ISSN: 2307-7565 VOLUME 9 ISSUE 1 JUNE 2022

Jordan Journal of Natural History

الجمعية الملكية لحماية الطبيعة
RSCN
Nature Conservation Monitoring Center

Address:
Jordan Journal of Natural History, Email: jjnh@rscn.org.jo
Conservation Monitoring Centre \ The Royal Society for the Conservation of Nature
Dahiat Al Rasheed, Bulding No. 4, Baker Al Baw Street,
Amman, P.O. Box 1215 Code 11941 Jordan

Jordan Journal of Natural History

Editorial Preface

It is a pleasure to present issue 8 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.

The editorial board will make every effort to ensure prompt processing of the manuscripts received and to widen the circulation of the journal as far as possible. A group of distinguished scholars have agreed to serve on the editorial board. Without the service and dedication of these eminent scholars, JJNH would have never existed. Now, the editorial board is encouraged by the continuous growth of the journal and its formation into a true multidisciplinary publication. We are also honored to have the privilege of working with all members of the international advisory board served by a team of highly reputable researchers from different countries across the globe. We are also delighted with our team of national and international reviewers who are actively involved in research in different natural history fields and who provide authors with high quality reviews and helpful comments to improve their manuscripts.

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.

June, 2022

الجمعية الملكية لحماية الطبيعة
RSCN
Nature Conservation Monitoring Center

Instruction to Authors

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.

Type of Manuscript

The journal publishes high-quality original scientific papers, short communications, correspondence, methodology and case studies. Review articles are usually by invitation only. However, review articles of current interest and high standards will be considered. Manuscripts, or the essence of their content, must be previously unpublished and should not be under simultaneous consideration by another journal. The authors should also declare if any similar work has been submitted to or published by another journal. They should also declare that it has not been submitted/published elsewhere in the same form, in English or in any other language, without the written consent of the Publisher.

The authors should also declare that the paper is the original work of the author(s) and not copied (in whole or in part) from any other work. All papers will automatically checked for duplicate publication and plagiarism. If detected, appropriate action will be taken in accordance with International Ethical Guideline. By virtue of the submitted manuscript, the corresponding author acknowledges that all the co-authors have seen and approved the final version of the manuscript. The corresponding author should provide all co-authors with information regarding the manuscript, and obtain their approval before submitting any revisions. Electronic submission of manuscripts strongly recommended, if the text, tables and figures are included in a single Microsoft Word file. Submit manuscript as e-mail attachment to the Editorial Office at jjnh@rscn.org.jo. After submission, a manuscript number will be communicated to the corresponding author.

Peer-Review Process

It is requested to submit, with the manuscript, the names, addresses and e-mail addresses of at least 4-6 potential reviewers. It is the sole right of the editor to decide whether or not the suggested reviewers to be used. The reviewers' comments will be sent to authors within 6-8 weeks after submission. Manuscripts and figures for review will not be returned to authors whether the editorial board decision is to accept, revise, or reject. All Case Reports and Short Communication must include at least one table and/or one figure.

Manuscript Format

Title Page: The title page should include concise title; a short running title, author(s) full name(s), affiliation, complete postal address, e-mail addresses, (phone, and fax numbers if available) of the author to whom all correspondence should be addressed.

Abstract: an abstract not exceeding 300 words, summarized account of the subject, results and conclusions should be given.

Keywords: Three to seven keywords should be included for each paper. Use of abbreviations should be avoided, only standard abbreviations, well known in the established area may be used, if appropriate. These keywords will be used for indexing.

Introduction: Should include a short introduction to the background, a brief literature survey, the scope and aim of the work done.

Materials and Methods: Give adequate information to allow the experiment to be reproduced. Already published methods should be mentioned with references. Significant modifications of published methods and new methods should be described in detail. Subheading can be used.

Results: Results should be concise and should not include discussions. Text, tables and figures should not duplicate the same information. Newly described taxa must be distinguished from related taxa. For newly described species, the holotype should be deposited and numbered in a recognized museum.

Discussion: Concise discussion without repeating the results with the significance of the present work should be provided. Citations should be given in support of the findings.

Acknowledgment: A brief acknowledgment section may be given after the conclusion section just before the references. The acknowledgment of people who provided assistance in manuscript preparation, funding for research, etc. should be listed in this section.

References

References should be listed alphabetically at the end of the manuscript. Every reference referred in the text must be also present in the reference list and vice versa. In the text, a reference identified by means of an author's name should be followed by the year of publication in parentheses (e.g. (Brown, 2020). For two authors, both authors' names followed by the year of publication (e.g. (Nelson & Brown, 2017). When there are more than two authors all authors should be listed separated by and before the last author as in (Amer, Z., Katebeth, A. and Hmiadan, N. A. (2019) When two or more works of an author has been published during the same year, the reference should be identified by the letters "a", "b", "c", etc., placed after the year of publication. This should be followed both in the text and reference list. e.g., Hilly, (2002a, 2002b); Hilly and Nelson, (2004). Articles in preparation or submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., Al-Eisawi D. M, University of Jordan, personal communication). Titles of journals must be abbreviated according to the latest edition of the World List of Scientific Periodicals. Journal title should be given in full. The author is responsible for the accuracy and completeness of the references and for their correct textual citation. Failure to do so may result in the paper being withdraw from the evaluation process. Example of correct reference form is given as follows:

Reference to a journal publication

Ogunseitan, O A. 1998. Protein method for investigating mercuric reductase gene expression in aquatic environments. *Applied and Environmental Microbiology*, 64 (2): 695-702.

Rabia, B and Attum O. 2018. Shoreline encounter and stranding rates of cetanceans and loggerhead turtles *Caretta caretta* in North Sinai, Egypt. *Jordan Journal of Natural History*, 5(1): 75-78.

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.

Reference to a book

Brown WY and White SR.1985. The Elements of Style, 3rd ed. MacMillan, New York.

Reference to a chapter in an edited book

Mettam, GR and Adams, L B. 2010. How to prepare an electronic version of your article. *In*: Jones, B S and Smith, R Z. (Eds.), Introduction to the Electronic Age. Kluwer Academic Publishers. Netherlands, Pp. 281–304.

Conferences and Meetings

Embabi, N. S. 1990. Environmental Aspects of Distribution of Mangrove in the United Arab Emirates. Proceedings of the First ASWAS Conference. University of the United Arab Emirates. Al- Ain, United Arab Emirates.

Figures and Tables

It is in the author's interest to provide the highest quality figure format possible. Figures must be saved separate to text. Please do not embed figures in the file. Files should be saved as one of the following formats: TIFF (tagged image file format), PostScript or EPS (encapsulated PostScript), and should contain all the necessary font information and the source file of the application. All figures and tables must be numbered in the order in which they appear in the paper (e.g. Figure 1, Figure 2) and their position should be indicated in the text. In multi-part figures, each part should be labelled (e.g. Figure 1(a), Figure 1(b)). Tables should be numbered using Arabic numerals.

Both black and white and coloured photographs are accepted. However, these photographs need to be of high quality, and minimum of 300 dpi resolution. They should not to be submitted within the text, but as a separate attachment with a file name refers to the figure location within the text (e.g Figure 1).

Copyright

Submission of a manuscript clearly indicates that the study has not been published before or is not under consideration for publication elsewhere (except as an abstract or as part of a published lecture or academic thesis). Publication is permitted by all authors and after accepted for publication will not be submitted for publication anywhere else, using English or any other language, without a written approval of the copyright-holder. The journal may consider manuscripts that are translations of articles originally published in another language. In this case, the consent of the journal in which the article was originally published must be obtained and the fact that the article has already been published must be made clear on submission and stated in the abstract. It is compulsory for authors to ensure that no material submitted as part of a manuscript infringes existing copyrights, or the rights of a third party.

Ethical Consent

All manuscripts reporting the results of experimental investigation involving human subjects should include a statement confirming that each subject or subject's guardian obtains an informed consent, after the approval of the experimental protocol by a local human ethics committee or IRB. When reporting experiments on animals, authors should indicate whether the institutional and national guide for the care and use of laboratory animals was followed.

Plagiarism

The JJNH hold no responsibility for plagiarism. If a published paper is found later to be extensively plagiarized and is found to be a duplicate or redundant publication, a note of retraction will be published, and copies of the correspondence will be sent to the authors' head of institute.

Galley Proofs

The editorial office will send proofs of the manuscript to the corresponding author as an e-mail attachment for final proof reading and it will be the responsibility of the corresponding author to return the galley proof materials appropriately corrected within the stipulated time. Authors will be asked to check any typographical or minor clerical errors in the manuscript at this stage. No other major alteration in the manuscript is allowed. After publication, authors can freely access the full text of the article as well as can download and print the PDF file.

Publication Charges

There are no page charges for publication in Jordan Journal of Natural History.

Authorship Policy

A statements should be provided during the submission process outlining their individual contributions of all authors to the paper and will appear above the acknowledgement section of the published paper. Any changes in authorship prior to or after publication must be agreed upon by all authors, including those being added or removed. It is the responsibility of the corresponding author to obtain confirmation from all co-authors and to provide evidence of this to the editorial office with a full explanation about why the change was necessary.

Open Access Policy

Accepted manuscripts in JJNH are freely available to both subscribers and the wider public with permitted reuse.

Reprints

Five (5) reprints are provided to corresponding author free of charge within two weeks after the printed journal date. For orders of more reprints, a reprint order form and prices will be sent with article proofs, which should be returned directly to the Editor for processing.

Disclaimer

Articles, communication, or editorials published by JJNH represent the sole opinions of the authors. The publisher shoulders no responsibility or liability what so ever for the use or misuse of the information published by JJNH.

Manuscript Style

Times New Roman font size 12 should be used. Lines should be doubled spaced. Titles and subtitles should be bold, font size 14, with first word and proper nouns cap only, and paragraphs should be indented. After final acceptance of the manuscript, the author(s) should sign a copyright form for the journal. No page charges are due for publishing in the journal.

The table below summarizes the manuscript style:

Section	Format
Title	Bold, Times New Roman, Font size 16, Centred as, e.g., Vegetation and Flora of Azraq Wetland Reserve
Author/s	An Author and Another(s) the first name and family name should be written in full without abbreviations as (Nashat A. Hmaidan), Centred, Regular, Times New
Affiliation	[1]Department, University, City, Country; Institute, Full Address,
	[2]Department, University, City, Country, Centred, Italic, Times New Roman, size 14
Abstract	Text smaller, indented both sides, Centred, Regular, Time New Roman, size 12
Key words	word; another word; lower case except names. Position aligned with abstract
Headings	A. Bold initial cap only (size bold), Times New Roman, size 14 B. Bold italic initial cap only (size bold, italic), Times New Roman, size 14 C. Italic initial cap only (size italic), Times New Roman, size 14 D. Italic initial cap only (size italic) Text runs on after a punctuation mark, Times New Roman, size 14 All ranged left, numbers to be included if supplied, no indent below
Paragraph	Indented Paragraph: use this for the first paragraph in a section, or to continue after an extract. New paragraph: use this style when you need to begin a new paragraph

Jordan Journal of Natural History
Conservation Monitoring Centre
The Royal Society for the Conservation of Nature
Dahiat Al Rasheed, Bulding No. 4, Baker Al Baw Street,
P. O. Box 1215 Al Jubaiha, Amman 11941 Jordan
Email: jjnh@rscn.org.jo

Table of Contents

Jordan Journal of Natural History, 9 (1), 2022 Pages: 11-18

Complementary Information on *Leiurus jordanensis* Lourenço, Modry and Amr, 2002, with a Description of an Adult Male (Scorpiones: Buthidae)

Bassam Abu Afifeh[1], Mohammad Al-Saraireh[2], Zuhair S. Amr[3]* and Wilson R. Lourenço[4]

[1]Ministry of Education, Al Rumman Secondary School; [2]Oncology Department, Royal Medical Services, Amman; [3]Department of Biology, Jordan University of Science and Technology, Irbid, Jordan;[4]Muséum national d'Histoire naturelle, Sorbonne Universités, Institut de Systématique, Evolution, Biodiversité (ISYEB), UMR7205-CNRS, MNHN, UPMC, EPHE, CP 53, 57 rue Cuvier, 75005 Paris, France

Received: December 15, 2021; Revised: December 28, 2021; Accepted: January 7, 2022

Abstract: The remarkable buthid scorpion *Leiurus jordanensis* Lourenço, Modry and Amr, 2002, discovered in the south of Jordan, was described on the basis of a single adult female probably. Limited information on adult males were presented in subsequent publications. The present note describes an adult male of *L. jordanensis*, collected from the type locality. Complementary information is also provided for this species.

Key-Words: Scorpion, *Leiurus jordanensis*, Buthidae, Al Mudawwarah, Jordan.

Introduction

The genus *Leiurus* was originally described as *Androctonus* (*Leiurus*) *quinquestriatus* by Ehrenberg, 1828 in Hemprich and Ehrenberg (1828). As for its composition, the genus *Leiurus* was considered monotypic with two valid subspecies defined by Vachon (1949): *Leiurus quinquestriatus quinquestriatus* (Ehrenberg, 1828) and *Leiurus quinquestriatus hebraeus* (Birula, 1908). The taxonomic situation of the genus *Leiurus* remained unchanged for almost 200 years, which rendered the discovery of a new species in Jordan even more remarkable. Obviously, the composition of this genus changed drastically over the recent years (Lourenço and El-Hennawy, 2021). *Leiurus jordanensis* was described based on a single female specimen, probably not even a full adult, but some comments and/or supplementary information were provided in subsequent publications. Kovařík (2007) questioned the validity of the speceis and stated that variations in colour may be attributed to the colour and texture of the substrate, however, it is possible that further studies may show that *Leiurus quinquestriatus*, *L. jordanensis* and *L. savanicola* are conspecific. Hendrixson (2006), Lowe *et al.* (2014), and Amr *et al*. (2015) provided further information on the species. Although some information was given on a subadult male specimen by Lowe *et al.* (2014), the morphology of the adult male remains unclear.

In the present note, a full adult male of *L. jordanensis*, collected in the type locality, is described and illustrated precisely.

Material and Methods

Illustrations and measurements were made with the aid of a Wild M5 stereo-microscope with a drawing tube (camera lucida) and an ocular micrometer. Photos were produced with the use of a Leica Wild M3Z stereomicroscope. Measurements follow Stahnke (1970) and are given in mm. Trichobothrial notations follow Vachon (1974) and morphological terminology mostly follows Vachon (1952) and Hjelle (1990). The studied material will be deposited in the collections of the Muséum national d'Histoire naturelle, Paris, and at the University of Jordan in Amman, Jordan.

*Corresponding author: amrz@just.edu.jo

Results and Discussion

Taxonomic treatment

Family Buthidae C. L. Koch, 1837
Genus *Leiurus* Ehrenberg, 1828
Leiurus jordanensis: Lourenço, Modrý & Amr, 2002: 637–641, figs. 2–7, tab. I., 637; Amr and Abu Baker, 2004: 238; Hendrixson, 2006: 83, fig. 17; 93, fig. 12; Kovařík, 2007: 140; El-Hennawy, 2009: 122; Lowe *et al.*, 2014: 99, 100, 105, Tab 3B, figs. 92-93; Amr *et al.*, 2015: 34, fig. 2.
New material studied: one male and one female topotypes. Jordan, Al Mudawwarah (29° 23' 05.7" N, 35°54' 10.2" E), 24.10. 2020, *leg*. B. Abu Afifeh and M. Al-Saraireh. They were deposited in the Muséum national d'Histoire naturelle, Paris. Other specimens were also examined and deposited in the collections of the University of Jordan, Amman, Jordan, including one subadult male, one subadult female, three adult females, Jordan, Al Mudawwarah (29° 23' 05.7" N, 35°54' 10.2" E), 23-24.10. 2020, *leg*. B. Abu Afifeh and M. Al-Saraireh.

Revised diagnosis for the species

Very slender scorpions; this character is more pronounced in males (Table 1). Scorpions of a large size, averaging 100 mm in total length. *Leiurus jordanensis* shows a conspicuous coloration pattern which is globally dark, blackish to brownish. Only one other species of *Leiurus* equally presents a dark pattern of coloration, *Leiurus ater* Lourenço, 2019 from the mountain systems in Chad (Lourenço, 2019). All other known species of *Leiurus* show a rather pale pattern of coloration, which is globally yellow with more or less marked dark spots on the body. In *L. jordanensis*, the ventrolateral carinae of metasomal segment V are armed with spinoid granules, and the anal arch is composed of three spinoid lobes and 12-14 ventral granules. Metasomal carinae are strongly marked, and the intercarinal spaces are smooth to shagreened. The fixed and movable fingers of the pedipalps have twelve rows of granules and marked accessory granules. The fixed and movable fingers of the pedipalps have twelve rows of granules and marked accessory granules. Pectinal tooth counts range from 33 to 38 in males and from 27 to 33 in females. The trichobothrial pattern is similar to that in other species of the genus.

Description of the male

Coloration: Generally blackish-brown with carapace paler than tergites (Figure 1). Prosoma: Carapace blackish-brown to yellow-brown; anterior region darker, forming an inverted triangle which extends from the lateral eyes to behind the middle eyes; lateral margins with some narrow paler zones. Mesosoma: Tergites blackish brown with some paler zones laterally. Metasomal segments blackish-brown. Vesicle pale yellow; aculeus yellowish at the base and dark red at its extremity. Venter reddish-yellow; sternite VII with brown spots. Chelicerae yellowish with dense reticulated dark spots on the anterior half; teeth blackish. Pedipalps: Blackish-brown overall except for the chelae fingers which are yellow to slightly brownish-yellow; rows of granules on the dentate margins of the fingers dark red. Legs: the three proximal segments are brownish-yellow, and the four most distal ones are yellow to pale yellow.

Morphology: Prosoma (Figure 2A): Anterior margin of carapace weakly emarginated. All carapace carinae are strongly developed, including central median, posterior median, anterior median, central lateral, and central median; posterior median carinae terminating distally in a small spinoid process that extends very slightly beyond the posterior margin of the carapace. Intercarinal spaces with very few irregular granules and almost smooth laterally and distally. Median ocular tubercle only slightly anterior to the centre of the carapace, almost in a central position; median eyes are separated slightly by more than two ocular diameters. Four pairs of lateral eyes; the fourth eye is only half the

Table 1. Comparative morphometric values (in mm) of the male and female topotypes of Leiurus jordanensis from Al Mudawwarah, Jordan.

	♂	♀
Total length (Including telson)	95.9	89.3
Carapace: Length / Anterior width / Posterior width	9.7 / 7.1 / 10.8	10.1 / 7.2 / 12.2
Mesosoma length	24.8	20.7
Metasomal segment I: Length/ width	7.8 /5.4	7.4 /5.6
Length / width ratio	1.44	1.32
Metasomal segment II: Length/ width	9.7/ 4.6	8.8 / 4.8
Length / width ratio	2.11	1.83
Metasomal segment III: Length/ width	9.8/ 4.2	9.3/ 4.4
Length / width ratio	2.33	2.11
Metasomal segment IV: Length/ width	11.1 / 3.8	10.8/ 4.0
Length / width ratio	2.92	2.70
Metasomal segment V: length/ width/ depth	12.7/ 3.4 / 3.2	12.3/ 3.7 / 3.3
Length / width ratio	3.74	3.32
Telson: length/ width/ depth	10.3 / 3.5 / 3.7	9.9 / 3.7 / 3.7
Pedipalp		
Femur: length/ width	11.4/ 2.4	11.7 / 2.9
Length / width ratio	4.75	4.03
Patella: length/ width	13.1 / 2.9	13.1 / 3.4
Length / width ratio	4.52	3.85
Chela: length/ width/ depth	21.6 / 2.4 / 2.7	22.7/ 3.0 / 3.2
Length / width ratio	9.0	7.57
Movable finger: length	15.2	15.8

size of the three others. Mesosoma (Figure 2A): Tergites I and II pentacarinate; III and IV tricarinate. All carinae strong, granular; each carina terminating distally with a spinoid process that extends slightly beyond the posterior margin of tergite. Median carinae on I moderate to strong; on II-VI strong, crenulate; terminating distally on each segment with a spinoid process that extends very slightly beyond the posterior margin of the tergite. Tergite VII pentacarinate, with lateral pairs of carinae strong and fused; median carinae present on proximal one-half to 2/3 of the total length, moderate to strong. Intercarinal spaces weakly granular, almost smooth, except for the lateral margins of tergites III-VI which are strongly granulated. Sternites (Figure 2B): Lateral carinae absent from sternite III; moderate to strong on sternites IV-VI; strong, crenulate on VII. Submedian carinae on sternites III moderate, irregularly granular; on IV moderate to weak;

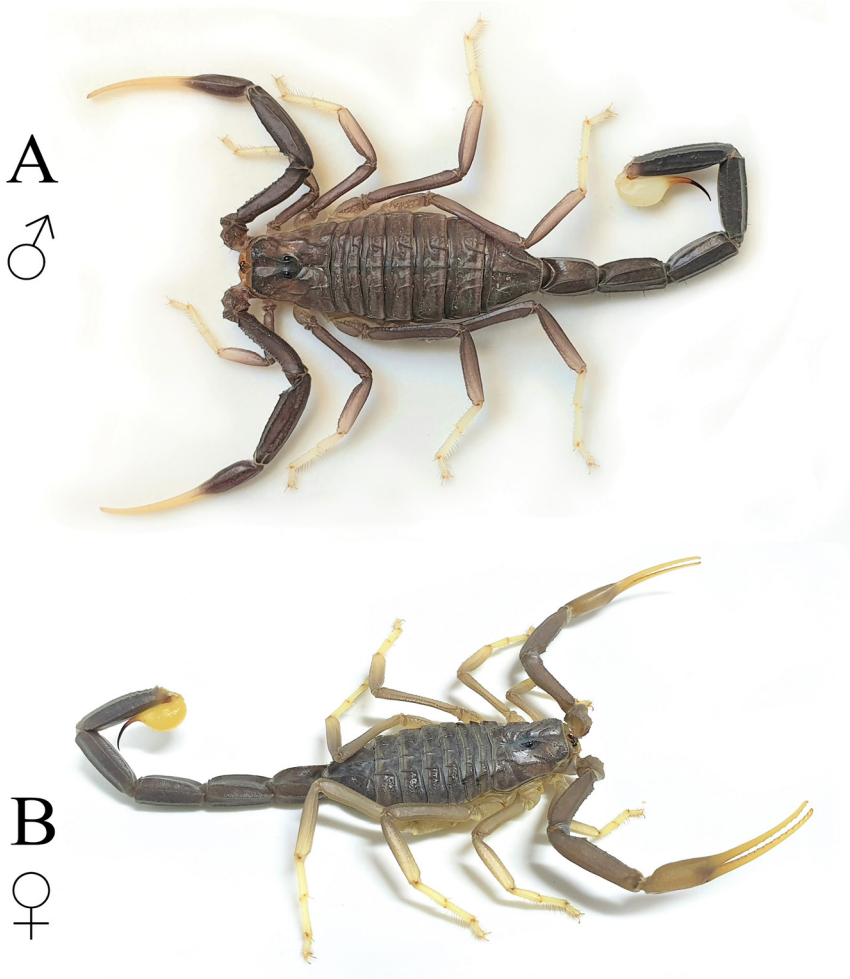


Figure 1. *In vivo Leiurus jordanensis* from Al Mudawwarah, Jordan. **A**. Adult male. **B**. Adult female.

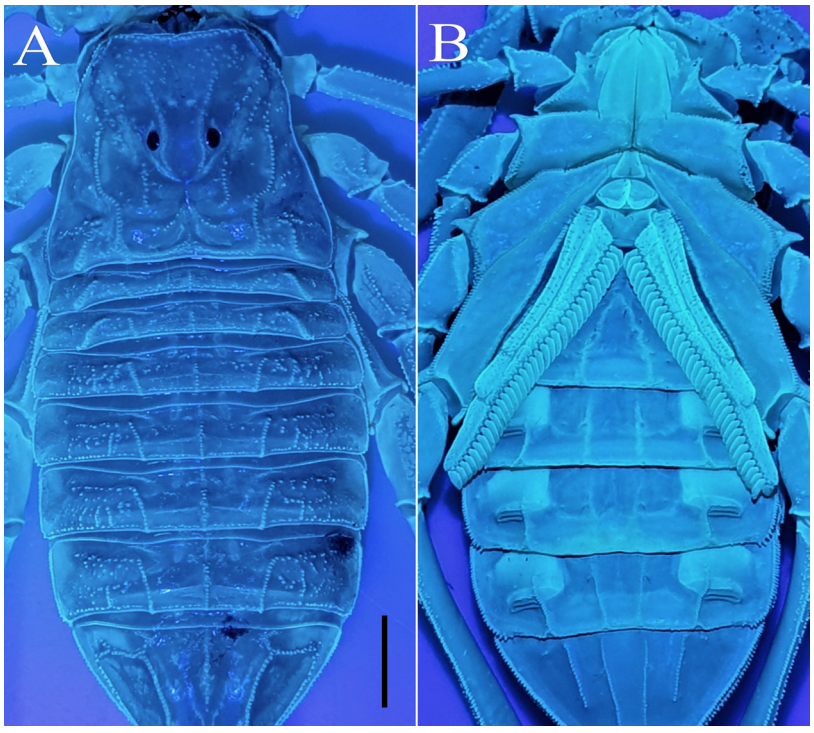
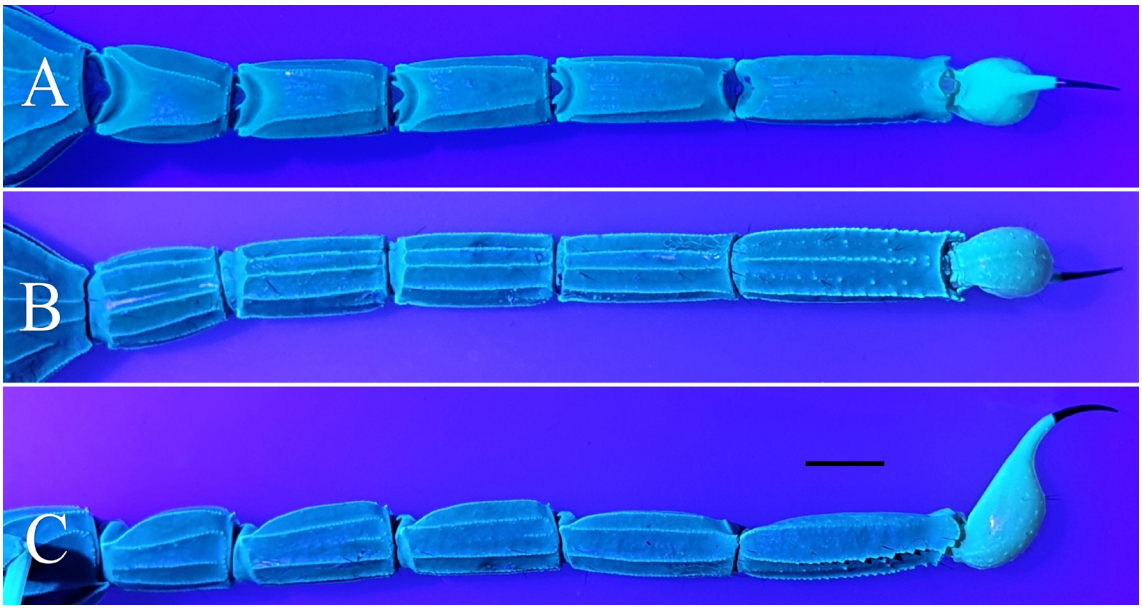


Figure 2. *Leiurus jordanensis* male topotype. **A**. Carapace and tergites. **B**. Coxosternal area and sternites. (Scale bar = 4 mm).

on V weak to obsolete; on VI moderate; on VII strong crenulate. Pectines long; pectinal tooth counts ranging from 35 to 38 in males and from 29 to 33 in females. Metasoma (Figure 3): Metasomal segments I to III with 10 carinae, crenulate; lateral inframedian carinae on I moderate to strong, crenulate; on II present on posterior one-third, crenulate; on III limited to posterior one-fifth; IV with 8 carinae. Dorsolateral carinae moderate to strong, without any more enlarged denticles distally. All the other carinae moderate to strong on segments I to IV. Segment V with 5 carinae; ventromedian carinae moderate to strong with several spinoid granules distally; anal arch with 3 spinoid lobes and 12-14 ventral granules. Dorsal furrows of all segments moderately to weakly developed with a thin granulation, almost smooth; intercarinal spaces globally smooth, with only a few better marked granules on segment V.

Telson smooth. Subaculear tubercle absent (Figure 3). Chelicerae: With two reduced denticles at the base of the movable finger, but never fused (Vachon, 1963). Pedipalps: Femur



Figures 3. *Leiurus jordanensis* Male topotype. Metasoma: **A**. Dorsal aspect, **B**. Ventral aspect, **C**. Lateral aspect. (Scale bar = 5 mm).

pentacarinate; all carinae strongly crenulated (Figures 4e and f). Patella with seven carinae, moderate to strong; dorsointernal carinae with one conspicuous spinoid granule distally and several smaller granules (Figures 4c and d). Chela slender, with elongated fingers; all carinae almost vestigial. Trichobothrial pattern orthobothriotaxic (Figure 4), type A (Vachon, 1974); dorsal trichobothria of femur in beta configuration (Vachon, 1975); *db* is distal to *est* of the fixed finger of peddipaplp chela and $eb_{1,2}$ of external face of patella are at the same level. Legs with the ventral aspect of tarsi presenting numerous thin setae not well arranged in rows. Strong tibial spurs present on legs III and IV. Pedal spurs are present and are strong on all legs. Dentate margins of the fixed and movable fingers are composed of twelve linear rows of granules and conspicuous accessory granules (Figure 5).

Habitat

The habitat of *L. jordanensis* consists of sandstone cliffs surrounded by flat sand fields (Figure 6), with small sand dunes and xeric hammada with scattered *Haloxylon persicum* and *Anabasis* sp. bushes. Details on the habitat of this species were given by Lourenço *et al.* (2002).

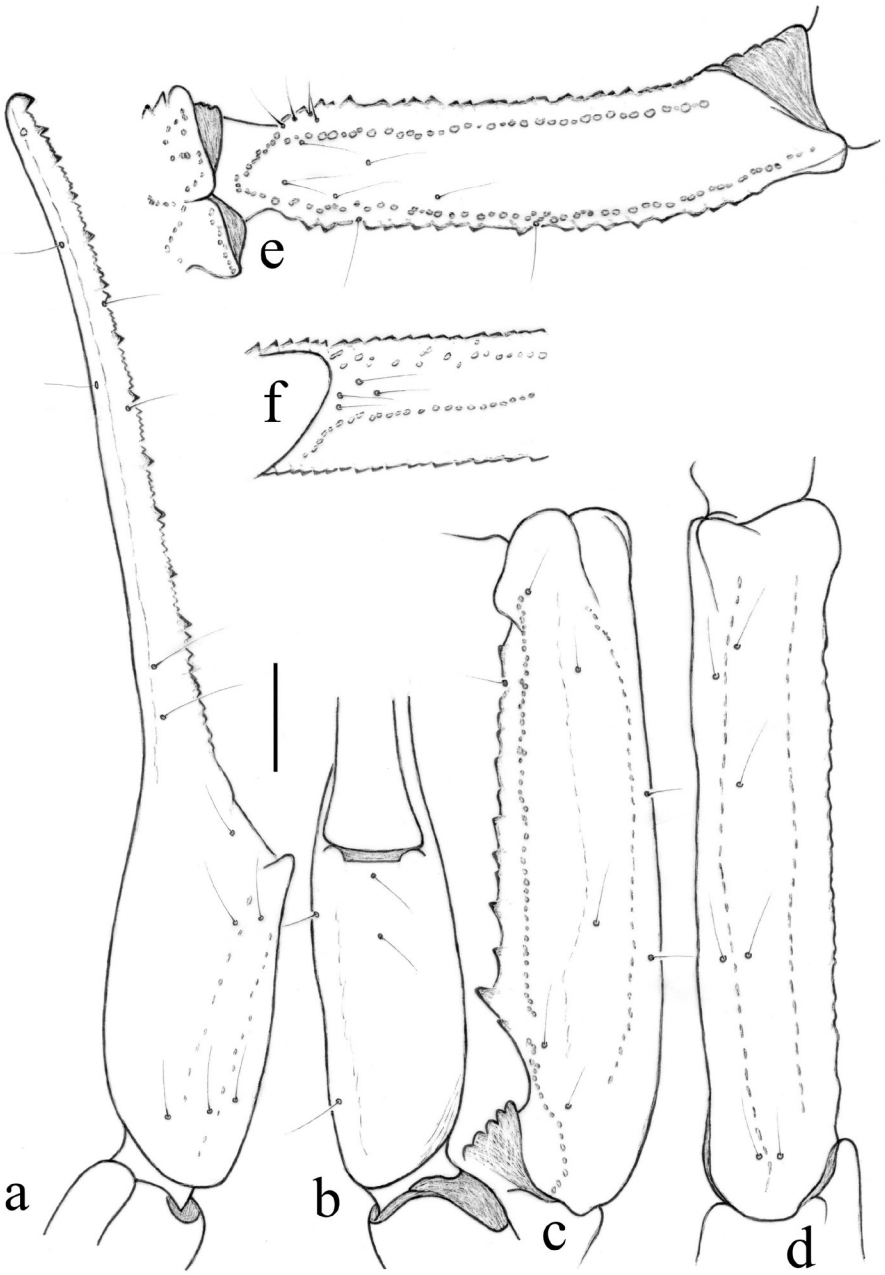


Figure 4. *Leiurus jordanensis* Male topotype. Trichobothrial pattern. Chela: **a**. dorso-external aspect. **b**. ventral aspect. Patella: **c**. dorsal aspect. **d**. external aspect. Femur: **e**. dorsal aspect. **f**. internal aspect. (Scale bar = 2 mm).

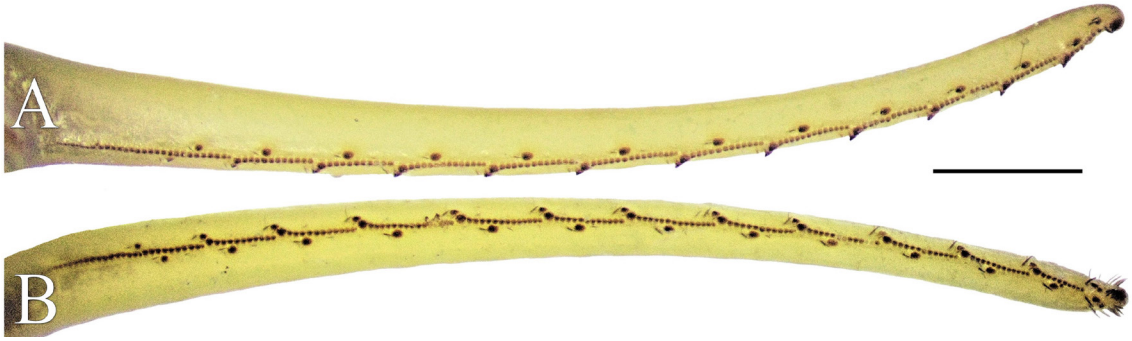


Figure 5. Fingers of pedipalp chela of male *Leiurus jordanensis*. **A**. Fixed finger, **B**. Movable finger. (Scale bar = 2 mm).

Figure 6. Typical habitat for *L. jordanensis* in Al Mudawwarah, south Jordan.

References

Amr, Z. and Abu Baker, M. 2004. The scorpions of Jordan. *Denisia*, **14**(2): 237–244.

Amr, Z, Abed, OA, Al Share, T, Hamidan, N and Prendini, L. 2015. New records of Jordanian scorpions. *Jordan Journal of Natural History*, **2**: 30–38.

El-Hennawy, H.K. 2009. Scorpions of Saudi Arabia (List of species, their distribution, and identification key). *Serket*, **11**(3/4): 119–128.

Hemprich, FW. and Ehrenberg, C.G. 1828. Zoologica II. Arachnoidea. Plate I: *Buthus*; plate II: *Androctonus*. In: Symbolae Physicae seu Icones et Descriptiones Animalium evertebratorum sepositis Insectis quae ex itinere per Africam borealem et Asiam occidentalem. Friderici Guilelmi Hemprich et Christiani Godofredi Ehrenberg, medicinae et chirurgiae doctorum, studio novae aut illustratae redierunt. Percensuit et regis iussu et impensis edidit Dr. C. G. Ehrenberg. - Decas prima. Berolini ex officina Academica, Venditur a Mittlero.

Hendrixson, BE. 2006. Buthid scorpions of Saudi Arabia, with notes on other families (Scorpione: Buthidae, Liochelidae, Scorpionidae). *Fauna of Arabia*, **21**: 33-120

Hjelle, JT. 1990. Anatomy and morphology. In: Polis GA (ed.) **The Biology of Scorpions**. Stanford University Press, Stanford, Pp. 9-63

Kovařík, F. 2007. *Leiurus nasheri* sp. n. from Yemen (Scorpiones, Buthidae). *Acta Societatis Zoologicae Bohemicae*, **71**:137-141.

Lourenço, WR. 2019. Nouvelles considérations sur les *Leiurus* Ehrenberg, 1828 collectés dans la région du Tibesti, Tchad et description d'une nouvelle espèce (Scorpiones: Buthidae). *Revista Ibérica de Aracnología*, **34**: 133-137.

Lourenço, WR. and El-Hennawy, HK. 2021. New considerations on the *Leiurus* Ehrenberg (Scorpiones: Buthidae) distributed in Africa and description of a particular species from Egypt. *Serket*, **17**(4): 325-334.

Lourenço, WR., Modry, D and Amr, Z. 2002. Description of a new species of *Leiurus* Ehrenberg, 1828 (Scorpiones, Buthidae) from the South of Jordan. *Revue suisse de Zoologie*, **109**(3): 635-642.

Lowe, G, Yagmur, EA and Kovařík, F. 2014. A review of the genus *Leiurus* Ehrenberg, 1828 (Scorpiones: Buthidae) with description of four new species from the Arabian Peninsula. *Euscorpius*, **191**: 1-129.

Stahnke, HL. 1970. Scorpion nomenclature and mensuration. Entomological News, **81**: 297-316.

Vachon, M. 1949. Etude sur les Scorpions. III (suite). Description des Scorpions du Nord de l'Afrique. *Archives de l'Institut Pasteur d'Algérie*, **27** (2): 134-169.

Vachon, M. 1952. **Etude sur les Scorpions**. Institut Pasteur d'Algérie, Alger: 482 pp

Vachon, M. 1963. De l'utilité, en systématique, d'une nomenclature des dents des chélicères chez les Scorpions. *Bulletin du Muséum national d'Histoire naturelle, 2e sér.,* **35** (2): 161-166.

Vachon, M. 1974. Etude des caractères utilisés pour classer les familles et les genres de Scorpions (Arachnides). 1. La trichobothriotaxie en arachnologie. Sigles trichobothriaux et types de trichobothriotaxie chez les Scorpions. *Bulletin du Muséum national d'Histoire naturelle, 3è sér., n° 140, Zoologie*, **104**: 857-958.

Vachon, M. 1975. Sur l'utilisation de la trichobothriotaxie du bras des pédipalpes des Scorpions (Arachnides) dans le classement des genres de la famille des Buthidae Simon. *Comptes Rendus des Séances de l'Académie des Sciences*, **281** (D): 1597-1599.

Jordan Journal of Natural History, 9 (1), 2022 Pages: 19-23

Notes on Captive Breeding of Three Snake Species (Colubridae) from the Russian Far East

Nikita E. Pokhilyuk

Kamen-Rybolov 692682, Primorsky Krai, Russian Federation

Received: January 7, 2022; Revised: March 5, 2022; Accepted: March 12, 2022

Abstract: *Rhabdophis tigrinus, Elaphe schrenckii*, and *Elaphe dione* are three common snake species in northeast Asia. The present work focuses on the reproductive biology of the snake populations inhabiting Primorye (the southern Russian Far East). Over the period from 2019 to 2021, the researcher incubated five clutches of snake eggs which were either found in the wild or obtained from wild-caught individuals. Herein, the results are presented concerning the clutches' size, duration of incubation, and thermal conditions for each species. During the study, the researcher observed a correlation between the snakes' body length and the clutch size in *E. schrenckii* and a correlation between thermal conditions and the duration of the incubation period in *R. tigrinus.* Higher thermal conditions resulted in reducing the length of the incubation period.

Key words: breeding; incubation; Russian Far East; *Elaphe schrenckii; Rhabdophis tigrinus; Elaphe dione.*

Introduction

Rhabdophis tigrinus (Boie, 1826), *Elaphe schrenckii* (Strauch, 1873), and *Elaphe dione* (Pallas, 1773) are snake species inhabiting the Korean Peninsula, northeastern China, and the Russian Far East (Dunaev and Orlova, 2014). Despite being common and abundant species, there is little scientific literature on the reproduction of these snakes. In Russia, the data concerning these species are especially sparse due to their limited distribution across the country. Primorsky Krai (hereafter, Primorye) is the area where these three species are most abundant, unlike all other parts of the Russian Far East. Here, the bulk of herpetological studies on local snakes were conducted by A. A. Emelianov (1878–1946) and Yu. M. Korotkov (1935–1996). The interspecific and geographical variation of different reproductive traits (e.g. clutch size) for reptiles has already been observed in lizards (Wang, *et al*., 2011) and snakes (Tryon and Murphy, 1982; Zuffi, *et al.,* 2007; Klenina, 2013). Thus, clutch sizes in the northern populations of *Hierophis viridiflavus* were significantly larger than those in the southern ones (Zuffi, *et al.,* 2007). This study compares the resulting data and findings with the existing information from different literature sources.

Field work for this study took place in western Primorye, which is comprised of two districts adjoining the Chinese–Russian border. These notes are an attempt to summarize the sporadic field observations and the experience in incubating wild snakes' egg clutches and to contribute additional data to the knowledge of these species' reproductive biology.

Materials and Methods

All wild individuals and egg clutches, presented herein, except for *Elaphe schrenckii,* were found at a small quarry (44.936841 N, 131.711838 E), 12 km northeast of the village of Dvoryanka (Khankaysky District, Primorye). The site is located on the northern side of a hill (157 m asl) covered with Quercus mongolica and surrounded with crop fields. A pile of construction waste at the quarry provides local snakes with shelter and a suitable place for

*Corresponding author: hitcher11111@gmail.com

laying eggs. Two *E. schrenckii* were found in the Upper Komissarovka valley (44.742719 N, 131.404069 E) west of Barabash-Levada (Pogranichny District, Primorye). All captive snakes were temporarily kept in two plywood enclosures (70 x 40 x 40 cm and 100 x 39 x 39 cm) at ambient temperatures. Provided with different prey items, water, and hiding places, the animals were kept for two or three weeks until they laid eggs. After that, all of them were returned to their habitats. During the course of the study, five snake clutches representing different species (fifty-five eggs in total) were incubated.

All eggs were put into round plastic containers filled with damp vermiculite. The containers had ventilation holes and were placed next to a heat source. The temperature measurements were taken by means of an alcohol thermometer. The eggs were incubated at fluctuating temperatures. To sustain a high humidity level, the walls of the containers and the vermiculite around the clutch were sprayed with water, at least, twice a week.

In most cases, the eggs were stuck together. No attempt was made neither to separate them nor to change their position. After the snakes hatched, they were fed and released back into the wild.

Results

The tiger keelback (*Rhabdophis tigrinus*)

On July 5, 2019, a clutch of sixteen eggs (30 x 15 mm) were found in the pile of construction debris (Figure 1A). A few meters away, the researcher also found a large female, *Rhabdophis tigrinus* , which is thought to have laid those eggs the night before. One egg was damaged and, accordingly, it was separated. The clutch was taken for further incubation. The eggs were incubated at 26–29 °C. The first egg hatched at 23:00 h on August 5, and the last snake emerged on the night of August 7. All fifteen hatchlings were alive. The incubation success rate was 100%. The incubation period, starting from finding the eggs till the first snake's emergence, lasted thirty-two days.

On June 30, 2020, a gravid female of *R. tigrinus* was caught (blue morph) (Figure 1B). The snake took shelter in a plywood enclosure (70 x 40 x 40 cm) where it was hiding most of the time, and feeding on live frogs. . On the morning of July 12, a clutch consisting of fourteen eggs was found (Figure 1C). They were incubated at 29–30 °C. On August 9, the first cut on one egg was observed at 14:20 h. Nevertheless, the hatchlings remained inside the eggs until night. The next evening, the last of the fourteen snakes hatched out. The hatchlings were 215–225 mm (average = 218.93 mm) in total length with SVL ranging from 170 to 184 mm (average = 176.79 mm) and the tail length ranging from 35 to 47 mm (average = 42.14 mm). The incubation success rate was 100%. None of the hatchlings inherited the blue coloration. The incubation period lasted twenty-nine days.

The steppes rat snake (*Elaphe dione*)

On August 10, 2019, a clutch of eggs was discovered under an old wooden board (Figure 1D). Later, when the incubation ended and the hatchlings emerged, the clutch proved to belong to *Elaphe dione.* There were six eggs (50 x 18 mm), out of which only two were taken. The eggs were incubated at 27–29 °C, and both rat snakes emerged on August 26. Unfortunately, the exact duration of incubation period could not be provided. Given the fact that no eggs were found during the previous visit (July 25, 2019), it was assumed that the incubation period may vary from eighteen to thirty-two days.

The Amur rat snake (*Elaphe schrenckii*)

On June 22, 2021, two gravid female *E. schrenckii* were caught. Both snakes (approximately 135 cm and 145 cm in total length) were housed in the enclosures, depending on their size. The larger female fed exclusively on quail eggs, ignoring any live prey, while the other, on the contrary, ignored the eggs and fed on live mice and sparrows. On July 21 at 19:30 h, the larger

snake began laying eggs (Figure 1E). There were thirteen eggs in the clutch. They were incubated at 27–29 °C, and the first cut on one egg was seen at 16:00 h on August 31. Four hours later, the first hatchling emerged from the egg. A total of ten snakes hatched successfully, and three embryos were found dead inside their eggs, providing an incubation success rate of 76.9 %. The incubation period lasted forty-one days.

On the morning of July 25, a clutch (eleven eggs) of the smaller female was discovered (Figure 1F). Being incubated at 26–29 °C, the first snake cut its egg on the evening of September 3. Next morning, all eggs were cut (one was cut by the researcher), and all eleven hatchlings left their eggs. The incubation success rate was 100%. The incubation period lasted forty-one days.

Discussion

The number of eggs in a clutch is known to differ significantly in every species. The clutch size of *R. tigrinus* can reach up to twenty-five (average = 10.9) eggs (Korotkov, 1985). The two clutches in this study consist of sixteen and fourteen eggs respectively, which is slightly above the average for Russian populations. Webb (1962) reported the clutches of nine, eleven, and thirteen eggs from Korea, while Won (1971; cited by Szyndlar and Hung Dam, 1987) reported eight-thirty-two eggs for Korean populations. According to Sura (1981), a specimen from Korea laid a total of twenty-seven eggs over the period from June 13 to July 18. Two females of less than 72 cm (SVL) examined by Pope (1929) in China contained five and nine eggs.

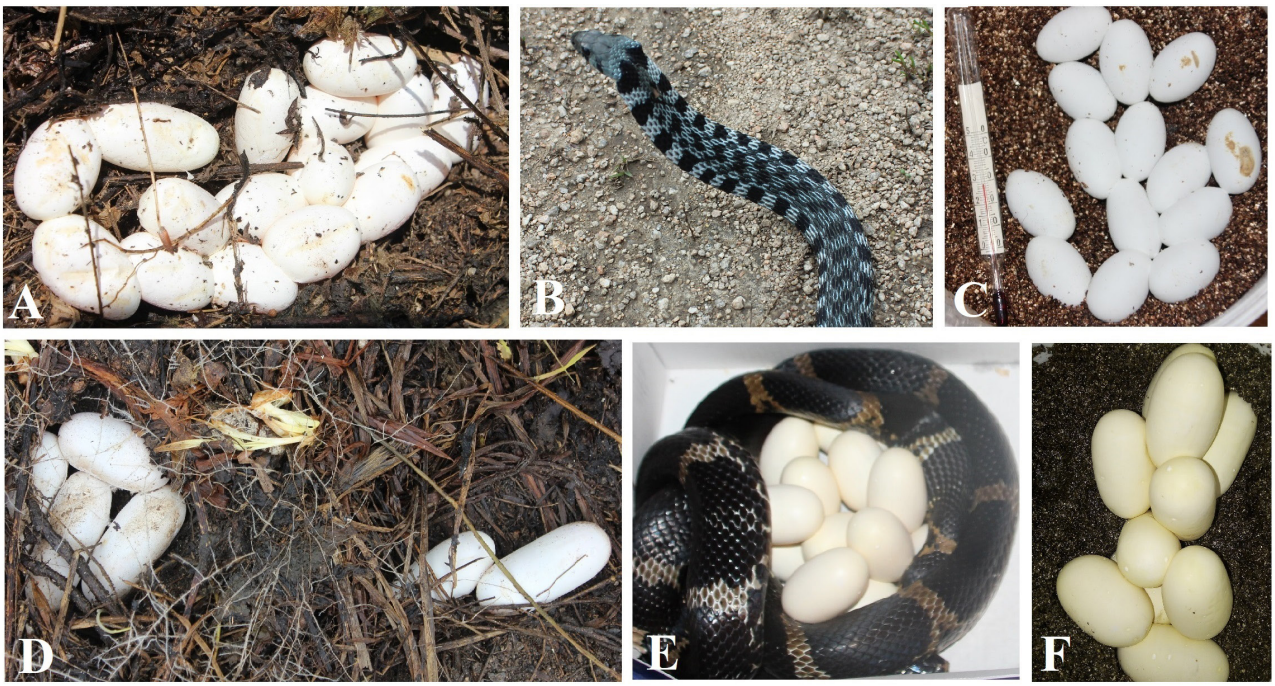


Figure 1. A) The *Rhabdophis tigrinus* clutch found on July 5, 2019; B) The 'blue' female *R. tigrinus* found on June 30, 2020; C) The *R. tigrinus* clutch of 2020 during incubation; D) The clutch of *Elaphe dione* found on August 10, 2019; E) The larger female of *Elaphe schrenckii* laying eggs on July 21, 2021; F) The clutch of the smaller *E. schrenckii* during incubation.

The clutches of *Elaphe schrenckii* in this study consisted of thirteen and eleven eggs. Korotkov (1985) wrote that *E. schrenckii* can lay from seven to twenty-four eggs (average = 10.7 eggs for individuals of over 130 cm in SVL); Tagirova (2009), who had been studying the northern populations of these snakes in the Amur basin, reported 12–13, 14, and 16 eggs for individuals of 124–130, 136–150, and 167 cm in total length respectively. Emelianov documented thirty eggs as the maximum number (Emelianov, 2018). Both of the studied female *E. schrenckii* were not less than 130 cm in total length, and the

size of their clutches corresponds with the average number for Russian populations. The difference in the number of eggs depending on snakes' size has also been observed.

The clutch of *Elaphe dione*, found by the researcher, contained only six eggs. Unfortunately, the size of the female that laid the eggs is unknown, and a single clutch is not sufficient to draw any conclusions. The size of *E. dione* clutches in Primorye can vary from twelve (Emelianov, 2018) to twenty-four eggs (Korotkov, 1985) which is significantly higher than the researcher's observations. In European Russia, Klenina (2013) recorded the clutch sizes of 5–14, 10–16, 8–11 and 5–11 eggs for the Volga basin. Her studies took place in Samara Oblast, Ulyanovsk Oblast, Saratov Oblast, and Volgograd Oblast respectively. In Korea, Webb (1962) reported a female (915 mm in total length) containing nine eggs, and Szyndlar and Hung Dam (1987) reported six to eight eggs.

The incubation temperature can affect not only the duration of the incubation period but also the incubation success rate and physical characteristics of hatchlings (Chen and Ji, 2002; Blouin-Demers and Patterson, 2008; Mengjie, *et al.,* 2012). According to Chen and Ji (2002), *R. tigrinus lateralis* eggs incubated at 24, 27, and 30 ºC hatched after 45, 32, and 27 days, respectively. The hatchlings incubated at lower temperatures proved to be bigger, heavier, and had much lower mortality rate than the ones from thermal conditions of 33 ºC (Chen and Ji, 2002). Sura (1981) incubated his clutch at fluctuating temperatures (20–30 ºC) for thirty-four days. Emelianov (2018) confirmed incubating eggs of *R. tigrinus* for about forty-five to fifty days at 20–25 ºC; Won (1971) mentioned thirty-five to forty days without specifying any thermal conditions. The increase of temperatures in the present study has reduced the duration of the incubation period for *R. tigrinus* clutches from thirty-two to to twenty-nine days. This vividly demonstrates the connection between the temperature conditions and the duration of the incubation period.

Conclusions

The data obtained from the observations in this study vividly demonstrate that the duration of snakes' eggs incubation period is strongly affected by thermal conditions. In fact, an increase in temperature shortens the incubation period.

The clutches' size in *Elaphe schrenckii* and *Rhabdophis tigrinus* from western Primorye is similar to the average values known for both Russian and Korean populations. The clutch size of *Elaphe dione* is closer to the ones of the Korean specimens but requires further studies and a larger sample size.

Acknowledgements

The researcher would like to thank his father, Evgeny P. Pokhilyuk, for his help and support during the field work. Gratitude is also extended to the anonymous referees for their help in improving the manuscript.

References

Blouin-Demers, G and Patterson L. 2008. The effect of constant and fluctuating incubation temperatures on the phenotype of black ratsnakes (*Elaphe obsoleta*). *Canadian Journal of Zoology,* **86**: 882-889.

Chen, HL and Ji X. 2002. The effects of thermal environments on duration of incubation, hatching success and hatchling traits in a colubrid snake *Rhabdophis tigrinus lateralis* (Boie). *Acta Ecologica Sinica,* **22**: 1850-1858.

Dunaev EA and Orlova VF.2014. **Zmei. Vidy fauny Rossii. Atlas-opredelitel'** (**Snakes. Species of Russian fauna. Field Guide**). Moscow: Fiton, 120 pp. [In Russian]

Emelianov, AA.2018. **Amfibii i reptilii Sovetskogo Dal'nego Vostoka** (**Amphibians and reptiles of the Soviet Far East**). Vladivostok: Dalnauka, 416 pp. [In Russian]

Klenina AA. 2013. The reproductive biology of Pallas coluber *Elaphe dione* in the

Volga River basin. *Izvestia of Samara Scientific Center of the Russian Academy of Sciences*, **15** (3/7): 2210-2213.

Korotkov, YuM. 1985. **Nazemnyye presmykayushchiesya Dal'nego Vostoka SSSR** [**Terrestrial reptiles of the USSR Far East**]. Vladivostok: Far Eastern Publishing house, 136 pp. [In Russian]

Mengjie, C, Si, Zh, Ruoru, C, Fei, M and Longhui, L. 2012. Effect of incubation temperature on behavior and metabolism in the Chinese cornsnake, *Elaphe bimaculata*. *Acta Ecologica Sinica,* **32**: 6836-6841.

Pope, CH. 1929. Notes on reptiles from Fukien and other Chinese provinces. *Bulletin of the American Museum of Natural History,* **58**: 335-487.

Sura, P. 1981. Captive breeding of *Elaphe rufodorsata* and *Rhabdophis tigrinus* from the Korean People's Democratic Republic. *The British Herpetological Society Bulletin,* **3**: 20-24.

Szyndlar, Z and Hung Dam O. 1987. Reptiles of the Democratic People's Republic of Korea. Part 1. Serpentes. *Chinese Herpetological Research,* **1**: 22-59.

Tagirova, VT. 2009. **Zhizn' Priamuskikh amfibii i reptilii** (**The life history of amphibians and reptiles in Priamurye**). Khabarovsk: Priamurskie vedomosti, 208 pp. [In Russian]

Tryon, BW and Murphy JB. 1982. Miscellaneous notes on the reproductive biology of reptiles. 5. Thirteen varieties of the genus *Lampropeltis*, species *mexicana, triangulum*, and *zonata*. *Transactions of the Kansas Academy of Science,* **85**: 96-119.

Wang, Y, Weihong, J, Wei, Zh, Yu, N and Liu, N. 2011. Geographic Variation in Clutch and Egg Size for the Lizard *Phrynocephalus przewalskii* (Squamata: Agamidae). *Asian Herpetological Research*, **2**: 97-102. 10.3724/SP.J.1245.2011.00097

Webb, RG, Knox, JJ and Byers, GW. 1962. Some reptiles and amphibians from Korea. *University of Kansas Publications, Museum of Natural History,* **15(2)**: 149-173.

Won, HK.1971. **Amphibian and reptilian fauna of Korea**. Pyongyang: Kwahagwon Chulpansa, 170 pp. [In Korean]

Zuffi, M, Fornasiero, S and Bonnet, X. 2007. Geographic variation in reproductive output of female European whip snakes (*Hierophis viridiflavus*). *The Herpetological Journal*, **17:** 219-224.

Jordan Journal of Natural History, 9 (1), 2022 pages: 24-40

On the Flora of the Northeastern Desert of Jordan

Yassen Ananbeh[1], Jamil Lahham[2], Ahmad El Oqlah[2], Nisreen Al-Quraan[3], Khaled Abulaila[4] and Mustafa Shudiefat[1,*]

[1]Royal Botanical Garden, Amman, [2]Department of Biology, Yarmouk University, Irbid, [3]Department of Biotechnology and Genetic Engineering, Jordan University of Science and Technology, Irbid, [4] Plant Biodiversity and Genetic Resources, National Agricultural Research Center (NARC), Amman, Jordan

Received: January 7, 2022; Revised: March 5, 2022; Accepted: March 12, 2022

Abstract: A total of 194 species which belong to forty-four families were recorded from the northeastern desert of Jordan between 2010 and 2013. This is the first documentation of the flora of Jawa and Um Al Quttain areas and their vicinities. The most diverse families were Asteraceae (22.6%), Fabacae (9.7%), Lamiacaea (8.2%), and Cruciferae (6.7%), while fourteen families were represented by a single species. Most recorded plants were annual plants (45%). The flora of the study area is a mixture of Saharo-Arabian, Irano-Turanian, and Mediterranean elements. The present study shows that Jawa and Um Al Quttain plant communities have a high species diversity.

Key words: Badia, Flora, Jordan**,** Angiosperms.

Introduction

Little is known about the flora of the eastern desert of Jordan. Indeed, there had been many old botanists who worked on the flora of Jordan including the eastern Badia.*Flora Orientalis,* the work of the Swiss botanist in the Middle East, Boissier, (1867-1988) was and is still considered as a milestone reference on the Flora of the whole region of the Middle East, including Jordan. Also significant is the work of Post, G. which was revised and published by Dinsmore (1932-1933) on the Flora of Syria, Palestine, and Sinai. Zohary's work together with Feinbrun-Dothan (1966-1986) as presented in the major reference of *Flora Palaestina*, is considered to be the main reference on the flora of Jordan until this time. Moreover, amongst the earliest studies is a work conducted by Boulos *et al*. (1977) on the flora of Al Safawi and Al Ruwshid areas (H4 and H5), where 198 species were listed. Later, Cope and El-Eisawi (1998) listed 322 species most of which were collected west of Al Safawi area. Al-Eisawi (1985) studied the vegetation in Jordan and recognized nine bioclimatic subdivisions which belong to four biogeographical regions. Other studies focused on the flora of Al Azraq area including Townsend (1967) and Nelson (1973). Recently, Kherissat and Al-Eisawi (2019) listed 206 species which belong to 138 genera and thirty-five families from Wadi Hassan, in the northwestern desert of Jordan. Al Eisawi (1998) produced a field guide for the flora of Jordan. Taifour and El-Oqlah (2017) revised the flora of Jordan, with a total of 2531 species which belong to 112 families from the northwestern desert. This communication documents the flora of the northeastern parts of Jordan, especially around Um Al Quttain and Al Safawi areas.

Materiales and Methods

Study Area

The present study was conducted in eight major areas extending from Um Al Quttain to the Burqu' area between 2010 and 2013 (Table 1). The study area also covers a few collections from Al Shawmari and the Wildlife Reserves.

Jordan Badia constitutes 80% of the Hashemite Kingdom of Jordan.

*Corresponding author: mshudiefat@royalbotanicgarden.org

Table 1. localities of collection with corresponding coordinates

Locality	N	E
Al Beqawywh	32^0 03’	37^0 07’
Al Hazim	31^0 35’	37^0 15’
Al Shawmari	30^0 37’	36^0 28’
Azraq	31° 49’	36° 47’
Burqu’a	32^0 37’	37^0 58’
Jawa	31^0 51’	35^0 56’
Marab Emish	32° 15’	37° 22’
Safawi	32^0 l0’	37^0 07’
Um Al Quttain	32^0 19’	36^0 38’
Wadi Salama	32^0 25’	37^0 14’

Geographically, the area extends from the east, to the western mountains bordering the Jordan Valley. It is elevated between 700 and 1100 meters above sea level. Badia is different from the desert, as there is much more extensive plant and animal life. It falls within an arid climatic zone. Rainfall is erratic both spatially and temporally, with a maximum of 200 mm annually. Air temperature fluctuates widely between a daily mean minimum of 10° C, mean maximum of 24.5° C and a mean daily temperature of 17.5° C. Occasionally, the absolute minimum and Azraq maximum temperatures might reach -5° C and 46° C respectively (Allison *et al*., 1998). The area is bounded by Syria to the north and Saudi Arabia in the south. The east and west margins approximately follow the perimeter of extensive basalt outcrops, which cover a large part of the ground surface between the towns of Azraq and Al Ruwayshid (Amr, 2008).

Rout transects were used to sample the flora of the area; individual plants or plant communities were registered wherever noticed even if not intercepted by the rout. Herbarium specimens were prepared whenever possible and the collected plants were photographed at location and were later identified based on the key of Zohary (1966 and 1972) and Feinbrun-Dothan (1978 and 1986). Whenever needed, they were compared with the voucher specimens kept at the Royal Botanic Garden/ Jordan.

Results

Following the Angiosperm Phylogeny Group IV system, a total of 196 species of angiosperms, , which belong to forty-four families and one species of gymnosperms were recorded from the study area as follows:

Gymnosperms

1. Ephedraceae

1. *Ephedra alata* Decne., Ann. Sci. Nat. (Paris) 2: 239. 1824.
   Locality**:** Safawi, 12.4.2013.

Angiosperms

2. Aizoaceae

1. *Aizoanthemum hispanicum* (L.) H.E.K. Hartmann, Illustr. Handb. Succ. Pl.: Aizoaceae A-E: 29. 2001.
   Syn.: *Aizoon hispanicum* L., Sp. Pl. 1: 488. 1753.
   Locality: Marab Emish, 2.5.2013.
2. *Aizoon canariense* L., Sp. Pl. 1: 488. 1753
   Locality: Marab Emish, 2.5.2013.

3. Amaranthaceae

1. *Anabasis syriaca* Iljin, Bot. Mater. Gerb. Bot. Inst. Komarova Akad. Nauk S.S.S.R. 20: 138. 1960.
   Locality: Safawi, 12.4.2013; Marab Emish, 2.5.2013.
2. *Atriplex leucoclada* Boiss. var. *leucoclada* Zohary, Diagn. Pl. Orient. 12: 95. 1853.

Locality: Safawi, 12.4.2013; Marab Emish, 2.5.2013.

3. *Caroxylon vermiculatum* (L.) Akhani & Roalson, Int. J. Pl. Sci. 168: 948. 2007.
   Syn.: *Salsola vermiculata* L., Sp. Pl. 1: 223. 1753; *Salsola villosa* Del. ex Roem. & Schult., Syst. Veg. ed. 15, 6 : 232 (1820); *Salsola vermiculata* L. var. *villosa* (Delile ex Roem. & Schult.) Moq.
   Locality: Marab Emish, 11.4.2013.
4. *Halothamnus lancifolius* (Boiss.) Kothe-Heinr., Biblioth. Bot. 143: 88. 1993.
   Locality: Marab Emish, 11.4.2013; Um Al Quttain, 12.4.2013.
5. *Noaea mucronata* (Forssk.) Asch. & Schweinf., Ill. Fl. Égypte 131. 1887.
   Syn.: *Salsola mucronata* Forssk., Fl. Aegypt.-Arab. 56 1775; *Anabasis spinosissima* L.f., Suppl. 173 1781.
   Locality: Um Al Quttain, 12.4.2013.
6. *Salsola rosmarinus* (Bunge ex Boiss.) Eig, Palestine J. Bot., Jerusalem Ser. 3: 132. 1945.
   Syn. *Suaeda rosmarinus* Ehrenb. ex Boiss. (1879); *Seidlitzia rosmarinus* Bunge ex Boiss. (1879).
   Locality: Safawi, 12.4.2013; Marab Emish, 2.5.2013, Jaffar, Mdwarah

4. Amaryllidaceae

1. *Allium ascalonicum* L., Fl. Palaest.: 117. 1756.
   Syn.: *Allium hierochuntinum* Boiss., Fl. Orient. 5: 244. 1882.
   Locality: Safawi, 12.4.2013.
2. *Allium paniculatum* L., Syst. Nat. ed. 10, 2: 978. 1759.
   Locality:
3. *Allium rothii* Zucc., Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 3: 232. 1843.
   Locality: Um Al Quttain, 12.4.2013.

5. Apiaceae

1. *Bifora testiculata* (L.) Roth, Enum. Pl. Phaen. Germ. 1: 888. 1827.
   Syn.: *Coriandrum testiculatum* L., Sp. Pl. 1: 256. 1753.
   Locality: Um Al Quttain, 12.4.2013.
2. *Coriandrum sativum* L., Sp. Pl. 1: 256. 1753.
   Locality: Um Al Quttain, 12.4.2013.
3. *Ducrosia flabellifolia* Boiss., Ann. Sci. Nat., Bot. sér. 3, 1: 341. 1844.
   Locality: Um Al Quttain, 20.4.2013
4. *Malabaila secacul* (Mill.) Boiss., Fl. Orient. 2: 1057. 1872.
   Syn.: *Tordylium secacul* Mill., Gard. Dict. ed. 8: 5. 1768. *Heracleum carmeli* Labill., Icon. Pl. Syr. 5: 3. 1812.
   Locality: Marab Emish, 12.4.2013.
5. *Torilis arvensis* (Huds.) Link, Enum. Hort. Berol. Alt. 1: 265. 1821.
   Syn.: *Caucalis arvensis* Huds., Fl. Angl. 98. 1762
   Locality: Marab Emish, 11.4.2013.

6. Arecaceae

1. *Phoenix dactylifera* L., Sp. Pl. 2: 1188. 1753
   Locality: Al Hazim, 21013.

7. Asparagaceae

1. *Drimia undulata* Stearn, Ann. Mus. Goulandris 4: 208. 1978.
   Syn.: *Urginea undulata* (Desf.) Steinh., Ann. Sci. Nat., Bot. sér. 2, 1: 330. 1834.
   Locality: Marab Emish, 11.4.2013.
2. *Leopoldia bicolor* (Boiss.) Eig & Feinbrun, Palestine J. Bot., Jerusalem Ser. 4: 58. 1947.
   Locality: Marab Emish, 11.4.2013.

8. Asteraceae

1. *Aaronsohnia factorovskyi* Warb. & Eig, Leafl. Agric. Exp. Sta. Zionist Organ. Inst. 6: 40. 1927.
   Locality: Marab Emish, 11.4.2013.
2. *Achillea cretica* L., Sp. Pl. 2: 899. 1753.
   Syn.: *Achillea santolina* L., Sp. Pl. 2: 896. 1753.
   Locality: Jawa.
3. *Achillea falcata* L., Sp. Pl. 2: 897. 1753.
   Locality: Marab Emish, 11.4.2013.
4. *Achillea fragrantissima* (Forssk.) Sch. Bip., Flora 38: 13. 1855.
   Syn. *Santolina fragrantissima* Forssk. (1775).
   Locality: Marab Emish, 11.4.2013.

Safwai. Azraq.

5. *Anthemis bornmuelleri* Stoj. & Acht., Notizbl. Bot. Gart. Berlin-Dahlem 13: 522. 1937.
   Locality: Marab Emish, 11.4.2013; Um Al Quttain, 12.4.2013.
6. *Anthemis melampodina* Delile, Fl. Egypte 268. t. 45. 1813.
7. *Anthemis rascheyana* Boiss. Diagn. Pl.Prient.Se.:8:198(1849).
   Locality: Um Al Quttain, 12.4.2013.
8. *Anvillea garcinii* (Burm.f.) DC., Prodr. 5: 487. 1836.
   Syn.: *Anthemis garcinii* Burm.f., Fl. Ind. (N. L. Burman) 183. 1768.
   Locality: Marab Emish, 11.4.2013
9. *Artemisia sieberi* Besser, Bull. Soc. Imp. Naturalistes Moscou 9: 80. 1836.
   Syn.: *Artemisia herba-alba* Asso, Syn. Stirp. Aragon. 117.
   Locality: Marab Emish, 11.4.2013; Um Al Quttain, 12.4.2013; Burqu'a.
10. *Asteriscus graveolens* Less., Syn. Gen. Compos. 210. 1832.
    Locality: Marab Emish, 11.4.2013.
11. *Atractylis cancellata* L., Sp. Pl. 2: 830. 1753.
    Locality: Jawa. Safwai.
12. *Atractylis phaeolepis* Pomel, Nouv. Mat. Fl. Atl. 273. 1875.
    Syn.: *Atractylis mutica* Townsend, Kew Bull. 21:53, f.2 (1967).
    Locality: Marab Emish, 11.4.2013.
13. Calendula arvensis L., Sp. Pl., ed. 2. 2: 1303. 1763.
    Locality: Marab Emish, 11.4.2013.
15. *Carthamus nitidus* Boiss., Fl. Orient. 3: 708. 1875.
    Locality: Jawa, 2010.
16. *Centaurea aegyptiaca* L., Mant. Pl. 118. 1767.
    Locality: Marab Emish, 11.4.2013.
17. *Centaurea ammocyanus* Boiss., Diagn. Pl. Orient. ser. 1, 10: 109. 1849.
    Locality: Jawa, 2010.
18. *Crepis aspera* L., Sp. Pl., ed. 2. 2: 1133. 1763.
    Locality: Jawa, 2010.
19. *Echinops glaberrimus* DC. In Decne., Ann.Sci.Ser.2,2:260 (1834).
    Locality: Marab Emish, 11.4.2013.
20. *Filago anatolica* (Boiss. & Heldr.) Chrtek & Holub, Preslia xxxv. 3. 1963.
    Syn.: *Evax anatolica* Boiss. & Heldr., Diagn. Pl. Orient. ser. 1, 11: 2. 1849.
    Locality: Jawa, 2010.
21. *Filago argentea* (Pomel) Chrtek & Holub
    Locality: Marab Emish, 11.4.2013. Safwai.
22. *Geropogon hybridus* (L.) Sch.Bip., Webb & Berth. Phyt. Canar. 2. 472. 1850.
    Syn.: *Tragopogon hybridus* L., Sp. Pl. 2: 789. 1753.
    Locality: Marab Emish, 20.4.2013.
23. *Gundelia tournefortii* L., Sp. Pl. 2: 814. 1753.
    Syn.: *Guizotia abyssinica* (L.f.) Cass.
    Locality: Marab Emish 20.4.2013.
24. *Gymnarrhena micrantha* Desf., Mém. Mus. Par. iv., 2. t. 1. 1818.
    Locality: Marab Emish, 11.4.2013.
25. *Lactuca orientalis* (Boiss.) Boiss., Fl. Orient. 3: 819. 1875.
    Syn.: *Phaenopus orientalis* Boiss., Voy. Bot. Midi Esp. 390. 1893
    Locality: Marab Emish, 11.4.2013.
26. *Lasiopogon muscoides* (Desf.) DC., Prodr. [A. P. de Candolle] 6: 246. 1838
    Syn.: *Gnaphalium muscoides* Desf., Fl. Atlant. 2: 267. 1799.
    Locality: Marab Emish, 20.4.2013.
27. *Launaea fragilis* (Asso) Pau
    Locality: Marab Emish, 11.4.2013.
28. *Launaea mucronata* Muschl. subsp. *cassiniana* (Jaub. & Spach) N.Kilian, Willdenowia 25(1): 277. 1995.
    Syn.: *Sonchus cassinianus* Jaub. & Spach, Ill. Pl. Orient. iii. 112. 1848; *Launaea cassiniana* Muschl., Man. Fl. Egypt ii. 1058. 1912.
    Locality: Marab Emish, 11.4.2013.
29. *Launaea nudicaulis* (L.) Hook.f., Fl. Brit. India [J. D. Hooker] 3: 416. 1881.
    Syn.: *Chondrilla nudicaulis* L., Mant. Pl. Altera 278. 1771.
    Locality: Um Al Quttain, 12.4.2013.2.5.2013.
30. *Matricaria aurea* (Loefl.) Sch.Bip., Bonplandia 8: 369. 1860.
    Locality: Um Al Quttain, 12.4.2013.

31. *Notobasis syriaca* (L.) Cass., Dict. Sci. Nat., ed. 2. [F. Cuvier] 25: 225. 1822; 35: 170. 1825.
Syn.: *Carduus syriacus* L., Sp. Pl. 2: 823. 1753.
Locality: Marab Emish, 11.4.2013.
32. *Onopordum jordanicola* Eig, Palestine J. Bot., Jerusalem Ser. 2: 196. 1942.
Locality: Marab Emish, 11.4.2013.
33. *Onopordum macrocephalum* Eig, Palestine J. Bot., Jerusalem Ser. 2: 194. 1942.
Syn.: *Onopordum transjordanicum* Eig, Palestine J. Bot., Jerusalem Ser. 2: 194. 1942.
Locality: Marab Emish, 11.4.2013.
34. *Phagnalon rupestre* (L.) DC.,Prodr. [A. P. de Candolle] 5: 396. 1836.
Syn.: *Conyza rupestris* L., Mant. Pl. 113. 1767.
Locality: Safawi, 12.4.2013.
35. *Pulicaria incisa* (Lam.) DC., Prodr. [A. P. de Candolle] 5: 479. 1836.
Syn.: *Inula incisa* Lam., Encycl. 3(1): 256. 1789.
Locality: Jawa, 12.4.2013.
36. *Scorzonera papposa* DC., Prodr. [A. P. de Candolle] 7(1): 119. 1838.
Syn.: *Scorzonera kurdica* Boiss. & Noë
Locality: Burqu'a, 2010; Um Al Quttain, 12.4.2013.
37. *Scorzonera psychrophila* Boiss. & Hausskn. ex Boiss. & Hausskn., Fl. Orient. 3: 777. 1875.
Syn.: *Scorzonera judaica* Eig, Repert. Spec. Nov. Regni Veg. Beih. 63(1): 78, nomen. 1931.
Locality: Burqu'a,
38. *Scorzonera pusilla* Pall., Reise Russ. Reich. ii.: 744; 329. 1773.
Locality: Marab Emish, 4.3.2007.
39. *Scorzonera shweinfurthii* Boiss.,Fl. Suppl.320 (1888).
Locality: Marab Emish, 17.3.2007.
40. *Senecio glaucus* L., Sp. Pl. 2: 868. 1753.
Locality: Um Al Quttain, 12.4.2013.
41. *Silybum marianum* (L.) Gaertn., Fruct. Sem. Pl. 2(3): 378, t. 168. 1791.
Syn.: *Carduus marianus* L., Sp. Pl. 2: 823. 1753
Locality: Marab Emish, 11.4.2013. Um Al Quttain, 12.4.2013.
42. *Sonchus asper* (L.) Hill. ssp. *glausescens* (Jordan) Ball.
Locality: Um Al Quttain, 12.4.2013.
43. *Tragopogon buphthalmoides* (DC.) Boiss., Fl. Orient. 3: 750. 1875.
Syn.: *Scorzonera buphthalmoides* DC., Prodr. [A. P. de Candolle] 7(1): 121. 1838.
Locality: Marab Emish, 11.4.2013.
44. *Tragopogon collinus* DC., Prodr. [A. P. de Candolle] 7(1): 115. 1838.
Locality: Um Al Quttain, 12.4.2013.

9. Berberidaceae

1. *Bongardia chrysogonum* (L.) Spach, Hist. Nat. Vég. 8: 65. 1839.
Locality: Jawa, 20.4.2013.
2. *Leontice leontopetalum* L., Sp. Pl. 1: 312. 1753.
Locality: Jawa, 20.4.2013.

10. Boraginaceae

1. *Alkanna tinctoria* Tausch, Flora 7: 234. 1824.
Locality: Marab Emish, 11.4.2013.
2. *Anchusa aegyptiaca* (L.) A.DC., Prodr. 10: 48. 1846.
Locality: Marab Emish, 11.4.2013.
3. *Anchusa milleri* Willd., Bot. Gart. Halle Nachtr. 1: 11. 1801.
Locality: Marab Emish, 11.4.2013.
4. *Anchusa strigosa* Banks & Sol., Nat. Hist. Aleppo ed. 2, 2: 246. 1794.
Locality: Marab Emish, 11.4.2013. Um Al Quttain, 12.4.2013.
5. *Buglossoides tenuiflora* (L.f.) I.M.Johnst., J. Arnold Arbor. 35: 42. 1954.
Syn.: *Lithospermum tenuiflorum* L.f., Suppl. Pl. 130. 1782 [1781 publ. Apr. 1782].
Locality: Marab Emish, 11.4.2013.
6. *Nonea melanocarpa* Boiss., Diagn. Pl. Orient., ser. 1 2(11): 96. 1849.
Locality: Marab Emish, 20.4.2013.
7. *Paracaryum rugulosum* (DC.) Boiss., Diagn. Pl. Orient. 11: 129. 1849.
Locality: Marab Emish, 11.4.2013.

11. Brassicaceae

1. *Alyssum szovitsianum* Fisch. & C.A.Mey., Index Seminum (LE) 4: 31. 1837
   Syn.: *Alyssum campestre* (C.A.Mey.) Boiss. var. *micranthum*; *Alyssum pyramidatulum* Bornm.; *Alyssum marginatum* Steud. ex Boiss., Ann. Sci. Nat., Bot. 2, 17: 157. 1842.
   Locality: Marab Emish, 11.4.2013
2. *Brassica tournefortii* Gouan, Ill. Observ. Bot. 44. 1773.
   Locality: Marab Emish, 11.4.2013.
3. *Diplotaxis harra* (Forssk.) Boiss., Fl. Orient. 1: 388. 1867
   Syn.: *Sinapis harra* Forssk., Fl. Aegypt.-Arab. 118. 1775 [1 Oct 1775].
   Locality: Burqu'a, 2010; Um Al Quttain, 12.4.2013.
4. *Eruca vesicaria* (L.) Cav. subsp. *sativa* (Mill.) Thell.
   Syn.: *Eruca sativa* Mill., Gard. Dict. ed. 8 1 1768
   Syn.: *Eruca sativa* Mill. var. *eriocarpa* (Boiss.) Post; *Eruca cappadocica* Reut.; *Eruca cappadocica* Reut. var. *eriocarpa* Boiss.; *Eruca lativalvis* Boiss., Fl. Orient. 1: 396. 1867; *Eruca eruca* (L.) Asch. & Buchenau.
   Locality: Um Al Quttain, 12.4.2013.
5. *Erucaria microcarpa* Boiss., Diagn. Pl. Orient. 8: 47. 1849.
   Locality: Marab Emish, 11.4.2013.
6. *Glasteria glastifolia* (DC) Kuntze
   Syn.: *Texieria glastifolia* (DC) Jaub.et. Spach.III. Pl.or.1:t.1(1842).
   Locality: Marab Emish, 11.4.2013. Um Al Quttain, 12.4.2013.
7. *Isatis lusitanica* L., Sp. Pl. 670. 1753.
   Syn.: *Isatis aleppica* Scop., Delic. Fl. Faun. Insubr. 2: 81, t. 16. 1787 [Feb-Mar 1787].
   Locality: Jawa, 20.4.2013.
8. *Lepidium aucheri* Boiss., Ann. Sci. Nat., Bot. II, 17: 195. 1842.
   Locality: Jawa, 20.4.2013.
9. *Lepidium draba* L., Sp. Pl. 2: 645. 1753.
   Syn.: *Cardaria draba* (L.) Desv. subsp. *draba*; *Cardaria draba* (L.) Desv., J. Bot. Agric. 3: 163. 1813.; *Lepidium draba* L. subsp. *eu-draba* Thell.
   Locality: Marab Emish, 11.4.2013.
10. *Malcolmia africana* (L.) R.Br., Hortus Kew. 4: 121. 1812.
    Syn.: *Hesperis africana* L., Sp. Pl. 2: 663. 1753 [1 May 1753].
    Locality: Jawa, 20.4.2013.
11. *Malcolmia crenulata* (DC.) Boiss., Fl. Orient. 1: 229. 1867.
    Locality: Jawa, 20.4.2013.
12. *Sisymbrium irio* L., Sp. Pl. 659. 1753.
    Locality: Marab Emish, 11.4.2013.
13. *Zilla spinosa* (Turra) Prantl, Nat. Pflanzenfam. 3(2): 175. 1891
    Syn.: *Zilla myagroides* Forssk.
    Locality: Burqu'a, 2010. Jawa, 20.4.2013.Wadi Al Buttum.

12. Capparaceae

1. *Capparis spinosa* L., Sp. Pl. 1: 503. 1753
   Syn.: *Capparis spinosa* L. var. *canescens* Coss., Ann. Sci. Nat., Bot. 11: 28. 1849 ; *Capparis spinosa* (DC.) Boiss. var. *leucophylla*; *Capparis spinosa* (Boiss.) Boiss. var. *parviflora*; *Capparis spinosa* L. var. *deserti* Zohary, Bull. Res. Counc. Israel D, 8:54 (1960); *Capparis spinosa* L. var. *arvensis* Zohary, Bull. Res. Counc. Israel D, 8:53 (1960); *Capparis ovata* Desf., Fl. Atlant. 1: 404. 1798; *Capparis sicula* Duhamel, Traité Arbr. Arbust. 1: 159. 1755; *Capparis leucophylla* DC., Prodr. 1: 246. 1824; *Capparis cartilaginea* (Non Decne.) auctt. incl. Blakelock; *Capparis parviflora* Boiss. var. *glaberrima* Hand.-Mazz.; *Capparis ovata* Desf. var. *kurdica* Zohary; *Capparis leucophylla* DC. var. *parviflora* (Boiss.) Zohary
   Locality: Burqu'a, 2010.

13. Caprifoliaceae

1. *Lomelosia porphyroneura* (Blakelock) Greuter & Burdet, Willdenowia 15: 75. 1985.
   Syn. *Scabiosa porphyroneura* Blakelock (1849).
   Locality: Marab Emish, 11.4.2013. Dayr Al Kahef.
2. *Pterocephalus papposus* (L.) Coult., Mém.

Dipsac. 32. 1823.
Syn.: *Pterocephalus plumosus* (L.) Coult., Mém. Dipsac. 31. 1823; *Scabiosa papposa* L., Sp. Pl. 1: 101. 1753; *Knautia plumosa* L., Mant. Pl. Altera 197. 1771.
Locality: Marab Emish, 11.4.2013.

3. *Valerianella coronata* (L.) DC., Fl. Franç. ed. 3, 4: 241. 1805
Syn.: *Valeriana locusta* L. var. *coronata*, Sp. Pl. 1: 34. 1753.
Locality: Marab Emish, 11.4.2013.

14. Caryophyllaceae

1. *Dianthus monadelphus* Vent., Choix Pl. t. 39. 1807.
Locality: Marab Emish, 11.4.2013.
2. *Dianthus monadelphus* Vent. subsp. *judaicus* (Boiss.) Greuter & Burdet, Willdenowia 12(2): 186. 1982.
Syn. *Dianthus judaicus* Boiss. (1849); *D. auraniticus* Post (1888).
Locality: NE Al Beqawywh.
3. *Herniaria hirsuta* L., Rev. Bot. Recueil Mens. 2: 371. 1847.
4. *Silene conoidea* L., Sp. Pl. 1: 418. 1753.
Locality: Jawa, 2010.
5. *Silene damascena* Boiss. & Gaill., Diagn. Pl. Orient. 2, 6: 34. 1859.
Locality: Um Al Quttain, 12.4.2013. Dayr Al Kahef.
6. *Vaccaria hispanica* (Mill.) Rauschert, Wiss. Z. Martin-Luther-Univ. Halle-Wittenberg, Math.-Naturwiss. Reihe 14: 496 (1965).
Syn.: *Vaccaria pyramidata* Medik., Philos. Bot. 1: 96. 1789.
Locality: Marab Emish, 11.4.2013.

15. Colchicaceae

1. *Colchicum tunicatum* Feinbrun, Palestine J. Bot., Jerusalem Ser. 6: 87. 1953
Locality: Jawa, 27.10.2007.

16. Convolvulaceae

1. *Convolvulus althaeoides* L., Sp. Pl. 1: 156. 1753
Locality: Jawa, 2010.

17. Crassulaceae

1. *Umbilicus intermedius Boiss* DC., Prodr. 3: 400 (1828) var. *intermedius* (Boiss.) Chamberlain, Fl. Turk. 4:213 (1972).
Syn. *Cotyledon intermedia* (Boiss.) Bornm. (1904); *Umbilicus intermedius* Boiss. (1872); *U. pendulinus* DC. var. *intermedius* (Boiss.) Post (1896).
Locality: Um Al Quttain, 12.4.2013. Jawa, 2010

18. Cucurbitaceae

1. *Citrullus colocynthis* (L.) Schrad., Linnaea 12: 414. 1838.
Syn.: *Cucumis colocynthis* L., Sp. Pl. 2: 1011. 1753.
Locality: Al Beqawywh, 8.10.2009. Burqu'.

19. Euphorbiaceae

1. *Andrachne telephioides* L. Sp.Pl.1753.
Locality: Marab Emish, 12.3.2013.
2. *Chrozophora tinctoria* (L.) Juss., Euphorb. Gen. 110. 1824.
Syn.: *Croton tinctorius* L., Sp. Pl. 2: 1004. 1753; *Chrozophora obliqua* (Vahl) A.Juss. ex Spreng., Euphorb. Gen. 28. 1824; *Chrozophora verbascifolia* (Willd.) A.Juss. ex Spreng., Syst. Veg. 3: 851 (1826); *Chrozophora hierosolymitana* Spreng., Syst. Veg. 3: 850. 1826.
Locality: Marab Emish, 12.3.2013.
3. *Euphorbia chamaepeplus* Boiss. & Gaill., Diagn. Pl. Orient. ser. 2, 4: 88. 1859.
Syn.: *Euphorbia herniariifolia* (Non Willd.) Anth.
Locality: Jawa, 2010.
4. *Euphorbia helioscopia* L., Sp. Pl. 1: 459. 1753.
Locality: Marab Emish, 12.3.2013.
5. *Euphorbia hierosolymitana* Boiss., Diagn. Pl. Orient. 12: 110. 1853.
Syn. *Euphorbia thamnoides* Boiss. (1860)
Locality: Marab Emish, 12.3.2013.
6. *Euphorbia retusa* Forssk., Fl. Aegypt.-Arab. 93. 1775.
Syn. *Euphorbia kahirensis* Raeusch. (1797).

Locality: Marab Emish, 12.3.2013. Safawi-Ruwaished

20. Fabaceae

1. *Astragalus bombycinus* Boiss., Diagn. Pl. Orient. ser. 1, 2: 50. 1843.
   Syn.: *Astragalus palmyrensis* Post
   Locality: Jawa, 20.4.2013
2. *Astragalus caprinus* L., Fl. Sicul. Syn. 2(1): 315. 1844.
   Syn.: *Astragalus beershabensis* Eig & Samuelson ex Rech.f., Ark. Bot. ser. 2, 1: 309. 1950; *Astragalus platyraphis* Fisch., Mém. Acad. Imp. Sci. St.-Pétersbourg, Sér. 7. 11(16): 37. 1868.
   Locality: Um Al Quttain, 20.4.2013.
3. *Astragalus guttatus* Banks & Sol., Nat. Hist. Aleppo 2: 260. 1794.
   Locality: Jawa, 2010.
4. *Astragalus oleifolius* DC., Astragalogia 192 (ed. quarto), no. 87. 1802.
   Syn.: *Astragalus deinacanthus* Boiss., Diagn. Pl. Orient. ser. 1, 2(9): 76. 1849; *Astracantha deinacanthus* (Boiss.) Podlech, Mitt. Bot. Staatssamml. München 19: 9. 1983.
   Locality: Um Al Quttain, 20.4.2013.
5. *Astragalus sanctus* Boiss., Diagn. Pl. Orient. ser. 1, 9: 47. 1849.
   Locality: Marab Emish, 11.4.2013.
6. *Astragalus spinosus* (Forssk.) Muschl., Verh. Bot. Vereins Prov. Brandenburg 49. 98. 1908.
   Locality: Marab Emish, 11.4.2013.
7. *Coronilla scorpioides* (L.) W.D.J.Koch, Syn. Fl. Germ. 188. 1835.
   Locality: Um Al Quttain, 20.4.2013.
8. *Hippocrepis areolata* Desv., Mém. Soc. Linn. Paris 4: 329. 1827.
   Syn.: *Hippocrepis bicontorta* Loisel., Mém. Soc. Linn. Paris 6: 424. 1827; *Hippocrepis cornigera* Boiss., Diagn. Pl. Orient. ser. 1, 2: 102. 1843 [Mar 1843].
   Locality: Marab Emish, 11.4.2013.
9. *Hippocrepis multisiliquosa* L., Sp. Pl. 2: 744. 1753.
   Locality: Um Al Quttain, 20.4.2013.
10. *Hippocrepis unisiliquosa* L., Sp. Pl. 2: 744. 1753.
    Locality: Um Al Quttain, 20.4.2013.
11. *Lathyrus annuus* L., Demonstr. Pl. 20. 1753.
    Syn.: *Lathyrus hierosolymitanus* Boiss., Diagn. Pl. Orient. ser. 1, 9: 127. 1849.
    Locality: Marab Emish, 11.4.2013.
12. *Lotus palustris* Willd., Sp. Pl., ed. 4. 3(2): 1394. 1802.
    Syn.: *Onobrychis cadmea* Boiss., Diagn. Pl. Orient. ser. 1, 2: 96. 1843.
    Locality: Ma'an. Modwarah.
13. *Lotus ornithopodioides* L., Sp. Pl. 2: 775. 1753.
    Locality: Azraq. Wadi Al Bottom. Qasr Amra.
14. *Onobrychis ptolematica* (Dlile) DC.prodr. 2:347.
    Locality: Marab Emish, 11.4.2013.
15. *Pisum fulvum* Sibth. & Sm., Fl. Graec. 7. 79. t. 688. 1806-1840.
    Locality: Um Al Quttain, 20.4.2013.
16. *Retama raetam* Webb & Berthel., Hist. Nat. Iles Canaries 2: 56. 1842.
    Locality: Al Hazim, 2010; Um Al Quttain, 20.4.2013.
17. *Trigonella stellata* Forssk., Fl. Aegypt.-Arab. 140. 1775.
    Locality: Marab Emish, 11.4.2013.
18. *Tripodion tetraphyllum* (L.) Fourr.Ann. asoc.Linn.Lyon.ser.2, 16:359.1868
    Syn.: *Physanthyllis tetraphylla* (L.) Boiss. Voy.Bot.Espangne 2 162 .t.162.1840
    Locality: Um Al Quttain, 20.4.2013. Dayr Al Kahef.
19. *Vicia peregrina* L.Sp.Pl.2:737.1753.
    Locality: Um Al Quttain, 20.4.2013.

21. Geraniaceae

1. *Erodium glaucophyllum* (L.) L'Hér., Hort. Kew. 2: 416. 1789.
   Syn.: *Geranium glaucophyllum* L., Sp. Pl. 2: 679. 1753.
   Locality: Marab Emish, 12.3.2013
2. *Erodium laciniatum* (Cav.) Willd., Sp. Pl., ed. 4. 3(1): 633. 1800
   Syn.: *Erodium strigosum* Karel.; *Geranium laciniatum* Cav., Diss. 4: 228. 1787.

Locality: Jawa, 20.4.2013.

3. *Geranium tuberosum* L., Sp. Pl. 2: 680. 1753.
   Locality: Um Al Quttain, 26.5.2013.

22. Iridaceae

1. *Crocus moabiticus* Bornm., Repert. Spec. Nov. Regni Veg. 10: 383. 1912.
   Locality: Dayr Al Kahef.
2. *Iris atropurpurea* Baker, Gard. Chron. 1: 330. 1889.
   Locality: Um Al Quttain, 12.4.2013.
3. *Iris bostrensis* Mouterde, Bull. Soc. Bot. France 101: 420. 1955
   Locality: Dayr Al Kahef.
4. *Moraea sisyrinchium* (L.) Ker Gawl., Ann. Bot. 1(2): 241. 1804
   Syn.: *Iris sisyrinchium* L., Sp. Pl. 1: 40. 1753; *Gynandriris sisyrinchium* (L.) Parl., Nuov. Gen. Sp. Monocot. 52. 1854.
   Locality: Marab Emish, 2010.

23. Ixiolirionaceae

1. *Ixiolirion tataricum* (Pall.) Schult. & Schult.f., Syst. Veg. 7: 752. 1829.
   Syn.: *Amaryllis montana* Labill., Icon. Pl. Syr. 2: 5. 1791 [Jul 1791]; *Ixiolirion montanum* (Labill.) Schult. & Schult.f., App. 37 (1821); *Ixiolirion pallasii* Fisch. & C.A.Mey. ex Ledeb., Fl. Ross. (Ledeb.) 4(12): 116. 1852; *Amaryllis tatarica* Pall., Reise Russ. Reich. 3: 727. 1776.
   Locality: Um Al Quttain, 26.5.2013.

24. Lamiaceae

1. *Ajuga chamaepitys* (L.) Schreb. subsp. *chia* (Schreb.) Arcang., Comp. Fl. Ital. 560. 1882
   Syn.: *Ajuga chia* Schreb., Pl. Verticill. Unilab. Gen. Sp. 25 1774.
   Locality: Marab Emish, 12.4.2013
2. *Ballota undulata* (Sieber ex Fresen.) Benth., Labiat. Gen. Spec. 595. 1834.
   Locality: Um Al Quttain, 2.5.2013.
3. *Eremostachys transjordanica* Eig, Palestine J. Bot., Jerusalem Ser. 4: 173. 1948.
   Locality: Marab Emish, 12.4.2013.
4. *Marrubium cuneatum* Banks & Sol., Nat. Hist. Aleppo ed. 2, 2: 255. 1794.
   Locality: Marab Emish, 12.4.2013.
5. *Moluccella laevis* L., Sp. Pl. 2: 587. 1753.
   Locality: Marab Emish, 12.4.2013.
6. *Phlomis brachyodon* (Boiss.) Zohary ex Rech.f., Oesterr. Bot. Z. 89: 290. 1940.
   Syn.: *Phlomis armeniaca* Willd. var. *brachyodon* Boiss., Diagn. Pl. Orient. 12: 88. 1853.
   Locality: Marab Emish, 12.4.2013.
7. *Salvia ceratophylla* L., Sp. Pl. 1: 27. 1753.
   Locality: Um Al Quttain, 20.4.2013.
8. *Salvia deserti* Decne., Ann. Sci. Nat., Bot. sér. 2, 2: 248. 1834.
   Locality: Al Hazim. Rwasheed. Safwai.
9. *Salvia lanigera* Poir., Encycl. Suppl. 5: 49. 1817.
   Locality: Um Al Quttain, 20.4.2013.
10. *Salvis sclarea* L.,Sp.Pl.27 (1753).
   Locality: Marab Emish, 12.4.2013.
12. *Salvia spinosa* L., Mant. Pl. Altera 511. 1771.
   Locality: Um Al Quttain, 20.4.2013.
13. *Teucrium capitatum* L., Sp. Pl. 2: 566. 1753.
   Locality: Marab Emish, 12.4.2013
14. *Teucrium pollium* L., Sp.Pl.2:566 1753.
   Locality: Um Al Quttain, 20.4.2013.
15. *Thymus bovei* Benth., Labiat. Gen. Spec. 342. 1834.
   Locality: Jawa, 20.4.2013
16. *Vitex agnus-castus* L., Sp. Pl. 2: 638. 1753.
   Locality: Wadi Salama, 2010. Marab Emish, 12.3.2013.

25. Liliaceae

1. *Gagea commutata* K. Koch, Linnaea 22: 227. 1849
   Locality: Um Al Quttain, 20.4.2013. Safwai
2. *Gagea reticulata* (Pall.) Schult. & Schult.f., Syst. Veg. 7: 542. 1829.
   Syn.: *Ornithogalum circinnatum* L.f.; *Gagea reticulata* (Pall.) J.A. & J.H.Schultes var. *tenuifolia* Boiss.; *Gagea tenuifolia* (Boiss.) Fomin; *Ornithogalum reticulatum* Pall., Reise Russ. Reich. 3: 727. 1776.

Locality: Marab Emish, 20.4.2013.

3. *Tulipa biflora* Pall., Reise Russ. Reich. 3: 727. 1776
   Syn.: *Tulipa polychroma* Stapf, Denkschr. Akad. Wien l. 18. 1885
   Locality: Jawa,

26. Linaceae

1. *Linum album* Kotschy ex Boiss., Diagn. Pl. Orient. 6: 27. 1846.
   Locality: Safawi-Ruwaishid.
2. *Linum mucronatum* Bertol., Misc. Bot. 1: 18. 1842
   Locality: Um Al Quttain, 20.4.2013. Dayr Al Kahf.
3. *Linum nodiflorum* L., Sp. Pl. 1: 280. 1753
   Locality: Dayr Al Kahf.
4. *Linum utatissimum* L., Sp. Pl. 1: 277 1753
   Locality: Marab Emish, 20.4.2013.

27. Malvaceae

1. *Alcea acaulis* (Cav.) Alef., Oesterr. Bot. Z. 12: 251. 1862.
   Syn.: *Althaea acaulis* Cav., Diss. 2, Secunda Diss. Bot. 93 (t. 27, f. 3). 1786.
   Locality: Jawa, 20.4.2013.
2. *Alcea chrysantha* (Sam.) Zohary, Bull. Res. Council Israel. Sect. D, Bot. 11: 221. 1963.
   Syn.: *Althea chrysantha* (Sam.)1935
   Locality: Wadi Salma, 2013.
3. *Malva neglecta* Wallr., Syll. Pl. Nov. 1: 140. 1824.
   Locality: Marab Emish, 11.4.2013.
4. *Malva parviflora* L., Demonstr. Pl. 18. 1753.
   Syn.: *Malva microcarpa*; *Malva parviflora* L. var. *cristata* Boiss.; *Malva parviflora* L. var. *microcarpa* (Pers.) Fiori & Paol.
   Locality: Dayr Al Kahf. Marab Emish.

28. Nitrariaceae

1. *Nitraria retusa* (Fossk.) Aschers., Verh. Bot. Ver. Prov. Brandenb.18:94 (1876).
   Locality: Al Hazim, 15.4.2012.
2. *Peganum harmala* L., Sp. Pl. 1: 444. 1753.
   Syn.: *Peganum harmala* L. var. *stenophyllum* Boiss.
   Locality: Burqu, 2010. Marab Emish, 11.4.2013.

29. Orobanchaceae

1. *Cistanche salsa* (C.A.Mey.) Beck, Nat. Pflanzenfam. [Engler & Prantl] iv. III b. 129. 1893.
   Syn. *Phelipaea salsa* C.A.Mey. (1830).
   Locality: Al Hazim.
2. *Cistanche tubulosa* (Schenk) Wight ex Hook.f., Fl. Brit. India, 4. 2: 324. 1884.
   Syn.: *Phelypaea tubulosa* Schenk, Pl. Spec. Schubert 23. 1840.
   Locality: Um Al Quttain, 11.4.2013.
3. *Orobanche cernua* Loefl., Iter Hispan. 152. 1758.
   Locality: Al Shawmari, 2012.

30. Papaveraceae

1. *Fumaria densiflora* DC., Cat. Pl. Horti Monsp. 113. 1813.
   Syn.: *Fumaria micrantha* Lag., Gen. Sp. Pl. [Lagasca] 21. 1816.
   Locality**:** Um Al Quttain, 12.4.2013.
2. *Glaucium arabicum* Fresen., Mus. Senckenberg. 1: 174. 1833.
   Locality**:** Jawa, 30.5.2013.
3. *Hypecoum aegyptiacum* (Forssk.) Asch. & Schweinf., Mém. Inst. Égypt. 2: 37. 1887.
   Locality: Marab Emish. Dayr Al Kahf.
4. *Papaver hybridum* L., Sp. Pl. 1: 506. 1753.
   Locality: Marab Emish, 11.4.2013.
5. *Papaver polytrichum* Boiss. & Kotschy, Diagn. Pl. Orient. ser. 2, 5: 14. 1856.
   Locality: Marab Emish, 11.4.2013.
6. *Roemeria hybrida* (L.) DC., Syst. Nat. [Candolle] 2: 92. 1821
   Locality: Marab Emish, 11.4.2013.

31. Plantaginaceae

1. *Nanorrhinum heterophyllum* (Schousb.) Ghebr Dandy, Fl. Pl. Sudan 3. 137. 1956.
   Syn.: *Linaria spartioides* Brouss. ex Buch, Phys. Beschr. Canar. Ins. 163. 1828; *Kickxia spartioides* (Brouss. ex Buch) Janch., Oesterr. Bot. Z. 82: 152. 1933.
   Locality: Jawa, 3.5.2013.

32. Poaceae

1. *Phragmites australis* (Cav.) Trin. ex Steud., Nomencl. Bot. , ed. 2, 2: 324. 1841.
   Syn.: *Phragmites australis* subsp. *maritimus* (Mabille) Soó.
   Locality: Um Al Quttain, 12.4.2013.
2. *Poa bulbosa* L., Sp. Pl. 70 (1753)
   Syn. *Poa eigii* Feinbrun (1941)
   Locality**:** Um Al Quttain, 12.4.2013.

33. Polygonaceae

1. *Rheum palaestinum* Feinbrun, Palestine J. Bot., Jerusalem Ser. 3: 117. 1944.
   Locality: Jawa, 12.4.2013.
2. *Rumex vesicarius* L., Sp. Pl. 1: 336. 1753
   Locality: Jawa, 12.4.2013.

34. Primulaceae

1. *Androsace maxima* L., Sp. Pl. 1: 141. 1753.
   Locality: Marab Emish, 11.4.2013.

35. Ranunculaceae

1. *Adonis aleppica* Boiss., Ann. Sci. Nat., Bot. sér. 2, 16: 350. 1841
   Locality: Dayr Al Kahf. Mafraq.
2. *Adonis dentata* Delile, Descr. Egypte, Hist. Nat. 287. 1813.
   Locality: Jawa, 12.4.2013.
3. *Ranunculus damascenus* Boiss. & Gaill., Diagn. Pl. Orient. ser. 2, 6: 5. 1859
   Locality: Marab Emish, 11.4.2013.

36. Resedaceae

1. *Caylusea hexagyna* (Forssk.) M.L. Green, Stand.-Sp. Nom. Conserv. 29, 63. 1926
   Syn.: *Reseda hexagyna* Forssk., Fl. Aegypt.-Arab. 92. 1775.
   Locality: Jawa, 2.5.2013.
2. *Reseda alba* L., Sp. Pl. 1: 449. 1753.
   Locality: Marab Emish, 11.4.2013.
3. *Reseda decursiva* Forssk., Fl. Aegypt.-Arab. 67. 1775
   Locality: Marab Emish, 12.4.2013.

37. Rubiaceae

1. *Galium pisiferum* Boiss., Diagn. Pl. Orient. ser. 1, 10: 67. 1849.
   Locality: Um Al Quttain, 20.4.2013.
2. *Valantia hispida* L., Syst. Nat., ed. 10. 2: 1307. 1759
   Locality: Jawa, 2.5.2013.

38. Rutaceae

1. *Ruta buxbaumii* Poir., Encycl. 6: 336. 1804
   Syn.: *Haplophyllum buxbaumii* (Poir.) G. Don, Gen. Hist. 1: 780. 1831
   Locality: Marab Emish, 11.4.2013.

39. Scrophulariaceae

1. *Scrophularia peyronii* Post, Bull. Herb. Boissier 1. 28.1893
   Locality: Jawa, 3.5.2013.
2. *Verbascum eremobium* Murb., Acta Univ. Lund., 2 29(2): 458. 1933
   Locality: Jawa, 3.5.2013.
3. *Verbascum transjordanicum* Murb., Acta Univ. Lund., 2 35(1): 5.4 1939.
   Locality: Azraq, Ruwaishid.

40. Solanaceae

1. *Hyoscyamus desertorum* (Asch. ex Boiss.) Täckh., Svensk Bot. Tidskr. xxxvi. 252. 1942.
   Locality: Um Al Quttain, 12.4.2013.
2. *Hyoscyamus reticulatus* L., Sp. Pl., ed. 2. 1: 257. 1762.
   Locality: Um Al Quttain, 12.4.2013.
3. *Solanum nigrum* L., Sp. Pl. 1: 186. 1753.
   Locality: Jawa, 3.5.2013.

41. Urticaceae

1. *Parietaria alsinifolia* Delile, Descr. Egypte, Hist. Nat., 2: 281, pl. 50, f. 2. 1813
   Syn.: *Freirea alsinaefolia* (Delile) Gaudich., Voy. Uranie 502 1826
   Locality: Jawa, 3.5.2013.

42. Asphodalaceae

1. *Asphodeline recurva* Post, Bull. Herb. Boissier 3: 166. 1895
   Locality: Jawa, 3.5.2013.

43. Zygophyllaceae

1. *Fagonia bruguieri* DC., Prodr. 1: 704. 1824
   Syn.: *Fagonia parviflora* Zohary,

Diagn. Pl. Orient. ser. 1, 8: 124. 1849 [Jan-Feb 1849]; *Fagonia bruguieri* DC. var. *rechingeri* Hadidi; *Fagonia olivieri* DC. var. *glandulosa* Hadidi.
Locality: Jawa, 20.4.2013.

44. **Tamaricaceae**

Tamarix aphylla (L.) H. Karst., Deut. Fl. (Karsten) 641. 1882.
Syn. *Thuja aphylla* L. (1755); *Tamarix articulata* Vahl (1791), nom. illeg.
Locality: Azraq.

Discussion

Part of the Saharo-Arabian realm is represented entirely by the lava desert of pebble hammada (Harra) which harbours various habitats including the bare basalt rocks and flat silty wadis beds with *Artemisia sieberi* as the leading species. The pebble Hammada covers vast area extending from Mafraq to Al Ruwaished and up north to the Syrian borders. The species that can be seen within Harra include *Achillea frargantissima, Artemisia sieberi, Anabasis articulata, Caroxylon vermiculatum*, *Tamarix aphylla, Zilla spinosa, Matricaria aurea, Astragalus spinosa, Peganum harmala, Euphorbia retusa, Fagonia mollis, Asteriscus graveolens, Ferula blabche, Glaucium arabicum,* and *Linum album.* Also, *Onopordom transjordanicum,* is considered endemic to Jordan. At areas with permanent water and well water, species such as *Cynodon dactylon, Amaranthus* sp. *Urtica* sp., *Malva* sp. can be seen.

One of the main marabs within this block is marab Shbeika that harbours high plant coverage. The plant species recorded include, *Hammada eggii, Anabasis articulata, Aleuropus littoralis, Heliotropium* sp., *Oligomeris* sp. *Noaea mucronata, Herneiaria hirsute, Trigonella stellata, Zila spinosa, Atriplex leucoclada, Halogeton alopecuropides, Achillea fragrantissima, Citrillus colycinthus,* and *Vitex angus-castus*

The grassland steppe is represented by pure grasslands, grassy undulating hills, and grasslands with coarse and fine wadis, and grasslands on scattered basalt near the east. As a continuation to the steppe vegetation above, main plain associations include *Centaurea damascene* and *Lactuca orientalis, A. sieberi, Poa bulbosa* and *Stipa capensis.* Associations of *Caroxylon vermiculatum*, and *Anabasis articulata*.

Other existing species include *Atriplex halimus, Anabasis syriaca, A. articulata, Anhcusa stigosa, Nonea mucronata, Caroxylon vermiculatum , Notobasis syriaca, Hyocyamus reticulata, Alcea acaule, Retama raetam*, and *Gymnarrhena micrantha*. Many bulbous species from the lily and the Iris families were recorded including *Moraea sisyrinnchium*, *Gladiolus* sp., *Tulipa polychroma, Glaucium grandiflorum, Allium stamineum*, and *Gagea reticulata*.

The "*harra*", referring to the above description of the Desert Ecosystem, harbours various habitats including the bare basalt rocks and flat silty wadis beds with *A. sieberi* as the leading species. Other habitats such as marabs and mud flats, and sandy hammada do occur within this relatively large vegetation type. The Wadi vegetation is often referred to as run-off hammada. Runoff hammada exists within Harra and the chert/gravel hammada where vegetation is confined to the wadis and watersheds are usually rich and dense in comparison to the surrounding areas. The vegetation at these wadis differs from one area to another as shown here. In general, the leading species in these wadis are *Retama raetam, Tamarix aphylla, Astragalus* spp., *Achillea fragrantissima, Artemisia sieberi, Atriplex halimus, Anabasis articulata,* and *Peganum halrmala.*

Noteworthy species recorded in the *harra* area include *Iris postii* (Aretain area), *Alcea chrysantha*, *Rheum palaestinum*, and *Onopordom transjordanicum* (*Harra*). These are considered endemic to Jordan and require special attention.

Acknowledgments

The researchers would like to express their gratitude to GEF/SGP for funding this study through the project entitled "Plant Biodiversity in the Eastern Badia and Their

Use". Also, special thanks go to the Badia Ecological Education centre-Anageed al Khair Cooperative Society and the Badia Research and Development Program (BRDP) for their generous and logistic support during this study. Thanks are also extended to Dr. Zuhair Amr for helping in plates' preparations.

References

Al Eisawi, D.M.H. 1998. **Field Guide to Wild Flowers of Jordan and Neighbouring Countries**. Amman. Al Rai Commercial Press.

Al-Eisawi, D.M. 1985. Vegetation in Jordan. In: Hadidi, A. (Edit.). **Studies in the History and Archaeology of Jordan**. Vol. II. pp. 45-57. Dep. of Antiquities Amman, Jordan.

Allison, R. J., Higgitt, D. L., Kirk, A. J., Warburton, J., Al-Homoud, A., Sunna, B. F. and White, K. (1998). Geology, geomorphology, hydrology, groundwater and physical resources, *In*: Dutton, R. W., Clarke, J. I. & Battikhi, A. (Eds), **Arid Land Resources and their Management: Jordan's Desert Margin**, London: Kegan Paul International, pp. 21-46.

Amr, Z. 2008. Biodiversity of reptiles and mammals in the Eastern Desert. *In*: Dutton, R. and Shahbaz, M. (Eds.) **Jordan's Arid Badia: Deepening our Understanding**. Smith Gordon & Co. UK.

Boissier, E. (1867-1888). **Flora Orientalis**, 5 Vol. & Supplement. Basil and Geneva. H. Georg.

Boulos, L., Lahham, J. and Jallad, W. 1977. Studies on the flora of Jordan 7. On the desert flora or the area of H-4 and H5 pumping stations, N. E. Jordan. *Candollea,* 32: 255-268.

Cope, T. A. and El-Eisawi, D. 1998. Checklist of the Flora. pp:183–8. *In:* Dutton, R. W., Clarke, J.I. and Battikhi, A.M. (Eds.). **Arid Land Research and their Management, Jordan Desert Margin;** Kegan Paul International. Limited. UK.

Feinbrun-Dothan, N. 1978. **Flora Palaestina**. Part 3. The Israel Academy of Sciences and Humanities, Jerusalem. 1298 pp.

Feinbrun-Dothan, N. 1986. **Flora Palaestina**. Part 4. Israel Academy of Sciences and Humanities, Jerusalem. 525+xxiii pp.

Kherissat, F. and Al-Eisawi, D. 2019. Checklist of Wadi Hassan flora, Northeastern Badia, Jordan. *Plant Diversity*, **41**: 166-173.

Nelson, B. 1973. Azraq: desert oasis. Allen Lane.

Post, G. and Dinsmore 1932-1933. **Flora of Syria Palestine and Sinai**, 2 Vol. American University of Beirut. Beirut. Pp. 928.

Taifour, H. and El-Oqlah, A. 2017. **The Plants of Jordan: Annotated Checklist**. Ghazanfar, S. (Ed.). Kew Publishing, Royal Botanic Gardens, Kew. 162 pp.

Townsend, C.C. 1967. Some Interesting Plants from the Azraq National Park, Jordan. *Kew Bulletin,* **21**: 53-58.

Zohary, M. 1966. **Flora Palaestina**. Part I. The Israel Academy of Sciences and Humanities, Jerusalem. 364 pp.

Zohary, M. 1972. **Flora Palaestina**. Part 2. The Israel Academy of Sciences and Humanities, Jerusalem. 656 pp.

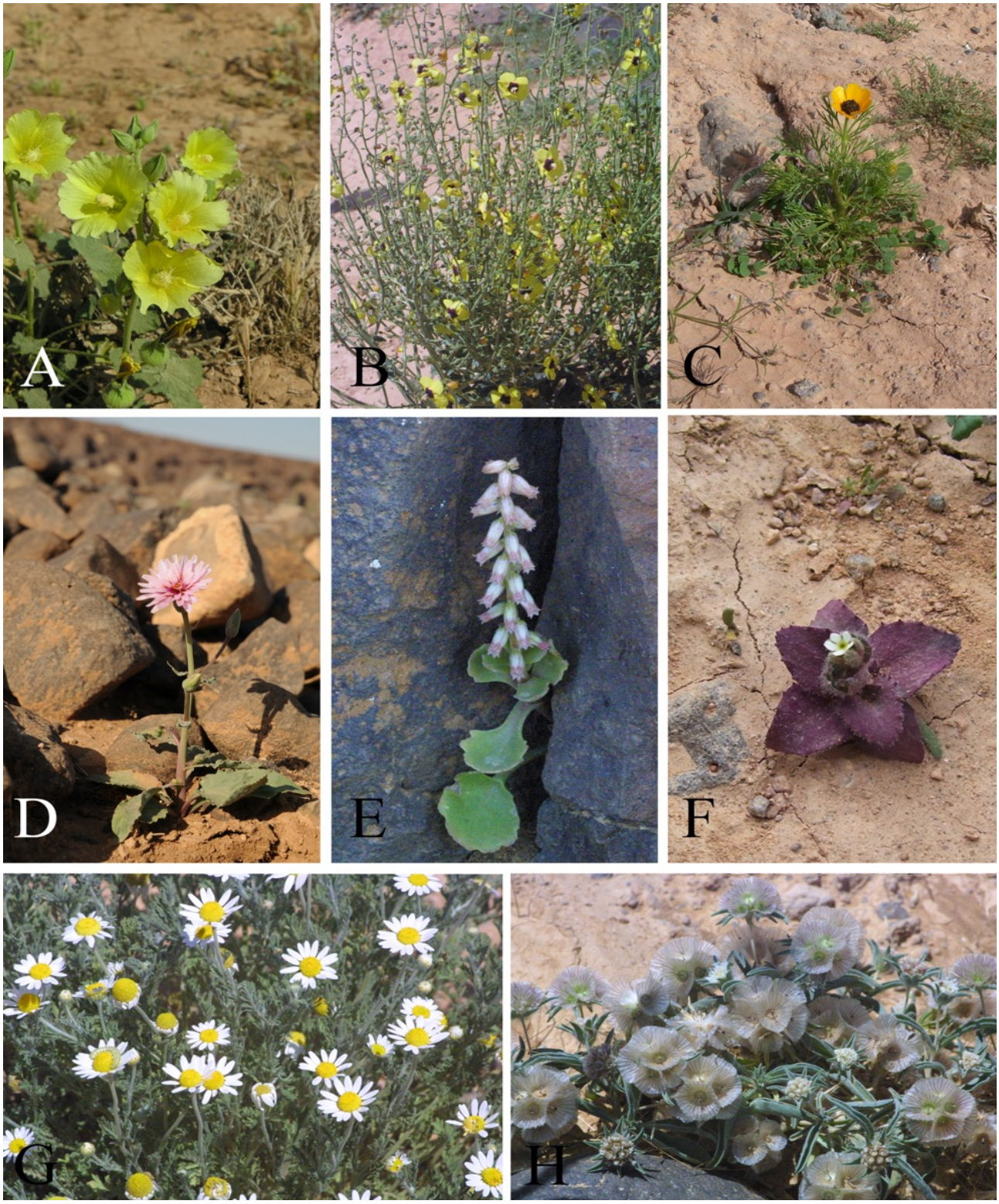
Plate 1

A. *Aizoon hispanicum* **B**. *Convolvulus althaeoides*. **C**. *Anchusa milleri*. **D**. *Asteriscus hierochunticus*. **E**. *Bongardia chrysogonum*. **F**. *Alyssum szowitsianum*. G. *Glaucium leiocarpum*. H. *Gagea reticulata*. **I**. *Linum album*. **J**. *Linum nodiflorum*

Plate 2

A. *Capparis spinosa* **B**. *Astragalus spinosus*. **C**. *Rheum palaestinum*. **D**. *Colchicum tunicatum*. **E**. *Crocus aleppicus*. **F**. *Moraea sisyrinchium*.

Plate 3



A. *Alcea chrysantha*. **B**. *Verbascum jordanicum*. **C**. *Adonis dentata*. **D**. *Scorzonera papposa*. **E**. *Umbelicus intermedius*. **F.** *Androsace maxima*. **G**. *Anthemis*. *bornmuelleri* **H**. *Lomelosia porphyroneura*.

Plate 4

A. *Malabaila secacul*. **B**. T*orilis arvensis*. **C**. *Hyoscyamus reticulatus*. **D**. *Verbascum eremobium*. **E**. *Reseda alba*. **F**. *Alcea acaulis*. **G**. *Allium rothii*. **H**. *Iris atropurpurea*. **I.** *Salvia lanigera*. **J**. *Euphorbia helioscopia*.

Jordan Journal of Natural History, 9 (1), 2022 pages 41-48

Four New Records of Snake Species in Ar'ar Region, Northern Border of Saudi Arabia

Ahmed Mohajja Alshammari

Biology department, Faculty of Science, University of Ha'il, P.O. Box 2440, Ha'il 81451, Saudi Arabia

Received: March 19, 2022; Revised: April 14, 2022; Accepted: April 16, 2022

Abstract : The current study represents the first comprehensive survey of snakes in the Arar region, northern Saudi Arabia. A total of twenty-seven specimens representing seven species that belong to four families (Viperidae, Colubridae, Psammophiidae, and Elapidae) are documented. The present study includes new records of snakes from the Arar region, namely *Psammophis schokari*, *Walterinnesia aegyptia*, *Echis coloratus*, and *Lytorhynchus kennedyi*.

Keywords: Ar'ar, *Lytorhynchus kennedyi*, new records, snakes.

Introduction

The country of Saudi Arabia has different and diverse environments, extending over an area of about 2,250,000 km^2. Despite the harshness of the desert and its climate, it is a shelter for many reptiles (Alshammari and Busais, 2020). In Saudi Arabia, the herpetofauna includes five species of turtles, seven species of amphibians, fifty-five species of snakes, and one hundred species of lizards (Al-Sadoon, 2010).

The reptiles of the Kingdom of Saudi Arabia have been the center of interest in several studies. Over the past thirty years, a number of publications have investigated the distribution, systematics, and ecology of the reptiles of the Kingdom of Saudi Arabia (Farag and Banaja, 1980; Al-Sadoon,1988 and 2010; Arnold, 1986; Alshammari, 2012; Gasperetti, 1988; Aloufi and Amr, 2015; Alsadoon, *et.al*., 2017; Busais 2019; Alshammari and Busais 2020).

All previous studies have provided invaluable information about the herpetofauna of Saudi Arabia in general. However, the northern border province has not been fully studied; in fact, there is a real poor representation of its herpetofauna. Accordingly, this study aims to document the ophiofauna of the Ar'ar region in northern Saudi Arabia.

*Corresponding author: dr.mohajja@gmail.com

Material and Methods

The current study covers the region of Ar'ar located in the north of the Kingdom of Saudi Arabia (N 30° 55' 13", E 40° 0' 3") adjacent to Iraq. It is characterized as a desert area at an altitude of 530 m asl, with intermittent wadi systems in addition to the presence of sand-dune habitats on its southern border with Al-Jouf region. The Ar'ar region has a continental climate; and the average annual temperature ranges from 15.4°C (minimum temperature) to 30°C (maximum temperature), and the average annual precipitation is 57.6 mm (National Center for Meteorology, 2022). Field studies were conducted over the period from March to mid-October from 2019 to 2021. Twenty-six sites were selected to cover all habitats in the region of Ar'ar (Table 1, Figure 1). The surveys, conducted at these sites during the day and at night, resulted in collecting twenty-seven specimens. The specimens were deposited at the Biology Department Museum of Ha'il University (Figure 2).

Results

A total of twenty-seven specimens belonging to four families (Viperidae, Colubridae, Psammophiidae, and Elapidae) representing seven species of snakes were collected and observed during this study. The families Colubridae, Psammophiidae and Viperidae were represented by two genera with one species for each, whereas Elapidae was represented by only one species in the Ar'ar region.

Table 1. The localities of the North Border Province, Kingdom of Saudi Arabia, covered in this study.

No.	Locality	Coordinates (*)		Description (**)
1	Abar Alowaysi	N41° 07' 00"	E 31° 10' 00"	Water supplier
2	Abar Al-lowayzieah	N41° 20 '00"	E 31° 15' 00"	Water supplier
3	Abar Almera'	N40° 14' 00"	E 31° 44' 00"	Water supplier
4	Umm Khenser	N41° 36' 00"	E 30° 42' 00"	Residential area and facilities
5	Umm Aldeyan	N41° 59' 00"	E 30° 57' 00"	Residential area and facilities
6	Ebn Bakor	N40° 39' 00"	E 31° 13' 00"	Residential area and facilities
7	Ebn Sa'ed	N40° 47' 00"	E 31° 04' 00"	Residential area and facilities
8	Hazm Aljalameed	N40° 06' 00"	E 31° 17' 00"	Residential area and facilities
9	Hozoom Alsha'ran	N39° 54' 00"	E 31° 04' 00"	Mountainous area
10	Alhamad (1)	N39° 54' 00"	E 31° 15' 00"	Flat Area
11	Alhamad (2)	N40° 03' 00"	E 31° 09' 00"	Flat Area
12	Ad Dadab	N41° 17' 00"	E 30° 50' 00"	Residential area and facilities
13	As Sulaymaniyah	N41° 09' 00"	E 30° 34' 00"	Residential area and facilities
14	Sehan Albehayrat	N39° 52' 00"	E 31° 38' 00"	Valley
15	She'eeb Alhilali	N41° 06' 00"	E 30° 47' 00"	Valley
16	Veidat Mersel	N41° 56' 00"	E 30° 46' 00"	Annual rain water swamp
17	Garat Alqat'a	N41° 47' 00"	E 30° 24' 00"	Mountainous area
18	Qa' Albardaweel	N41° 35' 00"	E 31° 01' 00"	Annual rain water swamp
19	Almojayles	N40° 01' 00"	E 31° 22' 00"	Mountainous area
20	Wadi Alobayed	N40° 40' 00"	E 31° 34' 00"	Valley
21	Wadi Badanh	N40° 37' 00"	E 31° 07' 00"	Valley
22	Wadi Shadi Hamer	N41° 08' 00"	E 31° 20' 00"	Valley
23	Wadi Ar'ar (1)	N40° 40' 00"	E 31° 34' 00"	Valley
24	Wadi Ar'ar (2)	N40° 02' 00"	E 31° 00' 00"	Valley
25	Wadi Algorabah	N40° 37' 00"	E 30° 55' 00"	Valley
26	Wadi Almera	N40° 22' 00"	E 31° 50' 00"	Valley

(*) and (**) Source: A Guide for Wild Trips' Enthusiasts in the Kingdom of Saudi Arabia, The Saudi Geological Survey, first edition, 2003.

Relative abundance data indicated that viperids are the most abundant (n=11, 40.74%), followed by Colubrids (n=7, 25.93%), Psammophiids (n=6, 22.22%), and Elapids are the least common (n=3, 11.11%) of the total individuals recorded (Figure 2). At the species level, *Cerastes gasperettii* was the most encountered species with ten observations accounting for 37.04% of the total records, followed by *Spalerosophis diadema cliffordi* with six observations 22.22%, while *Lytorhynchus kennedyi* and *Echis coloratus* were the least observed species with one observation for each (3.70% for each species).

Five out of the total observed species were identified as venomous snakes. These include the two viper species of *Cerastes gasperettii* (Leviton and Anderson, 1967), and *Echis coloratus* (Günther, 1878), two species of Psammophiidae, *Psammophis schokari* (Forskål, 1775), *Rhagerhis moilensis* (Reuss, 1834), and one species of the elapid Snake, *Walterinnesia aegyptia* **(**Lataste, 1887**).**

Taxonomic Account

Family Colubridae

Lytorhynchus kennedyi Schmidt, 1939

Common name: Kennedy's Leafnose Snake**,** (Figure 3A)

Material examined: HUM1001, Wadi Almera, 21.6.2021.

Remarks: This species was originally described from the area between Homs and

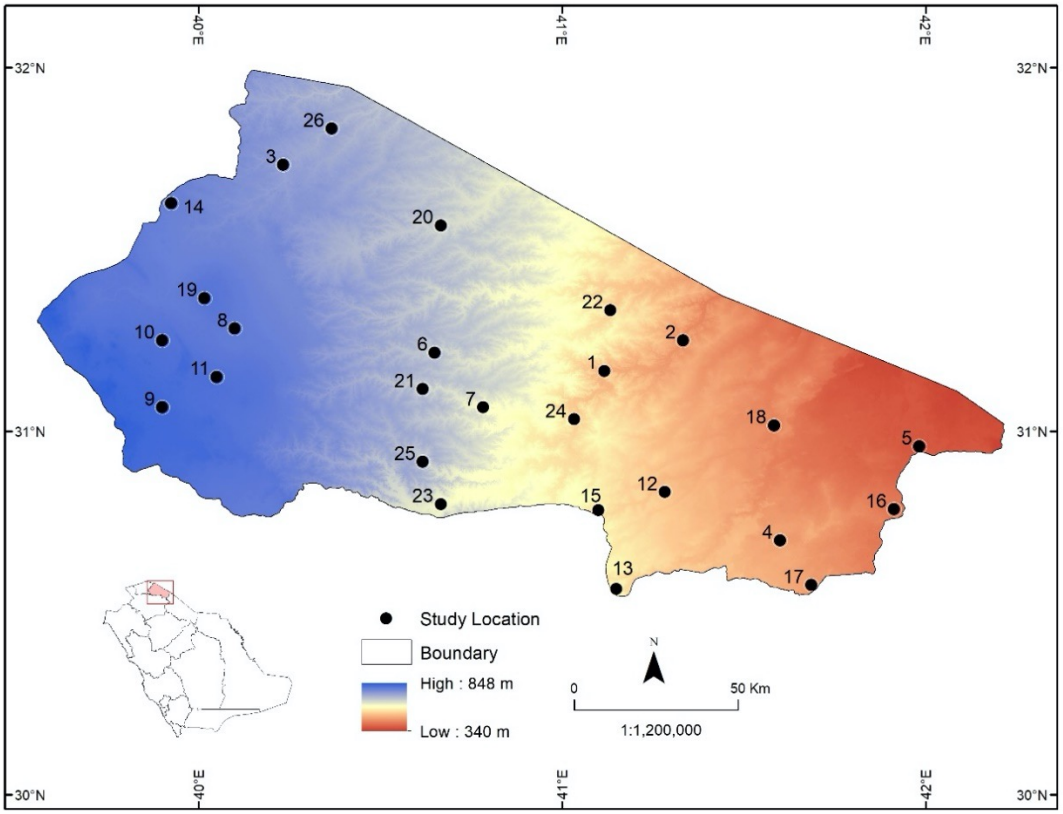


Figure 1. The outline map of the Arabian Peninsula presenting the Kingdom of Saudi Arabia region of Ar'ar and the location covered by this study (dotted map). The numbering of the localities corresponds to the numbering in Table 1.

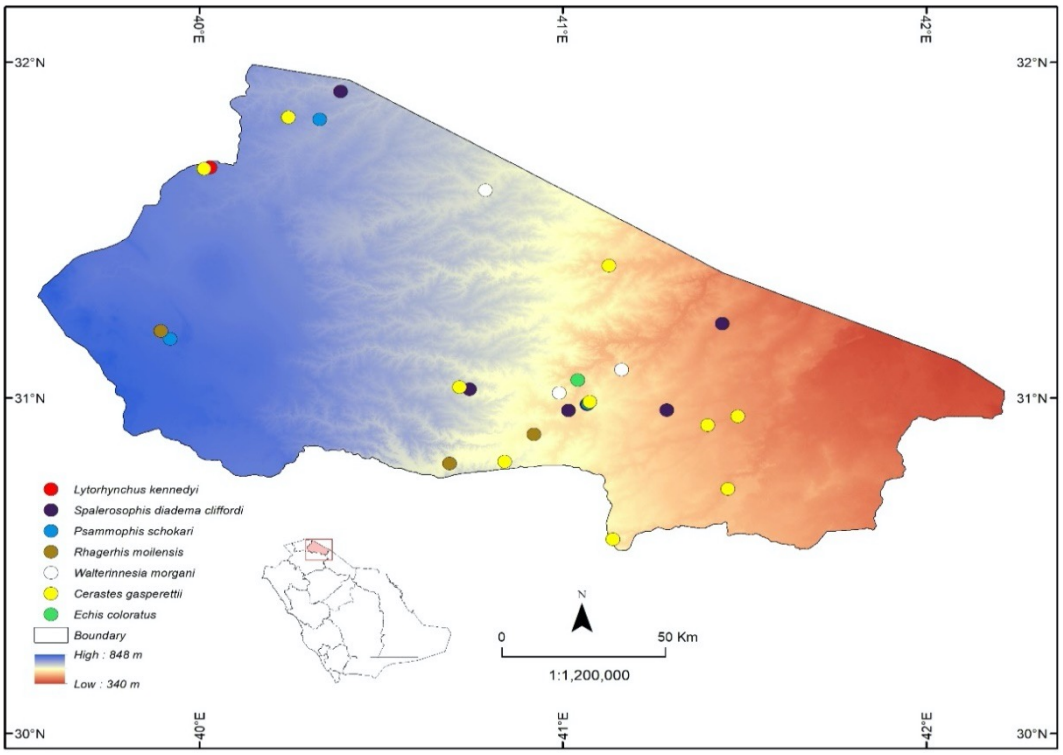


Figure 2. Locations of snakes from the Ar'ar region. The colored circles indicate the different species.

Palmyra, Syria (Schmidt, 1939). Its current distribution is confined to Jordan, Iraq, and Syria. This species is distributed over thr region from Jordan through the center and northeast of Syria extending to the west of Iraq (Sindaco *et al*., 2013). A single specimen of *L. kenneddyi* was collected from Wadi Almera, north of Hazm Aljalameed Center near the Saudi-Iraqi border (Alshammari, 2021).

Spalerosophis diadema cliffordi Schlegel, 1837

Common name: Diadem Snake (Figure 3B)

Material examined: HUM1002, Almansorieah Garden (Ar'ar city), 02.4.2019. HUM1003, East of Jedaidat Ar'ar border center, 15.5.2021.

Observed: Arar Public Park, on 13.6.2019. North of the Aldaidab Village, on 22.8.2019. North of Wadi Almera, on 5.4.2020. South of the Ebn Sa'aied village, on 19.5.2021.

Remarks: The Clifford's Diadem Snake is commonly distributed throughout the Arabian Peninsula and is reported from the central, eastern, western regions (Gasperetti, 1988, Aloufi *et.al*., 2021) and Ha'il Province (Alshammari and Busais, 2020). It was recorded in Ar'ar from Badanah (Gaspertti, 1988). It seems to be a common species in the Ar'ar region. Six specimens of this class of snakes were collected from the studied region which includes open areas with scant vegetation; they were also spotted close to the city's public parks.

Family Psammophiidae

Psammophis schokari Forskål, 1775

Common name: Schokari Sand Racer (Figure 3C)

Materials examined: HUM1004, North of the Hozoom Alsha'ran, 14.5.2020.

Observed: Almansorieah Garden (Ar'ar city), 2.4.2019. Wadi Almera, 15.7.2020.

Remarks: Three specimens of *P. schokari* were collected from three areas with different altitudes. The distribution of this species ranges from northwestern Africa to northern Somalia and spreads across the Arabian Peninsula to the northwest of India. It is common in Saudi Arabia (Corkill and Cochrane, 1965; Farag and Banaja, 1980; Gasperetti, 1988; Schätti and Gasperetti, 1994; Al-Sadoon, 2010; Ashammari *et al.,* 2017).

Rhagerhis moilensis Reuss, 1834

Common name: Moila Snake (Figure 3D)

Materials examined: HUM1005, Ar'ar Cattle market, 6.6.2020.

Observed: Wadi Arar Dam, Sakaka Road, 11.4.2021. Alhamad (1), 22.5.2019.

Remarks: This species was previously recorded from the south of Hijrat Manahi Bin Bakar **(**Gasperetti, 1988). From the study area, three specimens of the Moila snake were recorded. This species lives in sandy desert environments and grassy plains. Throughout Saudi Arabia, the accounts of this class of snake show that they are commonly dotted (Gaspertti, 1988; Schatti and Gaspertti, 1994; Al-Sadoon, 2010; Sendaco *et al.,* 2013; Alshammari and Busais,2020).

Family Elapidae

Walterinnesia aegyptia Lataste, 1887

Common name: Desert Cobra (Figure 3E)

Materials examined: HUM1006, Abar Alowaysi, 7.9.2020.

Observed: Wadi Alobayed, 11.8.2020. Sha'eeb Hilal, 2.8.2019.

Remarks: *Walterinnesia aegyptia* is distributed over the northeastern parts of Saudi Arabia, Syria, southeast of Turkey, Iraq, and southwest of Iran (Sindaco *et al.,* 2013). Al-Sadoon *et al.* (2017) reported this species from the Turaif region. Furthermore, it is re-

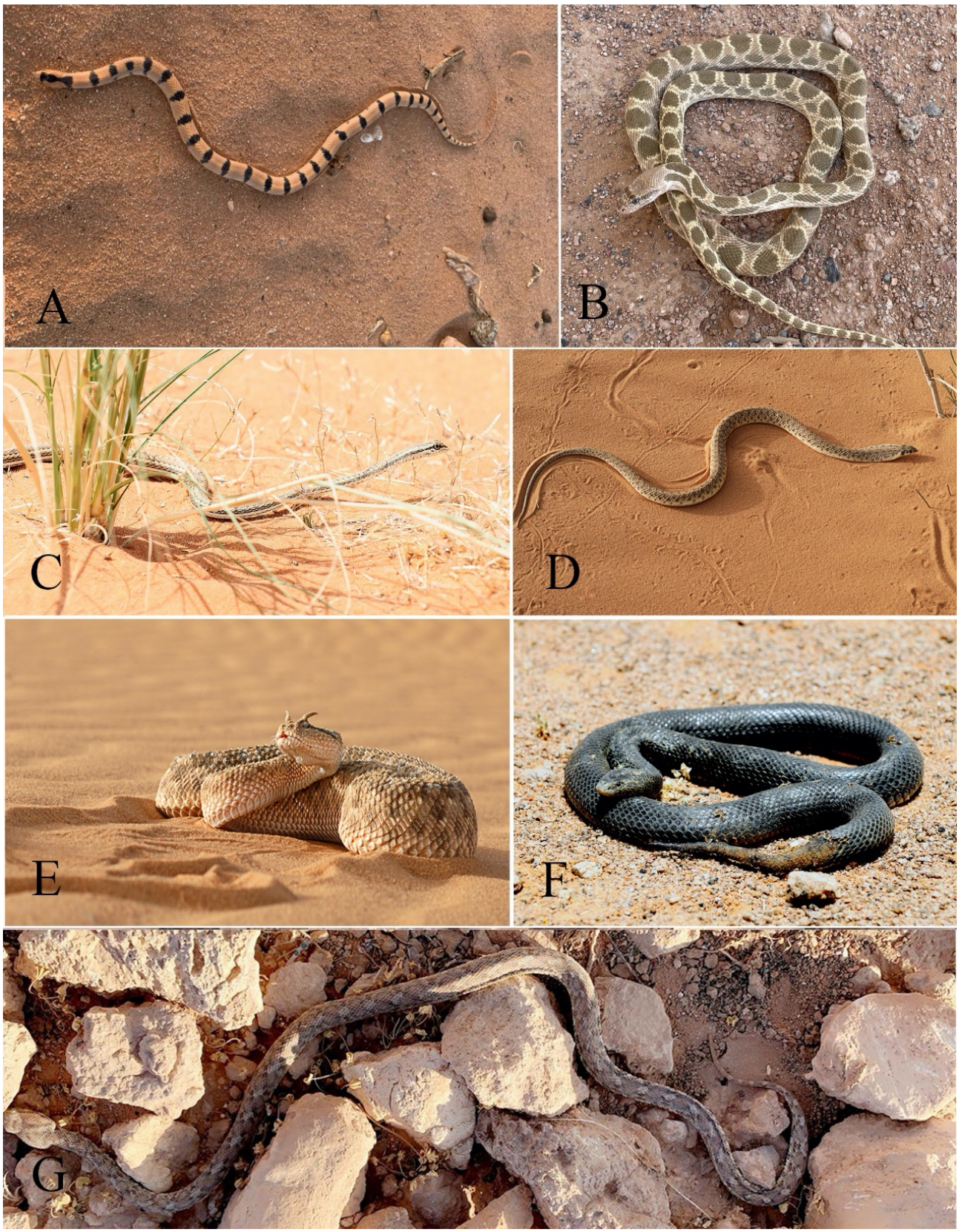


Figure 3. Snakes from the Region of Ar'ar, North Border Province, Saudi Arabia. **A** *Lytorhynchus kennedyi*. **B**. *Spalerosophis diadema cliffordi* **C**. *Psammophis schokari* **D**. *Rhagerhis moilensis* **E**. *Cerastes gasperettii* **F.** *Walterinnesia aegyptia* **G**. *Echis coloratus.*

ported from Ha'il (Alshammari and Busais, 2020). Three specimens were collected from rocky valleys and open areas close to herders of cattle, sheep, and camels. It is considered as one of the most venomous snakes.

Family Viperidae

Cerastes gasperetti (Leviton & Anderson, 1967)

Common name: Arabian Horned Viper (Figure 3F)

Materials examined: HUM1007, North of the Alsuliamainh Village, 22.9.2020. HUM1008, south of Almesa'deah farm, 22.5.2021. HUM1009, 25 km Arar Sakaka Road, 27.6.2019. HUM1010, North of the Aldaidab Village, 15.9.2019.

Observed: Almansorieah Garden (Ar'ar city), 28.6.2019. Wadi Shadi Hamer, 4.4.2021. Wadi Almera, 2.8.2021. South of the Ebn Sa'aied village, 20.5.2021. Northwest of Wadi Sehan Albehairat, 8.8.2020. Southwest Qa' Alberdweel, 26.8.2021.

Remarks: This is the most common viper to be found insand habitats in the Arabian Peninsula. Ten specimens of the Arabian Horned Viper were collected during this study. Some specimens were observed hiding themselves in the sand. *Cerastes gasperettii* can be spotted in the Arabian Peninsula, Iraq, Jordan, and to the west of Iran (Amr and Disi, 2011; Schätti and Gasperetti, 1994; Sindaco *et al*., 2013). This species was previously recorded in Ar'ar from Badanah (Gaspertti, 1988).

Echis coloratus (Gunther, 1878)

Common name: Palestine Saw-scaled Viper (Figure 3G)

Materials examined: HUM1011, Wadi Ar'ar (N Ar'ar city), 22.9.2020.

Remarks: One specimen was collected from rocky and sandy regions. In the Kingdom of Saudi Arabia, this species is very aggressive, and it is considered as one of the most dangerous venomous snakes (Busais, 2019). It has been reported from the Tabuk region (Aloufi and Amr, 2015), Turaif region (Alsadoon *et.al*, 2017), and Ha'il region (Alshammari and Busais 2020).

Discussion

Despite the diversity of the reptiles of the Kingdom of Saudi Arabia, snakes occupy habitats within different ecological regions that are commensurate with their environmental requirements. Many studies have been conducted on the Kingdom's snakes across different regions; however, the snakes of the Ar'ar region of the northern border of the Kingdom have not been studied before. The results of this study are consistent with the results of other studies in northern Saudi Arabia (Al-Sadoon *et.al,* 2017; Aloufi and Amr, 2015), or other regions through the reports of several authors such as Faraj and Banaja (1980), Al-Sadoon (2010), Masoud (2012), Masood and Asiry (2012), Sindaco *et al.* (2013), Alshammari and Ibrahim (2015), Alshammari *et al.* (2017), Aloufi and Amr (2015) and, Alshammari and Busais (2020). This report presents different types of species such as, *E. coloratus*, *W. aegyptia*, *P. schokari*, *Rhagerhis moilensis*, *Cerastes gasperettii*, and *Spalerosophis diadema cliffordi*. It confirms the surveys conducted by Al-Sadoon *et al.* (2017) in Tarif, and Aloufi and Amr (2015) in Tabuk. However, in this study, a new species of snake was recorded in the Arabian Peninsula *Lytorhynchus kennedyi* (Alshammari, 2021), with three species of snakes namely as *P. schokari*, *W. aegyptia* and *E. coloratus* as new records from the Ar'ar region.

The current study is the first to investigate a the wide range of snakes in the Ar'ar region, on the northern borders of the Kingdom of Saudi Arabia. According to the survey conducted during the study period, seven species of snakes that belong to four different families (Viperidae, Colubridae, Psammophiidae and Elapidae) were recorded. The distribution of these species varies in relation to abundance and habitat. The most abundant families

recorded by the current study's survey include Psammophiidae, Colubridae, and Viperidae with two species for each family. On the other hand, the study recorded only one species of the family Elapidae. However, three species of snakes that belong to the family Colubridae and two species that belong to the Colubridae family were recorded. Moreover, the families Viperidae and Psammophiidae were recorded by Al-Sadoon *et al.* (2017). The current survey shows that four species of snakes were recorded for the first time in the Arar region in the Kingdom of Saudi Arabia. The present study also reports the first record of Kennedy's Leafnose Snake from the Arabian Peninsula. In conclusion, as this is the first faunal reptile investigation of the Ar'ar region of Saudi Arabia, further rigorous surveys sampling different seasons are recommended to increase the number of the species records from the northern border regions of Saudi Arabia.

Acknowledgement

I would like to thank Mr. Hammoud Al-Anazi for preparing the map. I would also like to thank Abdulaziz Abdullah Al-Salman and Othman Muhammad Al-Omar for their assistance in fieldwork.

References

Aloufi, AA, Amr, Z S and Abu Baker, MA. 2021. Reptiles and Amphibians of Al Madinah Al Munawwarh Province, Saudi Arabia. *Russian Journal of Herpetology*, **28** (3): 123-137.

Aloufi, AA and Amr, ZS. 2015. On the herpetofauna of the Province of Tabuk, northwest Saudi Arabia (Amphibia, Reptilia). *Herpetozoa,* **27** (3/4): 147–158.

Al-Sadoon, MK. 1988. Survey of the reptilian fauna of the Kingdom of Saudi Arabia. II. The lizard and amphisbaenian fauna of Riyadh Province. *Bull. Maryland Herpetological Society*, **24**: 58–76.

Al-Sadoon, MK. 2010. Survey of the reptilian fauna of the kingdom of Saudi Arabia IV. The lizards, snakes and amphisbaenian fauna of Al-Hassa Region. *Journal of the Egyptian-German Society of Zoology,* **61B**: 59–85.

Al-Sadoon, MK, Paray, BA and Al-Otaibi, H. 2017. Survey of the reptilian fauna of the kingdom of Saudi Arabia VI. The snake fauna of Turaif Region. *Saudi Journal of Biological Sciences*, **24**: 925–928.

Alshammari, AM. 2021. First record of Kennedy's Leafnose Snake, Lytorhynchus kennedyi (Squamata: Colubridae), for Saudi Arabia. *Herpetology Notes,* 14:1273-1275.

Alshammari, AM. 2012. Additional records of lizards in Ha'il Province, Saudi Arabia. *Russian Journal of Herpetology*, 19: 287–291.

Alshammari, AM and Busais, S M. 2020. Distribution of Snakes in Ha'il Province, Saudi Arabia, with an identification key to the species. *Russian Journal of Herpetology*, 27(1): 5 – 10.

Alshammari, AM and Ibrahim, AA. 2015. Lizards and Snakes in the historical Faid Protected Area (Faid Hema), Ha'il region, Saudi Arabia. *Herpetological Conservation and Biollogy*, **10**: 1021-1029.

Alshammari, AM, Busais, SM and Ibrahim, AA. 2017. Snakes in the Province of Ha'il, Kingdom of Saudi Arabia, including two new records. *Herpetozoa*, **30**: 59-63.

Amr, ZS and Disi, A. 2011. Systematics, distribution and ecology of the snakes of Jordan. *Vertebrate Zoology*, **61**: 179-266.

Arnold, EN. 1986. A key and annotated checklist to the Lizards and Amphisbaenians of Arabia. *Fauna Saudi Arabia,* 8: 385–435.

Busais, S. A. 2019. **Vipers and Serpents in Jazan, Saudi Arabia**, Jazan Press, Saudi Arabia, 108 pp

Corkill, N. and Cochrane, J. 1965. The snakes

of the Arabian Peninsula and Socotra. *The Journal of the Bombay Natural History Society*, **62**(3): 475 – 506.

Farag, AA and Banaja, AA. 1980. Amphibians and reptiles from the western region of Saudi Arabia. *Bulletin Science King Abdel Aziz University*, **4**: 5–29.

Gasperetti, J. 1988. The snakes of Arabia. Fauna Saudi Arabia, **9:** 169–450.

Hussein, MF. 1966. On the reptiles of Riyadh and its surroundings in Saudi Arabia. In: *5th Arab Science Congress*. Baghdad. p. 479–485.

Mandaviile, JP. 1967. The Hooded *Malpolon moilensis* reuss and notes on other snakes of North-Eastern Arabia. *The Journal of the Bombay Natural History Society,* **64**(1): 115–117.

Masood, MF. 2012. Ecological distribution of snakes' fauna of Jazan region of Saudi Arabia. *Egyptian Academic Journal of Biological Sciences*, **4**(1): 183–197.

Masood, MF and Asiry, AA. 2012. Ecological studies on diversity of herpetofauna in Asir region, Kingdom of Saudi Arabia. *Egyptian Academic Journal of Biological Sciences,* **4**(1): 143–163.

National Center for Meteorology. 2022. https://ncm.gov.sa/ar/Pages/default.aspx.

Schätti, B and Gasperetti, J. 1994. A contribution to the herpetofauna of Southwest Arabia. *Fauna of Saudi Arabia*, **14**: 384-423.

Schmidt, KP. 1939. Reptiles and amphibians from Southerwestern Asia. *Field Museum of Natural History, zoology series*, **24:** 49-92.

Sindaco, R, Venchi, A and Grieco, C. 2013. *The Reptiles of the Western Palearctic. Vol. 2. Annotated Checklist and Distributional Atlas of the Snakes of Europe, North Africa, Middle East and Central Asia*, Edizioni Belvedere, Latina, Italy.

Jordan Journal of Natural History, 9 (1), 2022 pages: 49-54

A Possible Case of Hypopigmentation in the Southern Spotted Skunk (*Spilogale angustifrons celeris* Hall, 1938)

José Manuel Mora[1*] and Inés Azofeifa[2]

[1]Carrera de Gestión Ecoturística, Sede Central, Universidad Técnica Nacional, Alajuela, [2]Maestría en Desarrollo Sostenible, Sede de Occidente, Universidad de Costa Rica, San Ramón, Costa Rica.

Received: February 26, 2022; Accepted: April 22, 2022

Abstract: Several chromatic anomalies have been reported in Neotropical mammals including hypopigmentation. This abnormality is a genetic mutation affecting melanin biosynthesis, pigment granule trafficking, or membrane sorting which results in insufficiently pigmented indviduals. The southern spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) inhabits the areas from the mountains of Nicaragua to central Costa Rica. An individual of this species, which was found dead in northwestern Costa Rica, exhibited brown reddish discolored parts on its coat instead of black, which appeared to be a case of hypopigmentation. This is the first case of a chromatic disorder reported in the southern spotted skunk within the whole natural distribution range of this species. There are only few cases of chromatic aberrations reported in the mammals of Costa Rica.

Keywords: Anthropic impacts; carnivore; Costa Rica; chromatic disorder; mammal.

Introduction

Color disorders are pigmentation anomalies that cause abnormal discoloration of the skin and its derivatives of vertebrates (Lucati and López-Baucells, 2017). There are several types of chromatic abnormalities including some that have been reported in different groups of vertebrates including mammals (McCardle, 2012). Chromatic disorders can be genetic or environmental (Lucati and López-Baucells, 2017). However, there is still no uniform criteria to determine or even name these anomalies. Despite this, several efforts have been made in these directions; there are excellent publications defining color disorders in snakes (Borteiro *et al*., 2021), birds (van Grouw, 2013; Mahabal *et al*., 2017), and mammals (Abreu *et al*., 2013; Lucati and López-Baucells, 2017; Mahabal *et al.,* 2019). In the Neotropics, chromatic anomalies have been reported in several orders of mammals, and there have been several publications with reports of cases in different groups, mostly bats (Chiroptera); such cases included albinism, leucism, and piebaldism (Abreu *et al.,* 2013; Mello *et al.*, 2016).

One of the chromatic aberrations that have been identified in mammals is hypopigmentation. It is an anomaly that includes or is equivalent to instances of erythrism, flavism, rufism, silvering and tawny (Lucati and López-Baucells, 2017), depending on the case. Hypomelanism is a similar condition sometimes classified under hypopigmentation and consists of an inherited disorder resulting in beige, golden, yellowish, or reddish individuals with insufficiently pigmented skin (Červený, 1980; Zamolo *et al.,* 2013). Perhaps a more exhaustive classification is needed for mammals such as those proposed for other tetrapods. However, for the time being, those color disorders, implying mutations and affecting melanin biosynthesis, pigment granule trafficking, or membrane sorting, should be called hypopigmentation (Lucati and López-Baucells, 2017; Mello *et al*., 2016).

The southern spotted skunk (*Spilogale angustifrons* Howell, 1902) is distributed across the areas from southern Mexico to Costa Rica, which are elevated up to 3000 m (Reid, 2009). The subspecies *Spilogale angustifrons celeris* (Hall, 1938) inhabits the areas extending from the mountains of Nicaragua to central Costa Rica (Dragoo,

*Corresponding author: jomora@pdx.edu

2009). It is mainly found in forested habitats in the northern section of the country (Dragoo, 2009). This species also uses varied habitats ranging from grasslands to rainforests, including rocky terrains, pine forests, dense scrubs, and farmlands (Reid, 2009). This skunk has a head-body length of 210-240 mm, and the tail is 101-145mm. It weighs 240-533g with males being slightly larger than females (Dragoo, 2009). The southern spotted skunk is black with a complex pattern of white stripes and spots (Reid, 2009). It has a white patch between the eyes and on the last third of its tail (Dragoo, 2009). *Spilogale angustifrons* is a species recognized a few years ago, therefore, little is known about its conservation status. It is thought to be common in some areas, but in Costa Rica it is rare and is protected under the list of species with reduced or threatened populations (SINAC, 2017). In fact, it is classified as Least Concern (LC) by the IUCN Red List (Helgen *et al.,* 2016).

Materials and Methods

Anthropic impacts on wildlife such as road killings and electrocutions have been investigated by researchers. One of the roads under study is Route 159, a paved road that runs between Playa Panamá and Playa Hermosa at Sardinal, Carrillo, Guanacaste in the Tropical dry Forest (TdF) of northwestern Costa Rica. The TdF as a life zone is characterized by its biotemperature (greater than 17°C), a potential evapotranspiration to a precipitation ratio of 1–2, and low rainfall (500– 2000 mm of precipitation a year) (Holdridge, 1967; Kalacska *et al.,* 2004). Rain is concentrated during the rainy season, and there are four to six months with basically no precipitation (Janzen, 1983). Normally, the TdF has less species than lowland wet forests, but it has more structural and physiological diversity in life forms (Kalacska *et al.,* 2004). The majority of the woody species are deciduous mainly due to the long dry season (Frankie *et al*., 1974). As a result, there is a mix of deciduous and evergreen species causing a phenological complexity not encountered in wet forests (Kalacska *et al.,* 2004). The study area at the sides of Route 159 is composed of secondary forests, pasturelands, open areas, and some buildings at about 200 m (Figure 1).

Results

A southern spotted skunk was found dead on Route 159 (10° 34’ 54.7” N, 85° 39’ 41.9” W; Figure 2) on May 6, 2021. The individual was an adult male with a head and body length of about 240 mm. Some parts of this individual exhibited a brown reddish coloration instead of black which appeared to be a case of hypopigmentation (Figure 2). Indeed, this is the first case of a chromatic disorder in the southern spotted skunk to be reported within the whole natural distribution range of this species.

Discussion

There are few reported cases of chromatic aberrations in the mammals of Costa Rica. In fact, only seven reports for bats: one albino, five leucistic, and one piebald (Mora and Sánchez, 2022) were found. There are also reports of melanism in jaguars (*Panthera onca*), jaguarundi (*Herpailurus yagouaroundi*), northern tiger cats (*Leopardus tigrinus oncilla*), margays (*Leopardus wiedii*) (Mooring *et al*., 2020) and a leucistic coyote (Arroyo-Arce *et al.,* 2019). However, several of these cases were wrongly diagnosed or named. Additionally, a rare case of color shifting from black to yellow has been reported in the howler monkey (*Alouatta palliata*) (Galván *et al.,* 2019). Even though hypopigmentation is a common phenomenon, no reports of the existence of this color disorder, or any other, were found for *Spilogale angustifrons* throughout its distribution range. In fact, hypopigmentation as such was not reported in any of the mammals of Costa Rica.

Pigmentation of the skin, hair, and the eyes is controlled by multiple alleles, and different alleles control the amount of pigmentation (Mc Cardle, 2012). Eumelanins are responsible

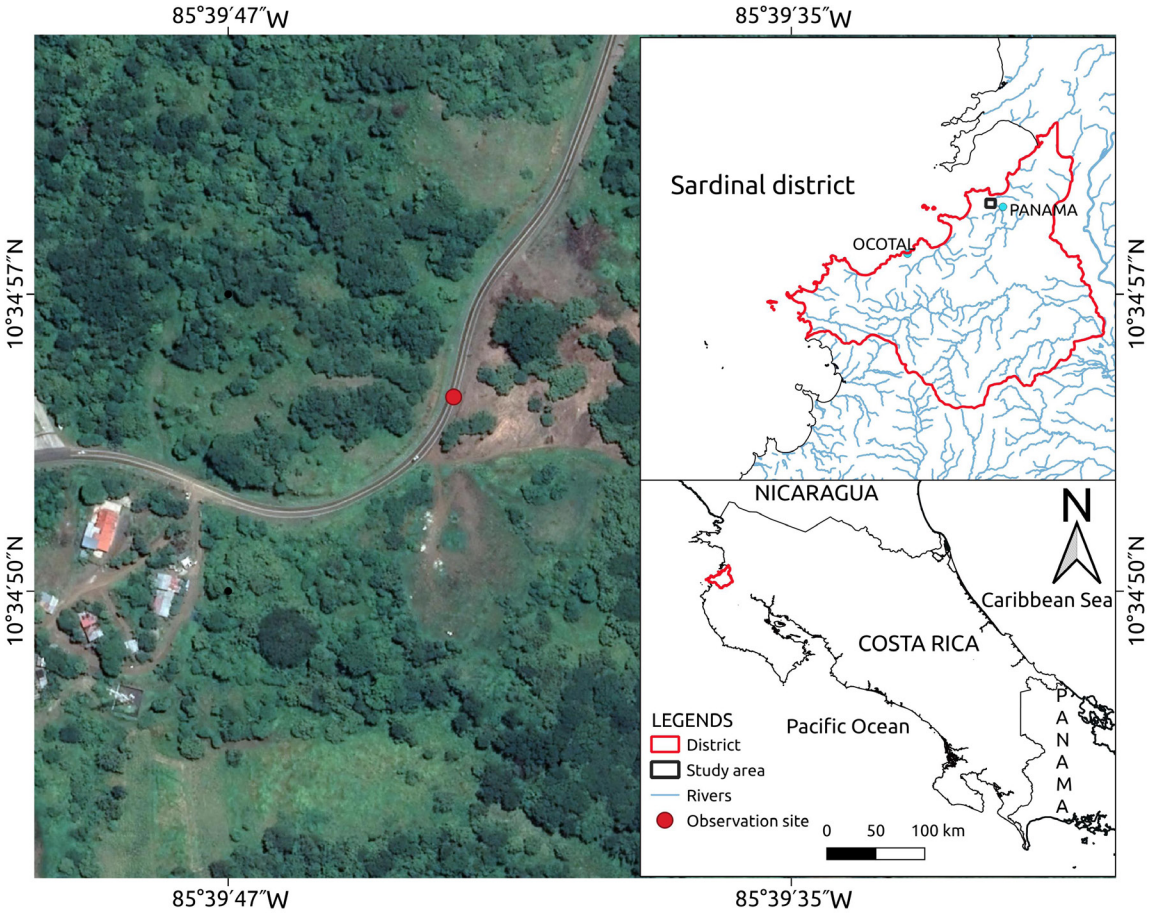


Figure 1. Point where a Southern Spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) was found dead on Route 159, Sardinal, Carrillo, Guanacaste, Costa Rica. Figure by G. Chaves (Cachí).

Figure 2. A Southern Spotted skunk (*Spilogale angustifrons celeris* Hall, 1938) found dead on Route 159, Sardinal, Carrillo, Guanacaste, Costa Rica.

for black, grey, and dark brown pigments, while pheomelanins are responsible for warm reddish brown colors to pale buff including orange and yellow (Ito and Wakamatsu, 2003; van Grouw, 2021). With the exception of the white stripes, the pelage of the spotted skunk is pitch black, which is a consequence of the production and subsequent deposition of eumelanin in hairs (Ito and Wakamatsu, 2003). It was assumed that the dead skunk showed a major proportion of pheomelanin compared to eumelanin which normally colors individuals, or a lower concentration of eumelanin in its pelage at any case. At least in albino animals, phaeomelanin becomes affected first, and then eumelanin is reduced step by step (Acevedo *et al*., 2008). In Brown mutations (incompletely colored melanin), the number of eumelanin pigment granules is unchanged, but the pigment's color is altered due to incomplete synthesis (van Grouw, 2021). Brown has not been used to name color aberrations in mammals. In this abnormality, eumelanin is changed in color (qualitative reduction) due to incomplete melanin synthesis, but phaeomelanin is unaffected (van Grouw, 2021). The result is that the original black color becomes brown with the eyes and feet being slightly lighter than normal (van Grouw, 2021). It was not possible to note or compare this last condition in the dead skunk. Nevertheless, some relevant phenomena could be the case for the skunk reported here. An appropriated determination or diagnosis, other than hypopigmentation, is very difficult given the fact that breeding tests are impossible, nor was it possible for the researchers to conduct hair analyses. This is true for most wild animals, as a result, almost all aberrations can be identified only by appearance, or the phenotype of the individuals (van Grouw, 2021). However, one important point to be noted is that hypopigmentation can lead to poor vision, greater predation risk, lower mating success, and lower survival rates (Laikre *et al*., 1996; Caro, 2005). On the other hand, factors such as deforestation, low habitat quality, pollution, poor-quality diet, and hybridization events may be linked to pigmentation anomalies (Aximoff *et al*., 2020).

Chromatic aberrations are caused by either a deficiency or excess in melanin (Hofreiter and Schoneberg, 2010; Abreu *et al*., 2013). Although they have been reported in many mammals, they are relatively uncommon in these vertebrates. At least in part, this may be due to , the lack of interest in reporting these abnormalities in scientific journals. However, it is necessary to collect information on these cases as they could have been a consequence of some factors related to human activities (Galván *et al.,* 2019). Understanding the possible evolutionary costs or benefits derived from color disorders is essential to explain adaptations to the increasingly changing landscape (Bilandžija *et al*., 2013). Monitoring chromatic abnormalities in large-scale geographic studies may help identify populations exposed to environmental stress or inbreeding (Mc Cardle, 2012). Researchers should be encouraged to report records of chromatic abnormalities in wildlife to help achieve an understanding of this phenomenon and the insights behind the ecological and physiological implications of these conditions which may leave a significant impact on animal survival (Fertl *et al*., 2004; Samson *et al*., 2017). Records of chromatic disorders in wild animals are rare as the abnormal colored individuals are often more susceptible to predation and can be subject to immunological deficiencies (Sazima and Di-Bernardo, 1991; Aximoff *et al*., 2021).

Acknowledgments

The researchers thank G. Chaves (Cachí) for the elaboration of figure 1. JMM acknowledges Emilce Rivera, the GEC department head, UTN, for the continuous academic support.

References

Abreu, MSL, Machado, R, Barbieri, F, Freitas, NS and Oliveira, LR. 2013. Anomalous colour in Neotropical mammals: a review with new records for *Didelphis* sp. (Didelphidae, Didelphimorphia) and *Arctocephalus australis* (Otariidae, Carnivora). *Brazilian Journal of Biology,* **73(1)**: 185- 194.

Acevedo, J, Torres, D and Aguayo-Lobo, A. 2008. Rare piebald and partially leucistic Antarctic fur seals, *Arctocephalus gazella*, at Cape Shirreff, Livingston Island, Antarctica. *Polar Biology,* **32(1):** 41-45.

Arroyo-Arce, S, Corrales-Gutiérrez, D, Espinoza-Muñoz, D, Araya-Gamboa, D, Chávez-Ramos, M and Salom-Pérez, R. 2019. A leucistic female *Canis latrans* (Carnivora: Canidae) in Costa Rica. *Cuadernos de Investigación UNED*, **11 (3):** 451-454.

Aximoff, I, Zaluar, MT, Pissinatti, A, Bastos, PA, De Assis Morais, T, Rosa, CA and Vale MM. 2020. Anomalous pigmentation in invasive and native marmosets, *Callithrix jacchus*, *Callithrix penicillata* (Primates, Callitrichidae), and their hybrids in Brazil. *Folia Primatologica,* **91(2):**149-158.

Aximoff, IA, Hübel, M, Freitas, AC, Rosa, C and Caravaggi, A. 2021. Natural history notes on interactions and abnormal coloration in carnivores in the Araucaria forest, Southern Brazil. *Oecologia Australis*, **25(4)**: 862-870.

Bilandžija, H, Ma, L, Parkhurst, A and Jeffery, WR. 2013. A potential benefit of albinism in *Astyanax* cavefish: downregulation of the oca2 gene increases tyrosine and catecholamine levels as an alternative to melanin synthesis. *PLoS One*, **8**: e80823.

Borteiro, C, Abegg, AD, Oda, FH, Cardozo, D, Kolenc, F, Etchandy, I, Bisaiz, I, Prigioni, C and Baldo, D. 2021. Aberrant colourations in wild snakes: case study in Neotropical taxa and a review of terminology. *Salamandra*, **57(1):**124-138.

Caro, T. 2005. The adaptive significance of coloration in mammals. *BioScience*, **55(2)**: 125-136.

Červený, J. 1980. Abnormal coloration in bats (Chiroptera) of Czechoslovakia. *Nyctalus (N.F.)*, **1**: 193-202.

Dragoo, JW. 2009. Family Mephitidae (skunks). *In*: Wilson, DE and Mittermeier RA. (Eds), **Handbook of the Mammals of the World. Volume 1, Carnivores**. Lynx Edicions. Barcelona, Spain, Pp. 532-563.

Fertl, D, Barros, NB, Rowlett, RA, Estes, S and Richlen, M. 2004. An update on anomalously white cetaceans, including the first account for the pantropocal spotted dolphin (*Stenella attenuata graffmani*). *Latin American Journal of Aquatic Mammals*, **3(2)**: 163-166.

Frankie, GW, Baker, HG and Opler, PA. 1974. Comparative phenological studies of trees in tropical wet and dry forests in the lowlands of Costa Rica. *Journal of Ecology*, **62(3)**: 881-899.

Galván, I, Jorge, A, Sánchez-Murillo, F and Gutiérrez-Espeleta, G. 2019. A recent shift in the pigmentation phenotype of a wild Neotropical primate. *Mammalian Biology*, **94**: 66-68.

Helgen, K, Reid, F, Timm, R. 2016. *Spilogale angustifrons*. The IUCN red list of threatened species 2016. Available from: 10.2305/IUCN.UK.2016-1. RLTS.T136636A45221538.en

Hofreiter, M and Schoneberg, T. 2010. The genetc and evolutonary basis of colour variaton in vertebrates. Cellular and Molecular Life Sciences, **67(15)**: 2591-2603.

Holdridge, L. 1967. **Life Zone Ecology**. Tropical Science Center, San José, Costa Rica. 206 pp.

Ito, S and Wakamatsu, K. 2003. Quantitative

analysis of eumelanin and pheomelanin in humans, mice, and other animals: a comparative review. *Pigment Cell Melanoma Research*, **16(5)**: 523-531.

Janzen, DH. (Ed.). 1983. **Costa Rican Natural History**. University of Chicago Press, Chicago, USA. 816 pp.

Kalacska, M, Sanchez-Azofeifa, GA, Calvo-Alvarado, JC, Quesada, M, Rivard, B, and Jazen, DH. 2004. Species composition, similarity, and diversity in three successional stages of a seasonally dry tropical forest. *Forest Ecology and Management*, **200 (2004):** 227-247.

Laikre L, Andren, R, Larsson, H and Ryman, N. 1996. Inbreeding depression in brown bear *Ursus arctos*. *Biological Conservation*, **76 (1):** 69-72.

Lucati, F and López-Baucells, A. 2017. Chromatic disorders in bats: a review of pigmentation anomalies and the misuse of terms to describe them. *Mammalian Review*, **47 (2)**: 112-123.

Mahabal, A, van Grouw, H, Sharma, RM and Thakur, S. 2016. How common is albinism really? Colour aberratons in Indian birds reviewed. *Dutch Birding*, **38**: 301-309.

Mahabal, A, Sharma, RM, Patl, RN and Jadhav, S. 2019. Colour aberraton in Indian mammals: a review from 1886 to 2017. *Journal of Threatened Taxa*, **11(6)**:13690-13719.

McCardle, H. 2012. **Albinism in Wild Vertebrates**. Master Thesis. Texas State University. San Marcos, Texas, USA. 71 Pp.

Mello, LM, Corrêa, LLC and Oliveira, SV. 2016. Albinism in Molina's hog-nosed skunk, *Conepatus chinga* (Mammalia, Carnivora, Mephitidae). *Revista de Ciências Ambientais*, **10(2):** 157-161.

Mooring, MS, Eppert, AA and Botts, RT. 2020. Natural selection of melanism in Costa Rican jaguar and oncilla: A test of Gloger's rule and the temporal segregation hypothesis. *Tropical Conservation Science*, **13**: 1-15.

Mora, JM and Sánchez, R. 2022. First case of piebaldism in *Eumops auripendulus* in Costa Rica. Submitted to *Therya Notes*.

Reid, FA. 2009. **A Field Guide to the Mammals of Central America and Southeast Mexico**. Oxford University Press, New York, USA. 346 Pp.

Samson, A, Ramakrishnan, B and Bargavi, S. 2017. Leucism in the three-striped palm squirrel (*Funambulus palmarum*) at Gudalur Forest Division, Tamil Nadu, Southern India. *Thery*a, **8(3)**: 261-262.

Sazima, I and Di-Bernardo, M. 1991. Albinismo em serpentes neotropicais. *Memórias do Instituto Butantan*, **53**: 167-173.

SINAC. 2017. **Listado de Especies de Fauna Silvestre en Peligro de Extinción**. MINAE ALCANCE DIGITAL N° 239 a La Gaceta N° 187 de la fecha 03 10 2017 R- SINAC-CONAC-092-2017. San José, Costa Rica.

van Grouw, H. 2013. What colour is that bird? The causes and recognition of common colour aberrations in birds. *British Birds*, **106**:17-29.

van Grouw, H. 2021. What's in a name? Nomenclature for colour aberrations in birds reviewed. *Bulletin of the British Ornithologists' Club*, **141(3)**: 276-299.

Zamolo, A, Zidar, S, Mihelič, T and Kotnik, J. 2013. First record of a flavistic lesser horseshoe bat *Rhinolophus hipposideros* (Bechstein, 1800) in Slovenia. *Natura Sloveniae*, **15(1)**: 47-49.

Jordan Journal of Natural History, 9 (1), 2022 pages: 55-71

The Current Status and Population of the Threatened Bird Species in the Ahwar of Southern Iraq: Conservation and Management Approach

Mudhafar A. Salim

Arab Regional Centre for World Heritage. Manama, the Kingdom of Bahrain

Received: January 15, 2022; Revised March 25, 2022; Accepted: May 20, 2022

Abstract: The marshes of Southern Iraq, or 'Ahwar' are vast freshwater wetlands that extend over a fluctuated area of more than 2000 km^2 in southern Iraq. These wetlands consist of four major components (Huwaiza, West Hammar, Central Marshes, and East Hammar) each of which has its own environmental features and significance. The Ahwar has been selected as a World Heritage property in 2016 for its outstanding universal, cultural, and natural values (OUV) . One of the key attributes of the exceptional environmental value of this site is its unique spot containing various freshwater wetland habitats in the middle of an extremely hot and dry region housing a considerable number of birds some of which are threatened on the global level. The current study sheds light on the current status of fourteen globally threatened bird species found in the Ahwar region (breeding or non-breeding species). it also describes the habitats and the current conservation status of these bird species which include nine waterbirds, and five water-related bird species in addition to those found frequently around and within the Ahwar region. The latter group of birds mainly uses the buffer zones along with some dry extensions within the natural components of the Ahwar. In addition, the current research presents, for the first time , a recent population estimation of the migrant and resident bird species in the Ahwar area for the sake of establishing a baseline for their monitoring programs in the future. This work uses the latest version of the IUCN Red List (Version 3.1) for the categorizing of the conservation status of the studied birds. Also, the study provides an assessment on the regional level (Regional RedList Assessment) of the current status of the fourteen bird species that live inside and around the Ahwar. By presenting these bird species, for the first time, as a key component of the biodiversity of this region , by highlighting the major threats to their survival, and by estimating their numbers, and determining their spatial distribution, this paper hopes to contribute to prioritizing the conservation efforts of the bird species in the unique freshwater ecosystem of the Ahwar.

Keywords: Ahwar World Heritage property, Iraq, Iraqi Marshes, Threatened birds.

Introduction

Wetlands enrich biodiversity by providing a wide range of aquatic habitats for rich lists of flora and fauna species; however, the various human activities have resulted in the destruction and degradation of wetlands worldwide. In fact, a considerable number of key freshwater wetlands housing a lot of habitats and their species suffer from various types of threats (Moser *et.al.,* 1996). The marshes of Southern Iraq (called locally Ahwar), are vast freshwater bodies located in the lower Mesopotamian region within a depression formed at the northeastern parts of the Arabian plate close to the Iranian or Eurasian plate (Figure 1). During peak times in the 1970s, this area has covered around 15,000 to 20,000 square kilometers (IMoEN, 2014). These freshwater marshes are fed by the Euphrates and Tigris rivers and partly by rain at the northern parts (Kubba and Salim, 2011). The Ahwar area is currently divided into four major parts: Western Hammar, Eastern Hammar, the Central Marshes, and Al-Huwaiza Marshes. These four components

*Corresponding author: m.salim@arcwh.org

include different types of wetlands such as the open-water lakes, dense reed-beds, vast stripes of mudflats, in addition to the marsh margin habitats (Abdulhassan, *et.al*., 2009). This wide range of panoramic habitats has magnified the richness and significance of this area as a source of biodiversity (KBA) on the regional (Middle East) level. More importantly, this biodiversity helped recognize the Ahwar region as a Ramsar site on the global level (Scott, 1995). In addition to the significance of the Ahwar area in terms of biodiversity, this area has its own cultural richness being considered once as a central part of the cradle of civilizations on the global level (IMoEN, 2014).

One of the key factors which render the Ahwar region ecologically valuable is that it harbors twenty-five bird species categorized either as globally-threatened or near-threatened species (Salim, *et.al.,* 2021). These natural (four wetland marsh areas) and cultural (three archaeological sites) characteristics, among others , have clearly highlighted the outstanding Universal Value (OUV) of this area, and subsequently helped inscribe it as a mixed Serial World Heritage property in 2016 (IMoEN, 2014; Salim, *et.al*., 2021).

The habitats and landscape diversity of the Ahwar in addition to its vast area have all contributed to the significance of this area on the global level for quite a wide range of migrant and resident birds (Kubba and Salim, 2011). It provides an important and crucial ring in the migration routes of the waterfowl and water-related bird species between Eurasian and African regions (Scott and Carp, 1982 Salim, *et.al.,* 2006). A total of 197 species are considered as regular winter visitors or passage migrants from Europe and Asia and further twenty species are considered as rare visitors or vagrants (Salim, *et.al.,* 2021).

The Ahwar area has suffered from serious threats which affected its attributes as a whole in many different ways (Becker, 2014, Al-Yamani, *et.al*., 2007). The current research assesses the current status of the threatened birds in the Ahwar following the mechanism of the Red List assessment of the species (see the paragraph below). It investigates the different factors facing the threatened birds and their habitats and sheds light on the proposed solutions that have been listed in the recommendations below for the sake of contributing to the effectiveness of the management of this significant area.

The IUCN Red List Categories and Criteria are considered as a useful tool for categorizing the different levels of species worldwide based on the threats they are facing (IUCN, 2021). The Red List is a good practical tool

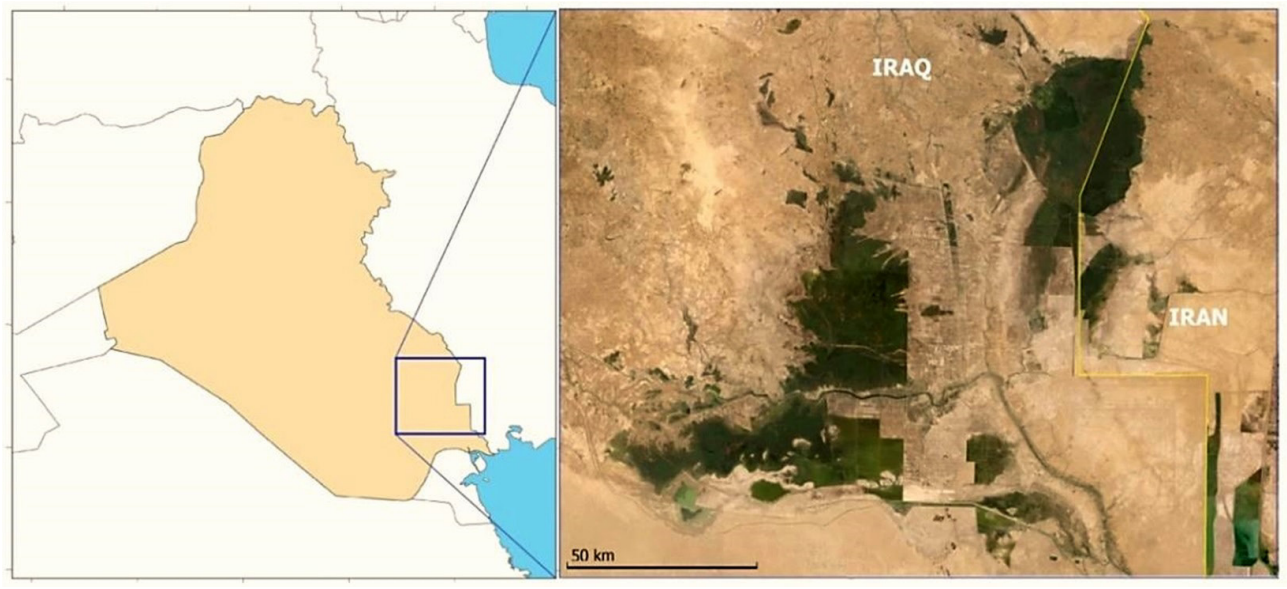


Figure 1. A regional map showing the location of the Ahwar in southern Iraq (left); a general view of southern Iraq's marshes (right).

for dealing with the conservation efforts in a protected area on the national, regional, and global levels. It consists of nine categories: Not Evaluated, Data Deficient, Least Concern, Near-threatened, Vulnerable, Endangered, Critically-endangered, Extinct in the Wild, and Extent. Among the different levels (categories) of the Red List, the current paper covers the 'Threatened Species' only. Figure 3 shows the different categories of the IUCN Red List and the specific categories used by the current paper.

Materials and Methods

The spatial scope of the current study covers the entire four components of the Ahwar in southern Iraq: Huwaiza, Central Marshes, East Hammar, and West Hammar. These four natural components are situated within the three Governorates of southern Iraq: Basra, Missan, and Thi-Qar around the central coordinate (31° 6' 14.00" N, 47° 13' 8.00" E) (Figure 2). Different habitats located in the abovementioned components were visited at different times in order to have the best coverage of the bird species that represent the birds communities in these areas. In addition to the previous surveys that were carried out by various technical teams of the Ministry of Environment and other NGOs over the period 2005-2012, seven surveys were planned and conducted by the author (as part of IOCN's national surveys scheme) targeting the four components of the Ahwar starting after 2012 until 2021; the IOCN surveys have continued beyond this date. The surveys have targeted different habitats inside the Ahwar in addition to the margins of the survey area for the sake of having the

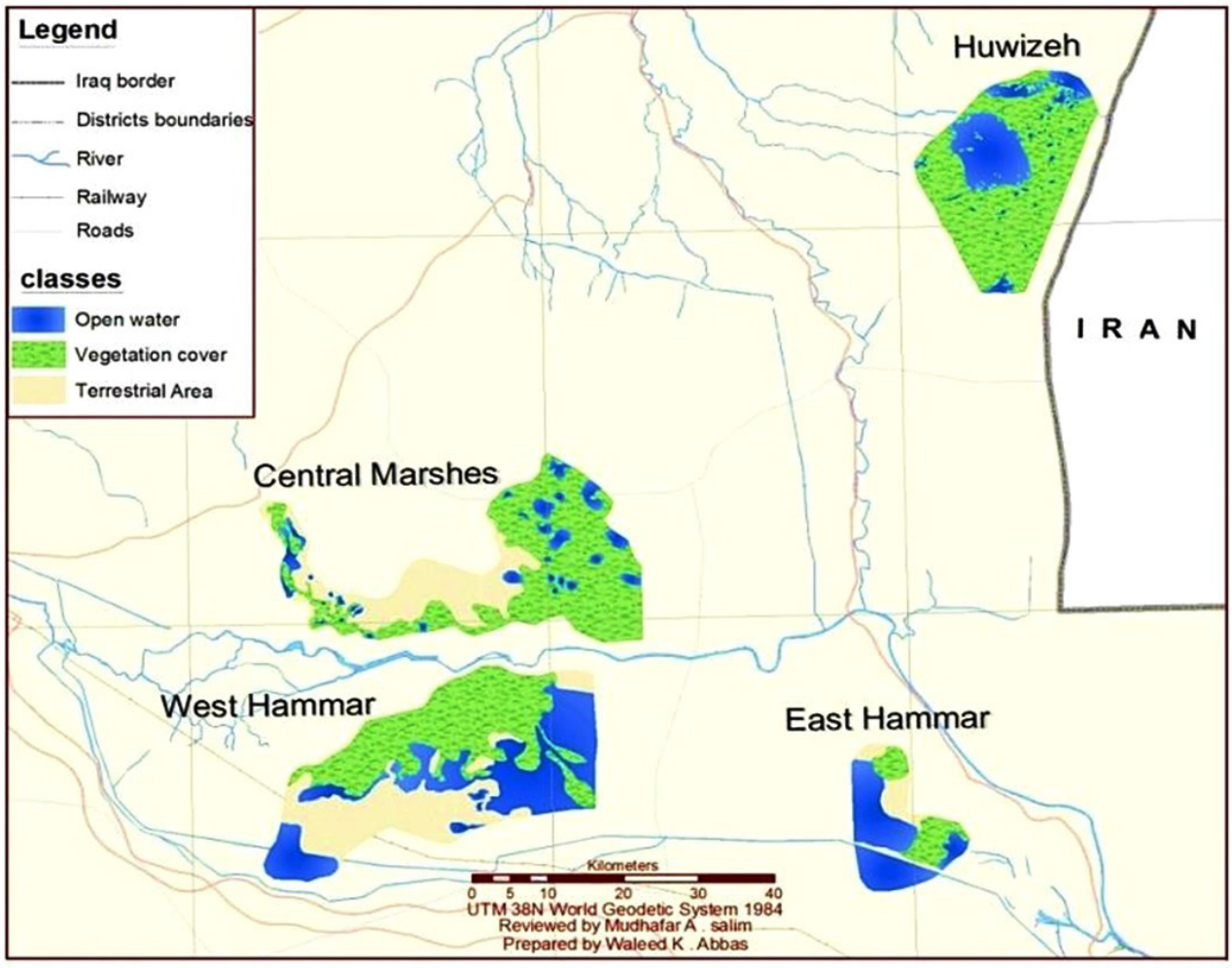


Figure 2. The map shows the study area that includes the four natural components of Ahwar World Heritage property. The map also shows the types and distribution of the different habitats within the four components. (Source of the map: MoEN).

points of these surveys distributed as far as possible.

The surveys were conducted across different seasons (all four seasons included) for each component in order to have a better coverage of the movements of the birds in the Ahwar. Summer surveys were dedicated for the breeding bird species, and the fall and spring surveys were dedicated for the migrant birds, while the winter surveys targeted wintering bird species, mainly waterfowls. Area-count methodology was used during the surveys in order to cover as many areas as possible, in addition, some transect surveys were done at specific habitats, mainly in the areas of Huwaiza, East Hammar, and West Hammar.

The counting of birds was conducted either by direct observation during the surveys, or in most cases by estimating the population by extrapolating the numbers for each species observed at the suitable habitat. The areas of unsuitable habitats i.e., polluted habitats or those that suffer from frequent disturbance have been excluded from the extrapolation process. The suitable habitats' areas have been elaborated based on direct field observations, the author's experience in the Ahwar (taking into consideration the seasonal variation), and by consulting recent satellite images.

The latest version of the IUCN Red List (Version 3.1) has been adopted for the categorizing of the conservation status of the birds in the current paper. Only threatened bird species were tackled in this paper for their important conservation status and to assist the management to take specific action on the ground. The figure below (Figure 3) shows the scope in this paper which involves only the Critically Endangered, Endangered, and Vulnerable bird species that live inside and around the Ahwar.

In order to highlight the specific conditions and the current status of each targeted species, this paper has briefly described the current distribution and the status of these species within the Ahwar as well as the description of their habitats. The current study also briefly describes the current conservation status of each of the twenty-two bird species which have been assessed on the regional level (Regional Assessment) and which live inside and around the Ahwar (IUCN & ARC-WH, 2013). In addition to the results of the field observations, the "Field Guide to the Birds of Iraq" was used to describe the status

Figure 3. the scope of bird species investigated in the current paper according to the different IUCN Red List Categories.

of the birds in Iraq along with the description of their habitats (Salim, et.al., 2006).

Results

The Globally-threatened Bird Species in the Ahwar

The birds accounts below represent those species that have been globally assessed by the IUCN RedList as 'Threatened' species. These bird species include true waterbirds and those that can be found close to the marshes and are dependent on these wetlands either for foraging or roosting.
The estimated population of each species represents the numbers of the individuals or breeding pairs in the Ahwar area.

The White-headed Duck

Oxyura leucocephala. This Endangered duck species winters in the four components of the Ahwar in quite few numbers. They can be mixed with other diving duck species. This species prefers open water surfaces, both, in brackish and fresh waters.
The estimated population of the wintering individuals ranges from 50 to 100 ducks annually but not on a regular basis. Key threats: Habitat destruction (shortage of water), poaching, and disturbance.

Steppe Eagle

Aquila nipalensis. This Endangered species is one of the common raptors found during the migration season soaring over the Ahwar sky, mainly close the edges, but can rarely be found over the depths of the Ahwar. Part of the migrant population remains in the Ahwar area during winter.

The estimated wintering and passing population of this species within the Ahwar area ranges from about 200 to 550 individuals. Key threats: Poaching, electrocution by power lines, and disturbance.

Basra Reed-warbler

Acrocephalus griseldis. This Endangered species is a common breeding summer visitor to the Ahwar. Its nests can be found within the reed-stalks in the water, with more concentration in the shallow areas and those reed-beds close to the margins of the Ahwar. The Ahwar is considered as the most important breeding grounds for this endangered species on the global and national levels (Kubba and Salim, 2011). The estimated breeding pairs ranges nearly from 4,500 to7,000 in the Ahwar region.
Key threats: Habitat destruction (mainly reed-cutting), and disturbance.

Acrocephalus griseldis in the Marshes of Southern Iraq ©Mudhafar Salim.

Lesser White-fronted Goose

Anser erythropus. This Vulnerable goose is an uncommon winter visitor of the seasonal marshes east of the river Tigris, and few of this species winter at other marshes and wetlands in Iraq. This species might be found in quite few numbers in the Huwaiza component, with less possibility of appearance in the other three components. The estimated population of the wintering

birds in the Ahwar's four components ranges from 80 to150 individuals mixed with other goose species including the Graylag Goose and the white-fronted Goose.
Key threats: Poaching, habitat destruction, and disturbance.

Common Pochard

Aythya ferina. This Vulnerable diving duck is an uncommon winter visitor of the marshes of southern Iraq and other waterbodies. It is usually seen in few numbers mixed with other diving duck species or Coot flocks. This species prefers the open and relatively deep waterbodies. The estimated population of the wintering birds in the Ahwar ranges from 400 to 800 individuals.
Key threats: Poaching, habitat destruction, and disturbance.

Red-breasted Goose

Branta ruficollis. This Vulnerable species can be found in the marshes in quite few numbers, however, old observations were higher than the current observation (Salim, *et.al*., 2009). The wintering population of this species is concentrated in the wetlands of northern Iraq. The estimated population of the wintering birds in the Ahwar ranges between 20 and 50 individuals mixed with other goose and duck species. Key threats: Poaching, habitat destruction, and disturbance.

Marbled Teal

Marmaronetta angustirostris. This Vulnerable duck has two populations in Iraq – the breeding, and the non-breeding migrant populations. No studies were conducted to reveal whether the breeding population migrates elsewhere within the Middle East region or stays as resident population(s). Based on long-term observations, it appeared that this species is quite nomadic and showed an unstable distribution (Salim, *et. al.,* 2021; Abed, 2014). It prefers the marshes with a dense reedbed cover, marginal shrubs, and open-water areas. It breeds within the muddy margins of the marshes under dense bushes (Abed, *et. al.,* 2017). The estimated population of the breeding pairs in the Ahwar ranges between 900 and 1500 pairs,

Marmaronetta angustirostris is a breeding species in the Ahwar ©Mudhafar Salim.

and the wintering birds ranges from 2000 to 4000 individuals. Key threats: Poaching, eggs and chicks collecting, habitat destruction, and disturbance.

Greater Spotted Eagle

Clanga clanga. This Vulnerable eagle is relatively one of the common raptors to be found during the migration seasons. It can be found either soaring over the depths of Ahwar waterbodies (especially during migration seasons), or perching on vantage points close to the edges of the marshes. Part of the migrant population winters in the Ahwar area. The estimated wintering and passing population of this species ranges from around 100 to 450 individuals.
Key threats: Poaching, electrocution by power lines, and disturbance.

Eastern Imperial Eagle

Aquila heliacal. This Vulnerable eagle is an uncommon winter visitor and passage migrant in the Ahwar. It passes across the area of southern Iraq in few numbers and can be found in different habitats not only close to the wetlands; however, it can be occasionally found perching on a vantage point within the Ahwar. The estimated wintering and passing population of this species in the Ahwar ranges from around 30 to 70 individuals.
Key threats: Poaching, electrocution by power lines, and disturbance.

The Threatened, Non-waterbirds observed in and around the Ahwar

In addition to the threatened waterfowls, other water birds, and water-related bird species, the non-waterbirds species group have also been included to increase the benefit from the current paper. This group includes those birds that are not closely-dependent on water but have been observed frequently either flying over the Ahwar, or close to the wet margins of the study area. As their distribution might extend far from the Ahwar, no population estimation was made for this group.

Saker Falcon

Falco cherrug. This endangered falcon prefers the dryer habitats but might be found in quite few numbers (or even as a rare bird) around the marshes especially within the dry patches. They might chase their prey (like Sandgrouse and other birds) around their drinking areas. It can be found during the passage and winter seasons. This Endangered bird species is severely wanted by hunters and falconers wherever it can be found. Key threats: Catching by falconers, and disturbance.

Egyptian Vulture

Neophron percnopterus. Despite the lack of studies dedicated to birds' migration, it is clear that the area of southern Iraq might represent a passage area for this vulture; however, these passage individuals might not stay for a long time within this area. This endangered passage vulture can be found soaring around the southern wetlands during their passage from their breeding grounds (the closest is Zagros mountains) heading to their wintering grounds in Africa. Key threats: Poaching, pesticides, electrocution by power lines, and disturbance.

Neophron percnopterus might be considered as a rare/ uncommon passage migrant in the Ahwar
©Mudhafar Salim.

Lesser Kestrel

Falco naumanni. This Vulnerable small falcon is considered as a passage migrant in the areas around the Ahwar, however, it can be infrequently found within the margins of the Ahwar especially during the passage season. All of the individuals of this species are migrant, passing over the area of southern Iraq from their breeding grounds. Key threats: Poaching, habitat destruction, pesticides, and disturbance.

European Turtle-dove

Streptopelia turtur. This Vulnerable dove is considered as a passage migrant in Iraq; only a small population remains for breeding in suitable areas. Despite that, this species prefers relatively dryer areas and thorny trees, but it can be found in few numbers around the Ahwar on thorny shrubs. Key threats: Poaching, and habitat destruction.

Asian Houbara

Chlamydotis macqueenii. This Vulnerable species is well-known as the desert dweller, but few individuals or even small groups, can be found close to the wet margins of the Ahwar especially those areas of sandy grounds. This Vulnerable bird species is severely wanted by hunters and falconers wherever it can be found. Key threats: Poaching, catching by falconers, habitat destruction, and disturbance.

The Regionally-assessed Bird Species from the Ahwar

During the capacity-building programme arranged by the Arab Regional Centre for World Heritage (ARC-WH) as part of the preparations for the downstream processing and nomination dossier of the Ahwar as a World Heritage property (IMoEN, 2014), a regional red-list assessment was conducted

Chlamydotis macqueenii found occasionally close to the margins of the Ahwar ©Mudhafar Salim.

to highlight the regionally-threatened bird species. The status of twenty-two bird species inhabiting the Ahwar was also discussed and analyzed in this assessment (IUCN and ARC-WH, 2013). The current paper (through the accounts below) discusses these regionally-assessed birds species with an update of their current status and population estimation based on the results of the recent surveys carried out in the Ahwar area.

Lesser White-fronted Goose

Anser erythropus. Based on the regional assessment (the Ahwar area), this bird species was found to be Critically-endangered around the marshes of southern Iraq. As described in the globally-assessed species above, this bird can be found during winter in the Ahwar only in few numbers. The updated estimated population and threats have already been given above along with the key threats.

White-headed Duck

Oxyura leucocephala. This species has been assessed on the regional level (the Ahwar area) as Critically Endangered based on its current conservation status in the Ahwar. It can be found mainly in Huwaiza in addition to other wetlands. The updated estimated population and threats have already been given above along with the key threats.

African Darter

Anhinga rufa. Based on the regional assessment (the Ahwar area), this unique bird is a Critically-endangered species based on its current conservation status in the Ahwar. During recent surveys, this species was found only in Huwaiza, specifically around the eastern parts of Huwaiza as a breeder and in quite few numbers. Historically, this species was found in other components of the Ahwar, but the breeding and wintering individuals were only found in Huwaiza based on the recent surveys. It seems that the distribution of this species declined down from its typical range in the Ahwar due to the quantity and the quality of the water. The estimated breeding pairs are less than twenty located in the eastern and northeastern Huwaiza component only, and are not found elsewhere in the Ahwar.
Key Threats: collecting the eggs and chicks, poaching, habitat destruction, and disturbance.

Goliath Heron

Ardea goliath. Based on the regional assessment, this bird species is Critically-endangered in the Ahwar, similar to the previous species. This unique species has been assessed on the regional level (the Ahwar area) based on its current conservation

The Ahwar provides crucial breeding and feeding habitats for *Anhinga rufa* ©Mudhafar Salim.

status in the Ahwar. Few observations confirmed the presence of few individuals of this species in remote areas in the eastern parts of Huwaiza. The estimated breeding pairs are less than ten located in tiny stripes in eastern Huwaiza and are not to be found elsewhere in the Ahwar.
Key Threats: poaching, habitat destruction, and disturbance.

African Scared Ibis

Threskiornis aethiopicus. This species has been assessed on the regional level (the Ahwar area) as Critically Endangered based on its current conservation status in the Ahwar. During recent surveys, this species was found only in few numbers in Huwaiza as a breeder. There has been only one observation of an individual in the Western Hammar, so it might be rare in the other three components of Ahwar. The estimated breeding pairs range from 20 to70in the Ahwar. Key Threats: collecting the eggs and chicks, poaching, habitat destruction, and disturbance.

Greater Spotted Eagle

Clanga clanga. Based on a regional assessment, this bird species is Endangered. In addition to its global assessment (See its account above), this species has been assessed on a regional level (the Ahwar area) based on its current conservation status in the Ahwar. Its status was described above along with the estimated population and the key threats.

Imperial Eagle

Aquila heliaca. In addition to its global assessment (See its account above), this species has also been assessed on the regional level (the Ahwar area) as Endangered based on its current conservation status in the Ahwar. Its status was described above along with the estimated population and the key threats.

The Ahwar hosts few breeding colonies of *Threskiornis aethiopicus* that are important on the Middle-East level ©Mudhafar Salim.

Eurasian Spoonbill

Platalea leucorodia. This species has been assessed on the regional level (the Ahwar area) as Endangered based on its current conservation status in the Ahwar. During the recent surveys, this species was found breeding only in Huwaiza, specifically in the eastern parts of Huwaiza and in quite few numbers in a mixed breeding colony. Elsewhere, few individuals were found in small groups occasionally within the Ahwar. The estimated breeding population of this species in Ahwar ranges from 50 to 150 breeding pairs. Key threats: collecting the eggs and chicks, poaching, habitat destruction, and disturbance.

Purple Swamphen

Porphyrio porphyria. This species has been assessed on the regional level (the Ahwar area) as Endangered based on its current conservation status in the Ahwar. During the recent surveys, this species was found breeding all over the Ahwar, specifically at the marshes of dense reedbeds and in quite considerable numbers. It was assessed as Endangered due to the severe hunting pressure in particular during the breeding season. The estimated breeding population of this species in the Ahwar ranges from around 7,000 to 10,000 breeding pairs. Key threats: Poaching, eggs and chicks collecting, habitat destruction, and disturbance.

Black-tailed Godwit

Limosa limosa . This migrant species has been assessed on the regional level (the Ahwar area) as Endangered based on its current conservation status in the Ahwar, and due to habitat destruction – mainly shortage of water on mudflat stripes. This wader prefers the open mudflats and cannot t be found in the grassy or reedbed areas; therefore, the majority of its local population is concentrated either in buffer zones or

Platalea leucorodia breeds in Ahwar and migrates within the Middle East region ©Mudhafar Salim.

around them. The estimated wintering and passing population of this species in Ahwar ranges from 4,000 to 8,000 individuals. Key threats: habitat destruction and disturbance.

Basra Reed-warbler

Acrocephalus griseldis. In addition to its global assessment as Endangered species (See its account above), this breeding migrant has been assessed on the regional level (the Ahwar area) as Endangered based on its current conservation status in the Ahwar and due to the habitat destruction factor. It breeds in the Ahwar in quite considerable numbers to the extent that Ahwar is considered as their key breeding grounds on the global level. The conservation status along with their population estimation and the key threats are provided above.

Black Francolin

Francolinus francolinus. Based on the regional assessment, this bird species is Vulnerable. This bird is not considered as a marsh-dweller species, but it might be found in considerable numbers around the Ahwar and within the dryer patches and stripes within the Ahwar. It has been assessed on the regional level (the Ahwar area) as Vulnerable based on its current conservation status and due to the severe hunting pressure especially during the breeding season. Estimating the population of this species might not be possible or feasible because its suitable habitats extend beyond the buffer zones of the Ahwar. Key threats: Poaching, habitat destruction, and disturbance.

Francolinus francolinus is a common breeding species around the Ahwar ©Mudhafar Salim.

Little Grebe

Tachybaptus ruficollis iraquensis. The race of this species (*T. r. iraquensis*) is a breeding sub-species (Salim, *et. al*., 2021), that has been assessed on the regional level (the Ahwar area) as Vulnerable based on its current conservation status in the Ahwar, and due to the habitat destruction and disturbance factors. The estimated breeding pairs range from 11,000 to 15,000 in the Ahwar.
Key threats: Habitat destruction, disturbance, and the accidental netting by fishnets.

The Iraqi sub-species *Tachybaptus ruficollis iraquensis* breeds in considerable numbers in the Ahwar ©Mudhafar Salim.

Pygmy Cormorant

Phalacrocorax pygmeus. This species has been assessed on the regional level (the Ahwar area) as Vulnerable based on its current conservation status in the Ahwar. During the recent surveys, this species was found breeding only in Huwaiza and in quite considerable numbers, but it was assessed as Vulnerable due to habitat destruction and disturbance. The estimated breeding population ranges between 2,000 and 4,000 pairs in the Ahwar. However, this population might suffer more decline on the local level due to the expanding of Azim marshes after constructing the border embankment between Iraq and Iran. The wintering population of this species is quite unstable on an annual basis, and this might be due to the increasing availability of suitable habitats at the Iranian

The Ahwar is an important region for the breeding of *Phalacrocorax pygmeus* ©Mudhafar Salim.

neighboring marshes; however, it might range from 3,000 to5,000 individuals. Key threats: Poaching, habitat destruction, and disturbance.

In addition to the species listed above, there are some additional bird species that were regionally assessed within the same project as vulnerable due to different reasons and factors. These species include the White-tailed Lapwing *Vanellus leucurus*, the Slender-billed Gull *Larus genei*, the Whiskered Tern *Chlidonias hybrid*, the White-winged Tern *Chlidonias leucopterus*, the Pied Kingfisher *Ceryle rudis*, the Graceful Prinia *Prinia gracilis*, the Iraq Babbler *Turdoides altirostris*, and the Mesopotamian Crow *Corvus cornix capellanus*.

The Ahwar provides vital breeding habitats for considerable populations of the water-dweller bird-species, in addition to those that live around this area. This freshwater wetland is considered as the last largest freshwater marsh area for birds that migrate from their breeding grounds in Eurasia, heading to Africa to spend the winter (Salim, *et.al.,* 2009; Salim, *et.al.,* 2021). As far as global significance is concerned, the Basra Reed Warbler is the most important species with Iraq probably holding over 90% of the world breeding population. It is mostly concentrated in the Lower Mesopotamian marshes. In addition, this e ndangered species breeds in few scattered and fragmented regions in Iran, Kuwait and Palestine (Porter and Aspinall, 2010).

It is important to highlight the significance of the Ahwar for different types of bird groups including endemic species and subspecies. The Basra Reed Warbler has already been mentioned in this work along with the Iraq Babbler. This species lives and breeds within the intensive reed-stalks in quite considerable numbers in the Ahwar area. In addition, the Hypocolius, which is endemic to the Middle East, has a considerable breeding population within the dryer areas around the Ahwar. Some more endemic (locally/regionally important) subspecies are also significant from the conservation point of view; these include: the Black Francolin, the Little Grebe, the Sacred Ibis, the Goliath Heron, the African Darter, and the Mesopotamian Crow (Salim, *et.al.,* 2009; Kubba and Salim, 2011). The current status and estimated populations of most of these species have been highlighted in the current paper.

Discussion

Different types and categories of threats cause the degradation in the resident and migrant bird populations. In fact, these threats also affect the birds themselves (like poaching), and their breeding, foraging, or roosting habitats(Moser, *et.al.,* 1996; Becker, 2014). Several surveys carried out by the researcher over the period 2005-2020 have included an assessment of the threats targeting the birds' populations as well as their habitats. Additionally, the significant results of the monitoring programs prepared by the technical staff of the Environment HQs in the three Governorates of Basra, Thi-Qar, and Missan have been adopted by this research as well.

The researcher found that mentioning these different types of threats which affect the birds and their habitats in the Ahwar adds to the value of the current paper.

Figure 4 illustrates the thirteen typical factors and threats found across the four natural components in the Ahwar based on recent fieldwork and the results of the surveys. It demonstrates and compares the status and the level of each sort of threat/factor (isolated bar) in each component (color code) so the share of each risk factor gets to be self-evident among the diverse components (IMoEN and ARC-WH, 2018).

Regarding the effects of different types of threats/factors in each of the Ahwar components, the figure below outlines clearly which of the four natural components is more influenced by the diverse threats and factors than the others. It is clear that the Central Marshes component is the most affected due to the seriousness and the pressure of these factors and threats. The West Hammar and Huwaiza components were comparatively

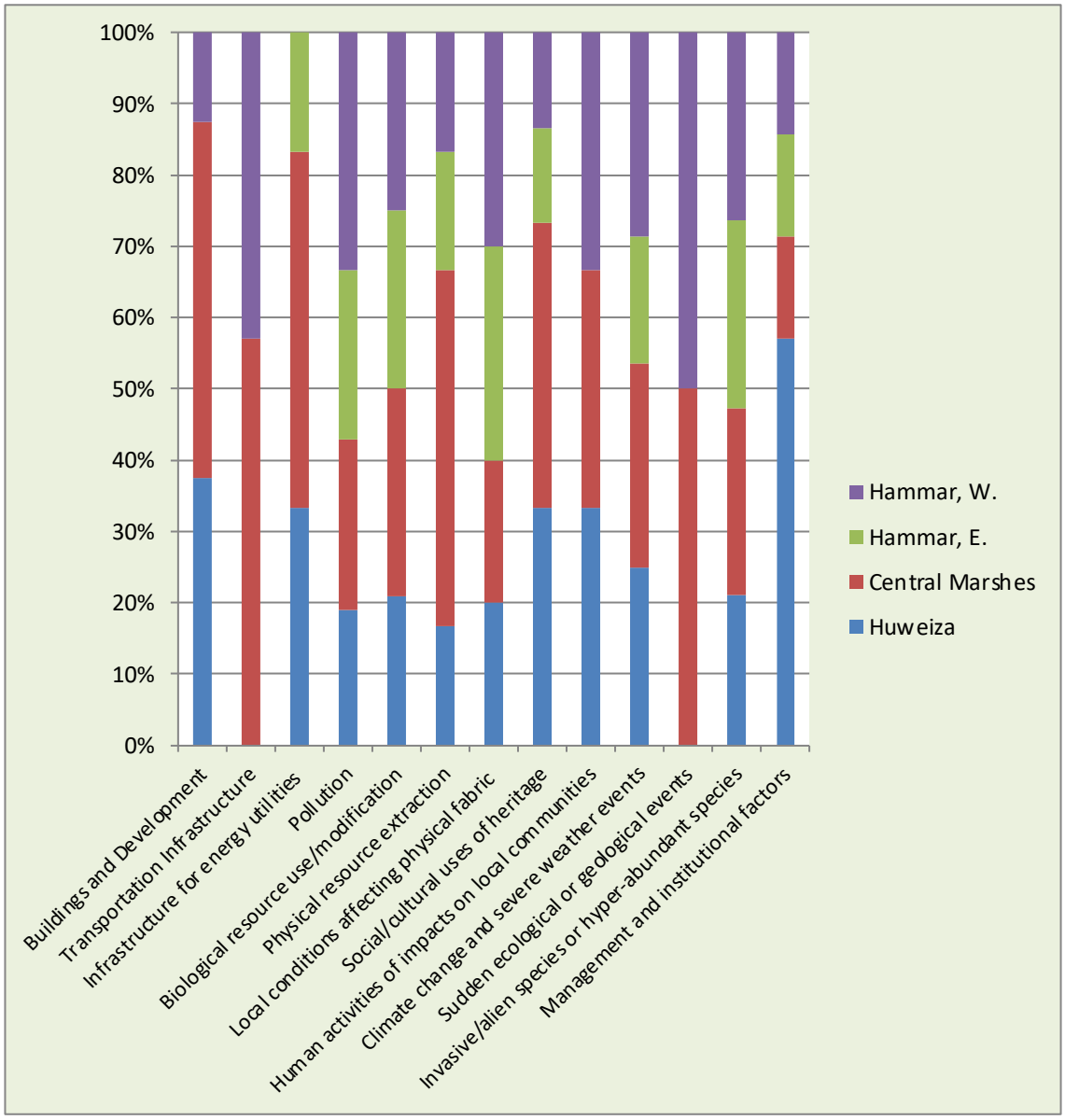


Figure 4. shows the different levels of various kinds of threats in the four components of the Ahwar (showed in four colours).

under a similar level of pressure and threats, whereas the East Hammar was comparatively the least affected among the rest of the natural components of the Ahwar (IMoEN and ARC-WH, 2018).

The extensive surveys which have been conducted recently by ornithologists show that despite the drainage during the 1980s and 1990s, no breeding bird species have become extinct in the marshes of southern Iraq (Salim, *et. al.,* 2009). Nevertheless, it is clear that noticeable change has occurred in the bird species' population especially after the return of the majority of the dwellers to the marshes following their restoration.

The other factor that might be of crucial influence is the constructing of the soil embankment which has cut the natural flow of the Azim marshes which extending inside the Iranian lands to from the Huwaiza marshes. It becomes clear then that the most critical factor which influences the birds and their habitats in the Ahwar is the shortage and fluctuation of freshwater amounts which feed these marshes (IMoEN and ARC-WH, 2018).

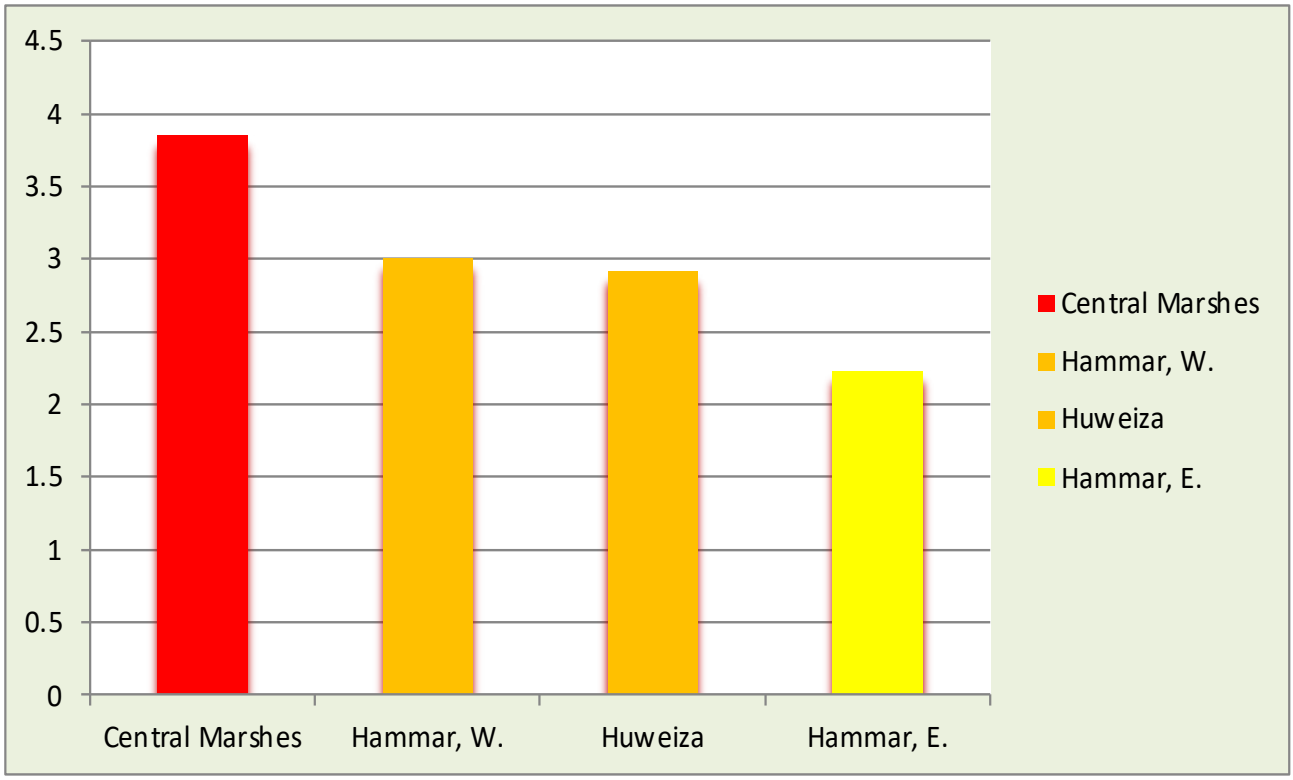


Figure 5. The effects of different kinds of threats and factors on the four components of the Ahwar (showed in four colours).

Recommendations

Based on the results presented in this paper, the researcher would like to present and highlight the following recommendations:

1. The threatened bird species (as part of the entire threatened flora and fauna) of the Ahwar should be dealt with as a priority issue in this environmentally important area, and more attention should be given to update the management plan of the natural components of the Ahwar.
2. There should be a program dedicated to the monitoring of the threatened birds in the Ahwar area, and this should cover both populations: the resident, and the migrant bird species. The updated results of the monitoring program are to be shared with the World Heritage Center (via the formal channels) to acquire the suitable technical advice as quickly as possible.
3. Special efforts should be given to the breeding, roosting, and foraging habitats of the threatened birds mentioned in this paper, in addition to giving more priority to their conservation.
4. More institutional cooperation and coordination on the local and national levels should be established and applied on the ground in order to facilitate the efforts and minimize the required resources for the monitoring and protection activities.
5. Conducting long-term capacity building programmes for the staff directly involved in the monitoring programme with more focusing on bird identification.
6. Long-term awareness and education programmes should be designed and applied on the local and national levels regarding the threatened birds and their habitats in the Ahwar area.

Acknowledgement

The author would like to thank the Arab Regional Centre for World Heritage (ARC-WH) for encouraging scientific research and spreading knowledge on the natural heritage of Arab countries; their support to conduct this study is much appreciated. Sincere

thanks go to t the Iraqi Organization for the Conservation of Nature (IOCN) for their help and for providing updated information.

References

Abed A S. 2014. Bio-Ecological study of Marbled Teal *Marmaronetta angustirostris* in Hor Al- Dalmaj - Iraq. Ph.D. dissertation, University of Baghdad, Iraq.

Abed AS, Salim M. A and Hussain L.I. 2017. Distribution of the Marbled Teal *Marmaronetta angustirostris* over different habitats in Al-Dalmej Wetlands, Iraq. A*dvance Research Journal Discoveries*. **11.0,C-3**:10-13.

Abdulhassan, N, Salim, MA., Al-Obaidi, GS., Al-Saffar, MA. and Al-Sudani, M. 2009. **Habitat Mapping and Monitoring Project - Classification and Description of Southern Iraqi Marshlands**. Nat. Iq., Iraq.

Al-Yamani, FY , Bishop, JM, Al-Rifaie, K and Ismail, W. 2007. The effects of the river diversion, Mesopotamian Marsh drainage and restoration, and river damming on the marine environment of the northwestern Arabian Gulf. *Aquatic Ecosystem Health and Management*. **10**, (3): 277-289.

Becker, RH. 2014. The Stalled Recovery of the Iraqi Marshes. *Remote Sens*., **6** (2): 1260-1274.

Iraqi Ministry of Environment. 2014. Ahwar of Southern Iraq: Refuge of Biodiversity and Relict Landscape of the Mesopotamian Cities. Nomination dossier for inscription of the Ahwar as World Heritage property. Republic of Iraq. 266pp.

IMoEN and ARC-WH. 2018. The First Threats Assessment on the Factors and Threats That Affect the OUV in the Four Natural Components of the Ahwar WH Property. The Iraqi Ministry of Environment and the Arab Regional Centre for World Heritage, Manama, Kingdom of Bahrain– internal technical report.

IUCN and ARC-WH. 2013. Regional Red List Assessment of Selected Species in the Marshes of Southern Iraq - Ahwar. ARC-WH, Unpublished Technical Report.

IUCN. (2021) (https://www.iucnredlist.org/search). (Downloaded @ 2021) Red List.

Kubba, SA and Salim, MA. 2011. Chapter 6: The Wetlands Wildlife And Ecosystem. *In*: **The Iraqi Marshes and the Marsh Arabs: Their Culture and Environmen**. Middle East Studies. ITHACA.

Moser, M, Prentice C. and Frazier S. 1996. A global overview of wetland loss and degradation. *In*: **Technical Session B of the 6th Ramsar Conference of Parties**. Brisbane. pp. 21–31.

Porter, R and Aspinall, S. 2010. **Birds of the Middle East**. Christopher Helm, London.

Salim, MA , Porter, R, Schiermacker-Hansen, P, Christensen, S. and Al- Jbour, S. 2006. **Field guide to the birds of Iraq**. NI/ BirdLife International, Baghdad.

Salim, MA, Porter, R and Rubec, C. 2009. A summary of birds recorded in the marshes of southern Iraq, 2005–2008. *BioRisk* **3**: 205–219.

Salim, MA, Porter, RF, and Abed, SA. 2021. Chapter 19: The Ornithological Importance of the Southern Marshes of Iraq. *In*: **Southern Iraq's Marshes: Their Environment and Conservation** – Compiled by Laith Jawad. Coastal Research Library 36. Springer.

Salim, MA, Al-Shekhly, OF, Majeed, KA and Porter, RF. 2012. An annotated checklist of the birds of Iraq. *Sandgrouse*. **34**:4-43.

Scott, D. and Carp, E. 1982. A midwinter survey of wetlands in Mesopotamia, Iraq: 1979. *Sandgrouse*, **4**: 6–76.

Scott, D.A. 1995. **Directory of Wetlands in the Middle East**; IUCN-The World Conservation Union and International Waterfowl and Wetlands Research Bureau: Gland, Switzerland and Slimbridge, UK, 1995.

Jordan Journal of Natural History, 9 (1), 2022 pages: 72 - 82

Agro-management Approaches for the Sustainability of the Biodiversity of Ancient Olive Orchards in Palestine

Ahmad Alomary[1], Raed Alkowni[2*], Samer Jarrar[3,4], Banan Alsheikh[4] and Generosa Jenny Calabrese[1]

[1]Mediterranean Agronomic institute of Bari (CIHEAM Bari) 70100 Valenzano, Bari, Italy; [2] Department of Biology and Biotechnology, An-Najah National University, Nablus; [3] Palestinian Academy for Science and Technology (PALAST), Ramallah; [4] National Agricultural Research Center (NARC), Jenin, Palestine.

Received: April 17, 2022; Revised May 26, 2022; Accepted: June 3, 2022

Abstract: Ancient Olive Orchards (AOOs) occupy most of the Palestinian lands and represent a vital cultural heritage. This study is aimed at assessing the impact of different farming systems on flora biodiversity. Fields with two different farming systems (organic-registered and traditional-managed) were subjected to soil fertility, biodiversity indices, and a socio-economic analysis between the years 2017-2018. The results showed a higher percentage (1.74%) of total organic matter in the organic-registered fields. Biodiversity indices (Shannon diversity index (H`) and Margalef's index (D)) recorded higher values as well (3.27; 10.12, respectively), reflecting the impact of agricultural practices on wild diversity. The same was noted in ecological infrastructures where 330 different species in forty-eight families were identified. Even so, both farming systems were insignificantly different; and that might be attributed to the similarity of practices between them in Palestine. From a socioeconomic point of view, these practices are of a low cost and are economically wise while adding quality to the products. In Misilyah, AOOs were found to harbor plant biodiversity in synergic harmony. Thus, applying organic farming practices is recommended as the best socio-economic approach for biodiversity sustainability. Such practices are also potentially profitable through eco-tourism and are symbolic and representative of the national heritage of this area. Also, they can provide an additional source of income for the people of this area.

Keywords: Biodiversity; Ancient olive; Conservation; *Flora Palestina*; Agroecology

Introduction

The Mediterranean landscape is characterized by the presence of olive trees and olive groves. A large part of olive production in the world is annexed to the Mediterranean area since olive trees are part of the agricultural tradition and historical events of the people (Dessane, 2003). Also, olive oil has the most economical value in the marketing chain of many Mediterranean countries; therefore, it has a high economic and social impact.

Olive orchards are also considered a habitat for many plant and animal species (Perrino *et al*., 2011; Biondi *et al*., 2007), which means that the Mediterranean region is unique for its widespread and ancient olive orchards (AOOs). In fact, it can be easily concluded that olive agroecosystems are about 2.800 years old (Zohary, l973) and thus, are high in biodiversity.

Agricultural practices are closely related to the biodiversity of wild flora and fauna communities. More than any other human activity, agriculture is impartibly linked to biodiversity benefiting, modifying, and even contributing to its maintenance (Barberi *et al*., 2010; Chapin *et al.,* 2000; Wood and Lenné; 1997).

The role of agricultural systems in biodiversity conservation is complex going in both directions being both a source for biodiversity and a threat to it (Rey Benayas and Bullock, 2012). Farmers may economically benefit from the intensive use of land, but the costs paid by societies are high (pollution of water by pesticides, leaching of excess nutrients, habitat loss for native species. Thus, the total or social economic value of

*Corresponding author: ralkowni@najah.edu

agro-biodiversity must include the value of ecological services that it can provide (Jackson *et al*., 2007). Organic farming is expected to sustain soil, ecosystems, and people. Combining tradition, innovation and science might promote fair relations and a good quality of life for all those involved.

Olives in Palestine date back to 4,000 years ago, and are considered among the most important crops (Basheer-Salimia *et al*., 2009) covering about 51% of the total cultivated area (Basheer-Salimia and Ward, 2014). This study is aimed at assessing the impact of agro-management practices (organic and conventional) on plant diversity in ancient olive orchards and checking for any putative conservation actions.

Materials and Methods

Field selection criteria

Fields were selected based on the number of ancient olive trees, area, and management system (traditional or organic farming). Several olive orchards in the northern part of the West Bank were visited and investigated for their olive trees age and size during the period 2016-2017. Olive trunk diameters were the main criteria in determining the oldness of trees. Trunk circumference was measured at the height of 130 cm from the base of the tree for that purpose.

Fields of more than one hectare in size; and with more than 60% of its olive trees being ancient, were chosen for this study. The selected ancient olive orchards were visited several times between December and April over the period from 2017 to 2018 to report the farming practices. The first survey was conducted in April 2017; the second was in July 2017 and the third was in April 2018.

Soil fertility

Soil was analyzed at the National Agricultural Research Center (NARC) labs according to the International Centre for Agriculture Research in Dry Areas (ICARDA) soil analysis procedures. Briefly, three samples from each field were collected at the depth of 30 cm, and were mixed and left to dry in the open air. Soil organic matter (Organic carbon) was determined by the rapid oxidation method (ICARDA, 2001). Soil soluble salts were prepared from 100 g of air-dried soil in 100 ml of distilled water. The solution was shaken for thirty minutes in the rotating shaker, and was filtered and Na^+ and K^+, ions were determined using Flame photometry, while titration was used for measuring Mg^{2+}, Ca^{2+} and Cl^-. The Kjeldahl method was applied for determining nitrogen in organic substances as total Kjeldahl Nitrogen (TKN), while the Olsen Method measured phosphorus.

Assessment of biodiversity in ancient olive orchards

Biodiversity assessment in the selected six fields was carried over three different periods between 2017 and 2018. The first one was in April 2017 and is referred to as (T1); the second was in July 2017 (T2); and the last one was in April 2018 (T3). Sampling of the floristic components included both cultivated plots and ecological infrastructures. At the end of the surveys, a list of all plant species with their corresponding families were developed, and the threatened species were highlighted. The simplified Raunkiaer method (Cappelletti, 1976) was applied to the cultivated plots for categorizing the biodiversity of herbaceous species. It was applied at a fixed number (9 to 10) per plot, using a square metal frame (point quadrats) of an agreed side of 0.25 m. The systemic sampling method with diagonals of 4-5 throws was used in the ancient olive groves where the ground cover was not uniform.

The diversity indices were calculated using the Species Richness (S), Shannon diversity index (H`), and Shannon's equitability (E_H) or (evenness) to provide information not simply about species numbers, but also about community composition (Shannon, 1949).

The species richness (S) which reflects

the number of existing species within the studied area was achieved by counting the identified species in these fields. Local and international botanical experts in plant taxonomy and classification were consulted, and a taxonomical identification software available online was used for further verifications. Threatened species were expected according to experts and local community observations.

The Shannon diversity index (H`) was then calculated using Shannon and Weaver formula:

$$H' = -\sum_{i-1} pi \times lnp_i$$

Where S is the total number of species in the community, and *P*i is the proportion of S made up of the i^{th} species.
Besides, data analysis were applied to assess the degree of distribution existing in the field's diversity using Shannon Equitability Index (E_H) following this formula:

$$E_H = H'/H_{MAX}$$

Where H_{max} = ln S (Equitability values assumed to be between 0 and 1, where 1 signifies a field of complete evenness). In addition, the Margalef's index (D) for measuring species richness related to sample size was calculated following this formula:

$$D = \frac{n-1}{lnN}$$

Where (n) is the number of species, and (N) stands for the total number of individuals
Ecological infrastructures were also surveyed, and their biodiversity indices were estimated according to the Braun-Blanquet (BB) (1932) method based on the observation of the tested areas with a minimum size of 50 m^2. BB method is usually applied for the assessment of agricultural areas. The surveys were conducted by walking along the subunits, reporting all species found there and assessing the percentage of coverage for each species, considering the code values of Braun – Blanquet Code as in Table 1. After assessing the percentage of the coverage for each layer, the assessment of the species composition inside the layers was summed up.

Statistical data analysis

The data were analyzed by one-way ANOVA at ($p<0.05$). The software package from Simple Interactive Statistical Analysis was used.

Results

Properties of selected ancient olive orchards

Fields surveys were conducted early during the year of 2017 and ancient olive orchards (AOOs) were allocated. Ancient olive trees were determined based on trunk size (> 1m

Table 1: The Braun – Blanquet Code and biodiversity values for each species coverage class. The species coverage was coded from (5:high coverage to 1: (less than 5% coverage). The (+) was given to scarce species coverage, while (r) was used for those with very few individuals (Braun-Blanquet, 1932).

Coverage (%)	Braun – Blanquet Code	Biodiversity values
Species coverage 80 – 100	5	1
Species coverage 60 – 80	4	2
Species coverage 40 – 60	3	3
Species coverage 20 – 40	2	4
Species coverage 1 – 20	1	5
Negligible cover Species coverage < 1	+	6
Very rare species, presenting only isolated individuals	R	7

at height of 130 cm) (Figure1). The selected orchards are located in Misilyah (32° 23.21907'N 35° 17.28221' E) in the Jenin province in the northern part of the West Bank-Palestine.

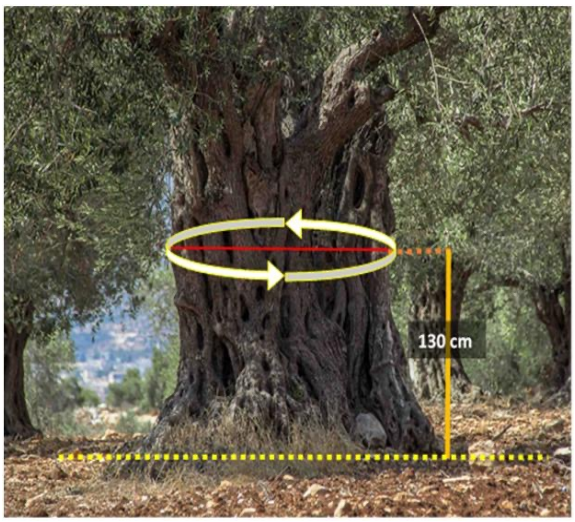


Figure 1. An ancient olive tree which was determined by measuring its trunk diameter at the height of 130 cm of tree base in olive orchards (left);aerial view of the selected olive orchards located in Misilyah (right).

The selected fields were irregularly planted with > 50 ancient olive trees per hectare. No intercropping plants were noticed except for a few ignored almond trees. The selected fields were categorized based on their farming managements: organically certified fields and traditionally farmed ones. Fields (*No.*1, 2, 3) were those converted to organic since 2014 and are certified by the Institute for Market ecology (IMO), an international organic certification body, while fields (*No.* 4, 5, 6) were considered as traditionally farmed ones (Figure1).

The organically certified fields AOOs apply biodiversity-eco-friendly farming methods such as the mechanical control of herbs (shredding tools and /or minimum tillage), and use organic fertilizers (manure/compost) instead of chemicals in addition to leaving shrubs and natural growing plants among their olive trees and field borders (Ecological infrastructure) undisturbed.

Both organic and conventional/ traditional farming approaches were reported to have common agricultural practices such as plowing, pruning and the application of manure as fertilizers. In general, all fields tend to plow the soil two-three times during the year that is in November, February, and at the end of March, depending on the weather and the vegetation growth. The main tool used by farmers in these fields was the chisel plow which loosens the soil surface to the depth of 8-10 cm to control weeds and increases soil's water-holding capacity. Moreover, the use of herbicides was reported in the conventional fields several times during the year, and animal grazing was also noticed several times during the research study period.

Impact assessments of farming practices on soil fertility

The soil samples were tested to detect any variations in soil chemical composition between organic and conventional fields. The results showed that the total organic matter as well as trace elements were higher in the organic fields than in the conventional ones (Table 2).

Table 2. Soil chemical analysis.

Test	Organic managed fields			Conventional managed fields		
	*No.*1	*No.*2	*No.*3	*No.*4	*No.*5	*No.*6
Organic Matter %	1.75	1.74	1.72	1.51	1.67	1.69
NO_3 (ppm)	3.18	6.63	2.95	2.56	4.02	2.74
P_2O (ppm)	4.14	4.04	3.23	2.12	2.63	2.83
Ca (ppm)	50.1	90.2	50.1	50.1	74.1	58.11
Mg (ppm)	24.3	24.3	18.2	18.2	18.2	8.5
Na (ppm)	12	6	6	10	12	9
K (ppm)	9	9	6	9	10	7

However, no significant differences were found in the soil analysis between the organic and conventional fields. More soil analyses with large sample sizes are recommended for a better understanding of the soil fertility and correlation between the organic and conventional ones.

Biodiversity measurements

Fields were surveyed during different sampling periods from 2017 to 2018 in order to reveal any changes in *flora* communities related to agricultural practices. AOOs were found to be in marvelous harmony with nature and reflect the old history of synergism (Figure 2). These fields were traditionally farmed.

The simplified Raunkiaer method of assessment was applied to the cultivated plots and the data were calculated using the Shannon diversity indices (H`; S; and E_H) along with Margalef's index (D). The Braun-Blanquet (BB) method of assessment was applied to check the ecological infrastructure. The results of the three surveys are shown in Table 3.

Figure 2. Ancient olive tree with synergic harmony with wild nature.

Table 3. Biodiversity assessment in all selected fields.

April 2017	H`	S	E_H	D	BB
No.1	**3.27**	40	**0.89**	7.68	412
No.2	3.18	47	0.83	8.15	306
No.3	3.25	47	0.84	8.47	**491**
No.4	2.35	56	0.58	8.73	304
No.5	2.39	36	0.67	5.91	297
No.6	2.94	**64**	0.71	**10.12**	416
July 2017	**H`**	**S**	E_H	**D**	**BB**
No.1	**2.26**	**13**	0.88	**3.34**	31
No.2	1.26	5	0.78	1.05	34
No.3	1.28	4	0.93	0.94	35
No.4	0.68	2	**0.98**	0.29	41
No.5	1.98	8	0.95	2.3	40
No.6	1.63	6	0.91	1.8	**48**
April 2018	**H`**	**S**	E_H	**D**	**BB**
No.1	**2.88**	26	**0.88**	5.46	270
No.2	2.87	28	0.86	5.9	221
No.3	2.56	24	0.81	5.38	**428**
No.4	2.25	26	0.69	4.8	200
No.5	2.11	23	0.67	4.6	236
No.6	2.75	**37**	0.76	**6.26**	346

Using the Shannon diversity index (H`), biodiversity was found to be higher in all surveyed organic fields (Figure 3); the highest biodiversity value was recorded as (3.27) in the April 2017 survey.

The results revealed the negative impact of agricultural practices on biodiversity in the cultivated fields. The lowest H` value was recorded for the conventional-farming Field #4 (0.68) in the July 2017 survey even though the highest number of species (64) was also recorded in the conventional Field #6 in April`s surveys. Indeed, the values of the Shannon species richness (S) and Margalef's index (D), used for measuring the species richness in relation to the sample size, were in accordance.

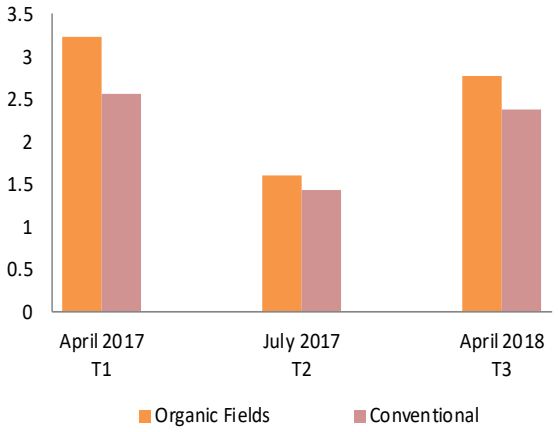


Figure 3. The biodiversity indexes using Shannon diversity index (H`) were higher in organic fields

The lowest species richness was reported in the conventional fields as in Field #4 inspected through the July 2017 survey.

Equitability index (E_H); which expressed the diversity evenness, scored high in the organic fields in April`s surveys; Field #1 (0.89 and 0.88), while the lowest value was recorded for the conventional Field #4 (0.58) in April 2017. Expectedly, conventional fields showed more equitability than the organic ones in the July 2017 survey, with less species and more uniformity.

Ecological infrastructures, which host different species more than the cultivated fields, gave advantages to the margins of organic fields over the conventionally farmed ones in Spring time while in the July survey, they were in favor of the conventional ones based on the Braun-Blanquet modified method (Table 1).

Life form spectra of flora community

The surveys resulted in recording a list of 330 different species which belong to forty-eight families: *Asteraceae* (18%), *Fabaceae* (17%); *Poaceae* (10%), *Apiaceae* (6%), *Lamiaceae* (5%), and *Brassicaceae* (4%). The chorology of the explored species was similar to those characterizing the olive groves underlining the prevailing plant species of the Mediterranean component. These plants were categorized based on their abundance in the area (Table 4) according to the wild plants' checklist (Al-Sheikh, 2019).

Table 4. Abundance of surveyed plant species

Category	*No.*
Very common -CC	133
Common -C	98
Frequent -F	66
Potentially rare -RP	1
Rare -R	20
Very rare -RR	11
1-3 sits only -O	1
Total	330

A poster indicating the most threatened species was developed (Figure 4). Comparing plant species in the cultivated fields (CF) and ecological infrastructure (EI) can provide further information on the effect of the agricultural practices on the flora.

The plant species classified included (*Therophytes; Phanerophytes; Hemicryptophytes; Geophytes; Chamaephytes*.

Among many others). Comparative studies of their distribution in both cultivated fields (CF) and Ecological Infrastructure (EI) were done in April 2017 and 2018 (Table 5). Except for *Thermophiles*, all other tested classes were found to be covered in the ecological infrastructure more than in the cultivated fields.

The obtained results from life form analysis for the April survey (T1) showed that the main life form in all the cultivated parts of the fields was *Therophytes,* with an average of 91.5%, followed by *Hemicryptophytes* (4.2%).

As for the ecological infrastructure, the main life form was *Therophytes*, which formed 63%; followed by the rich life form of *Hemicryptophytes* that formed 18.8%. The lowest representative life form was *Geophytes* reaching up to 3% on average. When comparing the results with the second survey of April 2018 (T3) it was found that the main common life forms in the cultivated plots were still the same.

Socio-economic value

A questionnaire was developed for reporting the socioeconomic values of the ancient olive orchards and their plant biodiversity in Misilyah. The results showed that ancient olive trees can add value to the village olive industry (oil, fruit, wood, soap ...etc.); and is attractive to eco-tourisms; besides, it is considered as a symbol of the village's national heritage.

The collected data showed that more than two thirds of surveyed participants were aware of the synergism between Olive orchards and wild plants (herbs, shrubs, and trees), as they harbor the beneficial bacteria which provide olives with nutrients. At least 62% agreed that wild plants in the olive fields must be protected by avoiding the use of chemical herbicides and/or excessive deep plowing. The 56% of those surveyed believed that in addition to their importance in nature, wild plants can provide a source of additional income to the farmers. The majority of participants (88%) believed that wild sage, thyme, and many other plant species almost disappeared due to overharvesting and/or excessive use of herbicides.

About 48% of the participants think that ancient olive trees and their ecosystem could provide additional income by encouraging eco-tourism in Misilyah and through the potentiality intercropping systems.

The benefits of ancient olive orchards and their related biodiversity, which will generate additional values and income to the Misilyah village, encouraged the Misilyah local council to contact governmental and non-governmental organizations for the sake of protecting this ecosystem.

More than 60% of the surveyed people believed that biodiversity in the ancient olive fields must be protected, particularly from rural expansion, as mentioned by one third of the surveyed farmers .

Besides, more than 56% of those questioned were convinced of maintaining the biodiversity of the ancient olive orchards for they could be perfect for attracting eco-tourism.

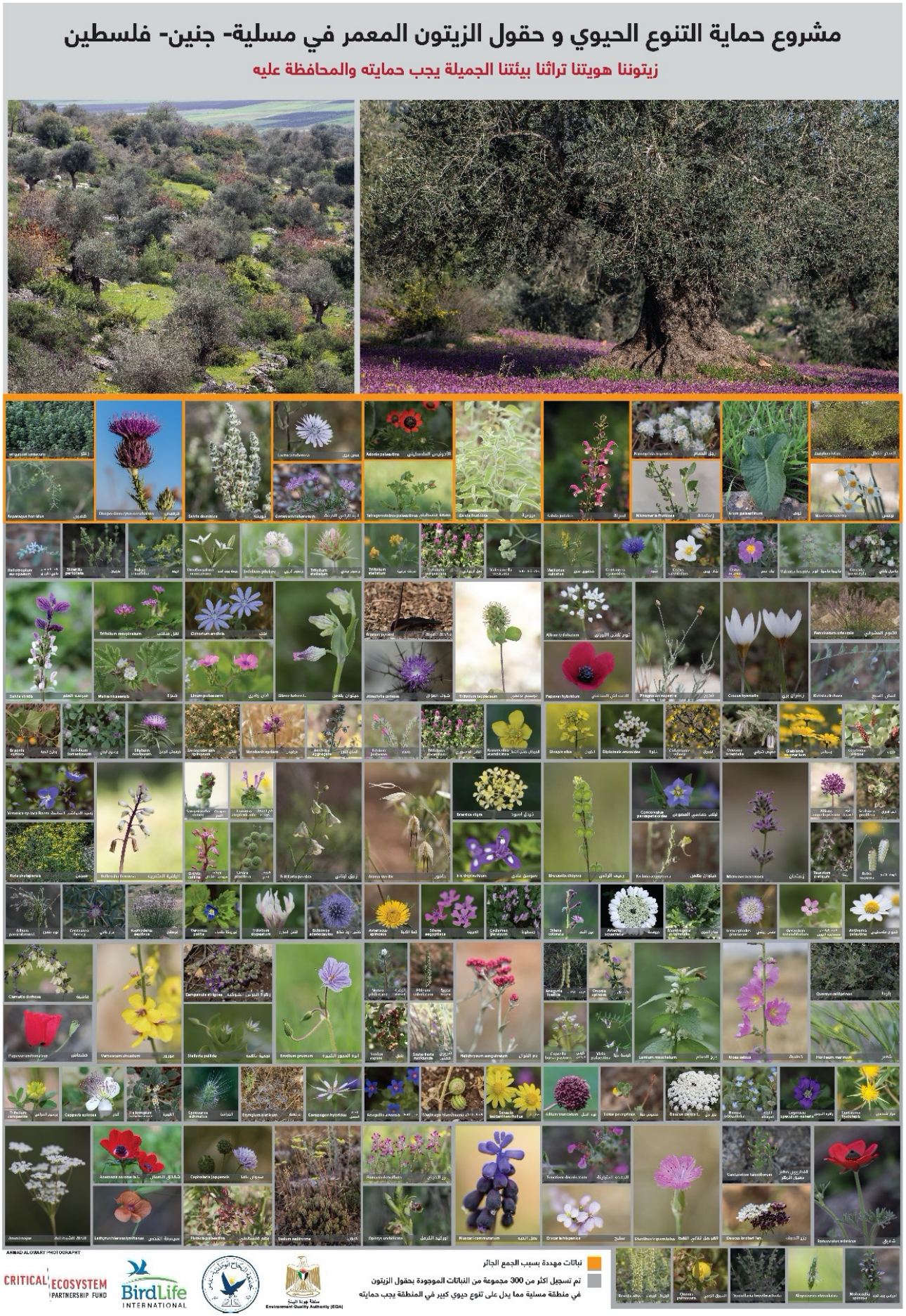


Figure 4. Plant biodiversity photographed in Misilyah showing the most threatened species

Table 5. The average life form in all the fields in T1 and T3 for the plant classes: *Therophytes*; *Phanerophytes*; *Hemicryptophytes*; *Geophytes*; and *Chamaephytes*.

	CF/EI	*Therophytes*	*Phanerophytes*	*Hemicryptophytes*	*Geophytes*	*Chamaephytes*
Average in (T1)	CF	91.5%	0.8%	4.2%	1.5%	2.0%
	EI	63.0%	7.7%	18.8%	3.0%	7.2%
Average in (T3)	CF	91.5%	0.0%	6.5%	1.3%	0.7%
	EI	56.0%	11.7%	19.2%	2.7%	10.3%

Discussion

The Mediterranean basin, which is considered as one of the thirty-six hot spot areas of the world, is characterized by its species richness and also hosts the world's most ancient olive groves (Médail *et al*., 2019; Myers *et al*., 2000; CEPF, 2010, Loumou and Giourga, 2003). Palestine is one of the eastern Mediterranean countries with fields holding olive trees that are hundreds if not thousands of years old (MIFTAH, 2014). The northern part of the West Bank was chosen in this study for the field surveys of AOOs because the majority of olive cultivation is there (Figure 1). The northern olive orchards represent approximately 95.4% of the total area that is cultivated with olive in Palestine and account for about 44% of the whole olive trees in the country (Srouji, 2012). Moreover, there are major groves cultivated according to the organic system comprising about 91% of the total organic olive groves in the West Bank.

The olive-tree trunk diameter was used in recognizing the AOOs. The average diameter reached up to 2 m. in the Misilyah village in the Jenin provinces, the richest place with these ancient olive trees, Furthermore, the Jenin governorate was found to be the highest among other governorates in terms of the total production of olive oil, and its production accounts for 29% of the total production in the West Bank. The estimated average productivity of olive oil was 47 kg/dunum, with an annual total production of 23,947 tons in 2015 (ARIJ, 2015).

A list of 330 taxa belonging to forty-six families have been recorded in this research. This was the first survey of *flora* biodiversity to be conducted in this area. It was hard to cover the whole census of flora community in the olive fields during one season of growth; that is why the survey was extended for two to four years for the sake of collecting new species. The results can be considered as a contribution to a better knowledge about the flora community structure in the olive fields of Jenin and of Palestine as a whole.

Organic farming protects the on-field biodiversity as advised by several researchers (Calabrese et al., 2016). In Palestine, there are no previous surveys or studies conducted to assess the fauna and flora biodiversity in the ancient olive fields as well as the impact of agricultural practices on that. Worse still, there are no previous studies on the morphological characterization of the ancient olive trees and their habitat. The analysis and characterization of the olive grove agro-ecosystems in terms of vegetation biodiversity surprisingly showed that the traditional cultural practices were less harmful to the environment, creating a variety of structural conditions that allow the diversification of plant and animal species thus contributes to the high overall level of biodiversity in AOOs.

Biodiversity indices can be considered as a reflection of the human impact on the ecosystem (Vačkář *et al.,* 2012; Gorrod and Keith 2009). Even though both the organic and conventional practices showed good biodiversity indexes, the calculated indices of biodiversity values from the collected data of the three surveys for the cultivated plots showed advantages of the organic practices over the traditional ones. This might be attributed to the t classical conventional practices of Palestinian farmers which in

most cases resemble the organic ones. Also, equitability was higher in the organic fields as herbicides were probably used in the conventional fields. Moreover, grazing was observed in the organic fields which might have enhanced the flora community growth of some species even more.

In all fields, *Therophytes* were the main life form in both of the cultivated parts and the ecological infrastructure. They are the main annual plants that can survive unfavorable seasons in the form of seeds. On the other hand, *Hemicryptophytes* geophytes and *Chamaephytes* were affected by agricultural practices like plowing and are less presented in the cultivated parts of the fields.

The presence of ecological infrastructures was quite important as they were useful to ensure the presence of biodiversity associated with farmlands to contribute to supporting production processes through the supply of environmental services (Pecheur *et al.,* 2020). Ecological infrastructures were found to be quite various, such as hedges, wildflower strips, conservation headland, grass strips, ruder areas, small ponds, dry stone walls, dirt roads, heaps of stones, among others. In addition to that, areas of production were defined also as ecological infrastructures, such as the case of pastures, meadows and fallow lands, which contribute to the conservation of biodiversity of the agro-ecosystem. Field margins were found to be very important in improving the components of biodiversity (*flora* and *fauna*) as seen through the BB values (Table 3).

Finally, there was a lack of knowledge regarding the ancient olive orchards and their characterizations in Palestine as well as the importance of ecological infrastructure in their fields. The fields were found rich in flora biodiversity, and the organic management system showed slightly better results in terms of biodiversity richness. There are no significant differences in the practices of the farmers in the organic and conventional fields during the research period. Even so, herbicides must be forbidden as they are destructive of the flora diversity.

This research study is the first of its kind to be carried in the region; however, more studies are recommended to characterize the ancient olive trees and their habitat to valorize their values as sustainable agro-ecosystem and a symbol of the cultural heritage of the Palestinian ancient olive orchards. Without doubt, the traditional agricultural practices of the farmers are still eco-friendly, yet reporting and improving the traditional practices are highly recommended. Also working with the government and the local communities to protect the ancient olive trees and increase the awareness regarding their values is highly advisable.

Acknowledgement

BirdLife International and CEPF generously contributed to funding part of this research activities.

References

Al-Sheikh, B. 2019. **Checklist and Ecological Database of Plants of the West Bank Palestine**. National Agricultural Research Center, Jenin, 229 pp

ARIJ 2015. **Palestinian Agricultural Production and Marketing between Reality and Challenges**. Palestine.

Barberi P, Burgio G, Dinelli G, Moonen AC, Otto S, Vazzana C and Zanin G. 2010. Functional biodiversity in the agricultural landscape: relationships between weeds and arthropod fauna. *Weed Research*, **50(5)**: 388-401

Basheer-Salimia, RA, Awad, MK, and Kalaitzis, P. 2009. Genetic Fingerprinting of Palestinian Olive (Olea europea L.) Cultivars Using SNP Markers. *Jordan Journal of Agricultural Sciences*, **5 (3):** 282-294

Basheer-Salimia, R and Ward, J. 2014. Climate change and its effects on olive tree physiology in Palestine. *Review of Research Journal*. 3. 10.9780/2249-894X/372014/688.

Biondi E, Biscotti N, Casavecchia S, Marrese M. 2007. "Oliveti secolari": habitat nuovo proposto per l'inserimento

nell'Allegato I della Direttiva (92/43 CEE). *Fitosociologia* **44 (2)(suppl. 1)**: 213- 218.

Braun-Blanquet J. 1932. **Plant sociology**. McGraw Hill, London New York.

Cappelletti C. 1976. **Trattato di botanica**, Utet, Torino.

CEPF. 2010. **Ecosystem profile – Mediterranean basin biodiversity hotspot**. Critical Ecosystem Partnership Fund, Arlington, USA.

Chapin III SF, Zavaleta ES, Eviner VT, Naylor RL, Vitousek PM, Reynolds HL, Hooper DU, Lavorel S, Sala OE, Hobbie SE, Mack MC and Díaz S. 2000. Consequences of changing biodiversity. *Nature*, **405(6783)**: 234-242.

Dessane D. 2003. **Energy efficiency and Life Cycle Analysis of organic and conventional olive groves in the Messara Valley, Crete, Greece**. M.Sc. Thesis, Wageningen University, 67 p

Calabrese G., Abdellatif O.M., Perrino E.V. 2016. Correlations between Organic and Conventional Management, on-Field Biodiversity and Landscape Diversity, in Olive Groves in Apulia (Italy). *Advances in Plants & Agriculture Research*. **5(4):** 00187. DOI: 10.15406/apar.2016.05.00187

Gorrod E. J. and Keith D. A. 2009. Observer variation in field assessments of vegetation condition: Implications for biodiversity conservation. *Ecological Management & Restoration,* **10(1)**: 31-40

ICARDA. 2001. **Soil and Plant Analysis Laboratory Manual**, International Center for Agricultural Research in the Dry Areas, Ryan, J.; Estefan, G.; Rashid, A., pp 172

Jackson LE, Pascual U and Hodgkin T. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agriculture, Ecosystems and Environment*, **121(3)**: 196-210

Loumou A., and Giourga C. 2003. Olive orchards: The life and identity of the Mediterranean. *Agriculture and Human Values*, **20**: 87–95

Médail F, Monnet A, Pavon D, Nikolic T, Dimopoulos P, Bacchetta G, Arroyo J, Barina Z, Cheikh Albassatneh M, Domina G, Fady B, Matevski V, Mifsud S and Leriche A. 2019. What is a tree in the Mediterranean Basin hotspot? A critical analysis. *Forest Ecosystems.* **6,** 17 (2019). https://doi.org/10.1186/s40663-019-0170-6

MIFTAH. 2014. **Olive trees – more than just a tree in Palestine**. Palestine 1-3

Myers N, Mittermeier R, Mittermeier C, da Fonseca G, Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature* **403,** 853–858 (2000). https://doi.org/10.1038/35002501

Pecheur E, Piqueray J, Monty A, Dufrêne M, Mahy Gé. 2020. The influence of ecological infrastructures adjacent to crops on their carabid assemblages in intensive agroecosystems. *PeerJ* **8**:e8094 http://doi.org/10.7717/peerj.8094

Perrino EV, Calabrese G, Ladisa G, Viti R, Mimiola G. 2011. Primi dati sulla biodiversità della flora vascolare di oliveti secolari in Puglia. *Informatore Botanico Italiano*, **43(1)**: 39-64.

Rey Benayas J. and Bullock J. 2012. Restoration of Biodiversity and Ecosystem Services on Agricultural Land. *Ecosystems*, **15(6)**: 883-899.

Shannon CE, Weaver W. 1949. **The Mathematical Theory of Communication**. University of Illinois Press, Urbana, p.117.

Srouji F. 2012. **Prospects for non-conventional agriculture in Palestine with special focus on organic farming**. Palestine Policy Economics Research Institute.

Vačkář D., ten Brink B., Loh J., Baillie J. E. M. and Reyers B. 2012. Review of multispecies indices for monitoring human impacts on biodiversity. *Ecological Indicators*, **17(0):** 58-67

Wood D. and Lenne´ J. 1997. The conservation of agrobiodiversity on-farm: questioning the emerging paradigm. *Biodiversity and Conservation*, **6(1)**: 109-129.

Zohary M. 1973. **Geobotanical Foundations of the Middle East**. Vol. 1-2, Gustav Fischer Verlag Press, Stuttgart, Swets and Zeitlinger, Amsterdam.

Jordan Journal of Natural History, 9 (1), 2022 pages: 83-88

Rodents Diversity in Wadi As Sulai, Riyadh Province, Kingdom of Saudi Arabia

Mounir R. Abi-Said[1,*] and Mohammad S. Al-Zein[2]

[1]Laboratory of Geosciences, Georesources, and Environment, Department of Life and Earth Sciences, Faculty of Science II, Lebanese University. PO Box 90656 Jdeideh, Fanar; [2]Department of Biology, Faculty of Arts & Sciences, American University of Beirut, Riad El Solh 1107 2020 Beirut Lebanon.

Received: June 2, 2022; Revised June 25, 2022; Accepted: June 30, 2022

Abstract: The rodents of Ar Riyadh Province, Kingdom of Saudi Arabia are not well documented. Twenty Sheman live traps were distributed in 23 sites along Wadi As Sulai in Ar Riyadh Province between February and April 2016 as a part of an ecological survey for the area. Nine species of rodents belonging to two families were caught four of which were reported for the first time at the species level in Ar Riyadh Province namely, *Gerbillus dasyurus, Gerbilus cheesmani, Gerbilus nanus,* and *Meriones crassus*. External, cranial, and dental measurements were recorded.

Keywords: Rodents, Dipodidae, Muridae, Wadi As Sulai, Riyadh, Saudi Arabia.

Introduction

Rodents are considered as pests and vectors of many zoonotic diseases. Nonetheless, rodents play important ecological roles that are vital for the sustainability of ecosystems. Rodents are keystone species in many ecosystems controlling the ecosystem's structure and affecting vertebrate and invertebrate species richness (Brown and Heske, 1990; Delibes-Mateos *et al*., 2011). They constitute an important prey base for a large number of predators in addition to being seed disseminators and forest regenerators (Orrock *et al*., 2004; Howe and Brown, 2000). Moreover, rodents play important ecological roles in desert ecosystems (Reichman, 1979). Hence studying rodent distribution and their existence in an ecosystem will lead to better understanding of the ecosystem.

Few studies on rodents have been conducted in Saudi Arabia (e.g. Harrison, 1972; Buttiker and Harisson, 1982; Al-Rajhi *et al*., 1993; Al-Ahmed and Al-Dawood, 2001; López-Antoñanzas and Sen, 2006; Strauss *et al.,* 2008; Henry and Dubost, 2012; Sarli *et al*., 2016). Harrison and Bates (1991) reported 46 rodent species (excluding the Sciuridae and the Hystricidae) in the Arabian Peninsula, twenty-two species of which are present in Saudi Arabia. According to the first Saudi Arabian National Report on the Convention on Biological Diversity, 22 species and subspecies of rodents belonging to fourteen genera and five families exist in Saudi Arabia and five of which are endemic to Saudi Arabia (*Gerbillus cheesmani arduus; Meriones rex philbyi; Meriones crassus longifrons; Meriones libycus arimalius; Psammomys obesus dianae*) (Abu Zinada *et al.,* 2003). Lewis *et al*. (1963) reported eight rodent species from Northern Saudi Arabia, Al Kalili (1984) documented five species of rodents from the southwest of Saudi Arabia. Very few assessments examined rodents in Ar-Riyadh Province. Four species belonging to two families were reported from Ar Riyadh city (Al-Rajhi *et al* 1993) and Al-Ahmed and Al-Dawood (2002) collected six species from Wadi Hanifah, which is parallel to Wadi As-Sulai in Riyadh city where the current study was conducted.

Wadi As-Sulai is a new project that surrounds Ar-Riyadh city parallel to Wadi Hanifa. It represents a man-made drainage system for rainwater drainage around Riyadh city. No studies on rodents were conducted on this site. Hence Rodents were studied in this area as a part of an environmental impact assessment study for the Wadi. Most recently, Abi-Said *et al* (2020) reported on the presence of at least 11 species of rodents

*Corresponding author: mabisaid9@gmail.com

based on remains from pellets of the Pharaoh Eagle Owl *Bubo ascalaphus*. This study aims to augment the information on rodents in Ar-Riyadh Province and to highlight the effect of the drainage system on their population.

Material and Methods

Area description

The area of Wadi As-Sulai is a representative of the desert ecosystem sheltering typical desert life forms. It is part of the Kharj drainage basin, is an ephemeral waterway that collects runoff water from more elevated areas surrounding it. Water draining into the wadi comes from the natural watershed (2,550 km^2), which includes Eastern Riyadh, with additional inputs from water treatment plants; the water is ultimately lost in the desert. Wadi As-Sulai stretches for ca. 120 km from north to south, its width sometimes only a few meters. It is comprised of habitats that range from semi-natural to widely disturbed, the major disturbances being grazing, pollution (discharge of partially treated and crude wastewater, construction wastes, litter, etc.), urbanization, and off-road driving. Fencing in the airport area as well as the National Guard area has partially excluded people and their animals; thus, these areas are more densely vegetated than adjacent areas. Apart from seasonal water bodies, the Wadi includes some sand/silt pans in addition to semi-permanent and permanent water bodies, some filled with treated or partially treated wastewater.

Rodent trapping

The trapping stretched from the February 3rd to April 12th, 2016. Twenty-three sites covering all the Wadi were selected for rodent trapping using 20 Sherman live traps for one night per site (Figure 1).

Due to the limited number of traps, three stations were selected per night. In each station, twenty traps baited with peanut butter, oat, sunflower seeds, and canary feed-mix were set at dusk and were checked the next day at dawn. Traps were arranged in line transects close to burrows. The caught animals were identified according to Harrison and Bates (1991), measured, photographed, skinned and skulls were cleaned and measured. All animals were taken as specimens and kept at the Department of Life and Earth Sciences collection, Lebanese University.

Results

A total of 460 trapping nights resulted in trapping 62 individuals belonging to nine species belonging to two families (Table 1, Figure 2). The conservation status of all trapped species were of least concern (LC) according to IUCN redlist 2016. The most trapped rodent was *Acomys dimidiatus* (30.65%) followed by *Meriones libycus* (27.42%) and the *Gerbillus* spp. were the least trapped (Table 1). *A. dimidiatus* were caught in rocky areas while the *M. libycus* were caught in sandy areas while *Rattus rattus* and *Mus musculus* around urban areas.

Table 1. List of rodent species and their trapping percentage at Wadi As Sulai

Family	Scientific Name	N	%
Dipodidae	*Jaculus jaculus*	6	9.68
Muridae	*Acomys dimidiatus*	19	30.65
	Gerbillus cheesmani	3	4.84
	Gerbillus dasyurus	1	1.61
	Gerbillus nanus	2	3.22
	Meriones crassus	8	12.90
	Meriones libycus	17	27.42
	Mus musculus	2	3.23
	Rattus rattus	4	6.45

External, cranial, and dental measurements of species caught were recorded (Tables 2 and 3).

Discussion

During this rapid survey, nine species of rodents were identified (Table 1). Al-Ahmed and Al-Dawood (2002) identified six rodent species in Wadi Hanifah which is parallel to

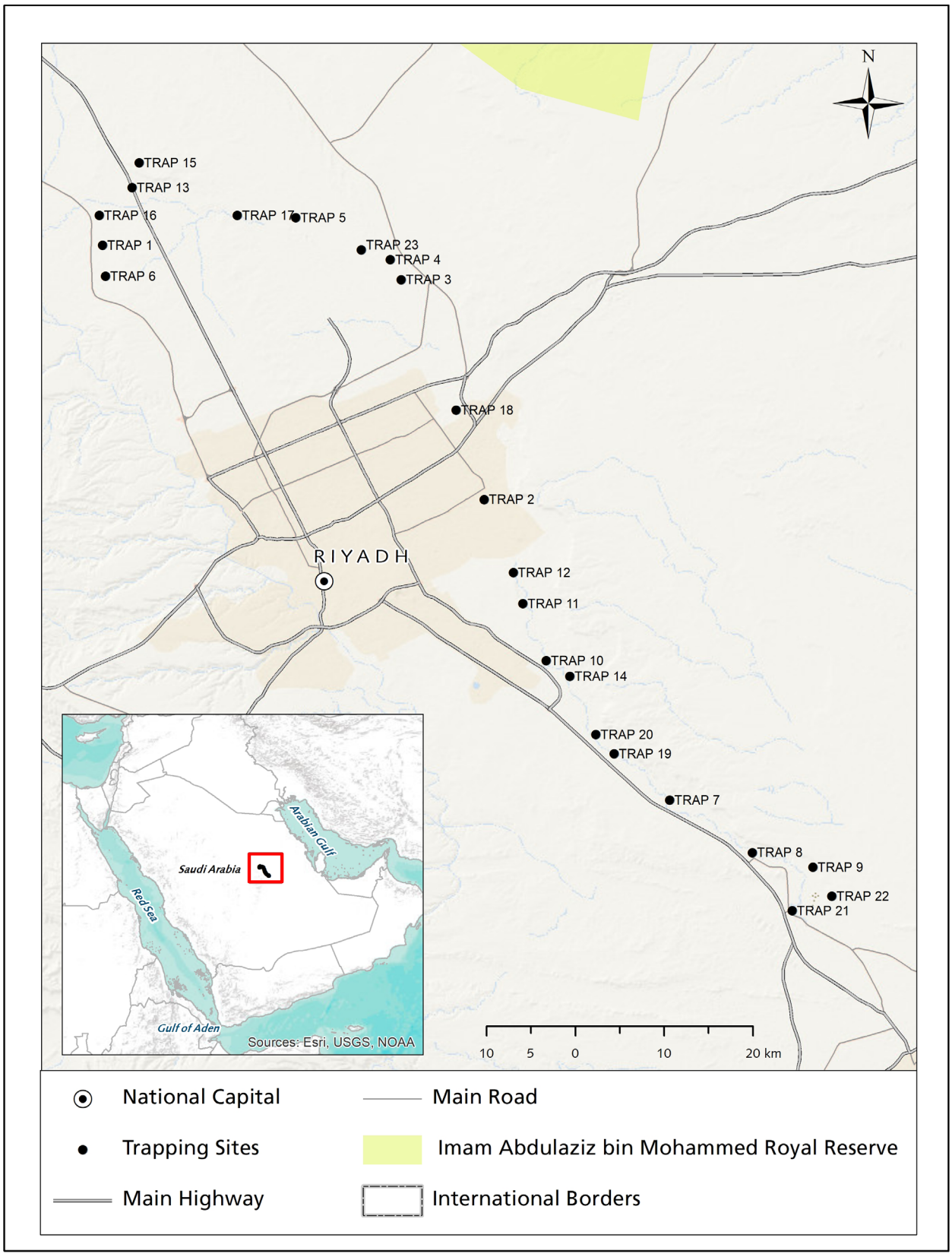


Figure 1. Trapping sites along Wadi As Sulai

Table 2. External measurements of the rodents trapped in Wadi As Sulai

Species	N	Wt. (g)	HB (mm)	TL (mm)	HL (mm)	HW (mm)	E (mm)	HF (mm)
A. dimidiatus	19	41.22	109.49	96.52	33.46	15.51	17.25	20.45
D. dasyrus	1	18	84.12	114.43	27.77	14.52	12.5	20.52
G. cheesmani	3	23.5	89.22	116.45	29.59	16.04	12.01	25.675
G. nanus	2	14.5	77.12	103.75	27.5	14.45	9.01	23.54
J. jaculus	6	48.5	114.21	168.16	34.07	25.79	19.66	60.72
M. libycus	17	146.1	167.2	156.5	44.1	23.5	17.3	41.38
M. crassus	8	80.33	126.88	138.73	38.13	21.29	14.01	33.78
M. musculus	2	7.6	65.66	69.85	21.21	10.42	12.72	18.51
R. rattus	4	161	184.14	185.84	39.98	21.71	24.93	35.45

HB: Head and body, **TL**: Tail; **HF**: Hindfoot; **HL**: Head length, **HW**: Head width, **E**: Ear; **Wt**. **g**: wight in grams

Table 3. Cranial and dental measurements of rodents trapped in Wadi As Sulai

Species	N	IC	ZB	BB	GTL	CBL	MXC	MDC	M
A. dimidiatus	19	4.93	13.71	11.2	30.41	28.83	4.79	4.47	18.25
D. dasyrus	1	5.23	11.03	12.73	26.42	23.32	3.79	3.13	14.22
G. cheesmani	3	5.2	12.67	9.67	21.42	19.24	3.72	3.72	15.34
G. nanus	2	5.04	11.57	12.83	28.9	25.8	3.98	3.75	12.48
J. jaculus	6	11.01	20.61	22.5	31.9	28.1	4.65	4.46	18.7
M. crassus	8	5.86	15.34	13.23	30.86	28.53	5.24	5.12	19.06
M. libycus	17	6.85	17.4	14.61	36.82	34.43	5.54	6.57	20.36
M. musculus	2	3.59	9.01	7.94	NA	19.97	3.16	2.77	11.28
R. rattus	4	5.95	18.37	13.52	41.11	38.92	6.55	6.16	24.46

GtL: Greatest length of skull; **ZB**: Zygomatic breadth; **IC**: Interorbital constriction; **BB**: Brain case breadth; **MXC**: Maxillary cheekteeth; **MDC**: Mandibular cheekteeth; **M**: Mandible length (incisor included).

Wadi As Sulai these included *A. dimidiatus, M. libycus*, *M. musculus* and three subspecies of *R. rattus*. While El-Bahrawy and Al-Dakhil (1993) trapped seven rodent species in Ar Riyadh namely; *J. jaculus, A. dimidiatus, M. musculus, R. rattus, R. norvegicus*, and one *Meriones* spp, and one *Gerbillus* spp. Al-Rajhi *et al*. (1993) collected only four species *A. dimidiatus*, *M. libycus, M. musculus,* and *R. rattus*. This high number of species caught is probably due to the suitable season for rodent activity where a favorable climate prevails compared to the other study in Wadi Hanifah that was carried on between August and November when the weather is very hot. The high percentage of *A. dimidiatus* is owed to the suitable landscape of rocky structures where this species can hide easily. Similarly, the high percentage of *M. libycus* caught is due to the spread of farmlands within the study site. Similarly, Al-Ahmed and Al-Dawood (2002) trapped more *M. libycus* in farmlands in Wadi Hanifah is also similar to the results reported by El-Bahrawy and Al-Dakhil (1993), Al-Rajhi *et al*. (1993) and Abi-Said *et al.* (2020).

Moreover, e*xternal,* cranial, and dental measurements of species caught were similar to those reported by Harrison and Bates (1991) and Aulagnier *et al.* (2009). This study augments the rodent fauna in Ar Riyadh Province and highlights the importance of timing the trapping activity to match the activity of the rodents in the study site. This rapid survey identified four rodents that were not reported to the species level including;

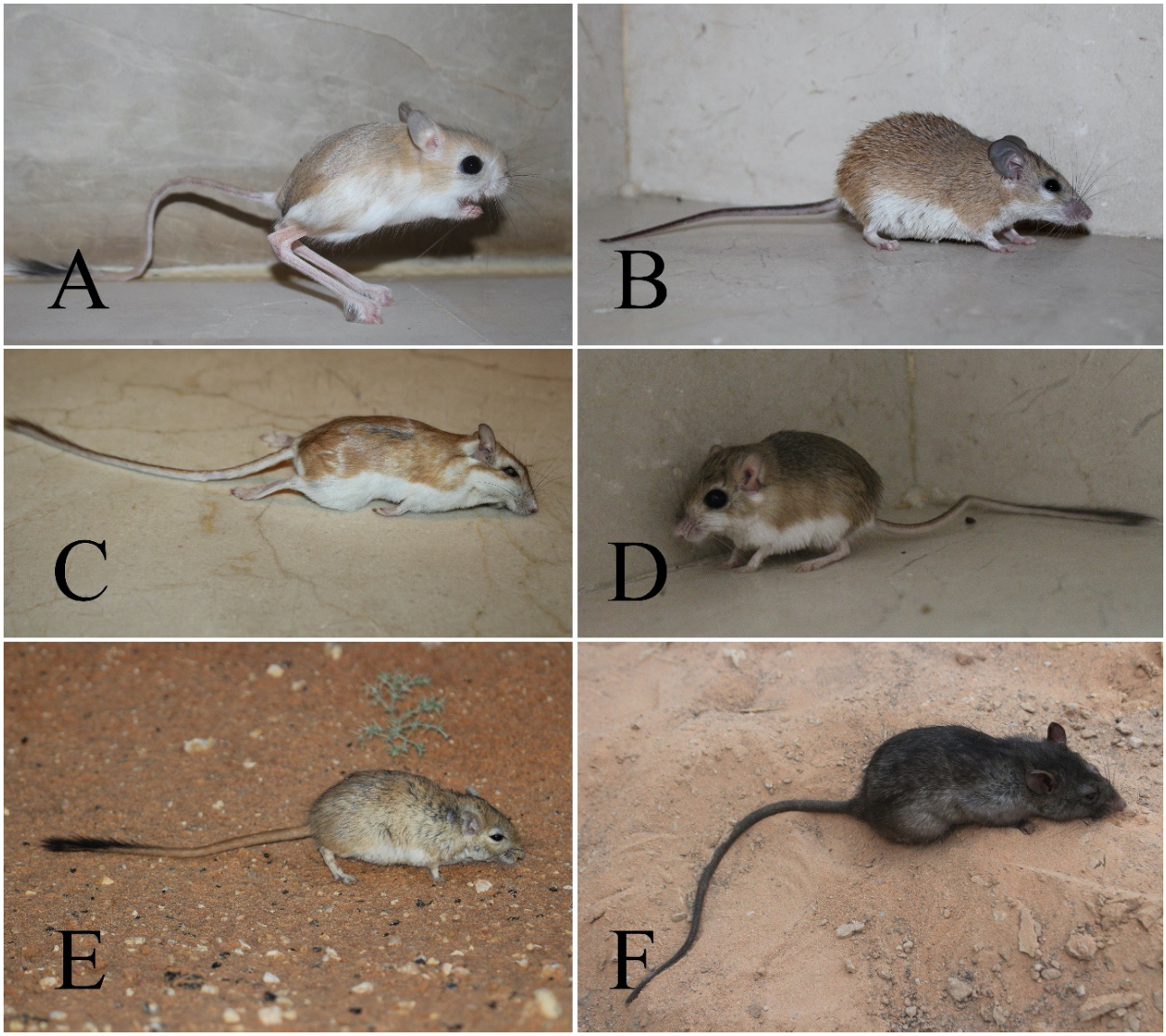


Figure 2: A. The three-toed jarboa, *Jaculus jaculus*. **B**. Arabian spiny mouse, *Acomys dimidiatus*. **C**. Cheesmani gerbil, *Gerbillus cheesmani*. **D**. Wagner's gerbil, *Gerbillus dasyurus*. **E**. The Libyan jird, *Meriones libycus*. **F**. The black rat, *Rattus rattus*.

G. cheesmani, *G. dasyrus, G. nanus*, and *M. crassus*, and provided additional external and cranial measurements. Hence a comprehensive study to cover the entire Ar Riyadh Province is needed to document the small mammals present and their relative abundance.

References

Abi-Said, MR, Al Zein, MS, Amr, ZS and Abu Baker, MA. 2020. Diet of the desert eagle owl, *Bubo ascalaphus*, in eastern Saudi Arabia. *Pakistan Journal of Zoology*, **52**: 1169–1171.

Abu Zinada, A H, Robinson, E R, Nader, I A and Al Wetaid, Y I. 2003. First Saudi Arabian National Report on the Convention on Biological Diversity. *The National Commission for Wildlife Conservation and Development, Riyadh*.

Al-Ahmed, A M and Al-Dawood, AS. 2001. Rodents and their ectoparasites in Wadi Hanifah, Riyadh City, Saudi Arabia. *Journal Egyptian Society of Parasitology*, **31**:737-744.

Al-Khalili, A D. 1984. New records of ectoparasites of small rodents from SW Saudi Arabia. *Fauna of Saudi Arabia*, **6**: 510–512.

Al-Rajhi, D H, Tag-EL-Din, A, Hussein, H I and Mostafa, S. 1993. Trapping of Rodent Pests in Riyadh Region,

Saudi Arabia. *Agricultural Research Bulletin*. 36 pp.

Aulagnier, S, Haffner, P, Mitchell-Jones, AJ, Moutou, F, and Zima, J. 2009. **Mammals of Europe, North Africa and the Middle East**. A & C Black Publishers Ltd., London, UK.

Brown, J H and Heske, E J. 1990. Control of a desert-grassland transition by a keystone rodent guild. *Science (Washington)*, **250** (4988): 1705-1707.

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

Delibes-Mateos, M, Smith, A T, Slobodchikoff, C N and Swenson, J E. 2011. The paradox of keystone species persecuted as pests: a call for the conservation of abundant small mammals in their native range. *Biological Conservation*, **144**: 1335-1346.

El Bahrawy, AA and Al Dakhil, MA. 1993. Studies on the ectoparasites (fleas and lice) on rodents in Riyadh and its surroundings, Saudi Arabia. *Journal of the Egyptian Society of Parasitology*, **23**:723-35.

Harrison, DL. 1972. **The Mammals of Arabia**. 3. Lagomorpha and Rodentia. Benn, London. pp. 382–670.

Harrison, DL and Bates, PJJ. 1991. **The Mammals of Arabia**. Sevenoaks: Harrison Zoological Museum.

Henry, O and Dubost, G. 2012. Breeding periods of *Gerbillus cheesmani* (Rodentia, Muridae) in Saudi Arabia. *Mammalia*, **76**: 383-387.

Howe, HF and Brown, JS. 2000. Early effects of rodent granivory on experimental forb communities. *Ecological Applications*, **10**: 917-924.

IUCN Red List of Threatened Species 2016: e.T136471A115208221. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T136471A22453198.en.

Lewis, RE, Lewis, JH and Harrison, DL.1973. On a collection of mammals from Northern Saudi Arabia. *Journal of Zoology*, **144**:61-74.

López-Antoñanzas, R and Sen, S. 2006. New Saudi Arabian Miocene jumping mouse (Zapodidae): systematics and phylogeny. *Journal of Vertebrate Paleontology*, **26**: 170-181.

Orrock, JL, Danielson, BJ and Brinkerhoff, RJ. 2004. Rodent foraging is affected by indirect, but not by direct, cues of predation risk. *Behavioral Ecology*, **15**: 433–437.

Reichman, O J. 1979. Desert granivore foraging and its impact on seed densities and distributions. *Ecology*, **60**:1085-92.

Sarli, J, Lutermann, H, Alagaili, AN, Mohammed, OB and Bennett, NC. 2016. Seasonal reproduction in the Arabian spiny mouse, *Acomys dimidiatus* (Rodentia: Muridae) from Saudi Arabia: The role of rainfall and temperature. *Journal of Arid Environments*, **124**:352-359.

Strauss, MW, Shah, MS 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.

Jordan Journal of Natural History, 9 (1), 2022 pages: 89-90

Short Communication

Pin Tail Snipe (*Gallinago stenura*) : A Rare Winter visitor In Nilgiris, Tamil Nadu, India

Nizamudheen Moinudheen[1] and Arockianathan Samson[2*]

[1]Independant Researcher in Nilgiri Hills, Ooty 643001, Tamil Nadu; [2] Department of Zoology and Wildlife Biology, Government Arts College, Udhagamandalam 643 002, The Nilgiris, Tamil Nadu, India

The pin-tailed snipe (*Gallinago stenura*) also known as the pintail snipe, is a small stocky wader. It breeds in northern Russia and migrates to spend the non-breeding season in southern Asia from Pakistan to Indonesia. It is the most common migrant snipe in southern India, Sri Lanka and much of Southeast Asia. It is a vagrant to north-western and northern Australia, and to East Africa Kenya. These birds forage in mud or soft soil, probing or picking up food by sight. They mainly feeds on of molluscs, adult and larval insects, earthworms and occasionally crustaceans, seeds and other plant matter (del Hoyo *et al*. 1996). In this note we portray the first record of Pin Tail Snipe in Nilgiris, Tamil Nadu, Southern India.

On 12 January 2022 10:30 AM we observed a Pin Tail Snipe in the swamp of Thalakundha area (N 11.442433, E 76.667853), The Nilgiris, Tamil Nadu. Initially we suspected that it's a Common Snipe but after the keen identification features of the bird the wings are less pointed than common snipe, and lack the white trailing edge of that species. The short greenish-grey legs and a long straight dark bill. The body is mottled brown on top, with cream lines down their back and pale underneath with a streaked buff breast and white belly. They have a dark stripe through the eye, with light stripes above and below it confirmed that it's a Pin tail Snipe. Based on the published literatures there only two available record which confirm that Pain tail snipe occurrences in Nilgiris. Davison (1883) was first recorded the Pin tail Snipe in Nilgiris. Zarri *et al*. (2005) recorded only one bird at Avalanche, near the Guest House on 20 February 2004 and he mention that it was once common and a favourite game bird in the Nilgiris. After the two official records there are no observation was done in Nilgiris on Pin tail Snipe even though eBirds (2022) database doesn't have records of Pin tail Snipe in Nilgiris till now. Hence our observation showed the occurrences of rare winter migrant of Pin tail Snipe after 18 years reported in Nilgiris region. In recent year's lots of new records as well as well reoccurrences of water birds have been continuously reported in Nilgiris region (Samson and Ramakrishnan, 2018 a,b; Moinudeen and Samson, 2021). Hence this present observation shed a light on migratory water birds in Nilgiris for further observations.

*Corresponding author: kingvulture1786@gmail.com

References

Davison, W. 1883. Notes on some birds collectedon the Nilgiris and parts of Wynaad and southernMysore. *Stray Feathers*, **10** (5): 329-419.

del Hoyo, J, Elliott, A and Sargatal, J. 1996. **Handbook of the Birds of the World**. Vol. 3: Hoatzin to Auks. Lynx Edicions, Barcelona.

eBird (2022). eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. (Accessed: January 24, 2022).

Moinudheen, N. and Samson, A. 2021. Record of Garganey in Nilgiris. *Bird-o-soar #69, In: Zoo's Print,* **36** (1): 29–30.

Samson, A and Ramakrishnan, B. 2018. Occurrence of Black Stork in Mudumalai Tiger Reserve. *Nilgiri Natural History Society* **7** (2):8.

Samson, A. and Ramakrishnan, B. 2018. White Stork: Sighting record of Ciconia ciconia (Linnaeus, 1758) in Mudumalai Tiger Reserve, Nilgiris, India. Bird-o-soar #19. In: Zoo's Print, **33**(8): 16-18.

Zarri, AA, Rahmani, AR and Senthilmurugan, B. 2005.Annotated avifauna of the Upper Nilgiris,Western Ghats, Tamil Nuda, India. *Buceros,* **10** (1): 1-46.

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.

ISSN: 2307-7565