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Jordan Journal of Natural History

Editorial Preface

It is a pleasure to present issue 7 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, we would like to thank our readers and authors for their continuing interest in JJNH, and each member of our editorial and review boards for their continued hard work, support and dedication, which made it possible to bring another new issue of JJNH to the multidisciplinary international audience. We very much appreciate your support as we strive to make JJNH one of the most leading and authoritative journals in the field of Natural History Sciences.

December, 2020

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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.

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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.

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Key words	word; another word; lower case except names. Position aligned with abstract
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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

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Table of Contents

Jordan Journal of Natural History, 7, 2020 Pages: 11-29

Recent Observations on Amphibians and Reptiles in the Hashemite Kingdom of Jordan

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Abstract: The herpetofauna of Jordan has been extensively studied over the past few decades not only by local herpetologists but by foreign ones as well. Additional information on the current status, distribution, and ecology of amphibians and reptiles is indeed crucial for the conservation authorities as it enables them to take an inventory of certain areas together with some protection and conservation actions. Herein, this study reports observations of three amphibians and thirty-two reptile species along with some distributional and ecological notes.

Keywords: Herpetofauna, Faunistics, New records, Levant, Middle East.

Introduction

The Hashemite Kingdom of Jordan together with other Levant countries (south-central Turkey, Syria, Lebanon, and Palestine) represents a geographical bridge that connects Africa, Europe, and Asia (Disi, 1996). In addition to having a long and complex geomorphological history, the Levant countries are well-known for their high level of biodiversity and endemism in the Western Palearctic region as far as many species are concerned including reptiles and amphibians (Sindaco and Jeremčenko, 2008; Ficetola *et al*., 2018).

For more than 100 years, herpetofauna of Jordan has attracted the attention not only of local and foreign herpetologists as well. This has resulted in publishing new records, observations, and inventories of protected areas (Wittenberg, 1992; Sindaco *et al*., 1995; Abu Baker *et al*., 2004; 2005), in addition to large overviews and checklists based on international collaboration (Disi *et al*., 2001; Disi and Amr, 2010; Amr and Disi, 2011). The use of DNA sequencing, modern molecular methods, and integrative taxonomy enabled researchers to reveal the cryptic diversity among certain species; some of which were later described as new species (Moravec *et al.*, 2011; Melnikov *et al*., 2012; Nazarov *et al*., 2013). This shows that despite the long and intense herpetofauna research in this country, there are still more research to be conducted and more faunistic gaps to be filled. Herein, this study reports additional records and observations of thirty-five recorded species of amphibians and reptiles.

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Materials and Methods

During late September of 2019, a group of four Czech naturalists conducted day and night surveys at thirteen localities in Jordan (Figure 1; Table 1) with the objective of observing and mapping the herpetofaunal diversity. The date, time, and number of individuals were documented. The geographical coordinates and altitude of all records were documented using GPS navigation. All observed species together with their habitats were photographed if possible (Figure 2).

All animals, if captured, were released

at the same place without any physical harm after being photographed. Most species were identified using the available literature and identification keys (Arnold, 1980b; Disi *et al*., 2001; Disi and Amr, 2010; Amr and Disi, 2011; Moravec *et al*., 2011). The species, which were not examined in details, were determined with respect to their distributional and ecological status and their species determination, is therefore, discussed. Records of certain species that were not summarized by Disi and Amr (2010) or Amr and Disi (2011) were considered in this study as new ones.

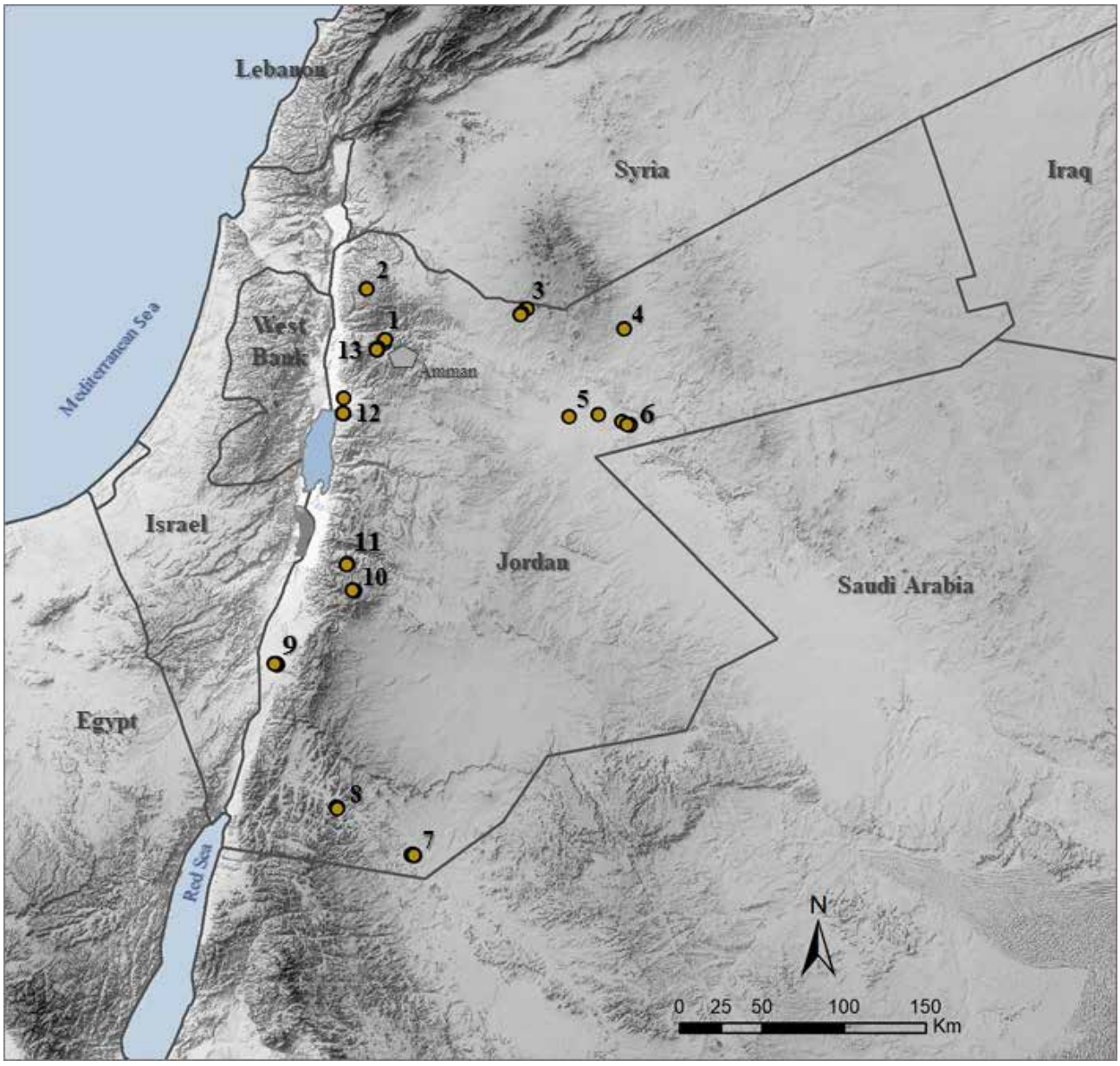


Figure 1. Map of the Hashemite Kingdom of Jordan. Dots with numbers represent visited localities. Numbers of localities correspond to the numbers in Table 1 and Table 2.

Results

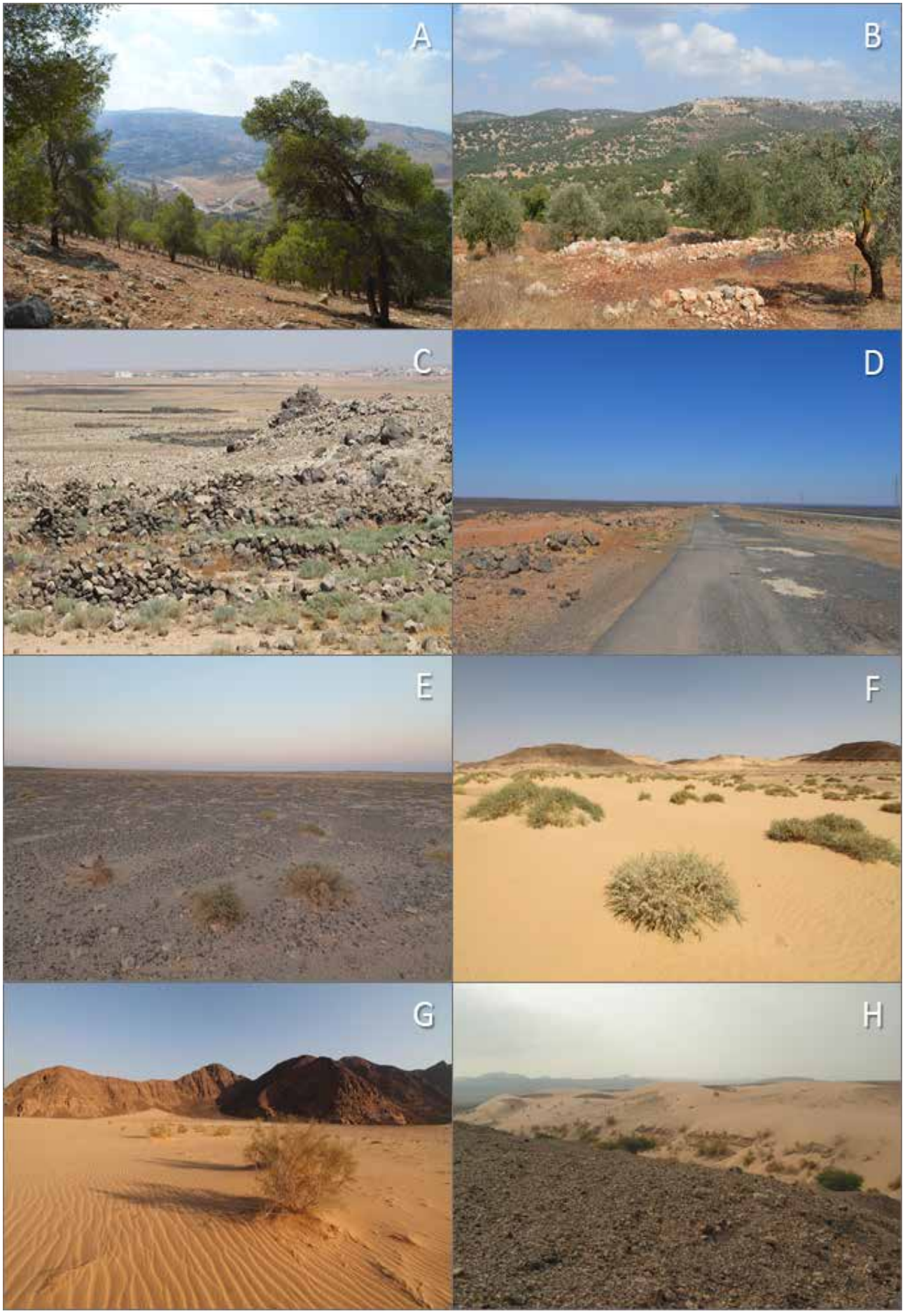
All of the thirteen visited localities with their GPS coordinates are shown in Table 1. A summary of the sympatrically observed species in each locality is presented in Table 2. The numbers of each locality in Table 2 correspond to the locality numbers in Table 1.

Amphibians

Family Bufonidae

Bufotes sitibundus (Pallas, 1771) – Figure 3A

Observed individuals: 1 (1.5 km E of Al Rumaymin); 4 (10 km NE of Tafila, wadi); 10 (Umm Al Quttein).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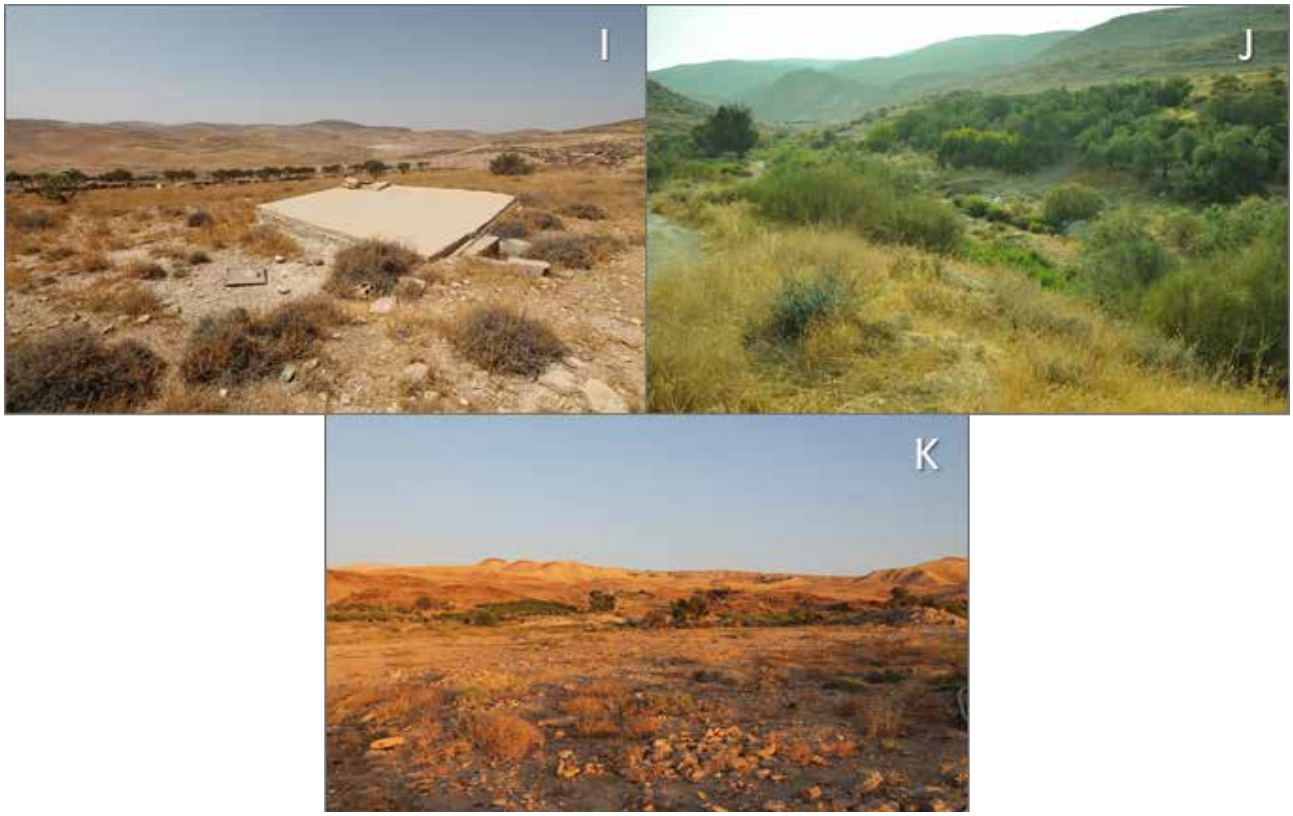

Figure 2. Variety of visited habitats. Numbers in parentheses correspond to localities in Fig. 1. A: 600 m NE of Rujm Shubayl (1); B: 1,5 km SW of Zubyia (2); C: Umm Al Qutein (3); D: 5 km NE of Safawi (4); E: 20 km NE of S. Arabia border crossing (6); F: 2 km E of Mudawwara (7); G: 2,5 km SE of Munayshir (8); H: Wadi Araba (9); I: 10 km SE of Tafila (10); J: 10 km NE of Tafila (11); K: 4 km SE of Swemeh, E of Dead Sea (12).

Occurrence in Jordan: Distributed over a variety of habitats, including semideserts, limited only to suitable breeding sites (see map in Disi and Amr, 2010).

Comments: The name, *B. variabilis,* to which Middle Eastern populations were traditionally referred, is a junior synonym of *B. sitibundus* (Pallas, 1771) (Dufresnes *et al*., 2019b).

Table 1. All 13 visited localities with their GPS coordinates. Numbers correspond to the numbers of localities in Figure 1 and Table 2.

Number and name of locality	GPS coordinates (latitude [N]; longitude [E])
1. 600 m NE of Rujm Shubayl	32.1509; 35.8565
2. 1.5 km SW of Zubyia	32.4270; 35.7522
3. Umm Al Quttein	32.3166; 36.629
4. 5 km NE of Safawi	32.2093; 37.1657
5. road from A5 to Al Hazim	31.7271; 36.8624
6. 20 km NE of S. Arabia border crossing	31.6830; 37.1956
7. 2 km E of Mudawwara	29.3159; 36.0023
8. 2.5 km SE of Munayshir	29.5792; 35.5916
9. Wadi Araba	30.3660; 35.2628
10. 10 km SE of Tafila	30.7675; 35.6858
11. 10 km NE of Tafila, wadi	30.9158; 35.6461
12. 4 km SE of Swemeh, E of Dead Sea	31.7425; 35.6242
13. 1.5 km E of Al Rumaymin	32.1036; 35.8153

Table 2. Summary of sympatrically observed species on each locality. Numbers correspond to the numbers of localities in Figure 1 and Table 1.

Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Bufotes sitibundus			•								•		•
Hyla felixarabica			•								•		
Pelophylax bedriagae													•
Pristurus sp.								•					
Bunopus tuberculatus						•	•						
Hemidactylus dawudazraqi	•		•							•	•	•	
Stenodactylus doriae							•	•					
Stenodactylus slevini							•						
Stenodactylus sthenodactylus												•	
Tropiocolotes nattereri								•				•	
Ptyodactylus cf. ananjevae							•						
Ptyodactylus guttatus									•	•	•	•	•
Ptyodactylus hasselqustii								•					
Ptyodactylus puiseuxi		•	•										
Phrynocephalus arabicus							•	•					
Pseudotrapelus sinaitus werneri				•									
Stellagama stellio picea			•										
Stellagama stellio ssp.	•	•								•			•
Trapelus ruderatus			•										
Trapelus agnetae					•	•							
Ophisops elegans	•	•											•
Acanthodactylus schmidti							•						
Acanthodactylus tilburyi							•						
Mesalina sp.				•									
Chamaeleo chamaeleon										•	•		•
Scincus scincus							•						
Testudo graeca	•		•										
Spalerosophis diadema							•						
Dolichophis jugularis											•		
Atractaspis engaddensis												•	
Malpolon insignitus		•											
Malpolon moilensis					•								
Walterinnesia aegyptia											•		
Echis coloratus								•	•				
Macrovipera lebetinus											•		

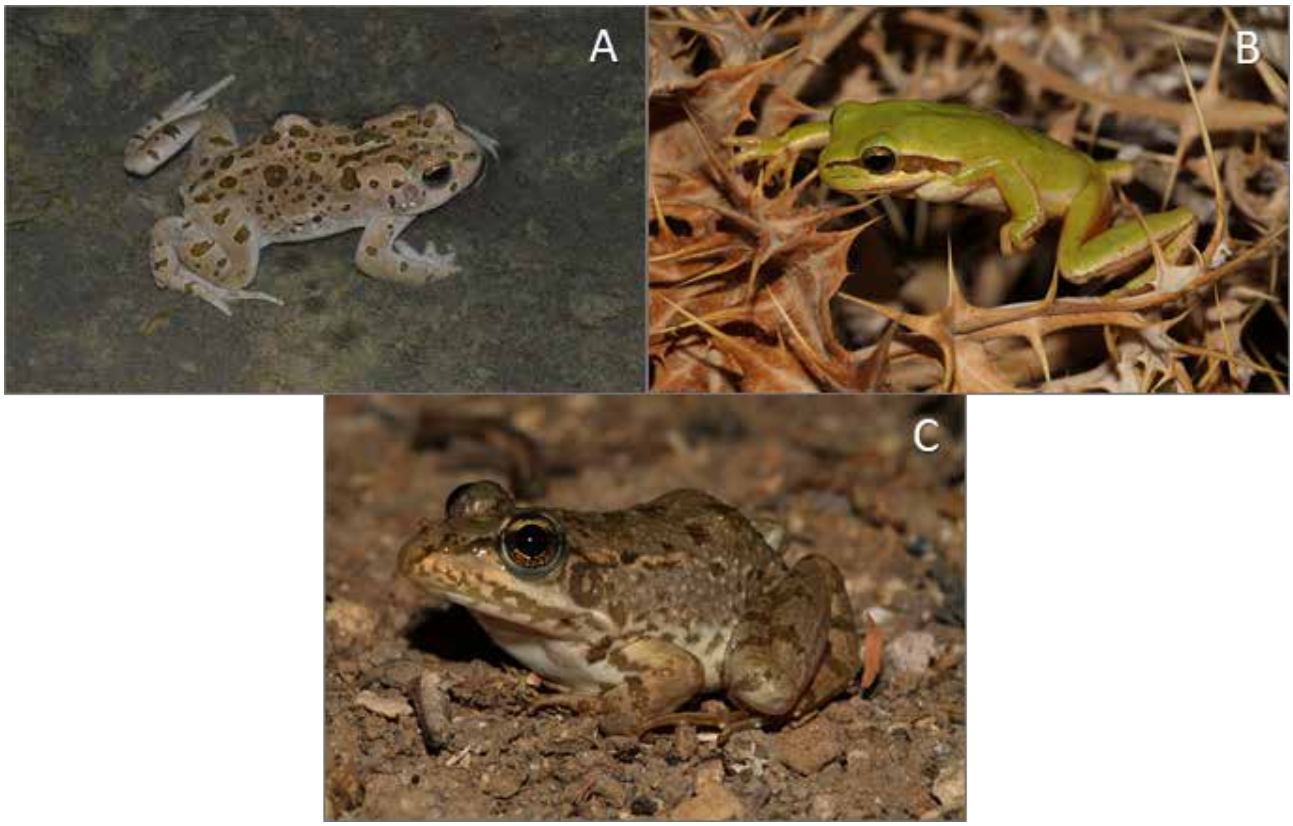

Figure 3. A: *Bufotes sitibundus*, 10 km NE of Tafila; B: *Hyla felixarabica*, 10 km NE of Tafila; C: *Pelophylax bedriagae,* 1.5 km E of Al Rumaymin.

Family Hylidae

Hyla felixarabica Gvoždík, Moravec, Klütsch and Kotlík, 2010 – Figure 3B.

Observed individuals: 10 (Umm Al Quttein); 5 (Tafila region).

Occurrence in Jordan: Wadi Mujib, Wadi Fidan, Zara, Wadi Hasa, and Wadi Dana (Gvoždík *et al*., 2010); it is questionable which records of *H. savignyi* sensu lato in Disi *et al*. (2001) and Disi and Amr (2010) represent in fact the new species *H. felixarabica* described by Gvoždík *et al*. (2010).

New records: Umm Al Quttein, Roman water source.

Comments: It should be taken into account that the observed specimens were not examined in detail or compared by molecular methods. Both localities are found in the east of the Rift Valley; based on the available literature (Gvoždík e*t al*., 2010; Dufresnes *et al.*, 2019a), these records were considered as *H. felixarabica* rather than *H. savigny* Audouin, 1827.

Family Ranidae

Pelophylax bedriagae (Camerano, 1882) – Figure 3C.

Observed individuals: 1 (1.5 km E of Al Rumaymin).

Occurrence in Jordan: Mediterranean habitats with an isolated population in the Azraq wetlands (Disi *et al*., 2001; Disi and Amr, 2010).

Comments: A single individual was observed at night in the vicinity of an olive orchard.

Reptiles

Family Sphaerodactylidae

Pristurus sp. – Figure 4A

Observed individuals: 8 (2.5 km SE of Munayshir).

Occurrence in Jordan: Described from the vicinity of Guweira (Haas, 1943); Wadi Rumm; Aqaba mountains (Disi *et al*., 2001).

Comments: Several individuals were observed on steep rocky slopes surrounded by sandstone cliffs. This species is diurnal

Figure 4. A: *Pristurus sp*., 2.5 km SE of Munayshir; B: *Bunopus tuberculatus*, 20 km NE of S. Arabia border crossing; C: *Hemidactylus dawudazraqi*, 600 m NE of Rujm Shubayl; D: *Stenodactylus doriae*, 2 km E of Mudawwara; E: *Stenodactylus slevini*, 2 km E of Mudawwara; F: *Stenodactylus sthenodactylus*, 4 km SE of Swemeh, E of Dead Sea.; G: *Tropiocolotes nattereri*, 12. 4 km SE of Swemeh, E of Dead Sea.

and heliothermic. They were found to be extremely shy and always prepared to hide when approached. All of them were found close to rocky crevices.

See Badiane *et al*. (2014), who provided more information regarding the phylogeny and taxonomy of this genus. According to their molecular phylogenetic analysis, *P. rupestris* is paraphyletic. The populations from Jordan together with other samples clustering in the so-called western clade are preliminarily marked as *Pristurus sp*. until more type specimens will be examined and taxonomic conclusions will be made.

Family Gekkonidae

Bunopus tuberculatus Blanford, 1874 – Figure 4B

Observed individuals: 1 (20 km NE of S. Arabia border crossing); 2 (2 km E of Mudawwarah).

Occurrence in Jordan: Wadi Araba; Wadi Rumm; Abar Al Hazim; Azraq; Shawmari NR (Disi *et al*., 2001; Disi, 2011).

New records: 2 km E of Mudawwarah.

Comments: It is questionable whether populations from Jordan and the rest of the Arabian Peninsula are conspecific with those from the type locality in southeastern Iran (Arnold, 1980a; Leviton *et al*., 1992). Červenka *et al*. (2008) and later on Khosravani *et al*. (2017), who studied the phylogenetic relationships of this genus, found *Bunopus tuberculatus* to be paraphyletic.

Hemidactylus dawudazraqi Moravec, Kratochvíl, Amr, Jandzik, Šmíd and Gvoždík, 2011 – Figure 4C

Observed individuals: 3 (4 km SE of Swemeh, E of Dead Sea); 3 (Wadi Araba); 2 (10 km NE of Tafila, wadi); 1 (Umm Al Quttein, ruins).

Occurrence in Jordan: Azraq; Wadi Mujib; Little Petra; Jawa (see map in Moravec *et al.* 2011); some of the previous records (see Disi *et al*., 2001) might represent records of other species from the *Hemidactylus turcicus* species complex.

Comments: The specimens were neither examined in details, nor compared by molecular methods; rather, all observed individuals were considered as *Hemidactylus dawudazraqi* based on the researchers' current knowledge of the distribution of both of these two species of the genus *Hemidactylus* known from Jordan up to date (*H. dawudazraqi* and *H. mindiae*). The third species *H. lavadeserticus* is highly expected to be present in the black lava desert in the north of the country (Disi *et al*., 2001; Amr *et al*., 2007; Moravec *et al*., 2011). *Hemidactylus dawudazraqi* was formerly thought to be the common Mediterranean synantropic species *Hemidactylus turcicus* (Disi *et al*., 2001). However, the integrative taxonomic approach revealed that it represents a cryptic species from the *Hemidactylus turcicus* species complex and was described as a new distinct species (Moravec *et al*., 2011).

Stenodactylus doriae Blanford, 1874 – Figure 4D

Observed individuals: 15 (2 km E of Mudawwara); 3 (2.5 km SE of Munayshir); 8 (Wadi Araba).

Occurrence in Jordan: Wadi Araba; Abar Al Hazim; Wadi Rumm; Mudawwarah (Disi *et al.*, 2001; Disi 2011).

Comments: Typical psammophilous species found in sandy deserts across the whole Arabian Peninsula. Wadi Araba represents its westernmost distribution limit on both sides of the valley (Werner, 1987). As mentioned by Arnold (1980b) and Metallinou *et al*. (2012), different species of the genus *Stenodactylus* may be found as sympatric in Jordan, however they differ in the ecological niche partitioning. *Stenodactylus doriae* is usually found on sands, whereas the smaller *Stenodactylus slevini* inhabits the transitional zone between the sandy and the stony deserts (Disi *et al*., 2001).

Stenodactylus slevini Haas, 1957 – Figure 4E

Observed individuals: 11 (2 km E of Mudawwara).

Occurrence in Jordan: Mudawwara; Batn Al Ghul; northern Badia (Disi *et al*., 2001; Disi, 2011).

Comments: Individuals were found in the

transitional zone between the sandy and the stony deserts.

Stenodactylus sthenodactylus
Lichtenstein, 1823 – Figure 4F
Observed individuals: 2 (4 km SE of Swemeh, E of Dead Sea).
Occurrence in Jordan: The Dead Sea region; Wadi Araba; Wadi Rumm (Disi *et al*., 2001; Disi, 2011).
Comments: Both individuals were found early after sunset foraging on the ground.

Tropiocolotes nattereri Steindachner, 1901 – Figure 4G
Observed individuals: 1 (2.5 km SE of Munayshir); 1 (4 km SE of Swemeh, E of Dead Sea).
Occurrence in Jordan: The Dead Sea region; Wadi Araba; Wadi Rumm (Disi *et al*., 2001; Disi, 2011).
Comments: Individuals were observed early after sunset foraging on the ground.

Family Phyllodactylidae
Ptyodactylus cf. ananjevae Nazarov, Melnikov and Melnikova, 2013 – Figure 5A
Observed individuals: 1 (2 km E of Mudawwara).
Occurrence in Jordan: check the information given below (Nazarov *et al*., 2013).
Comments: The specimen was neither examined in detail, nor compared by molecular methods. This record was considered as *Ptyodactylus cf. ananjevae* based on the published photographs, the vicinity of the type locality (Nazarov *et al.*, 2013), and its general look. This species was described from the *Ptyodactylus hasselquistii* species complex based on the specimens collected in the vicinity of Mudawwara. So far, it is known only from the material collected from the type locality (Nazarov *et al*., 2013). Further sampling is necessary to clarify the status of this species, its distribution range, and whether the records from Mudawwarah represent *Ptyodactylus hasselquistii* or *Ptyodactylus ananjevae*.

Ptyodactylus guttatus Heyden, 1827 – Figure 5 B
Observed individuals: 3 (Wadi Araba); 2 (10 km SE of Tafila); 2 (10 km NE of Tafila, wadi); 2 (4 km SE of Swemeh, E of Dead Sea); 2 (1.5 km E of Al Rumaymin).
Occurrence in Jordan: Irano-Turanian habitats; the Dead Sea region; Wadi Araba; Wadi Dana; Wadi Rumm (Disi *et al.*, 2001; Disi, 2011).

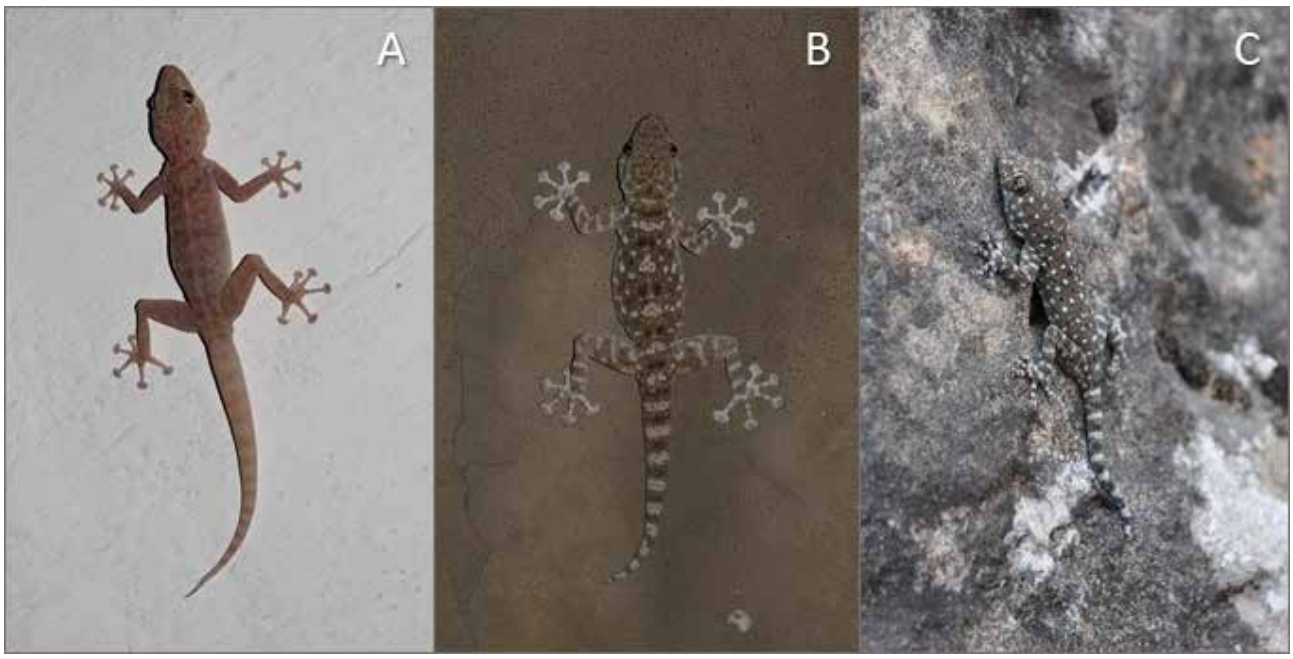

Figure 5. A: *Ptyodactylus ananjevae*, 2 km E of Mudawwara; B: *Ptyodactylus guttatus*, 1.5 km E of Al Rumaymin; C: *Ptyodactylus puiseuxi*, 1.5 km SW of Zubyia.

Comments: All individuals were observed early after sunset climbing on the rocks or walls.

Ptyodactylus hasselqustii (Donndorf, 1798)
Observed individuals: 5 (2.5 km SE of Munayshir)
Occurrence in Jordan: Wadi Rumm; lower parts of Wadi Araba; Aqaba mountains; Mudawwarah (Disi *et al*., 2001; Disi, 2011).
Comments: All individuals were found early after sunset on rocky boulders.

Ptyodactylus puiseuxi Boutan, 1893 – Figure 5C
Observed individuals: 3 (1.5 km SW of Zubyia); 1 (Umm Al Quttein, ruins); 9 (4 km SW of Umm Al Quttein).
Occurrence in Jordan: Mediterranean habitats in the western and north-western Jordan; Eastern desert = northern Badia (Disi *et al*., 2001; Disi, 2011).
Comments: It was observed in the morning hours basking on the rocks.

Family Agamidae
Phrynocephalus arabicus Anderson, 1894 – Figure 6A
Observed individuals: 6 (2 km E of Mudawwara); 1 (2.5 km SE of Munayshir).
Occurrence in Jordan: Wadi Rumm; Mudawwarah region (Disi *et al*., 2001; Disi, 2011).
Comments: This species is diurnal and heliophilous. All individuals were observed on the loose sand in the morning and in the late afternoon. When threatened, they run in the distance, where they dig themselves in the sand. In Jordan, this species was recorded for the first time in 1988 (Wittenberg, 1992). Another species *Phrynocephalus maculatus* was recorded in Jordan in 2003 in the northern Badia region (Abu Baker *et al*., 2005), and later it was recorded in the Mudawwarah region as well (Scholz *et al*., 2013). In comparison with *Phrynocephalus arabicus*, it inhabits hard soils and gravel plains (Abu Baker *et al*., 2005).

Pseudotrapelus sinaitus werneri Moravec 2002 – Figure 6B
Observed individuals: 1 (5 km NE of Safawi)
Occurrence in Jordan: *Pseudotrapelus sinaitus werneri* – Eastern desert (Moravec, 2002).
Comments: A single individual was observed at midday basking on a rock. Another species of the genus *Pseudotrapelus aqabensis* was described from Aqaba. Later, it was confirmed that it does not represent a closely-related species to *Pseudotrapelus sinaitus* (Melnikov *et al*., 2012; Tamar *et al*., 2016).

Stellagama stellio picea (Parker, 1935) – Figure 6C
Observed individuals: 3 (SW of Umm Al Quttein, along the road); 2 (4 km SW of Umm Al Quttein)
Occurrence in Jordan: Eastern desert = northern Badia (Disi *et al*., 2001; Disi, 2011).
Comments: This diurnal species was observed in the black lava desert on the rocks or walls in the morning hours.

Stellagama stellio ssp. (Linneaus, 1758)
Observed individuals: 1 (600 m NE of Rujm Shubayl); 1 (1.5 km SW of Zubyia); 2 (10 km SE of Tafila, abandoned building); 1 (3 km S of Al Kafrayn, along the road); 1 (1,5 km NE of Ayn Khunayzir); 1 (1,5 km E of Al Rumaymin).
Occurrence in Jordan: Mediterranean habitats and the western mountain region (Disi *et al*., 2001).
Comments: This diurnal species was observed on the rocks during daytime.

Trapelus ruderatus Olivier, 1804 – Figure 6D
Observed individuals: 1 (4 km SW of Umm Al Quttein).
Occurrence in Jordan: Mediterranean and Irano-Turanian habitats in western Jordan; northern Badia (Disi *et al*., 2001; Disi, 2011).
Comments: A single individual was observed among rocks in the morning hours.

Trapelus agnetae (Werner, 1929) – Figure 6E
Observed individuals: 1 (20 km NE of S. Arabia border crossing); 1 (road from A5 to Al Hazim).
Occurrence in Jordan: *Trapelus pallidus agnetae* – Eastern desert = northern Badia.

Figure 6. A: *Phrynocephalus arabicus*; 2 km E of Mudawwara; B: *Pseudotrapelus sinaitus werneri*, 5 km NE of Safawi; C: *Stellagama stellio picea,* Umm Al Qutein; D: *Trapelus ruderatus*, Umm Al Qutein; E: *Trapelus cf. agnetae*, 20 km NE of S. Arabia border crossing.

Comments: The taxonomy of agamids of the genus *Trapelus* in Jordan is not stable (Disi *et al*., 2001; Wagner *et al*., 2011). Several different names were used for this species including (*Trapelus pallidus agnetae*, *Trapelus palidus haasi,* and *Trapelus agnetae*). A comprehensive study is recommended with sampling across the Middle East along with molecular analyses to reveal whether the populations from Egypt and Palestine belong to the same species of the populations in east of Wadi Araba in Jordan. The species previously referred to *Trapelus pallidus* is distributed mostly in Irano-Turanian ecozone, but can also be found in Wadi Araba (Disi *et al*., 2001).

Family Lacertidae

Ophisops elegans Ménétries, 1832

Observed individuals: 10 (600 m NE of Rujm Shubayl); 3 (1.5 km SW of Zubyia); 1 (1.5 km E of Al Rumaymin)

Occurrence in Jordan: Mediterranean and Irano-Turanian ecozones; Eastern desert = northern Badia (Disi *et al*., 2001).

Comments: All individuals were observed

in the morning and around midday. When approached, they quickly ran under bushes, stones, or into rocky crevices.

Acanthodactylus schmidti Haas, 1957 – Figure 7A

Observed individuals: 3 (2 km E of Mudawwara); 1 (2.5 km SE of Munayshir).

Occurrence in Jordan: Southern Jordan (Batn Al Ghul, Mudawwarah region, Wadi Rumm) and Eastern desert = northern Badia (Abar Al Hazim area) (Disi *et al*., 2001; Disi, 2011).

Comments: Individuals were observed in the morning and in the late afternoon in sandy areas with a scattered bush vegetation.

Acanthodactylus tilburyi Arnold, 1986

Observed individuals: 1 (2 km E of Mudawwara).

Occurrence in Jordan: Mudawwarah region (Disi *et al.*, 2001) and northern Badia (Disi, 2011).

Comments: This small lacertid species was recorded in Jordan for the first time by Modrý *et al*. (1999). This species is active during the early morning hours until noontime.

Mesalina guttulata species complex – Figure 7B

Observed individuals: 1 (5 km NE of Safawi).

Occurrence in Jordan: Eastern desert; vicinity of Safawi (see Sindaco *et al*., 2018 for map of the sampled localities).

Comments: Populations from Jordan may represent an undescribed species (Sindaco *et al*., 2018).

Family Chamaeleonidae

Chamaeleo chamaeleon (Linnaeus, 1758) – Figure 7C

Observed individuals: 2 (10 km SE of Tafila, olive orchard); 1 (10 km NE of Tafila); 1 (1.5 km E of Al Rumaymin).

Occurrence in Jordan: Widespread in Mediterranean habitats but can also be found in Wadi Rumm and Azraq wetlands as relict populations (Abu Baker *et al*., 2004; Disi, 2011).

Comments: Populations from Jordan are referred to the subspecies *Chamaeleo chamaeleon recticrista* (Disi *et al*., 2001). In the Tafila region, the locals were surprisingly afraid of its presence in their orchard.

Family Scincidae

Scincus scincus (Linnaeus, 1758)

Observed individuals: 1 (2 km E of Mudawwara).

Occurrence in Jordan: Southern Jordan – Wadi Rumm; Mudawwarah region; Eastern desert = northern Badia – Abar Al Hazim area (Disi *et al*., 2001; Amr and Disi, 2011).

Comments: Populations from Jordan are referred to the subspecies *Scincus sincus meccensis* (Arnold and Leviton, 1977). Specimen escaped and unfortunately was not photographed.

Family Testudinidae

Testudo graeca Linnaeus, 1758 – Figure 7D

Observed individuals: 3 (600 m NE of Rujm Shubayl); 1 (4 km SW of Umm Al Quttein).

Occurrence in Jordan: Mediterranean habitats in western Jordan (Disi *et al*., 2001).

New records: 4 km SW of Umm Al Quttein.

Comments: The observation from 4 km SW of Umm Al Quttein represents an interesting record from the black lava desert and falls into Irano-Turanian ecozone. However, some previous records of this species from remote areas outside its Mediterranean distribution were considered as human introduced (Disi *et al*, 2001). It was reported in the black lava desert in SW Syria (Jabal ad Durūz Mountains) (Široký *et al*., 2007).

Family Colubridae

Spalerosophis diadema (Schlegel, 1837) – Figure 8A

Observed individuals: 1 (2 km., E of Mudawwara).

Occurrence in Jordan: Widely distributed in Jordan, where it inhabits a variety of different habitats (see map for this species in Disi *et al*., 2001 or Amr and Disi, 2011).

New records: 2 km E of Mudawwara.

Comments: A single individual was found early after sunset foraging on the ground.

Dolichophis jugularis (Linneaus, 1758) – Figure 8B

Observed individuals: 1 (10 km NE of Tafila, wadi).

Occurrence in Jordan: Mediterranean habitats and the western mountain region (Disi *et al*.,

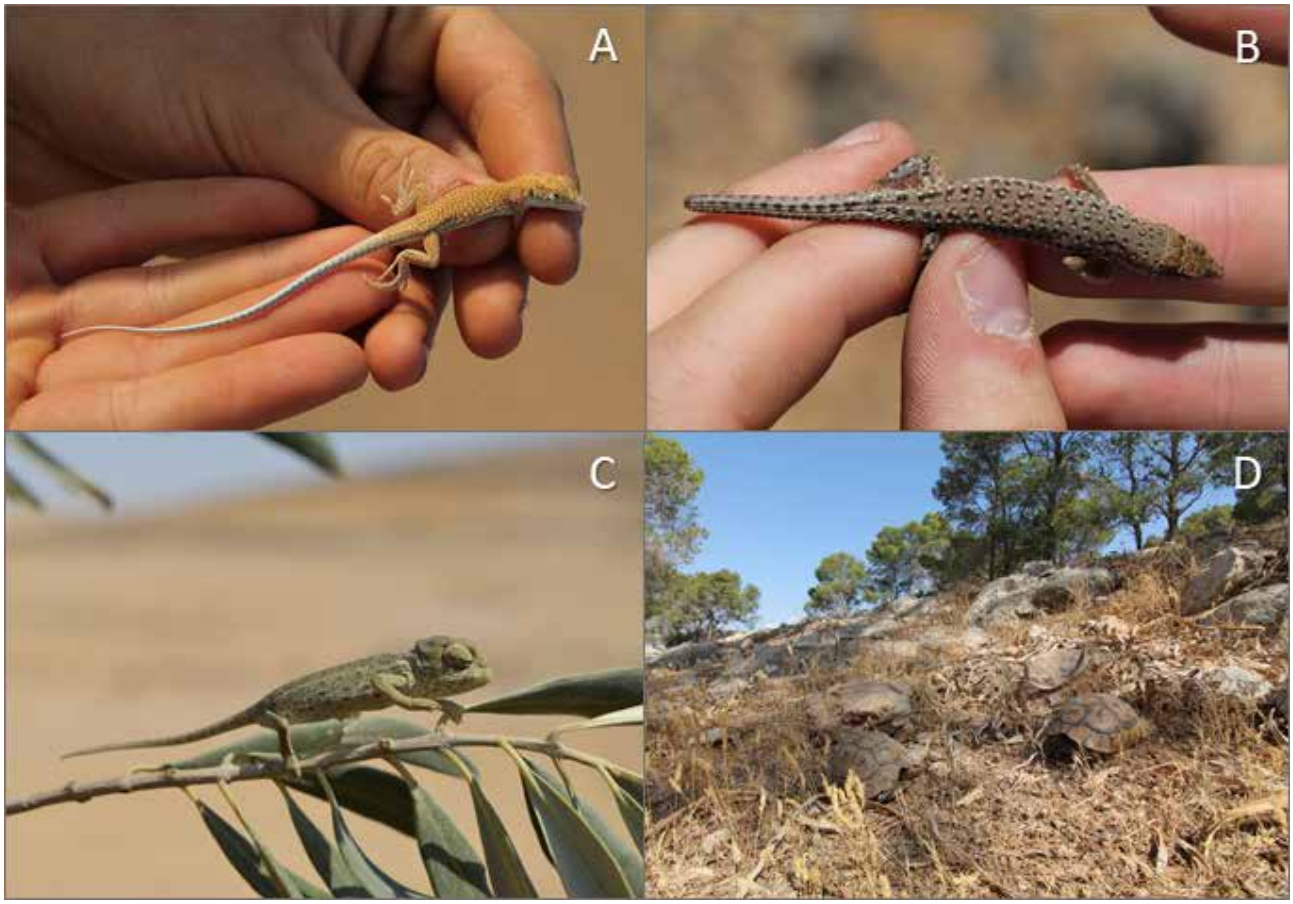

Figure 7. A: *Acanthodactylus schmidti*, 2.5 km SE of Munayshir; B: *Mesalina sp*., 5 km NE of Safawi; C: *Chamaeleo chamaeleon*, 10 km SE of Tafila; D: *Testudo graeca*, 600 m NE of Rujm Shubayl.

2001; Amr and Disi, 2011).
Comments: One juvenile was found in an olive orchard in the morning. Adults might be confused with *Walterinnesia aegyptia*, because of its uniformly black colour. However, young individuals have a spotted pattern, which disappears in adults. According to Disi *et al*. (2001), it is one of the most feared snake species by the local people, possibly because of its size and aggressiveness when cornered.

Family Atractaspididae
Atractaspis engaddensis Haas, 1950 – Figure 8C
Observed individuals: 1 (4 km SE of Swemeh, E of Dead Sea).
Occurrence in Jordan: The Dead Sea region (Wadi Faynan; Wadi Mujib NR; shores of the Dead Sea) (Disi *et al*. 2001; Amr and Disi 2011).
Comments: A single individual was found early after sunset foraging on the ground. This nocturnal and fossorial species was recorded for the first time in Jordan in the 1990s (Al Oran and Amr, 1995). Its distribution in Jordan might be associated with the Levant rift as almost all known records of this species come from the Dead Sea region and its close surroundings (Amr and Disi, 2011).

Family Psammophiidae
Malpolon insignitus (Geoffroy-saint. Hilaire, 1827) – Figure 8D
Observed individuals: 1 (1.5 km SW of Zubyia).
Occurrence in Jordan: Mediterranean habitats in western and north-western Jordan but can also be found in Irano-Turanian ecozone (see Disi *et al*., 2001; Amr and Disi, 2011).
Comments: One juvenile individual was observed around midday close to a stone wall bordering an olive orchard. In Jordan, it reaches its southernmost distribution range limit (Amr and Disi, 2011).

Malpolon moilensis (Reuss, 1834) – Figure 8E

Figure 8. A: *Spalerosophis diadema*, 2 km E of Mudawwara; B: *Dolichophis jugularis*, 10 km NE of Tafila; C: *Atractaspis engaddensis*, 4 km SE of Swemeh, E of Dead Sea; D: *Malpolon insignitus*, 1.5 km SW of Zubyia; E: *Malpolon moilensis,* 20 km NE of S. Arabia border crossing; F: *Walterinnesia aegyptia*, 10 km NE of Tafila; G: *Echis coloratus*, 20 km NE of S. Arabia border crossing; H: *Macrovipera lebetinu*s, 10 km NE of Tafila.

Observed individuals: 1 (road from A5 to Al Hazim).
Occurrence in Jordan: Wadi Araba; Eastern Desert = northern Badia (Disi *et al*., 2001; Amr and Disi, 2011).
Comments: In the late evening nearly before sunset, one individual was found under a bush in a flat gravel plain habitat with a scattered bush vegetation. The generic allocation is unstable; sometimes this species is considered to belong to the genus *Rhagerhis* showing some unique morphological diagnosis (Amr and Disi, 2011; Böhme and De Pury, 2011), other times, it is referred to *Malpolon* based on molecular evidence (Carranza *et al*., 2006; Kelly *et al*., 2008; Figueroa *et al*., 2016).

Family Elapidae
Walterinnesia aegyptia Lataste, 1887 – Figure 8F
Observed individuals: 1 (10 km NE of Tafila, wadi).
Occurrence in Jordan: Wadi Araba; the western mountain region; Eastern desert = northern Badia (Shawmari NR; Azraq; Qasr Burqu'; Al Karak; As Salt) (Amr and Disi, 2011).
New records: 10 km NE of Tafila, wadi.
Comments: A single individual was observed in a wadi with a flowing stream surrounded by pomegranate and olive orchards. At first sight, one may confuse it with *Dolichophis jugularis* or *Atractaspis engaddensis*, because of its uniformly black colour.

Family Viperidae
Echis coloratus coloratus Günther, 1878 – Figure 8G
Observed individuals: 1 (2.5 km SE of Munayshir); 2 (Wadi Araba)
Occurrence in Jordan: Aqaba; Mudawwara; Wadi Rumm (Disi *et al*., 2001; Amr and Disi, 2011); New records: Wadi Araba (although previously recorded as from Wadi Araba, the researchers' precise record corresponds with the known area of distribution reported by Disi *et al*. (2001) or Amr and Disi (2011).
Comments: All observed individuals were found early after sunset foraging among rocks.

Echis coloratus terraesanctae Günther, 1878
Observed individuals: 1 (4 km SE of Swemeh, E of Dead Sea).
Occurrence in Jordan: The Dead Sea region; The Jordan Valley (Babocsay, 2003; Amr and Disi, 2011).
Comments: A single individual was observed early after sunset foraging among rocks.

Macrovipera lebetinus (Linnaeus, 1758) – Figure 8H
Observed individuals: 4 (10 km NE of Tafila, wadi)
Occurrence in Jordan: Sail El Aina; Al Harir; 25 km SE of Al Karak; Dana NR (Disi *et al*., 2001; Amr and Disi, 2011); Karka (Al Saraireh and Ghyada, 2017).
New records: 10 km NE of Tafila, wadi.
Comments: Four adult individuals were observed early after sunset in a wadi surrounded by promergranate and olive orchards. In Jordan, this species was recorded for the first time in the 1990s from the Tafila region, and since then, it has been known only from few localities (Al Oran *et al*., 1998; Disi *et al*., 2001; Amr and Disi, 2011). It has been suggested that the population from Jordan is relict separated from the continuous area of distribution in southern Syria (Al Oran e*t al*., 1998; Disi *et al*., 2014). There might be also a competition with other large viperid snakes *Daboia palestinae*, which adapt better to human cultivated habitats than the former species. Populations from Jordan are generally referred to the subspecies *Macrovipera lebetinus obtuse*; however, this subspecific status was not proven by any molecular phylogenetic analyses, because no samples from Jordan were used (Stmpel and Joger, 2009).

Discussion and Conclusion
Despite the small amount of time spent in the field, the researchers have proved that Jordanian herpetofauna is very diverse and rich in species. Out of a total of 103 extant reptile and amphibian species recorded from Jordan (Disi *et al*., 2014), only 35 (three

species of amphibians and 32 species of reptiles in 13 families) were recorded. The current study provides new records for seven species (*H. felixarabica, B. tuberculatus, T. graeca, S. diadema, W. aegyptia, E. coloratus,* and *M. lebetinus*) that were not summarized before by Disi and Amr .2010; and Amr and Disi. 2011. These new records are generally not surprising because they are located in the areas with suitable environmental conditions or represent only a small range extension.

The researchers stress the need for more field surveys to be carried out in the yet unexplored parts of Jordan as these places still hold a potential for new discoveries.

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Jordan Journal of Natural History, 7, 2020 Pages: 30-36

Vertebrate Specimens Deposited at Kurdistan Natural History Museum

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Abstract: The Kurdistan Natural History Museum (KNHM) at Salahaddin University is a recognized Iraqi university-based museum. It serves as an important resource for undergraduate and graduate education, with the aim of collecting and studying the biodiversity in Iraq especially of vertebrates (fishes, amphibians, reptiles, birds, and mammals) since 2003. A total of 106 specimens of vertebrates were collected from the Kurdistan region, including Erbil, Duhok, and Sulaimaniyah provinces and northeastern Iraq. The specimens included nineteen species of fishes belonging to four families, four amphibians belonging to four families, forty-one reptiles belonging to nine families, twenty-five bird species belonging to fourteen families, and nineteen species of mammals belonging to eleven families. All specimens were preserved, or taxidermed in a standard method followed by international museums. Some suggestions are listed to improve and increase the number of museum specimens.

Keywords: Vertebrates, Kurdistan Natural History Museum, Iraq

Introduction

Preserving animals in special spaces such as museums is very important and constitutes a database for researchers from which they can conduct studies on different aspects in biology, including taxonomy, systematics, biodiversity, and evolution. There are several references worldwide concerned with vertebrates' classification, anatomical structures, ecology, local nomenclature, and zoogeographical distribution. In Iraq, biological researches, both old and new, have contributed to each category. Also, local natural history museums play a big role in documenting the biodiversity of countries by housing types and voucher specimens of described species for comparison and to be sources for scientific discoveries and inspiration (Allmon, 1994; Qumsiyeh and Amr, 2020).

The fauna of Iraq has been subject for studies over the past years. The most comprehensive studies on the vertebrates of Iraq include freshwater and marine fishes (Khalaf, 1961; Al-Daham, 1977, 1979, 1982, 1984; Al-Rudainy, 2008; Coad, 2010), reptiles and amphibians (Khalaf, 1959; Rahemo and Mohammed, 2014; Al-Barazengy et al., 2015), birds (Allouse, 1960; 1962), and mammals (Hatt, 1959; Harrison and Bates, 1991).

Recent papers have included new records or descriptions of new species of the reptiles of Iraq (Afrasiab and Ali, 1989; Afrasiab and Mohammed, 2009, 2011, 2014; Afrasiab et al., 2013, 2018, 2019; Habeeb and Nasrulla, 2016; Habeeb, 2018). The aim of this study is to document the vertebrate fauna curated at the Kurdistan Natural History Museum (KNHM) for researchers and professionals.

Materials and Methods

Collected specimens kept at the KNHM of the College of Science at Salahaddin University in Erbil, Iraq, are listed together with the number of specimens, locality, and date of collection. Figures 1 show Kurdistan's three provinces and the location of the Kurdistan Natural History Museum.

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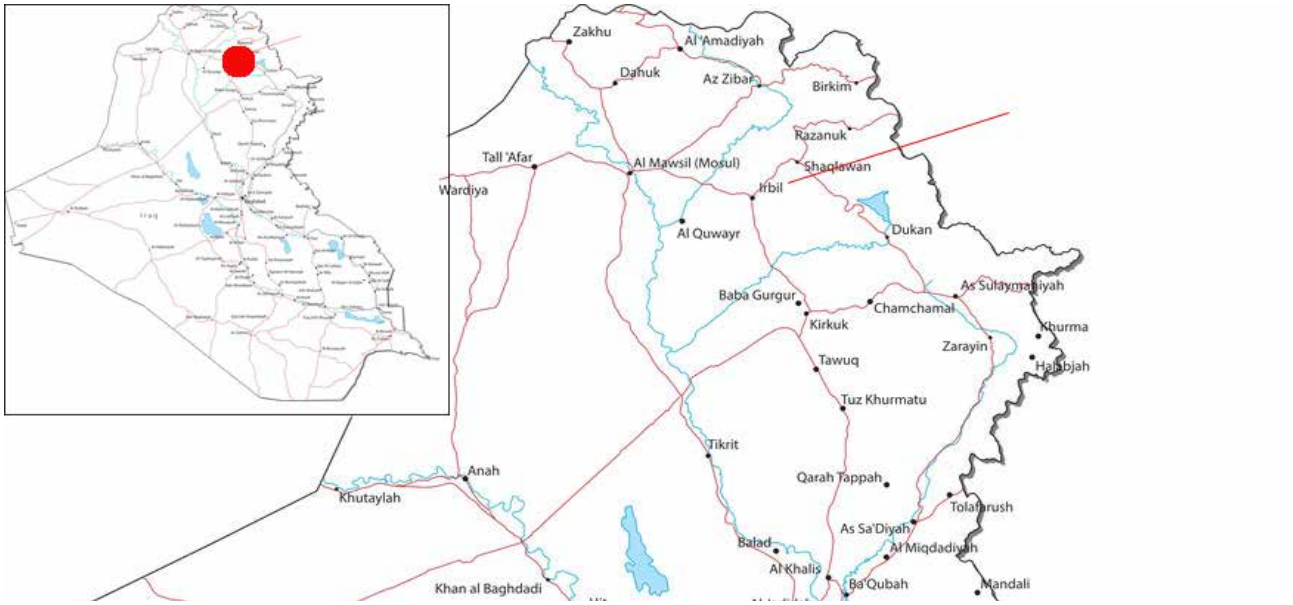

Figure 1. Map of Iraq with Kurdistan's three provinces and the location of the Natural History museum (KNHM).

Results

Freshwater Fishes

Nineteen species of freshwater fishes belonging to four families are listed below (Table 1).

Amphibians

Four species of amphibians belonging to four families are listed below (Table 2).

Reptiles

Forty-one species of reptiles within 13 families are listed below (Table 3).

Birds

Twenty five species of birds belonging to fourteen familes are listed below (Table 4).

Mammals

A total of nineteen species of mammals are listed below (Table 5).

Table 1. List of freshwater fishes at KNHM collection.

Family	Specimens	No	Location	Date
Cyprinidae	*Alburnus mossulensis* Heckel, 1843	5	Upper Zab river	August 2009
	Aspius vorax Heckel, 1843	3	Upper Zab river	August 2009
	Barbus barbulus Heckel, 1849	3	Upper Zab river Dukan lake	August 2009 February 2015
	Barbus grypus Heckel, 1843	3	Upper Zab river Dukan lake	August 2009 February 2015
	Cyprinus carpio Linnaeus, 1758	5	Upper Zab river Dukan lake	August 2009 February 2015
	Carassius carassius(Linnaeus, 1758)	3	Upper Zab river Dukan lake	August 2009 February 2015
	Carasobarbus luteus (Heckel, 1843)	4	Upper Zab river Dukan lake	August 2009 November 2014
	Capoeta barrios Lortet in Barrois, 1894	5	Upper Zab river	September 2010
	Capoeta trutta (Heckel, 1843)	4	Upper Zab river	July 2010

	Chondrostoma regium (Heckel, 1843)	4	Upper Zab river Dukan lake	August 2009 October 2014
	Cyprinion macrostomum Heckel,1843	4	Upper Zab river Dukan lake	August 2010 October 2014
	Garra rufa (Heckel, 1843)	5	Upper Zab river	April 2010
	Garra vsriabilis (Heckel, 1843)	4	Upper Zab river	April 2010
	Luciobarbus esocinus (Heckel, 1843)	3	Upper Zab river Dukan lake	August 2009 October 2014
	Luciobarbus xanthopterus (Heckel, 1843)	3	Upper Zab river Dukan lake	August 2009 October 2014
	Squalius cephalus (Linnaeus, 1758)	3	Upper Zab river	April 2010
Sisoridae	*Glyptothorax kurdistanicus* (Berg, 1931)	3	Upper Zab river Dukan lake	July 2010
Siluridae	*Silurus triostegus* Heckel 1843	2	Upper Zab river	May 2013
Mastacembelidae	*Mastacembelus mastacembelus* **(**Banks & Solander in Russel, 1794)	4	Upper Zab river Dukan lake	August 2010 April 2014

Table 2. List of amphibians at KNHM collection

Family	Specimens	No	Location	Date
Salamandridae	*Neurergus crocatus* Cope, 1862	4	Duhok Erbil	May 2016
Ranidae	*Pelophyylax ridibundus* (Pallas, 1771)	5	Erbil	May 2006
Bufonidae	*Bufotes Pseudepidalea) viridis* (Laurenti, 1768)	5	Erbil	April 2006
Hylidae	*Hyla savignyi* (Audouin 1829)	5	Erbil Sulaimaniyah	March 2015

Table 3. A List of the reptiles in the KNHM collection

Family	Specimens	No.	Location	Date
Testudinidae	*Testudo graeca* Pallas, 1814	3	Erbil	May 2013
Gekkonidae	*Ascaccus griseonotus* (Dixon & Anderson, 1973),	5	Sulaimaniyah	June 2009
	Asaccus elisae (Werner, 1895),	1	Mosul	May 2007
	Asaccus saffinae Afrasiab & Mohammed, 2009	4	Erbil	June 2008
	Cyrtopodium scabrum (Heyden, 1827),	5	Erbil Duhok Sulaimaniyah	May 2005
Agamidae	*Laudakia nupta nupta* (De Fillippi, 1843),	6	Erbil Duhok Sulaimaniyah	June 2009
	Paralaudakia caucasia (Eichwald, 1831)	3	Erbil Duhok	May 2010
	Trapelus ruderatus (Olivier, 1804)	4	Erbil Duhok	August 2009
Lacertidae	*Lacerta mediamedia* Lantz & Cyren, 1920,	5	Erbil Duhok	May 2008
	Ophisops elegans Menetries,1832	4	Erbil Duhok Sulaimaniyah	May 2010

Varanida	*Varanus griseus* (Daudin, 1803)	1	Erbil Duhok Sulaimaniyah	May 2018
Scincidae	*Heremites vitiata* (Olivier, 1804)	5	Erbil Duhok Sulaimaniyah	April 2010
	Heremites aurata (Linnaeus, 1758)	4	Erbil Duhok Sulaimaniyah	August 2008
Anguidae	*Ophisaurus apodus* Pallas, 1775)	2	Sulaimaniyah	June 2009
Typhlopidae	*Typhlops vermicularis* (Merrem, 1820)	4	Erbil Duhok	July 2010
Leptotyphlopidae	*Leptotyphlops macrorhynchus* (Jan, 1860)	5	Erbil Duhok	May 2010
Boidae	*Eryx jaculus jaculus* (Linnaeus, 1758)	3	Erbil	April 2017
Colubridae	*Dolichophis jugularis* (Linnaeus, 1758)	2	Erbil Duhok	August 2010
	Platyceps ventromaculatus Gray, 1834		Erbil	May 2015
	Eirenis lineomaculata Schmidt, 1939	2	Erbil	May 2017
	Eirenis persicus (Anderson, 1872)	1	Erbil	April 2015
	Eirenis decemlineata (Dumeril, Bibron & Dumeril. 1854)	1	Erbil	May 2018
	Eirenis collaris (Ménétriés, 1832)	3	Sulaimaniyah	June 2016
	Eirenis coronella (Schlegel, 1837)	1	Sulaimaniyah	May 2017
	Eirenis rothii Jan, 1863	3	Erbil Duhok	April 2014
	Eirenis thospitis Schmidtler & Lanza, 1990	2	Sulaimaniyah Erbil	April 2016
	Hemorrhois nummifer(Reuss, 1834)		Erbil	April 2009
	Hemorrhois ravergieri (Ménétriés, 1832)	2	Erbil	June 2010
	Malpolon insignitus (Geoffroy Saint-Hilaire, 1827)	2	Kirkuk	September 2016
	Natrix tessellata (Laurenti, 1768)	5	Erbil Duhok Sulaimaniyah	July 2010
	Natrix natrix (Pallas, 1814)	2	Erbil Mosul	June 2011
	Rhynchocalamus melanocephalus (Jan, 1862)	4	Erbil Duhok	April 2010
	Platyceps rogersi (Anderson, 1893)	1	Erbil	May 2013
	Psammophis schokari (Forskål, 1775)	1	Erbil	June 2012
	Spalerosophis diadem acliffordii (Schlegel, 1837)	2	Sulaimaniyah Erbil	March 2014
	Spalerosophis microlepis (Jan, 1865)	2	Sulaimaniyah	August 2013
	Telescopus tessellatus martini (Schmidt, 1939)	1	Erbil	May 2015
	Zamenis hohenackeri (Strauch, 1873)	2	Erbil	May 2009
Elapidae	*Walterinnesia morgani* (Mocquard, 1905)	1	Kirkuk	May 2015
Viperidae	*Macrovipera lebetina* (Dwigubsky, 1832)	3	Erbil Duhok Kirkuk	June 2010

Table 4. A List of Birds in the KNHM collection

Family	Specimens	No	Location	Date
Columbidae	*Columba livia* Gmelin, 1789	3	Erbil Duhok Sulaimaniyah	September 2006
	Streptopelia senegalensis	2	Erbil Duhok Sulaimaniyah	July 2005
	Streptopelia decaocto (Frivaldszky, 1838)	2	Erbil Duhok Sulaimaniyah	April 2006
Pteroclidae	*Pterocles alchata* (Linnaeus, 1766)	2	Erbil Mosul	August 2003
Phasianidae	*Alectoris chukar*(Gray, JE, 1830)	3	Erbil Duhok	February 2003
	Francolinus francolinus (Linnaeus, 1766)	2	Erbil	March 2003
	Ammoperdix griseogularis (von Brandt, 1843)	1	Unknown	May 2004
	Gallus gallus domesticus(Linnaeus, 1758)	3	Erbil	February 2004
Meropidae	*Merops apiaster* Linnaeus, 1758	2	Erbil	April 2008
Strigidae	*Bubo bubo* (Linnaeus, 1758)	1	Sulaimaniyah	May 2008
Tytonidae	*Tyto alba* (Scopoli, 1769)	1	Unknown	April 2007
Accipitridae	*Aquila chrysaetos* (Linnaeus, 1758)	1	Unknown	June 2009
Ciconiidae	*Ciconia ciconia* (Linnaeus, 1758)	1	Sulaimaniyah	March 2007
Anatidae	*Anas platyrhynchos*Linnaeus, 1758	2	Unknown	September 2009
	Cygnus olor (Gmelin, JF, 1789)	1	Upper Zab river	May 2003
	Mergellus albellus (Linnaeus, 1758)	1	Upper Zab river	February 2004
Ardeidae	*Botaurus stellaris* (Linnaeus, 1758)	1	Unknown	June 2006
	Ixobrychus minutus(Linnaeus, 1766)	1	Unknown	June 2005
	Ardea alba Linnaeus, 1758	1	Upper Zab river	May 2007
Corvidae	*Corvus corax* Linnaeus, 1758	2	Unknown	July 2006
Sturnidae	*Sturnus vulgaris* Linnaeus, 1758	3	Erbil	May 2004
Laridae	*Larus michahellis* Naumann,1840	1	Upper Zab river	February 2006
	*Larus cachinnans*Pallas, 1811	1	Upper Zab river	June 2006
Rallidae	*Gallinula chloropus* (Linnaeus, 1758)	1	Unknown	March 2005

Table 5. List of mammals at KNHM collection

Family	Specimens	No.	Location	Date
Erinaceidae	*Erinaceus europaeus* (Linnaeus, 1758)	1	Erbil	September 2009
Rhinolophidae	*Rhinolophus sp.*	1	Unknown	March 2005
Muridae	*Mus musculus* (Linnaeus, 1758)	3	Erbil	May 2003
	Apodemus sylvaticus (Linnaeus, 1758)	2	Erbil	February 2004
	Rattus rattus (Linnaeus, 1758)	2	Erbil	June 2006
Sciuridae	*Sciurus anomalus* Gmelin, 1778	1	Duhok	June 2006
Felidae	*Lynx lynx* (Linnaeus, 1758)	1	Duhok	June 2005
	Panthera pardus saxicolor Pocock, 1927	1	Erbil	May 2011
Bovidae	*Capra hircus* (Linnaeus, 1758)	1	Erbil	July 2006
	Capra aegagrus (Erxleben, 1777)	1	Duhok	May 2004

Leporidae	*Oryctolagus cuniculus domesticus* (Linnaeus, 1758)	2	Erbil	February 2006
Canidae	*Canis lupus* (Linnaeus, 1758)	1	Erbil	September 2009
	Canis aureus aureus (Linnaeus, 1758)	1	Duhok	May 2003
	Canis familiaris (Linnaeus, 1758)	1	Erbil	February 2004
	Vulpes vulpes (Linnaeus, 1758)	1	Erbil	June 2006
Mustelidae	*Mustela nivalis* (Linnaeus, 1766)	1	Unknown	June 2005
	Lutra lutra (Linnaeus, 1758)	1	Sulaimaniyah	May 2007
Ursidae	*Ursus arctos syriacus* (Hemprich & Ehrenberg, 1828)	1	Duhok	July 2006
Hyaenidae	*Hyaena hyaena* (Linnaeus, 1758)	1	Erbil	May 2004

Discussion

It is important to investigate the geographical distribution of all the species reported in this research in Iraq and the neighboring countries. For example, the cave-dwelling gecko, *Asaccus saffinae*, which has been described from Saffine Mountains in northern of Iraq is not known in any other locality in Iraq (Afrasiab and Mohammed, 2009).

The staff at the KNHM museum show great interest in conducting organized scientific field trips to the mountain regions in different habitats to collect representatives of the vertebrate fauna of this little known region. Collecting specimens over the past six years has been difficult due to the instability and regional conflict. The staff encourages people to donate specimens to the KNHM museum using all kinds of media. As the museum is frequently visited by school and university students, specialists, and guests from the government, its staff takes this opportunity to introduce the mission of the museum in order to fulfill its targets. Also, one of the important goals of the museum is to have more trained staff in taxonomy, exhibitions and to enable researchers of publishing scholarly papers.

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Jordan Journal of Natural History, 7, 2020 Pages: 37- 49

Assessment of Macrobenthic Invertebrate Fauna and Physicochemical Characteristics of Etim Ekpo River, South-South, Nigeria

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Abstract: The benthic macroinvertebrate fauna and the physicochemical characteristics of Etim Ekpo River in South-South, Nigeria were investigated from November 2018 to August 2019 in three stations. The aim was to relate the water quality and benthic macroinvertebrate fauna to the anthropogenic activities in the river. Standard methods were used in the collection and analyses of the water samples while Van veen grab was used to collect the benthic macroinvertebrates fauna. The mean values of physicochemical parameters were: water temperature (26.3-26.5ºC), dissolved oxygen (3.18– 4.83 mg/L), electrical conductivity (109.4– 112.4 µS/cm), pH (6.2 – 6.9), total dissolved solids (68.1–73.4 mg/L), total suspended solids (29.5 – 37.5mg/L), biochemical oxygen demand (3.6 – 4.5 mg/L), phosphate (5.7 – 8.7 mg/L) and nitrate (11.3 – 18.2 mg/L). Higher values in most of the parameters were recorded in Stations 1 and 3. Three phyla of macrobenthic invertebrates were recorded; Arthropoda, represented by five species; Polychaeta represented the annelids while mollusca was represented by two gastropod snails. Arthropoda had the highest percentage of abundance (73.7%), followed by Annelids (21.9%) while Mollusca had the least (4.4%). *Macromia magnifica* was the dominant species with a relative abundance of 27.97% while *Pila ovate* was the least abundant (1.63%). Most of the benthic macroinvertebrates recorded were pollution-tolerant species, while the biodiversity indices indicated a disturbed environment. The benthic macrofauna and the physicochemical characteristics showed that the river has been seriously impacted by some of the anthropogenic activities going on in the watershed.

Keywords: Anthropogenic, Assessment, Benthic, Macroinvertebrate, Physico-chemical parameters, Pollution

Introduction

Water is an indispensable natural resource on earth; all life forms including human beings depend on water. Freshwater systems have now become the dumping site of wastes and other pollutants emanating from anthropogenic activities (Amah-Jerry *et al.*, 2017; Anyanwu and Ukaegbu, 2019). Studies (Esoka and Umaru, 2006; Adebayo *et al.*, 2007; Jonah *et al.*, 2019) have shown that freshwater bodies in Nigeria are witnessing a rising trend in water pollution attributed to human activities. Human activities such as industrial processes, mining, agriculture, household waste production and urbanization contribute to the pollution load of the aquatic ecosystems altering the physicochemical status and community structure of aquatic organisms including macroinvertebrates fauna (Kucuk, 2008; Anyanwu *et al.,* 2013; Arimoro *et al.,* 2015; Anyanwu and Jerry, 2017).

In freshwater, the macrobenthic invertebrates are mainly made up of insects, others include crustaceans, gastropods, bivalves and oligochaetes (Allan, 1995; Thorp and Covich, 2001; Merritt *et al.*, 2008). These groups of organisms also play critical roles in the

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ecology as decomposers, nutrient recyclers, consumers, and preys in aquatic ecosystem (Wallace and Webster, 1996; Covich *et al.,* 1999; Vanni, 2002; Moore, 2006). Benthic organisms are relatively sedentary, long-lived and respond differently to varying environmental conditions (Williams *et al.,* 2009).

Benthic organisms serve as bio-indicators and have been extensively used in long-term monitoring of aquatic ecosystem health (Simboura *et al.,* 1995; Williams *et al.,* 2009; Sharma *et al.*, 2010; Balogun *et al.,* 2011; Abowei *et al.,* 2012). Some species have physiological adaptations to tolerate organic pollution and low levels of dissolved oxygen (Simboura *et al.,* 1995).

Etim Ekpo River is one of the highly utilized rivers in Akwa Ibom State, South-South Nigeria; the area is subjected to various illicit human activities such as dredging and sand mining. Other activities include indiscriminate disposal of sewage and domestic waste, laundry and washing cars. Various levels of farming activities were also observed along the banks of the river. These activities may have a direct and indirect impact on the water quality and on the diversity of macroinvertebrate fauna and other biocoenosis.

Several studies have been carried out on macroinvertebrates' assemblage and water quality characteristics in Nigeria. Ibemenuga *et al.,* (2017) studied the influence of abattoir wastes on macroinvertebrates' distribution in River Idemili, South-Eastern Nigeria, while Iyagbaye *et al.,* (2017) studied the diversity and seasonal variation of the benthic macro-invertebrates of Ovia River (Iguoriakhi), Edo State, Southern Nigeria. Edegbene *et al.,* (2019) on the other hand, developed and applied a macroinvertebrate-based multimetric index for assessing water quality condition of impacted urban river systems in the Niger Delta, Nigeria, whereas Olaniyan *et al.,* (2019) studied the macroinvertebrate fauna of Oluwa River, Ilaje Local Government Area, Ondo State, Southwest Nigeria. Recently, Aliu *et al.,* (2020) assessed three major tributaries (Obudu, Opa and Esinmirin rivers) of a tropical reservoir in Ile-Ife, Southwest Nigeria and Edegbene (2020) studied the probable menacing effects of the Typha grass and some selected environmental variables on the composition and diversity of benthic macroinvertebrates of Kalgwai Dam, Jigawa State, Northwest Nigeria. Among all these, there is no study concerned with the Etim Ekpo River.

The aim of this study is to assess the benthic macroinvertebrate fauna and physicochemical characteristics of the Etim Ekpo River, South-south, Nigeria vis-à-vis anthropogenic activities.

Materials and Methods

Study Area and Sampling Stations

Etim Ekpo is one of the highly utilized rivers in Etim Ekpo Local Government Area of South-Southern Nigerian State of Akwa Ibom. The section of the river studied lies within the Latitude (5º17"34' - 5º34"20' North) and Longitude (7º60"11' - 7º64"10' East); receiving runoffs from the activities in the watershed (Figure 1). Accessibility and the observed anthropogenic activities were the criteria used for selecting the sampling stations.

The river takes its source from Udoawangwo River in Ikot Ekpene Local Government Area and discharges into the Ukanafun River in the Ukanafun Local Government Area of Akwa Ibom State, Nigeria. The two major tributaries, Ikot Akpan and Itung Achan Ika stream drain into the river and play a major role in the hydrology of the river.

Station 1 (5º17"34'N, 7º60"11'E) was upstream, and the Control Station was located in Nkwot Ikono. The anthropogenic activities were intense and include mining and the selling of sand, farming, bathing, laundry and indiscriminate disposal of sewage and domestic waste. Station 2 (5º30'16N, 7º39'15E) was about 6km downstream of Station 1, and was located between Uruk Ata Ikot Isemin and Utu Etim Ekpo before the head bridge. Human activities were moderate and include farming, dredging, bathing,

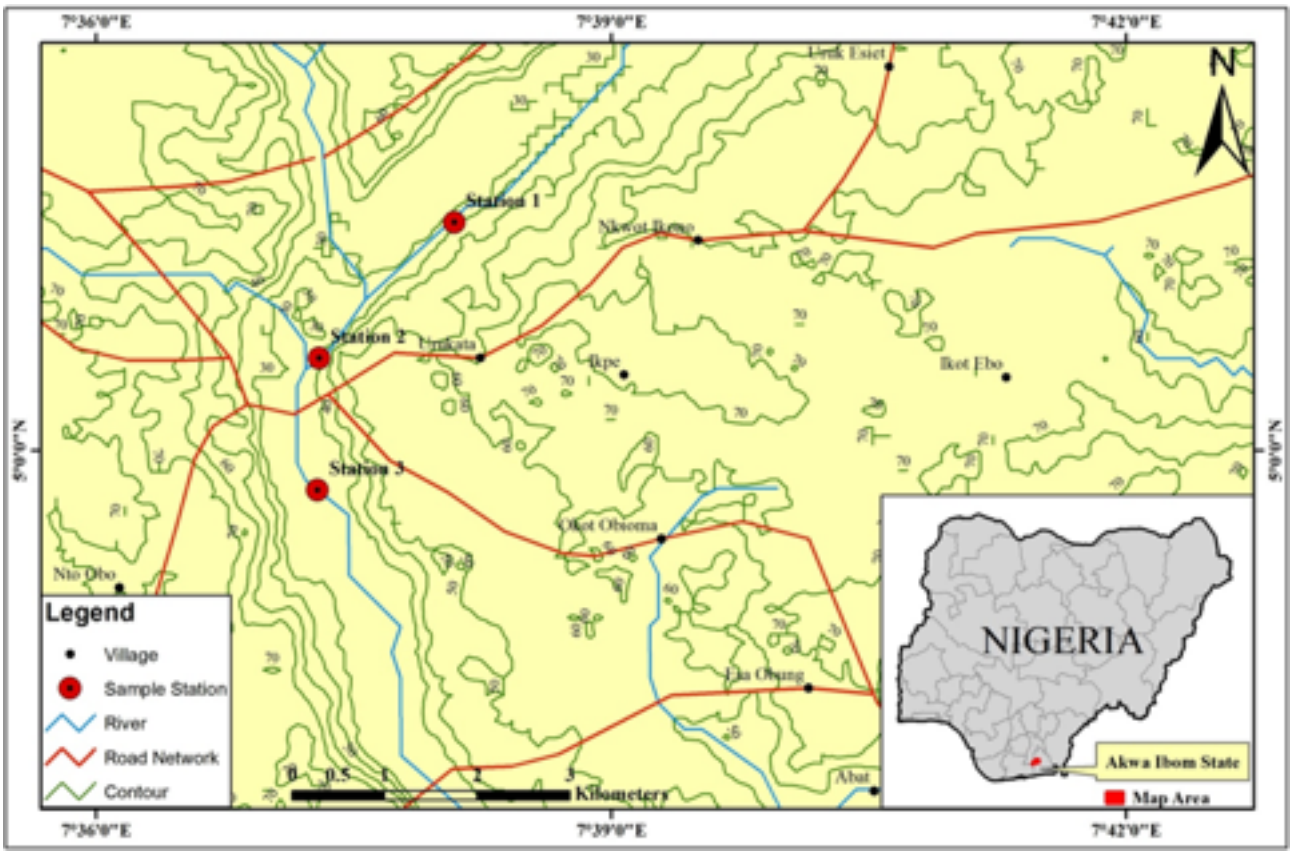

Figure 1. Map of Etim Ekpo River, South – south Nigeria showing the sampling stations.

laundry, and the washing of cars. Sandy and muddy sediments were observed in some sections, while the dominant vegetation was *Paniculum maximum*. Station 3 (5º34”20’N, 7º64’10E) was located at Uruk Ata Ikot Ekpo, It was about 2.5km downstream of Station 2. The substrate was muddy and sandy and the vegetation was mostly *Bambusa vulgaris* and P*aniculum maximum*. The human activities were also intense and included an indiscriminate disposal of sewage and domestic wastes, dredging, fishing, bathing, laundry, extensive farming, and washing of cars. Runoffs from the settlements are also discharged into the river at this Station.

Sample Collection

Water Samples

The water sampling was carried out monthly between November 2018 and August, 2019. A 1litre water sampler was used in the sample collections, and the samples were transferred to sterilized plastic bottles. Some parameters including water temperature, dissolved oxygen, hydrogen ion (pH), electrical conductivity, and total dissolved solids were determined *in-situ*. Water temperature was determined using mercury-in-glass thermometer, and dissolved oxygen with DO meter (Lutron DO-5509 Model), while pH/EC/TDS Meter (HANNA 3100 Model) was used for the determination of hydrogen-ion concentration, electrical conductivity and total dissolved solids. Other parameters were analysed in Akwa Ibom State Ministry of Science and Technology Laboratory, Uyo, using standard methods (AOAC, 2000; APHA, 2005).

The data obtained were summarized using Microsoft Excel, while the significant difference ($P<0.05$) among the stations was determined by One-way Analysis of Variance (ANOVA). Significant variations were isolated using the Least Significant Difference (LSD) test.

Macroinvertebrates Samples

Van-veen grab (0.05m^2) was used in the macro-invertebrates sampling; collected in four replicates. The pooled sediment samples

from each station were thoroughly washed in a 0.05mm sieve and the retained residues were transferred into wide-mouth plastic containers and preserved with 10% formalin solution.

A preliminary identification was carried out in the field before the samples were taken to the laboratory for accurate identification and confirmation. Taxonomic keys and materials (Willoughby, 1976; Pennak, 1978; Merritt and Cummins, 1996; Merritt *et al*., 2008; Umar *et al.,* 2013) were used for the identification and confirmation of the isolated organisms. The relative abundance (%) of the groups and species were calculated. The community structure of the macroinvertebrates was determined using ecological indices (Shannon-weiner index (H), Margalef's index (d) and Evenness index). PAST Statistical Software Package (Version 3.24) was used to determine ecological indices (Hammer *et al.,* 2001).

Results

Physicochemical Characteristics

Mean values of physicochemical characteristics are presented in Table 1. Mean water temperatures were between 26.3 and 26.5^{o}C. The temperature values were within the acceptable limits set by FMEnv (2011). The highest temperature (28.8^{o}C) was recorded in Station 1 in December 2018.

The mean values of Dissolved Oxygen (DO) ranged between 3.18 mg/L and 4.83 mg/L. Station 3 had the lowest value. All the DO values were below the acceptable limit (>6 mg/L) set by FMEnv (2011) except for 7.0 and 6.6 mg/L recorded in December 2018 and August 2019 respectively in Station 2. The lowest value (1.6 mg/L) was recorded during the early rains in May 2019. One-way ANOVA showed that Station 2 was significantly higher than Stations 1 and 3 ($P<0.05$).

The mean values for Electrical conductivity ranged from 109.4 to 112.4 µS/cm; Stations 2 and 3 had the higher mean values, while the least was recorded in Station 1. The highest EC value (172.1µS/cm) was recorded in May 2019 after early rains in Station 1. The mean pH values were slightly acidic; ranging between 6.2 and 6.9. One-way ANOVA also showed that Station 2 had significantly higher pH values than Stations 1 and 3 ($P<0.05$). The lowest values (6.0) were recorded in Stations 1 (May 2019) and 3 (December 2018, January and June 2019). The Total Dissolved Solids (TDS) followed the same trend with electrical conductivity; though the highest value (97.3 mg/L) was recorded in April 2019 (Station 3). The mean TDS values were between 68.1 mg/L and 73.4 mg/L. ANOVA showed that Station 3 differed significantly from Stations 1 and 2 ($P<0.05$). The highest TDS value was recorded in Station 3 in April 2019. The mean values for total suspended solids (TSS) ranged between 29.5 and 37.5 mg/L. The lowest mean value was recorded in Station 1, while Station 2 had the highest. The highest TSS value was recorded in Station 2 in May 2019 after early rains.

A mean value range of 3.6 to 4.5 mg/L was recorded for Biochemical Oxygen Demand (BOD). All the mean values exceeded the acceptable limit of 3.0 mg/L set by FMEnv (2011), especially in station 3. The highest values were recorded between May and June 2019 in all Stations.

The mean concentrations of phosphate exceeded the acceptable limit (3.5 mg/L); ranging from 5.9 to 8.7 mg/L. Higher mean values were recorded in Stations 1 and 3. The highest value (21.4 mg/L) was recorded in Station 3 also in May 2019 after early rains.

The mean nitrate values ranged from 11.3 to 18.2 mg/L. Higher mean values were also recorded in Stations 1 and 3 as in phosphate. The highest value (34.1 mg/L) was also recorded in Station 3 after early rains in May 2019. All values were within the acceptable limit (50mg/L) set by FMEnv (2011).

Macroinvertebrate Fauna

The composition, abundance, and distribution of macroinvertebrate fauna are presented in Table 2. Three phyla, nine species, and

Table 1. A summary of the physicochemical characteristics of the Etim Ekpo River, South – south Nigeria

Parameters	Stn 1 X±SEM	Stn 2 X±SEM	Stn 3 X±SEM	P-Value	FMEnv (2011)
Temp. ^{o}C	26.4±0.47 (24.0 – 28.8)	26.5±0.62 (24.3 – 29.2)	26.3±0.45 (24.0 – 28.6)	P>0.05	<40^{o}C
DO mg/L	3.42 ± 0.31^{a} (2.4 – 5.0)	4.83 ± 0.47^{b} (2.8 – 7.0)	3.18 ± 0.33^{a} (1.6 – 5.0)	P<0.05	> 6.0 mg/L
EC (uS/cm)	109.4±10.69 (59.5 – 172.1)	111.6±8.55 (64.8 – 140.2)	112.4±8.86 (67.7 – 147.9)	P>0.05	-
pH	6.2±0.04^{a} (6.0 – 6.4)	6.9±0.13^{b} (6.8 – 7.8)	6.2±0.06^{a} (6.0 – 6.5)	P<0.05	6.5 – 8.5
TDS (mg/L)	68.1± 5.60^{a} (42.5 – 95.6)	73.2±5.18^{a} (44.7 – 90.5)	73.4±5.96^{b} (43.4 – 97.3)	P<0.05	-
TSS (mg/L)	29.5±3.35 (15.5 – 46.0)	37.5±3.86 (22.8 – 53.7)	30.1±4.09 (14.2 – 47.0)	P>0.05	-
BOD (mg/L)	3.6±0.52 (1.9 – 6.1)	3.7±0.42 (1.5 – 5.5)	4.5 ± 0.39 (2.6 – 6.9)	P>0.05	3.0 mg/L
Phosphate (mg/L)	8.3±1.65 (1.7 – 16.1)	5.9±1.03 (2.1 – 12.6)	8.7±1.62 (3.8 – 21.4)	P>0.05	3.5 mg/L
Nitrate (mg/L)	16.4±2.62 (7.4 – 33.3)	11.3 ±1.60 (3.8 – 18.4)	18.2±2.36 (8.0 – 34.1)	P>0.05	50 mg/L

a, b = Means with different superscripts across the rows are significantly different at p<0.05; SEM= Standard Error of Mean; FMEnv (2011) - National Environmental (Surface and Groundwater Quality Control) Regulations

a total of 429 benthic macroinvertebrates individuals were recorded. Arthropoda accounted for the highest group relative abundance (73.7%), followed by Annelida (21.9%) and Mollusca (4.4%). *Macromia magnifica* accounted for the highest species relative abundance (27.97%), followed by *Glycera* spp. (15.85%), *Progomphus* larvae (14.68%), C*hironomus* larvae (10.98%), *Callibaetis pictus* (10.96%), *Isoperla ornate* (9.09%), *Turbifex* larvae (6.06%) and the least was *Pila ovate* (1.63%).

Some of the species (*Chironomus* spp., *Progomphus larva,* C*allilbaetis pictus*, *Turbifex* spp., *Glycera* spp., *Pila ovate and Physa* spp.) recorded belong to the tolerant group. Most of the tolerant species recorded higher numbers in Station 2. All the sampling stations were dominated by Arthropods and the least was Mollusca; the order Odonata had the highest number (183 individuals, 42.6%), followed by Polychaeta (68 individuals, 15.85%) and the least was Gastropoda (19 individuals, 4.4%).

Spatially, the highest number of individuals (169 individuals, 39.4%) was recorded for Station 2, Station 1 followed with 138 individuals (32.2%) and Station 3 with 122 individuals (28.4%). Station 2 accounted for the highest number of species, which were 9, while seven species each were recorded for Stations 1 and 3. The highest number of individuals (60) was recorded during the early rains in June 2019, while the lowest (24) was recorded during one of the peaks of the wet season in July 2019.

In terms of community structure, the highest Margalef's species richness index (1.559) was recorded for Station 2, and decreased in the order of 1.249 and 1.218 in Stations 3 and 1 respectively. On the other hand, Station 2 also had highest (1.932) Shannon-Weiner index, Station 1 was the next with 1.715, and Station 3 with the lowest value of 1.667. The highest Evenness Index value (0.7935) was recorded in Station 1, while the lowest (0.7564) was recorded in Station 3.

Discussion

The productivity of the aquatic ecosystems in terms of biota is generally determined by the physicochemical characteristics of the water body (Wu *et al*., 2017; Arimoro, *et al.,* 2018; Anyanwu *et al.,* 2019).

The surface water temperature values were lower than the acceptable limit. The highest water temperature was recorded during the peak of the dry season in December 2018 (station 1). Air temperatures influence water temperatures (Mohseni and Stefan, 1999; Webb *et al*., 2003). Naturally, water bodies exhibit daily changes in temperature due to different activities or phenomena that can influence such changes (Gebreyohannes *et al.,* 2015).

All the dissolved oxygen values were lower than the acceptable limit except in December 2018 and August 2019 in Station 2, which may be attributed to the small perturbation and seasonal influence. Relatively higher DO values were recorded in Station 2 throughout the study. Dissolved oxygen usually increase with less precipitation, improved clarity, and photosynthesis (Kale, 2016) as may be the case in August and December. The high discharge of organic and inorganic pollutants into Stations 1 and 3 from the nearby farms and communities might have been responsible for the poor dissolved oxygen content. Ayobahan *et al.,* (2014) observed that fluctuations in the dissolved oxygen level are attributed to the presence of organic pollutants in the body of water through human activities. The degradation of organic matters in water by bacteria results in the depletion of dissolved oxygen (Mahre *et al.,* 2007). The lowest DO value recorded during early rains (May 2019) in Station 3 might have been influenced by the season. DO contents of a river were mainly influenced by the decomposition of organic matter inputs from the increased runoff after rain (Ling *et al.,* 2017) especially after a period of dryness.

The values of electrical conductivity and total dissolved solids were slightly varied across the stations; the higher values recorded in Stations 2 and 3 might have been as a result of discharges into the Stations from two major tributaries (Ikot Akpan and Itung Achan Ika), human activities, and surface runoffs from the nearby communities along Etim Ekpo River. The highest EC value was recorded in Station 3 during early rain in May 2019 and might have been influenced by the season, while the highest TDS value recorded also in Station 3 in April 2019 before the onset of rains may be attributed to anthropogenic activities. Girardi *et al.,* (2016) recorded the highest EC values after four hours of rainfall, which was attributed to runoff transporting substances rich in ions and polar molecules. Ewa *et al.,* (2011) reported that a high level of EC usually corresponds to a high value of TDS. Ohimain *et al.,* (2008), Seiyaboh *et al.,* (2013) and Rehman *et al.,* (2016) reported that dredging and sand mining contribute to the increase in both EC and TDS values as observed in Stations 2 and 3.

Low pH values were observed especially during some months in Stations 1 and 3, which might have been caused by the constant dredging and some unregulated sand-mining activities. Studies including Ohimain *et al.,* (2008), Seiyaboh *et al.,* (2013) and Amah-Jerry *et al*., (2017) have reported that human activities, such as the dredging and mining of sand, lower the pH levels of water bodies. Studies have established a strong relationship between water pH and the composition of the macroinvertebrate community (Winterbour and Mc Diffett, 1996; Earle and Callaghan, 1998; Varner, 2001). Tripole *et al.,* (2006) reported changes such as the decrease in abundance and richness and the replacement by more tolerant species in the macroinvertebrate community due to decreased pH values. Tripole *et al.,* (2008) also reported a total absence of macroinvertebrates in the stations with pH values lower than 5.5.

The high TSS values observed in Station 2 especially in May 2019 may be attributed to the high runoffs transporting large amounts of sediment from upstream (Station 1) and the Ikot Akpan stream discharging into Station 2 in addition to the

season. Ling *et al.,* (2017) reported higher TSS values after early rain events.

The entire mean BOD values exceeded the limits especially in Station 3; with the highest values recorded between May and June 2019 in all stations. This might have been resulted from the discharge of organic and inorganic pollutants through runoffs from the surrounding farmlands and re-suspension and circulation of organic matters through the dredging and sand-mining activities influenced by the season (Akankali *et al*., 2017; Ling *et al.,* 2017). According to Nwankwo *et al.,* (2014), BOD is one of the indicators of organic pollution in a river, therefore, BOD affects water quality. The high value of BOD is reflected in the corresponding low value of DO observed in Station 3. Mahre *et al.,* (2007) reported that when BOD is high, the DO is reduced because the available oxygen in the water is being consumed by bacteria in the process of degrading organic matters.

Phosphate had mean values that exceeded the limits, and significantly higher values were recorded in Stations 1 and 3. Organic and inorganic wastes (including fertilizer) with a high phosphate content might have been responsible for the higher phosphate values observed in Stations 1 and 3. The highest value was recorded in Station 3 (May 2019), which is attributable to the seasonal influence. Mandal *et al.,* (2012) observed that the phosphate contamination comes from anthropogenic activities including runoffs laden with fertilizers and pesticides. Zhang *et al.,* (2019) reported that both of the taxonomic and functional beta diversities of the macroinvertebrate assemblages were regulated by total phosphorus, which acted as the major environmental factor. This regulation resulted in the abundance of pollution-tolerant species.

Nitrates on the other hand, followed the same trend of phosphate. All the mean values were within the acceptable limit; it was observed that Stations 1 and 3 were relatively higher than Station 2 suggesting an anthropogenic impact. Chapman (1996) reported that nitrate values above 5 mg/l are indications of pollution resulting from organic sources. The highest nitrate value was also recorded during early rains in May 2019, and was attributed to the season similar to the case of phosphate.

The macrobenthos recorded was generally low in number when compared with the findings of Andem *et al.,* (2015) and Anyanwu *et al.,* (2019). The order of abundance was arthropoda > annelida > mollusca as observed in Avoaja *et al*., (2007) and Andem *et al.,* (2012). Arthropoda was also the dominant group recorded in Anyanwu *et al.,* (2019), while mollusca was the dominant group recorded in Anyanwu and Jerry (2017). Alterations in the habitat structure and the physicochemical characteristics of the river through dredging and sand mining might have been responsible for the low species diversity observed in Stations 1 and 3. Lawal (2011) reported that the river bed and channel degradations as well as the lowered water levels are some of the destructions caused by river sand mining in the aquatic habitats. On the other hand, Gubbay (2003) reported that when the environment of a river has been altered as a result of sand excavation, the biota are also altered because they tend to adapt to the prevailing conditions rather than recover from their poor conditions. Anthropogenic activities as observed in this study may lead to the homogenization of environmental conditions, which in turn will result in biotic homogenization (Zorzalalmeida *et al.,* 2017).

The highest number of macroinvertebrates was recorded in June 2019, while the least was recorded in July 2019; such variance is attributed to the seasonal influence. Ling *et al.,* (2017) reported a high input of nutrients coming with the early rains of May and June, which supports the growth and development of aquatic biota. On the other hand, July is among the peaks of the wet season in the region, which usually has a negative impact on aquatic biota. Reductions in macroinvertebrate abundances, by more than a half, usually occur after heavy rainfalls (McCabe, 2010).

Most of the recorded species (*Chironomus* sp., C*allilbaetis pictus*, *Turbifex* sp., *Glycera* spp., *Pila ovate and Physa* sp.) belong to the tolerant group that is capable of surviving in a degraded

environment (Adeogun and Fafioye, 2011; Adebayo *et al*., 2019; Anyanwu *et al.,*, 2019). Chironomidae taxa are known to be tolerant to water pollution (Dalu and Chauke, 2020) and most tolerant to a low pH (Tripole *et al.,*, 2006; 2008). The presence or occurrence of *Chironomus* and *Tubifex* spp are indications of organic pollution (Aina and Fafioye, 2011; Chanazah *et al.*, 2018). Khalil *et al.,* (2016) reported the dominance of oxygen depletion tolerance species (including *Physa* spp) which is attributed to low dissolved and high BOD values. Ogidiaka *et al.,* (2012) also linked the presence of tolerant species in the stations to the high BOD levels in the Ogunpa River, Ibadan. Station 2 had higher numbers of the tolerant species, which may be attributed to an ecological phenomenon known as the invertebrate drift from Station 1 and Ikot Akpan stream discharging into the river before Station 2. Naman *et al.,* (2016) described the invertebrate drift as a basic process in streams whereby aquatic invertebrates exhibit a passive or active downstream movement. According to Koehnken *et al.,* (2020), sand mining affects the macroinvertebrate drift, species abundance, and community structures among others things.

Biodiversity indices have been applied in macroinvertebrate assessments in order to evaluate the environmental conditions of the waterbodies. Shekhar *et al.,* (2008) proposed a Shannon-wiener diversity index classification; values > 4 were for clean fresh waterbodies; values 3 – 4 were for slightly-polluted waters, while values for the severely-polluted waters fall below 2. All the Shannon-wiener index values recorded were < 2; though, a higher value was recorded in Station 2. The Margalef taxa richness index followed the same trend of the Shannon-wiener index. The Shannon-wiener diversity and Margalef species richness indices were low especially in Stations 1 and 3 indicating a severe stress of anthropogenic impacts (Zorzalalmeida *et al.,* 2017). The relatively higher values of the Shannon-wiener and Margalef indices recorded in Station 2 suggested less environmental disturbances. Evenness values were low though Station 1 has a relatively higher value. These values were slightly higher than the values recorded by Anyanwu *et al.,* (2019) and Edegbene (2020) suggesting unstable environmental conditions. When species in a community are not evenly distributed, the evenness index will be low indicating an unstable environment and the presence of dominant species (Victor and Ogbeibu, 1991).

Conclusion

Benthic macroinvertebrates have been used as bio-indicator organisms to evaluate the drastic changes in water quality arising from human activities. Most of the species recorded were pollution-tolerant. The poor water quality and the low diversity of macroinvertebrate fauna can be partly explained by the impacts of the different anthropogenic activities on the river. The impacts of the anthropogenic activities are better explained by the community structure of the macroinvertebrates which was not fully captured by the water quality parameters as in some cases. This study, therefore, recommends a constant monitoring of the river in order to forestall a further degradation of the water quality and the diversity of the biota.

Conflict of interest

The authors hereby state that this research and the manuscript production comply with ethical standards, and none of the authors has any potential conflict of interest. The authors further declare that this research was not been funded by any agency.

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Jordan Journal of Natural History, 7, 2020 Pages: 50- 59

The Current Conservation Status of some Wild Plant Species in the District of Bannu, Pakistan

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Abestract: The present study documents the conservation status of 135 plant species belonging to 115 genera and thirty-eight families in Bannu. The information about conservation was collected through questioners, personal observation, group discussions and interviews. The Asteraceae constitutes a dominant family with twenty species followed by Poaceae with nineteen species. In the present report, fifty-two species (38.52 %) were found to be rare, vulnerable (45 Species; 33.33%), Infrequent (18 species; 13.33%), endangered (12 Species; 8.89%) and eight species (5.93%) were dominant. It was not possible through the present investigation to conclude that most wild plant species are going to become endangered due to urbanization and agriculture in the area though natural vegetation habitats are changing rapidly.

Keywords: Medicinal herbs, Conservation, Endangered Species.

Introduction

The conservation status of organisms indicates the features of plant species in the area. The conservation status of species depends on many factors affecting conservation such as fuel demand, farming land, grazing, deforestation, reproduction rates and the known threats. It is estimated that some 270,000-425,000 vascular plant species are already known (Govaerts, 2001). Based on the samples of species that have been evaluated, the percentage of endangered species is estimated at 40 percent of all organisms as calculated by the International Union for the Conservation of Nature (IUCN) (Anon., 2008).

Alam and Ali (2009) classified *Astragalus gilgitensis* as a Critically Endangered (CR). According to Khan *et al.*, (2011a) four flowering plant species are threatened. Khan *et al*., (2012a) reported one specie from Tehsil Takht-e-Nasrati, District Karak, Pakistan as a threatened plant. According to Khan *et al*., (2013a), habitat loss and removal, the preface of alien species, pollution and diseases, over-exploitation, and climate change are among the threats facing plants which are an important part of the ecosystem. Plant biodiversity is also under tremendous pressures due to population explosion, unplanned urbanization, deforestation and the over-exploitation of natural resources (Khan *et al*., 2013b).

Unfortunately, very little work has been done on the conservation status of plants in Pakistan and, extremely limited information is available on this subject (Khan 2013). Khan and Husssain (2013a) reported seven plant species form Takht-e-Nasratti Pakistan as threatened species. These studies are principally based on the IUCN criteria and with the support of quantitative data. In contrast, according to the recent red list of

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IUCN (Anon., 2008) only nineteen flowering plants species have been listed from Pakistan. Regarding Pakistan, previous workers have classified plant species as threatened or rare on the basis of literature or herbarium specimens. Less work has been done based on the IUCN red list categories or criteria (Khan 2013). The research area has a rich biodiversity consisting of different types of plants, some of which are used for their medicinal values. Different studies across various areas of Pakistan have been carried out (Hussain, *et al.,* 2006; Shinwari, 2010; Murad, *et al.,* 2011; Khan, *et al.,* 2011a, 2012c, 2013c). The present research is aimed at collecting, compiling, and documenting the conservation position of plants on the basis of the diverse and disperse traditional local information in the District of Bannu. Such a study makes the conservation position of some plant species available in the future for plant ecologists.

Methods

Research Area

The District of Bannu lies between 32.43^0 to 33.06^0 North and from 70.22^0 to 70.57^0 East. It is bounded in the North by the Tribal Area, in the East by the District of Karak, and in the South by Lakki Marwat (Figure 1). The district has a total area of 1227 km2. The total population of the district is estimated at 677350 people with an annual growth rate of 2.81 %. The greater part of the population lives in villages. The climate of the research area is warm during summers and cold in winters. The summer season starts from May till August. June is the hottest month for this area. In July and August, the weather is hot and moist, while June is the hottest month with mean minimum and maximum temperatures of 30 C° and 42 C° respectively. Winter months include December, January, and February. The mean maximum rainfall occurs during the month of August and that is 111.25 millimeters. About 45% area of the district is irrigated mostly through canals, while 10 % of the people have their own tube wells for the purpose of irrigation. This is why abundant crops during both summer and winter seasons are harvested each year. The area has a broad spectrum of plant biodiversity, but no regular forestation. The distribution of trees is of the patchy type. Every kind of crop and fruit i.e. wheat, maize, rice, barley and sugarcane can be grown there, and bananas, dates, figs and rice are unique in their taste, smell, and shape.

Research Protocol

The study was prepared by frequently conducting surveys. The plant specimens were collected from Jun, 2017 to September, 2019. The samples were pressed, dried, and mounted on herbarium sheets. They were identified with the help of floristic literature (Nasir and Ali, 1970-1989; Ali and Nasir, 1990-1992; Ali and Qaiser, 1992- 2009.

The correctly-identified specimens were deposited in the herbarium of the Department of Biological sciences, FGCB Mardan. The area is divided based on plant accessibility. Habit, habitat, altitudinal range, population size, distribution range, impacts of multiple threats including habitat destruction, erosion, fuel wood cutting, grazing, poultry farms, and invasive species have been studied in the habitat. Plant specimens were collected from different parts of the research area. The nature of the habitat has been analyzed through soil erosion, invasive species, and the impacts of anthropogenic activities. Demographic information (age, sex) and conservation status data were gathered at each site using semi-structured questionnaires of the standard method according to Khan, (2013). During the surveys, personal observations were also recorded. The analysis of the data was made possible with the help of group discussions and questions directed at different age groups which included both sexes of the society. The data were classified, tabulated, analyzed to reach conclusions for the final report.

Figure 1. Map of the District of Bannu showing the research spot.

Results

In the present study, the conservation status of some wild plant species was determined in the District of Bannu. A total of 135 species belonging to 115 genera and thirty-eight families were found.

The *Asteraceae* was dominant with twenty species followed by *Poaceae* with nineteen species, *Amaranthaceae, Euphorbiaceae* and *Papilionaceae* with seven species. *Malvaceae* and *Polygonaceae* with five species. *Chenopodiaceae* with four species. *Plantaginaceae* and *Zygophyllaceae* with three species. *Apiaceae*, *Caryophyllaceae, Convolvulaceae, Cucurbitaceae, Gentianaceae* and *Verbenaceae* have two species. *Aizoaceae, Apocynaceae, Asclepiadaceae, Asphodelaceae, Cyperaceae, Fumariaceae, Iridaceae, Lamiaceae, Linaceae, Nyctaginaceae, Orchidaceae, Orobanchaceae, Oxalidaceae, Papaveraceae, Primulaceae, Ranunculaceae, Resedaceae, Tiliaceae* and *Typhaceae* with a single species (Figure 2; Table 1).

The plants were divided on the basis of their conservation status into five classes, and these are: endangered, vulnerable, rare, infrequent, and dominant. In the present report, fifty-two species (38.52 %) were found to be rare, vulnerable (45 Species; 33.33%), Infrequent (18 species; 13.33%), endangered (12 Species; 8.89%) and eight species (5.93%) were dominant (Figure 3; Table 1).

Discussion

Since the beginning of civilization, people have used plants to fulfill the various daily life requirements. The study has been designed to report on the conservation status of plants through anthropogenic activities in the District of Bannu. One of the objectives of this study is to record the conservation status of plants in the research area, which has a great wealth of medicinal plants. The work can be considered as a bird's-eye view as the information collected and described here is, with no doubt, little, but without such information the botanical aspects of the area remain incomplete.

The work will surely provide much help for future workers in this field. The area consists of both irrigated and rain-dependent, regions which are much different in their floristic composition. Due to irrigation facilities the

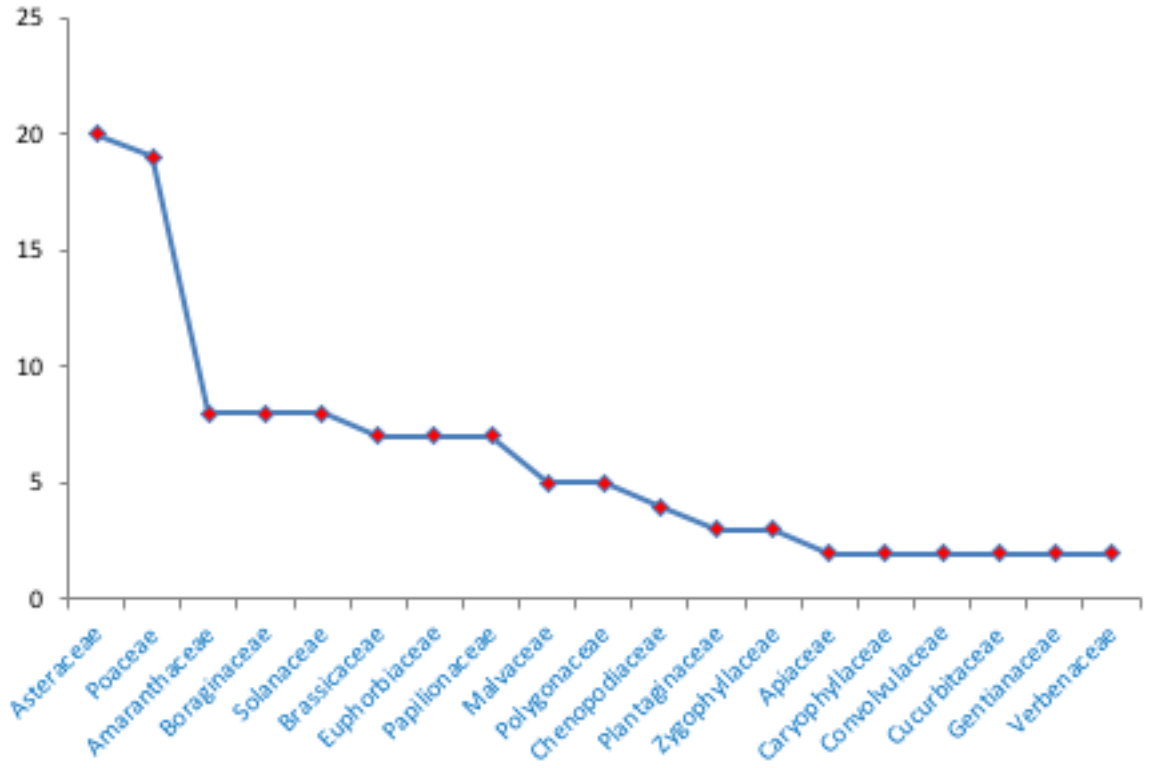

Figure 2. Families in the research area.

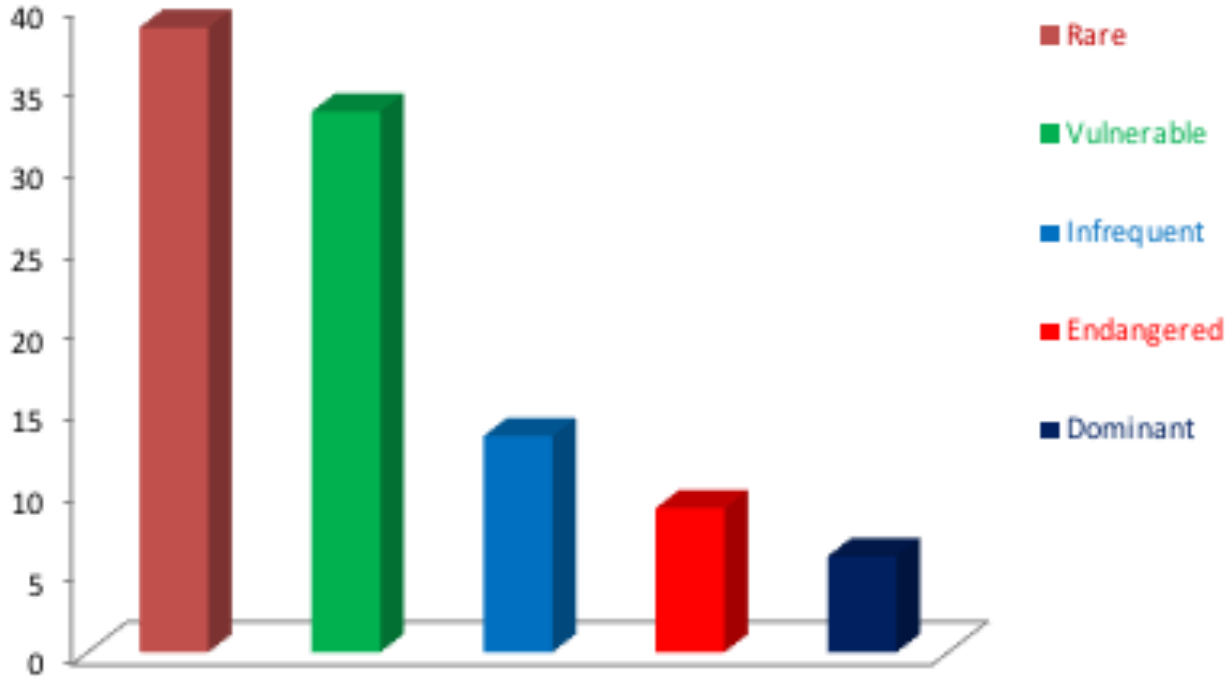

Figure 3. Conservation status of plant species in the research area.

flora, particularly cultivated flora, is very much different from the plants in the rain-dependent areas. Few fruit orchards can be seen in the research area. From the present investigation, it is noticed that each species have limited to a slight distribution range and definite habitat. The species habitat is concerned with the changes in location.

The main reasons behind the intermission and destruction of the environment of plants in the area include road structure, red bricks factories, oil and gas

Table 1. Floristic list and conservation status of some wild plant species in the Bannu District AY= Availability, CN= Collection, GH= Growth, PU= Plant used, TS= Total score, SS= Status, R= Rare, V= Vulnerable, I= Infrequent, E= Endangered, D= Dominant.

Botanical Name	**Family**	AY	CN	GH	PU	TS	SS
Abutilon indicum (L) Sweet	*Malvaceae*	2.5	0.4	1.4	3.6	7.9	V
Achyranthes aspera L.	*Amaranthaceae*	0.4	2.1	0.3	3.7	6.5	V
Achyranthes bidentata Blume	*Amaranthaceae*	2.9	2.5	2.7	2.9	11	R
Aerva javanica (Burm. f.) Juss.	*Amaranthaceae*	1.3	3.5	1.3	3.5	9.6	R
Alhagi maurorum Medic.	*Papilionaceae*	0.4	1.5	3.2	2.7	7.8	V
Alopecurus nepalensis Trin ex Steud	*Poaceae*	1.5	2.5	3.5	2.2	9.7	R
Alternanthera sessiles (L.) R.Br. Ex.Dc	*Amaranthaceae*	2.7	2.4	3.4	2.4	10.9	R
Amaranthus blitoides S. Watson	*Amaranthaceae*	2.6	2.4	3.4	2.4	10.8	R
Amaranthus viridis L.	*Amaranthaceae*	2.8	2.1	2.3	3.2	10.4	R
Anagallis arvensis L.	*Primulaceae*	2.3	1.4	0.9	3.8	8.4	R
Aristida adscensionis L.	*Poaceae*	2.1	1.6	0.8	3.4	7.9	V
Aristida cyanantha Nees ex Steud.	*Poaceae*	0.4	0.7	0.4	1.3	2.8	E
Arnebia hispidissima (Lehm.) A. DC.	*Boraginaceae*	2.5	2.5	3.7	3.6	12.3	I
Asphadelus tunifolius Car.	*Asphodelaceae*	1.3	0.7	1.5	2.8	6.3	V
Astragalus hamosus L.	*Papilionaceae*	1.6	2.2	3.6	3.5	10.9	R
Atriplex stocksii Boiss.	*Chenopodiaceae*	1.5	2.3	3.7	3.7	11.2	R
Avena fatua L	*Poaceae*	1.5	2.4	3.5	3.5	10.9	R
Boerhavia procumbens Banks ex Roxb	*Nyctaginaceae*	1.4	0.8	1.4	3.1	6.7	V
Brassica compestris L.	*Brassicaceae*	3.8	3.8	3.6	3.9	15.1	D
Brassica tournefortii Gouan	*Brassicaceae*	3.7	3.7	3.8	3.9	15.1	D
Calendula officinalis L.	*Asteraceae*	1.4	2.1	0.9	3.4	7.8	V
Calotropis procera (willd.) R. Br.	*Asclepiadaceae*	0.5	0.6	1.9	3.6	6.6	V
Carduus argentatus L.	*Asteraceae*	3.4	1.6	3.6	3.7	12.3	I
Carthamus persicus Willd	*Asteraceae*	3.2	1.7	3.8	3.7	12.4	I
Carthamus tinctorus L.	*Asteraceae*	2.4	1.3	3.8	3.7	11.2	R
Celosia argentea L.	*Amaranthaceae*	1.4	2.7	3.7	3.6	11.4	R
Cenchrus ciliaris L.	*Poaceae*	3.2	1.7	3.7	3.7	12.3	I
Centaurea iberica Spreng.	*Asteraceae*	0.7	0.7	1.3	0.7	3.4	E
Centaurium pulchellum (Sw.) Druce	*Gentianaceae*	0.6	0.8	1.2	0.6	3.2	E
Chenopodium ambrosioides L	*Chenopodiaceae*	1.2	1.3	1.2	3.7	7.4	V
Chenopodium album L.	*Chenopodiaceae*	1.3	2.5	3.7	3.8	11.3	R
Chenopodium murale L	*Chenopodiaceae*	2.4	3.7	3.6	3.7	13.4	I
Chrozophora plicata (Vahl) A. Juss. ex Spreng	*Euphorbiaceae*	2.8	2.9	3.6	3.6	12.9	I
Cirsium arvense (L) Scop	*Asteraceae*	2.8	2.8	3.7	3.8	13.1	I

Cistanche tubulosa (Shehenk.) Wight.	*Orobanchaceae*	0.5	1.7	0.8	0.9	3.9	E
Citrullus colocynthis (L.) Shred.	*Cucurbitaceae*	0.3	2.6	1.7	2.6	7.2	V
Convolvulus arvensis L	*Convolvulaceae*	0.5	2.1	0.4	3.6	6.6	V
Convolvulus spicatus Peter ex Hallier f.	*Convolvulaceae*	0.4	1.8	0.7	0.7	3.6	E
Conyza bonariensis (L.) Cronquist	*Asteraceae*	0.4	2.1	0.3	3.7	6.5	V
Corchorus depressus (L.) Stocks	*Tiliaceae*	2.9	2.5	2.7	1.7	9.8	R
Croton bonplandianus Bat.	*Euphorbiaceae*	2.4	2.5	2.9	1.7	9.5	R
Cymbopogon distense Schutt.	*Poaceae*	2.6	2.6	3.1	2.3	10.6	R
Cynodon dactylon (L.) Pers	*Poaceae*	0.4	2.3	3.2	1.7	7.6	V
Cyperus rotundus L.	*Cyperaceae*	1.5	2.5	3.5	2.2	9.7	R
Datura alba Nees.	*Solanaceae*	3.9	3.8	3.7	3.8	15.2	D
Dichanthium annulatum Forssk	*Poaceae*	1.5	0.9	1.4	3.5	7.3	V
Digera muricata (L.) Mart	*Amaranthaceae*	2.6	2.4	3.4	2.4	10.8	R
Dinebra retroflexa (Vahl) Panzer	*Poaceae*	2.3	1.4	0.9	3.8	8.4	R
Echinochloa crus-galli (L) P. Beauv	*Poaceae*	2.1	1.6	0.8	3.4	7.9	V
Echinops echinatus L.	*Asteraceae*	0.5	0.5	0.7	2.1	3.8	E
Eclipta alba (L.) Hassk.	*Asteraceae*	0.6	0.4	0.5	1.9	3.4	E
Eleusine indica (L) Gaertn	*Asteraceae*	1.3	0.7	1.5	2.8	6.3	V
Enneapogon avrnuceus (Lindl.) C. E. Hubbard	*Poaceae*	1.2	0.3	1.7	3.7	6.9	V
Eragrostis pilosa (L.) P. Beauv.	*Poaceae*	1.5	2.3	3.7	3.7	11.2	R
Eruca sativa Mill.	*Brassicaceae*	0.7	0.8	0.3	1.6	3.4	E
Erythraea ramosissima DC.	*Gentianaceae*	3.4	1.7	3.6	3.7	12.4	I
Euphorbia helioscopia L.	*Euphorbiaceae*	3.2	1.8	3.5	3.7	12.2	I
Euphorbia oblongata Griseb.	*Euphorbiaceae*	1.4	2.1	0.9	3.4	7.8	V
Euphorbia prostrata Ait.	*Euphorbiaceae*	1.7	0.4	1.8	3.5	7.4	V
Fagonia cretica L.	*Zygophyllaceae*	2.4	1.3	3.8	3.7	11.2	R
Farsetia jacquemontii (Hook.f. and Thoms.) Jafri	*Brassicaceae*	1.4	2.7	3.7	3.6	11.4	R
Filago pyramidata L.	*Asteraceae*	3.2	1.7	3.7	3.7	12.3	I
Fumaria parviflora Lam.	*Fumariaceae*	2.9	1.4	3.7	3.6	11.6	R
Galium tricorne Stokes	*Boraginaceae*	3.3	1.6	3.7	3.6	12.2	I
Helianthus annus L.	*Asteraceae*	1.2	1.3	1.2	3.7	7.4	V
Heliotropium crispum Desf.	*Boraginaceae*	1.4	1.4	0.9	3.4	7.1	V
Heliotropium europaeum (F. and M.) Kazmi	*Boraginaceae*	0.7	2.9	3.4	3.9	10.9	R
Heliotropium strigosum Willd.	*Boraginaceae*	0.5	0.4	0.7	2.2	3.8	E
Hibiscus trionum L.	*Malvaceae*	0.4	0.3	0.8	1.9	3.4	E
Hyoscyamus niger L.	*Solanaceae*	3.7	3.7	3.8	3.9	15.1	D
Hypecoum pendulum L.	*Papaveraceae*	0.5	2.5	1.6	2.5	7.1	V
Ifloga spicata Forssk.	*Asteraceae*	0.3	2.6	1.7	2.6	7.2	V
Iris lactea Pallas	*Iridaceae*	2.4	0.6	1.3	3.5	7.8	V
Lactuca serriola L.	*Asteraceae*	2.5	0.4	1.4	3.6	7.9	V
Lathyrus aphaca L.	*Papilionaceae*	2.9	2.5	2.7	1.7	9.8	R

Launaea angustifolia (Desf.) Kuntze	*Asteraceae*	2.4	2.5	2.9	1.7	9.5	R
Launaea procumbens (Roxb.) Ramayya and Rajagpal	*Asteraceae*	2.6	2.6	3.1	2.3	10.6	R
Leptochloa panicea (Retz) Ohwi	*Poaceae*	1.3	3.5	1.3	3.5	9.6	R
Linum corymbulosum Reichenb.	*Linaceae*	0.4	2.3	3.2	1.7	7.6	V
Malcolmia Africana (L.) R.Br.	*Brassicaceae*	1.5	2.5	3.5	2.2	9.7	R
Malva neglecta Wallr	*Malvaceae*	2.3	1.6	0.7	3.2	7.8	V
Malvastrum coromandelianum (L.) Garcke	*Malvaceae*	1.5	0.9	1.4	3.5	7.3	V
Medicago polymerpha L.	*Papilionaceae*	2.6	2.4	3.4	2.4	10.8	R
Melilotus parviflora (L) All.	*Papilionaceae*	2.8	2.1	2.3	3.2	10.4	R
Nerium indicum Mill.	*Apocynaceae*	0.4	1.6	0.7	0.7	3.4	E
Neslia apiculata Fisch.	*Brassicaceae*	2.1	1.6	0.8	3.4	7.9	V
Nicotiana plumbaginifolia Viv.	*Solanaceae*	2.2	1.7	0.4	3.1	7.4	V
Nonea philistaea Boiss.	*Boraginaceae*	1.7	0.4	1.8	3.5	7.4	V
Nonea pulla (L.) DC.	*Boraginaceae*	1.5	0.7	1.4	3.6	7.2	V
Oligomeris linifolia (Vahl.) Macbride	*Resedaceae*	1.5	2.3	3.7	3.7	11.2	R
Onosma chitralicum I. M. Johnston	*Boraginaceae*	1.5	2.4	3.5	3.5	10.9	R
Oxalis corniculata L.	*Oxalidaceae*	2.9	2.5	2.6	2.7	10.7	R
Oxyria digyna (L.) Hill	*Polygonaceae*	2.5	0.4	1.4	3.6	7.9	V
Parthenium hysterophorus L.	*Asteraceae*	0.4	2.1	0.3	3.7	6.5	V
Pegnum harmala L.	*Zygophyllaceae*	2.9	2.5	2.7	2.9	11	R
Phalaris minor Retz	*Poaceae*	1.3	3.5	1.3	3.5	9.6	R
Phyla nodiflora L.	*Verbenaceae*	0.4	1.5	3.2	2.7	7.8	V
Phyllanthus niruri L.	*Euphorbiaceae*	1.5	2.5	3.5	2.2	9.7	R
Physalis angulata L	*Solanaceae*	2.7	2.4	3.4	2.4	10.9	R
Plantago lanceolata L.	*Plantaginaceae*	2.6	2.4	3.4	2.4	10.8	R
Plantago ovate Forssk	*Plantaginaceae*	2.8	2.1	2.3	3.2	10.4	R
P*oa botryoides* (Trin. ex Griseb.) Kom.	*Poaceae*	2.3	1.4	0.9	3.8	8.4	R
Poa bulbosa L.	*Poaceae*	2.1	1.6	0.8	3.4	7.9	V
Polygonum barbatum L.	*Polygonaceae*	3.8	3.9	3.6	3.8	15.1	D
Polygonum biaristatum Aitch and Hemsl	*Polygonaceae*	2.5	2.5	3.7	3.6	12.3	I
Polygonum plebejum R.Br	*Polygonaceae*	1.3	0.7	1.5	2.8	6.3	V
Portulaca oleracea L.	*Aizaaceae*	1.6	2.2	3.6	3.5	10.9	R
Psammogeton biternatum Edgew.	*Apiaceae*	1.5	2.3	3.7	3.7	11.2	R
Ranunculus muricatus L.	*Ranunculaceae*	1.5	2.4	3.5	3.5	10.9	R
Ricinus communis L.	*Euphorbiaceae*	2.5	1.4	3.8	3.7	11.4	R
Rumex dentatus (Meisn)Rech.f	*Polygonaceae*	3.8	3.8	3.6	3.9	15.1	D
Sacharum arundinaceum H. K. F	*Poaceae*	0.4	0.7	0.4	1.3	2.8	E
Salvia plebeia R.Br	*Lamiaceae*	1.4	2.1	0.9	3.4	7.8	V
Setaria pumila (Poir.) Poam	*Poaceae*	0.5	0.6	1.9	3.6	6.6	V

Sida cardifolia L.	*Malvaceae*	3.4	1.6	3.6	3.7	12.3	I
Silene vulgaris (Moench) Garcke,	*Caryophyllaceae*	3.2	1.7	3.8	3.7	12.4	I
Sisymbrium irio L.	*Brassicaceae*	2.4	1.3	3.8	3.7	11.2	R
Solanum nigrum L	*Solanaceae*	1.4	2.7	3.7	3.6	11.4	R
Solanum surattense Burm. f	*Solanaceae*	3.2	1.7	3.7	3.7	12.3	I
Sonchus asper (L.) Hill	*Asteraceae*	2.9	1.4	3.7	3.6	11.6	R
Sorghum halepense (L.) Pers	*Poaceae*	3.8	3.9	3.9	3.9	15.5	D
Spergula fallax (Lowe) E. H. L. Krause	*Caryophyllaceae*	1.2	1.3	1.2	3.7	7.4	V
Taraxacum officinale F.H Wiggers	*Asteraceae*	1.3	2.5	3.7	3.8	11.3	R
Torilis nodosa (L.) Gaertn.	*Apiaceae*	2.4	3.7	3.6	3.7	13.4	I
Tribulus terrestris L.	*Zygophyllaceae*	2.8	2.9	3.6	3.6	12.9	I
Trichosanthes dioica Roxb	*Cucurbitaceae*	2.8	2.8	3.7	3.8	13.1	I
Trigonella corniculata (L.) Linn.	*Papilionaceae*	3.8	3.9	3.9	3.8	15.4	D
Typha orientallis C.Presl	*Typhaceae*	0.3	2.6	1.7	2.6	7.2	V
Verbena officinalis L.	*Verbenaceae*	0.5	2.1	0.4	3.6	6.6	V
Veronica agrestis L.	*Plantaginaceae*	2.5	0.4	1.4	3.6	7.9	V
Vicia hirsute (L) S.F. Gray.Nat.	*Papilionaceae*	0.4	2.1	0.3	3.7	6.5	V
Withania coagulans Dunal.	*Solanaceae*	2.9	2.5	2.7	1.7	9.8	R
Withania somnifera L.	*Solanaceae*	2.4	2.5	2.9	1.7	9.5	R
Xanthium strumarium L.	*Asteraceae*	2.6	2.6	3.1	2.3	10.6	R
Zeuxine strateumatica (L.) Schlechter	*Orchidaceae*	0.4	2.3	3.2	1.7	7.6	V

reservoirs. Khan *et al.,* (2011) and Khan and Hussain, (2013) stated that erosion causes a severe damage during rains, individuals of plant species growing in sandy and river banks were found to be more vulnerable to erosion than the plants found on slopes and cliffs. Such situation was also found in the research area and the results of the study agreed with the findings of these workers. The present study indicates that the whole plant is commonly used against different diseases and as food. The observations from the local people confirm that the richness and diversity of plants are declining, while at the same time, the number of plants used as medicine increased gradually with the increasing awareness in the research area.

Similar finding were also reported from other areas of Pakistan (Hussain, *et al*., 2006; Shinwari, 2010; Khan *et al*., 2011a,b, 2012, 2013b,c). According to Khan and Hussain (2012), the population size is often affected by the dry periods during the growing season. Those species which are found over a wide geographic range, but are consistently rare throughout their distribution, need immediate attention (Rabinowitz, 1981). Grazing is an ecological problem observed more in the rain-dependent areas than the irrigated areas, and is believed to change the habitat of the native flora.

The force and effect of grazing range from almost the invisible removal of plant materials to the harsh reduction of vegetation wealth and the following extensive erosion (Khan and Hussain, 2012b). From the conservation point of view, endangered species were reported from few localities in the research area. According to Davis *et al*., (1995), no accurate information has been published about the impacts of the unsustainable use of plant species. Hence, urgent conservation steps must be taken to avoid the eradication of wild plants from the research area.

The plant species are a major source

of medicine in addition to fulfilling other requirements for the local communities. The herbs are not used properly because of the shortage of trained manpower and resources. The local people collect whole plants along with their roots to be used as food and for treatment. According to (Engler, 2008; Khan, *et al*., 2012b; Khan and Musharaf, 2014), the over-exploitation of plant species for medicinal and food purposes by the local communities and migrants is a complex problem and a major cause of plant extinction.

It has been noted that the elderly people have more knowledge about the folk uses and conservation of medicinal plants than the younger generation. Most of the plants used by the local people are not conserved but are over-exploited in the research area. Therefore, there is an urgent need for conserving these plants so that the future generations may benefit from these valuable herbs that constitute a real gift from nature to mankind.

Conclusion

Local people use plants as medication, food, fodder for cattle, and even for cosmetic purposes. The number of women using allopathic medicine is negligible because of their dependence on medicines from local plants. These plants are also a source of relations between the women and the natural resources of the area.

The investigated area has a rich diversity of medicinal plants and provides a conductive habitat and ideal conditions for their growth. It is necessary to stop the collection of whole plants and their smuggling to other districts. Alternate environmentally-friendly and sustainable jobs should be provided for the local inhabitants for the sake of maintaining a living properly.

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Disclosure of Conflict of Interest

The authors declare no conflict of interests.

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Jordan Journal of Natural History, 7, 2020 Pages: 60- 63

Melanism in the Ussuri Pitviper (*Gloydius ussuriensis*) from the Republic of Korea, with Remarks on Color Variations

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Abstract: *Gloydius ussuriensis* is a species of pitviper inhabiting eastern Asia. Body coloration of this species is highly variable, but the extent of this variation has not been documented in detail. Herein, this work reports a melanistic individual of this species observed on Jeju island, Republic of Korea. This study confirms that this melanistic *G. ussuriensis* has never been observed outside Jeju. The geological environment of the island and the insular melanism can be considered as potential explanations.

Keywords: Melanism, Color variation, *Gloydius ussuriensis*, Jeju Island, Republic of Korea

Introduction

Gloydius ussuriensis is a species of pitviper (subfamily Crotalinae) inhabiting the Russian Far East, northeastern China, and the Korean Peninsula (Orlov, *et al.*, 2014). The body coloration of this species generally ranges from brown to grey (Lee *et al.*, 2012); however, it is highly variable within these color shades, and individuals often exhibit body coloration ranging from reddish or orange brown to reddish grey (Lee, *et al.*, 2012). The current study reports an observation on the melanistic *G. ussuriensis* individual from Jeju Island, Republic of Korea, with remarks on color variations in the species.

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Materials and Methods

During a field survey on 3 July 2019 at 3:07 p.m., we found an adult *G. ussuriensis* with an unusual melanistic body coloration in a forest of Seonheul-ri, Jeju Island, Republic of Korea (33.52684829 N, 126.7281346 E; WGS 84; 80 m asl). The individual was approximately 40 cm snout-to-vent length, and its overall body coloration was black with large circular patterns of a lighter color distributed irregularly along the length of the body (Figure. 1A). The coloration was significantly darker than the typical body coloration of *G. ussuriensis* (Figure. 1B ~ Figure. 1C).

Results and Discussion

As imminent shedding, dirt, and other debris accumulated between scales can make a snake's body coloration appear darker than the original coloration, we examined the scales closely to ensure that the original body coloration of the individual was not obscured by such factors. It was noted that this individual had shed recently at the time of observation; judging from the clear eye caps, dorsal scales, and shiny ventral scales with clearly visible mottled patterns. Also, it was noticed that no accumulated debris existed between the scales. Therefore, the original body coloration of this individual was not affected by any confounding factors, and thus it represents a melanistic form of *G. ussuriensis*.

According to the observations of *G.*

Figure 1. Body color and pattern variation in *Gloydius ussuriensis* observed in the Republic of Korea. (A) A melanistic individual observed in Seonheul-ri, Jeju Island, on 3 July 2019 reported herein. Note the coloration of this individual is significantly darker than the individuals of typical color form (B and C). (B) A grayish brown individual observed in Woraksan National Park, Republic of Korea. (C) A reddish brown individual photographed in Odaesan National Park, Republic of Korea. All photographs by YS.

ussuriensis uploaded on the citizen science platforms Naturing (https://www.naturing.net) and iNaturalist (https://www.inaturalist.org), and to our personal observations on the species in the wild, it seems that the frequency of dark grey and melanistic color morphs is higher in Jeju (thirty-seven cases) compared to the Korean mainland and elsewhere (six cases; GBIF occurrence download, https://doi.org/10.15468/dl.t693qz). Furthermore, completely melanistic individuals have not been recorded outside Jeju so far (Naturing observation,https://www.naturing.net/o/504616; https://www.naturing.net/o/498972; GBIF occurrence download, https://doi.org/10.15468/dl.t693qz). These lines of evidence suggest the possible existence of regional scale color variations between Jeju and the Korean mainland.

One of the possible reasons behind this color variations is the geological history of Jeju island and its environment. Due to its volcanic origin in the Quaternary, Jeju island is mostly composed of basalt. Therefore, the background substrate coloration on the island is generally darker than that of the mainland, which is composed mostly of other igneous (e.g. granite) and metamorphic rocks (Park, *et al.,* 2010; Chough, 2013). This difference in substrate coloration coupled with differential

predation pressure on the island (Kang, *et al.,* 2018) may have benefited the survival of individuals with darker coloration. For example, the population of the Oriental fire-bellied toads (*Bombina orientalis*) on Jeju island show a dark brown dorsal coloration exclusively, whereas the mainland populations generally show green but highly variable dorsal colorations (Kang, *et al.* 2017). Related predation experiments have linked body color to predation pressure on Jeju island compared to the Korean mainland (Kang, *et al.,* 2017; 2018).

Another possible explanation for the darker coloration on Jeju island is the general effect of island environments on phenotypes (Russell, *et al.*, 2011; Novosolov, *et al*., 2012). The island effect, or syndrome, can lead to the divergence of various organismal traits, including morphology, life history and reproductive biology (Adler and Levins, 1994; Roulin and Salamin, 2010, Novosolov, *et al.*, 2012). In vertebrates, there are numerous examples of island populations exhibiting markedly different phenotypes from their mainland counterparts (Adler and Levins, 1994; Fitzpatrick, 1998; Goltsman, *et al*., 2006; Luther and Greenberg, 2011). These include behavioral variations, with, for instance, insular lizard species differing in life history traits from the closely-related mainland species (Novosolov, *et al*., 2012; Novosolov and Meiri, 2013). Furthermore, there are other examples of body color variation and insular melanism, such as the lizard genus *Podarcis* (*P. hispanica atrata*; Castilla, 1994; Buades, *et al.*, 2013), and the owl *Tyto alba* (Roulin and Salamin, 2010). Jeju island is known to impact the phenotype of several species, and another example is the Japanese treefrogs (*Dryophytes japonicus*), displaying a larger overall body size in Jeju (Jang, *et al*., 2011; Koo, 2014).

Regarding *B. orientalis*, the colonization of Jeju island followed a single dispersal event from the mainland shortly after the formation of the island during the Early Pleistocene (Fong, *et al*., 2016). A similar process of dispersal and isolation is likely responsible for the presence of melanistic *G. ussuriensis* in Jeju. Additional studies are needed to investigate the frequency of different color variants across the range of *G. ussuriensis* and to test whether there is selective pressure on body coloration at the regional scale.

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Jordan Journal of Natural History, 7, 2020 Pages: 64- 92

Taxonomical Studies on the Cephalopods (Cephalopoda: Mollusca) Inhabiting both the Egyptian Mediterranean and the Red Sea Waters

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Abstract: Specimens were obtained from fishing trawlers operating in the Egyptian Mediterranean Sea, the Suez Gulf, and the Red Sea. Specimens were also obtained from Alexandria and Suez fish markets. The species included in the class Cephalopoda are ecologically and commercially important around the world. The class includes four groups: Cuttlefishes, Squids, Octopuses, and Nautilii. The first three groups are present in the Egyptian Mediterranean and the Red Sea waters. They constitute a main component in the fisheries industry. In order to understand the biology and ecology of any species, their identification should be conducted properly to maximize the accuracy of any study. The present work is the first-in-kind, and was prepared to focus on the cephalopod species inhabiting both the Egyptian Mediterranean and the Red Sea waters. Six cephalopod species inhabit both the Egyptian Mediterranean and the Red Sea waters; these include one cuttlefish species: *Sepia dollfusi,* two squid species: *Loligo forbesi* and *Sepioteuthis lessonian,* and three octopus species: *Octopus vulgaris, Octopus macropus,* and *Octopus defilippi.* Two of them, namely *Sepia dollfusi,* and, *Sepioteuthis lessoniana* dwelling in the Red Sea and migrated to the Mediterranean waters through the Suez Canal. Specimen parts were drawn by means of a zoom stereoscopic microscope provided with a camera lucida drawing tube and the specimen parts were also photographed by a Canon digital camera.

Key words: Taxonomy, Cephalopods, Mollusca, Egyptian. Mediterranean Sea, Red Sea.

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Introduction

Cuttlefishes, Squids, Octopuses, and Nautilii are the most important representatives of the class Cephalopoda. The class includes about 1000 known species, which represent about 2.07% from the phylum Mollusca (Hassan, 1974). As a group, they include the largest species of both modern and fossil invertebrates in the coastal and the oceanic waters, inhabiting different kinds of grounds. Commercially, they represent a remarkable and significant fishery in many areas around the world. From the total catch of the world cephalopod fishery, about 71.8% were squids, 13.6% cuttlefishes, and 14.6% octopuses (Jereb and Roper 2005).

Many studies at the beginning of the nineteenth century concentrated on the fauna of the northern part of the Gulf of Suez. Savigny (1817) was the first to mention Cephalopoda in the Red Sea; he also identified seventy species which had not been confirmed before in the Red Sea waters (Edwards and Head, 1987).

Many twentieth-century studies of the Red Sea have provided an exciting direction to many expeditions. Although most of these expeditions were oceanographic explorations, they also served as zoogeographical studies with regional details (Edwards and Head, 1987). Robson (1926) recorded three cephalopod species from the Cambridge Expedition to the Suez Canal, namely: *Ascarosepion singhalensis* (Goodrich), which is synonymous to *Sepia pharaonis* Ehrenberg, 1831, *Lophosepion lefebrei* d'Orbigny synonymous to *Sepia gibba* Ehrenberg, 1831, and *Octopus horridus* d'Orbigny (Zebra Octopus). Robson (1926) recorded six cephalopod species from the Suez Canal.

Adam (1959) described ten cephalopods from the Gulf of Suez and three from the Gulf of Aqaba. Adam (1960) recorded seven cephalopod species from Aqaba Gulf. Eman (1984) recorded eight cephalopods from the Gulf of Suez and Aqaba. About ten Sepioidea species were recorded from the Egyptian waters (Steuer, 1939; Emam, 1983; Riad, 1993; 2000a, 2000b, 2008a, 2008b and 2015.). Steuer (1939) recorded one Sepioidea species. S*epia officinalis* from the Mediterranean Sea, *Sepia prashadi*, and *Sepia savignyi* from the Red sea were studied by Emam (1983). Riad (1993) recorded nine cephalopoda species from the Egyptian Mediterranean waters, two of them were sepioidea: *Sepia officinalis* and S*epia elegans*. Four were squids: *Loligo vulgaris*, *Loligo forbesi*, *Alloteuthis media*, and *Illex coindetii*. Emam and Saad (1998) studied the morphometric and population dynamics of *Sepia dollfusi* from the northern region of the Red sea.

There are also many studies conducted during the twenty century. Emam and Aly (2000) studied the male reproductive system of the *Seoioteuthis lessoniana* from the Suez Gulf. Riad (2008b) recorded one new record of cephalopoda species *Sepioteuthis lessoniana* from the Egyptian Mediterranean waters which migrated from the Red sea. Emam and Gareb (2010) studied the morphology, the digestible and reproductive system of the male of *Sepioteuthis lessoniana* from Abo Qir Bay in the Alexandria Mediterranean waters. Riad (2000b) recorded two first record species from Alexandria Mediterranean waters, namely *Rossia macrosoma* and *Octopus defillipi*. Riad (2008a) recorded ten cephalopod species from the Suez Gulf and the Red Sea, three of them were sepioidea: *Sepia dollfusi*, *Sepia pharaonis*, and *Sepia elongate*. Riad (2015) recorded one new record of Sepioidea species, namely *Sepia dollfusi* from the Egyptian Mediterranean waters which is dewlling in the Red Sea and migrated to the Mediterranean Sea through the Suez Canal.

The present work was conducted using morphological features. The aim of the present work is to add more information to the limited taxonomical studies of the Cephalopoda species inhabiting both the Egyptian Red and the Mediterranean Sea waters.

Materials and Methods

The specimens were obtained from fishing trawlers operating in the Egyptian Mediterranean Sea from Sidi Abd El- Rahman, west of Alexandria to Rosetta (Figure 1) and from the Suez Gulf, Red Sea (Figure 2). Specimens were also obtained from Alexandria and Suez fish markets over the period from January 2019 to December 2019. The samples were preserved in a 5% formalin sea water solution, and were kept in the Taxonomy and Biodiversity of Aquatic Biota Lab. (reference collection center), National Institute of Oceanography and Fisheries, Alexandria, Egypt.

According to Roper *et al*., (1984), the following characteristics were carefully examined for the identification of the species: External morphology, tentacular club, hectocotylized arm, tentacular club sucker, tentacular club sucker ring, arm sucker, arm sucker ring, radula, gill, shell, and funnel (siphon). The specimen parts were drawn by means of a zoom stereoscopic microscope provided with a camera-lucida drawing tube. The specimen parts were also photographed by a Canon Digital camera.

Results and Discussion

The species in the present work are illustrated as follows:

Phylum: Mollusca
Class: Cephalopoda Cuvier, l798.
Subclass: Coleoidea Bather, l888.
Order: Sepioidea Naef, 1916.
Family: Sepiidae Keferstein, 1866.
Genus *Sepia* Linnaeus, 1758
Sepia dollfusi Adam, 1941b**.** The Suez Gulf, the Red Sea and Alexandria, Mediterranean waters.

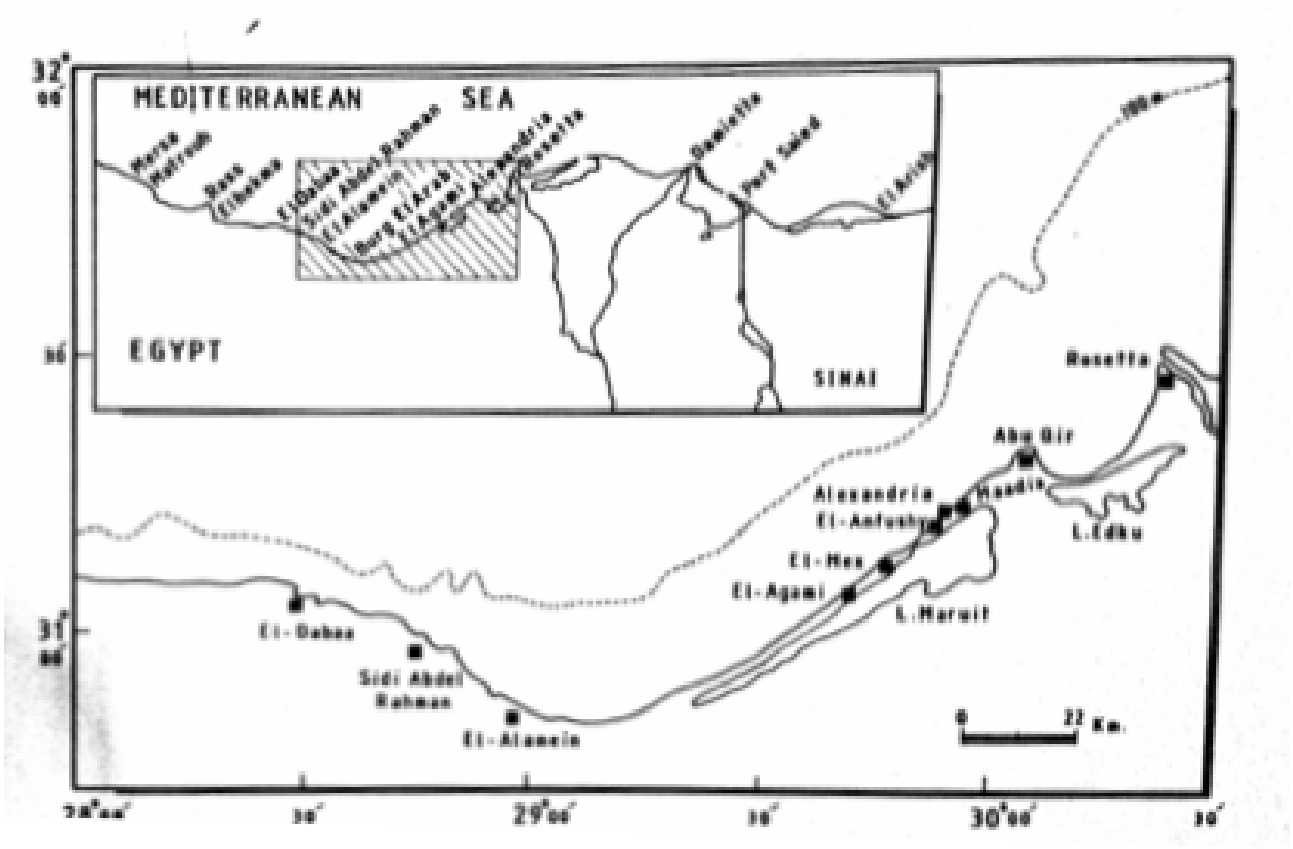

Figure 1. Alexandria coast (Egyptian Mediterranean Sea)

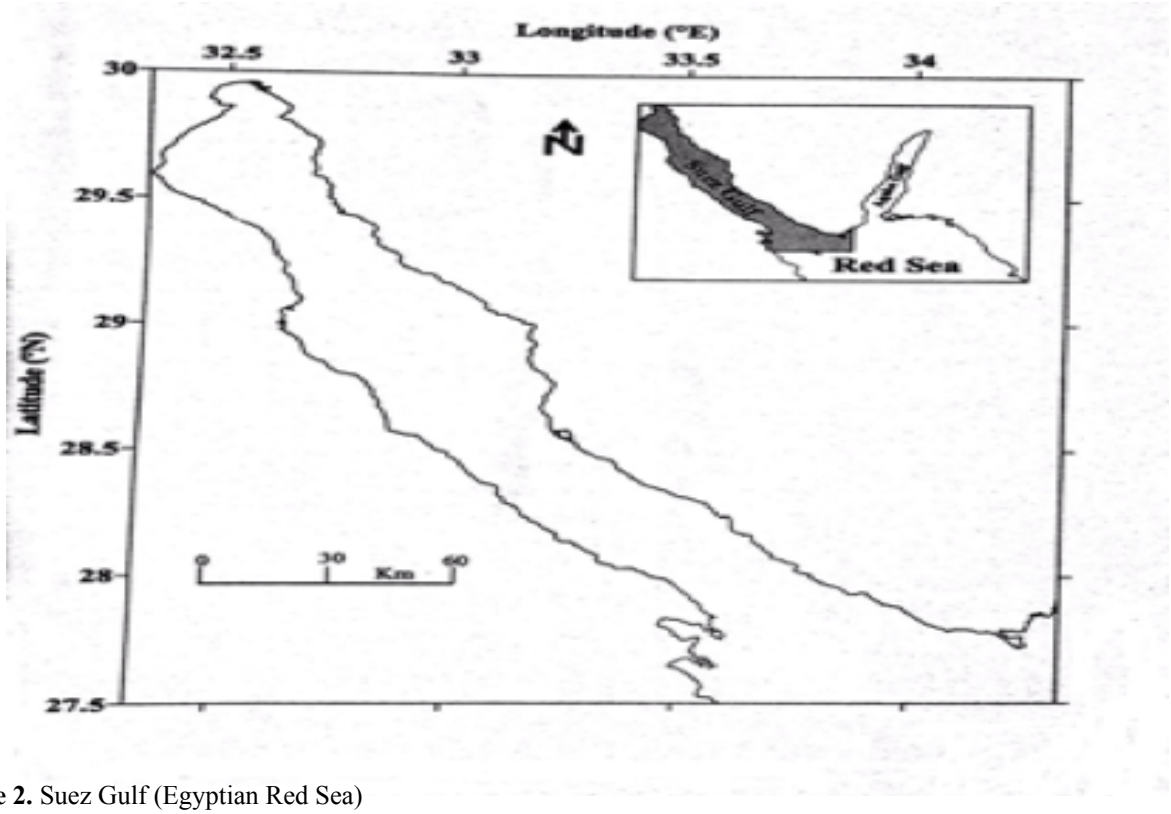

Figure 2. Suez Gulf (Egyptian Red Sea)

Order:Teuthoidea Naef, 1916.
Suborder:Myopsida d, Orbigny, 1845.
Family: Loligonidae Steenstrup, 1861.
Genus *Loligo* Schneider, 1784.
Loligo forbesi Steemstrup, 1856. The Suez Gulf, the Red Sea. Alexandria Mediterranean waters.
Genus: *Sepioteuthis*
Sepioteuthis lessoniana Lsson, 1830. The Suez Gulf, the Red sea, and Alexandria Mediterranean waters.
Order: Octopoda Leach, 1818.
Suborder Incirrata Grimpe, 1916.
Family: Octopodidae d›Orbigny, 1845.
Subfamily: Octopodinae
Genus *Octopus* Lamarck, 1798.
Octopus Vulgaris Cuvier, l797. Alexandria, Mediterranean waters and the Red Sea.
Octopus macropus Risso, 1826. Alexandria, Mediterranean waters and the Red Sea
Octopus Defilippi Verany, 1851. Alexandria, Mediterranean waters, and the Red Sea.

Phylum: Mollusca
Class: Cephalopoda Cuvier, 1798
Subclass: Coleoid Bather, 1888.
The Subclass Coleoidea embraces four orders: Sepioidea Naef, 1916; Tauthoidea Naef, 1916; Octopoda Leach, 1818, and Vampyromorpha Pickford, 1939.
Only the first three orders are represented in the current study.
Order: Sepioidea Naef, 1916.
This order is characterized by the following features: shell calcareous or chitinous; 10 circumoral appendages; tentacles retractile into pockets; suckers with chitinous rings; posterior fin lobes free, not connected at midline; eyes covered with a transparent membrane, false eyelids present; one pair of gills, without a branchial canal between the afferent and efferent branchial blood vessels; liver divided or bilobed, each tooth of radula with a single projection; buccal membrane present; olfactory organ a ciliated pit. This order comprises five families: Spirulidae Owen, 1836, Sepüdae Keferstein, 1866 Sepiadariidae Naef, 1912), SepiolidaeLeach, 1817, and Sepiadariidae Owen, 1836, Sepiidae Keferstein 1866, Appell f, 1898. (Gereb and Roper, 2005). In the Egyptian Mediterranean waters and the Red Sea, this order is represented by only one family, Sepiidae, which has a significant commercial value.

1.3 **Sepioidea Species of the East Mediterranean Waters**

Seven Sepioidea species are known to occur in the Mediterranean waters:
Sepia elegans BlainVille, 1827*;*
Sepia officinalis Linnaeus, 1758*;*
Sepia orbignyana Ferussac, 1826*;*
Sepiola rondeleti Leach, 1817;
Sepietta oweniana d›Orbigny, 1840*;*
Rondeletiola minor Naef, 1912; and
*Rossia mac*rosoma Delle chiaje, 1829 (Gereb and Roper, 2005; ; Katagan and Kocatas, 1990).

The Sepioidea species were recorded in both the Egyptian Mediterranean and the Red Sea waters).

The following species were recorded as follows:
Class: Cephalopoda Cuvier, l798.
Subclass: Coleoidea Bather, l888.
Order: Sepioidea Naef, 1916.
Family: Sepiidae Keferstein, 1866.
Genus*: Sepia* Linnaeus, 1758.
A cuttlebone with a spine (rostrum) is present on the posterior end (occasionally damaged or absent); as long as the body; bordered by a horny margin. No glandular pore on the ventral surface at the posterior end of the mantle. This genus is represented in the Egyptian waters by seven species, *Sepia Officinalis* Linnaeus, 1758; *Sepia elegans* Blainville, 1827; *Sepia dollfusi, Sepia pharaonis, Sepia elongata, Sepia prashadi,* and *Sepia savignyi*.

Key to the Species of the Genus *Sepia* in the Egyptian Waters.

1-The tentacular club is provided with transverse rows of suckers, five or six in each, the median longitudinal row is remarkably enlarged, Left arm IV (hectocotylized) is reduced in size, with five-eight horizontal rows of reduced suckers.....***Sepia officinalis***.

2-The tentacular club is short with six-eight suckers on each transverse row; few of the suckers are enlarged while three are greatly developed in the center.
Two thirds of the left arm IV (hectocotylized) possess about nine-eleven zigzag rows of minute suckers.....***Sepia elegans.***

3-The tentacular club has five-seven suckers in the middle row larger than the others. The left arm IV (hectocotylized) is modified in about half of the terminal part forwarded by twelve transversal rows of four minute suckers.....***Sepia dollfusi.***

4-The middle part of the tentacular club bears eight transverse rows of suckers, five or six median suckers are enlarged. There are five longitudinal rows of suckers**.** Hectocotylized arm: with ten-twelve quadriserial rows of normal suckers at the base followed by ten rows with ventral suckers (two rows) normal, as for the dorsal, two rows are minute and are separated from the ventral rows by a fleshy transversely groove ridge....***Sepia pharaonis***

5-The tentacular club is small with a well-developed keel, of a length of about 15% of the tentacle. The hectocotylized arm shows a unique structure that is hard, enlarged, and wrapped around a free edge endowed with seven transverse wrinkles without suckers (The proximal and distal parts of the hectocotylized arm carry erratically normal suckers. .....***Sepia elongate.***

6- The hectocotylus is present on the left ventral arm: four rows of normal size suckers are proximally situtaed, twelve-fourteen rows of reduced suckers are medially situated, then a normal size hectocotylus in two ventral series is displaced laterally, with a gap in between on the proximal part of the modified region. ***Sepia prashadi.***

7- Club straight, slender; sucker-bearing surface convex, with eight suckers in the transverse rows; suckers differ slightly in size; several suckers of the inner two or three rows are very slightly larger than rest.....***Sepia savignyi***

Cuttlefishes inhabiting both the Egyptian Mediterranean and the Red Sea waters waters. One species was recorded, namely *Sepia dollfuss.*

Sepia dollfuss Adam, 1941 **(Plates 1 and 2)**
Synonymy: None
World distribution: the Red Sea and the southern part of the Suez Canal (Nesis, 1987). From the Southern part of the Suez Canal and the Suez Gulf to Zanzibar, Madagascar, Southern Japan, Indonesia, and Western and Northern Australia (Nesis, 1987).
Local name: Sobet (Mediterranean) (Riad, 1993) and Sobia (Red Sea) (Riad, 2008a).

Local distribution: The species of the present study was captured from the area off the east of Alexandria and the Suez Gulf, the Red Sea).

Description: Mantle is large with a weak open mantle cavity (Plate 1a). The tentacular club has seven subequal suckers in a longitudinal row (Plate 1 b). The tentacular club sucker ring has 35- 38 pointed teeth (Plate 1d). Arms are long with four rows of suckers (Plate 1 c). The arm sucker ring has 25-28 blunt teeth (Plate 1e). The gill has more than 25 gill lamellae (Plate 1f). The shell is oval, not rhomboidal, smoothly rounded posteriorly, its length is almost equal to the mantle length (Plate 2 a-b-c). The radula has more than eighteen teethe (Plate 2d-e).

Habitat: In the Egyptian waters. *Sepia dollfuss* dwells in the Red Sea and the Suez Gulf waters, and it is the primary fishery in the Suez Canal (Riad, 2008a). *Sepia dollfusi* migrated from the Red Sea to the Mediterranean Sea through the Suez Canal (Riad, 2015).

Order: Teuthoidea Naef, 1916
The order Teuthoidea embraces two suborders: Myopsida d'orbigny. 1845 and Oegopsida d'orbigny, 1845. There are ten arms, two of which are longer than the rest. The arms are not joined by a swimming web. The arms bear suckers on stalks with horny

rings. The lateral fins are well-developed. An internal, non-chambered, horny shell is present. They are shallow water (*Loligo*) or deep-sea pelagic animals (Architeuthis). The origin of the order Teuthoidea, or true squids, can be traced to the early Mesozoic (Permian Triassic) with a steady proliferation from the Jurassic through the recent times. The two suborders, Myopsida, (covered -eyed) near shore (neritic) squids, and Oegopsida, (open-eyed). Oceanic (pelagic) squids occur in the oceans and seas of the world. Some are demersal or epibenthic at some period of their life cycle, but most occur in the water column. Out of the ten circumoral appendages, the fourth pair, the tentacles, are contractile, but not retractile into pockets (occasionally tentacles secondarily lost); sucker ornamentation with chitinous rings and/ or hooks. Radula teeth commonly with a primary projection and a secondary cusp(s), especially on the median (rachidian) and the first lateral teeth; buccal membrane present. The olfactory organ consists of two projecting papillae; eyes without lids covered with a transparent membrane, with a minute pore (Myopsida) or are completely open to the sea, without a pore (Oegopsida). Gills with the bronchial canal between afferent and efferent branchial blood vessels. Shell internal, simple, rod or feather-like, chitinous. (Roper *et al.,* 1984).

(A) The Suborder Myopsida d'Orbigny, 1845. The suborder Myopsida is comprised only of two families, the small, non-commercial, *Pickfordia teuthidae* Voss, 1953, and Loliginidae Steenstrup, 1861. In this study, one family is represented: Loliginidae. A corneal membrane covering the eye with minute pore anteriorly. Arms and clubs are with suckers, never with hooks. Suckers are present on the buccal lappets. Females with a single gonoduct, not paired; with accessory nidamental glands. (Roper, *et al.* 1984).

1.3 **Teuthoidea Species of the East Mediterranean Waters** (Roper *et al.*, 1984 and Katagan and Kocatas, 1990).

Twenty-nine cephalopod species are known to occur in the Mediterranean Sea. Of these, thirteen teuthoidea species are known to extend to the Eastern Mediterranean Basin.

Loligo forbesi, Loligo vulgaris, Alloteuthis media, Alloteuthis subulata, Ancistroteuthis hchiensteini, Histioteuthis bennellii, Histioteuthis elongate, Brochioteuthis riisei, Illex coindeii, Todaropsis eblanae, Todarodes sagittatus, Ommastrephes coroli and *Ommastrephes pteropus.*

Morphology and Occurrence of the Teuthoidea Species Inhabiting the Egyptian Mediterranean and the Red Sea waters.

Family: Loliginidae d, Orbigny, 1848.

Shape variable from short and stout to long and slender. Fins terminal, but always united posteriorly, extending along the entire length of the mantle and quite wide (approx., 18% of the mantle length). Funnel looking apparatus, a simple, straight groove. Eyes covered with a transparent skin (corneal membrane); buccal connectives attached to the ventral borders of the fourth arms; seven buccal lappets are supplied with small suckers (except in Lolliguncula and Alloteuthis); eight arms and two tentacles around the mouth; two rows of suckers on the arms and four rows on the tentacular clubs, four rows of suckers on the manus, hooks are never present. Usually, the left arm IV (ventral) pair is hectocotylized in males (used to transfer sperm packets from the male to the female), the structure of the modified portion (hectocotylus) of the arm is useful in most species as a diagnostic character. The suckers on the hectocotylus are often reduced in size or number, or modified into fleshy papillae or flaps (lamellae), or they disappear altogether. Color: usually reddish-brown and is darker dorsally, but quite variable depending on the behavioral situation. This family embraces eight genera:

Loligo Schneider, 1784;
Doryteuthis Naef, 1912;
Lolliguncula Steenstrup, 1881;
Sepioteuthis Blainville, 1824;
Alloteuthis Wülker, 1920;

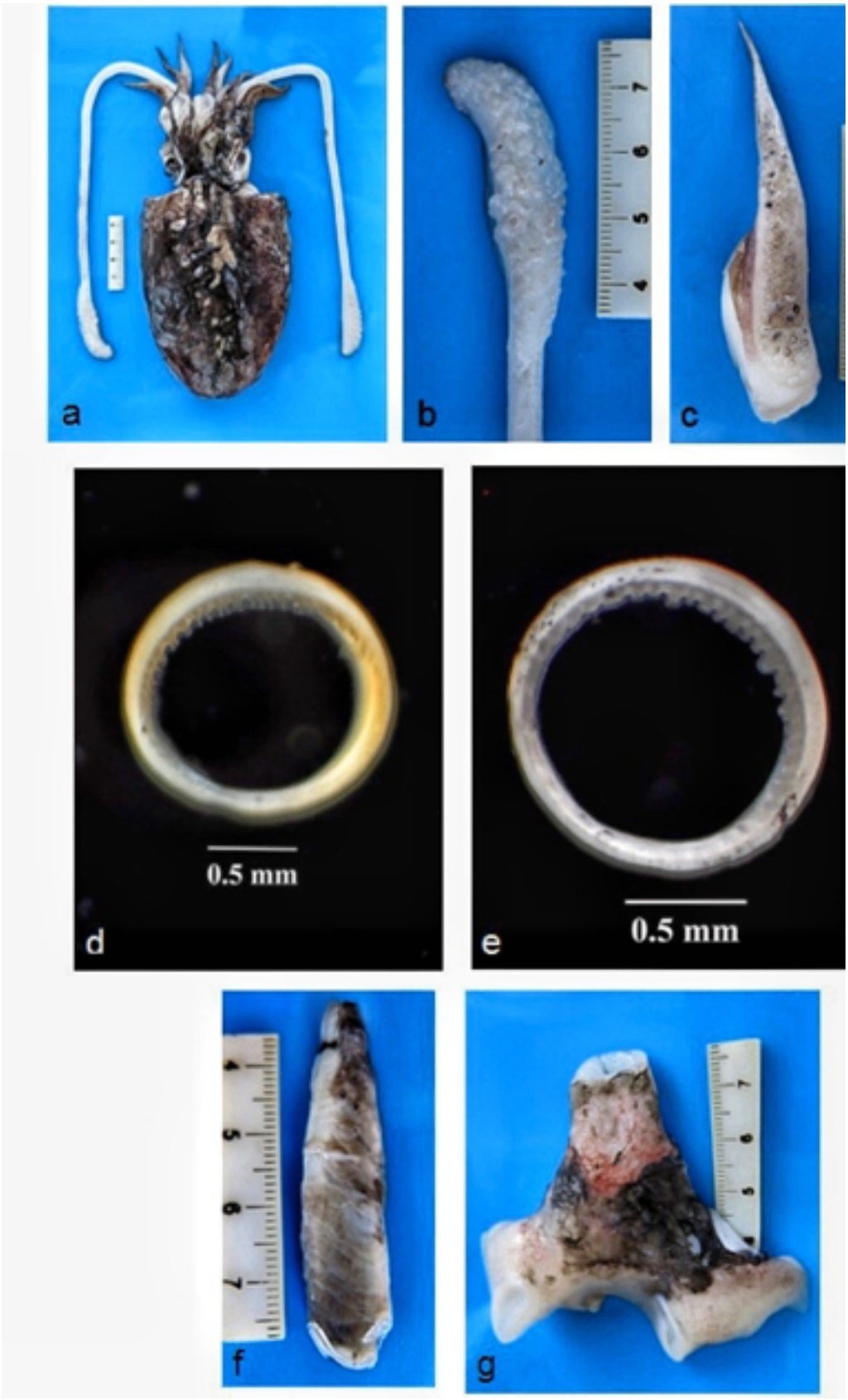

PLATE (1) *Sepia dollfusi*
(a) The animal (dorsal view). (b) Tentacular club. (c) Normal arm. (d) Tentacular club sucker ring. (e) Arm sucker ring. (f) Gill. (g) Funnel.

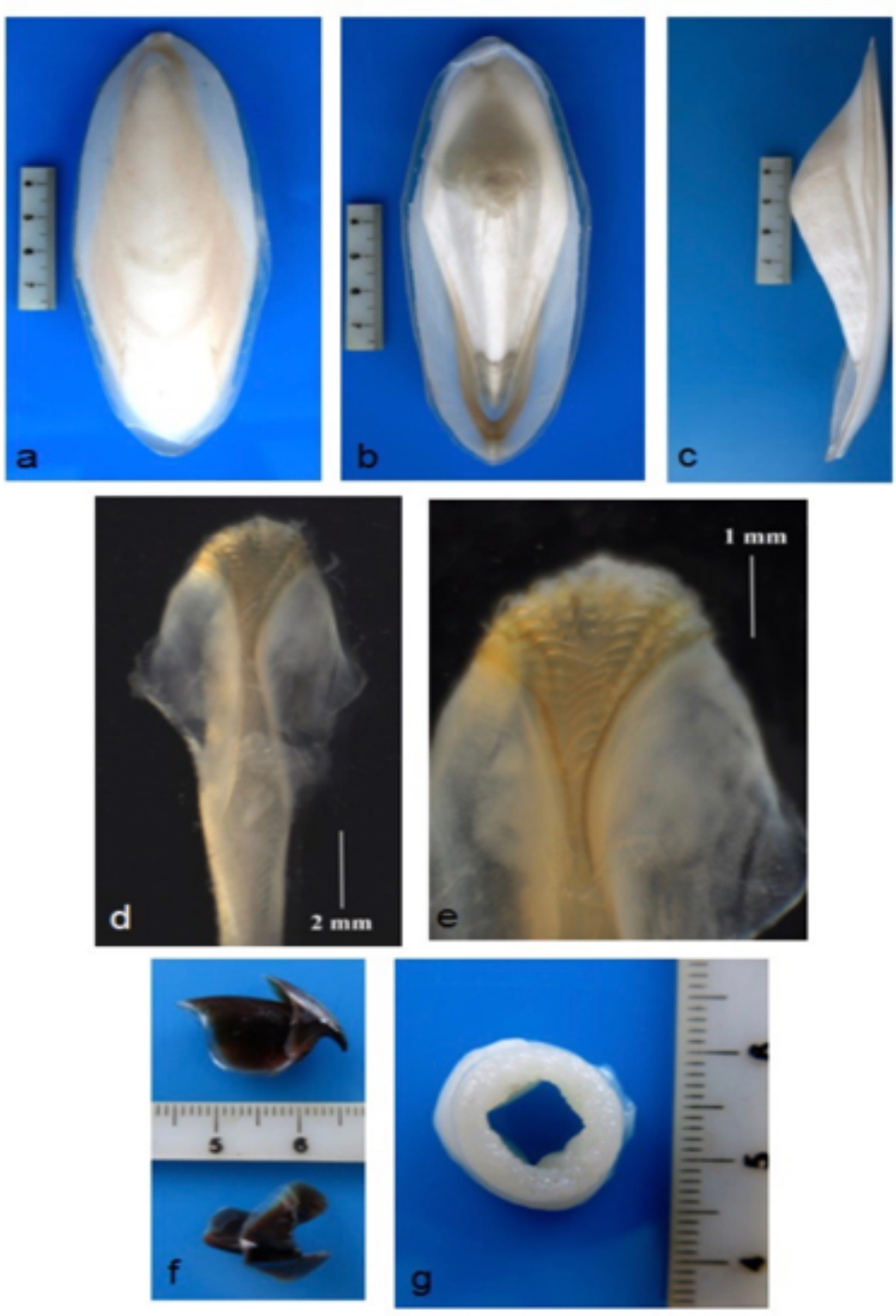

PLATE (2) *Sepia dollfusi*

(a) Shell (dorsal view). (b) Shell (ventral view). (c) Shell (lateral view). (d) Radula. (e) Enlarged part of radula. (f) Upper beak and lower beak. (g) Buccal op.

Uroteuthis Rehder, 1945;
Loliolus Steenstrup, 1856;
Loliolopsis Berry, 1929.

In this study, this family is represented by three genera only: *Loligo* Schneider, 1784; *Alloteuthis* Wülker, 1920, and *Sepioteuthis* Blainville, 1824.

Key to the Recorded Genera in the Present Study

1-Mantle elongate or short, robust, posteriorly pointed, but never produced into an elongated tail; the posterior border of fins is straight, or only slightly concave, or rounded. Fins lateral, rhombic in outline, with posterior borders straight or slightly concave; relatively long, usually over 60% of the mantle length; mantle elongate, bluntly to sharply pointed; left ventral IV hectocotylized in males; buccal arms with about fifteen small suckers in two rows. .....***Loligo*** Steenstrup, 1856.

2-Fins very long, over 90% of the mantle length, broad, Sepia- like, but much wider and more muscular; mantle very robust ....*Sepioteuthis* Lesson, 1830. Roper *et al*., (1984).

Genus: *Loligo* Schneider, 1784.

Keys to the Species of Genus *Loligo* in the Egyptian Waters.

1-Tentacular club with suckers, the two inner rows are larger than other suckers with about twenty transverse rows of minute suckers with about fifteen teeth in each sucker ring. .. ..***Loligo vulgaris.***

2-Tentacular club with four rows of subequal sucker), each sucker ring has about sixteen-twenty sharp teeth. .....***Loligo forbesi.***

3-Tentacular club with larger median suckers than the marginal with fourteen to seventeen short sharp teeth.....***Loligo duvauceli.***

Loligo forbesi inhabiting only the Egyptian Mediterranean and the Red Sea Waters.

(ii) *Loligo forbesi* Steenstrup, 1856 (Plate 3, Plate 4, A- M and plate 5, a-i)

Synonymy: None.

World distribution. Mediterranean Sea (Roper *et al*., 1984), the north-western Mediterranean Sea (Boletzky and Mangold, 1985), the Red Sea and East Africa (Roper *et al.,* 1984), Catalonian Sea (Sanchez, 1985), the eastern Atlantic Ocean from 20° N to 60° N (excluding the Baltic sea) (Roper *et al*., 1984).

Local name: Kalemaria. (Riad, 1993).

Local distribution: A few specimens (sixteen) were obtained by trawling offshore from Rosetta (2 m. 36 m. depth), and from the Alexandria water fish markets (Anfushy, Abu Qir, Meadeia and Rosetta). From fish trawls in the Suez Gulf (Ataka Harbor) and the adjacent area, the Red Sea.

Description: The mantle is slender; the fins are elongated and posteriorly concaved, extending to about 75% of the ML (plate 3). The manus of the tentacular club is provided with subequal suckers (Plates 4b and 5b), each sucker ring has about sixty-twnety sharp teeth (Plates 4f and 5e), but some suckers had less teeth (thirteen). The distal modified part of the left arm IV (hectocotylized) occupies about 35% of its To. L, covered with long papillae (twenty-eight to thirty), decreasing in size distally (Plates 4 C and 5c). The arms have two rows of suckers, each arm sucker ring is provided with twenty to thirty sharp teeth, the largest arm sucker rings has seven-eight teeth (plate 4h). Each gill is provided with about 60-gill lamellae (Plates 5e and 6h). There are seven radulae (Plate 5J), each radula has five-six suckers (Plates 5K and L), and each sucker ring has twenty teeth (Plate 5M).

Differentiation between *L. forbesi* and *L.vulgaris* depends mainly upon the relative size of the suckers on the tentacular club. In *L.forbesi*, there are four rows of subequal suckers, while in *L. vulgaris*, the suckers on the two inner rows are

considerably larger than other suckers. Some characters given in the present description have not been reported before in the literature such as the number of papillae of left arm IV (hectocotylized), the number of gill lamellae, the number of the radula, and the number of radula suckers, and the teeth of the radula sucker ring.

Out of the sixteen specimens collected, the largest had an ML of 28.1 cm, TL 52.5 cm, TW 180 gm (for the male) and an ML of 17.3 cm, TL 42.6 cm, TW 105 gm (for the female). The smallest showed the following measurements: an ML of 7.5 cm, TL 20.6 cm, TW 13.09 gm (for the male), and ML of 8cm, TL 21.3 cm,TW 14.74 gm (for the female). Poper *et al.*, (1984) reported larger sizes for the ML.

Habitat: A temperate shelf species found in the deeper waters of subtropical areas. The depth range extends from 100 to 400 m (Roper *et al*., 1984).

Genus:*Sepioteuthis* Blainville,1824.

Sepioteuthis lessoniana Lesson, 1830. **(Plates 6,7,8 and 9)**

Material: one male and one female were only available from a commercial fish trammel net. The first was with a dorsal mantle length of 19.5 cm and a total weight of 300 gm., while the second was with a dorsal mantle length of 20 cm, and its total weight was 350 gm.

Synonyms:

Sepioteuthis guinensis Quoy and Gaimard, 1832 *Sepioteuthis Lunulata Quoy* and Gaimard, 1832; *Sepioteuthis Mauritania* Quoy and Gaimard, 1823; *Sepioteuthis sinensis* d, Orbigny, 1835-1848; *Sepioteuthis arctipinnis* Gould, 1852; *Sepioteuthis brevis,*Owen 1881*; Sepioteuthis neoguinaica* Pfeffer, 1884; *Sepioteuthis indica* Goodrich, 1896; *Sepioteuthis sieboldi* Joubin, 1898; *Sepioteuthis malayana* Wiiker, 1913; *Sepioteuthis krempfi,* Robson,1928. (Roper *et al*. 1984).

World distribution: Widespread in the Indo-Pacific: the Red Sea, Arabian Sea eastward to 160°E, eastward to the Hawaiian Islands, northern Australia, and northward to central Japan. (Roper *et al*., 1984).

Common name: Big fin reef squid. (Roper *et al*., 1984).

Local name: Kalimaria (Riad, 1993).

Local distribution: the Suez Gulf, the Red Sea (Emam and Aly, 2000). Alexandria, Mediterranean waters (Riad, 2008b).

Description: Mantle long, robust, its width is about 43% of the mantle length (plates 6a and b) Fins very long, more than 90% of the mantle length, broad: Sepia-like but much wider and more muscular; and their width is up to 73% of the mantle length, greatest width occurs posterior to the midpoint of the fins (plate 6 e and plate 9f). The head width is much larger than the head length and bears two lateral oval eyes (plate 6a). The tentacular club is long, expanded with four rows of suckers, median manus suckers enlarged (plate 6c and plate 8a). Tentacular club sucker ring with seventeen to twenty-two sharp teeth (plate 8 j and plate 9h). Dactylus sucker ring with fourteen to sixteen teeth (plate 8i and plate 10j). Arm sucker ring with twenty-twenty-five long sharp teeth (plate 7k and plate 9g and i). Buccal lappets bear a small number of suckers (plate 6i and plate 9f). The buccal mass contains two beaks and a radula, the upper beak has a short blunt, curved rostrum, crest, large wings, and large lateral walls with posterior margins slightly indented (plate 7a and plate 8e). The lower beak has a short blunt rostrum, long hood, crest, large lateral walls, and small wings (plate 8b and plate 9g). The radula is small and consists of nine rows of rachidian teeth (plate 7g and h and plate 9e). The funnel lies below the head on the ventral side. It opens into the mantle cavity (plate 7e and plate 9a). The gill consists of about more than sixty pairs of Gill lamellae (plates 6f and g and plate 8d).

Order: Octopoda Leach, 1818

The order Octopoda is divided into two suborders, namely **Cirrata**, mostly deep-

PLATE (3) *Loligo forbesi*

sea pelagic and epibenthic forms that possess cirri along the arms and have paddle-shaped fins, and **Incirrata**, moderately deep to shallow-living benthic and epipelagic forms which possess neither cirri nor fins. Only the Incirrata are of a commercial interest, with some Octopus species. Eight circumoral arms, no tentacles; fins subterminal (on the sides of the mantle), widely separated, or absent; shell reduced, vestigial, "cartilaginous", or absent; suckers without chitinous rings, set directly on arms without stalks; eye open to the sea with primary and secondary (concentric) lids; a branchial canal present on the gills between down-folded filaments (some exceptions); liver a single with incorporated pancreas; central (rachidian) tooth of radula with one large projection and two or more small lateral cusps, first and second lateral teeth multicuspid; buccal membrane absent; olfactory organ a ciliated pit. This order is represented by one suborder in the Egyptian waters Incirrata

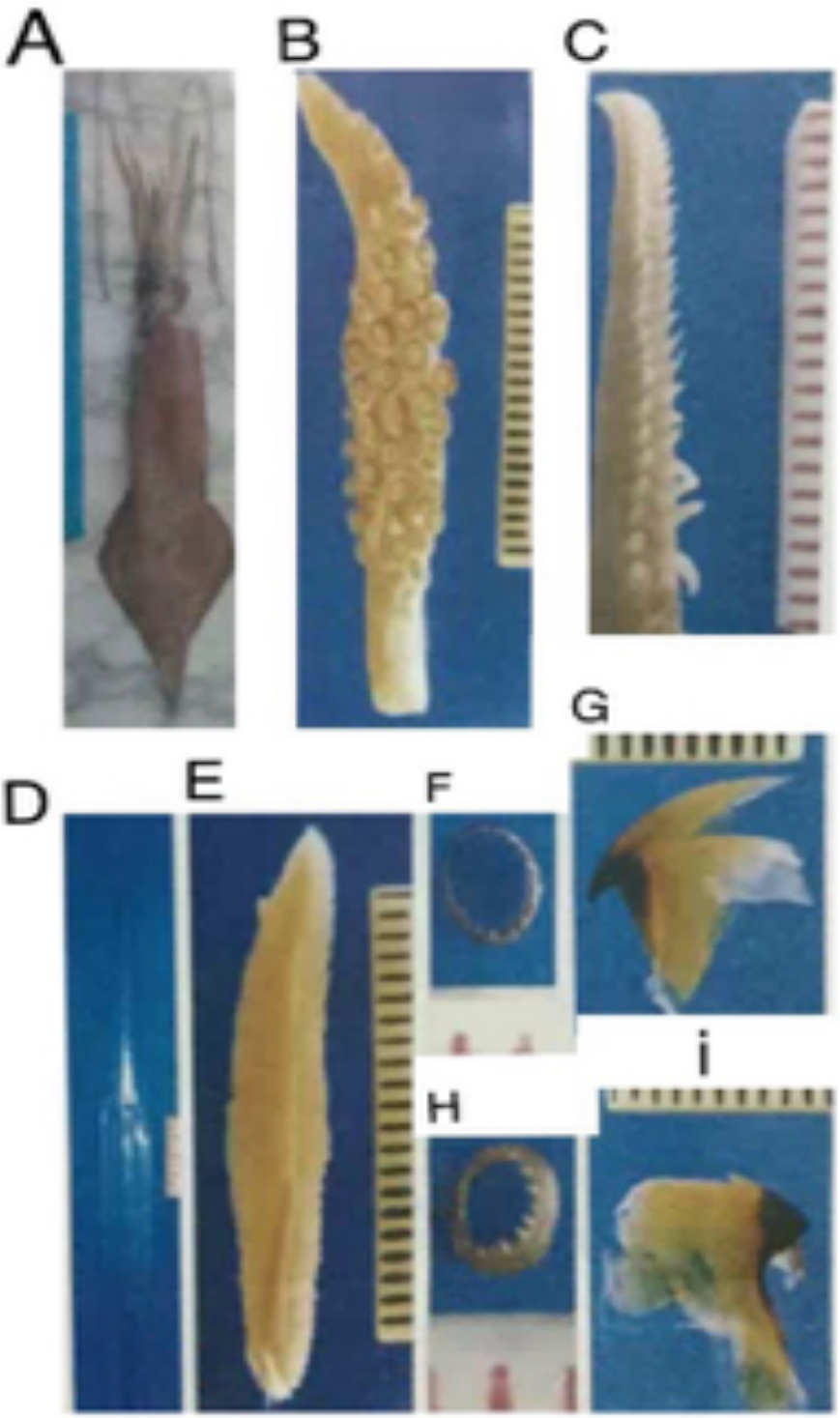

PLATE (4) *Loligo forbesi*
(A)The animal. (B) Tentacular club. (C) Left arm IV of male hectocotylized. (D) Shell. (E)Gill. (F) Tentacular club sucker ring. (G) Upper beak. (H) Arm sucker ring. (I) Lower beak.

Grimpe, 1916.

Suborder: Incirrata Grimpe 1916.
Eight arms with suckers only, no cirri, fins absent. The web is usually shallow. Only one of the eight families, Octopodidae d'Orbigny, 1845 is represented in the Egyptian waters.

Family: Octopodidae d›Orbigny, 1845
This family has inflated bodies. They have rather small heads; prominent eyes protected by eye-lids, fleshy lips to their mouths, and

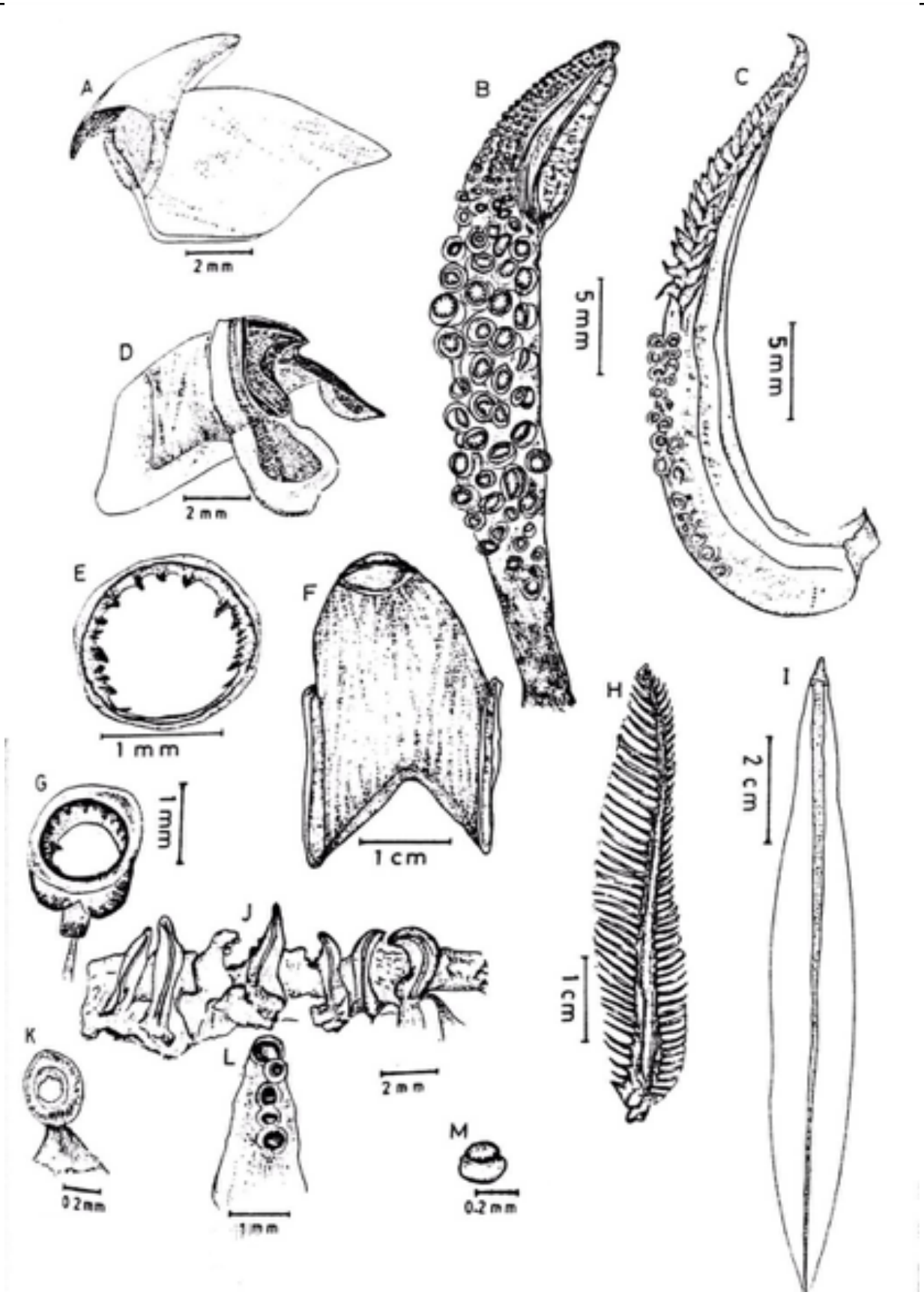

PLATE (5): *Loligo forbesi*

A-Upper beak. B-Tentacular club. C- Left arm IV of male hectocotylized. D - Lower beak. E- Tentacular club sucker ring. F- Funnel. G- Tentacular club sucker. H- Gill. I- Shell. J- Radula. K- Radula sucker. L- Enlarged part of radula. M- Radula sucker ring.

strongly-curved compressed beaks. Their arms are eight in number, and all similar, though more or less unequal; they bear sessile suckers. The mantle is always attached to the neck. The members of this group have no internal shell. They are active animals, swimming and creeping with the facility, but living chiefly among the crevices of rocky grounds. Most species with a W- or VV-shaped funnel organ. Three subfamilies are known: Eledoninae Gray, 1849; Octopodinae Grimpe, 1921; and Bathypolypodinae Robson, 1929. The third only is represented in this study.

Subfamily: Octopodinae

Ink sac present, sometimes small and deeply-buried in the liver, but ink always secreted. Arms with two rows of suckers.

Genus: *Octopus* Cuvier, 1797.

The hectocotylized arm is the third right one. Body firm, more or less muscular. Funnel organ W- or VV-shaped. Mantle aperture not narrow or slightly narrow. Hectocotylus is well developed, with more or less long differentiated ligula and calamus. Mantle aperture wide. No bright color rings scattered over the body and arms, no ocellar spots on the mantle, only round ocellar spots may be present on the web in front of eyes as well as different stripes, spot patterns, etc., there is rarely a coloration uniform.

The genus is represented in the present study by three species, namely *Octopus Vulgaris, Octopus Macropus,* and *Octopus Defilippi*.

Keys to the Species of the Genus *Octopus* in the Present Study.

Three cirri over each eye, arms are about equal in length, the modified part of arm III (hectocotylized) is very small and spoon-shaped, 11-gill lamellae per each gill. ....***Octopus vulgaris***

The dorsal body is ornamented with white spots, the arms are very long, right arm III of the male is hectocotylized with a large tubular ligula, extending to about 13-15% of its length, no cirri over the eyes, twelve gill lamellae per each gill.....***Octopus macropus***

Funnel elongate tube, third arm very much longer than other arms, right arm III of the male is hectocotylized and shorter than the opposite arm.....***Octopus defilippi***

***Octopus vulgaris* Cuvier, 1797. (Plates 10, 11, and 12)**

Synonymy:

Sepia rugosa Bosc, 1792;
Octopus granulatus Lamarck,1798 *Octopus vulgaris*. Lamarck, 1798;
Octopus cassiopeia Gray, 1849;
Octopus tuberculatus Risso, 1862;
Octopus trascheli Targioni- Tozzetti, 1869;
Octopus rugosus. Robson, 1929.

World distribution. West Mediterranean Sea, including Adriatic Sea (Roper *et al.*, 1984) Turkish waters, (Catagan and Kocatas, 1990), East Atlantic (Roper *et al.,* 1984). In the Atlantic Ocean from Long Island to southern Brazil and from the Southern North Sea to the Cape of Good Hope, Common in the Gulf of Mexico and the Caribbean Sea, (Nesis, 1987).

Local name: Okhtaboot, Folby, and Saba dule (Riad, 1993).

Local distribution. During this study the specimens were collected off shore from Abu Qir Bay (50-70 m. depth), El-Agamy (25-45 m. depth), Elhamra at Sidi Abd- Alrahman (40-80 m. depth), off El-Montazah (50 m. depth), Sidi Kreer. (40-50 m. depth) EL-Max (40 m. depth), off Kayet Bye (40 m. depth), and also from the commercial fish trawls in the Suez Gulf (Ataka Harbor). It is common in the Suez and Alexandria fish markets (Anfushy, Abu Qir, Maadeia, and Rosetta) (Riad, 1993).

Description: The body of *Octopus vulgaris* is oval and small compared with the head and arms, covered with flattened tubercles (Plate 10). The head is large, with prominent eyes; three cirri are placed over each eye. The arms are thick and about equal in length, seen on their inner surface are the suckers arranged in double rows (Plates 11i and 12 k), the bases of the arms are strongly

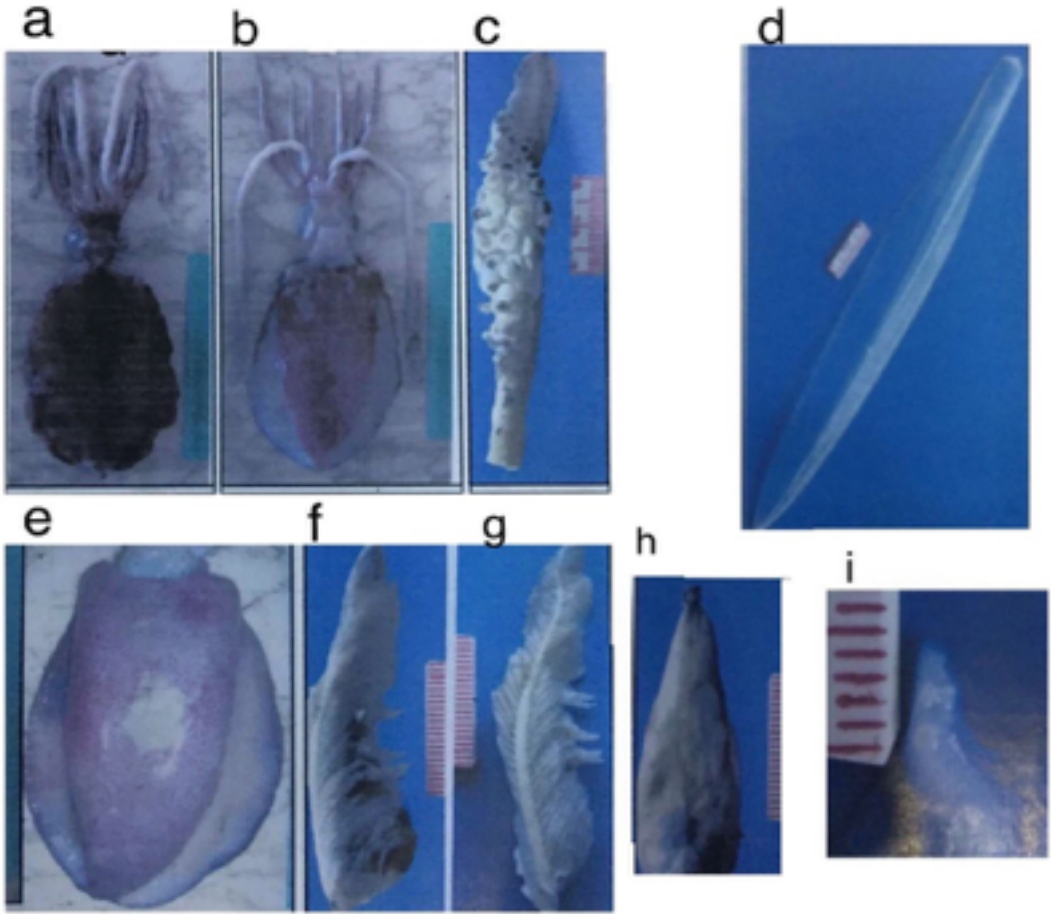

PLATE (6) *Sepioteuthis lessoniana*

a-The animal (dorsal view) b- The animal (ventral view).c-Tentacular club. d- Shell.e-Fin f- Gill (lateral view).g- Gill (dorsal view).h-Ink sac. I-Buccal lappets.

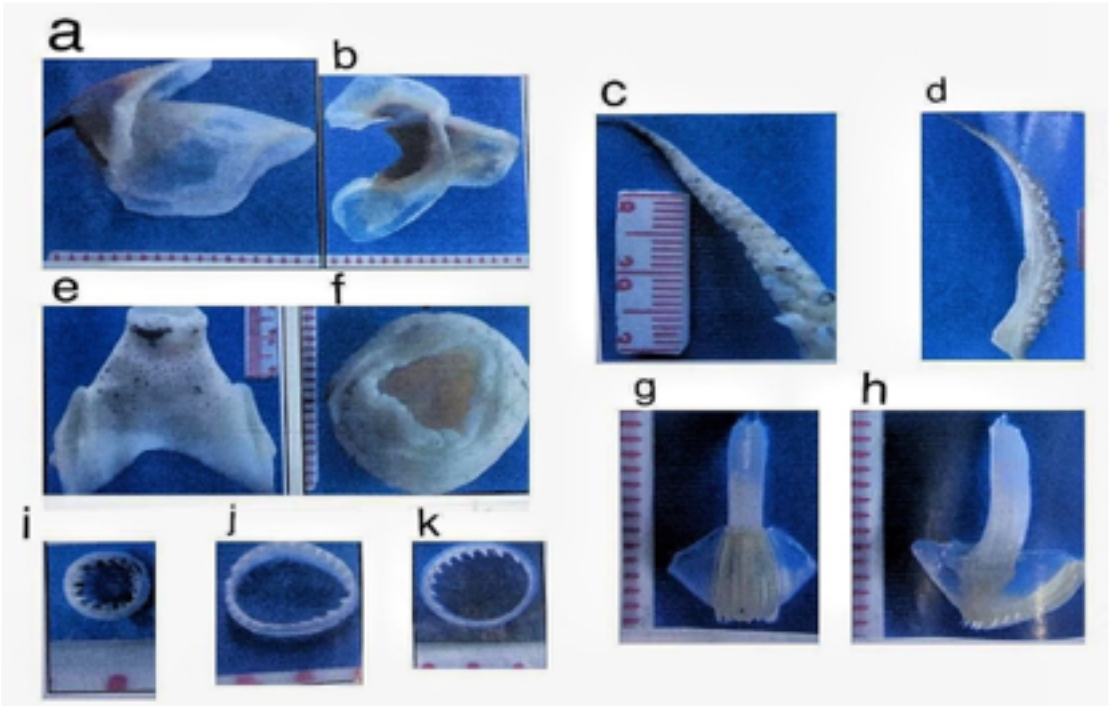

PLATE (7) *Sepioteuthis lessoniana*

a-Upper beak. b- Lower beak. C-Normal arm. d- Normal arm (lateral view). E-Funnel f- Buccl.g-Radula h-Radula (lateral view).i-Dactylus sucker ring.j-Tentacular club sucker ring.k- Arm sucker ring.

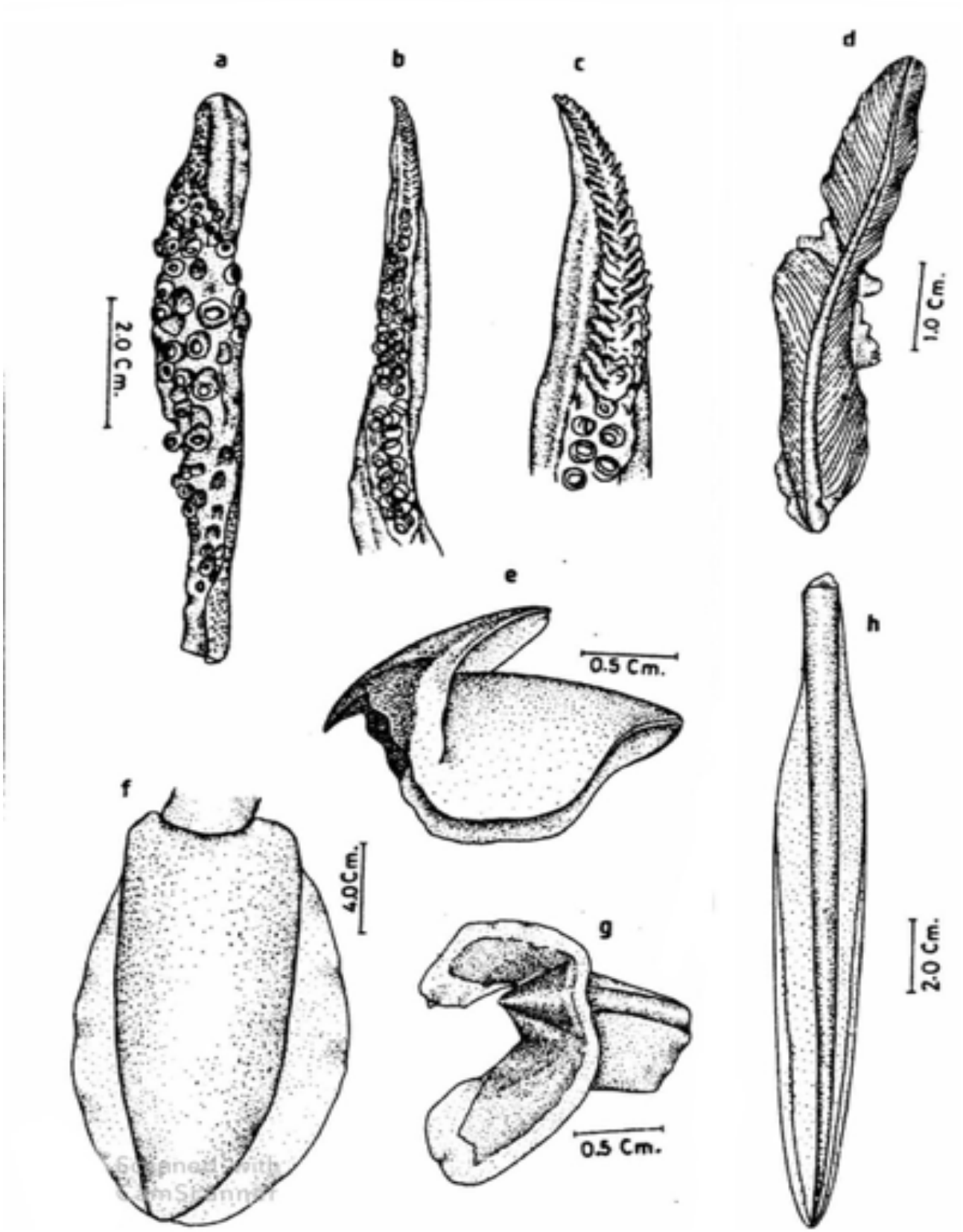

PLATE (8) *Sepioteuthis lessoniana*

(a) Tentacular club. (b) Left arm IV of male hectocotilized . (c)Modified part of hectocotilized arm. (d) Gill. (e) Upper beak. (f) Fin. (g) Lower beak. (h) Shell.

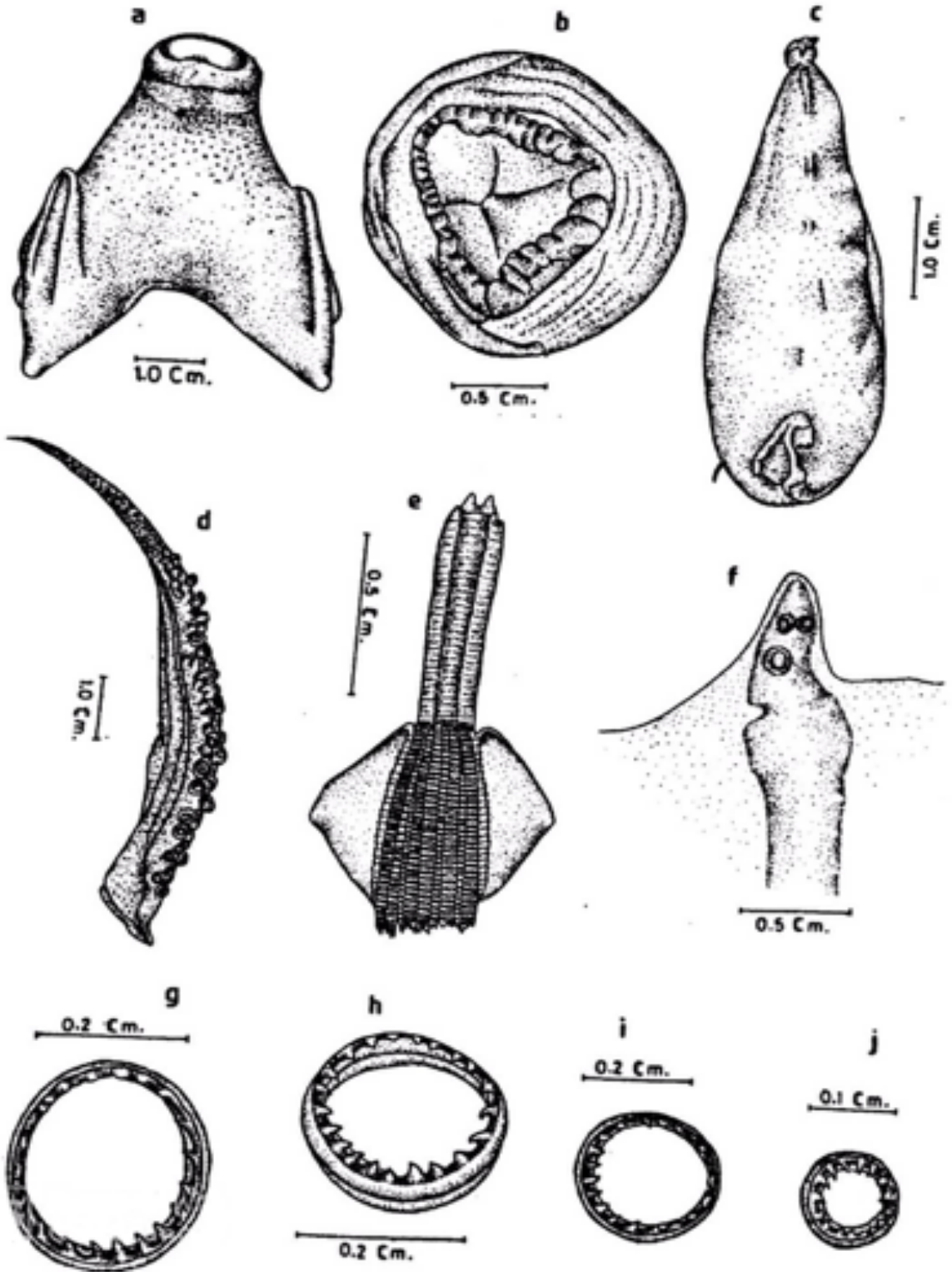

PLATE (9) *Sepioteuthis lessoniana*

(a) Funnel. (b) Buccl. (c) Ink sac. (d) Normal arm. (e) Radula. (f) Buccl lappets. (g) Arm sucker ring. (h) Tentacular club sucker ring. (i) Arm sucker ring. (j) Dactylus sucker ring.

webbed together. The dorsal pair of the arms is shorter than the other arms, and the length of the arms is about three times the body length (plate 10). The modified part of the right arm III of the male (hectocotylized) is very small and spoon-shaped; the ligula occupies about 2.25% of its length (plates 11c and12f). The gill is provided with eleven-gill lamellae, (Plates11d and 12g). *Octopus vulgaris* is differentiated from *Octopus macropus* by its shorter arms, the possession of a well-developed interbranchial membrane (connecting the arms up to 1/5 of their length), and the presence of three cirri over each eye. On the other hand, *Eledone moschata* differs from *Octopus vulgaris* by having a single row of suckers on the arms and by the presence of only one cirrus over each eye. The morphology of *Octopus vulgaris* from Alexandria waters and the Red Sea is in agreement with the literature, except for the following additional characteristics; three cirri over each eye; this character was only stated by Forbes and Hanley (1852). Of the specimens collected, the largest specimens had a total length of 104 cm for male and 99.6 cm-for females. Fischer, (1973) gave a maximum total length of 90-110 cm. Roper *et al*., (1984) reported much larger sizes, a total length of 130 cm for male and 120 cm for female. The largest specimens had a mantle length of 16.5 cm for the male and 13.9 cm for the female, and a total weight of 2285 g for males and 1470 g for females. The smallest specimens caught had a total length of 27.5 cm for the male and 26 cm for the female. Mantle length was of 5 cm for the male and 4.6 cm for female and the total weight was of 50 g for the male and 30 g for the female.

Habitat: On muddy sandy gravelly bottoms and also dwelling in cavities. Depth ranges from 10 to 300 m, Robson, (1932) and Roper *et al.*, (1984).

Octopus macropus Risso, 1797. **(Plates 13, 14, and 15)**

Synonymy:

Octopus macropodus, San Giovanni 1829.
Octopus cuvieri d›Orbigny, 1840;
Octopus longimanus d›Orbigny, 1840;
Octopus alderi Verany, 1851;
0ctopus bernudensis Hoyle, 1885;
Octopus chromatus Heilprins, 1888.

World distribution: Worldwide in warm waters (Roper *et al.*,1984). The Western and Eastern Mediterranean (Fischer, 1973). The Adriatic Sea (Riedle, 1970). The north Atlantic Ocean, the Indian Ocean, the central and western Pacific Ocean, the Gulf of Aqaba (Adam, 1960). North African coast (Fischer, 1973). Tropical Atlantic, Indo-West Pacific species, in the western Atlantic mainly near the Bermuda and Bahama Islands, Southern Florida to Brazil, the Caribbean Sea, western Africa to the Gulf of Guinea, Ascension and Santa Helena Islands (Nesis, 1987).

Local name: Okhtaboot or Saba dule and Hebal (Riad, 1993).

Local distribution: During the present study, the species was collected offshore from Abu Qir Bay (50-70 m depth), El-Agamy (25-45 m depth), Sidi-Abd- Alrahman (40-80 m depth), off El-Montazah (50 m depth), Sidi-Kreer (40- 50 m depth), El-Max (40 m depth), off Kait Bye (35 m depth)and from commercial fish trawl from Suez Gulf(Ataka Harbor). It is common in Suez and Alexandria fish markets (Anfushy, Abu Qir, Maadeia, and Rosetta) (Riad, 1993).

Description: The dorsal body is ornamented with white spots.The arms are very long, six-seven times longer than the body length (plate13), each has two rows of suckers; the first pair of arms I is much longer (Plate 13). The right arm III of the male is hectocotylized with a large tubular ligula, extending to about 13-15% of its length (ligula index), (Plates 14a and 15a). The cirri over the eyes are absent. The gill is provided with thirteen gill lamellae (Plates 14f and 15c). This species differs from *Octopus vulgaris* by the following characteristics. Its slender and longer arms, its poorly-developed interbranchial membrane. *Eledone moschata* differs from *Octopus macropus* by

its single row of suckers on the arms and by its single cirrus over each eye, while the cirri are absent in *Octopus macropus*.

The morphology of *Octopus macropus* in the present study is in agreement with that given in the literature. The largest specimens had a mantle length of 16.2 cm for the male and 15.8 for females. The total length is 137 cm for males and 130 cm for the female and the total weight is 880g for males and 625g for females. The maximal total length recorded for the same species by Fischer, (1973) ranged from 90-110 cm Jereb and Roper, (2005) gave greater measurements; total length 120-150 cm, mantle length 14 cm and total weight 2 kg The smallest specimens collected during this study showed the following measurements.

Total length 55 cm for males and 52 cm for the female. The mantle length is 5 cm for the male and 4.8 cm for the female. The total weight is 48g for the male and 40g for the female.

Habitat: The species lives on rocky bottoms, in crevices and holes, sometimes also on vegetated substrates (Fischer, 1973). A benthic shallow-water species occurring in coral reefs, reef flats, and on open bottoms (Jereb and Roper, 2005). In the present study, the species was captured from muddy sandy grounds at Abu Qir Bay.

Octopus defilippi Verany, 1845. **(Plates 16, 17, 18, and 19)**

Material: Seventeen individuals ranging between 5 cm for the mantle length of an animal weighing 30 g and 8.8 cm for the mantle length of an animal weighing 100g

Synonymy: *Macrotritopus species.*

World distribution: the Mediterranean Sea, the eastern Atlantic Ocean from Morocco to Angola, Cape Verde Islands, The western Atlantic, Bahamas, the Gulf of Mexico, the Caribbean Sea, Brazil, the Indian Ocean, Arabian Peninsula to Burma, and the south western Pacific Ocean (Roper, *et al*., 1984 and Nesis, 1987).

Local name: Akhtaboot or Sabaa dule (Riad, 1993).

Local distribution: The species was encountered through the present study from Sidi Abdel Rahman locality and from the commercial fish trawl in the Suez Gulf (Ataka Harbor) and the adjacent area. It is common in Suez and Alexandria fish markets (Anfushy, Abu Qir, Maadeia and Rosetta) (Riad, 1993).

Description: Mantle relatively very small, smooth-skinned, head narrower than the mantle, no pigmented ocellus, spots, or rings. (plates16 and 18a) Funnel elongate tube and W-shaped (plates19c, 18e, and 19b). All arms are very long, slender, symmetrical, 3rd arms very much longer than the other arms. Arm length exceeding 70-85% of the total length, arms with delicate tips (plates16 and 18a). Arms formula III > II >IV > I or III > IV > II > I] (plate16). Right arm III of the male (hectocotylized) shorter than the opposite arm bearing 60-100 suckers. Ligula well differentiated 1.8 to 2.5% of the hectocotylized arm length, groove very shallow calimus very small (plates 19b, 18c, and 19a), gill lamellae on outer demibranch (plates 17g 18d and 19e). Web depth 20-25% of the longest arm length. Web formula C > D > B>E> A (plate 18f) Suckers widely set, of a medium size. One cirrus over each eye (plates 18a and b).

Habitat: The present record inhabits the bioclastic bottom at 30-60 m depth. According to Rodper *et a*l., (1984), the species is little known as benthic species inhabiting sandy to muddy bottoms at 6 to 60 m water column depth, but was occasionally reported down to 200 macrotritopus larvae) and is characterized by extremely long arms III. The present work's samples showed the mantle length of the largest specimen to be 8.8 cm in an animal weighing 100 gm and in the smallest specimen to be 5 cm in an individual weighing 30 gm, while according to Roper et al., (1984), the maximum mantle

PLATE (10) *Octopus vulgaris*

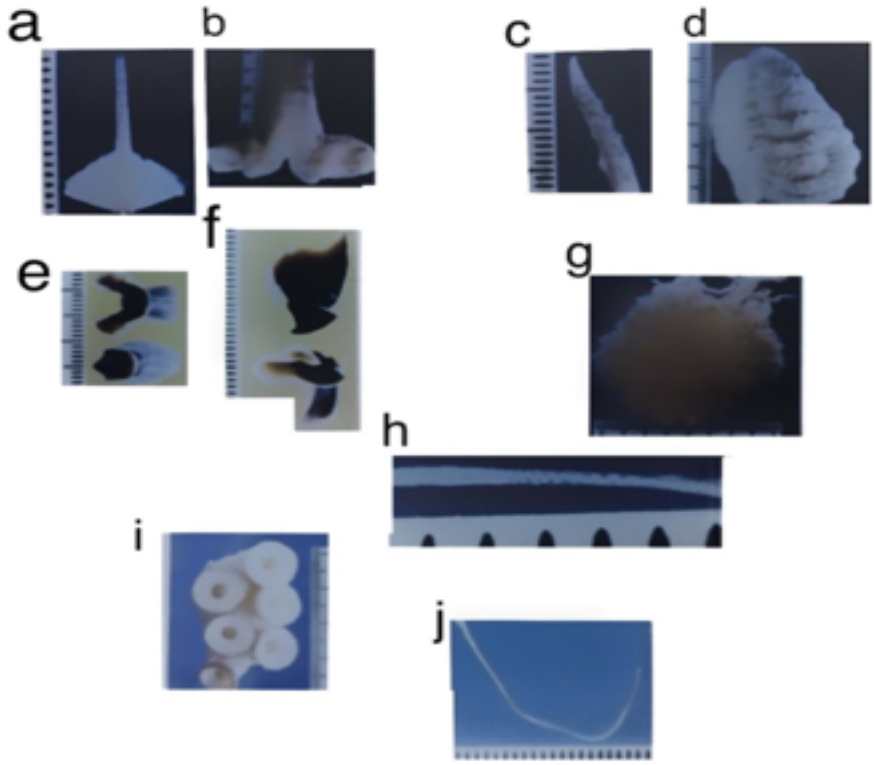

PLATE (11) *Octopus vulgaris*

A-Radula. B- Funnel. C- Right arm III of male hectocotylized . D- Gill E-Upper &lower beaks (dorsal view). F-Upper &lower beaks (lateral view). G- Egg cluster. H-Magnified part of spermatophore .I-Part of arm j- Spermatophore.

length is 9 cm and according to Mangold, (1998), the animal is small to medium in size (3.3 5.5 cm) (Roper *et al.*, 1984).

Remarks: Distinction of *Octopus defilippi* from the other *Octopus* spp. previously recorded in the Egyptian waters can be summarized as follows: *Octopus defilippi*: The mantle is relatively very small. Arm III is the largest arm, and there is a cirrus over each eye. *Eledone moschata*: One row of suckers exists on each arm and there is a clear cirrus over each eye. Octopus vulgaris: Shorter arms, a well-developed inter-brachial membrane (connecting the arms up to 1/5 of their length), the presence of three cirri over each eye. Octopus macropus: Slender and longer arms poorly- developed interbranchial membrane. Cirri are absent.

Conclusion

The specimens for the study were obtained from fishing trawlers operating in the Egyptian Mediterranean Sea, the Suez Gulf, and the Red Sea. The specimens were also obtained from Alexandria and Suez fish markets. The species that are included in class Cephalopoda are ecologically and commercially important in the world. The class includes four groups Cuttlefishes, Squids, Octopuses, and Nautilii. The first three groups are present in the Egyptian Mediterranean waters and the Red Sea. They constitute a main component in the fisheries industry. To understand the biology and ecology of any species, their identification should be conducted properly to maximize the accuracy of any study. The present study is the first of its kind, and was prepared to focus on the cephalopod species inhabiting both the Egyptian Mediterranean and the Red Sea waters. The present work was conducted using morphological features. It is aimed at obtaining more information about the limited taxonomical studies on Cephalopoda species inhabiting both the Egyptian Red Sea and the Mediterranean waters. Out of the six cephalopod species inhabiting the Egyptian Mediterranean and the Red Sea waters, there is only one cuttlefish species *Sepia dollfusi,* two squid species *Loligo*

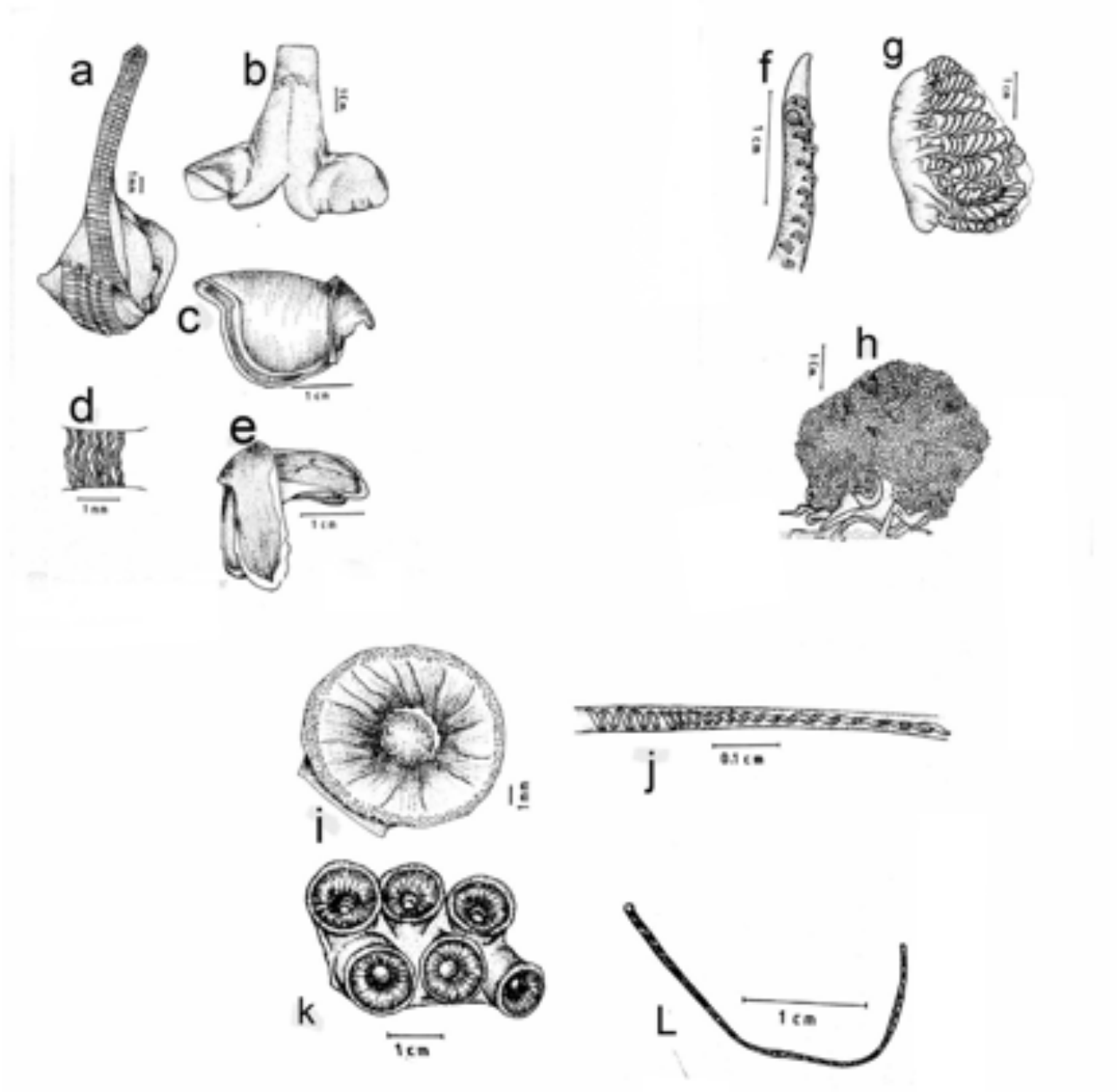

PLATE (12) *Octopus vulgaris*

A-Radula. B- Funnel. C- Upper beak D- Enlarged part of radula teeth. E- Lower beak.

F- Right arm III of male hectocotylized . G- Gill .H- Egg cluster. I- Arm sucker. J- Magnified part of spermatophore. K- Part of arm. L- Spermatophore.

forbesi and *Sepioteuthis lessonian*, and three octopus species *Octopus vulgaris, Octopus acropus,* and *Octopus defilippi.* Two of these, namely *Sepia dollfusi,* and*, Sepioteuthis lessoniana* are dwelling the Red Sea and migrated to the Mediterranean waters through the Suez Canal. Specimen parts were drawn using a zoom stereoscopic microscope provided with a camera lucida drawing tube and. The specimen parts were also photographed by a Canon digital camera.

PLATE (13) *Octopus macropus*

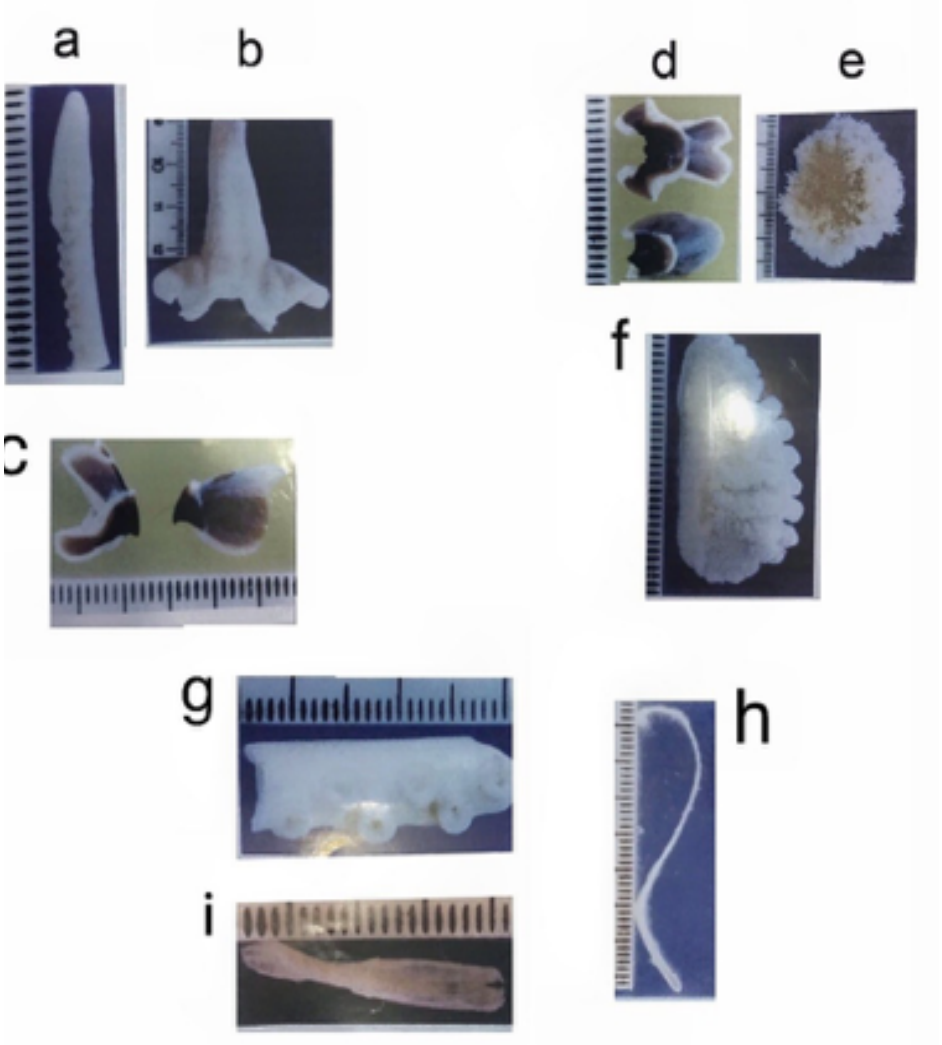

PLATE (14)

Octopus macropus

A- Right arm III of male hectocotylized.

B- Funnel.

C- Upper &Lower beaks (lateral view).

D- Upper &Lower beaks (dorsal view).

E- Egg cluster

F- Gill.

G- Part of arm.

H-Spermatophore. I-Radula.

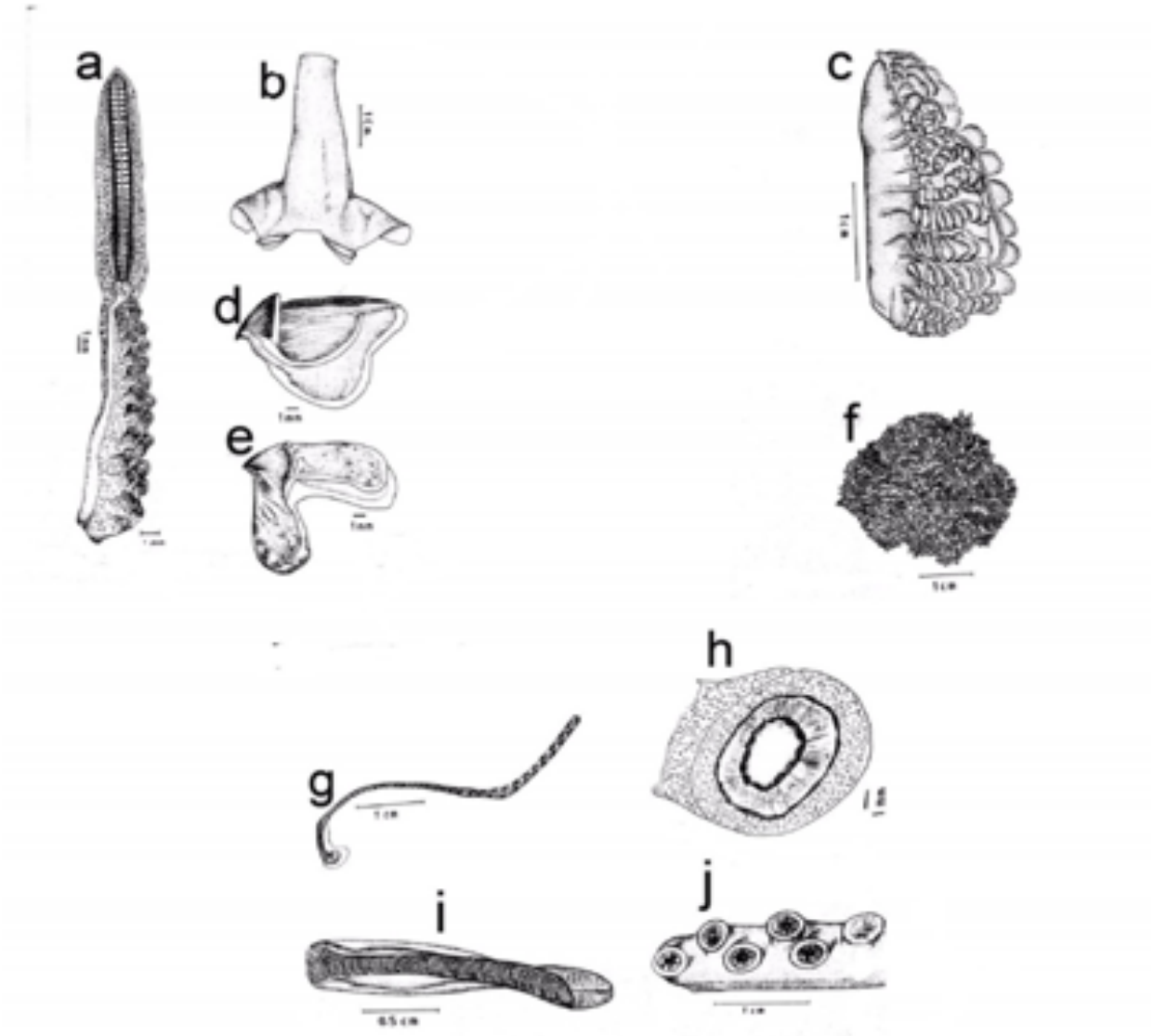

PLATE (15) *Octopus macropus*
A-Right arm III of male hectocotylized. B- Funnel. C- Gill. d- Upper beak. e- Lower beak. F- Egg cluster. G-Spermatophore. H- Arm sucker. I Radula. J- Part of arm.

PLATE (16) *Octopus defilippi*
Arm formula (III > II >IV > I or III > IV > II > I)

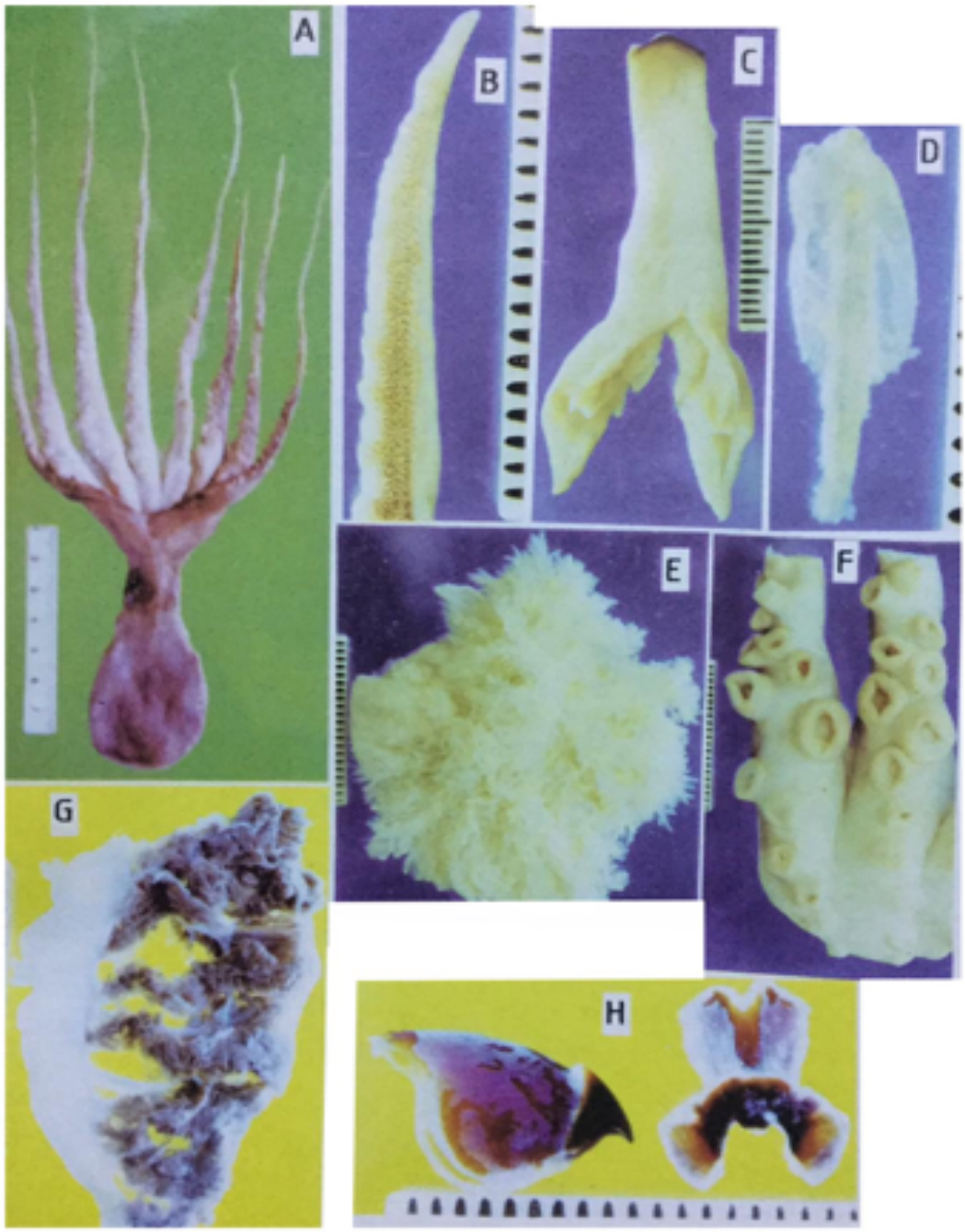

PLATE (17) *Octopus defilippi*

A-The animal. B- Right arm III of male hectocotylized. C- Funnel. D- Radula. E-Egg cluster. F- Arm suckers. G-Gill. H- Upper and lower beaks.

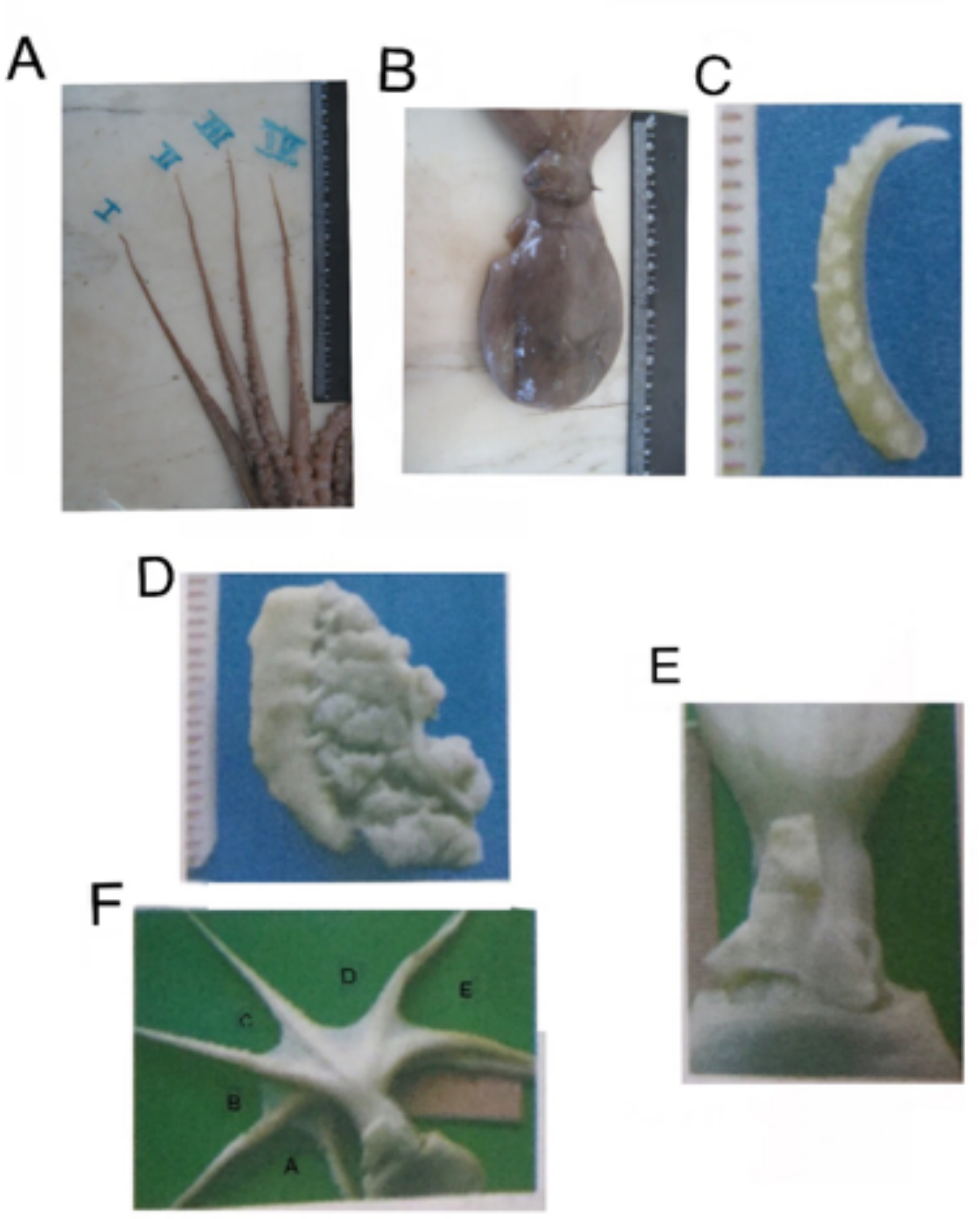

PLATE (18) *Octopus defilippi*

A-Animal arm (arm formula). B- One cirri over each eye. C- Right arm III of male hectocotylized. D- Gill. E- Funnel. F-Arm web (Web formula(C > D > B>E> A)

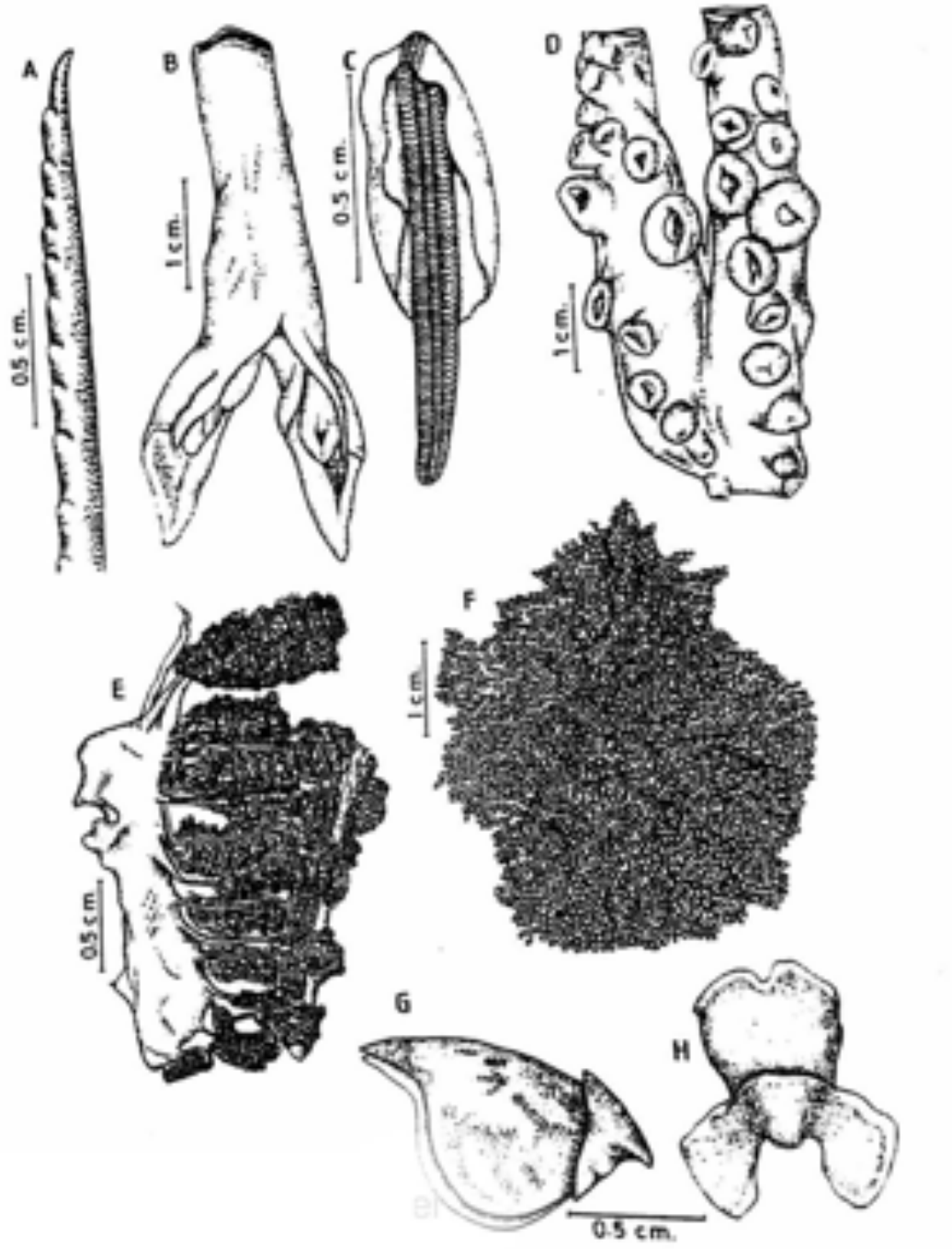

PLATE (19) *Octopus defilippi*

A-Right arm III of male hectocotylized. B- Funnel. C- Radula. D- Arm suckers. E- Gill. F- Egg cluster. G- Upper beak. H- Lower beak.

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The Garo Tribe's Ethnobotanical Knowledge about Medicinal Plants

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Abstract: Ethnic communities have primarily relied on forest resources to fulfil their demands of food, nutrition, and medicinal requirements since the time of immemorial. The Garos are one of the few remaining matrilineal societies in the world. An investigation was conducted to understand the knowledge the ethnic Garo peoples of Bangladesh have about the medicinal plants (MPs). The present study was done through structured questionnaires in consultations with the tribal herbal practitioners. A total of eighty-eight species belonging to fifty-one families and eighty-two genera were collected and recorded for their use against 104 ailments by the Garo people. Some diseases, e.g., fever, cough, diarrhea, skin diseases, constipation, catarrh, etc., were very common and could be treated with more than one plant. Six, out of ten, of the world top deadliest diseases, *viz*. heart diseases, bronchitis, diabetes, diarrheal diseases, tuberculosis, and cirrhosis, were treated by the ethnic Garo people with the help of medicinal plants. The major growth habits of these MPs include herbs (43; 49%), trees (26; 30%), shrubs (11; 13%) and climbers (8; 9%). Individually the fruits of the MPs were found to be leading the plant parts most used in the treatments followed by leaves, bark; however, combining more than one part *viz*. root, stem, leaf, fruit, and seeds or using the whole plant, occupies the lion share (54%) of the plant parts used for therapeutic purposes. The study confirms that the present information on MPs can be used in the field of botanical, pharmacological, and conservation research and for new drug discoveries in the future.

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Keywords: Ethnomedicinal plants, Therapeutic usages, Prescription, Drug discoveries

Introduction

Plants, especially medicinal plants (MPs), which produce secondary metabolites and essential oils, are a source for numerous medicinal compounds, as the diversity of their multidimensional chemical structures has made them superior to treat serious diseases. Plant-synthesized secondary metabolites have also been prioritized focusing on the effectiveness of plant-originated therapeutics for the treatment of COVID-19 due to the adverse effects of synthetic drugs (Bhuiyan *et al*., 2020). Since ancient times, people have tried to search for treatments to alleviate pain and cure different illnesses. In every period and over the successive centuries through the advancement of civilizations, the therapeutic properties of certain MPs were identified, noted, and conveyed to the successive generations. The documentation of traditional knowledge on ethnomedicinal plants has been considered as a high priority to support the discoveries of medications for benefiting mankind (Rana *et al*., 2010).

The usages of MPs and their history were recently reviewed by Petrovoska (2012). The oldest written evidence of MPs usage for the preparation of medicine has been found on a Sumerian clay slab from Nagpur, approximately 5,000 years ago. It is comprised of twleve recipes for drug preparation bearing on over 250 various plants, including alkaloids such as poppy, henbane, and mandrake (Kelly, 2009). The Rig Veda (4,500–1,600

BC) also noted that the Indo-Aryans used the Soma plant (*Amanita muscaria* (L.) Lam.), a narcotic and hallucinogenic mushroom, as a medicinal agent. MPs can be useful in medications against the recent COVID-19 pandemic (Jahan and Onay, 2020). They also create a tremendous opportunity for developing "green" integrative medicine (Vandebroek *et al*., 2020). Very recently, the WHO's Expert panel has endorsed a protocol for COVID-19 herbal medicine clinical trials (https://www.afro.who.int/news/expert-panel-endorses-protocol-covid-19-herbal-medicine-clinical-trials).

Bangladesh, as a part of the ancient Indian sub-continent, has a long history in the use of MPs in traditional medicine. Herbal medicines and MPs constitute an important part in treatment in indigenous medicine systems such as Ayurveda, Unani, Siddha, Traditional Chinese Medicine, Tibetan Medicine, Iranian, Julu, etc. Although Bangladesh is a tropical country with its small geographic area, it enjoys a very rich diversity of plant species in a wide range of ecosystems. A total of 1208 species of MPs are recorded from Bangladesh (Uddin and Lee, 2020). Bangladesh is also rich in ethnic biodiversity with about forty-five different ethnic communities widely spread over forested areas from hills to the plainland Sal forests in the central, northern, and north-western parts of the country (Anon., 2002; Sarwar, 2019). The Chakmas, Marmas, Tripuras, Tanchangya, Mros, Garos, Manipuri, Santals and Khasi are important communities both in population and their cultural heritage.

The Garos are an indigenous Tibeto-Burman ethnos from the Indian subcontinent, notably found in the Indian states of Meghalaya, Assam, Tripura, Nagaland, and neighboring areas of Bangladesh, notably Mymensingh, Netrokona, Jamalpur, Sherpur and Sylhet, who call themselves *A·chik Mande* (literally "hill people"; *a·chik* "bite soil" + *mande* "people") or simply *A·chik* or *Mande* (https://en.wikipedia.org/wiki/Indigenous_peoples_in_Bangladesh). The Garos are one of the few remaining societies in the world, whose line of descent go from a female ancestor (mother/grandmother) to the descendant. Like all other ethnic communities, Garos generally depend upon forest (plant) resources to fulfil their (primary) demands of food, nutrition and medicinal requirements.

The ethnic people depend on folk herbalist/ medicinal practitioners, known as "*Boiddos*" or "*Kavirajes*", for the healing of any kind of ailments. The following examples show the diversity and richness of their ethnobotanical knowledge: thirty-nine species are used by the Mro tribe of Bandarban (Miah and Chowdhury, 2003); thirty-two MPs are utilized by the Manipuri tribe in Bangladesh (Rana *et al*., 2010); seventy plant species are used by the Bwam, the Marma, the Murang and also the Tanchangya communities of the Bandarban hill district (Mohiuddin *et al*., 2012); fifty plant species are used by the Chakma traditional healers (Uddin *et al*., 2015a): eighty-two MP species are utilized by the Lusai tribe of the Bandarban (Uddin *et al*., 2015b); fifty-two MPs are used by the Khasia tribes of Maulvibazar (Bhatta and Datta, 2018). 117 plant species are used by the Pangkhua indigenous community of Bangladesh (Faruque *et al*., 2019); and 105 MPs by the Santal tribal people of Nawabganj Upazila of Dinajpur district (Khatun and Rahman, 2019) in Bangladesh. *Boiddos* rely almost solely on various MPs for the treatment of diverse ailments.

However, it seems that nowadays they are leaving their traditional occupation/ practices due to the following reasons: i. the decline in population and/or the merging with the mainstream Bangla-speaking population, ii. depletion/ scarcity of MP genetic resources, and iii. the availability of low-cost allopathic medicines. Moreover, the younger generation has very different ambitions. Accordingly, the traditional knowledge associated with ethnomedicine/MPs, is perhaps doomed to be lost. Some literature on the usage of MPs by the various ethnic groups and the common people as well is also available (Rahman, 1999; Uddin, 2006; Yusuf *et al*., 2009; Uddin *et al*., 2016). Most of the ethnobotanical literature published is concerned only with MPs used by ethnic people of the Chittagong

Hill Tracts areas and/or Sylhet region. Hitherto, no study has been conducted on the traditional healthcare practices of the Garo tribe (living at Nalitabari Upazila of Sherpur district). Hence, it becomes necessary to explore the perception and the indigenous healthcare practice of this tribe using MPs. The present study has therefore, been carried out for the sake of the documentation of plants of ethnomedicinal importance, the plant part(s) used, and the traditional formularies and doses employed by the Garos.

Materials and Methods

This research is focused on the investigation and documentation of indigenous knowledge and techniques, and the use of MPs by the Garo community inhabiting Nalitabari Upazila in the Sherpur district. The geographical location of the study area (*ca*. 327.61 sq. km) is between 25°01' to 25°13' N and 90°04' to 90°19' E (Figure 1). It is bounded by the Meghalaya state of India on the north, Sherpur Sadar and Nakla Upazilas on the south, Haluaghat Upazila on the east, and by Jhenaigati Upazila on the west. Ethnic communities such as Garo, Hajong, Hodi, Mandai and Koch belong to this Upazila (http://en.banglapedia.org/index.php?title=Nalitabari_Upazila); among them, Garo is the prominent tribe. The present study was carried out on the ethnic communities across different seasons – spring, (rainy) summer, autumn and winter, over the period from 2018 to 2019. The identification of key informants in the treatment of various diseases was based on the information obtained from the ethnic (Garo) people. Only five ethnic *Boiddos*, namely Mr Nirbasonmara, Mr Prithisonmara, Mr Bipinmara, Mr Anthonymara and Mr Sotanmara, were available for the interviews (address detail available upon request). Plants were collected from the forest with the help of the ethnic people; the healers allowed for the confirmations of the MPs they use for the treatment of various diseases. Data were collected during four survey trips in different seasons, and the voucher specimens were collected following the standard method of Martin (1995).

Voucher specimens and ethnomedicinal information were collected from the field during the flowering and fruiting periods. Traditional healers and knowledgeable persons were interviewed. While noting ethnomedicinal information, every care was taken to record the local names of the plants, the parts used, and the method of drug preparation and usage. Photographs were taken for each specimen not only to confirm the taxonomic identification, but also for future specimen record. The collected fresh (or dried) specimens were identified in the field through expert consultation, or by comparing them with herbarium specimens and/or published literature (Uddin, 2006; Yusuf *et al*., 2009; Uddin *et al*., 2016). The botanical names of MPs were updated using "The Plant List" database <http://www.theplantlist.org/>. The local names and medicinal uses were documented critically. The herbarium specimens were made accordingly (Jain and Rao, 1997). Voucher specimens were deposited at Prof. Dr Arshad Ali Herbarium at the Botanical Garden, Department of Crop Botany, Bangladesh Agricultural University. Some living plant collections were conserved in the MPs Garden at the same botanical garden. The gathered data were represented systematically in tabular form. Information such as botanical name, family, local name, habit, parts used, ethnomedicinal uses, and prescribed formulations were provided for each species (Tables 1 and 2).

Results

The present research reveals the ethnobotanical use of eighty-eight MP species belonging to fifty-one families and eighty-two genera to cure 104 human ailments among the Garo people (Tables 1 and 2). Herbs are among the foremost important components of ethnomedicine, sometimes called Herbal medicine. Within the present study, the growth habits of these MPs include herbs (43; 49%), trees (26; 30%), shrubs (11; 13%) and climbers (8; 9%) (Figure 2).

The Garo people commonly use plants and their parts including roots, rhizomes, tubers, leaves, stem, wood, bark, flowers, seeds, latex, pseudo-bulb, cone, or the whole plant and fruits for various purposes in their way of life (Table 1; Figure 3). More than one plant part *viz*. root, stem, leaf, fruit, seed, or the whole plant, were commonly used combinedly (more than 54% cases) for the medicinal preparation.

Out of fifty families, nineteen families possess more than one species and thirty-one families possess one species each (Table 1). Leguminosae represented the highest number of medicinal plants (8 species 9%), to be followed by Zingiberaceae (5 species 5.7%), and Apocynaceae (4 species 4.5%) (Figure 4).

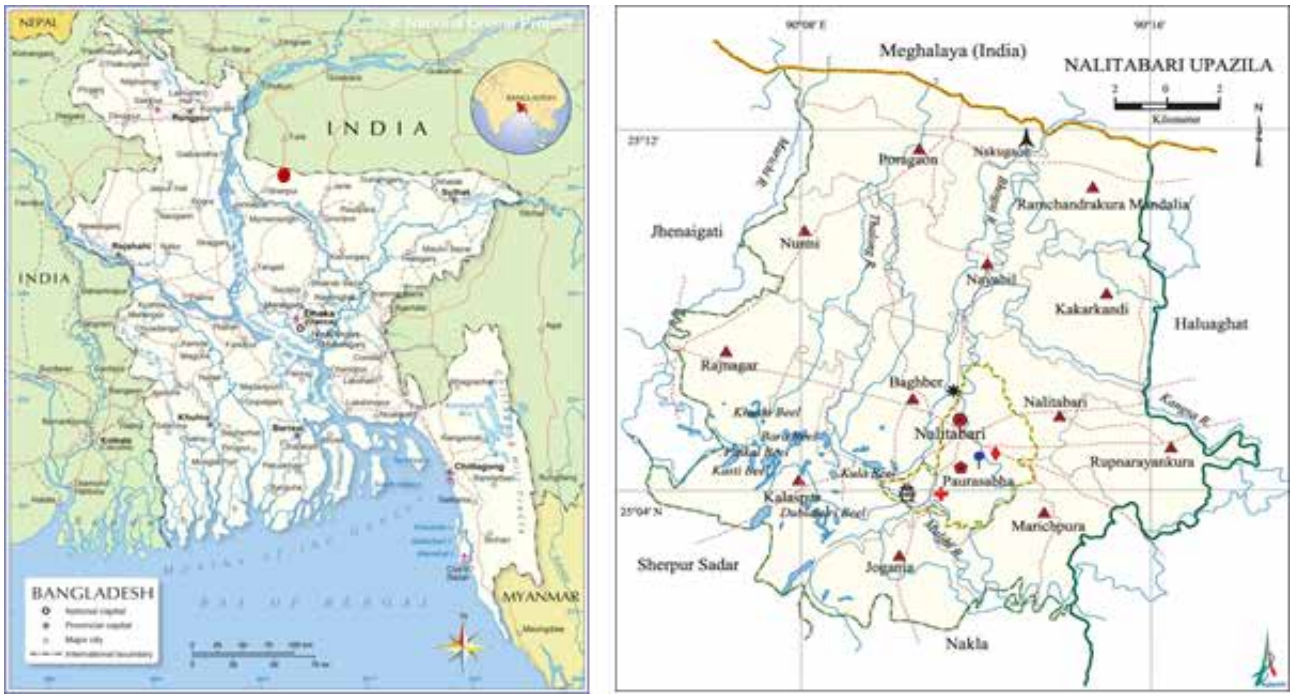

Figure 1. Map showing the location of Nalitabari Upazila, Sherpur (red spot on Bangladesh map). Source: (http://en.banglapedia.org/index.php?title=Nalitabari_Upazila)

Table 1. Scientific information of medicinal plants and the parts used by the Garo tribal community in the Nalitabari Upazila of the Sherpur District, Bangladesh

Sl. No.	Scientific Name	Family	Local name	Habit	Part(s) used
1	*Abroma augusta* (L.) L.f.	Sterculiaceae	Olotkambal	Shrub	Root, Bark, Leaf
2	*Abrus precatorius* L.	Leguminosae	Kunch	Woody Herb	Fruit, Seed, Root
3	*Acacia arabica* (Lam.) Willd.	Leguminosae	Arobi gach	Tree	Leaf, stem extract
4	*Aegle marmelos* (L.) Corrêa	Rutaceae	Bel	Tree	Leaf, Fruit
5	*Allium cepa* L.	Amaryllidaceae	Piyanj	Herb	Leaf, Bulb, Root
6	*Allium sativum* L.	Amaryllidaceae	Roshun	Herb	Leaf, Bulb, Root
7	*Aloe vera* (L.) Burm.f.	Asphodelaceae	Gritakumari	Herb	Leaf
8	*Alpinia galanga* (L.) Willd.	Zingiberaceae	Bach gach	Herb	Root, stem
9	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	Satim	Tree	Bark
10	*Amomum subulatum* Roxb.	Zingiberaceae	Elachi	Tree	Fruit with seeds
11	*Ananas comosus* (L.) Merr.	Bromeliaceae	Pineapple	Herb	Fruit, Young leaf
12	*Andrographis paniculata* (Burm.f.) Nees	Acanthaceae	Kalomegh	Herb	Leaf, Roots

13	*Artocarpus heterophyllus* Lam.	Moraceae	Kanthal gach	Tree	Fruit, seed
14	*Asarum europaeum* L.	Aristolochiaceae	Shugandhabala	Herb	Leaf
15	*Asparagus racemosus* Willd.	Asparagaceae	Satamuil	Climber	Root, stem, Leaf
16	*Azadirachta indica* A. Juss.	Meliaceae	Nim	Tree	Leaf, Bark
17	*Bacopa moniera* (L.) Wettst.	Scrophulariaceae	Brammi	Herb	Leaf, whole plant
18	*Bauhinia purpurea* L.	Leguminosae	Rakta kanchan	Tree	Leaf
19	*Berberis aristata* DC.	Berberidaceae	Daruhoridra	Tree	Roots, Stems
20	*Boerhaavia repens* Brand.	Nyctaginaceae	Punornova	Herb	Roots, stems, Leaf
21	*Borago Officinalis* L.	Boraginaneae	Jabani gach	Herb	Leaf
22	*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	Akanda	Shrub	Stems, Leaf
23	*Centella asiatica* (L.) Urb.	Apiaceae	Thankuni	Herb	Leaf, Young stems
24	*Cinnamomum zeylanicum* Blume	Lauraceae	Daruchni	Tree	Bark
25	*Citrus aurantifolia* (Christm.) Swingle	Rutaceae	Lebu	Herb	Juice
26	*Clitoria ternatea* L.	Leguminosae	Aporajita	Herb	Flower, Leaf
27	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Telakucha	Climber	Leaf, Root
28	*Cochlospermum religiosum* (L.) Alston	Bixaceae	Katira gach	Tree	Leaf, Stem
29	*Cordia dichotoma* G.Forst.	Boraginaceae	Sapesh gach	Tree	Leaf, sometime roots
30	*Coriandrum sativum* L.	Umbelliferae	Dhonia pata	Herb	Leaf, Seed
31	*Corymbia citriodora* (Hook.) Hill and Johnson	Myrtaceae	Euaclyptus tree	Tree	oil or Extracts
32	*Crocus sativus* L.	Iridaceae	Jafran gach	Herb	Leaf, stem
33	*Cuminum cyminum* L.	Apiaceae	Zira	Herb	Fruit
34	*Curcuma longa* L.	Zingiberaceae	Holud	Herb	Rhizome
35	*Cuscuta reflexa* Roxb.	Convolvulaceae	Sonaloti gach	Herb	Leaf with young stems, Fruit with seed
36	*Cynodon dactylon* (L) Pers.	Poaceae	Durba	herb	Whole plant
37	*Cyperus rotundus* L.	Cyperaceae	Nagori gach	Herb	Leaf, Fruit, Rhizome
38	*Datura metel* L.	Solanaceae	Dhutura	Herb	Seed, Leaf
39	*Daucus carota* L.	Umbelliferae	Gajar	Herb	Root
40	*Dillenia indica* L.	Dilleniaceae	chalta	Tree	Flower, fruits
41	*Eclipta prostrata* (L.) L.	Asteraceae	Vingu gach	Herb	Leaf extract
42	*Elettaria cardamomum* (L.) Maton	Zingiberaceae	Elachi gach (small)	Herb	Fruit, Seed
43	*Foeniculum vulgare* Mill.	Apiaceae	Mouri	Herb	Roots, Seeds
44	*Gloriosa superba* L.	Colchicaceae	Olatchandal	Herb	Leaf, Flower, Bark
45	*Glycyrrhiza glabra* L.	Leguminosae	Josthi modhu	Herb	Leaf, Stem, Root
46	*Hiptage madablota* Gaertn.	Malpighiaceae	Madhobilata	Climber	Flower
47	*Holarrhena pubescens* Wall. *ex* G. Don	Apocynaceae	Kurchi gach/ Indrojab	Shrub/small tree	Bark
48	*Ipomoea alba* L.	Convolvulaceae	Dudhi kalmi	Herb	Leaf, Twig
49	*Ipomoea mauritiana* Jacq.	Convolvulaceae	Bhuikumra	climber	Fruit, Root, Tuber
50	*Justicia adhatoda* L.	Acanthaceae	Bashok	Shrub	Leaf
51	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	Lau	Climber	Fruit

52	*Malva sylvestris* L.	Malvaceae	Khabba gach	Shrub	Seed
53	*Mangifera indica* L.	Anacardiaceae	Aam	Tree	Leaf, Bark, Fruit
54	*Mentha arvensis* L.	Lamiaceae	Pudina pata	Herb	Leaf
55	*Mentha viridis* (L.) L.	Lamiaceae	Pahari Pudina	Herb	Leaf
56	*Momordica charantia* L.	Cucurbitaceae	Corolla	Herb	Fruit, Twig, Leaf
57	*Moringa oleifera* Lam.	Moringaceae	Sajna gachh	Tree	Leaf, fruit
58	*Musa sapientum* L.	Musaceae	Kola gach	Herb	Fruit
59	*Nymphaea nouchali* Burm.f.	Nymphaeaceae	Shapla	Herb	Flowers
60	*Ocimum tenuiflorum* L.	Labiatae	Tuishi	Sub shrub	Leaf, Stem
61	*Pandanus tectorius* Parkinson *ex* Du Roi	Pandanaceae	Keura	Tree	Anther, Root, Leaf extract, Seed
62	*Phyllanthus emblica* L.	Euphorbiaceae	Amloki	Tree	Fruit
63	*Piper betle* L.	Piperaceae	pan	Climber	Leaf
64	*Piper cubeba* L.f.	Piperaceae	Kabab sugar	Climber	Seeds, Fruit
65	*Piper nigrum* L.	Piperaceae	Golmorich	Climber	Fruit
66	*Plantago ovata* Forssk.	Plantaginaceae	Ispaghol	Herb	Seed, Husk
67	*Portulaca oleracea* L.	Portulacaceae	Nune shak	Herb	Leaf, Young stems
68	*Prunus amygdalus* (Mill.) Webb	Rosaceae	Kagozi badam	Tree	Seed
69	*Psidium guajava* L.	Myrtaceae	Peyara	Small tree	Fruit
70	*Pterocarpus santalinus* L.f.	Leguminosae	Rakta chandan	Tree	Stem, Leaf
71	*Rauvolfia serpentina* (L.) Benth. *ex* Kurz	Apocynaceae	Sharpagandha	Herb	Bark of roots
72	*Rosa damascene* Herrm.	Rosaceae	Golap Gach	Shrub	Flowers extract
73	*Salvia plebeian* R.Br.	Labiatae	Bhui tuisi	Herb	Leaf, seed
74	*Saraca asoca* (Roxb.) Willd.	Leguminosae	Ashok gach	Tree	Bark, Seed
75	*Senna alata* (L.) Roxb.	Leguminosae	Datmardan	Shrub	Leaf
76	*Sesamum indicum* L.	Pedaliaceae	Tilgach	Herb	Seeds, Fruit
77	*Sida acuta* Burm.f.	Malvaceae	Urusia / Bon methi	Shrub	Areal parts, Seed, Root
78	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jam	Tree	Bark, Fruit, Seeds
79	*Tabernaemontana divaricata* R.Br. *ex* Roem. and Schult.	Apocynaceae	Tagar	Herb	Flower
80	*Tagetes patula* L.	Asteraceae	Gada	Herb	Flowers
81	*Tamarix dioica* Roxb. *ex* Roth	Tamaricaceae	Jhau gach	Shrub	Leaf, root, young
82	*Terminalia arjuna* (Roxb. *ex* DC.) Wight and Arn.	Combretaceae	Arjun	Tree	Bark
83	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Bohera	Tree	Fruit
84	*Terminalia chebula* Retz.	Combretaceae	Hortoki	Tree	Fruit
85	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	Goloncha	Climber	Root, Leaf
86	*Tribulus terrestris* L.	Zygophyllaceae	Gokhra gach	Herb	Plant extract
87	*Vitex negundo* L.	Verbenaceae	Nishinda	Shrub	Leaf
88	*Zingiber offcinale* L.	Zingiberaceae	Aada	Herb	Rhizome

Table 2. Medicinal plant species and their traditional uses and formulations by the Garo tribal community in the Nalitabari Upazila of the Sherpur District, Bangladesh

Sl. No.	Scientific Name	Diseases to be treated	Traditional Formulation and Dosage
1	*Abroma augusta*	Used against many gynaecology diseases – irregular and/or painful menstrual cycle, leucorrhoea, etc., diabetes, plies	Liquid extract of the bark, leaf, and juvenile roots to be used 3 or 4 times daily
2	*Abrus precatorius*	Diseases of the gastrointestinal tracts, leucorrhoea	Tablets are made from the powder of dried fruits and seeds. 3 tablets per day.
3	*Acacia arabica*	Cough, catarrh caused by smoking	Extract of leaves and stems to be used 3 times daily with honey and water.
4	*Aegle marmelos*	Diarrhea, stomach disorders, vomiting tendency and thirst	Juice of fruits to be used 3 times daily. Ripe and unripe fruits to be used for constipation.
5	*Allium cepa*	Catarrh, cough, weariness and fatigue, dandruff	Liquid extract of the roots to be used daily.
6	*Allium sativum*	Wounds, antiseptic, hypertension, diabetes, increases the power of heart	Burned rashun is used daily 2 times before meal
7	*Aloe vera*	Wounds, skin problems, constipation, physical weakness, gout and pain, sexual stimulant both for male and female	The internal portion of the leaves is separated; it is whitish in color and jelly-like. To be taken as a juice, daily one time before meal for constipation.
8	*Alpinia galanga*	Mental weakness. kidney weakness, maintains heart-beat, for urine problems	Tablets are made from the powder of dried roots or modified stems. 3-4 tablets per day.
9	*Alstonia scholaris*	Fever, diarrhea, dysentery	Tablets are made from the powder of dried barks. 3 tablets per day.
10	*Amomum subulatum*	Gastric, stomach disorder, bad smell of mouth, cleans the throat, increases appetite and the power of stomach	Tablets are made from the powder of dried fruits/ seeds, 4 tablets per day.
11	*Ananas comosus*	Appetite, gastrointestinal disorders, helps to digest, destroys worms	Fruit or fruit juice is directly taken. Young leaf is chewed for helminthiasis and jaundice.
12	*Andrographis paniculata*	Fever, ulcer, hypertension, overweight and high-level cholesterol of the blood	Juice of the whole plant for the treatment of fever and ulcer. Roots and leaves are mashed; tablet is made and then dried. 4 tablets per day.
13	*Artocarpus heterophyllus*	Vitamins and minerals, malnutrition, maintains body temperature	Fruits are directly consumed seeds are fried and consumed.
14	*Asarum europaeum*	Gastrointestinal diseases; increases the power of the stomach and liver	Liquid leave extracts to be used; Tablets are made from dried leaves powder. 4 tablets per day.
15	*Asparagus racemosus*	Epilepsy, stomach ulcer, male sexual diseases, such as lacking sperms, liquidness of semen, sexual instability	Root extract with milk for male sexual diseases and for weakness. Leaves, root and young stem are mashed then dried as tablets to be used 3 or 4 time.
16	*Azadirachta indica*	Allergy diabetes, skin diseases, constipation, rheumatic fever, gastrointestinal disorder, pimpless, piercing.	Liquid extract of leaves to be used. Also leaves are dried and powdered and are taken every morning.
17	*Bacopa moniera*	Nerve and brain diseases, increases the memorizing power	Leaves and the whole plant are mashed and tablets are made from the mashed product. After they become dry, 2 tablets are to be taken per day.

18	*Bauhinia purpurea*	Skin diseases, pimple, and bruises of the skin	Tablets are made from the powder of dried leaves. 3 or 4 tablets per day.
19	*Berberis aristata*	Itching in the anus, constipation, pain during passing stools	Tablets are made from the powder of dried Roots and stems. 3 or 4 tablets per day.
20	*Boerhaavia repens*	Gout, dropsy, irregular urine, kidney disorders	Leaves and juvenile stems, roots are mashed and tablets are made from the mashed product. After they become dry, 3 tablets are to be taken per day.
21	*Borago Officinalis*	Jaundice, inflammation and many other diseases of the uterus in women	Tablets are made from the powder of dried leaves. 4 tablets per day.
22	*Calotropis gigantea*	Anemia, joint-pain, eczema, flexibility of penis, sexual weakness in males, curviness of the penis	Leaves and Young stem are mashed, then dried. Tablets are produced from the mashed product. 3-4 tablets per day. For joint-pain to be used For fomentation by hot leaf.
23	*Centella asiatica*	Dysentery, itching of eye, dry catarrh, bronchitis	Leaf extracts (liquid) to be used in the eye. In other cases, green leaves are mashed; tablet is made, then dried. 4 times per day.
24	*Cinnamomum zeylanicum*	Increases appetite, removes the anorexia, cures the bruises of the mouth, asthma	Dried bark is turned into powder. To be used 6 time daily.
25	*Citrus aurantifolia*	Lacking Vit. C, scurvy, bruises of the mouth and palate, dandruff, facial scars and spots	Juice of the lemon to be used. Fruit juice for facial scars and spot. Fruits increase appetite.
26	*Clitoria ternatea*	Promotes memory and intelligence, treats eye infections, pimples of the face and many skin diseases, and diseases of urinary tracts	Roots, flowers and leaves are mashed and tablets are made from the mashed product. Then After they become dry, 4 tablets are taken per day. Flower extract to be used to treat eye infections.
27	*Coccinia grandis*	Diabetes, skin diseases, urinary tract infection, gonorrhea.	Liquid extract of leaves and roots to be used 2 times.
28	*Cochlospermum religiosum*	Catarrh, cough	Extract of leaves and stems to be used 4 times daily with sugar and water.
29	*Cordia dichotoma*	Asthma, dry catarrh, inflammation of the vocal cords	Leaves and roots are mashed; tablets are made and dried to be taken 4 tablets per day.
30	*Coriandrum sativum*	Increases appetite, provides minerals, cleans the cough from the throat, and removes the anorexia	Mashed leaves with water are to be taken 3 times per day. Take the seed extract 3 times daily.
31	*Corymbia citriodora*	Antiseptic, teeth pain, many skin diseases, stomach disorders, pneumonia	Liquid and oily extract of the tree to be used properly and daily.
32	*Crocus sativus*	Dysentery, blood dysentery, diarrhea, stomach disorders, and cholera	Tablets are made from the powder of dried leaves and young roots, to be used 3-4 times daily.
33	*Cuminum cyminum*	Antioxidant, removes many diseases of the larynx	Tablets are made from the powder of dried fruits. 2 tablets per day.
34	*Curcuma longa*	Removes many skin disorders and bruises	Mashed products are directly applied on the skins.
35	*Cuscuta reflexa*	Bilious disorders, jaundice, hepatitis, inflammation of liver, mental illness and constipation.	Leaves, fruit with seed and juvenile stems are mashed, then dried. Powders are produced from the dry product. Powder to be taken 4/5times daily.
36	*Cynodon dactylon*	Hepato-protective, anti-oxidant activity, heals wounds.	Macerated whole plant is applied to stop bleeding from cuts, whole plants extract for other uses.
37	*Cyperus rotundus*	Diarrhoea, fever, pain in hips, cough, cold and breathing problems	Tablets are made from the powder of dried leaves and stems. 3 tablets per day.

38	*Datura metel*	Joint pain, breathing problems, asthma, bronchitis	Tablets are made from the powder of dried seeds and leaves. To be used 1 time daily.
39	*Daucus carota*	Source for vitamins and minerals, removes weariness and fatigue	Modified root as vegetable.
40	*Dillenia indica*	Scurvy, cleans the urine tract and maintains its regularity, fever.	Fruit juice is directly consumed.
41	*Eclipta prostrata*	Dandruff, hair-loss, to blacken hair, fatigue and weariness excitation, increases the biological demand	Powder of dried leaves or liquid extract of green leaves to be used 4 times daily. For hair treatment mixed with oil in leaf extract.
42	*Elettaria cardamomum*	Storage cough, dry catarrh, asthma, bronchitis, breathing problems, cleans the throat, tonic	Tablets are made from the powder of dried seeds and fruits (dried by fire heat) to be used 4 times daily.
43	*Foeniculum vulgare*	Fever, kidney disorder, maintains the regularity of menstrual cycle	Tablets are made from the powder of dried roots and seeds combinedly. 4 tablets per day.
44	*Gloriosa superba*	Gynaecology diseases – irregular and/or painful menstrual cycle, leucorrhoea, etc., piles	Tablets are made from powder of dried leaves and flower. 3 tablets per day.
45	*Glycyrrhiza glabra*	Bronchitis, gastralgia, Cough, dry catarrh, hopping cough, asthma	Leaves and young stems and root are mashed, then tablets are made and dried. 3 tablets per day.
46	*Hiptage madablota*	Diseases of gastrointestinal tracts	Tablets are made from the powder of dried flowers. 2 tablets per day.
47	*Holarrhena pubescens*	Diarrhea, disorders of stomach	The barks are mashed; tablet is made, and dried. 3 tablets per day.
48	*Ipomoea alba*	Snakebites, scabies or eczema	Leaves are applied to boils and wounds. Leaves and twigs are boiled in water and consumed.
49	*Ipomoea mauritiana*	Tuberculosis, kidney pain and reduces miscarriage.	Tablets are made from the powder of dried fruit, root and tuber. 3 tablets per day.
50	*Justicia adhatoda*	Cough, dry catarrh, asthma, bronchitis	Juvenile leaves are mashed; tablet is made, then dried. 3 tablets per day; Young stems and leaves with boiled water and the extract is to be taken 3 or 4 times per day.
51	*Lagenaria siceraria*	Cholera, disorders of stomach.	Used as vegetable, consumed as a form of curry.
52	*Malva sylvestris*	Asthma, weakness of lung, catarrh caused by smoking	Powders are made from dry seeds, then tablets are made from the powder. 3 tablets per day.
53	*Mangifera indica*	Dental diseases, hypertension, gastric, indigestions, stomach disorder	Juvenile leaves are mashed and dried. Power is produced. 3 times per day. Decoction of bark and flower to prevent graying of hair.
54	*Mentha arvensis*	Skin diseases, pimples, makes skin soft and glorious	Mashed leaves are used directly or the liquid extract of leaves to be used regularly.
55	*Mentha viridis*	Hiccup, bilious vomiting, flatulence, colicky pain and cholera	Mashed leaves are used directly or the liquid extract of leaves juices to be used regularly.
56	*Momordica charantia*	Jaundice, piles, diabetes, antioxidant, gout, heart problems, anticancer agent	Used as Vegetable, consumed as a form of curry.
57	*Moringa oleifera*	Chicken pox, fat control	As a preventive measure against chickenpox 1/2 cup macerated leaves juice is taken. Leaf juice for fat control.
58	*Musa sapientum*	Urinary stones, constipation, stomach disorders, malnutrition, provides vitamins and minerals	Fruits are directly consumed.
59	*Nymphaea nouchali*	Cough, inflammation of the vocal cords, catarrh	Flowers are dried, then a powder is made; tablets are produced from powder. 6 tablets per day.

60	*Ocimum tenuiflorum*	Cough, cold, catarrh, many kinds of skin diseases, pimples, and piercing	Liquid extract of leaves is used about 5 times daily.
61	*Pandanus tectorius*	Leprosy, urinary tract problems, fatigue, weakness	Liquid extract of leaves to be used 4 times daily, or roots are dried and made into a powder to be used 3 times.
62	*Phyllanthus emblica*	Diabetes, dyspepsia, hair loss, to stop vomiting, scurvy, bruise of mouth and leap, dysentery, blood dysentery, diarrhoea	50 g juice obtained from crushed leaves is mixed with 20 g sugar and taken twice daily for 2 weeks.
63	*Piper betle*	Leucorrhoea, otorrhoea, increases the sexual power of the male and makes the penis strong, bad smell of mouth	Juice of the green leaves to be used 3 to 4 times daily.
64	*Piper cubeba*	Storage cough, dry catarrh, asthma, bronchitis and breath problem	Tablets are made from powder of dried seeds and fruits. 4 tablets per day.
65	*Piper nigrum*	Increases appetite, removes the vomiting tendency, Indigestions and many other gastrointestinal disorders	Tablets are produced from mashed product. Then dry. 2 tablets per day.
66	*Plantago ovata*	Constipation , chronic dysentery, gonorrhea	Seed and Husk is collected and dry to be taken it with water night and morning.
67	*Portulaca oleracea*	Pain in belly, increases the activity of stomach, chronic dysentery	Leaves with stems are mashed, tablet is made then dry 3 tablets to be taken per day.
68	*Prunus amygdalus*	Concentrates the semen of the male, removes the constipation and hair growth	Liquid and oily extract of the seeds is collected and use. or Tablets are made from powder of dried seeds, 3 tablets per day.
69	*Psidium guajava*	Diarrhoea, piles, fatigue and weariness, excitation	The Fruits are mashed and tablets are made. Then dry these. 6 tablets per day.
70	*Pterocarpus santalinus*	Gout, pain of gout, many skin disease, piles/hernia	Leaves and stems are mashed; tablets are made from the mashed product. Then dry it. 3 tablets per day.
71	*Rauvolfia serpentina*	Hypertension, insomnia, high-level blood cholesterol	Tablets are made from powder of dried bark of roots. 3 tablets per day.
72	*Rosa damascena*	Inflammation, fatigue, weakness, makes the body charmed	Liquid extract of flowers to be used 4 times daily.
73	*Salvia plebeia*	Gonorrhoea, menorrhagia	Liquid extract of leaves are used taken internally.
74	*Saraca asoca*	Gynaecology diseases e.g., irregular menstrual cycle, painful menstrual cycle, etc, increases the power of the uterus of woman	Liquid extract of the barks; Tablets are made from powder of dried barks. 4 tablets per day.
75	*Senna alata*	Skin disease, bruise	Leaves are mashed and tablets are made from the mashed product. Then dry it. To be used 3 times daily or directly mashed leaves.
76	*Sesamum indicum*	Fistula, burns associated with infection, night pollution, sexual instability, cold cough, catarrh, loss of hair, semen concentration, hair-fall	Liquid and oily extract of seeds is collected and to be used 2-3 times daily according to role.
77	*Sida acuta*	Demulcent and diuretic, rheumatic affections, gonorrhoea, chronic dysentery	Leaves juice are used to treat demulcent and diuretic. Infusion of roots with ginger is given in intermittent fever; chronic boil complaints.
78	*Syzygium cumini*	Bronchitis, vomiting, gargle and mouth wash, pain in bone joint, asthma, gout, infection in throat, hypertension, diabetes	Powder is made from the dry fruits, and then the powder is eaten with water 3 times daily.

79	*Tabernaemontana divaricata*	Weakness	Tablets are made from powder of dried flowers. To be used 4 times daily.
80	*Tagetes patula*	Eczema, antiseptics, stop bleeding, heal wounds	Mashed products are directly applied on the wounded skins.
81	*Tamarix dioica*	Jaundice, disease of urinary tracts	Leaves, root and young stem are mashed, then dried. Tablets are produced from the mashed product. To be used 4-6 times daily.
82	*Terminalia arjuna*	Heart disease, hypertension, ulcer, anemia	Cutting pieces of bark is dipped into water overnight, and then the water is consumed daily.
83	*Terminalia bellirica*	Acidity, constipation and stomach disorders, cough.	Powder are made from dried fruits, the powder is to be used 3 times daily.
84	*Terminalia chebula*	Gastritis, abdominal pain, dysentery, blood dysentery, diarrhea, stomach disorder, increase activity of liver	Powder are made from dried fruits, the powder is to be used 3 times daily.
85	*Tinospora sinensis*	Worm infestations, loss of appetite, liver disorder, disease of urinary tracts, fatigue, physical and mental weakness	Stem, roots and leaves are mashed; tablets are made from the mashed product; then dry it. 3 tablets per day.
86	*Tribulus terrestris*	Complexity of kidney, fever, clean the urine and maintain its regularity	Tablets are made from powder of dried external part of bark, 3 tablets per day.
87	*Vitex negundo*	Arthritis, spleen enlargement, gouts	Leaves are mashed and tablets are made from the mashed product. Then dry it. 4 tablets per day.
88	*Zingiber offcinale*	Cough, pain of belly, gastric, ulcer, indigestion and many other stomach disorders/evil wind	Juvenile zinger, with salt or dried zinger with salt to be taken 4 to 6 times daily.

Discussion

The present investigation provides ample information about the traditional medicinal practice using native MPs within the studied area. The traditional knowledge of the Garo ethnic people of Nalitabari Upazila has tremendous ethnobotanical and ethnomedicinal importance. Khatun and Rahman (2019) reported similar findings, although the tree is the dominant plant group reported by Rana *et al*. (2010). The ethnic group Santal used 105 species as MPs and out of these plant species, 44% belong to herbs, 28% trees, 18% shrubs, 10% climbers. Most of the species are used for the treatment of a few to several diseases; however, a few species are used for a single or very specific disease treatment. As an example, *Terminalia arjuna* is used for the treatment of heart diseases, *Ipomoea alba* for snakebites, *Moringa oleifera* for chickenpox, *Vitex negundo* for Gouts, etc. (Table 2). It was observed through this work that the ethnic groups collected medicinal plants in wild forms which means that the area had a poor cultivation of economically valuable medicinal plants. This situation could, on the long run, lead to the depletion of plant resources or even to their extinction from their natural habitat if the plant specimens were used in huge amounts for medicinal uses and other purposes. There were no permanent storage practices: the villagers collected fresh medicinal plants from the forest as per their requirements. Uddin *et al.* (2015a) identified and provided information on fifty plant species in forty-seven genera under thirty-seven families used to treat twenty-nine different ailments by the Chakma traditional healers. Khatun and Rahman (2019) reported that a total of 105 plant species under ninety-seven genera belonging to fifty-seven families were recorded as plants used by the Santals for the treatment of sixty-seven ailments.

The most frequently used individual plant part for medicinal preparations was the fruits (13; 14.77%) followed by the leaves (11 cases; 12.50%), bark and the flowers (5; 5.68% each) (Fig. 3). The study shows that different plant

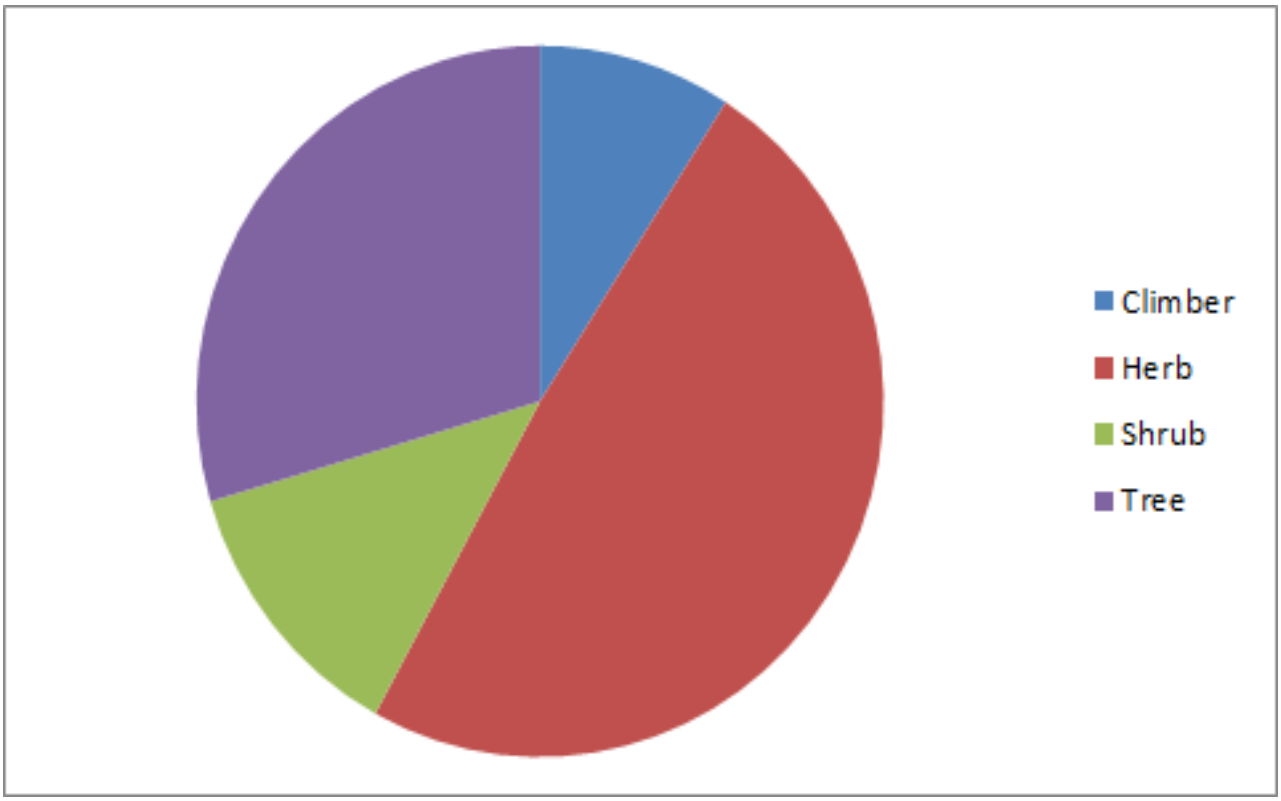

Figure 2. Habit wise distribution of medicinal plants used by the Garo tribal community, Bangladesh

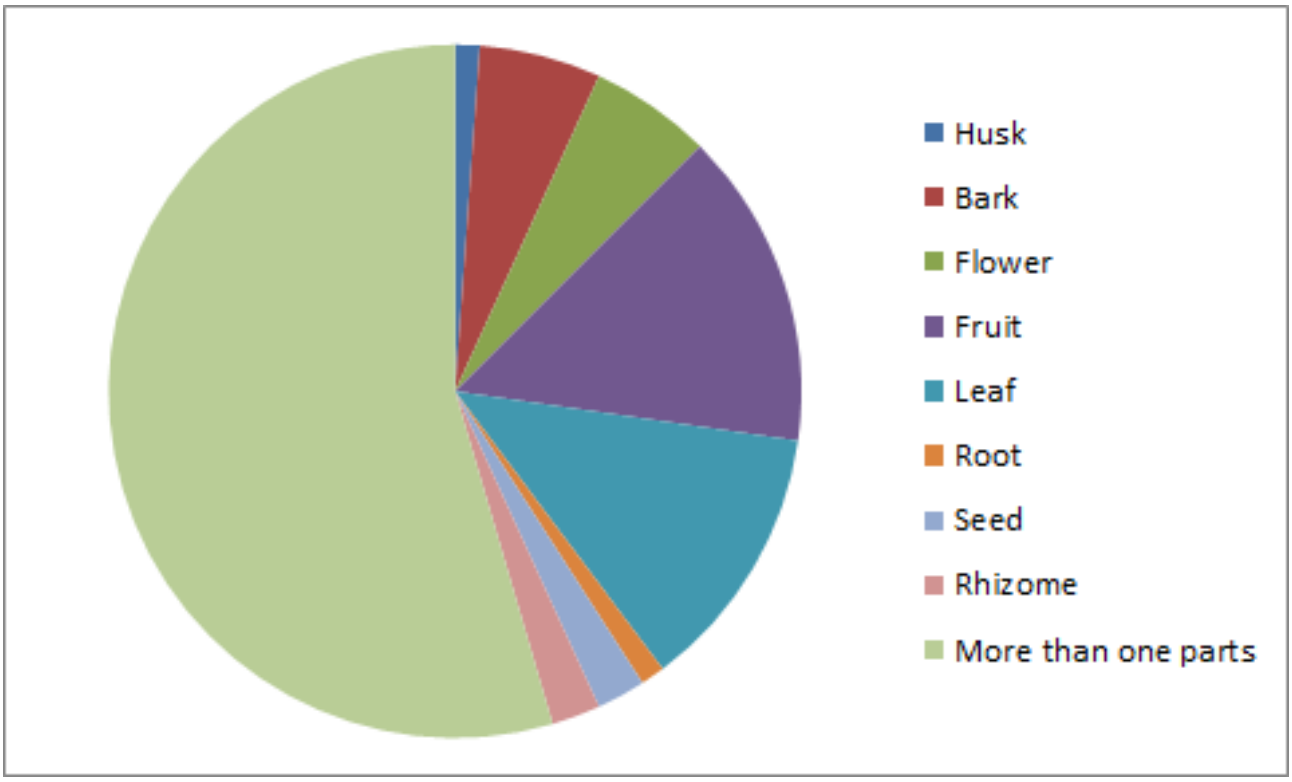

Figure 3. Utilization of plant parts of the medicinal plant species by the Garo tribal community, Bangladesh

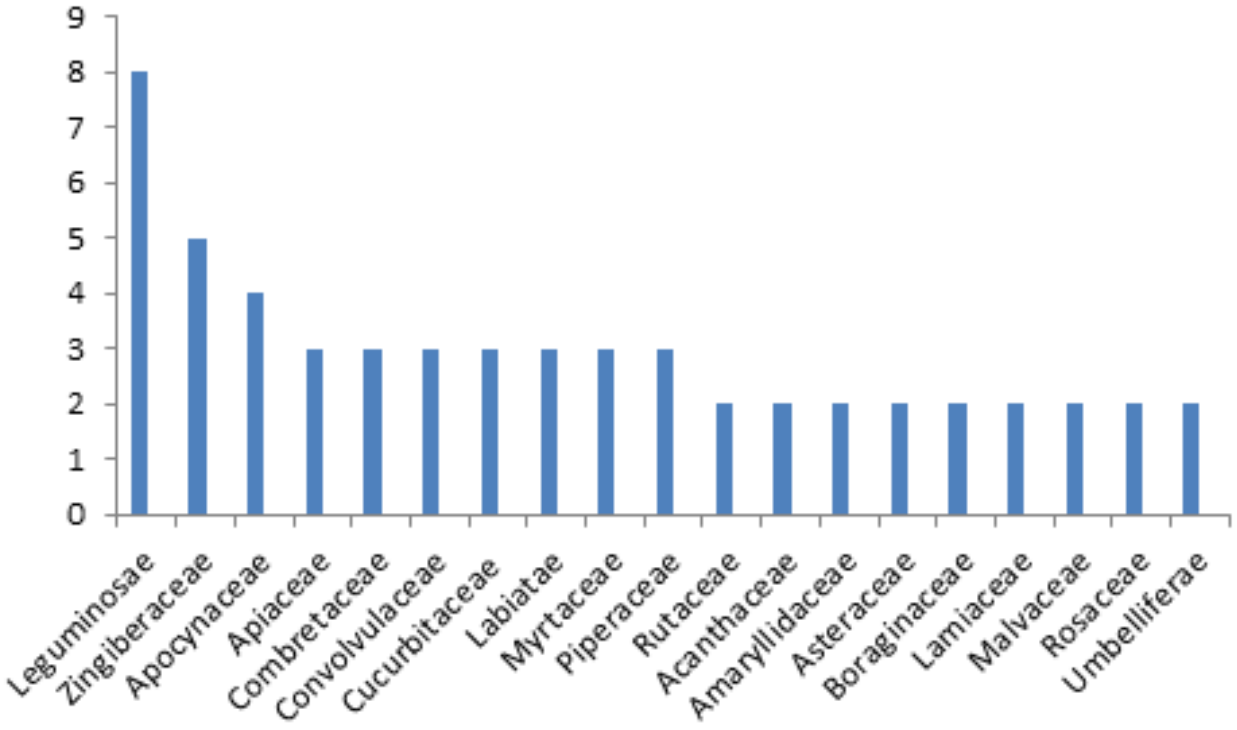

Figure 4. Family-wise distribution of the medicinal plant having more than two species in the Garo tribal community, Bangladesh

parts are used in the preparation of treatments against human ailments and this finding is consistent with previous studies (Malla *et al*., 2015; Uddin *et al*., 2015). The Santal people mostly used leaves (29%) followed by roots (12%), fruits (12%), whole plant (10%), seeds (9%), bark (9%), stems (5%), flowers (4%), latex (2%), rhizomes (2%), petioles (2%), gum (2%), bulb (1%), tubers (1%), pods (1%) and buds (1%) (Khatun and Rahman, 2019).

For Manipuri tribe, Combretaceae appeared as the most prominent family (3 species, 1 genus), followed by Apocynaceae, Piperaceae and Rubiaceae (2 species and 2 genera each), and Meliaceae (2 species, 1 genus). Rests are the family that contains one species each (Rana *et al*., 2010). Uddin *et al.* (2015a) reported that Apocynaceae is the most frequently used family within the context of the number of species used by the Chakma Community. Other important families used for medicinal plants include Caesalpiniaceae, Amaranthaceae, Rutaceae, Araceae, Zingiberaceae, Asteraceae, Liliaceae and Combretaceae, respectively.

Some diseases were reported/observed as very common among the ethnic Garo peoples and these could be treated with more than one plant e.g., fever (9 species), cough (15 species), skin diseases (15 species), constipation (10 species), diarrhea (8 species), catarrh (14 species), etc. (Table 2). According to the World Health Organization (WHO), ten diseases are recognized as the top deadliest, causing the majority of deaths worldwide (https://www.healthline.com/health/top-10-deadliest-diseases). Six of these diseases are treated by the ethnic Garo people with the help of medicinal plants, *viz*. Heart diseases are treated with two species, Bronchitis by seven species, diabetes by seven species, Diarrheal diseases by eight species, tuberculosis by one species and Cirrhosis (/ damage to the liver) by two species (Table 2).

Although the same MP species are used by different ethnic groups, the plant parts used and their prescriptions might be different. For example, the root of *Abroma augusta* is used by Garo ethnic group against many gynaecology diseases – irregular and/or painful menstrual cycle, leucorrhoea, plies, etc. (Table 2). Moreover, the seeds of *A*.

augusta are used by the Chakma tribe in the Khagrachari district for the treatment of neck pain (Yusuf *et al.,* 2009). *Centella asiatica* is used to treat itching in the eye, dry catarrh, bronchitis, etc. according to this paper (Table 2); but Marma has prescribed plant juice with common salt against blood dysentery (Yusuf *et al*., 2009). This MP (*C. asiatica*) is also used against flatulence, dysentery, and the bleeding of piles (Rana *et al*., 2010); and/or is advised by some other ethnic groups against diarrhea, menstrual problems, stomach pain, and as a stimulant, etc. (Mohiuddin *et al*., 2012). These types of variations in the uses of the same plants are described in details in MP books (Uddin, 2006; Yusuf *et al*., 2009; Uddin *et al*., 2016). Therefore, the knowledge of ethnic people on MPs should be well-documented to pave the way for many more life-saving drug discoveries.

Conclusion

The present research has revealed that a total of eighty-eight MP species belonging to fifty-one families and eighty-two genera were collected and recorded for their use against various (104) ailments by the Garo people. Herbs occupy predominantly the major growth habit followed by trees, shrubs, and climbers. The same plant has been used for the treatment of different ailments with different formulations by different ethnic groups. Therefore, the ethnobotanical knowledge on MPs must be rendered useful as it paves the way for further life-saving drugs, 'green' integrative medicine, and new discoveries in the post-COVID-19 era.

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Morphometric and Meristic Variation in Twelve Different Populations of *Garra rufa* (Heckel, 1843) from Iran

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Abstract: This study is carried out to examine the meristic characteristics and variations in the body shape of the red stone lapper, *Garra rufa* (Heckel, 1843) living in many river systems including the Tigris, Jarrahi, Zohreh, and Mond Basins using geometric and classical morphometric methods. The morphological differences of twelve populations of red stone lapper, *G. rufa* from Iranian inland water basins were studied using meristic, morphometric, and geometric (Landmark-point) methods. For this aim, twelve meristic characters were counted, nineteen classical morphometrics were measured, and sixteen ratios were calculated. As for the geometric part, thirteen homologous landmark-points were digitized using tpsDig2 software. All analyses showed significant differences in seven meristic and nineteen morphometric characters among the populations. Further analyses including PCA, CVA, and CA of geometric data have shown that there are significant differences in the head region and dorsal-fin base among the *G. rufa* populations. These results suggest that classical and geometric morphometric methods can distinguish red stone lapper populations of the Iranian inland waters from each other; the differences in body shape suggest that habitat parameters including physicochemical parameters may have caused these patterns of variation in the body shape of fishes.

Keywords: *Garra rufa*, Variation, Habitat, Geography, Plasticity.

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Introduction

Fishes are very sensitive to habitat conditions (Hossain *et al*., 2010); therefore, living in many rivers and experiencing the different habitat conditions may cause variations in the body shape of fishes (Costa and Cataudella, 2007).

On the other hand, existing in many rivers with variable conditions has proven that fishes have a high adaptation ability and can respond to habitat situations by phenotype plasticity which guarantees their generation survival in many waters (Gelsvartas, 2005). Many studies have confirmed that different populations of fish species living in different habitats show variations in their body shape; for example *Cyprinion* (Nasri *et al*., 2018); Trout Barb, *Capoeta trutta* (Keivany and Arab, 2017); *C. fusca* (Banimasani *et al*., 2019); *Squalius turcicus* (Mouludi-Saleh *et al*., 2020); Kura Barb (*Barbus lacerta*) (Zamani-Faradonbe and Eagderi, 2016; Zamani-Faradonbe *et al*., 2015b) and *Alburnus mossulensis* (Keivany *et al*., 2016a); Such differences appear to reflect the big ability of fish to survive under a range of conditions in rivers across Iran.

There are several techniques used to distinguish and compare the body shape of different populations including the geometric morphometric and classical morphometric methods. Geometric morphometrics is the Landmark-point method that is based on the digitalization and comparison of sampled body shapes (Bookstein, 1991; Zelditch *et al*., 2004). In the classical morphometric method, researchers use meristic characters such as the number of scales and fin rays

and other measurable characters (Naeem and Salam, 2005).

With at least thirteen valid species, the genus *Garra* Hamilton, 1822 is one of the most diverse genera of the Cyprinidae in Iranian waters that has a vast distribution area extending from the western to the eastern basins (Sayyadzadeh *et al*., 2015; Mousavi-Sabet and Eagderi, 2016; Mousavi-Sabet *et al*., 2019). The most widely distributed species of this genus is *Garra rufa* which lives in many tributaries flowing in the Tigris, Jarrahi, Zohreh, Fars, Maharlu, and the Mond basins; mostly, they live in lotic water, but sometimes they exist in lentic waters as well. *G. rufa* feeds on detritus, diatoms, algae, insects, and plants. Their vast distribution area suggests that this species is likely to have the ability to endure different habitat conditions which reflects their phenotype plasticity.

Coad (2010) and Kaya (2012) stated that *G. rufa* lives in moderate and fast rivers that are rocky and graveled, and mostly they have benthic characters.

The aim of this study is to assess the variations in the body shape of twelve populations of the red stone lapper, *G. rufa* from four basins in Iran. The results of this study can provide significant information for habitat conservation, and fish resource-management programs.

Materials and Methods

The Iranian drainage basins have been divided into 19-22 major basins based on fish distributions in different texts (Esmaeili *et al.,* 2017; Keivany *et al.,* 2016b). For this study, a total of 223 individuals of *Garra rufa* were collected during November, 2017 using electrofishing equipment (Samus Mp750, 45 cm diameter, aluminium ring anode) and downstream stop-nets with a 0.2 cm mesh size from twelve different flowing waters and rivers, namely the Tigris, Jarrahi, Zohreh, and the Mond basins (Figure 1); The collected specimens were anesthetized in 1% clove oil, and were then fixed in 10% formalin and transferred to the laboratory for meristic, morphometric and geometric studies.

The Classical Morphometric Method

A total of twelve meristic characters, including the number of lateral line scales (L.L), scales above L.L, scales bellow L.L to ventral fin, scales bellow L.L to the anal-fin, predorsal scales, circumpeduncular scales, dorsal, anal, pectoral, and ventral-fins soft rays, caudal-fin rays, and the number of barbells, were counted on the left side of the samples.

Also, nineteen morphometric characters were measured using a digital caliper (0.1 millimeter) on the left side of the specimens (Figure 2). Methods for the counting and measurements follow Kottelat and Freyhof, (2007). Some modification methods were used before the analysis of the morphometric data; three traits including snout length, orbital diameter, and postorbital length were used in the next analysis as the ratio of head length; predorsal fin length, dorsal fin base length, post dorsal fin length, preanal fin length, anal fin base length, post anal fin length, prepectoral fin length, Prepelvic fin length, pectoral-pelvic fins length, head length, head depth, body height, caudal peduncle depth were used as the ratio of standard length, and total, fork, and standard lengths were used in the further analysis without modification. After collecting data, the Kolmogorov– Smirnov test was used to test the normality of meristic and morphometric data, then the Kruskal–Wallis tests used for data following abnormal distribution and for data following normal distribution, one-way ANOVAs were applied (SPSS-19 software).

Geometric Morphometry and Body Shape

The left sides of all specimens were photographed using a Canon camera (12 MP resolutions); then to extract the body shape data, thirteen homologous landmark-points on the photographs were placed with the tpsDig2 software (Rohlf, 2003). In choosing

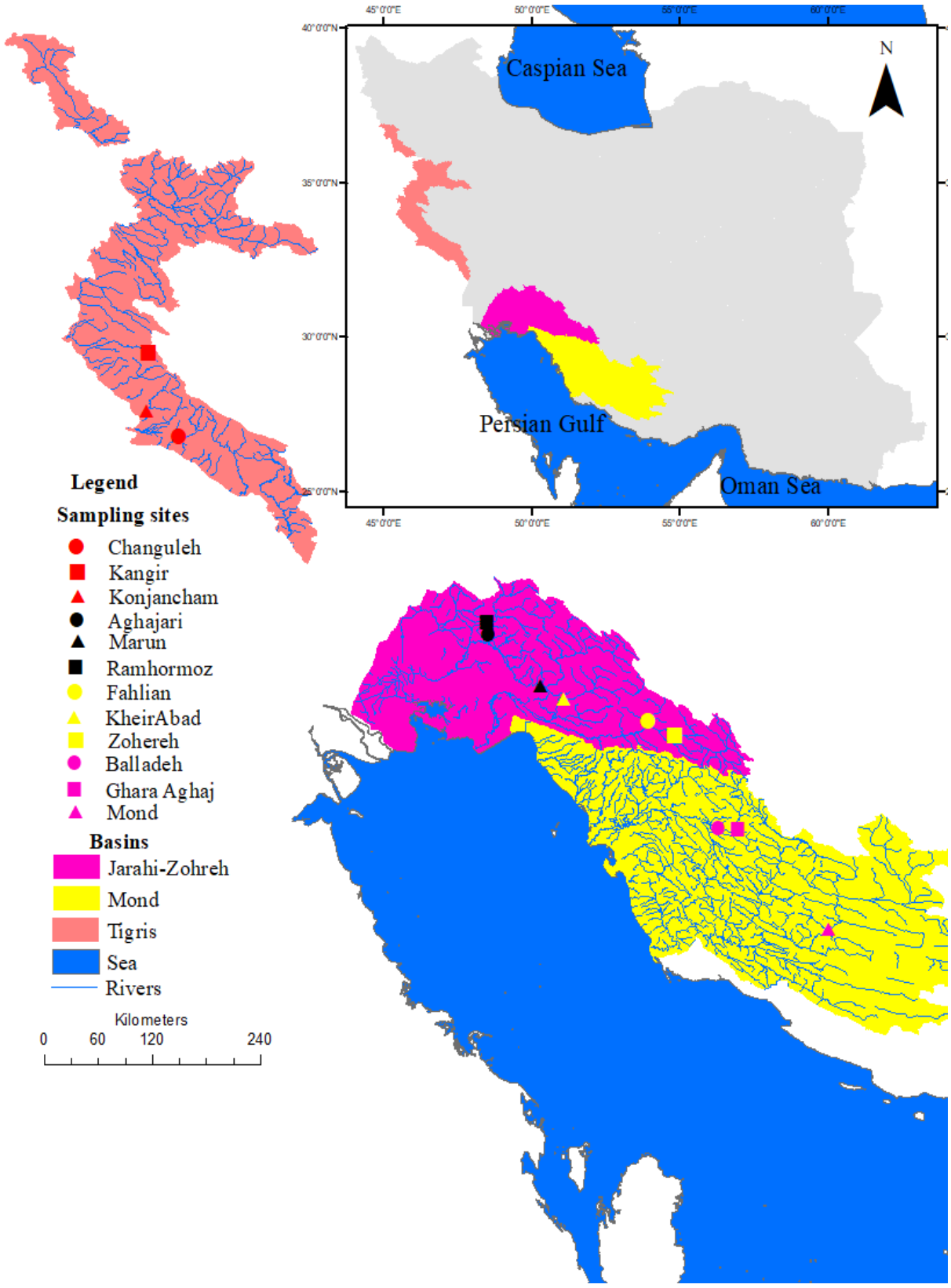

Figure 1. Map of Iran showing the sampling sites of the *Garra rufa* populations.

the landmarks, the researchers concentrated on the description of the fish's body shape (Figure 3). To remove non-shape variations such as information on the isometric size of the objects, their position, and spatial orientation from the data, the Generalized Procrustes Analysis was used (Dryden and Mardia, 1998).

Principal component analysis (PCA) was conducted to evaluate the structure and

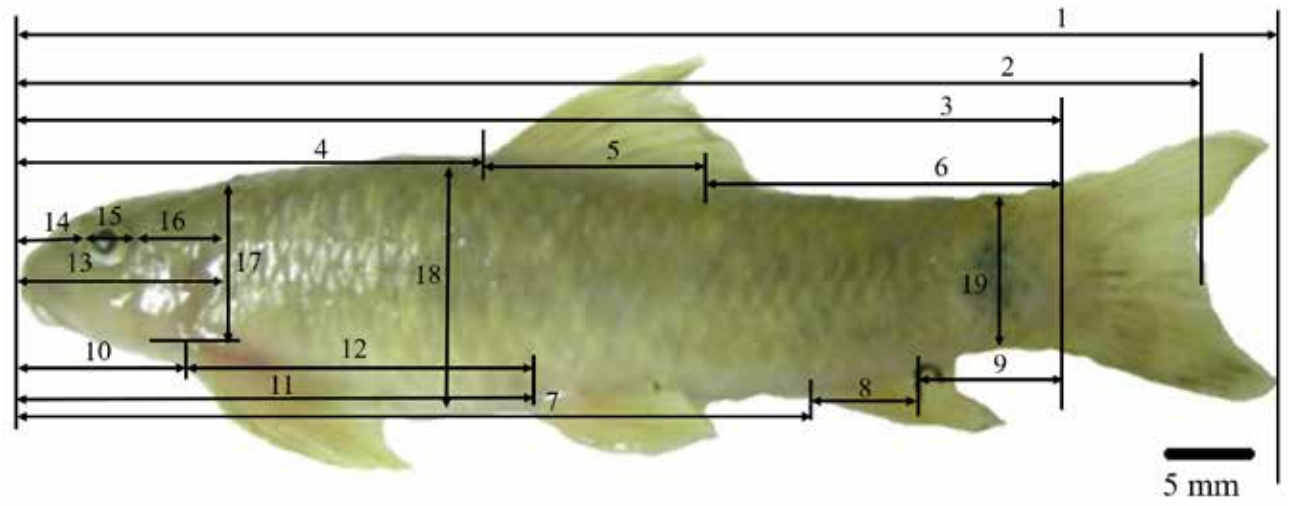

Figure 2. Morphometric measurements on *Garra rufa* body; 1: Total Length (TL); 2: Fork Length (FL); 3: Standard Length (SL); 4: Predorsal fin Length (PdL); 5: Dorsal fin Base Length (DfBL); 6: Post dorsal fin Length (PdL); 7: Preanal fin Length (PaL); 8: Anal fin Base Length (AfBL); 9: Caudal Peduncle Length (CPL); 10: Prepectoral fin Length (PpL); 11: Prepelvic fin Distance (PpD); 12: Pectoral-Pelvic fins Length (PVL); 13: Head Length (HL); 14: Snout Length (Snl); 15: Orbital (Eye) Diameter (OD); 16: Postorbital Length (PoL); 17: Head Depth at nape (HD); 18: Body Depth at dorsal fin origin (BD); 19: Caudal Peduncle Depth (CPD).

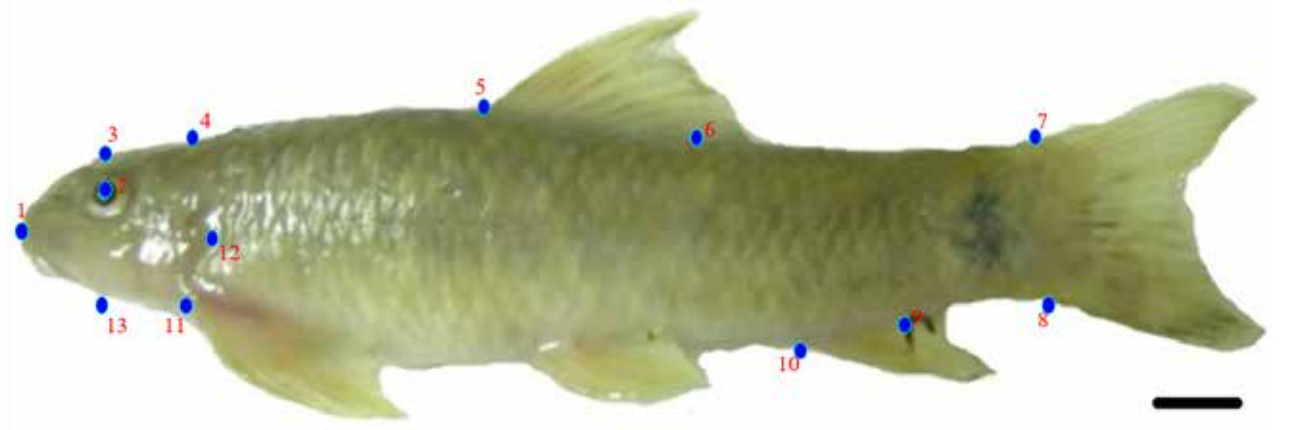

Figure 3. Selected landmark points' positions on the photos of the *Garra rufa* specimens, scale bar: 5 millimeters.

the contribution of the total variance of the data. Since the first three PCs encompass the largest portion of variability, the distribution of specimens on the grid, and the distribution of the portions of variability on them as well as the shape of deformation along the first three axes were analyzed. Deformation grids, on which the direction and amplitude of variability for every landmark points were denoted as a vector, were used to visualize the shape variability (Klingenberg, 2013). Canonical Variance Analysis (CVA) and Cluster Analysis (CA) were used to further quantify differences in shape (Bravi *et al*., 2013). Mahalanobis distance (Md) and Procrustes distance (Pd) were used to report the CVA results statistically. These Md and Pd measures are multivariate measurements of distance relative to the within-sample variation. All multivariate analyses were computed using PAST software (Hammer, 2012) and MorphoJ 1.01 (Klingenberg, 2011).

Results

The Classical Morphometric Method

Meristic Traits: After counting the meristic characters, the number of dorsal, anal, caudal-fin soft rays, and barbells were found to be fixed in all specimens (8, 5, 17, and 2, respectively); since predorsal scales have been embedded in the samples of some populations, statistical analysis was not performed on them. The results

of the Kolmogorov– Smirnov test showed that the number of lateral line scales (L.L), scales above L.L, scales bellow L.L to the ventral fin, scales bellow L.L to the anal-fin, predorsal scales, circumpeduncular scales, pectoral, and ventral-fin soft rays were nonparametric. The Kruskal–Wallis analysis results are presented in Table 1. According to Table 1, all studied populations have significant differences in meristic characters (p<0.001).

Morphometric Traits: The results of the Kolmogorov–Smirnov test showed that ten morphometric characters including standard length, post-dorsal fin length\SL, dorsal fin base length\SL, post-dorsal fin length\SL, preanal fin length\SL, anal fin base length\ SL, prepectoral fin length\SL, prepelvic fin distance\SL, pectoral-pelvic fins length\SL, head length\SL were parametric. Nine of these characters including total length, fork length, caudal peduncle length/SL, head depth at nape/SL, body depth at dorsal fin origin/SL, caudal peduncle depth/SL, snout length /HL, Orbital (Eye) diameter /HL, postorbital length /HL were nonparametric. The One Way ANOVA results for parametric distributed characters and the Kruskal–Wallis test for the non-parametric distributed characters showed that the morphometric characters were significantly different among the twelve studied populations of *G. rufa* samples (p<0.001) (Tables 2 and 3).

Geometric Morphometry

The first three PCs that were higher than the cut-off point of the Joliffe line (Joliffe, 2002) accounted for the majority of shape variations (65.52%): PC1 explained 37.94%, PC2 14.55%, PC2 13.03%, while each of the twenty-three remaining components explained less than 8% (Figure 4). The PCA scatter plot and deformation grids showed a high morphological variation in the populations (Figures 5 and 6). The main part of the body shape deformation is attributed to the landmark points of the head region (1, 3, 4, 11-13) and Dorsal-fin base (5, 6) (Figure 6). In order to assess intra-population differences in the body shape, CVA was performed on data of the *G. rufa* populations. The p-value of the permutation test in Canonical Variance Analysis (CVA) showed a significant difference (Wilks lambda = 0.0013, F = 3.93, $p < 0.001$) in the body shape among the populations. Based on the CVA scatter plot, the populations of the Changuleh, Mond, and Aghajari rivers were separated from other populations (Figure 7). The main part of the shape deformation was in the head region (1, 3, 4, 11-13) and dorsal-fin base (5, 6) (Figure 8). This analysis highlighted the significant differences among the populations; the highest values of Md (>4.00) and Pd were among Fahlian-Balladeh and Changuleh and Marun; Mond-Aghajari; Marun- Changuleh and Mond; Ramhormoz- Balladeh and Mond and Kheir Abad (Tables 4 and 5).

The cluster analysis (CA) of the different sampled populations showed at least two main groups, each of which has two sub-groups based on body shape (Figure 9). In the first group, the Ramhormuz population (from the Jarrahi- Zohreh Basin) was located in a separate sub-group, while the populations of Aghajari, Kheir Abad (from Jarrahi- Zohreh Basin), Konjancham, Changuleh (from the Tigris Basin), Ghara Aghaj, and Mond (from the Mond Basin) were in the same branch. As for the second group, the Fahlian population (from the Jarrahi- Zohreh Basin) was in a separate sub-group, while the populations of Kangir (from the Tigris Basin), Balladeh (from the Mond Basin), Marun, and Zohreh (from the Jarrahi- Zohreh Basin) were in the other branch of the second branch.

Discussion

In this study, three different methods, namely the meristic (countable), morphometric (measurable) and geometric (Landmarks-point based) methods were used to compare twelve populations of the red stone lapper, *Garra rufa* in the riverine waters of Iran. As mentioned before, the studied samples were captured from different waters flowing in the Tigris, Jarrahi, Zohreh and Mond basins. It is worth mentioning that all these rivers finally reach the Gulf.

Table 1. Meristic characters ranges, Minimum- Maximum (Mean ± SD) and Kruskal-Wallis test results for abnormal distributed characters of *Garra rufa* populations of Iran

	Aghajari	Balladeh	Changuleh	Fahlian	Ghara Aghaj	Kangir	Mond	Kheir Abad	Konjancham	Zohreh	Marun	Ramhormoz	p
1*	32-35 (33.3±0.9)	32.0-36.0 (34.2±0.9)	31.0-37.0 (34.1±1.4)	31.0-35.0 (33.3±1.2)	29.35 (32.4±1.5)	32.0-36.0 (34.3±11)	25.0-29.0 (27.5±1.3)	30.0-35.0 (32.7±1.2)	31.0-34.0 (32.4±0.9)	30.0-35.0 (33.3±1.1)	30.0-33.0 (31.8±1.0)	32.0-34.0 (33.2±0.7)	0.00
2	0.3-0.5 (3.7±0.6)	0.3-0.4 (3.6±0.5)	3.0-5.0 (3.9±0.3)	3.0-5.0 (3.05±0.8)	3.0-4.0 (3.3±0.5)	3.0-4.0 (3.8±0.4)	3.0-4.0 (3.0±2.0)	3.0-4.0 (3.4±0.5)	3.0-4.0 (3.3±0.5)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-4.0 (3.3±0.5)	0.00
3	0.3-0.4 (3.3±0.4)	3.0-4.0 (3.1±0.3)	3.0-4.0 (3.9±0.4)	3.0-3.0 (3.0±0.0)	2.0-4.0 (3.1±0.4)	3.0-3.0 (3.0±0.0)	2.0-3.0 (3.0±0.3)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	0.00
4	0.3-0.4 (3.2±0.4)	3.0-4.0 (3.3±0.5)	3.0-4.0 (3.5±0.5)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-4.0 (3.1±0.3)	2.0-3.0 (3.0±0.2)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	3.0-4.0 (3.2±0.4)	3.0-3.0 (3.0±0.0)	3.0-3.0 (3.0±0.0)	0.00
5	10.0-13.0 (11.9±0.8)	12.0-15.0 (13.9±0.7)	10.0-14.0 (11.9±0.8)	9.0-12.0 (10.5±1.1)	11.0-15.0 (12.7±0.8)	11.3-13.0 (12.1±0.6)	11.0-15.0 (12.8±1.1)	10.0-13.0 (11.6±0.7)	11.0-13.0 (11.9±0.7)	11.0-13.0 (11.9±0.8)	11.0-13.0 (12.3±0.8)	11.0-14.0 (11.8±1.1)	0.00
6	6.0-8.0 (7.7±0.6)	6.0-9.0 (8.3±0.7)	7.0-9.0 (7.8±0.4)	6.0-8.0 (7.2±0.7)	7.0-8.0 (7.8±0.4)	6.0-9.0 (7.5±0.8)	7.0-10.0 (8.2±0.9)	7.0-8.0 (7.4±0.5)	7.0-8.0 (7.8±0.4)	6.0-9.0 (7.3±0.8)	7.0-8.0 (7.8±0.4)	7.0-8.0 (7.8±0.4)	0.00
7	13-.016.0 (14.7-1.0)	13.0-16.0 (14.6±1.0)	11.0-15.0 (12.9±0.9)	13.0-15.0 (14.3±0.7)	12.0-16.0 (13.9±0.9)	13.0-17.0 (14.9±1.2)	11.0-15.0 (12.8±0.9)	10.0-15.0 (13.1±1.3)	11.0-14.0 (12.4±0.9)	11.0-16.0 (14.5±1.2)	11.0-15.0 (13.4±1.1)	14.0-17.0 (14.7±1.1)	0.00

* List of meristic character: 1) Lateral line scales, 2) scales above L.L, 3) scales bellow L.L to ventral fin, 4) scales bellow L.L to anal fin, 5) pectoral-fin soft rays, 6) ventral-fin soft rays, 7) circumpeduncular scales.

Table 2. Morphometric characters ranges, Minimum- Maximum (Mean ± SD), and One way ANOVA results for normal distributed characters of *Garra rufa* populations of Iran

	Aghajari	Balladeh	Changuleh	Fahlian	Ghara Aghaj	Kangir	Mond	Kheir Abad	Konjancham	Zohreh	Marun	Ramhormoz
1*	27.6-74.1 (47.3±11.5)^{cd}	38.3-79.6 (55.0±8.1)^{de}	26.1-58.4 (33.5±6.7)^{ab}	29.5-85.4 (51.7±22.3)^{cd}	32.9-90.7 (47.1±16.0)^{cd}	33.9-70.8 (57.0±10.5)^{de}	16.5-35.6 (27.7±4.7)^{a}	23.5-78.5 (46.2±13.6)^{cd}	30.1-84.7 (40.6±13.7)^{bc}	28.8-113.4 (68.2±25.4)^{f}	35.4-102.5 (62.3±24.1)^{ef}	24.6-33.6 (30.5±3.2)^{fe}
2	0.4-0.5 (0.5±0.0)^{d}	0.4-0.5 (0.5±0.0)^{a}	0.5-0.6 (0.5±0.0)^{c}	0.4-0.6 (0.5±0.1)^{c}	0.5-0.6 (0.5±0.0)^{bc}	0.4-0.5 (0.5±0.0)^{a}	0.5-0.6 (0.5±0.0)^{c}	0.4-0.5 (0.5±0.0)^{ab}	0.4-0.5 (0.5±0.0)^{bc}	04-0.9 (0.5±0.1)^{a}	0.4-0.5 (0.5±0.0)^{a}	0.5-0.5 (0.5±0.0)^{c}
3	0.2-0.2 (0.2±0.0)^{c}	0.1-0.2 (0.2±0.0)^{bc}	0.2-0.2 (0.2±0.0)^{c}	0.2-0.2 (0.2±0.0)^{bc}	0.1-0.2 (0.2±0.0)^{a}	0.1-0.2 (0.2±0.0)^{a}	0.1-0.2 (0.2±0.2)^{a}	0.1-0.2 (0.2±0.0)^{a}	0.1-0.2 (0.2±0.0)^{ab}	0.1-0.4 (0.2±0.1)^{bc}	0.2-0.2 (0.2±0.0)^{c}	0.1-0.2 (0.2±0.0)^{ab}
4	0.3-0.4 (0.3±0.0)^{cde}	0.3-0.4 (0.3±0.0)^{cde}	0.2-0.3 (0.3±0.0)^{ab}	0.3-0.4 (0.3±0.0)^{cde}	0.2-0.4 (0.3±0.0)^{cde}	0.3-0.4 (0.3±0.0)^{e}	0.2-0.4 (0.3±0.0)^{bcd}	0.3-0.4 (0.3±0.0)^{de}	0.3-0.4 (0.3±0.0)^{abc}	0.1-0.4 (0.3±0.1)^{cde}	0.3-0.4 (0.3±0.0)^{bc}	0.2-0.3 (0.3±0.0)^{a}
5	0.8-0.9 (0.8±0.0)^{bc}	0.8-0.9 (0.8±0.0)^{ab}	0.8-0.9 (0.8±0.0)^{c}	0.7-0.9 (0.8±0.0)^{a}	0.8-0.9 (0.8±0.0)^{c}	0.7-0.8 (0.8±0.0)^{a}	0.7-0.9 (0.8±0.0)^{abc}	0.8-0.9 (0.8±0.0)^{c}	0.8-0.9 (0.8±0.0)^{c}	0.3-0.9 (0.8±0.1)^{abc}	0.8-0.8 (0.8±0.0)^{abc}	0.8-0.8 (0.8±0.0)^{bc}
6	0.1-0.0 (0.1±0.0)^{ab}	0.1-0.1 (0.1±0.0)^{abcd}	0.1-0.1 (0.1±0.0)^{a}	0.1-0.1 (0.1±0.0)^{d}	0.1-0.1 (0.1±0.0)^{a}	0.1-0.1 (0.1±0.0)^{a}	0.1-0.1 (0.1±0.0)^{cd}	0.1-0.1 (0.1±0.0)^{ab}	0.1-0.1 (0.1±0.0)^{abc}	0.1-0.7 (0.1±0.1)^{bcd}	0.1-0.1 (0.1±0.0)^{d}	0.1-0.1 (0.1±0.0)^{abcd}
7	0.1-0.3 (0.2±0.0)^{ab}	0.2-0.3 (0.2±0.0)^{ab}	0.2-0.3 (0.3±0.0)^{c}	0.2-0.3 (0.2±0.0)^{b}	0.2-0.3 (0.3±0.0)^{c}	0.1-0.3 (0.2±0.0)^{a}	0.2-0.3 (0.3±0.0)^{c}	0.-0.3 (0.2±0.0)^{b}	0.2-0.3 (0.2±0.0)^{b}	0.1-0.3 (0.2±0.0)^{b}	0.1-0.3 (0.2±0.0)^{ab}	0.2-0.3 (0.3±0.0)^{c}
8	0.5-0.6 (0.6±0.0)^{defg}	0.5-0.6 (0.6±0.0)^{abc}	0.5-0.6 (0.6±0.0)^{defg}	0.4-0.6 (0.5±0.1)^{a}	0.5-0.7 (0.6±0.0)^{g}	0.5-0.6 (0.5±0.0)^{ab}	0.5-0.7 (0.6±0.0)^{efg}	0.5-0.6 (0.6±0.0)^{defg}	0.5-0.6 (0.6±0.0)^{cdef}	0.2-0.6 (0.5±0.1)^{bcd}	0.5-0.6 (0.6±0.0)^{cde}	0.6-0.7 (0.6±0.0)^{g}
9	0.1-0.4 (0.4±0.1)^{b}	0.3-0.4 (0.3±0.0)^{b}	0.3-0.8 (0.3±0.1)^{b}	0.2-0.4 (0.3±0.1)^{a}	0.3-0.4 (0.3±0.0)^{b}	0.3-0.4 (0.3±0.0)^{b}	0.2-0.4 (0.3±0.0)^{b}	0.3-0.5 (0.4±0.0)^{b}	0.3-0.4 (0.3±0.0)^{b}	0.3-0.5 (0.3±0.1)^{b}	0.3-0.4 (0.4±0.0)^{b}	0.3-0.4 (0.3±0.0)^{b}
10	0.2-0.3 (0.2±0.0)^{abcd}	0.2-0.3 (0.2±0.0)^{abc}	0.3-0.3 (0.3±0.0)^{g}	0.2-0.3 (0.3±0.0)^{cdef}	0.2-0.3 (0.3±0.0)^{defg}	0.1-0.3 (0.2±0.0)^{a}	0.2-0.3 (0.3±0.0)^{fg}	0.2-0.3 (0.3±0.0)^{bcde}	0.2-0.3 (0.2±0.0)^{bcd}	0.2-0.3 (0.2±0.0)^{abcd}	0.1-0.3 (0.2±0.0)^{ab}	0.3-0.3 (0.3±0.0)^{efg}

* List of morphometric characters: 1) SL, 2) Pdl\SL, 3) DfBL\SL, 4) PdL\SL, 5) PaL\SL, 6) AfBL\SL, 7) PpL\SL, 8) PpD\SL, 9) PVDL\SL, 10) HL\SL; a, b, c, d, e, f, g: Duncan results.

Table 3. Morphometric characters ranges, Minimum- Maximum (Mean ± SD), and Kruskal-Wallis test results for non-parametric distributed characters of *Garra rufa* populations of Iran.

	Aghajari	Balladeh	Changuleh	Fahlian	Ghara Aghaj	Kangir	Mond	Kheir Abad	Konjancham	Zohreh	Marun	Ramhormoz	p
1*	34.9-94.1 (60.2±14.7)	45.2-95.0 (66.6±10.0)	25.3-76.3 (43.9±9.1)	38.5-107.5 (65.6±26.9)	39.5-112.7 (57.3±19.6)	41.4-85.4 (67.8±12.2)	20.3-45.0 (35.3±5.9)	30.5-96.9 (58.0±16.7)	36.8-109.5 (50.5±18.0)	38.4-135.0 (84.5±29.8)	45.1-123.5 (78.0±27.9)	32.0-43.2 (38.6±4.0)	0.00
2	31.8-87.9 (54.8±13.7)	42.3-90.1 (61.4±9.5)	24.9-67.7 (39.4±8.1)	35.0-98.0 (59.7±25.0)	37.3-104.1 (53.3±18.1)	39.0-78.5 (63.2±11.4)	18.9-40.4 (32.2±5.2)	27.5-88.5 (53.0±15.1)	33.3-98.1 (45.9±16.1)	34.3-127.4 (77.2±28.2)	42.0-113.6 (71.1±25.7)	29.0-39.0 (35.2±3.5)	0.00
3	0.1-0.1 (0.1±0.0)	0.1-0.3 (0.1±0.1)	0.1-0.1 (0.1±0.0)	0.1-0.2 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.00
4	0.1-0.2 (0.2±0.0)	0.0-0.1 (0.1±0.0)	0.2-0.2 (0.2±0.0)	0.2-0.2 (0.2±0.0)	0.1-0.1 (0.1±0.0)	0.2-0.2 (0.2±0.0)	0.1-0.2 (0.2±0.0)	0.2-0.2 (0.2±0.0)	0.2-0.2 (0.2±0.0)	0.1-0.2 (0.2±0.0)	0.2-0.2 (0.2±0.0)	0.2-0.2 (0.2±0.0)	0.00
5	0.2-0.3 (0.3±0.0)	0.0-0.1 (0.1±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.3±0.0)	0.0-0.1 (0.1±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.3±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.3±0.0)	0.2-0.3 (0.3±0.0)	0.00
6	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.2 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.2 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.1-0.2 (0.1±0.0)	0.1-0.2 (0.1±0.0)	0.1-0.1 (0.1±0.0)	0.00
7	0.3-0.4 (0.4±0.0)	0.6-1.0 (0.7±0.1)	0.3-0.5 (0.4±0.0)	0.2-0.4 (0.3±0.0)	0.5-0.7 (0.6±0.1)	0.3-0.4 (0.3±0.0)	0.3-0.4 (0.3±0.0)	0.3-0.7 (0.4±0.1)	0.3-0.4 (0.4±0.0)	0.3-0.9 (0.4±0.1)	0.3-0.4 (0.4±0.0)	0.3-0.4 (0.4±0.0)	0.00
8	0.3-0.4 (0.3±0.0)	0.9-1.7 (1.1±0.2)	0.2-0.3 (0.3±0.3)	0.2-0.3 (0.3±0.0)	0.7-1.2 (0.9±0.2)	0.2-0.3 (0.3±0.0)	0.2-0.3 (0.3±0.0)	0.2-0.3 (0.3±0.0)	0.3-0.4 (0.3±0.0)	0.2-0.3 (0.2±0.0)	0.2-0.3 (0.3±0.0)	0.3-0.4 (0.4±0.0)	0.00
9	0.3-0.4 (0.4±0.0)	0.5-0.8 (0.6±0.1)	0.3-0.5 (0.4±0.0)	0.4-0.5 (0.4±0.0)	0.4-0.7 (0.5±0.1)	0.4-0.5 (0.4±0.1)	0.4-0.5 (0.4±0.0)	0.3-0.4 (0.4±0.0)	0.3-0.4 (0.4±0.0)	0.2-0.4 (0.4±0.1)	0.3-0.7 (0.4±0.1)	0.4-0.4 (0.4±0.0)	0.00

* List of morphometric characters: 1) TL, 2) FL, 3) CPL, 4) HD, 5) BD, 6) CPD, 7) SnL, 8) OD, 9) PoL.

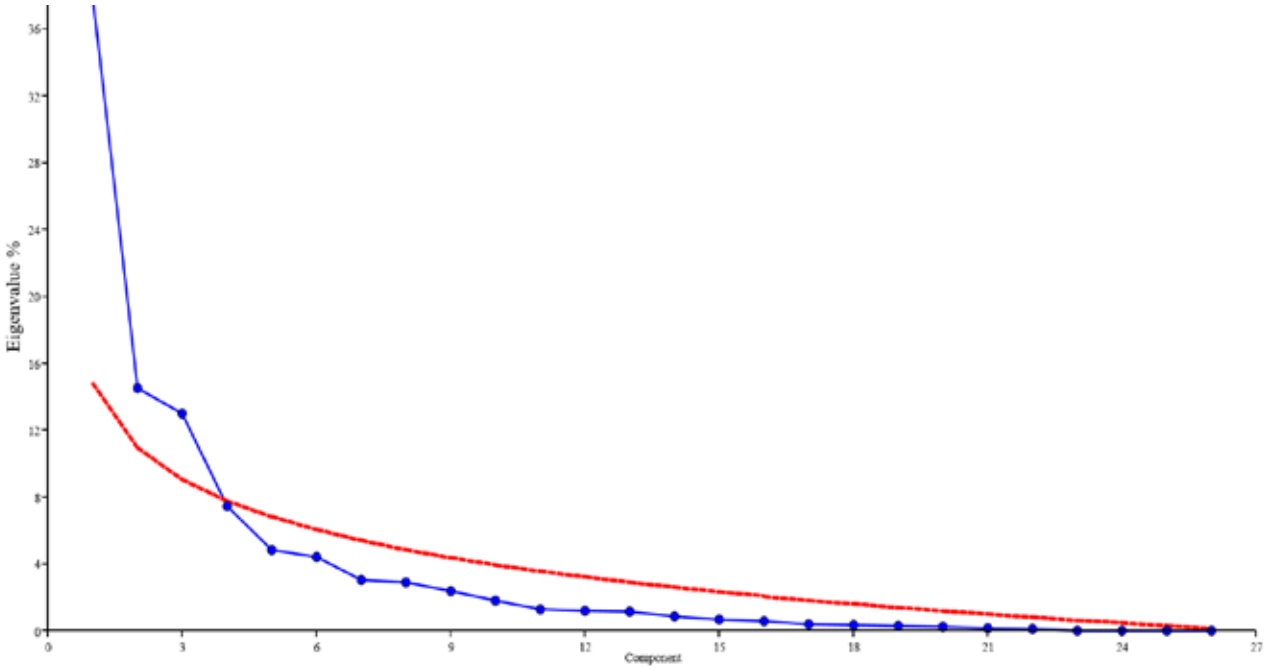

Figure 4. The plot of the Joliffe cut-off point in PCA of *Garra rufa* populations of Iran.

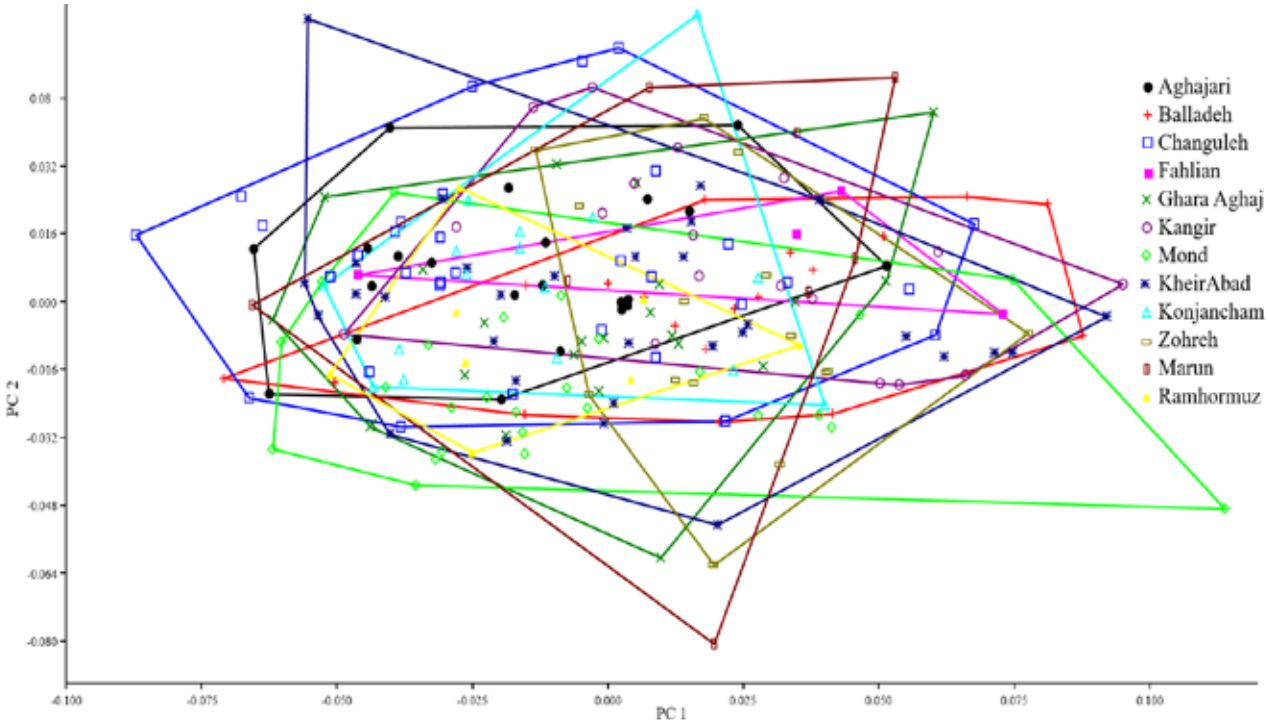

Figure 5. The scatter plot of Joliffe cut-off point in Principal Components Analysis of *Garra rufa* populations of Iran.

Despite the impressive development and progress made in new sciences such as genetics, the use of measurable and countable characters (morphometric and meristic) plays an important role in the study of fish species identification (Nelson *et al*., 2016) and new species introductions (Strauss and Bond, 1990).

In regards to the meristic characters, four were fixed in all of the specimens and these include the number of branched dorsal-fin rays (it was 8 in all specimens), branched anal-fin ray count (5 in all specimens), branched caudal-fin rays (17 in all specimens), and barbells (2 in all specimens). Such characters are keys to the identification and distinction of *G. rufa* from some other species of the genus *Garra* which exist in the Middle

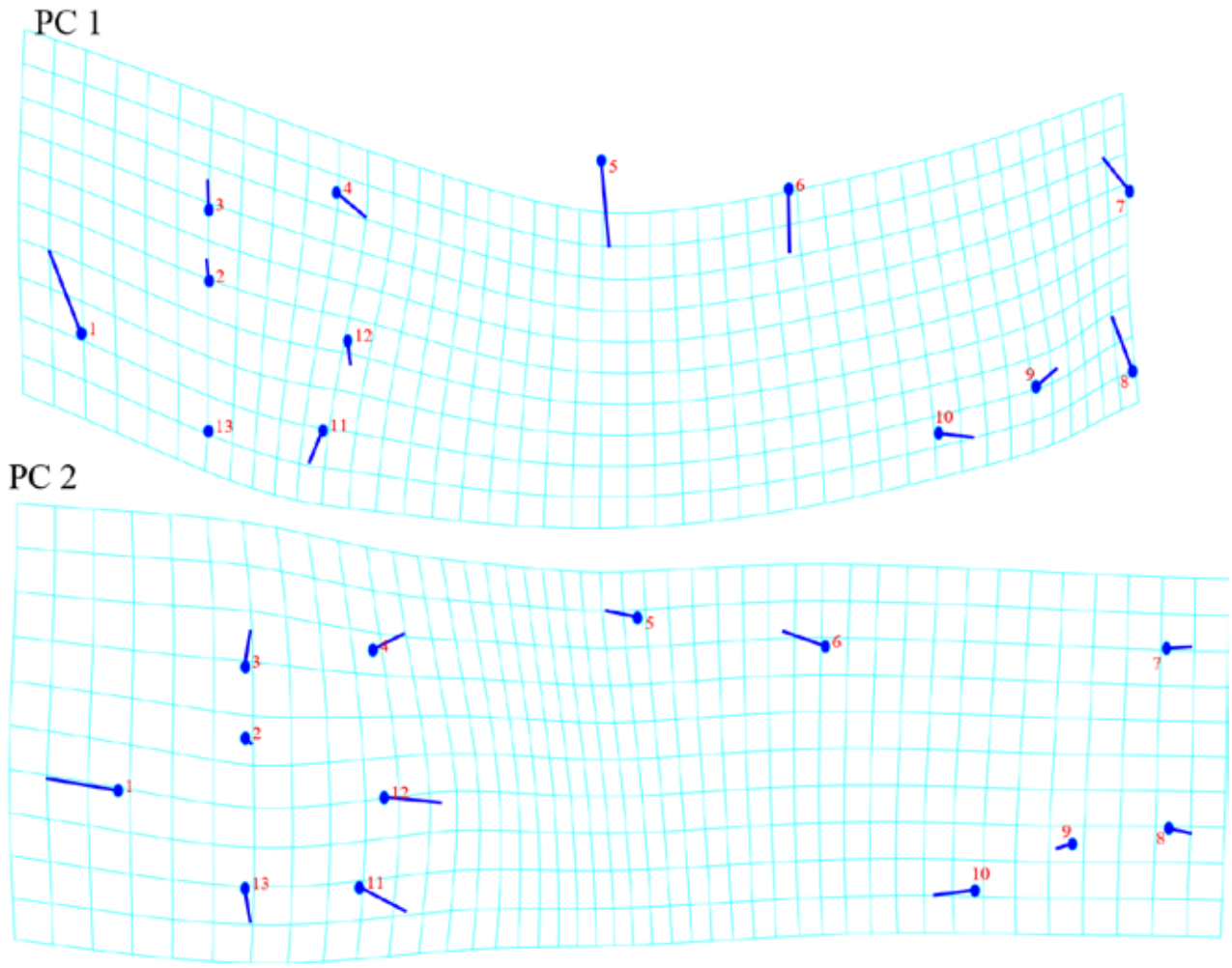

Figure 6. The body shape variation in the *Garra rufa* populations. Deformation grids are associated with the most positive values of the first two factors (PC1 and PC2) obtained by performing the ordination analysis of the Principal Components (PC).

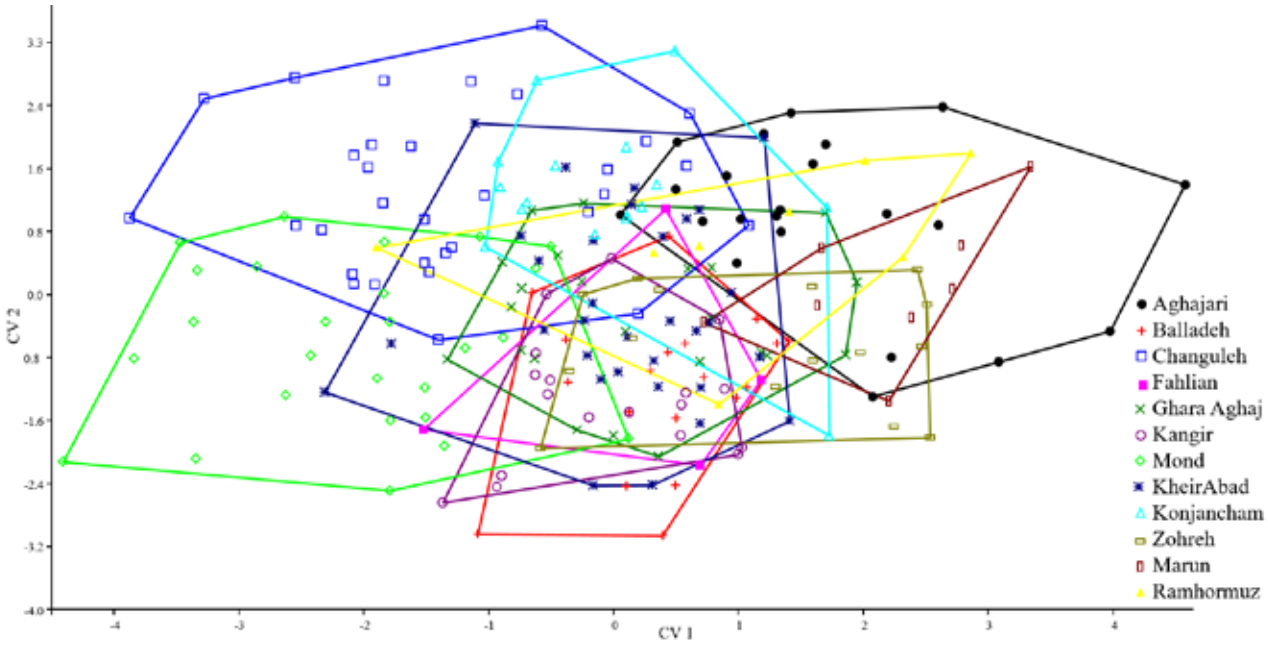

Figure 7. Graph of Canonical Variance Analysis results of body shape of *Garra rufa* populations of Iran.

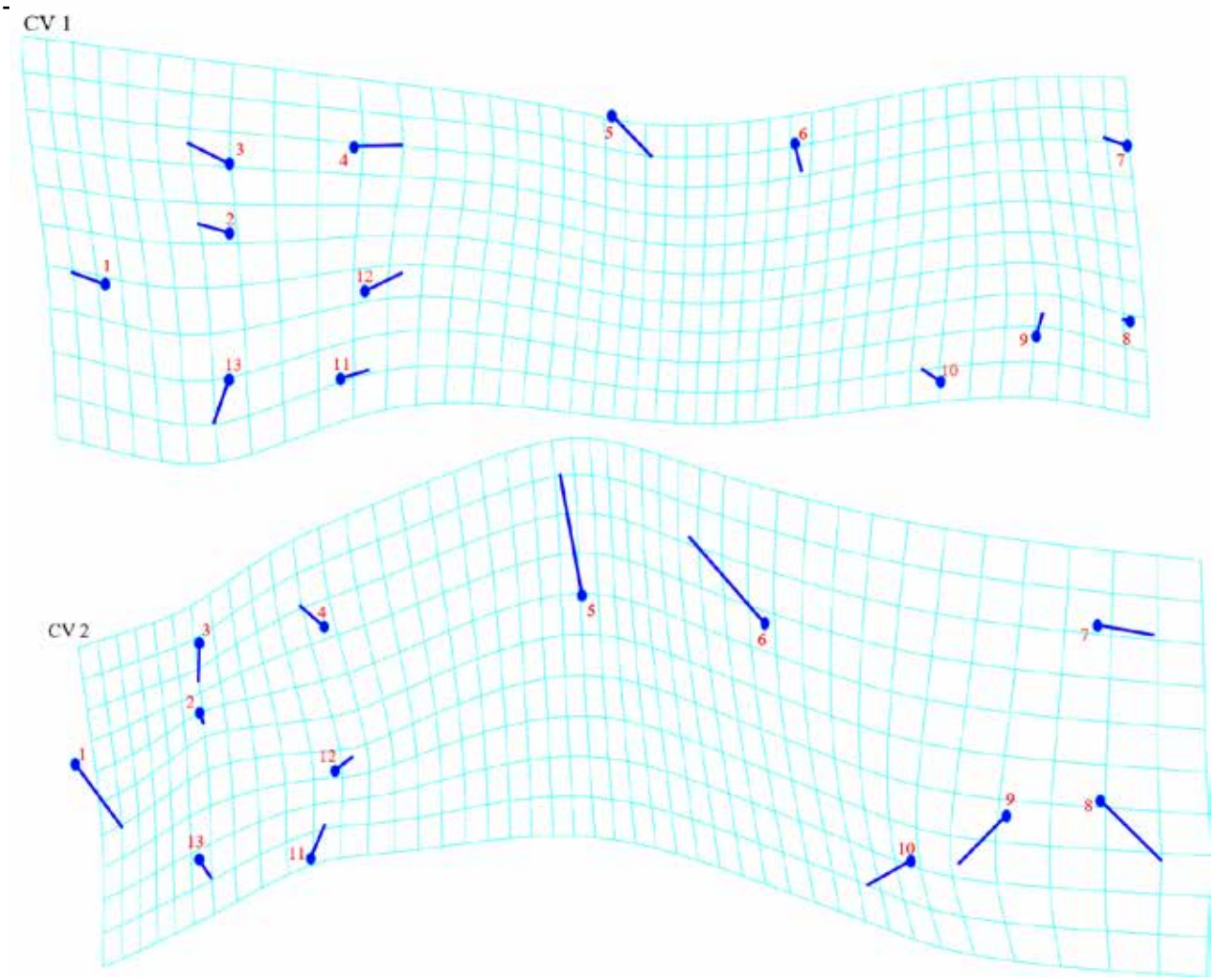

Figure 8. The body shape variation in all samples of *Garra rufa.* Deformation grids are associated with the most positive values of the first two factors (CV1 and CV2) obtained by performing the ordination analysis of the Canonical Variance (CV).

Table 4. Mahalanobis distance results of *Garra rufa* populations

		1	2	3	4	5	6	7	8	9	10	11
1	Aghajari											
2	Balladeh	3.04										
3	Changuleh	3.52	3.53									
4	Fahlian	3.92	4.28	4.30								
5	Ghara Aghaj	3.04	3.20	2.96	3.41							
6	Kangir	3.53	3.29	3.41	3.58	2.52						
7	Mond	4.27	3.59	2.97	3.78	3.58	3.49					
8	Kheir Abad	2.63	2.72	2.53	3.53	2.19	1.92	3.10				
9	Konjancham	2.47	3.11	2.02	4.00	2.92	3.20	3.25	2.16			
10	Zohreh	2.82	2.50	3.64	3.55	3.18	3.02	3.74	2.59	2.73		
11	Marun	2.46	3.65	4.22	4.35	3.82	4.01	4.75	3.45	3.50	2.53	
12	Ramhormoz	3.57	4.20	3.99	3.78	3.63	4.43	4.46	3.63	3.75	3.33	3.72

Table 5. Procrustes distance results of *Garra rufa* populations of Iran.

		1	2	3	4	5	6	7	8	9	10	11
1	Aghajari											
2	Balladeh	0.044										
3	Changuleh	0.036	0.046									
4	Fahlian	0.056	0.040	0.048								
5	Ghara Aghaj	0.034	0.038	0.027	0.042							
6	Kangir	0.045	0.033	0.051	0.039	0.039						
7	Mond	0.042	0.040	0.035	0.051	0.028	0.050					
8	KhairAbad	0.027	0.028	0.034	0.044	0.022	0.027	0.032				
9	Konjancham	0.021	0.038	0.021	0.049	0.026	0.043	0.032	0.023			
10	Zohreh	0.044	0.017	0.050	0.038	0.039	0.031	0.041	0.029	0.040		
11	Marun	0.037	0.027	0.045	0.037	0.039	0.032	0.045	0.031	0.037	0.023	
12	Ramhormoz	0.043	0.060	0.031	0.051	0.029	0.061	0.035	0.041	0.036	0.051	0.051

Eastern region, especially in Iranian waters (Esmaeili *et al*., 2016; Zamani- Faradonbe and Keivany., 2020).

Other meristic characters, namely the lateral line (L.L) scales, scales above L.L, scales bellow L.L to the ventral fin, scales bellow L.L to the anal fin, pectoral fin, ventral-fin soft rays, and the circumpeduncular scales were significantly different among the studied populations. This diversity in the meristic traits probably reflects the genetic diversity and also the different conditions of the habitats (Esmaeili *et al*., 2016; Keivany *et al*., 2016b).

The results of the comparison of the morphometric characters showed that there was some diversity in the body shape of the *G. rufa* populations. The sampling was carried out across a large area from the west to the south, and there could be different habitats with different conditions (Keivany *et al*., 2016b) affecting the body shape of fishes.

Ghalenoei *et al.* (2010) studied thirteen populations of *G. rufa* from Gamasiab, Dez, Karun, Kol, Khoramrud, Dalaki, Mond, Zohreh, Jarrahi, and Kashkan in Iran. Their results showed that the Mond river population was separated from the others, but other populations overlapped with each other in terms of the studied characteristics (p<0.05). Aquatic environmental factors such as water temperature and water velocity play important roles in changing body shape characters including morphometric traits which are so sensitive to environmental changes. Fishes can quickly adapt themselves to new conditions (Brraich and Akhter, 2015), and the genetic structure of fish mostly controls the meristic characters (Brraich and Akhter, 2015). Also, the morphology of fish can affect some important biological and physiological attributes in them including reproductivity, swimming performance, maneuvering ability, feeding, and avoidance from the hunter (Sfakiotakis *et al*., 1998).

Due to allometric growth patterns in the first stages of life history, morphological measurements change throughout that period (Elliott *et al*., 1995), but meristic characters do not in relation to the size of fish (Helfman *et al*., 2009), so before using the morphometric characters in the analysis, it is important to remove the size effects from them. In this study, the ratio method followed by Cicek *et al*. (2016) has been used; in this method the morphometric characters in the head area were modified as the ratio of head length and the morphometric characters in the body area were modified as the ratio of standard length.

The geometric morphometric results of this study showed significant shape differences among the populations of *G. ruffa*. In the deformation grid, the most differences

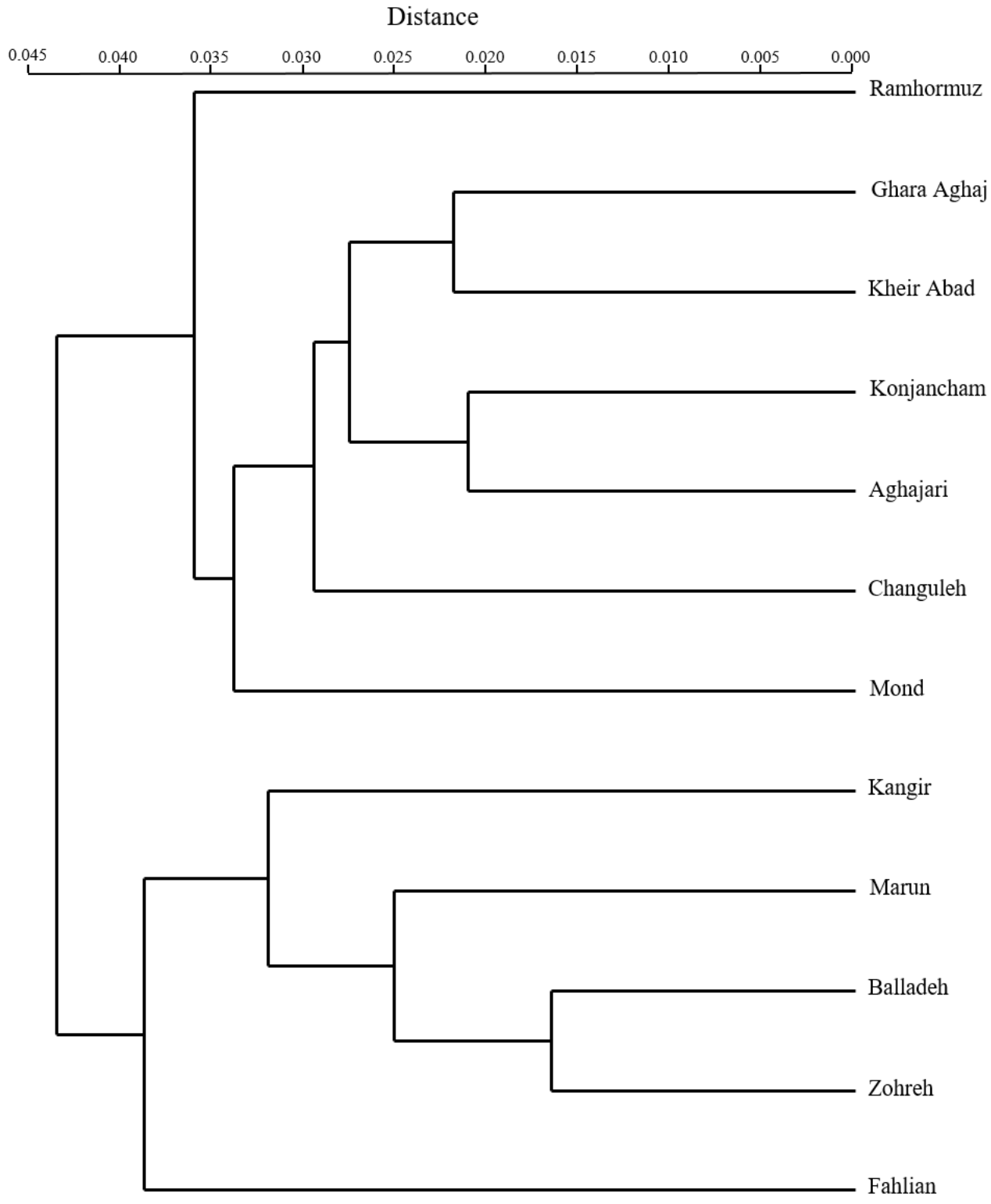

Figure 9. Dendrogram of Cluster analysis of the studied populations of *Garra rufa*

were in the head height and length, dorsal-fin position, and body depth. The morphological variations observed among the populations might have been influenced by the genetic makeup of the specimens as Anvarifar *et al*. (2012) found a relationship between RAPD genetic markers and morphology in *Capoeta gracilis* in Tajan River. This could be a reflection of the adaptation strategies that fish populations have against a mixture of environmental factors (chemical, physical, and biological factors). Chemical factors

include salinity and dissolved oxygen, and physical factors include temperature, radiation, water depth, and the current flow influence. Biological factors include food availability, the feeding mode, and habitat use (Spoljaric and Reimchen, 2011; Antonucci *et al*., 2012; Bravi *et al*., 2013).

The studied populations by Ghalenoei *et al.* (2010), Keivany *et al.* (2015), Cicek *et al.* (2016), Esmaeili *et al*. (2016 b), and this study showed that *G. rufa* has a vast habitat extending from at least the west to the east of Iran. Karahan (2007) and Çiçek (2009) suggested that the variations in the locations of *G. rufa* are quite high, and that there are many differences between them in terms of morphometric and meristic characteristics.

One of the important habitat factors is food availability which can affect fish morphology particularly feeding-related characters such as the head shape (Nicieza, 1995). Functional relationships which have been proven between morphology and the main ecological dimension are between the type of food (vegetable versus animal) and gut length which is different between herbivores and carnivores (Sturmbauer *et al*., 1992) and between prey size and mouth gape (Wainwright and Richard, 1995) which could finally affect the size of the head.

In lentic to low-velocity waters, deeper body is useful for rapid turning and maneuvering (Moyle and Cech, 2004); based on the body shape shown in the deformation grids, this kind of body shape can be seen in the population in which the dorsal-fin landmarks are upper than the consensus position such as Fahlian, Zohreh, Balladeh, Marun, and Kangir. In lotic and fast-flowing waters, the streamlined body shape would be useful; the population with this body shape, such as changuleh, can decrease being dragged in the water currents and hence reduces energy consumption to keep the position (Keast and Webb, 1966; Webb, 1984). Also, the fusiform body shape is advantageous in water currents for constantly moving and searching out prey (Keast and Webb, 1966; Webb, 1984).

Zamani-Faradonbe *et al*. (2015a) showed *Capoeta gracilis* specimens with a smaller head, longer caudal peduncle and relatively deeper body living in fast-flowing water and lower depth, substrate index, Periphyton Cover Index (PeCl) and Potamal Cover Index (PoCL). They also increase in the depth and width of the river along with the increasing PeCI, PoCI; larger bed stones induce a larger head and shorter and deeper caudal peduncle forming a relatively deeper body shape.

The results of the relationship between habitat factors and body shape of Kura barbel (*Barbus cyri*) suggested depth, width, the average diameter of stream bed as effective factors. Also, the results of 2B-PLS revealed that individuals with a deeper body, large head, and deep caudal peduncle are significantly related to more depth, lower velocity, lower width, and to river beds with a bigger number of large stones; whereas individuals with a fusiform body shape, that is a lower depth, smaller head, deeper caudal peduncle, have a significant relationship with higher velocity, more depth, greater width and river beds with smaller stones (Zamani-Faradonbe *et al*., 2015b).

The results of the present study showed significant body-shape differences among the populations of the species, *Garra rufa*, in Iranian inland waters; such information can be useful for further fisheries and stock managements or conservation programs in the region.

Acknowledgement

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Short Communication

The First Record of *Hottentotta jayakari* (Pocock, 1895) from Qatar

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Abstract: The present note provides the first record of *Hottentotta jayakari* (Pocock, 1895) from Qatar.

Keywords: Qatar, *Hottentotta jayakari,* Scorpions.

The scorpion fauna of Qatar remains very little known with no actual records. El-Hennawy (1992) listed eight species of scorpions from Qatar (*Androctonus crassicauda* (Olivier, 1807)*, Apistobuthus pterygocercus* Finnegan, 1932, *Buthacus leptochelys* (Ehrenberg, 1829), *Buthacus tadmorensis nigroaculeatus* Levy, *et al.,* 1973 (= *Buthacus macrocentrus* (Ehrenberg, 1828))*, Compsobuthus arabicus* Levy, *et al*., 1973, *Leiurus quinquestriatus* (Hemprich and Ehrenberg, 1829) (=*Leiurus arabicus* Lowe, *et al.,* 2014), *Orthochirus innesi* Simon, 1910, and *Scorpio kruglovi* (Birula,1910)), all representing extralimital distribution based on the maps proposed by Kinzelbach (1985). On 21.9.2020, a 7cm specimen of *Hottentotta jayakari* was found near Mehairja, Doha (25.316 N, 51.381 E) and was photographed while alive (Figure 1). The area is under development with gravel, rocks substratum, and few scattered vegetation. This record represents the first of *H. jayakari* for the State of Qatar.

Hottentotta jayakari (Pocock, 1895) has a wide range of distribution extending across the Arabian Peninsula, covering Oman (Kovařík, 2007), Saudi Arabia (Hendrixson, 2006; Al-Asmari, *et al*., 2013), The United Arab Emirates (Feulner, 1998; Hendrixson, 2006), and Yemen (Al-Safadi, 1992; Hendrixson, 2006), in addition to Iraq (Lourenço and Qi, 2007) and Iran (Navidpour, 2012). Mohedano *et al*. (2014) and Abu Baker and Yamaguchi (2017) recovered undetermined scorpion remains from pellets of Pharaoh Eagle Owl, *Bubo ascalaphus and the* Little Owl *Athene noctua* from Qatar. The epidemiology of scorpion stings was investigated in Qatar, and a total of 111 cases of scorpion stings were reviewed during 2010-2013 (Alkahlout, *et al*., 2015). This implies the presence of scorpions of medical importance. Ward *et al*. (2018) considered *H. jayakari* as a scorpion of medical significance. Further collection of scorpions from Qatar is needed to fill the gap in knowledge regarding this group.

Figure 1. *Hottentotta jayakari* (Pocock, 1895) from Qatar.

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Wolfgang Schneider (1953-2019)

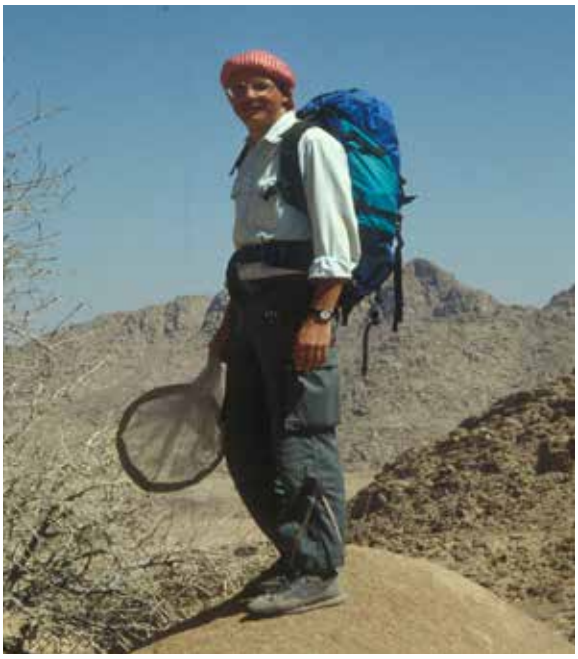
Photo of Wolgang while in Jordan in 1980 after a snow storm near his house in Fuhais (Photo by F. Krupp).

In 1979, when I was a research assistant at the Department of Biology, the University of Jordan, I was approached by a tall, blond and thin young man. He was frustrated by a meeting with the head of the department, where he had requested help to visit sites to collect dragonflies.

I immediately offered him my help and we arranged for a field trip the next day. We drove to the Jordan valley with his orange Volkswagen. This how I met Wolfgang Schneider. Wolfgang was an inspiration for me at that time to discover the natural history of Jordan. Years passed, but we kept good contact together along with his friend Friedhelm Krupp over the past forty years through mutual visits to Germany and Jordan, both at the scientific and personal levels.

Wolfgang as we use to call him in Arabic "*Deeb*" for "Wolf" in English was a genuine friend and big hearted. He is always willing to help whenever I asked for materials that I was unable to locate in Jordan.

Wolfgang Schneider was born in 10th of August 1953 at Bad Kreuznach, Germany and passed away on 17th of September 2019 at the age of 66. During his career, he visited the Middle East many times between 1978 and 2016 to collect dragonflies from Jordan, Syria, Lebanon and various countries of the Arabian Peninsula. His doctoral thesis is a landmark for entomologists in the Middle East and elsewhere with high quality illustrations. After he earned his doctoral



Wolfgang Schneider during a field trip in Saudi Arabia (Photo by F. Krupp).

degree, he held several positions; Officer at the Fishery Resources at the Food and Agriculture Organization (FAO), Rome, Italy from 1988-1991, head of the Zoology Department, Hessisches Landesmuseum Darmstadt, Germany 1993-2008. He served as the president of the Worldwide Dragonfly Association in 2009-2011, member of the 'IUCN – Dragonfly Specialist Group' from 2007 until his death.

He joined and headed several zoological expeditions to Oman, Saudi Arabia and Yemen. He also was a member of several professional societies and served as an editor and/or editorial board member of several scientific journals (Odonatologica, International Journal of Odonatology, Zoology in the Middle East, Fauna of Arabia, among others). His scientific career yielded over 90 scientific publications.

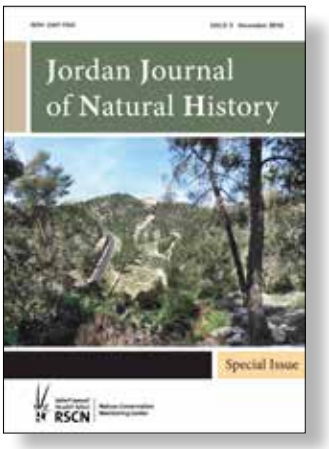
In 2007, Wolfgang's health deteriorated after a severe heart attack that prevented him from continuing to serve as a museum scientist and administrator, and he had to opt of early retirement. Wolfgang is missed and remembered by all his colleagues and friends in the Middle East.

Zuhair S. Amr

Jordan Journal of Natural History

2014

2015



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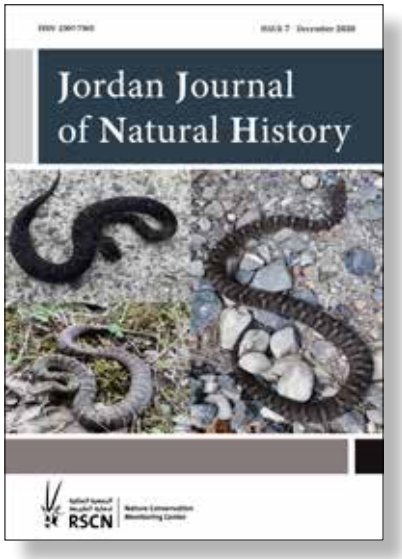

2020

The Royal Society for the Conservation of Nature

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

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