aims at collecting plant specimens representative of each species present within the reserve and deposit them at the Herbarium of the Royal Society for the Conservation of Nature (RSCN).

Materials and Methods

Fieldwork

In 2023, Several field trips to different locations were conducted during the late winter and spring from April to May while five field trips were made throughout the summer. Two sampling methods, transects and quadrates, were applied, and each addressed specific elements of the vegetation and flora. Specimens were also collected using these two methods.

Line Transects

To evaluate the flora and vegetation across the landscape, plant specimens were collected. Also, data on the distribution, density, and other significant vegetation features, including vegetation communities, vegetation types, and habitat determination were gathered and processed.

The random route transects were conducted along eleven routes, covering a total distance of 51 km. This approach was aimed at surveying the largest possible area and collecting plants representative of each vegetation type within the reserve. This method allowed the teams to move freely, gather extensive data, and collect samples from all habitats within the reserve (Figure 3A). A representative specimen of each of the floral species recorded along the transects was collected for deposition in the herbarium and for taxonomy verification. The coordinates of the collection localities were recorded to produce flora and plant community maps of the reserve. All floral and vegetation data were recorded using a handheld GPS device (Garmin GPSMAPS 73s).

Measures of Species Population and Distribution

Systematic methods were used to produce area-based samples (quadrats) that could be allocated to a map. An assessment of the vegetation cover in the reserve was undertaken using quadrat sampling. In these sampling sites, the reserve area was subdivided into 1x1 km² grids. At the center of each grid, a sampling plot of 10x10 m² was assigned. A total of twenty-one plots were selected for the study, with ten quadrats excluded because more than 60% of their area lay outside the reserve boundaries (Figure 3B). Once the location for a quadrat was selected, the four corners were determined using a tape measure. At each quadrat, a data sheet was completed to record a series of attributes necessary for calculating quantitative measures of ecological parameters, including abundance,

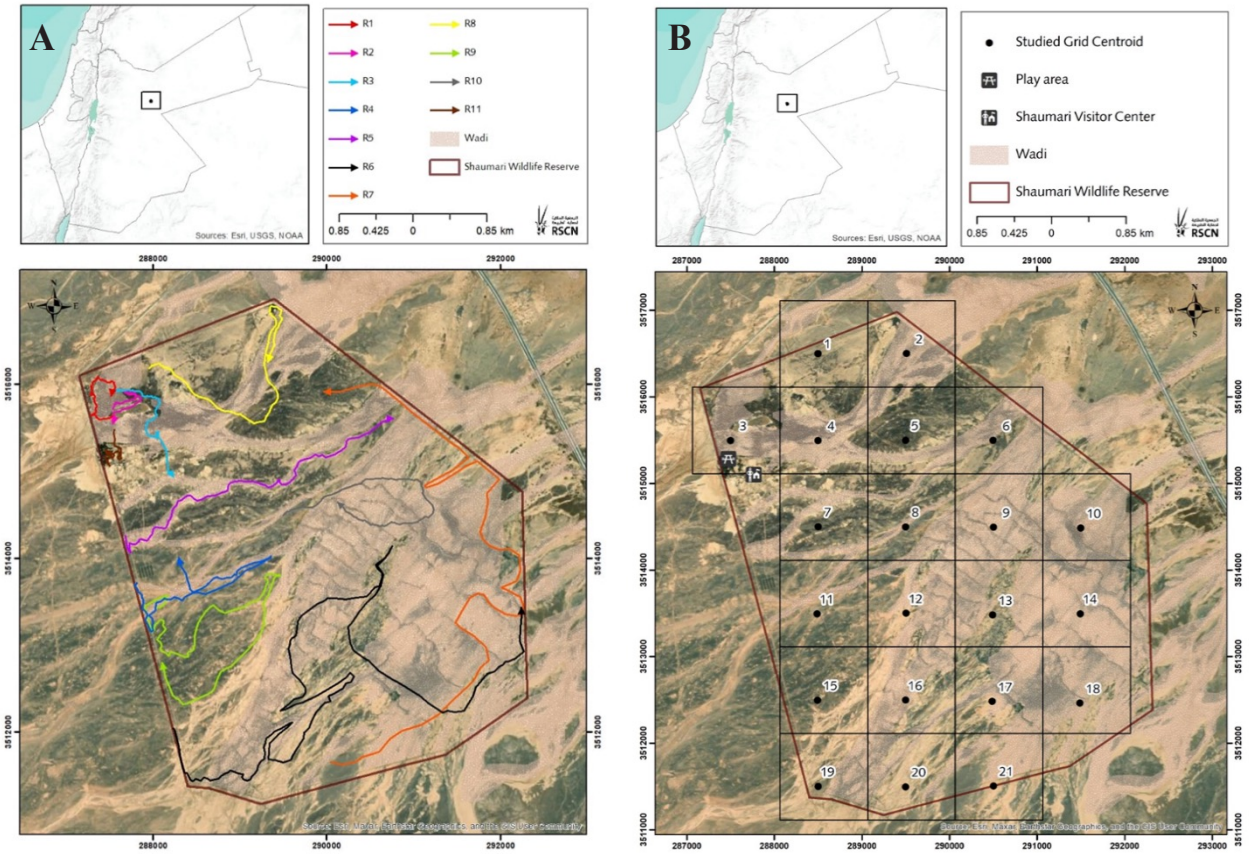

Figure 3. **A**: Random Routes Transects conducted in the Shaumari Wildlife Reserve. **B**: Location of quadrats conducted for the assessment of the flora in the Shaumari Wildlife

density, and frequency using the formulas based on (Ludwig and Reynolds, 1988).

Herbarium specimens' collection

All plant species recorded were collected, pressed, and assigned a reference number (Figure 4). The specimens were then identified in the laboratory using a dissecting microscope (40x magnification power) and based on Flora palaestina (volume 1, 2, 3, and 4) (Zohary 1966 and Feinbrun, 1986). The plant Names were revised according to the plant world online website (Kew, 2021). The plant species were poisoned chemically using a mixture of 150 g mercuric chloride (HgCl) and 350 g ammonium chloride (NH4Cl), dissolved in as little water as possible, with 10 L of 96% ethanol. The specimens were labeled, mounted, and a voucher specimen was deposited at the Herbarium of the Royal Society for the Conservation of Nature (RSCN) for each species.

Results

A total of 197 plant species were recorded in the Shaumari Wildlife Reserve, belonging to thirty-five families and 125 genera. Two species are evaluated as globally Endangered, namely *Bellevalia warburgii* and *Euphorbia grossheimii* (IUCN red list 2024). At the national level seventeen rare species were recorded in the reserve and eleven species were identified as endemic to Jordan including *Verbascum transjordanicum* (Figure 5). A list of the endangered and rare species is given in Table 1 (Al – Eisawi *et. al*., 2000). Based on their human uses, there are twenty-one plants used for medicinal purposes, thirteen edible species, thirty-two palatable plants, four poisonous species, and six woody plants. In addition, there are two species that are considered invasive plant species; *Xanthium spinosum* and *Xanthium strumarium* which are distributed in the northwest of the reserve and extend beyond the fence.

Figure 4. Herbarium specimen vouchers for the plant species collected from the Shaumari Wildlife Reserve. **(A)** *Limonium lobatum*, **(B)** *Bromus danthoniae*

Figure 5. *Verbasum transjordanicum*, an endemic species recorded from the Shaumari Wildlife Reserve.

Table 1. A List of Endemic and Rare Plant Species recorded from the Shaumari Wildlife Reserve

Species	Status at the national level
Achillea fragrantissima (Forssk.) Sch.Bip.	Near Endemic
Anthemis pseudocotula Boiss.	Rare
Astragalus transjordanicus Sam. ex Rech.f.	Endemic
Avena longiglumis Durieu.	Rare
Bellevalia warburgii Feinbrun.	Endemic
Brassica aucheri Boiss.	Rare
Bromus lanceolatus Roth var.lanatus Kerguelen.	Rare
Caroxylon tetragonum (Delile) Moq.	Rare
Centaurea ammocyanus Boiss.	Rare
Centaurea dumulosa Boiss.	Endemic
Ducrosia flabellifolia Boiss.	Rare
Echinops philistaeus Feinbrun & Zohary.	Endemic
Echinops polyceras Boiss.	Rare
Erodium arborescens (Desf.) Willd.	Rare
Euphorbia grossheimii (Prokh.) Prokh.	Rare
Galium aparine L.	Rare
Halocnemum strobilaceum (Pall.) M.Bieb.	Rare
Haplophyllum blanchei Boiss.	Near Endemic
Oloptum miliaceum (L.) Röser & Hamasha	Rare
Onopordum macrocephalum Eig	Endemic
Phalaris minor Retz.	Rare
Polygonum palaestinum Zohary.	Endemic
Rheum palaestinum Feinbrun.	Endemic
Sisymbrium damascenum Boiss. & Gaill.	Rare
Sisymbrium septulatum DC.	Rare
Sonchus suberosus Zohary & P.H.Davis	Endemic
Suaeda fruticosa Forssk. ex J.F.Gmel.	Rare
Verbascum transjordanicum Murb.	Endemic

Habitat Type

The field survey indicated that the reserve consists of four terrestrial habitats based on topography, soil type, and the distribution of dominant plant species (Figure 6) as follows:

Gravel plains with dwarf shrub vegetation habitat: It is flat land covered by gravel, constituting only a small area of about 48.9% of the total surface area of the reserve and is located in the Pl/Plg formation within the reserve. Vegetation in this habitat is sparse and is characterized by dwarf shrubs dominated by *Haloxylon salicornicum, Soda rosmarinus,* and *Anabasis articulata* (Figure 7A).

Wadis with sand or gravel floors and drainage channels: This habitat type accounts for 24.1% of the reserve area and consists of the main wadis covered by bushes, shrubs, and herbs with a very good vegetation cover. This habitat is located in the Alluvial and wadi deposits formation (Figure 7B).

Wadis with dike walls, and drainage channels: This habitat type accounts for 26.2% of the reserve area and consists of the wadi with a series of dike walls, about 2 meters in height (Figure 7C).

Urban areas: This habitat consists of reserve buildings and other infrastructure covering a small area of about 0.8% of the reserve.

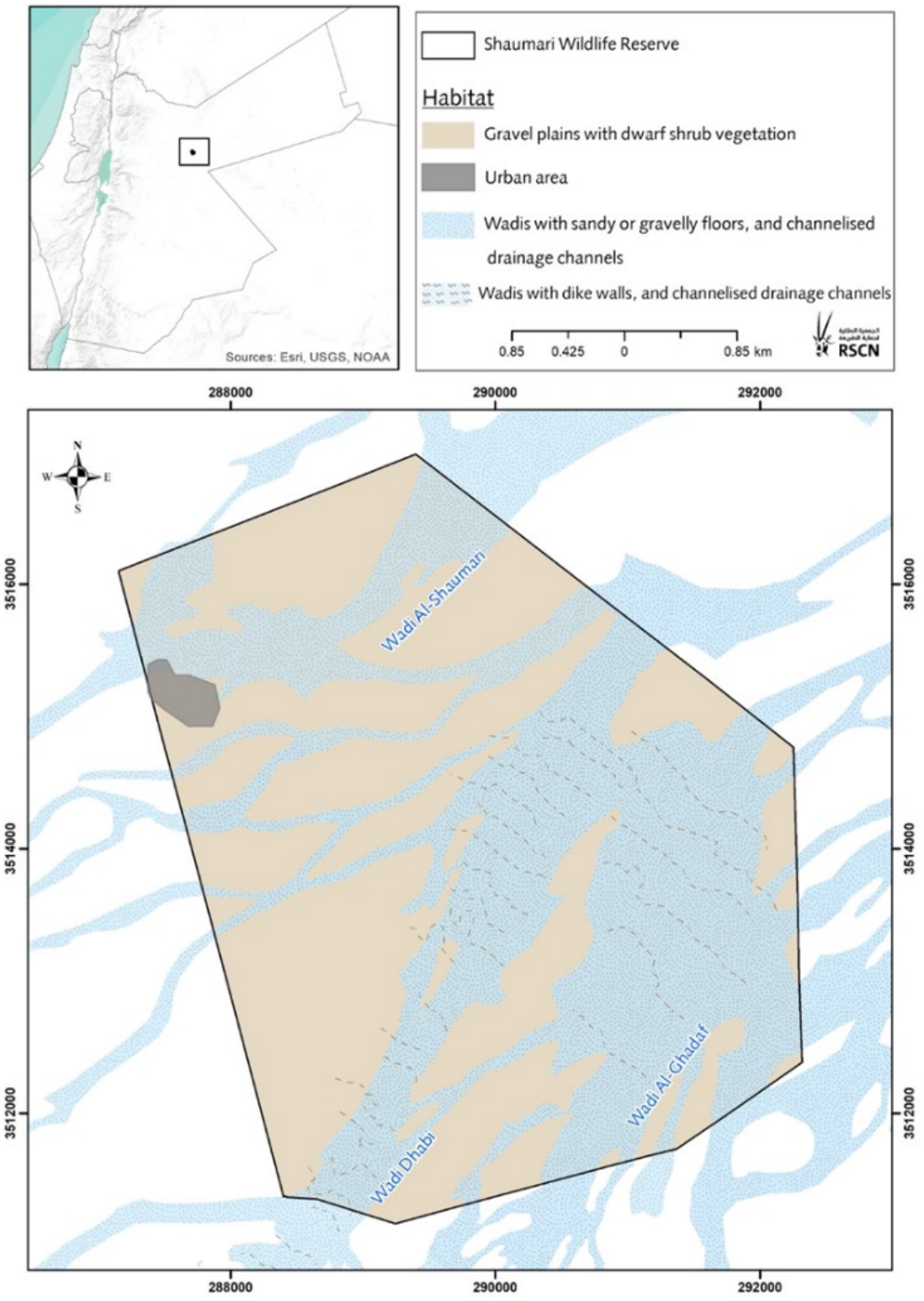

Figure 6. Habitat types in the Shaumari Wildlife Reserve.

Vegetation Types

Based on the topography and distribution of the dominant vegetation elements species in the Shaumari Wildlife Reserve, two main vegetation types were defined including Hammada and Saline vegetation. The Hammada vegetation is divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada shown in Figure 8 as follows:

Run-off Hammada: This vegetation represents wadi beds including three main

Figure. 7: Different habitat types in the Shaumari Wildlife Reserve, (A) Gravel plains with dwarf shrub vegetation, (B) Wadi with sand or gravel floors, and drainage channels, (C) Wadis with dike wall, and drainage channels

wadis; Al-Ghaddaf, Al-Dab'i, and Al-Shaumari wadis covering the largest part of the reserve and extending beyond the borders of the reserve with a dense vegetation cover dominated by shrubs such as *Atriplex halimus*. Most of the plant species were recorded from this vegetation type (Figure 9A).

Gravel Hammada Vegetation: This type is covered by gravel with a sparse vegetation not exceeding 10% of the area. It is characterized by low shrubs such as *Haloxylon salicornicum, Soda rosmarinus,*and *Anabasis articulata* (Figure 9B).

Sandy Hammada Vegetation: This type covers flat areas comprised of a mixture of gravel and small pebbles with sand. The vegetation cover is greater than that of the Gravel Hammada reaching about 20 to 25% of its area. It is characterized by low shrubs and some herbs. (Figure 9C).

Saline Vegetation: It can be found in the eastern part of the reserve, specifically in the Wadi Al-Ghadaf area, and is dominated by pure gypsum overlain with a thin layer of silt forming salt crusts on the surface. This vegetation is primarily dominated by *Tamarix passerinoides* and *Nitraria retusa*, with associated species such as *Limonium pruinosum* and *Alhagi maurorum* (Figure 9D).

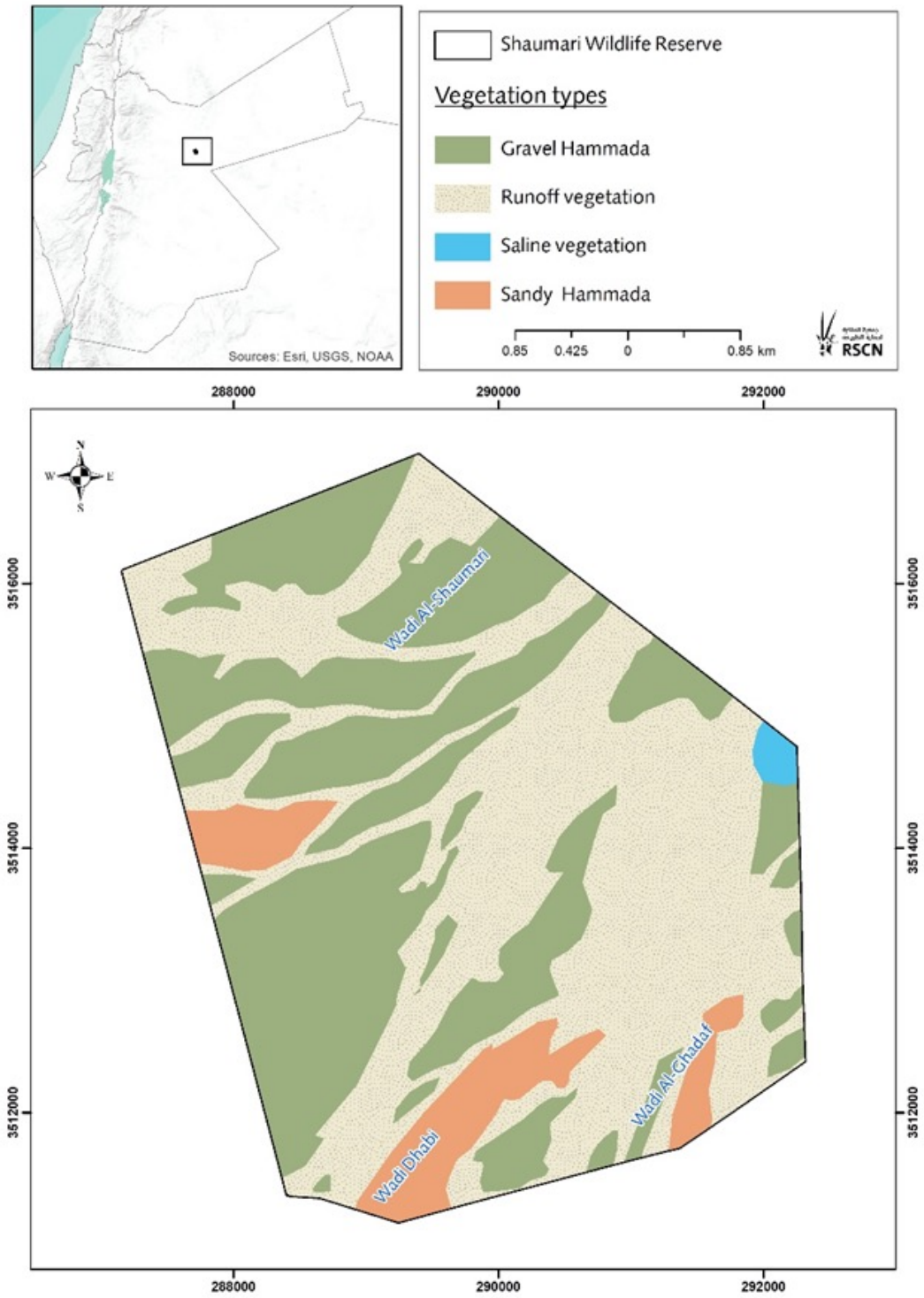

Figure 8. Vegetation types of the Shaumari Wildlife Reserve.

Vegetation Communities

The reserve is characterized by a mosaic of dwarf shrubland communities containing thirteen different plant communities, primarily distributed within the Run-off vegetation. These variations are presumed to arise from differences in soil type, texture, and salinity (Figure 10).

Vegetation Analysis

A total of thirty-three families were recorded in the Shaumari Wildlife Reserve. The Asteraceae family is the largest with a total of thirty-six species followed by Poaceae with twenty-eight species, Chenopodiaceae with twenty-three species, Brassicaceae with twenty species, and Fabaceae with fifteen species (Figure 11).

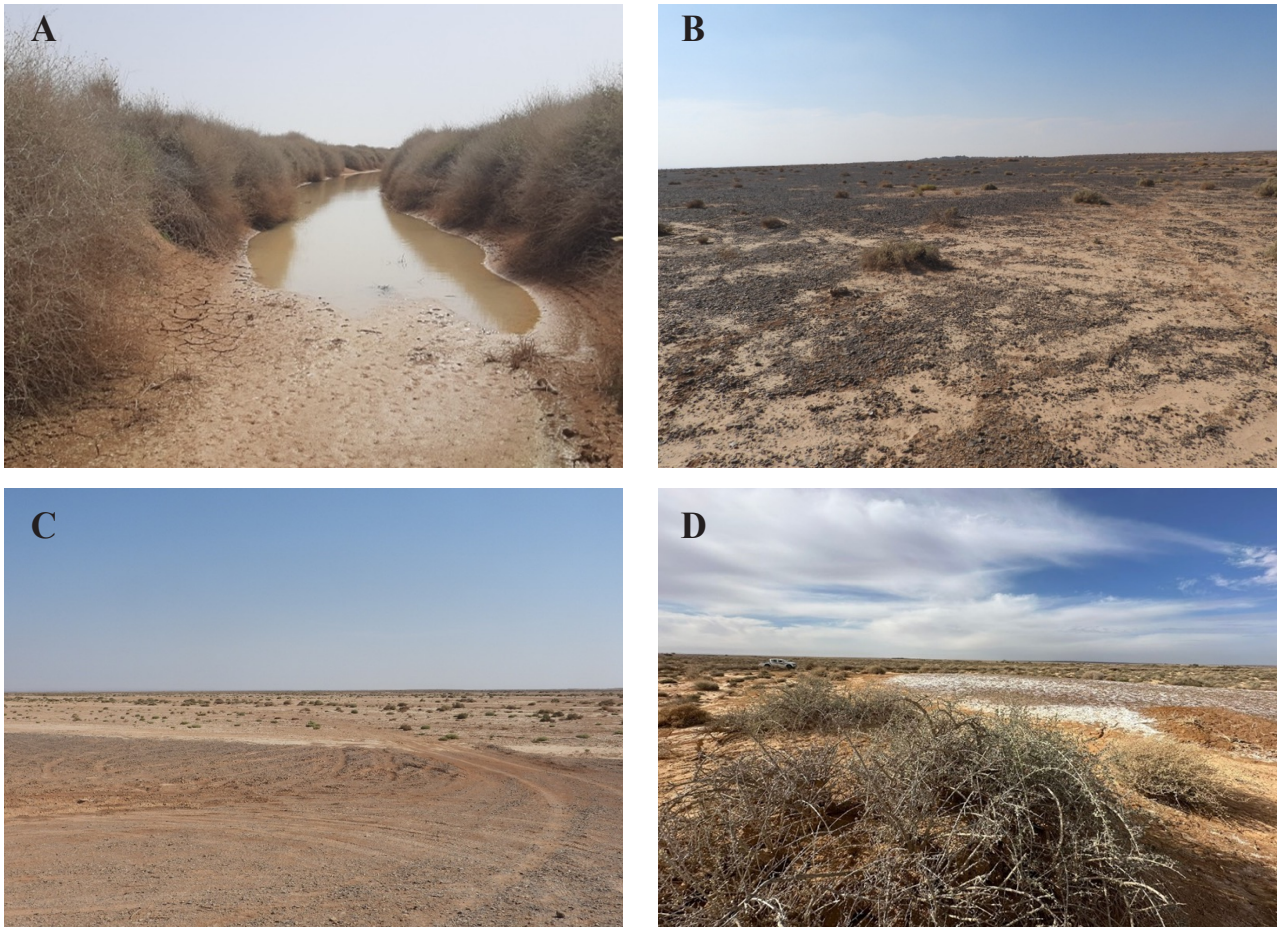

Figure 9. The different vegetation types identified in the Shaumari Wildlife Reserve (**A)** Run- off Hammada vegetation type in the Shaumari Wildlife Reserve (**B)** Gravel Hammada vegetation type in the Shaumari Wildlife Reserve (**C)** Sandy Hammada vegetation type in the Shaumari Wildlife Reserve (**D)** Saline vegetation type in the Shaumari Wildlife Reserve.

Vegetation attributes

Parameters such as abundance, frequency, and density were used to describe the status and structure of vegetation communities and the associations of flora species within the reserve. The total number of individuals in all studied plots of each species ranged from one for twenty-five individuals such as *Zygophyllum arabicum, Savignya parviflora,* and *Suaeda fruticosa* to 1041 individuals for *Plantago ovata*. As for plant community abundance, *Carduus australis* recorded the highest value among the species followed by *Plantago ovata* and *Bromus tectorum* (Figure 12). In relation to the species frequency (proportion of quadrats with species present), *Anabasis articulata* showed the highest value followed by *Erucaria boveana, Salsola rosmarinus,* and *Atriplex halimus* (Figure 13). Regarding density, *Plantago ovata* recorded the highest density among the species followed by *Malva parviflora*, *Plantago amplexicaulis,* and *Phalaris minor* (Figure 14).

Herbarium Specimen Collection

A total of 600 specimens of shoots and root material were collected to represent all plant species recorded throughout this survey. The specimens were identified, labeled, and mounted. A voucher specimen of each species was deposited at the herbarium of the Royal Society for the Conservation of Nature (RSCN) as mentioned earlier under materials and methods.

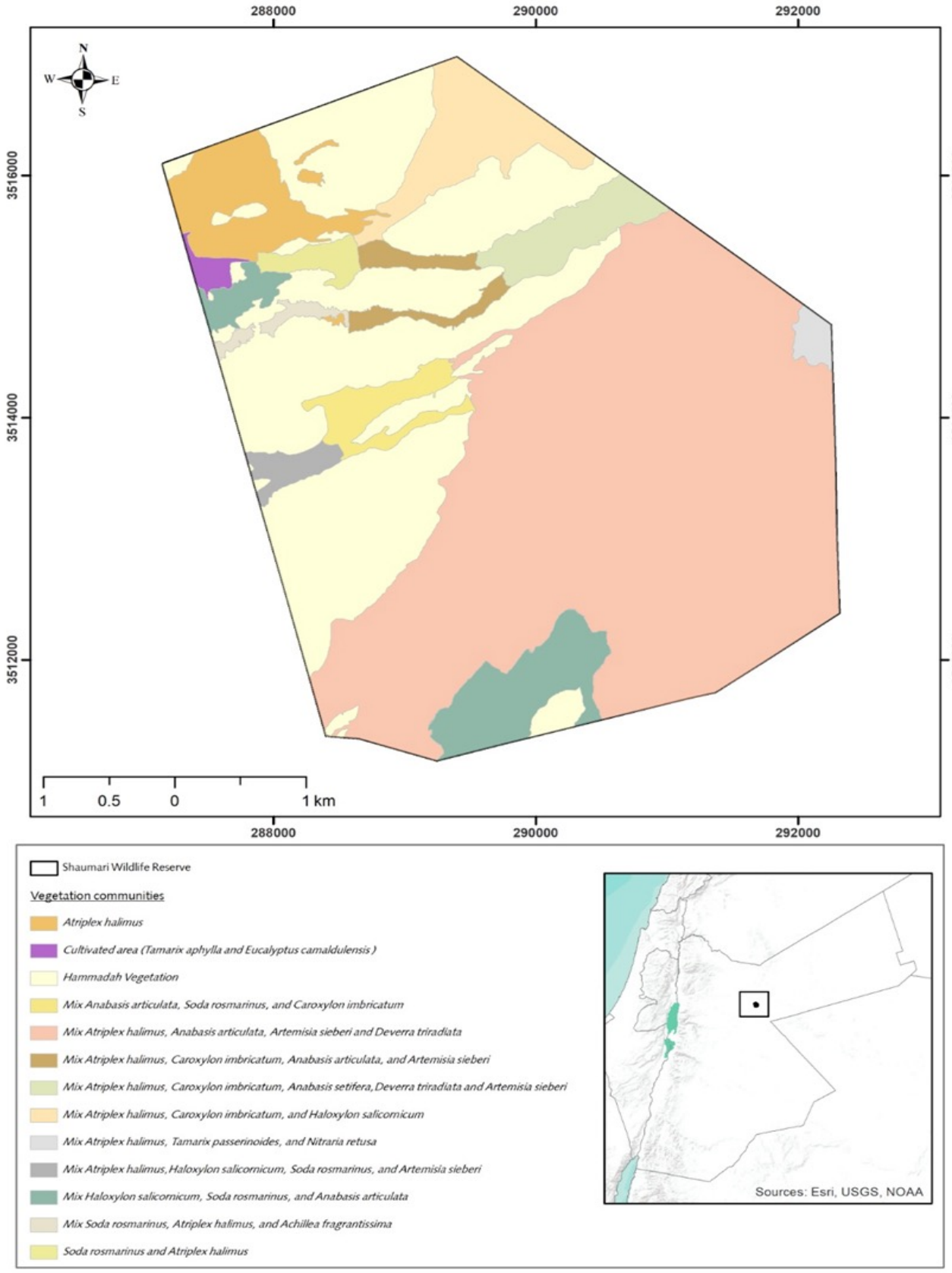

Figure 10. Vegetation Communities in the Shaumari Wildlife Reserve based on the current study.

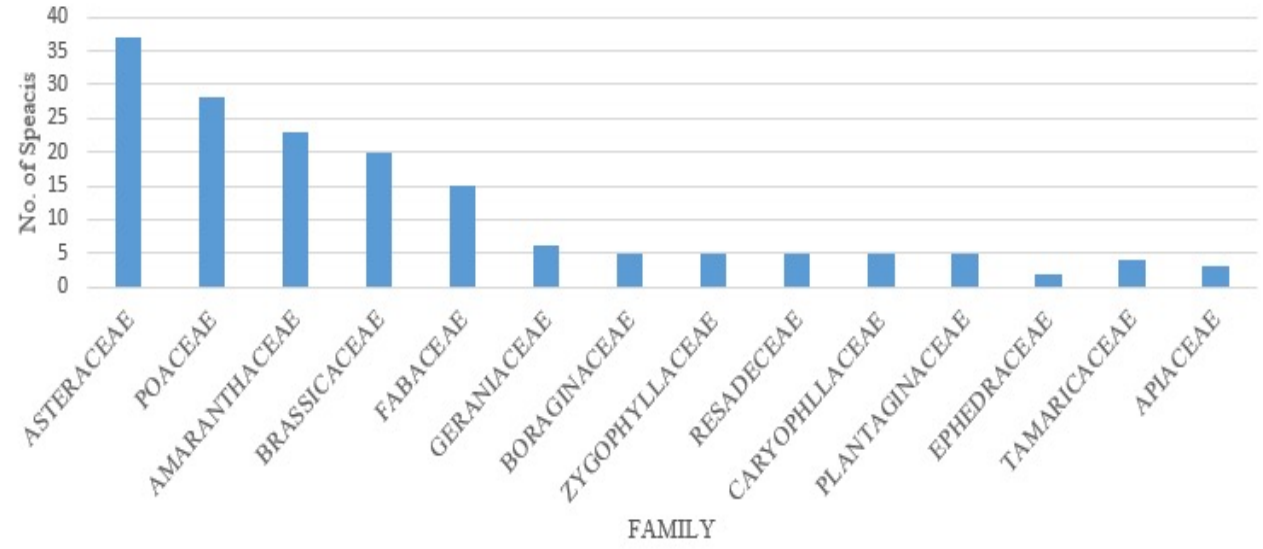

Figure 11. The largest families recorded in the Shaumari Wildlife Reserve.

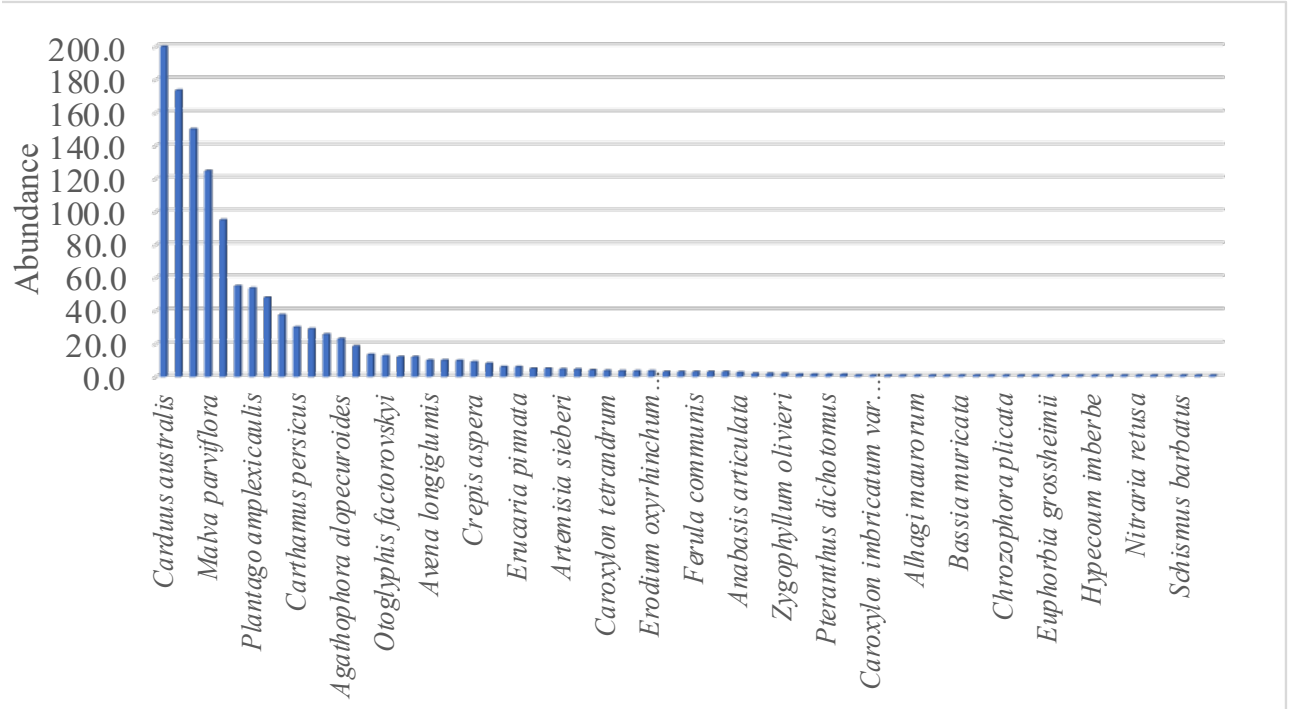

Figure 12. The species with the highest abundance values within the Shaumari Wildlife Reserve

Discussion

Flora Checklist

During this survey, a total of 197 plant species were recorded from the Shaumari Wildlife Reserve. This represents the highest number of plant species documented in the reserve surpassing previous studies. Clark (1997) recorded 168 plant species, while Al-Eisawi and Abu Yahya (2014) documented only eighty-one species throughout their study. The significant differences in species numbers among these studies may be attributed to several factors, including the timing and methodology of the surveys. Al-Eisawi and Abu Yahya (2014) conducted their survey between February and April, which may have been during an off-season for some species, whereas this survey was conducted during late winter and spring, from April to May, with additional field trips conducted throughout the summer. This timing difference could have resulted

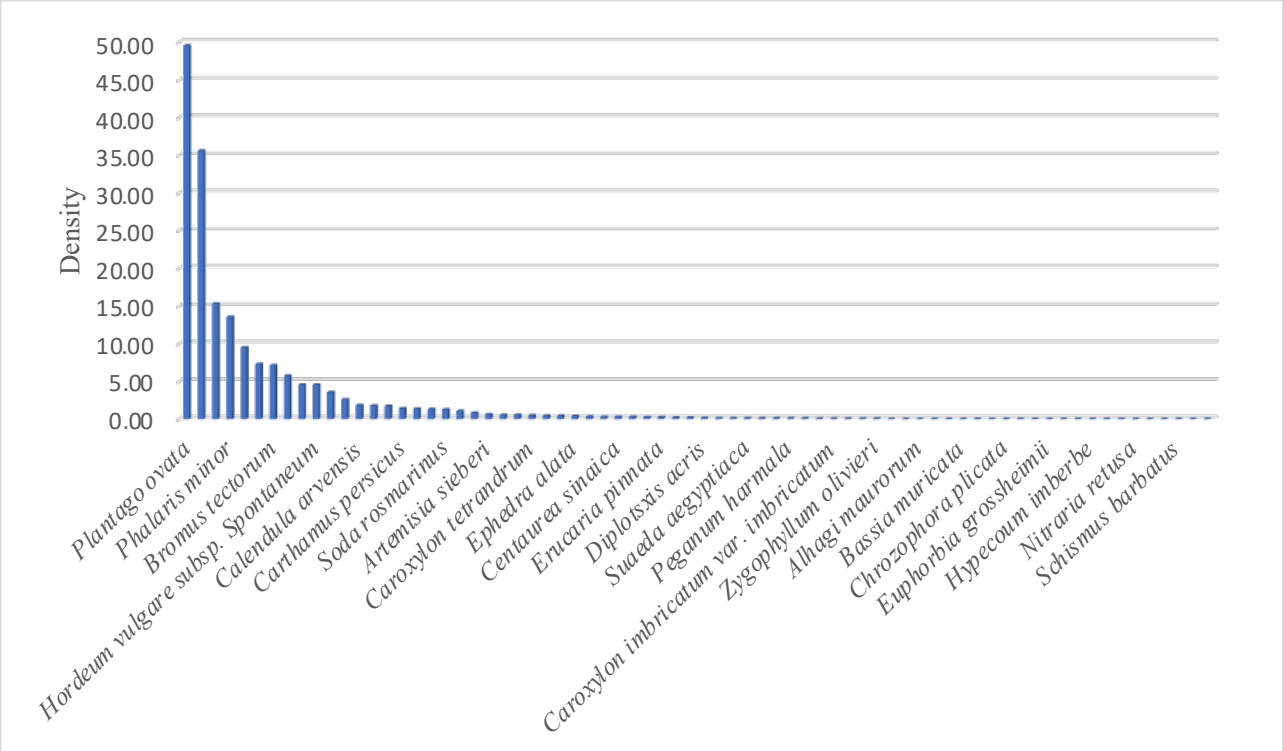

Figure 13. The species with the highest densities within the Shaumari Wildlife Reserve

in the underrepresentation of certain species, particularly those that are seasonal or less visible during specific months.

In contrast, the higher number of species recorded in this survey may reflect more favorable environmental conditions or more extensive sampling methods. This emphasizes the importance of conducting surveys at different times of the year and using varied sampling techniques to capture the full diversity of plant species in an area.

Despite the differences in species numbers, the studies share similarities in that they all reflect the dynamic nature of the reserve's plant communities. The variations in species composition over time highlight the influence of factors such as climate, rainfall, and ecological succession on the reserve's flora. These findings also underscore the importance of continued monitoring to better understand how plant communities evolve in response to environmental changes.

Two species are evaluated as globally Endangered: *Bellevalia warburgii* and *Euphorbia grossheimii* (IUCN Red List, 2023). Both species were previously recorded by Al-Eisawi, (2013) and Taifour *et al.* (2017) in Jordan, but this survey presents their first documentation within the Shaumari Wildlife Reserve. The new records of these endangered species in the reserve are significant as they contribute to the understanding of the distribution of rare and threatened species within protected areas. The presence of *Bellevalia warburgii* and *Euphorbia grossheimii* highlights the ecological importance of the reserve in conserving biodiversity and underscores the need for continued monitoring and the protection of these endangered species in their natural habitats.

Throughout the study, two species, *Xanthium spinosum* and *Xanthium strumarium*, were documented as invasive plant species in the Shaumari Wildlife Reserve. These species are highly invasive weeds capable of growing under a variety of environmental conditions. They can readily establish themselves in cultivated land and pastures posing a significant threat to native and endemic flora and fauna (Sharkas, 2011; Maxie, 2015; Kew, 2021). Notably, these two species have not been recorded in any previous studies conducted within the reserve. Their presence marks a new concern for the reserve's biodiversity highlighting the need

for monitoring and management strategies to prevent their spread and mitigate their impact on the native plant communities.

Habitat and Vegetation Types

Four terrestrial habitats were identified and delineated: Gravel plains with dwarf shrub vegetation habitat, Wadis with sandy or gravel floors, and drainage channels habitat, Wadis with dike wall, and drainage channels and Urban areas. These habitats are similar to those presented by (Clark, 1977), where he outlined the presence of wadis, hammada, dikes, and roads. However, the boundaries of these habitats were redrawn, and reserve buildings were identified. These habitats and topography were affecting the distribution of the dominant vegetation element species in the Shaumari Reserve and vegetation cover. Two vegetation types were identified in the Shaumari Reserve: Hammada and Saline vegetation types; this is consistent with (Al-Eisawi,1996) in describing the Badia desert of Jordan in general and the Shaumari Reserve in particular. The Hammada vegetation was further divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada. The presence of dikes along Wadi Dhabi and Wadi Ghadaf led to the deposition of a thin layer of sand on the ground surface between them, which can be described as the Sandy Hammada vegetation. This allows for the growth of some annual plants in that area (Peters, 2002 and Okin *et al.,* 2001). Additionally, the elevation in the reserve ranges from 500 to 529 meters above sea level from south to north. Water flows from south to north, with the lowest point in the northeastern part of the reserve. Water has pulled very fine soil particles and some silt, forming salt crusts on the surface. This area has become solid and salty forming Saline vegetation dominated by halophytic plants including *Tamarix passerinoides* and *Nitraria retusa* associated with *Limonium pruinosum* and *Alhagi maurorum* (Menzel *et al.,* 2013). The detailed map describing the distribution of vegetation types in the Shaumari Wildlife Reserve revealed a convergence in the occupied areas of both Run-off Hammada and Gravel Hammada vegetation types, which together form the total area of the reserve; this agrees with RSCN, 2002 and Al-Eisawi and Abu Yahia, 2014 results. It is noteworthy to mention that dense and diverse vegetation within the Shaumari Reserve is found around the wadi systems and along them. This wadi system, known as the Run-off Hammada vegetation, is well covered by bushes, shrubs, and herbs of leading species including *Atriplex halimus*. While the Gravel Hammada vegetation occupies the flat areas surrounding the wadi systems with sparse vegetation not exceeding 10% of the area.

Vegetation Communities

The reserve is characterized by a mosaic of dwarf shrubland communities which belong to the major type occurring in the Saharo-Arabian biogeographic region in Jordan. As mentioned previously, the whole class of vegetation cover is divided into three subdivisions: Run-off Hammada, Gravel Hammada, and Sandy Hammada. There are variations between plant association and, therefore, plant communities based on differences in soil quality, texture, humidity, and salinity. The *Atriplex halimus* is the most dominant plant species in the reserve present in most recorded plant communities. Despite agreeing with previous studies, there are differences in plant communities within it (RSCN, 2002 and Al-Eisawi and Abu Yahia, 2014). As previously mentioned, the vegetation cover and plant species are affected by sharp fluctuations in rainy seasons in the reserve. Moreover, it is evident that during this survey, some species have increased their dominance within the reserve, greatly impacting other species and their distribution.

Vegetation Parameters

These results indicate that the reserve plays a role in preventing desertification and serves as a good example for the rehabilitation of degraded desert areas, while studies on the

Badia and surrounding region of the reserve have shown that the vegetation cover is very weak and scattered, accounting for only 5%, with heights ranging from 20 cm to 70 cm (Al- Eisawi and Hatough, 1987). Thus, the vegetation cover in the reserve appears dense compared to its surrounding area.

In all parameters, there is a clear decline in the dominance of *Atriplex halimus* in the reserve, with both *Anabasis articulata* and *Suaeda rosmarinus* advancing, compared to the study by (Al-Eisawi and Abu Yahia, 2014), which indicated that *Atriplex halimus* was dominant in all data. It is most likely that the *Atriplex halimus* reached its peak at that time and has since declined. This raises concerns since *Atriplex halimus* is an important pastoral species in the reserve (RSCN, 2009). There was some regeneration of *Atriplex halimus* recorded in the southwestern part of the reserve, especially in the area affected by the fire that occurred in 2017, while regeneration in the northeastern and central part of the reserve was very weak or non-existent. This contradicts the documented regenerations of *Atriplex halimus* in the Grazing Capacity study of the reserve (RSCN, 2009). Finally, the community competition between species continues and is moving in favor of *Anabasis articulata* and *Suaeda rosmarinus* both of which are considered weak pastoral species. This will significantly impact the reserve and the species within it in the future.

Conclusion

The Shaumari Wildlife Reserve plays a role in preventing desertification and serves as a good example for the rehabilitation of degraded desert areas. The vegetation cover in the reserve is very dense compared to its surrounding areas. A total of 197 plant species belonging to thirty-five families and 125 genera have been recoded. Two species, *Bellevalia warburgii* and *Euphorbia grossheimii*, have been evaluated as globally endangered according to the IUCN Red List of Threatened Species (IUCN, 2024). Twenty-eight species hold ecological importance at the national level, as they are classified within the list of Endemic and are range-restricted (rare) in Jordan.

The reserve has different types of habitats and vegetation: Hammada flat areas, wadis, wadis including sandy dikes, and urban areas surrounding the visitor center. Thirteen different plant communities are distributed within the runoff vegetation in the reserve.

The *Atriplex halimus* community is declining in the reserve, with both *Anabasis articulata* and *Suaeda rosmarinus* taking the lead. There was some regeneration of *Atriplex halimus* recorded in the reserve, especially in the area affected by the fire that occurred in 2017. The community competition between species continues and is moving in favor of *Anabasis articulata* and *Suaeda rosmarinus*. This will significantly impact the reserve and the species within it in the future.

Recommendations

During this study, two species (*Xanthium spinosum* and *Xanthium strumarium*) were identified as invasive plant species. They are highly invasive weeds capable of growing under a variety of environmental conditions. It is important to eliminate and control the distribution of these species within the reserve.

The teamwork recommends creating 20m x 20m quadrates along the Wadis where all shrubs are cut to allow the species to grow again. These quadrates should be monitored every two years.

Additionally, the team recommends constructing rainwater harvesting structures for the Gravel Hammada vegetation including micro dams or ponds to collect rainwater, ensuring that the size of these structures does not exceed 2m. The installation of these structures will assist in gathering certain amounts of water, subsequently promoting the growth of annual species within these areas. Furthermore, this can help retain water for use during dry seasons. These structures can be constructed individually.

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References

Abed, A and Hmaidan, N. 2020. **The basics of Geology of Jordan Made Brief and Simple**. Royal Society for the Conservation Nature RSCN, Amman 106p [in Arabic].

Abed, A M. 2017. **Geology of Jordan, Environments and Water**. Dar Wael for Publish and Distribution, Amman 583p [in Arabic].

Abed, AM, Yasin, S, Sadaqa, R and Al-Hawari, Z. 2008. The paleoclimate of the eastern desert of Jordan during marine isotope stage 9. *Quaternary Research*, **69** (3), pp.458-468.

Al- Eisawi, D. 1996. V**egetation of Jordan.** UNESCO- Regional Office for Science and Technology for the Arab States. Cairo.

Al- Eisawi, D. 2013. **Flora of Jordan Checklist-revised edition**. The University of Jordan Press, Jordan

Al- Eisawi, D, Oran, S, El- Oqlah, A and Lahham, L. 2000. "**Jordan Country Study on Biological Diversit**y": Plant Biodiversity and Taxonomy, General Corporation for Environmental protection (GCEP) & UNDP

Al- Eisawi, D. and Hatough, A. 1987. Ecological Analysis of the Vegetation of Shaumari Reserve in Jordan. *Dirasat*, **XIV**: 12.

Al-Eisawi, D M, Abu Yahya, A and Ananbeh, Y. 2014. Flora and Vegetation of Shaumari Wildlife Reserve, A Baseline Survey (2014). RSCN. Amman, Jordan.

Al-Eisawi, D. M. and Abu Yahya, A. 2015. Flora of Shaumari Wildlife Reserve, Jordan, *Jordan Journal of Natural History*, **2**: 8- 21.

Austin, M. 2007. Species distribution models and ecological theory: a critical assessment and some possible new approaches. E*cological Modelling*, **200** (1-2): 1-19.

Clarke, J. 1977. Shaumari Wildlife Reserve / management plan.

Fadda, E. 1996. The geology of Wadi El Ghadaf area: Map sheet 3353-II. The NRA, Amman.

Feinbrun, N. 1986. **Flora Palaestina**. Vol. III, IV. The Israel Academy of Sciences and Humanities. Jerusalem.

Gruneberg, F and Dajani, F. 1964. The soil of Azraq area. Germ. Geol. Missionin Archive, BGR, Hannover, Germany.

Hatough, AM, Al-Eisawi, DM and Disi, AM., 1986. The effect of conservation on wildlife in Jordan. E*nvironmental Conservation*, **13** (4):331-335.

Ibrahim, K M. 1996. The regional geology of Al Azraq area map sheet No. 3553 I. Naticra/ Resources Authority, Geological Mapping Division, Bulletin 36. 67.

Ibrahim, K, Rabba, I and Tarawneh, K. 2001. Geological and mineral occurrences map of the northern Badia region, Jordan, scale 1: 250,000. A Joint Report of the Higher Council for Science and Technology and the NRA, 136.

The IUCN Red List of Threatened Species 2024. Version 2024-2. https://www.iucnredlist.org.

Kew, R B G. 2021. Plants of the World Online. [Online] Available at: https://powo.science.kew.org/ [Accessed December 2021].

Ludwig, JA. and Reynolds, JF. 1988. **Statistical Ecology: A Primer**

in Methods and Computing (Vol. 1). John Wiley & Sons.

Majed, L and Othman, YA. 2023. Vegetation Cover Assessment at Shaumari Wildlife Reserve Using Satellite Sensors Data, 10(2), pp.21-31.

Maxie, G. 2015. Jubb, **Kennedy and Palmer's Pathology of Domestic Animals**: volume 2 . Elsevier Health Sciences.

Menzel, U and Lieth, H. E. L. M. U. T. 2013. Halophyte Database Versi 2.0 in alphabetical order including some updates. **Cash Crop Halophytes: Recent Studies**, 221-250.

Okin, G S, Murray, B, and Schlesinger, W H. 2001. Degradation of sandy arid shrubland environments: observations, process modelling, and management implications. *Journal of Arid Environments*, **47** (2): 123-144.

Peters, D P. 2002. Plant species dominance at a grassland–shrubland ecotone: an individual-based gap dynamics model of herbaceous and woody species. *Ecological Modelling*, **152** (1): 5-32.

Sharkas, O. 2001. **Vegetation degradation in northeastern Jordan**. *In:* Sustainable land use in Deserts (pp. 208-217). Springer Berlin Heidelberg.

Taifour, H, El-Oqlah, A and Ghazanfar, SA. 2017. **The Plants of Jordan: An Annotated Checklist** (pp. 242-pp).

The Royal Society for the Conservation of Nature (RSCN). (2002). Shaumari Wildlife Reserve / Ecological Baseline Survey.

The Royal Society for the Conservation of Nature (RSCN). (2009). Determination of Grazing Capacity for Shaumari Wildlife Reserve.

Zohary, M. 1966. **Flora Palaestina**. Vol. I, II, III. The Israel Academy of Sciences and Humanities. Jerusalem.

Microalgae Diversity and Water Quality Assessment across Seven Hydro Systems in the Lower Sahara Wetland Complex, Algeria

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Abstract: The present work is aimed at establishing, for the first time, the ecological inventory and spatial distribution of the microalgae population in the wetlands of the Lower Sahara eco-complex. Water quality monitoring was carried out on a monthly basis over the period from April 2017 to March 2018 in seven hydro systems in the Lower Sahara wetland complex, while the microalgae sampling was carried out in April 2018. The results obtained indicated that the waters of the study sites did not present a clear thermal stratification and were moderately alkaline to alkaline pH, slightly brackish to very brackish, and generally clear. pH, turbidity, and salinity varied significantly depending on the study sites. The microalgae diversity revealed thirty-seven genera, thirty-one families, twenty-three orders, and six classes, with dominance in the number of genera belonging to the class Bacillariophyceae with an abundance of 80%. The highest values of total richness, Shannon-Weaver and Equitability indices were recorded at Lake Megarine (S=23, H’=3.33, E=74%). Cluster analysis showed four groups by cutting similar tree at a distance of 0.35**,** which suggests the significance of both the site typology and water salinity in the distribution of microalgae in the region.

Keywords: Microalgae; Water Quality; Diversity and Distribution; Hydro systems; Lower Sahara complex

Introduction

As elsewhere in the world and more particularly in the Mediterranean region, in Algeria, especially in the vast Sahara region, water resources are limited, fragile, and threatened (Margat and Vallée, 1999; Khamar *et al*., 2000; Mutin, 2000; Azzaoui *et al*., 2002). Worse still, there is the lack or insufficiency of data on the physicochemical quality of water in continental aquatic ecosystems and their evolution over time in addition to the bioecology of the biodiversity that lives there, in particular, their taxonomies, which are essential for highlighting the interactions between species and their biotope. To this end, Algeria, along with several other countries around the Mediterranean region, has been committed to developing and implementing a wetland strategy based on an ecosystem approach, to ensure the multi-sectoral and sustainable management of wetlands and their resources (DGF, 2016). The implementation of the national wetland strategy has enabled the creation of sixteen complexes, the largest of which is that of the Lower Sahara (DGF, 2016).

Microalgae constitute an important part of the ecology of aquatic environments (Gayral, 1975). They are the first link in the food chain in aquatic environments. They produce nearly 70% of atmospheric oxygen (Caratini, 1985) and are, thus, at the heart of the living world (Chadefaud, 1960). On the other hand, microalgae are considered the compartment that responds most quickly to variations in environmental parameters and, therefore, to the restoration processes, through which the drastic reduction or increase in nutrient inputs leads to increased competition within phytoplankton communities. Indeed, knowledge of the biomass, abundance and composition of a phytoplankton population is essential for evaluation and decision-making through which measurements of a situation or a spatio-temporal trend can be taken as objectively as possible (bio-indicator). (Garrido and Pasqualini, 2013). Better yet,

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is their socio-economic role, particularly in the pharmaceutical, agri-food, cosmetic and aquaculture industries (Spolaore *et al*., 2006). In the Saharan region, on both the ecological and socio-economic levels, little work has been devoted to the study of the physicochemical and biological quality of water, in particular through the exploration of microalgal communities. Few works can be cited here, namely Chaibi (2013), Labed (2013), Babaousmail (2014), Benakli and Meghchouche (2016), Khellou *et al.* (2018) and Adraoui *et al.*(2024). To fill this gap, this study is aimed at enhancing knowledge on phytoplankton biodiversity through the establishment, for the first time, of a taxonomic list, and as exhaustive as possible, the determination of the different ecological indices and their variation across the sites studied. The study also presents an evaluation of the water quality in six hydro-systems located in the complex of the wetlands of the lower Sahara with an analysis of the impact of environmental parameters on the distribution of the microalgae population in the Saharan region

Materials and Methods

Study Sites

The Lower Sahara Wetlands Complex (Fig. ure 1) is located in the southeastern part of Algeria and extends over 29,000 km between longitude 1°54'21.6" and 8°1'51.6" E and latitude 27°55'58.8" and 35°35'2.4" N. It is distinguished by a Saharan climate with a dry period that extends throughout the year. Despite the scarcity of water in the region, it harbors several wetlands of different typologies (Chott, Sebkhat and Wadis), which are classified, in some areas, as the Ramsar sites, including Chott Melrhir, Chott Merouane and Oued Khrouf, Chott Aïn El Beïda, Chott Oum El Raneb, and Chott Sidi Slimane. The Lower Sahara wetlands are subject to remarkable anthropogenic pressure, and they serve as an outlet for wastewater and water from agricultural drainage systems (Ghazi *et al*. 2016).

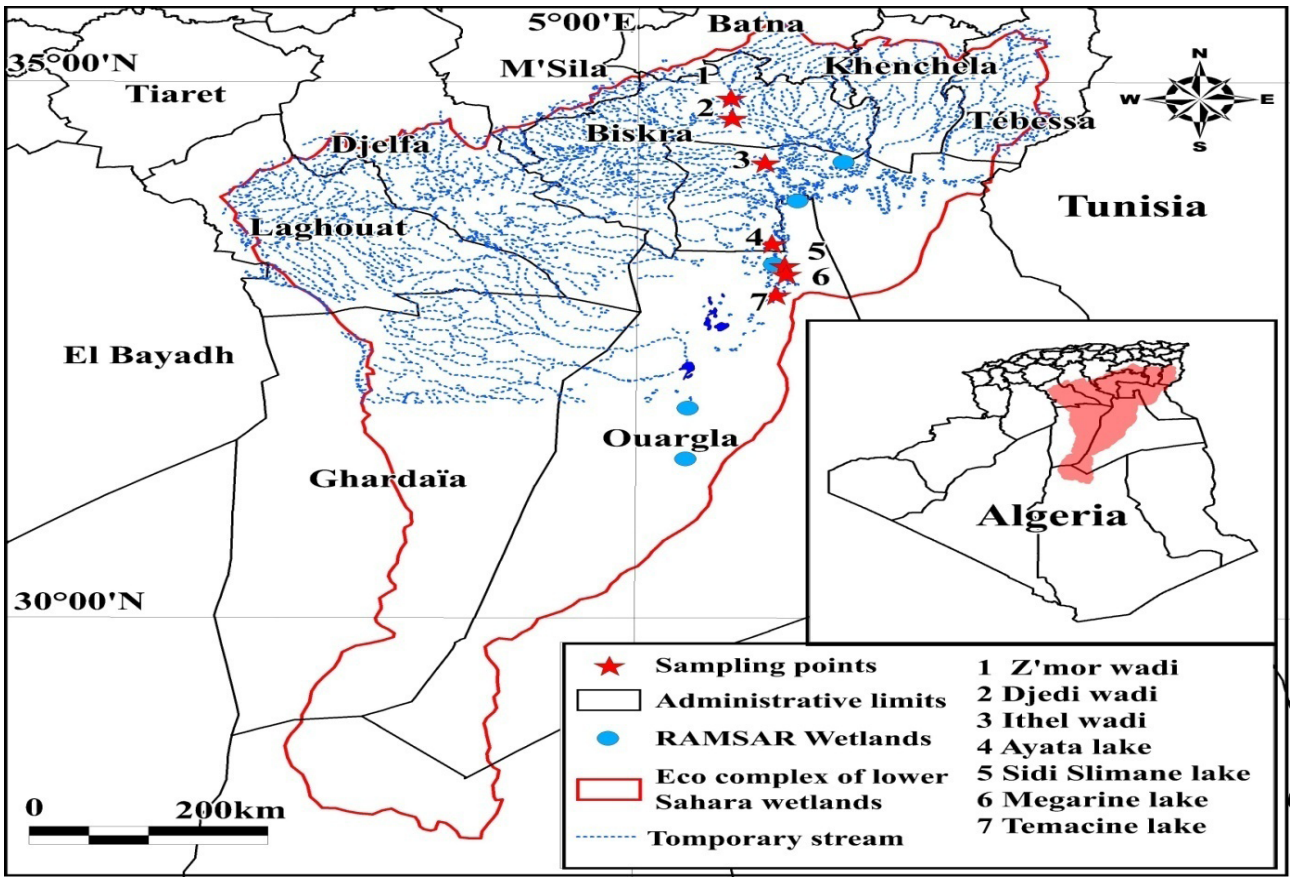

Figure 1. Geographical location of the sampling sites in the Lower Sahara wetland complex (Algeria)

Sample collection

In order to obtain qualitative and quantitative data on the microalgae community in the Lower Sahara Wetlands, seven sites were surveyed in April 2018. These include Z'mor Wadi, Djedi Wadi, Ithel Wadi, Lake Ayata, Lake Sidi Slimane, Lake Megarine, and Lake Temacine (3 lotic and 4 lentic hydro-systems). According to Laplace- Treyture *et al.,* (2010), the suitable sampling period should cover the summer period (hot in this study) extending from April to October. The environmental characteristics were recorded for each site using a range of descriptors, including water temperature in situ measured by a mercury thermometer, pH, turbidity, and salinity were measured using a pH meter, turbidity meter and a conductometer, respectively (excluding Lake Sidi Slimane) at the laboratory of the Algerian Water Agency (ADE) in Batna. A plankton net (silk net with a mesh less than 1 mm in diameter, a cylinder of 35 cm in diameter and a length of 45 cm) was also used in this study. A content of 100 ml was recovered from each site by filtering a constant volume (20 liters of natural surface water) from the first meter of the water column, removing floating particles at a sufficient distance from the bank (Druart and Rimet, 2008).

The samples were preserved in a 5% formaldehyde solution. The cells were counted using an optical microscope (SIZZ type) with different magnifications (Gr x 10) and (Gr x 40), a counting cell (Hemocytometer), a graduated pipette, and a camera to take instantaneous shots preceded by the addition of a few drops of Lugol's solution in a 250 ml sample (filtrate) to kill the algae, and finally weigh them down to facilitate their sedimentation. The identification of the microalgal flora was carried out through the microscopic observation of the morpho-anatomical criteria cited in different identification keys (Bourelly, 1985; Michel, 1987)

Diversity measurement:

Relative Abundance (A), richness (S), Shannon-Wiener diversity index (H′), and Equitability index and their variation depending on the study sites were calculated to measure spatial change in the microalgae community. (Shannon and Weaver, 1949; Daget, 1976).

$$A\% = \frac{n_i}{N} \times 100$$

$$H` = -\sum P_i log_2 P_i$$

$$(P_i = \frac{n_i}{N})$$

$$E = \frac{H`}{log_2 S}$$

Where *ni* is the individual number of species I; *Pi* is the ratio of the individual number of species i to the total individual number *N*; and *S* is the total number of species.

Statistical analysis

All environmental variables were checked for normality using the Shapiro-Wilks normality test. If the data passed the normality test, ANOVA and Tukey's HSD post-hoc tests were conducted to check the spatial variation in the physico-chemical quality of water in the five hydro-systems. Otherwise, the Kruskal–Wallis test was used. Dunnett's rank-based multiple comparisons were performed to identify which variables have the significant difference. To highlight the groups representing the phytoplankton populations, the hierarchical ascending classification (HAC) using Euclidean distance and "complete linkage" as aggregation criteria was applied to the study the sites.

Results

Physicochemical quality of water

In all the sites studied, the average annual water temperature was always higher than 20 ° C, while in Z'mor Wadi it was equal to 18.83±7.6 °C. This difference is not significant ($P > 0.05$). The minimum temperatures in the sites studied vary from 10.5 ° C in Lake Ayata to 7 ° C in Ithel Wadi, while the maximum values oscillate between 33 ° C in Z'mor Wadi and 46.9 ° C in Djedi

Wadi. (Table 1). The study of the variation of pH across the study sites, indicates that the averages of pH recorded oscillate between 7.8 and 8.4. The highest average was noted in Z'mor Wadi, while Ithel Wadi showed the minimum average. This variation is highly significant (F = 4.6; *P* = 0.001) (Table 1). Water turbidity varied from one site to another. It was between 2.5 NTU and 5.5 NTU (nephelometric turbidity unit) for the three studied lakes and the Ithel Wadis. On the other hand, the turbidity averages recorded in Z'mor Wadi and Djedi Wadi were greater than 9.8 NTU. For the latter site, the turbidity average was the highest at 16.6 NTU. The Kruskal–Wallis test indicates that turbidity varies in a highly significant manner depending on the study sites (K = 36.9; *P* < 0.0001). The Dunn's bilateral test confirms the results obtained and allows for the distinction of three groups, the first of which is represented by the three lakes, the second by the Z'mor Wadi, and the third by the Djedi Wadi (Table 1). The non-parametric test denotes that the spatial variation of salinity is significant (K = 58.62; *P* < 0.0001) and four homogeneous groups were identified. The recorded averages indicate that the salinity in Lake Ayata, Lake Temacine and the Djedi Wadi is low compared to other sites. The averages obtained are respectively of the order of 7.2 ‰; 6 ‰ and 3.5 ‰. On the other hand, in Z'mor and the Ithel Wadis as well as in Lake Megarine, salinity was always higher than 12.5 ‰. (Table 1)

Table 1: Spatial variation of the parameters of the physicochemical quality of water in the studied hydro-systems of the complex of the wetlands of the lower Sahara (SD: Standard deviation ; a, b and c indicate the groups of identical average)

Parameters / Sites	water temperature °C		pH		Water turbidity (NTU)		Salinity ‰	
	Mean ±SD	Min/Max	Mean ±SD	Min/Max	Mean ±SD	Min/Max	Mean ±SD	Min/Max
Z'mor Wadi,	18.8±7 [a]	9/33	8.4 ±0.6[a]	7.3/9.4	9.8± 8.4[b]	2.25/24	17.5± 2.5 [a]	15/24
Djedi Wadi,	25.8±11 [a]	10/46	8.3 ±0.4[a]	7.2/8.9	16.6± 10.2[a]	6.7/35	3.5 ±0.9 [c]	2.3/5.5
Ithel Wadi,	20.3±10 [a]	7/46	7.8 ±0.3[b]	7.2/8.4	5.5± 3.2[bc]	0.5/12	12.71 ± 6.1 [ab]	2/24
Lake Ayata,	22.5±7.4[a]	12/38	7.8±0.34[b]	6.9/8.7	4.1± 3.35[c]	0.42/12	7.24± 6.2[bc]	5.2/32.8
Lake Megarine	23.5±8.2[a]	12/38	7.8±0.42[b]	6.9/8.5	3.5± 2.35[c]	0.43/9.3	16.8± 9.7[a]	5.7/32.6
Lake Temacine	21.6±7.7([a])	7/35	7.9±0.44[ab]	6.8/8.6	2.5± 1.3[c]	0.6/6.3	6± 1.16[c]	1.7/7.1

Diversity and distribution of the microalgae community

In the studied hydro-systems of the northern Sahara, thirty-seven genera were recorded, thirty-one families, twenty-three orders, and six classes. Among the thirty-seven taxa identified, 71% (or 26 genera) belong to the class Bacillariophyceae, 15.8% belong to the class Cyanobacteria and two genera (2.9%) to the class Dinophyceae. The classes Synurophyceae, Trebouxiophyceae, and Dinophyceae are represented by only one genus. In terms of families, Amphipleuraceae which belongs to the class Bacillariophyceae is represented by three genera, followed by Naviculaceae, Tabellariaceae, and Stephanodiscaceae which belong to the class Bacillariophyceae each with two genera. Additionally, Oscillatoriaceae belongs to the Cyanobacteria family and includes two genera. The remaining families are represented by only one genus. Furthermore, the majority of inventoried orders are represented by one and/or two families with the exception of the Naviculales order which is considered the most diverse inclusive of seven families (Table 2).

Bacillariophyceae is omnipresent in the studied hydro-systems with abundance greater than 92%; their maximum abundance was observed at the Dejdi Wadi , with dominance of the genus *Cyclotella* followed by *Pleurosigma*. Cyanobacteria which come second in position in terms of abundance, reached maximum abundance at Lake Megarine, with the dominance of the genus *Merismopeda* at18%. The relative abundance of the genera belonging to Synurophyceae Trebouxiophyceae, Dinophyceae, Chlorophyceae, was always less than 5%. It is to be noted that *Oocystis* was present only in Lake Megarine and that *Synura* was reported only at the Z'mor Wadi and Lake Megarine (Figure 2)

Table 2: Taxonomic inventory of the microalgae recorded in the tested hydro-systems of the Lower Sahara wetlands complex

Class	Order	Family	Genera
Bacillariophyceae	Naviculales	Naviculaceae	*Navicula*
			Caloneis
		Amphipleuraceae	*Amphipleura*
			Frustulia
		Stauroneidaceae	*Stauroneis*
		Pinnulariaceae	*Pinnularia*
		Diploneidaceae	*Diploneis*
		Pleurosigmataceae	*Pleurosigma*
		Cymbellaceae	*Cymbella*
	Bacillariales	Bacillariaceae	*Nitzschia*
	Fragilariales	Fragilariaceae	*Synedra*
	Tabellariales	Tabellariaceae	*Diatoma*
			Asterionella
	Mastogloiales	Achnanthaceae	*Achnanthes*
	Cocconeidales	Cocconeidaceae	*Cocconeis*
	Eunotiales	Eunotiaceae	*Eunotia*
	Thalassophysales	Catenulaceae	*Amphra*
	Surirellales	Entomoneidaceae	*Entomoneis*
		Surirellaceae.	*Campylodiscus*
			Surirella
	Cymbellales	Gomphonemataceae	*Gomphonema*
	Melosirales	Melosiraceae	*Melosira*
	Rhopalodiales	Rhopalodiaceae	*Epithemia*
	Mastogloiales	Mastogloiaceae	*Skeletomastus*
	Stephanodiscales	Stephanodiscaceae	*Stephanodiscus*
			Cyclotella
Cyanobacteria	Nostocales	Hapalosiphonaceae	*Hapalosiphon*
		Nostocaceae	*Anabaena*
	Oscillatoriales	Oscillatoriaceae	*Oscillatoria*
			Lyngbya
	Chroococcales	Gomphosphaeriaceae	*Gomphosphaeria*
	Synechococcales	Merismopediaceae	*Merismopeda*
Synurophyceae	Synurales	Synuraceae	*Synura*
Trebouxiophyceae	Chlorellales	Oocystaceae	*Oocystis*
Dinophyceae	Gonyaulacales	Pyrophacaceae	*Pyrophacus*
	Gymnodiniales	Gymnodiniaceae	*Gymnodinium*
Chlorophyceae	Sphaeropleales	Scenedesmaceae	*Scendesmus*

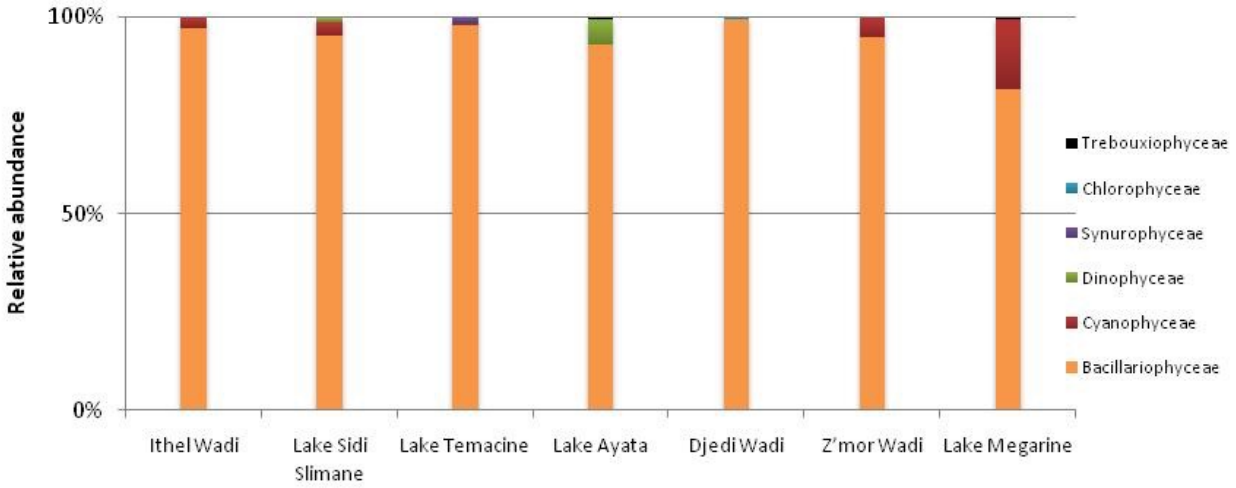

Figure 2. Spatial variation of microalgae abundance in the tested hydro-systems of Lower Sahara wetland complex (Algeria)

The highlighting of the variation in the diversity indices of the microalgae in the study sites indicates that Lake Megarine has the highest total richness with twenty-three taxa, followed by Lake Ayata and Z'mor Wadi. The total richness of the other sites was between fourteen and ten taxa (Table 2). The Shannon diversity index indicates that Lake Megarine is the most diverse site, and that the lowest diversity was noted at Djedi Wadi. In the latter, the calculated equitability was the lowest at 13%, while Lake Ayata showed the highest equitability at 87% (Table 3).

The analysis of the spatial distribution of the different genera of the microalgae in the studied sites produced four groups by cutting the similarity tree at a distance of 0.35 (Figure 3). The first group included only Lake Ayata, with six taxa (*Oscillatoria; Lyngbya; Hapalosiphon; Cymbella; Melosira; Anabaena*). The second group is represented by two sites, namely Lake Megarine and the Z'mor Wadi which showed the largest number of taxa (15 genera: *Caloneis; Gymnodinium; Entomoneis, Campylodiscus, Gomphonema, Asterionella, Synura, Eunotia, Stephanodiscus, Pyrophacus, Scendesmus, Skeletomatus, Achnanthes, Epithemia,*and *Merismopeda)*. The third group included Lake Sidi Slimane represented by eight taxa (*Navicula; Oocystis; Diploneis; Pinnularia; Synedra; Amphra; Gomphosphaeria*, nd *Cocconeis*). Lake Temacine, Ithel Wadi, and Djedi Wadi, make up the last group, which includes eight taxa (*Frustulia; Amphipleura; Cyclotella; Diatoma; Surirella; Stauronies; Nitzschia,* and *Pleurosigma*).

Discussion

The air temperature and solar energy whose seasonal variations determine the physicochemical and biological characteristics of the waters, especially the water temperature of shallow hydro-systems (Hamed *et al.*, 2012). Added to this is the effect of the warm waters of the groundwater tables in the study region which

Table 3: Total specific richness (S), Shanon diversity index (H') and equal distribution (E) of microalgae communities recorded in the tested hydro-systems of the Lower Sahara wetland complex

Sites Diversity index	Ithel Wadi	Lake Sidi Slimane	Lake Temacine	Lake Ayata	Djedi Wadi	Z'mor Wadi	Lake Megarine
S	13	14	12	20	10	17	23
H'	2,68	1,88	0,86	3,75	0,43	1,94	3,33
H'_{max}	3,70	3,81	3,58	4,32	3,32	4,09	4,52
E%	73%	49%	24%	87%	13%	47%	74%

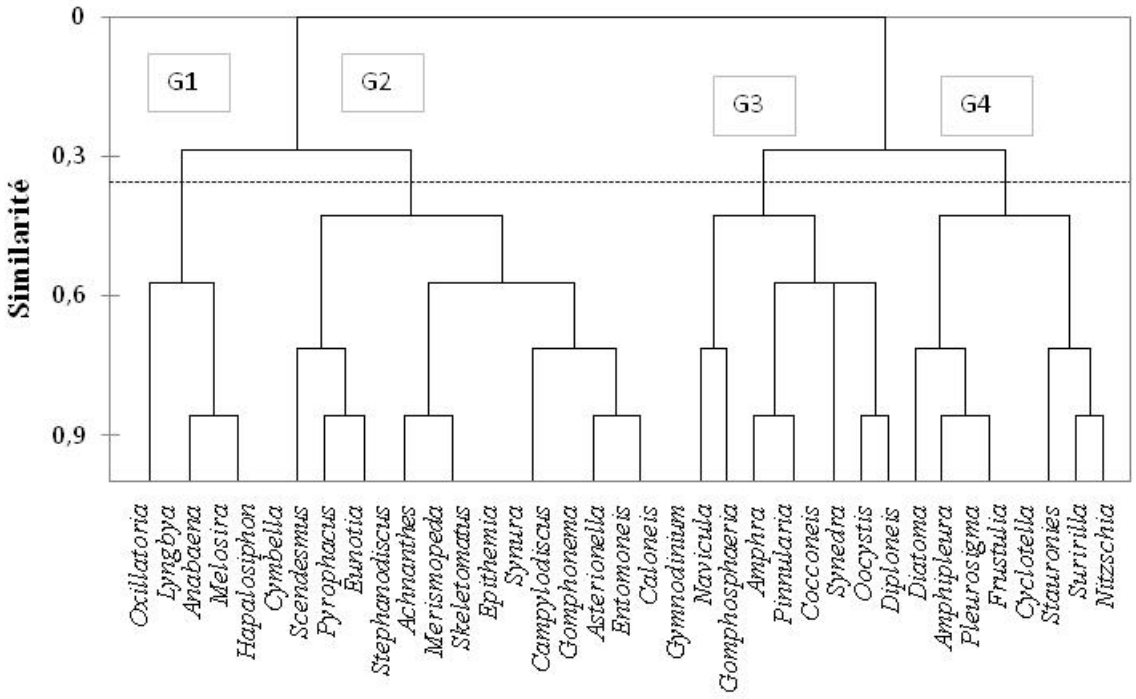

Figure 3. Cluster analysis on the presence-absence matrix of the microalgae taxa recorded in the tested hydro-systems in the Lower Sahara wetland complex (Algeria) (G1: Lake Ayata; G2: Lake Megarine, Z'mor Wadi; G3: Lake Sidi Slimane; G4: Lake Temacine, Ithel Wadi, Djedi Wadi)

are considered as a main source of supply in a direct or indirect way through the irrigation water surpluses coming from the drainage system of the neighboring palm groves; these largely control the variations in water temperatures of the studied sites (Tabouche & Achour, 2004; Debbakh, 2012).

The spatial variation of pH indicates that the sites studied are slightly alkaline to alkaline. According to the scale adopted by Hecker *et al.,* (1996) a pH > 7.4 characterizes alkaline waters. Indeed, pH is influenced by physical, chemical, and biological characteristics (Hade, 2004). The esults of this study indicate that the Z'mor and the Djedi Wadis have a pH higher than that recorded in the three studied lakes. This difference in the pH averages between lotic and lentic hydro systems can be explained by the biological activity; running waters are well oxygenated which increases the intensity of photosynthesis (Westlake and Ladle 1995), while in stagnant waters, the degradation of organic matter can lead to the acidification of the water (Tremblay *et al*, 2014).

In all studied sites, the recorded turbidity averages (<30 NTU) denote clear water according to the U.S. Environment Protection Agency classes. The obtained results reveal that the water quality of the study sites varies from very good to fair. In the three lakes studied, the averages of the turbidity recorded were comparable with those noted by Hammouda (2013), while the significant turbidity was higher in the Djedi wadi compared to the other sites. This reflects the significant status of this wadi as it represents the main collector of runoff waters for an area of approximately 9130 km2 on the southern flank of the Saharan Atlas (Bouchemal, 2017)

In the Saharan region, the origin of salinity is mainly primary but also secondary (Boutouga, 2012). According to Chevallier (2007), the waters of the Djedi Wadi are slightly brackish, while in the other sites, water is brackish to very brackish. Indeed, the intercalary continental aquifer in the northern region of Oued Rhir is more confined compared to the south; consequently, the waters of this aquifer are saltier (OSS, 2003).

The inventory of the microalgal flora recorded in the wetlands of the lower Sahara is comparable with several works carried out in the region, such as that of Chaibi (2013) in

Lake Ayata (23 genera), Babaousmail (2014) in Chott Ain El Baida and the drains of the Ouargla region (19 species), Khellou *et al.* (2018) in Lake Megarine (36 genera), and Adaouri *et al.* (2024) in the Central Sahara (77 species).

On the other hand, in the semiarid and humid bioclimatic stages, the census of the microalgae showed greater richness compared to the current study region. Chaibi (2013) reported the presence of seventy-two genera in the Timagad dam (Batna), and fifty-seven genera were recorded by Hamidouche and Tetah (2017) in the Bejaia region. Also, in most of the aforementioned works, Bacillariophyceae was always the best represented class, which agrees with the results of the current study. Indeed, Bacillariophyceae is one of the most important phytoplankton groups including over 100,000 species (Gorga, 2012). According to Zrinka *et al.* (2007), the abundance of the Cyclotella taxon can be explained by its broad tolerance to fluctuations in environmental factors, including salinity and temperature. Similarly, the genus Pleurosigma is distinguished by high conductance and is frequently found in marine and brackish environments. Thus, Adaouri *et al.* (2024) reported that the species *Cyclotella ocellata* can be found in sites with a lower salinity (0.2), which is the case for the Djedi wadi.

The difference among the four groups found after the hierarchical clustering is most likley due to the typology of the ecosystem on the one hand and the salinity of the water on the other. The homogeneous groups of the spatial variation in salinity obtained in the present study, are similar to the groups of the spatial distribution of microalgae communities formed by the CAH. Record (2009) pointed out the sensitivity of Bacillariophyceae to salinity and that it is very heterogeneous among the different taxa composing this group which affects their survival. In addition, the depth and flow of the hydro-systems play a major role in the growth and density of the algae (Saros *et al*. 2014). Necib *et al.* (2013) reported that some genera of Cyanobacteria are restricted to stagnant waters. Lavoie *et al*. (2007), indicated that some genera of Cyanobacteria including *Anabaena*, *Lyngbya* and *Oscillatoria* are considered very competitive by secreting cyanotoxins of different types to inhibit the growth of other groups of algae and eliminate their predators such as zooplankton.

In general, the diversity of the microalgae populations at the the different studied sites is consistent with the diversity found by previous works, notably that of Chaibi (2013). Also, several works indicate that diversity in artificial hydro-systems is greater compared to that in natural sites (Labed, 2013; Chaibi, 2013). Also, diversity in lentic ecosystems is greater than that in lotic ecosystems. Indeed, the higher the current, the more algae can be detached from the substrates, which reduces the diversity of fixed algae. This justifies the low values of the diversity indices calculated in the Djedi Wadi and Lake Temacine. Similarly, other factors play a very important role in the absence or presence of one or more taxonomic groups of the phytoplankton community. According to Min *et al.* (2021), conductivity, the concentration of organic matter, and the presence of freshwater organisms, control the dispersion of certain algae taxa.

References

Adaouri, I, Bouchelouche, D, Arab, S, Moussouni A, Lecohu, R and Arab A. 2024. Spatial distribution of microalgae in the Central Sahara of Algeria: Case of the Hoggar and Tassili cultural parks, *Kuwait Journal of Science*, **51**: 1-9

Azzaoui, S, Hanbali, ME and Leblanc M. 2002. Note technique: Cuivre, plomb, fer et manganèse dans le bassin versant du Sebou; Sources d'apport et impact sur la qualité des eaux de surface, *Water Quality Research Journal*, **37** (4):773-784.

Babaousmail, M. 2014. **Identification des algues du Sahara septentrional: L'effet des algues sur sur le stress salin (cas de la région de Ouargla)**.

Mémoire de master. Université de Ouargla. 62p

Benakli, L and Meghchouche A. 2016. **Contribution à l'étude de la bio-écologie des micro-algues à Ouargla**. Mémoire de Master. Université de Ouargla. 89p

Bouchemal, F. 2017. **Diagnostic de la qualité des eaux souterraines et superficielles de la région de Biskra.** Thèse de doctorat. Université de Biskra. 179 p

Bourelly P. 1985. **Les Algues d'eau douce**, Tome III: Les Algues bleues et rouges. Ed Boubee & Cie. California.

Boutouga, F. 2012. **Ressources et essai de gestion des eaux dans le Zab Est de Biskra**. Mémoire de magister. Université de Annaba. 172p

Caratini R. 1985. **Botanique**, Éd. Bordas, Paris

Chadefaud M. 1960. **Traité de Botanique Systématique**. Tome I : Les végétaux non vasculaires (Cryptrogamie). Masson et Cie

Chaibi, R. 2013. **Connaissance de l'ichtyofaune des eaux continentales da la région des Aurès et du Sahara septentrional**. Thèse de Doctorat. Université de Biskra. 237p

Chevallier, H. 2007. **L'eau un enjeu pour demain: état des lieux et perspectives**. Sang de la terre (Ed). France.

Daget J. 1976. **Les mod`eles math´ematiques en ´ecologie**. ´ed. Masson, Paris.

Debbakh, A. 2012. **Qualité et dynamique des eaux des systèmes Lacustres en amont de l'Oued Righ**. Mémoire de magister en hydraulique. Université de Ouargla. 176p

Druart JC and Rimet F. 2008. Protocoles d'analyse du phytoplancton de l'INRA : prélèvement, dénombrement et biovolumes. INRA-Thonon, Rapport SHL 283 – 2008.

Garrido, M., & Pasqualini, V. (2013). Du phytoplancton à la gestion des écosystèmes côtiers. *Stantari - Histoire naturelle et culturelle de la Corse,* **Issue** 33. 18-25.

Gayral P. 1975. **Les algues: morphologie, cytologie, reproduction, écologie**. Doin France.

Ghazi, C, Si Bachir, A and Idder, T. 2016. Morphometric, meristic and breeding biology of Tilapia zillii (Pisces, Cichlidae) in Lake Temacine (Northern Sahara, Algeria), *Bioressources*, **6** (1): 83-97

Groga, N. 2012. **Structure, fonctionnement et dynamique du phytoplancton dans le lac de Taabo** (Côte d'Ivoire) (Doctoral dissertation).

Hamed M, Guettache A and Bouamer L. 2012. **Etude des propriétés physico-chimiques et bactériologiques de l'eau du Barrage Djorf-Torba Bechar.** Mémoire d'ingéniorat. Université de Bechar

Hamidouche, N and Tetah, S. 2017. C**ontribution à l'étude de la flore algale en particulier les cyanobactéries de la lagune Tamelaht et du lac Mézaia**. Memoir de Master. Université de Bejaia.

Hammouda, N. 2013. C**ontribution à l'étude de l'effet de l'action anthropique sur les zones humides du Sud-est du Sahara (Cas de l'Oued Righ)**. Mémoire de master. Université de Ouargla. P60

Hecker N, Costa LT, Farinha JC and Thomas Vives P. 1996. Inventaire des zones humides méditerranéennes : collecte des données. Publication MedWet/ wetlands International/ Instituo da Conservaçao da Natureza VIII Lisbone,

Khamar, M, Bouya, D and Ronneau, C. 2000. Pollution métallique et organique des eaux et des sédiments d'un cours d'eau marocain par les rejets liquides urbains, *Water Quality Research Journal*, **35** (1): 147-161

Khellou, M, Laifa, A, Loudiki, M and Douma, M. 2018. Assessment of phytoplankton diversity in two lakes from the northeastern Algerian Sahara, *Applied Ecology and Environmental Research*, **16** (3):3407-3419

Labed, A. 2013. **Biodiversité et dynamique spatio-temporelle de la communauté phytoplanctonique de la zone humide artificielle du Barrage Koudiet M'douar (Timgad, Batna)**. Mémoire de magister. Université d'Oum El Bouaghi

Laplace-Treyture C, Chauvin C, Menay M, Moreau L and Dutartre A. 2010. Protocole standardisé d'échantillonnage et de conservation du phytoplancton en grands cours d'eau applicable aux réseaux de mesure DCE.

Lavoie, I, Laurion, I, Warren, A and Vincent WF. 2007. Les fleurs d'eau de Cyanobactéries. Revue littéraire. No. R916. INRS, Centre Eau, Terre et Environnement

Margat J and Vallée D. 1999. Vision méditerranéenne sur l'eau, la population et l'environnement au XXIème siècle. Plan Bleu.

Michel, R. 1987. **Atlas du phytoplancton marin ‹Diatomophycees›**, Ed. CNRS, Paris.

Mutin G., 2000. De l'eau pour tous?. Documentation photographique. 18 p. [halshs-00361557]

Necib, A, Rezig, H and Boughediri, L. 2013. La bio-indication de la pollution aquatique par les microalgues (Cas de l'Oued «Bounamoussa» et du Lac des» Oiseaux»), Revue Scientifique et Technique de Synthèse, **27**: 06-14

OSS. 2003. Système Aquifère du Sahara Septentrional «SASS» : Une conscience de bassin. Observatoire du Sahara et du Sahel. www.unesco.org/oss. 322p

Record. 2009. Surveillance des impacts environnementaux d'effluents aqueux de sites industriels par les diatomées dulçaquicoles : Synthèse bibliographique, 105 pages, n°3-12/2007.ETUDE N° 3-12/07

Saros, J, Strock, KE, Mccue, J, Hogan, E and Anderson, NJ. 2014. Response of Cyclotella species to nutrients and incubation depth in Arctic lakes, *Journal of Plankton Resesarch*, **36** (2): 450-460

Shannon CE and Weaver W. 1949. **The Mathematical Theory of Communication.** University of Illinois Press, Urbana.

Spolaore, P, Joannis-Cassan, C, Duran E and Isambert A. 2006. Commercial Applications of Microalgae, Journal of Bioscience and Bioengineering, **101**(2):87-96

Tabouche, N and Achour S. 2004. Etude de la qualité des eaux souterraines de la région orientale du Sahara Septentrional algérien. *Larhyss Journal*, **3** :99-113.

Tremblay, R, Pienitz, R and Legendre, P. 2014. Reconstructing phosphorus levels using models based on the modern diatom assemblages of 55 lakes in southern Quebec. Canadian Journal of Fisheries and Aquatic Sciences **71**: 887–914.

Westlake, DFand Ladle, M. 1995. **River and stream ecosystems of Great Britain**. *In* : Cushing, CE, Cummins, KW and Minshall, GW.(Eds.), Ecosystems of the world. 22. River and stream ecosystems. Elsevier. Amsterdam, Pp: 343- 388.

Zrinka, B, Keve, TK, Éva, Á, Damir, V, Katarina, CM and Marina, C. 2007. The occurrence and ecology of the centric diatom Cyclotella choctawhatcheeana Prasad in a Croatian estuary, *Nova Hedwigia*, **84** (1-2): 135-153

Jordan Journal of Natural History, 11 (2), 2024 134-141

Rodents of Qiddiya, Southwest Riyadh, Saudi Arabia

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Abastract: Rodents play a crucial role in ecosystems, serving as indicators of biodiversity richness and as essential components of the food web. They serve as prey for many carnivorous mammals, snakes, and birds. A study on rodent diversity was conducted in Qiddiya, southwest of Riyadh-Saudi Arabia, near the Tuwaiq Mountain range. A total of 410 Sherman live traps were evenly distributed across forty-one sites to ensure comprehensive coverage of the area and its diverse landscapes. Over 2460 trap-nights, 270 individuals were captured representing eight species from two families. Notably, a small population of *S. calurus* was documented for the first time in Jabal Al Tuwaiq. This finding underscores the need for further fieldwork and research to enhance the understanding of rodent diversity and distribution in the region.

Keywords: Rodents, Qiddiya, Saudi Arabia

Introduction

Rodents are the largest order of mammals with c. 1,500 species. They are distributed world wide and in most ecosystems and urban areas (Wilson *et al.,* 2016, 2017). Rodents play an important role in the ecosystem by dispersing seeds, providing food for many carnivores, and providing shelter for numerous fauna species that use their abundant burrows (Davidson *et al*., 2008, Whiteford and Kay 1999). Despite their ecological significance, rodents are relatively understudied compared to other faunal groups in the Kingdom of Saudi Arabia. This can be attributed to their shyness and elusive nature as nocturnal small mammals. Harrison and Bates (1991) documented the rodents and their distribution in the Kingdom of Saudi Arabia in their publication, "Mammals of Arabia." Recently, Al Malki *et. al* (2024) reported the presence of twenty species of rodents within four families from Saudi Arabia.

Despite these efforts, information on rodents in Riyadh Province remains notably scarce. A study on the Pharaoh owl (*Bubo ascalaphu*) pellet in Eastern Saudi Arabia documented eleven species of rodents belonging to two families Dipodidae, Muridae (Abi-Said *et al.,* 2020). Notably, a 2016 ecological study at Wadi As-Sulai – Riyadh identified sixteen mammal species, predominantly from the Rodentia family (Abi-Said and Al-Zein, 2022). This emphasizes the need for further research to enhance the understanding of Riyadh Province's mammalian diversity in general and rodents in particular. This study investigated the rodent diversity in the Qiddiya site in southwest Riyadh Province-Saudi Arabia, at the borders of Jabal Al Tuwaiq.

Materials and Methods

Description of Study Site

The study area is divided into two parts: The upper plateau, which is part of the Tuwaiq mountain, consists of rocky areas made of fossilized corals with high mountain cliffs, and the lower plateau which is made of a gravel-stoney-sandy desert with scattered plants with several wadies and streams. These wadis act as channels for rainwater; hence, they have a rich diversity of flora, mainly Acacia trees with numerous plant species. In addition, at the foot of the high mountains, another landscape appears and is made of big and small fallen rocks. Moreover, during the rainy season, some depressions become filled with water in addition to the

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artificial reservoirs. Nonetheless, these water collection places do not last long due to great sunlight intensity.

Trapping effort

The rodent survey was conducted during October, and December of 2023 and January, March, April, and May of 2024, with the site systematically divided into three different quadrats to ensure comprehensive coverage (Figure 1).

Locations of the rodent traps were initially identified using Google Earth and were later verified during the field visits. Traps were placed near accessible locations due to the challenging terrain. This approach did not compromise the assessment. Forty-one trapping stations were deployed in each month of the survey (Figure 2). At each station, ten Sherman live rodent traps, five meters apart from each other, were baited with a mix of peanut butter, oats, sunflower seeds, and canary feed mix. The traps were set at dusk and were checked the next day at dawn. The captured animals were identified on-site, recorded, photographed, and were then released.

Results

The survey resulted in trapping and spotting 270 individuals belonging to eight species of the order Rodentia, including one species of the family Dipodidae and seven species of the family Muridae, five of which belong to the sub-family Gerbillinae.

Table (1) shows the number of species and the percentage of observation over the study period. The lowest number of species was recorded in November 2023, with only four species observed, and the percentage of observations for that month was 4.83%, the lowest across all observations. This is most likely related to the season being winter

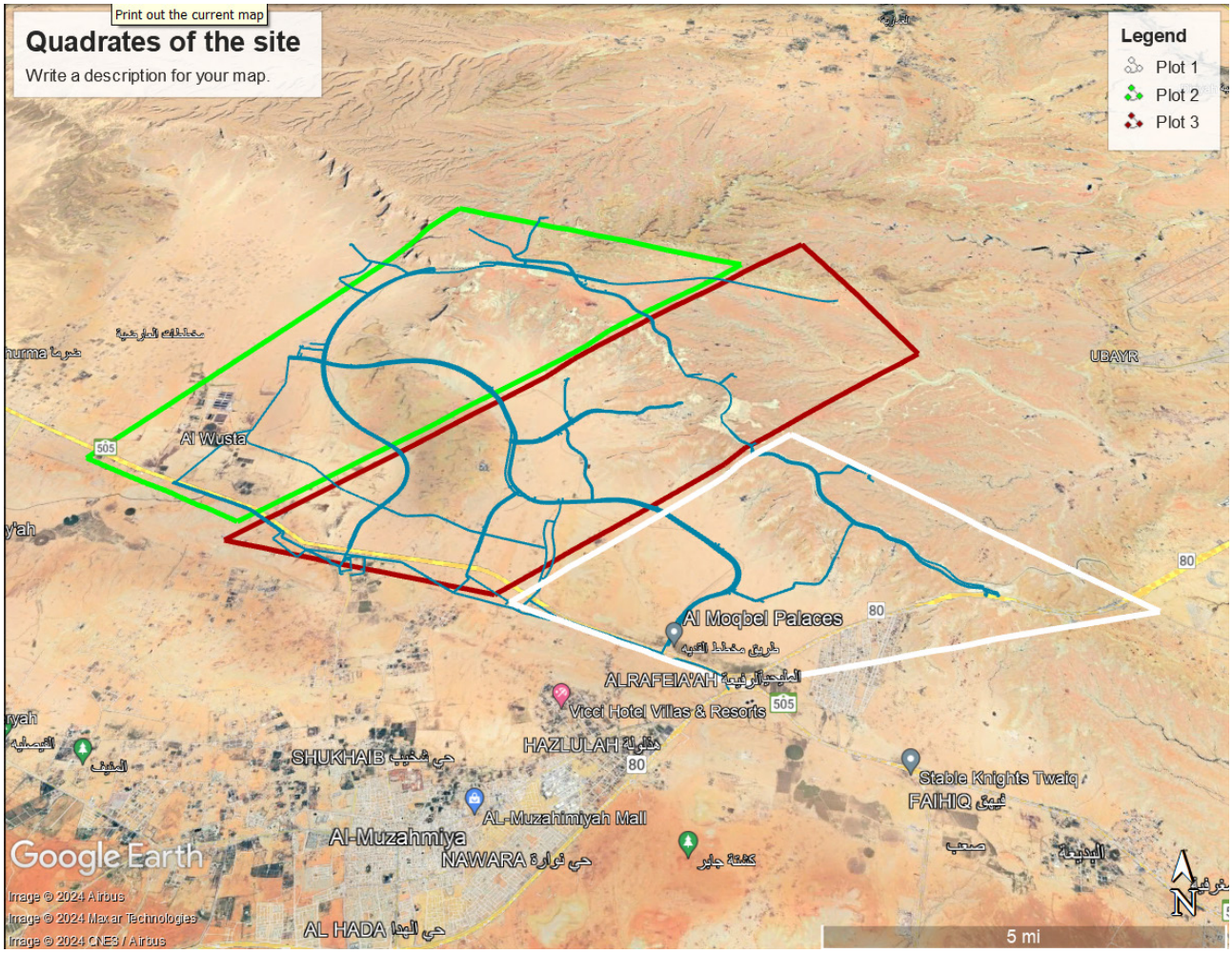

Figure 1. The three quadrates of the site

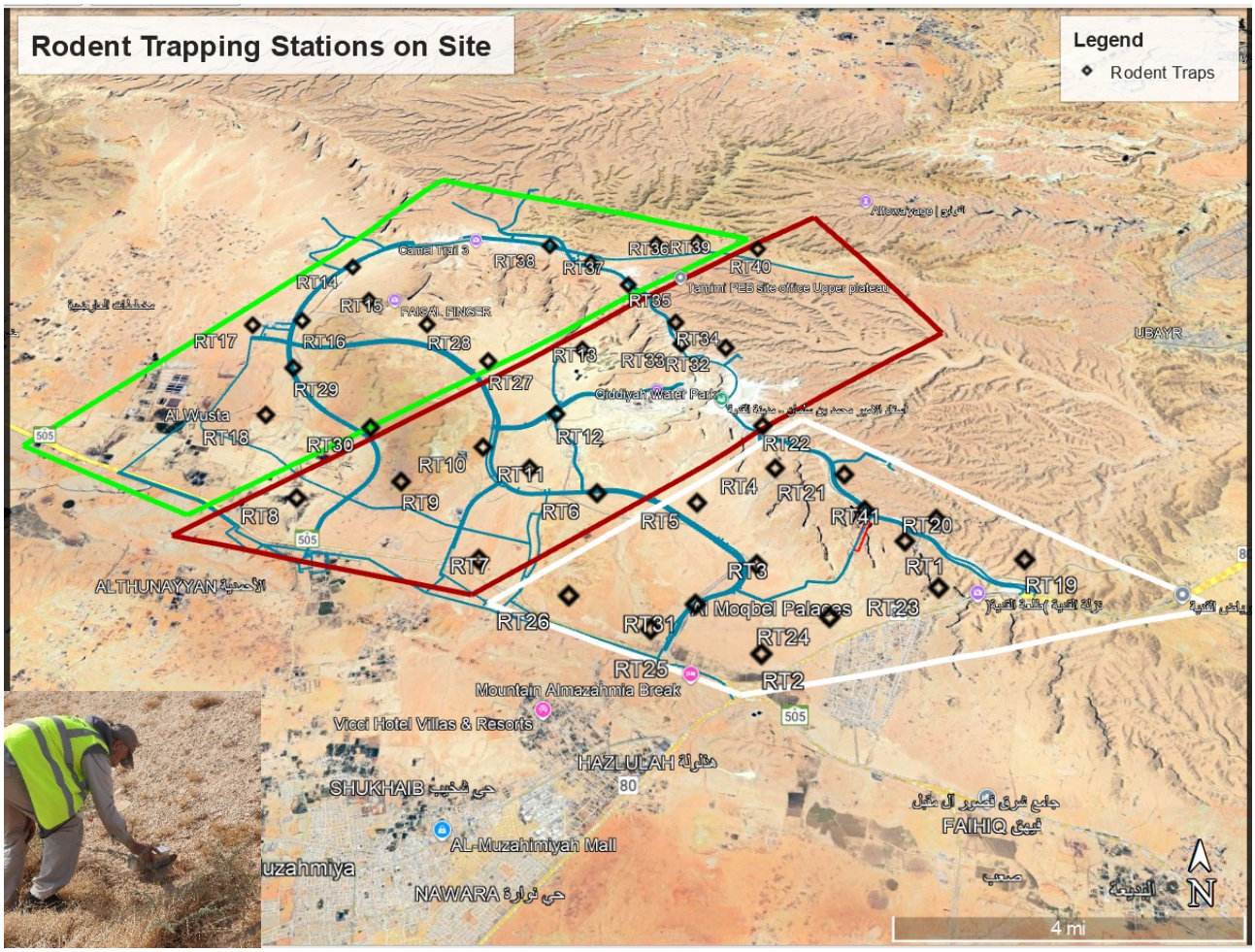

Figure 2. The locations of the rodent trapping stations

Table 1: Number of rodent species observed and the percentage of observed rodents per month of the fieldwork.

	October	November	January	March	April	May
Number of rodent species	5	4	8	7	7	7
Percentage of observed rodents	8.55	4.83	17.10	23.42	25.28	21.19

during which less activity is expected. The highest number of species (eight species) was recorded in January 2024. This is associated with the start of the active and breeding season. The highest percentage of observations was recorded in April 2024 at 25.28%, the highest across all observations). This can mainly be attributed to the start of the reproduction season, food availability, and good weather; most of the young were trapped during this month.

The family Dipodidae is represented by one species, namely the three-toed jerboa (*Jaculus loftusi* (Blanford, 1875)) (Figure 3A). They were encountered during each night drive at different locations throughout the site in the lower plateau on open sandy plains but not in the upper plateau since it is a rocky area with unsuitable habitat. The distribution of jerboa is shown in Figure 5. Similarly, this species was reported to be very common in Saudi Arabia (Al Malki *et al.,* 2024).

The subfamily Gerbillinae is represented by five species *Gerbillus nanus, Gerbillus dasyurus, Meriones crassus, Meriones libycus,* and *Sekeetamys calurus*. Their distribution is shown in Figure 5.

Baluchistan gerbil (*G. nanus,* Blanford, 1875) (Figure 3B) was found in the lower plateau in an open sandy area where they can dig their burrows easily to hide during daytime. This species was common on-site and represented 20.74% of all the rodents observed (Table 2). This species lives alongside *M. libycus*.

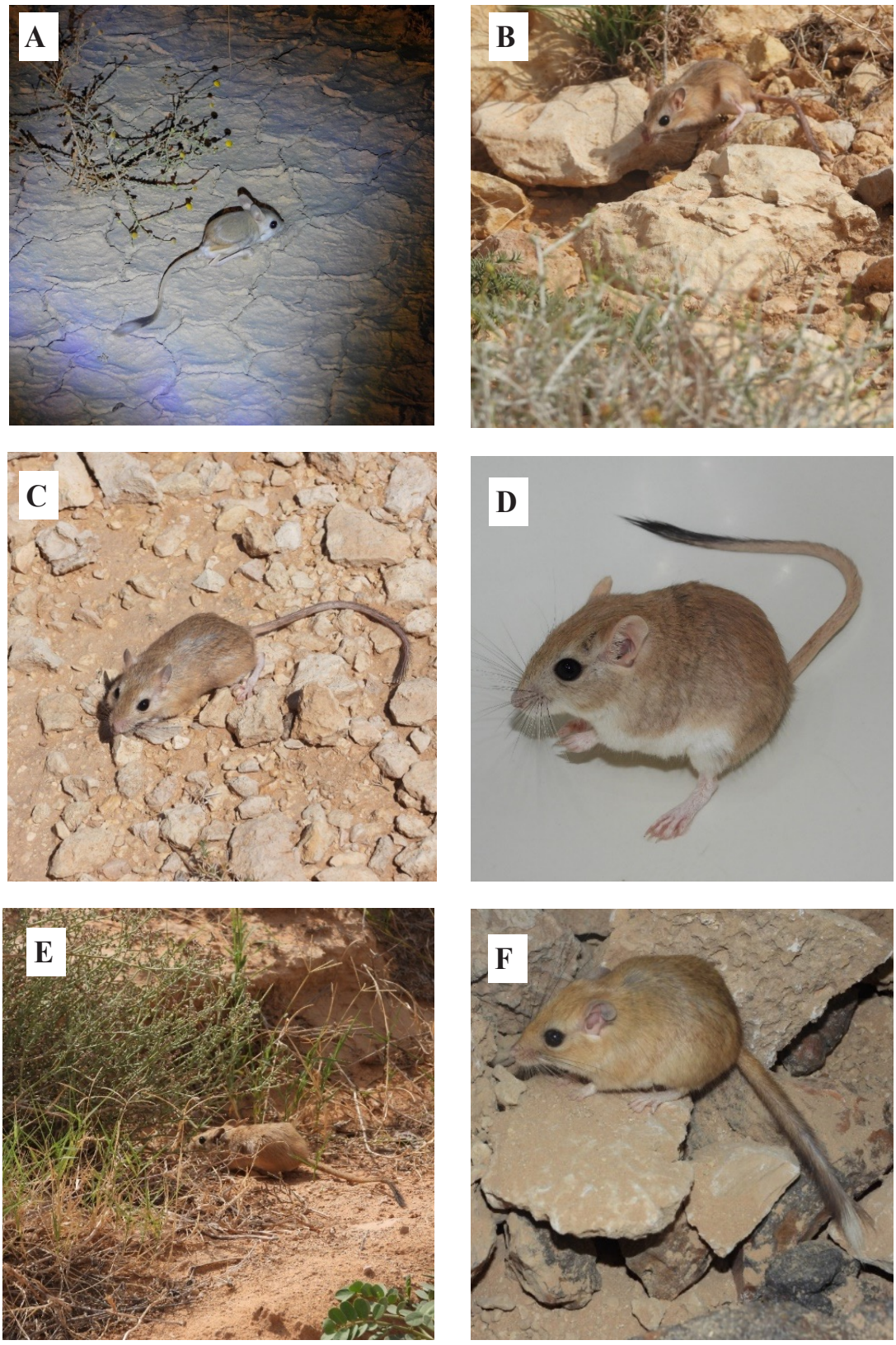

Figure 3. The three-toed jerboa (A) encountered during a night drive, the Balochistan gerbil(B), the Wagner's gerbil (C), the Sundevall's jird (D), the Libyan jird (E), and the bushy-tailed jird (F) caught by Sherman live rodent traps.

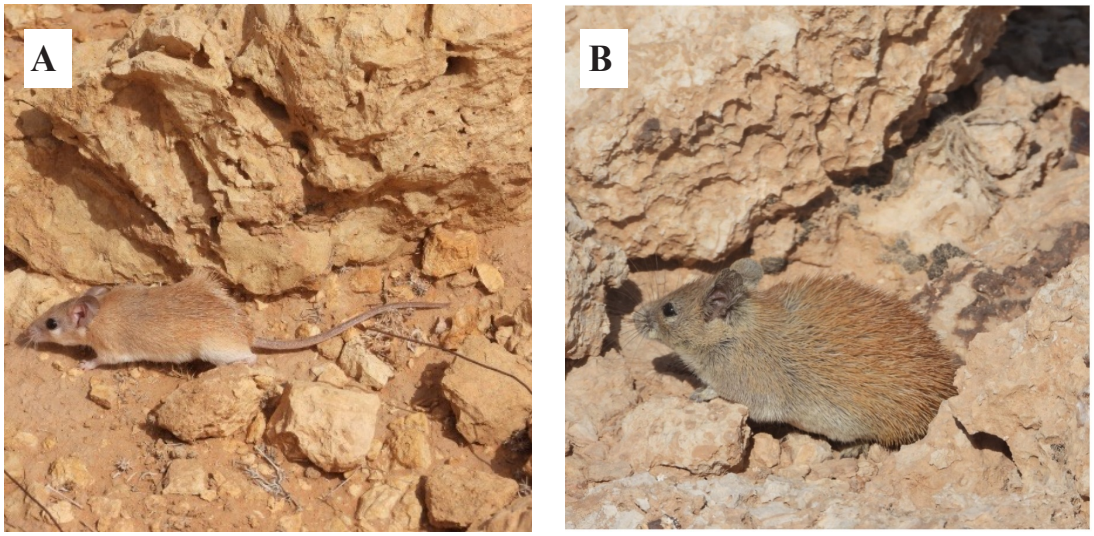

Figure 4. The Arabian spiny mouse (A) and The golden spiny mouse (B) caught by Sherman live rodent traps.

Table 2: Percentage of rodent species encountered in the study area.

	October		November		January		March		April		May		Total	
	N	% Obs.	N	% Obs.	N	% Obs.	N	% Obs.	N	% Obs.	N	% Obs.	N	% Obs.
Family: Dipoididae														
J. loftusi	4	17.39	1	7.69	4	8.69	10	15.87	5	7.35	2	3.51	26	9.63
Family: Muridae, Subfamily Gerbillinae														
G. nanus	5	21.74	4	30.77	7	15.22	10	15.87	21	30.90	9	15.79	56	20.74
G. dasyrus	1	4.35	0	0	2	4.35	5	7.94	5	7.35	4	7.02	17	6.29
M. crassus	0	0	0	0	1	2.17	0	0	0	0	0	0	1	0.37
M. libycus	6	26.09	7	53.85	14	30.43	19	30.16	15	22.1	11	19.29	72	26.67
S. calurus	0	0	0	0	1	2.17	1	1.59	0	0	0	0	2	0.74
Family: Muridae														
A. dimidiatus	7	30.43	1	7.69	15	32.61	13	20.63	16	23.5	23	40.35	75	27.78
A. russatus	0	0	0	0	2	4.35	5	7.94	6	8.82	8	14.03	22	7.78

Similarly, Scott and Dunstone (2000) and Strauss *et.al*., (2008) reported the presence of *G. nanus* along with *M. libycus*. In addition, this species was reported in the Riyadh Province (Abi-Said and A-Zein 2022) and is distributed in the Kingdom of Saudi Arabia (Al Malki *et.al.,* 2024).

Wagner's gerbil (*G. dasyrus,* Wagner, 1842) (Figure 3C) was found in both the lower and upper plateaus but was less common than *G. nanus*. It represented 6.29% of all rodent observations (Table 2). They were trapped in different habitats ranging from agricultural lands to wadies to mountainous rocky areas. Contrary to expectations, this species was reported to be very common in Saudi Arabia (Al Malki *et al.* 2024) but it was less represented in Qiddiya.

The Sundevall's jird (*M. crassus* Sundevall, 1842) (Figure 3D) was the least common. Only one individual was trapped in the upper plateau. Even though this species

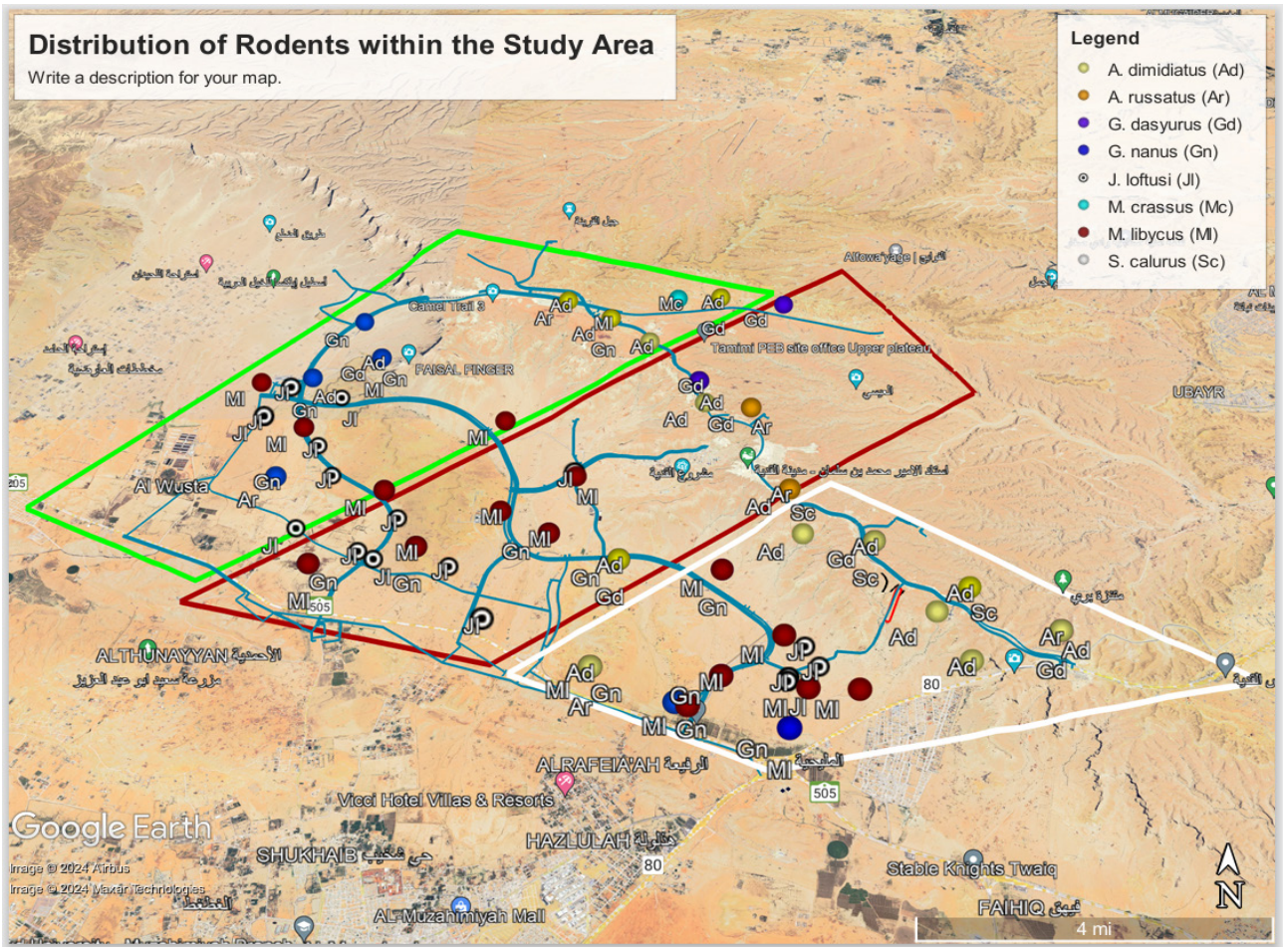

Figure 5. Distribution of rodents in the study area.

is very common in Saudi Arabia, it was less represented in Qiddya. This could be attributed to the scarcity of its habitat. Buttiker and Harrison (1982) mentioned that this species favors sabkhas and alluvial wadi beds which are uncommon in that site.

Libyan jird (*M. libycus* Lichtenstein, 1823) (Figure 3E) was very common in the study area. It represented 26.67% of all observed rodents (Table 2). The Libyan jird was trapped in the upper and lower plateaus and was seen during daytime and night drives. They inhabit open sandy areas where they dig many burrows for fast escape from predators. Similarly, this species was reported to be very common in Saudi Arabia (Harrison and Bates 1991, Al Malki *et al.,* 2024)

Finally, the Bushy-tailed jird (*S. calurus* Thomas, 1892) (Figure 3F) was trapped for the first time in Qiddiya. This is the first record for this species from Jabal Al Tuwaiq. This species inhabits rocky areas and was trapped only in the upper plateau between and under the rocks. Besides, this species was not common. It only represented 0.74% of all observed rodents (Table 2). It is known from a few places in Saudi Arabia (Nader, 1974, Abi-Said et al. 2020, Buttiker and Harrison 1982).

Family Muridae is represented by two species *Acomys dimidiatus* (Cretzschmar, 1826) and *Acomys russatus* (Wagner, 1840); their distribution is given in Figure 5.

The Arabian spiny mouse (*A. dimidiatus*) (Figure 4A) was found in both the upper and lower plateaus, in particular in rocky areas, bare lands or lands with trees and shrubs. This species was the most common. It represented 27.78% of all observed rodents (Table 2). This species is also common all over the kingdom in mountainous and rocky areas (Abi-Said *et.al*. 2020, Masseti 2010, Asiry and Fetho 2014).

The habitat of the Golden spiny mouse (*A. russatus*) (Figure 4B) is similar to that of the Arabian spiny mouse. The Golden spiny mouse was trapped in both the lower and upper plateaus, in rocky hills and terrains.

It was also encountered during daytime feeding among rocks. Nonetheless, it was not common on-site. It represented only 7.78% of all observed rodents (Table 2). In Saudi Arabia, this species was reported in few areas including the Riyadh Province (Abi-Said *et. al.* 2020, Alanazi *et al.* 2019), Wadi Liya (Vesey-Fitzgerald 1953), and Wadi Khumra (Vesey-Fitzgerald 1982)

Discussion

Rodents play a major role in the food chain. Their presence is crucial for the existence of many species. Their abundance and diversity reflect the richness of the ecosystem biodiversity since they are preyed upon by different animal species, including owls, birds of prey, and other carnivores. This study documented the rodent diversity in Qiddiya with a total of eight extant species representing 40% of the rodent fauna of the Kingdom of Saudi Arabia. This number is relatively high compared to other observations in other areas of the study site. This high diversity in such a relatively small area is probably due to the habitat and landscape diversity that consists of rocky landscapes, wadis, and plain sandy areas. Similarly, Horvath *et al*. (2001) reported that habitat heterogeneity positively affects species richness in The Lagos de Montebello National Park in Mexico. Likewise, in the Thousands Oak California habitat, heterogeneity had a direct effect on rodent species richness (Johnson and Karels 2016).
Habitat preference was observed for most trapped species. *Meriones libycus* and *Gerbillus nanus* occurred in sandy wadies close to the sparse vegetation, while *Acomys russatus* and *Acomys dimidiatus* were restricted to rocky areas. In addition, *Sekeetamys calurus* was found in a mountainous rocky area. *Jaculus loftusi* was widely distributed across the lower plateau where flat sandy areas prevailed. These results coincide with the findings of Abu Baher and Amr (2003), Amr *et al.* (2018), and Abed (2015).
The presence of the small population of the bushy-tailed jird (*S. calurus*) is the first record from Jabal Al Tuwaiq. Hence, it is important to protect this small and isolated population and to consider the places where it was trapped as a critical habitat. As for the rest of the rodents, they are very common, and none raises conservation concerns. This study highlights the importance of continued investigations and fieldwork to document the fauna and its distribution in the Kingdom of Saudi Arabia.

References

Abed, O A. 2015. Habitat use of Gerbillus nanus and Dipodillus dasyurus at Azraq Wetland Reserve, north eastern *Jordan. Jordan Journal of Natural History*, **2**:58-65.

Abi-Said, M and Al-Zein, MS. 2022. Rodents diversity in Wadi As Sulai, Riyadh Province, Kingdom of Saudi Arabia. *Jordan Journal of Natural History*, **9**:83–88.

Abi-Said, M R, Al Zein, M S, Abu Baker, M A and Amr, Z S. 2020. Diet of the desert eagle owl, Bubo ascalaphus, Savigny 1809 in Eastern Saudi Arabia. *Pakistan Journal of Zoology*, **52**:1169–1171

Abu Baker, M A and Amr Z. 2003. Rodent diversity in the Northeastern desert of Jordan, with special reference on the ecology of Gerbillus cheesmani (Mammalia: Rodentia). Casopis *Journal of the National Museum, Natural History Series*, **172** (1–4):141–152.

Al Malki, K A, Al Ghamdi, A R, Shuraim, F, Neyaz, F, Al Boug, A, Al Jbour, S, Angelici, F M and Amr, Z S. 2024. Diversity and conservation of Rodents in Saudi Arabia. *Diversity*,. **16**: 398.

Alanazi, A D, Al-Mohammed, H I, Alyousif, M S, Said, A E, Salim, B, Abdel-Shafy, S and Shaapan, R M. 2019. Species diversity and seasonal distribution of hard ticks (Acari: Ixodidae) infesting mammalian hosts in various districts

of Riyadh province. Saudi Arabia. *Journal Medical Entomology*, **56**:1027–1032

Amr, ZS, Baker, MAA, Qumsiyeh, M and Eid, E. 2018. Systematics, Distribution and ecological analysis of rodents in Jordan. *Zootaxa* **4397**: 1–94. https:// doi.org/ 0.11646/zootaxa.4397.1.1.

Asiry, KA and Fetoh, BEA. 2014. Occurrence of ectoparasitic arthropods associated with rodents in Hail region northern Saudi Arabia. *Environmental Science and Pollution Research*. **21**:10120–10128.

Buttiker, W and Harrison, DL. 1982. Mammals of Saudi Arabia. On a collection of Rodentia from Saudi Arabia. *Fauna Saudi Arabia*, **4**:488–502.

Davidson, A D, Lightfoot, D C and Mc Intyre, J L. 2008. Engineering rodents create key habitat for lizards. *Journal of Arid Environment*, **72**:2142–2149

Harrison, D L and Bates, P J J. 1991. **The Mammals of Arabia**. 2nd ed. Harrison Zoological Museum Publication. 354 pp.

Horváth, A, March, I J and Wolf, J H D. 2001 Rodent diversity and land use in Montebello, Chiapas, Mexico. Studies on Neotropical *Fauna and Environment*, **36** (3):16+9-176.

Johnson, A M and Karels T J. 2016. Partitioning the effects of habitat fragmentation on rodent species richness in an urban landscape. *Urban Ecosystem*, **19**:547-560

Masseti, M. 2010. The mammals of the Farasan archipelago, Saudi Arabia. *Turkish Journal of Zoology*, **34**: 359–365.

Nader, I A. 1974. A new record of the bushy-tailed jird, Sekeetamys calurus calurus Thomas, 1892 from Saudi Arabia. *Mammalia*, **38**:347–349

Scott, D M and Dunstone, N. 2000. Environmental determinants of the composition of desert-living rodent communities in the north-east Badia region of Jordan. *Journal of Zoology*, **251**:481–494.

Strauss, M W, Shah, M S and Shobrak, M. 2008. Rodent trapping in the Saja/ Umm Ar-Rimth Protected Area of Saudi Arabia using two different trap types. *Zoology in the Middle East*, **43**:31–39.

Vesey-Fitzgerald, D. 1953. Notes on some rodents from Saudi Arabia and Kuwait. *Journal of the Bombay Natural History Society*, **51**:424–428.

Whitford, W G and Kay, F R. 1999. Biopedturbation by mammals in deserts: A review. J*ournal of Arid Environment*, **41**:203–230.

Wilson, D, Lacher, T and Mittermeier, R. 2017. **Handbook of the Mammals of the World**. Volume 7 Rodents II; Lynx Edicions: Barcelona, Spain, 1008pp.

Wilson, D, Lacher, T and Mittermeier, R. 2016. **Handbook of the Mammals of the World**. Volume 6 Lagomorphs and Rodents I; Lynx Edicions: Barcelona, Spain, 987pp.

Jordan Journal of Natural History, 11 (2), 2024 142-143

Short Communication

Breeding Record of Pharaoh Eagle-Owl (*Bubo ascalaphus*) in the Eastern Desert of Jordan

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A breeding record of the Pharaoh Eagle-Owl (*Bubo ascalaphus*) was documented in March 2024 in the eastern desert of Jordan near the (Lat 32.986963°, Long: 38.376970°) in an area locally known as the Eastern Risha. The nest was located at the margin of a gully (runoff area), a typical habitat for this species that is offering shelter and camouflage. Observations confirmed the presence of three eggs, indicating active breeding at the site. The breeding activity was first confirmed on March 15th, 2024, by the authors as a direct observation evidence of the nest and eggs (Figure 1).

Historically, the Pharaoh Eagle-Owl has been recorded in different areas of Jordan, particularly in arid and semi-arid habitats (Jennings, 2010). Notable sightings include areas such as Wadi Rum, the Azraq wetlands, and various desert escarpments, with reports often emphasizing the species' preference for rocky outcrops and wadis (Amr and Disi, 2011; Andrews, 1995). Despite being relatively uncommon, the Pharaoh Eagle-Owl is considered a resilient species that thrives in suitable habitats across the Middle East. Breeding records, however, remain sparse, making this observation evidence to document the breeding that may help in understanding the species ecology in Jordan. The species is characterized by its large size, striking ear tufts, and mottled plumage, which provide excellent camouflage in desert environments (Jennings, 2010). Its diet mainly consists of small mammals, reptiles, and occasionally birds, reflecting its adaptability to the arid desert ecosystem. Previous breeding records in Jordan have often been associated with rocky cliffs and secluded wadis, underscoring the importance of these habitats for reproduction (Andrews, 1995).

Figure 1: Photograph of the Pharaoh -Owl nest and eggs before the flash flood**.**

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Early in April, three chicks were hatched, however, an event of heavy rainfall triggered a flash flood in the wadi, which destroyed the nest, and killed all the chicks.

Similar incidents have been documented in other regions, where nests of the same species have been wiped out by flash floods, demonstrating a recurrent threat to the breeding success of ground-nesting birds in arid and semi-arid habitats (Andrews, 1995). Comparative records from Wadi Rum and the Azraq wetlands highlight instances of nest loss due to extreme weather events, further emphasizing the species' vulnerability despite its ecological adaptability (Andrews, 1995). The Pharaoh Eagle-Owl's adaptability to harsh desert conditions is remarkable, yet the challenges posed by environmental instability demand continued research and conservation attention.

References

Amr, Z S and Disi, A M. 2011. **Jordan's Biodiversity: Birds**. Royal Society for the Conservation of Nature, Amman.

Andrews, I J. 1995. T**he Birds of the Hashemite Kingdom of Jordan**. I. J. Andrews, Musselburgh.

Jennings, M C. 2010. A**tlas of the Breeding Birds of Arabia**. King Abdulaziz City for Science and Technology, Riyadh.

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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