

Article

Diversity and Conservation of Bats in Saudi Arabia

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Abstract: The bats of Saudi Arabia consist of 30 species and 21 genera within 9 families (Pteropodidae, Rhinopomatidae, Rhinolophidae, Emballonuridae, Nycteridae, Hipposideridae, Miniopteridae, Molossidae, and Vespertilionidae). Some species have been recorded from only one locality: *Epomophorus labiatus*, *Hipposideros megalotis* and *Asellia patrizii*. The taxonomy of some species was updated. Details on the past and present distribution of the bats were included along with available data on their habitat preference and biology. An analysis of the bat fauna of Saudi Arabia revealed that they have six major zoogeographical affinities; Afrotropical (eight species), Saharo-Sindian (three species), Afrotropical-Palaearctic (four species), Palaearctic (four species), oriental (one species), and Afrotropical-oriental (two species). *Asellia patrizii* stands as an endemic species known only from Eritrea, Ethiopia, and Farasan Island in Saudi Arabia, and *Rhyneptesicus nasutus* is considered as a Middle East endemic species with distribution confined to Iraq, Iran, and Afghanistan, reaching as far as western Arabia. At least six more species are suspected to occur in Saudi Arabia, since they have been reported from neighboring Yemen. The threats to and conservation status of the bats of Saudi Arabia were highlighted.

Keywords: Chiroptera; Saudi Arabia; distribution; threats; conservation



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1. Introduction

Over the past century, several studies investigated the bats of Saudi Arabia, since the early 1920s up 1990s [1–24]. Most of the comprehensive studies on the bats of Saudi Arabia were published by Iyad Nader [6,9,24]. Other papers included records for single species; *Chaerephon nigeriae* [8], *Eidolon helvum* [13], *Plecotus christii* [18], *Hipposideros megalotis* [19], *Asellia patrizii* [20], *Epomophorus labiatus* [21], and *Scotophilus leucogaster* [22]. By the year 2000, a list that included 29 species was published [24], and the timing and pattern of molt in *Pipistrellus kuhlii* were studied in Saudi Arabia [25]. Since then, the bats of Tabuk Province were studied with 10 recorded species, including a new record for *Barbastella leucomelas* [26], and additional record of *Mops midas* [27]. Little has been done to update the bat fauna, and no information is available on the threats to and conservation status of the bats of Saudi Arabia.

In the surrounding countries, 19, 26, 4, 3, 3, 9, 17, and 31 bat species have been recorded from Iraq, Jordan, Bahrain, Kuwait, Qatar, United Arab Emirates, Oman, and Yemen, respectively [28–35].

In this paper, we updated the taxonomy and distributional data for 30 bat species based on previous records and the recent results of field work, addressed their zoogeographical affinities, and identified threats as well as the conservation measures that should be considered to protect the bats of Saudi Arabia.

Biogeographical Setting of Saudi Arabia

Saudi Arabia is a vast country occupying 2,000,000 km² with diverse habitats that range from extreme arid and basalt deserts to mountain ranges and highlands, sand and sandstone deserts, marine and freshwater ecosystems, and numerous wadi systems and oases (Figures 1–3).



Figure 1. Map of Saudi Arabia with political borders.

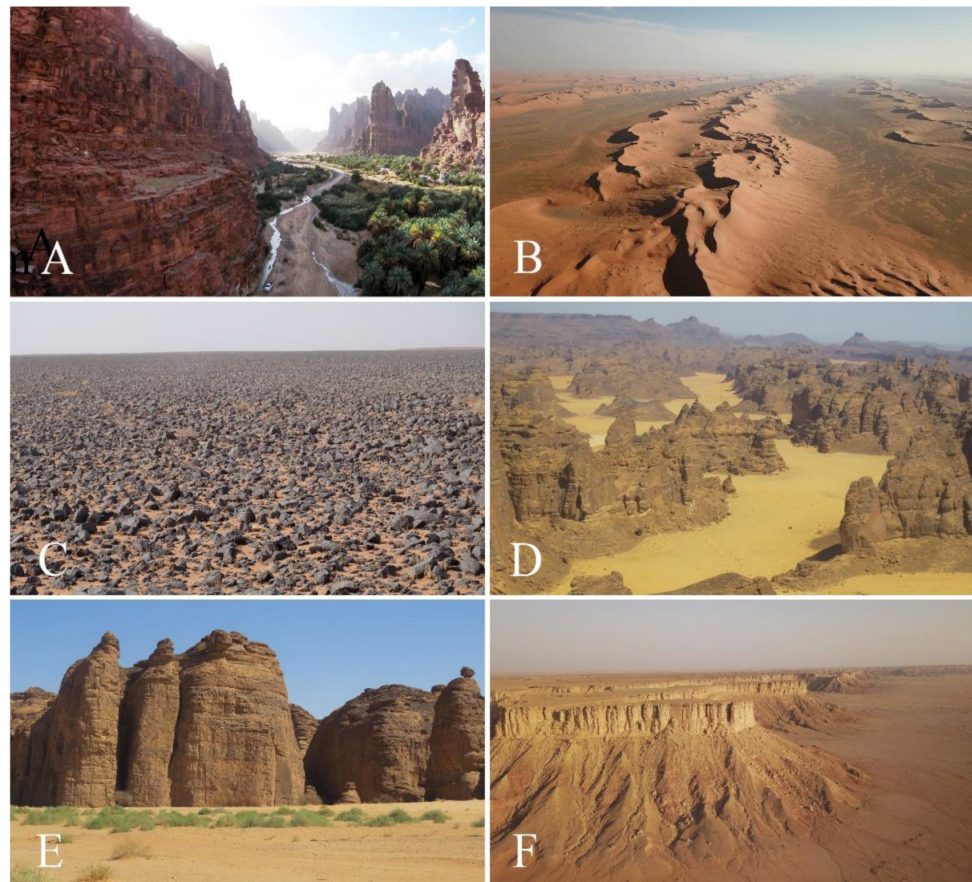


Figure 2. Arid and desert habitats in Saudi Arabia: (A) Ad Disah mountains, southwest Tabuk (photo by S. Al Jathli). (B) ‘Uruq Bani Ma’arid Protected Area, linear dunes (*Uruq*). (C) Harrat Al Harrah. (D) Arial view of Sharaan sand stones mountains in Al’Ula. (E) Sandstone desert in Sharaan Protected Area. (F) Most southern edge of Twaiq Mountains.

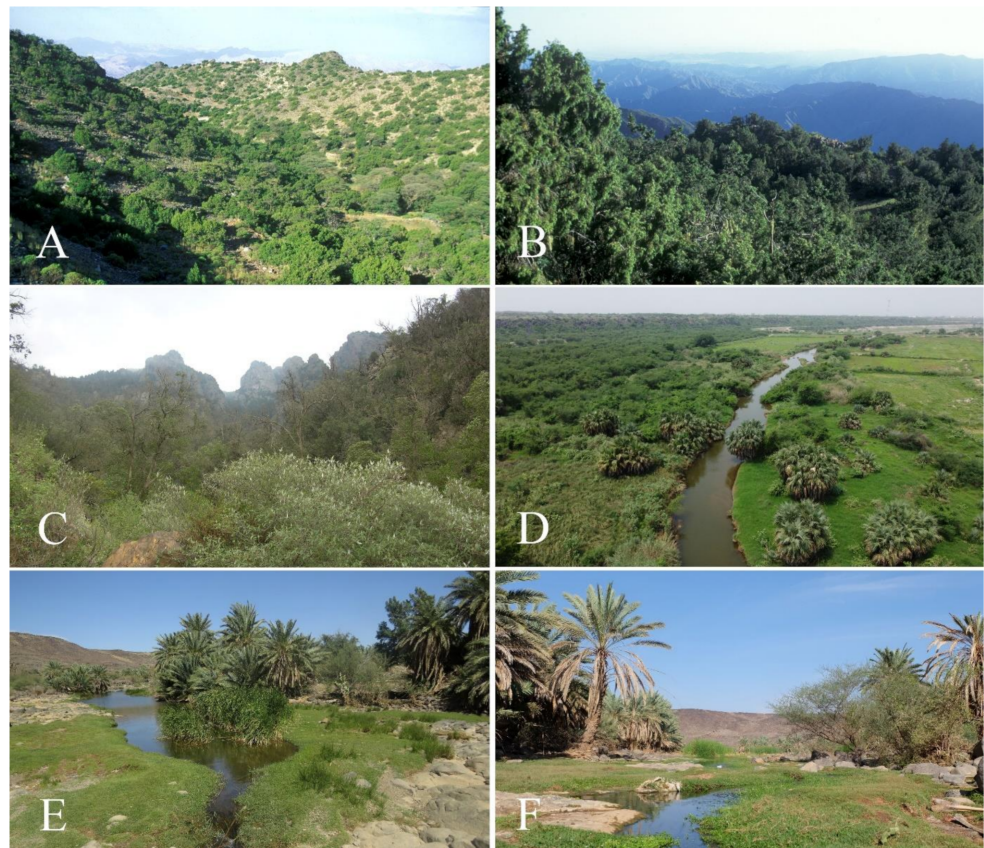


Figure 3. (A) Asir mountains (photo by O. Llewellyn). (B) *Juniperus procera* forests in Jabal Al Sawda. (C) Asir mountains. (D) Wadi Jazan (photo by Mohamed Fetini). (E) Springs in Khaybar area. (F) Wadi Al Khadrah, near Al Madinah Al Munawwarah.

Al-Nafie [36] identified four main phytogeographical regions in Saudi Arabia (Figure 4). The greatest part of the country of Saudi Arabia is occupied by the Saharo-Arabian region, extending from the north, throughout central Arabia, and reaching the Empty Quarter south wards. It includes As-Summan, Al Hammad, Al Hajarh, Al Wedyan and Najd plateaus, An-Nafud, Ad-Dahna and the Empty Quarter sand dunes. Many caves and rocky cliffs are known along the Arabian Shield, forming a crescent of sharp mountains with suitable habitats for bats.

The Afromontane region is located in the southwestern corner of Saudi Arabia with mountains higher than 1800 m asl. It is dominated by *Juniperus procera* and other evergreen shrubs and covers a narrow strip extending along the Asir and Sarawat mountains. Many large caves are present, housing large colonies of the Egyptian Fruit Bat. The Sudanian region stretches over a narrow strip along the Red Sea coast as well as the Arabian Gulf coast. Finally, the Sudanian-Zambian region surrounds the Afromontane, with overlap with the Sudanian region along the southwestern regions [37].



Figure 4. Phytogeographical regions of Saudi Arabia (modified after Al-Nafie 2008).

2. Materials and Methods

Previous records for the bats of Saudi Arabia were extracted from published papers, reports, and the bats collection of Prof. Iyad Nader deposited at the NCW. Additionally, personal observations and field work in different sites in Saudi Arabia by A. Obaid, A. Aloufi and Z. Amr using bat detectors were included. Data on bats' distribution cover 87 localities (Appendix A). Records for each species reported previously are indicated with the reference number in parentheses. Scientific and common names were checked according to Bats of the World: A Taxonomic and Geographic Database (<https://batnames.org>, accessed on 10 May 2023).

3. Results

Diversity of the Bat Fauna of Saudi Arabia

The bats of Saudi Arabia consist of 30 species in 9 families (Pteropodidae, Rhinopomatidae, Rhinolophidae, Emballonuridae, Nycteridae, Hipposideridae, Miniopteridae, Molossidae, and Vespertilionidae) and 21 genera. The family Vespertilionidae includes the highest number of species (ten), while the families Nycteridae and Miniopteridae include one species for each (Table 1).

Table 1. Bats recorded from Saudi Arabia.

Family	Scientific Name	Common Name
Pteropodidae	<i>Eidolon helvum</i> (Kerr, 1792)	Straw-coloured Fruit Bat
	<i>Epomophorus labiatus</i> (Temminck, 1837)	Ethiopian Epaulated Fruit Bat
	<i>Rousettus aegyptiacus</i> (Geoffroy, 1810)	Egyptian Fruit Bat
Rhinopomatidae	<i>Rhinopoma cystops</i> (Thomas, 1903)	Arabian Mouse-tailed Bat
	<i>Rhinopoma microphyllum</i> (Briinnich, 1782)	Greater Mouse-tailed Bat
Rhinopomatidae	<i>Rhinopoma cystops</i> (Thomas, 1903)	Arabian Mouse-tailed Bat
	<i>Rhinopoma microphyllum</i> (Briinnich, 1782)	Greater Mouse-tailed Bat

Table 1. Cont.

Family	Scientific Name	Common Name
Hipposideridae	<i>Asellia patrizii</i> (De Beaux, 1931)	Patrizi's Trident Leaf-nosed Bat
	<i>Asellia tridens</i> (Geoffroy, 1813)	Trident leaf-nosed Bat
	<i>Hipposideros tephros</i> (Cabrera, 1906)	The Lesser Leaf-nosed Bat
	<i>Hipposideros megalotis</i> (Heuglin, 1861)	Large-eared Leaf-nosed Bat
	<i>Chaerephon nigeriae</i> (Thomas, 1913)	Nigerian Free-tailed Bat
Molossidae	<i>Chaerephon pumila</i> (Cretzschmar, 1826)	Little Free-tailed Bat
	<i>Mops midas</i> (Sundevall, 1843)	Midas' Free-tailed Bat
	<i>Tadarida aegyptiaca</i> (E.Geoffroy, 1818)	Egyptian Free-tailed Bat
	<i>Tadarida teniotis</i> (Rafineque, 1814)	European Free-tailed Bat
	<i>Barbastella leucomelas</i> (Cretzschmar, 1830)	Eastern Barbastelle
Vespertilionidae	<i>Eptesicus bottae</i> (Peters, 1869)	Botta's serotine Bat
	<i>Rhyneptesicus nasutus</i> (Dobson, 1877)	Sind Bat
	<i>Hypsugo ariel</i> (Thomas, 1904)	Desert pipistrelle
	<i>Myotis emarginatus</i> (E.Geoffroy, 1806)	Notch-eared Bat
	<i>Nycticeinops schlieffeni</i> (Peters, 1860)	Schlieffen's Twilight Bat
	<i>Otonycteris hemprichii</i> (Peters, 1859)	Desert Long-eared Bat
	<i>Pipistrellus kuhlii</i> (Kuhl, 1817)	Khul's Pipistrelle
	<i>Plecotus christii</i> (Gray, 1838)	Christie's Big-eared Bat
Miniopteridae	<i>Scotophilus dinganii</i> (Smith, 1833)	Yellow-bellied House Bat
	<i>Miniopterus pallidus</i> (Thomas, 1907)	Pale bent-wing Bat

Family Pteropodidae

Eidolon helvum (Kerr, 1792) (Figure 5)



Figure 5. The Straw-coloured Fruit Bat, *Eidolon helvum* (photo by A. Reiter).

Previous records: Al Shugayri [13], Al Baha [24], and Bisha [38].

Recent records: Abu Al Sala'a, Jazan, Thee Ain, and Wadi Al Jouf.

Remarks: This is an African species with a distribution range extending from Mauritania, Senegal, and Gambia to Ethiopia, South Africa, SW Arabia and Oman, islands in the Gulf of Guinea, and off E Africa [39].

In Al Shugayri, this bat was collected while feeding on a wild fig tree. It also feeds on palm trees. The Straw-coloured Fruit Bat was found along with *Rousettus aegyptiacus* [13]. In Thee Ein, it was found in large numbers reaching up to 30 individuals roosting in palm trees. The same was observed in Jazan airport with a colony of over 50 individuals. The house crow, *Corvus splendens*, was documented to attack this bat species, and chase bats as they fly. In East Africa, reproduction and mating occurs between April and June, whereas fruits are quite abundant. Young bats are born through December to late February [13].

This species is considered as an agricultural pest in some parts of Saudi Arabia. It requires a certain degree of protection and should be added to the list of species under protection issued by the NCW.

Epomophorus labiatus (Temminck, 1837) (Figure 6A,B)



Figure 6. The Ethiopian Epaulated Fruit Bat, *Epomophorus labiatus*: (A) female, (B) male (photo by A. Reiter).

Previous records: Raydah escarpment [21]

Remarks: The Ethiopian Epaulated Fruit Bat is distributed in southwestern Saudi Arabia and Yemen and East Africa, from northeastern Nigeria to Eritrea and Malawi [40].

This African species was collected from humid habitats in Yemen [35]. Its presence in Saudi Arabia is based on a single record from the Raydah escarpment, which represents one of the most humid areas, with an abundance of water courses and trees, in southwestern Saudi Arabia. A bimodal pattern of reproduction has been suggested for this species in Yemen based on the maturity and lactating periods observed among captured individuals [35].

Rousettus aegyptiacus (Geoffroy, 1810) (Figure 7)

Figure 7. Small colony of the Egyptian Fruit Bat *Rousettus aegyptiacus* (photo by Z. Amr).

Previous Records: Mekkah, Al Madinah Al Munawwarah, Hail [41], Taif [6], Al Maski [7], Abha-Raydah escarpment, Al Baha, Wadi Khaytan [34], Bisha [38], Al Disah, Al Madinah Al Munawwarah, Muleh farms, and Taima-Al Hamra farms [26].

Recent records: Abha, Al Qaseem, Al Ula, Biljurashi, Jazan, Khamis Musheet. Far'a Alradadi, Wadi Al Aqeeq, Al Othaeb Farms, Al Muatadel Cave, Wadi Khadhrah, Ain Abo Dheba'a, Al Mendasah, Yanbu Al Nakhel, and Ain Al Hamah.

Remarks: The distribution of the Egyptian Fruit Bat extends from Egypt and the Levant through the western part of Saudi Arabia and Yemen to Oman and southern parts of Iran and Pakistan [42]. This species was found to frequent palm gardens in many parts of Saudi Arabia, such as Al Madinah Al Munawwarah, Al Baha, and Al Qaseem. It also frequents other fruit plantations, such as fig and grape gardens in southwestern Saudi Arabia. A large colony of over 500 individuals was observed at Al Hamra farms, Taima, Al Disah, and Muleh [26]. Additionally, Nader [6] observed a population of over 500 individuals in an abandoned fort near Taif. Hundreds of bats were seen flying over an artificial pool near farms rich in palm trees [26]. This is a rather very common species around Al Madinah Al Munawwarah Province; colonies reaching up to 300 individuals were spotted in farms and caves such as Al Muatadel Cave and Al Othaeb Farms. High numbers were observed feeding on palm trees in Beljarashi and Jazan in southwestern Saudi Arabia.

This bat becomes active after sunset and can travel long distances in search of food. Pregnant females were found during January and June while lactating females were observed during July [6].

Family Rhinopomatidae*Rhinopoma cystops* Thomas, 1903 (Figure 8)

Figure 8. The Arabian Mouse-tailed bat *Rhinopoma cystops* (photo by Z. Amr).

Previous records: Abha, Farasan Island, Midian, Al Bad'a, Maghair Shoaib [34], Al Madinah Al Munawwarah, near Riyadh [6], Al Jowa [9], Bisha, Naqi [38], and Sharma-Tor Qunibi [26].

Recent records: As Saqid Island.

Remarks: Nader [6] indicated a colony of about 40 individuals in a tunnel near Riyadh, and another colony in a cellar near Al Madinah Al Munawwarah. A large colony consisting of over 100 individuals was observed in a small cave in Tor Qunibi, Sharma, with a layer of guano about 15 cm in thickness, suggesting the presence of a large colony over time [26]. Specimens collected from Riyadh and Al Madinah Al Munawwarah had a large deposit of fat at the base of the tail [6]. The colony was found along with *R. microphyllum*. Another colony was located at As Sadiq Island, with over 30 individuals in a small underground cave. It was found along with *Asellia patrizi*.

Benda et al. [43] considered the Middle Eastern *Rhinopoma hardwickii* as *Rhinopoma cystops* based on Hulva et al. [44]. Hence, old records for *R. hardwickii* for Saudi Arabia should be considered as *R. cystops*.

Rhinopoma microphyllum (Briinnicb, 1782) (Figure 9)



Figure 9. The Greater Mouse-tailed Bat, *Rhinopoma microphyllum* (photo by NCW).

Previous records: Al Madinah Al Munawwarah [6], Ablah [34], Al Jowa [9], and Naqi [38].

Recent records: Al Frawaha Cave in Uruq Bani Ma'arid Protected Area.

Remarks: The Greater Mouse-tailed Bat is a xerophilous bat that inhabits caves, houses, and ruins. In Saudi Arabia, Nader [6] collected a specimen from a small cellar in an old abandoned Turkish fort near Jabal Ohud and collected three adult specimens from a cavern in Al Jowa [9]. They were found along with the Lesser Mouse-tailed Bat *R. cystops*. A colony of about 200 individuals was observed during May 2019 in Al Faroha Cave Area. This cave is about 30 m deep and about 2 m high.

Females give birth in June to August, and a single young is born [45]. It feeds on a wide variety of insects including Coleoptera, Hemiptera, Lepidoptera, and Orthoptera [45].

Family Rhinolophidae*Rhinolophus clivosus* Cretzschmar, 1828 (Figure 10)

Figure 10. Geoffroy's Horseshoe Bat, *Rhinolophus clivosus* (photo by A. Reiter).

Previous records: Mekka, Muwailih, Taif [2], Wadi Ad Dawasir [6], 50 km NNE Abha, Al Baha, Al Hajeb, Al Naji, Al Mothra, Raydah escarpment, Jabal Tuwaiq, Taif [9], and Al Moatham Castle [26].

Remarks: One individual was found in the ruins of Al Moatham Castle [26]. All pregnant females collected from Al Mothra and Al Hajeb had one embryo each during March [9]. Both localities were considered as maternity colonies. Additionally, it was found along with *Nycteris thebaica*. Little is known about the biology of this species. Females may have a more specialized diet of moths and butterflies [43].

Nader [9] stated that two subspecies are known from Saudi Arabia: *Rhinolophus clivosus clivosus* Cretzschmar, 1828 that was originally described from Mohila (=Muwailih), Red Sea Coast, Saudi Arabia, and *Rhinolophus clivosus acrotis* Heuglin, 1861.

Rhinolophus hipposideros (Bechstein, 1800) (Figure 11)



Figure 11. The Lesser Horseshoe Bat, *Rhinolophus hipposideros* (photo by A. Reiter).

Previous records: Taif [2], Al Ays, Al Mothra [9], and Al Ain [34].

Recent records: Abha.

Remarks: This species is considered as a rare species in the Arabian Peninsula, and it seems to be a solitary bat. Two females were collected from an abandoned house in Al Mothra [9]. In Jordan, females give birth during May to the first half of July and feed mainly on Auchenorrhyncha and Lepidoptera [29].

Family Emballonuridae

Taphozous nudiventris Cretzschmar, 1826 (Figure 12)



Figure 12. Naked-bellied Tomb Bat, *Taphozous nudiventris* (photo by A. Shehab).

Previous records: Najran [2], Al Jowa [9], and Taif [34].

Remarks: This species avoids extreme arid regions and prefers humid areas with water courses or swamps. It roosts in crevices in old building, caves, and ruins [34]. Large fat deposits in the abdominal regions as in *Rhinopoma* are exhibited by this species and seem to be a source of reserve nutrition for hibernation [46]. In Iraq, mating usually occurs during September and October, while hibernation extends from November to March [47]. In Syria, about 200–300 animals were spotted in several crevices located on cliffs on the southern side of the Euphrates [48].

Taphozous perforatus E. Geoffroy, 1818 (Figure 13)



Figure 13. The Egyptian Tomb Bat, *Taphozous perforatus* (photo by C. Dietz).

Previous records: NE Jeddah (Shumaisi) [2], Sabya [49], near Usfan [7], Al Baha, Mekka, Taif [34], and Bisha [38].

Recent records: Abha.

Remarks: The Egyptian Tomb Bat avoids extreme arid regions with preference for humid areas along the coastal belt of Arabia. Nader [7] collected 10 specimens during June from rooms in an old fort near Usfan and they were found along with *Asellia tridens*. No data are available on the reproduction of this species in Saudi Arabia. In Egypt, pregnant females were observed during April [50].

Family Nycteridae*Nycteris thebaica* É. Geoffroy Saint-Hilaire, 1813 (Figure 14)

Figure 14. Aden Slit-faced Bat, *Nycteris thebaica* (photo by A. Aloufi).

Previous records: Jeddah, Najran [2], Jizan, Sabya [49], Abha, Ahad Rufaida, Al Jowa, Al Mothra, Ben Yeshden, Buraiman, and Dir'iyah near Riyadh [10].

Recent records: Al Menshar, Far'a Alradadi, Wadi Khadhrhah, and Wadi Jizan Dam.

Remarks: It inhabits ruins, bungalows, abandoned well shafts, and caves [10,34]. Harrison and Bates [34] cited the observations of Yerbury and Thomas [51], where they captured this bat by "a butterfly net". It feeds on grasshoppers [34] and scorpions [52]. This feeding behavior may explain the low flying pattern. Females give birth to a single individual. More details on its biology are given by Gray et al. [53]. We have three observations for this bat from Al Madina Al Monwwarah Province, where it was netted from an old house with the number of individuals ranging from 2 to 11.

The form *najdiya* was reported from Dir'iyah near Riyadh [10], the other subspecies *Nycteris thebaica adana* was reported from Jeddah, Buraiman, Mothra, Ben Yeshden, Abha, Ahad Rufaida, Sabiya, Jizan, Al Jowa, and Najran [10].

Family Hipposideridae*Asellia patrizii* De Beaux, 1931

Previous records: Farasan and As Saqid islands [20].

Remarks: The Patrizi's Trident Leaf-nosed Bat is considered endemic to Ethiopia and the Farasan Islands in Saudi Arabia [20]. A specimen was captured in a room in the Coast Guard House on Farasan Kebir [20]. No further records have been obtained over the past 30 years. No details are available on the biology of this species. During field work conducted in March 2023, we were able to record echolocation calls for this species in a small underground cave on As Saqid Island.

Asellia tridens (Geoffroy, 1813) (Figure 15)

Figure 15. Trident Leaf-nosed Bat, *Asellia tridens* (photo by A. Aloufi).

Previous records: Hufuf [1], Jeddah and its vicinity [2], Durma, 80 km NW of Mekka, near Usfan [6], Al-Aytaliah [54], Abha, S of Riyadh, near Taif [34], Jubail, Ras al-Abkhara [55], and Al Beda' [26].

Recent records: Ara'ar, Ben Rasheed Cave, and Jal Al Mazour.

Remarks: The Trident Leaf-nosed Bat is a desert-adapted colonial species. A colony of 20–25 individuals was found in a concealed shelter under a rock ledge in Jubail [55], and an additional colony was found in an old fort near Mekka [6]. Roosting sites in Iraq are abandoned during winter, suggesting a migratory behavior [4]. This bat is known to occur along the coastal areas of the Arabian Peninsula [49]. Al-Robaee [47] stated that the Trident Leaf-nosed Bat has two quarters: winter quarters which they inhabit until April, and summer quarters. The gestation period is assumed to be 9–10 weeks with a single newborn. It was found along with *Taphozous perforatus* [6].

Hipposideros tephrus Cabrera, 1906 (Figure 16)

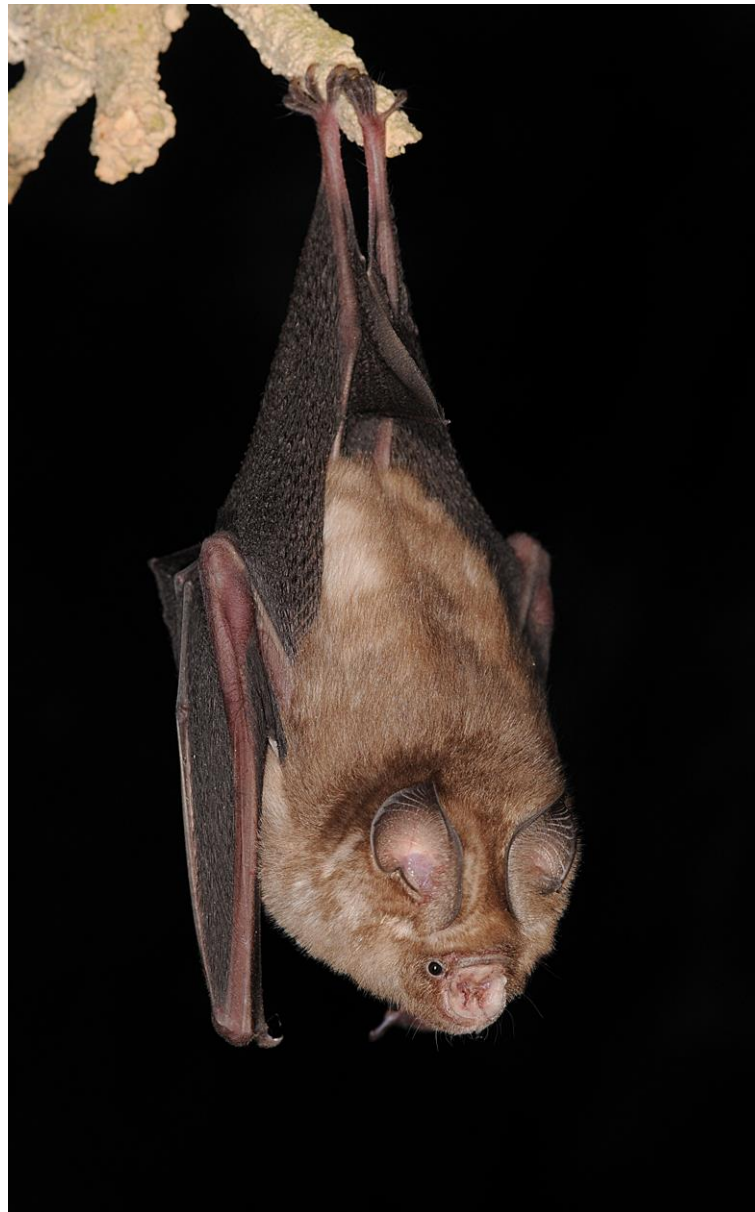


Figure 16. The Lesser Leaf-nosed Bat, *Hipposideros tephrus* (photo by C. Dietz).

Previous records: Al Jowa, Al Mothra [9], Al Baha, Ablah, and Wargan [34].

Remarks: This species was originally recorded as *Hipposideros caffer* (Sundevall, 1846) from Saudi Arabia. Based on molecular studies, Vallo et al. [56] revealed the presence of several lineages for the Arabian *Hipposideros caffer* complex and showed that it belongs to the *H. tephrus*. Earlier, Nader [9] suggested that the Saudi Arabian specimens should be assigned to *Hipposideros tephrus*. Little data were given on the habitat preference of this species in Saudi Arabia. It was found on an altitude reaching up to 1200 m asl in Wargan, and males were recovered from a cave in Ablah. A colony of up to 20 individuals was observed in a small tunnel-shaped cave in Yemen along with *Rhinolophus blasii* and *Myotis emarginatus* [35]. A female collected from Al Jowa was lactating during October [9]. Ectoparasites including an argasid tick and a bat fly (Family Streblidae) were found on one female from Al Jowa [9]. The Lesser Leaf-nosed Bat gives birth to a single young once a year [57].

Hipposideros megalotis (Heuglin, 1861)

Previous records: Jeddah [19].

Remarks: The Large-eared Leaf-nosed Bat was reported from Saudi Arabia, Ethiopia, Eritrea, Djibouti, and Kenya. This is a rare species only known in Somalia, Northeast Africa [19]. The recorded specimen represents a bat that fell in collision with a car in Jeddah. No details are available on the biology of this species.

Family Molossidae

Chaerephon nigeriae Thomas, 1913 (Figure 17)



Figure 17. The Nigerian Free-tailed Bat, *Chaerephon nigeriae* (photo by A. Reiter).

Previous records: Abha [7], Abha and Raydah escarpment [14].

Remarks: The Nigerian Free-tailed Bat's distribution range extends from western central Africa, reaching Ethiopia, Saudi Arabia, and Yemen [34]. The Nigerian free-tailed bat is an Afrotropical species inhabiting a wide variety of habitats across its range of distribution. It was collected along the semi-desert habitats of the Sarawat mountains bordering the deserts of the Tihama plain, at altitudes ranging between 300 and 2200 m asl. [35]. Specimens were mist-netted over a small water pool in Yemen [35]. No data are available on the biology of this species in the Arabian Peninsula.

Chaerephon pumila (Cretzschmar, 1826) (Figure 18)



Figure 18. The Little Free-tailed Bat, *Chaerephon pumila* (photo by A. Reiter).

Previous records: Sabya [3,6] and Jazan [49].

Remarks: This African species is distributed across the tropical and southern parts of Africa, reaching far to the east to Saudi Arabia and Yemen. The Little Free-tailed Bat occurs in desert habitats in western Tihama and southern Yemen [35]. It prefers open humid areas with relatively dense vegetation and water sources. Both Jazan and Sabya enjoy humid habitats that are suitable for the occurrence of this species. In Yemen, juveniles were captured during October, whereas lactating females were collected during November, suggesting two events of reproduction [35].

Mops midas (Sundevall, 1843)

Previous records: Al Jowa, Al Mowassam [9], and Haqw [27].

Remarks: The Midas Mops Bat occurs from Senegal to Saudi Arabia, south to Botswana, NE South Africa, and Zimbabwe; and Madagascar [58]. The specimens collected from Al Jowa were taken from a hole in a tree [9]. An adult female was lactating in October [9]. Further details on its biology are given by Dunlop [59].

Tadarida aegyptiaca (E. Geoffroy 1818) (Figure 19)



Figure 19. Egyptian Free-tailed Bat, *Tadarida aegyptiaca* (photo by A. Reiter).

Previous records: Sabihah [59] and Al Baha [14].

Recent records: Abha.

Remarks: The distribution of the Egyptian Free-tailed Bat extends across South Africa to Nigeria, Algeria, and Egypt to Saudi Arabia, Yemen and Oman, east to India and Sri Lanka, N to Afghanistan [50]. It occurs in warm, semi-arid, and arid regions where it roosts in caves and large buildings. In Egypt, it was collected from crevices in caves [50]. Females become reproductively active during May and June [50].

Tadarida teniotis (Rafinesque, 1814) (Figure 20)



Figure 20. European Free-tailed Bat, *Tadarida teniotis* (photo by C. Dietz).

Previous records: Taif, Wadi Sawawin [14], and Tabuk Sewage Treatment Plant [26].

Recent records: Al Madinah Al Munawwarah.

Remarks: The European Free-tailed Bat is known to occur in southwestern Europe, across North Africa to the Middle East, reaching as far as the southern states of the former Union to Afghanistan to W Bengal to China.

The European Free-tailed Bat was found to live in cracks and fissures along rocky cliffs or caves [60]. It can be found in extremely dry habitats in deserts as well as forested mountains. Its ability to fly at high altitudes and for long distances is perhaps responsible for the lack of specific records [61]. The European Free-tailed Bat's flight pattern is unique (fast and direct), owing to unique adaptations of their wings [61].

Females with a single embryo were collected in Lebanon [62]. The species was found to feed particularly on Lepidoptera, followed by Orthoptera, Heteroptera Neuroptera, and Hymenoptera [29].

Family Vespertilionidae

Barbastella leucomelas (Cretzschmar, 1830) (Figure 21)



Figure 21. Asian Barbastelle, *Barbastella leucomelas* (photo by A. Aloufi).

Previous records: Alagan-Algtar in Tabuk [26].

Remarks: This species has a wide range of distribution, extending from Nepal and China across the former Russian Federation, to Jordan and Saudi Arabia in the Middle East. The Asian Barbastelle is a bat species endemic to desert regions surrounding the northern edge of the Red Sea [29]. It was collected from sandstone deserts of the north of Tabuk [26]. Its presence in sandstone deserts of northwestern Saudi Arabia is highly possible. It was found to feed on Lepidoptera and Neuroptera [29]. It is a sedentary bat, with 3–8 females in nursery colonies, with females normally living separately to males.

Eptesicus bottae (Peters, 1869) (Figure 22)



Figure 22. Botta's Serotine Bat, *Eptesicus bottae* (Photo by A. Reiter).

Previous records: about 40 km north of Abha Misfera [17], Bisha [38], Alagan-Algtar, and Bajdah-Alsero [26].

Recent records: Al Madinah Al Munawwarah, Jeddah, and Neom.

Remarks: The distribution of Botta's Serotine Bat extends through Turkey, the Middle East to Egypt and Yemen, reaching east to Mongolia and Pakistan. This is a crevice-dwelling species, inhabiting buildings, ruins, and natural rock crevices throughout the year. It was captured in a sandstone desert in Alagan-Algtar, along with *B. leucomelas*. They were found to frequent water reservoirs for watering camels [26]. In Jordan, adult females were found pregnant with two embryos in May [29]. This insectivorous bat feeds on a wide variety of hymenopterans, lepidopterans, and coleopterans as the most important prey items [29].

Rhyneptesicus nasutus (Dobson, 1877) (Figure 23)



Figure 23. The Sind Bat, *Rhyneptesicus nasutus* (Photo by A. Reiter).

Previous records: Al Aflaj, Al Jowa, Dhahran [9], Shanna, and Jeddah [34].

Remarks: The Sind Bat occurs in Saudi Arabia, Oman, Yemen, Iraq, Iran, Afghanistan, and Pakistan. No data are available on its habitat preference in Saudi Arabia. It was previously recorded as *Eptesicus nasutus*. However, in Oman, it was found to be associated with crevices in the walls of buildings [34]. In Yemen, it was found along with *Eidolon helvum*, *Rousettus aegyptiacus*, *Nycticeinops schlieffenii*, *Scotophilus dinganii*, and *Chaerephon pumilus* [35]. No data are available on the biology of this species. The only citation is on a female that showed early pregnancy in March [63].

Nader [7] recognized two subspecies occurring in Saudi Arabia: *Rhyneptesicus nasutus matschiei* (Thomas, 1905) and *Rhyneptesicus nasutus batinensis* (Harrison, 1968).

Hypsugo ariel (Thomas, 1904) (Figure 24)



Figure 24. The Desert Pipistrelle, *Hypsugo ariel* (Photo by A. Aloufi).

Previous records: Taif [23], Al Moatham Castle, and Taima-Al Hamra farms [26].

Recent records: Abha, Al Madinah Al Munawwarah, Ibex Reserve, and Neom.

Remarks: The Desert Pipistrelle was recorded from Palestine, Jordan, Egypt, Saudi Arabia, and Sudan (60). Generally, this is a desert-adapted species occurring in arid regions of Jordan and Palestine. This species was found near old castles, open water systems near Tabuk, and agricultural areas in Taima Al Hamra farms. Two males were mist-netted over water from an escarpment near Taif [23]. It was found in large numbers (about 20) emerging from the ruins of the castle [26]. It was found along with *Rhinolophus clivosus* and *Rousettus aegyptiacus* [26]. Lactating females were observed from May to July in Palestine, and females may give birth twice a year [64]. It feeds on a wide variety of insects including Hymenoptera, Hemiptera, and others [64]. Details on its activity pattern were highlighted by Yom-Tov et al. [64]. More details on the biology of this species are given by Riskin [65]. *Hypsugo ariel* was considered previously as *Pipistrellus bodenheimeri*.

Myotis emarginatus (E. Geoffroy, 1806) (Figure 25)



Figure 25. The Notch-eared Bat, *Myotis emarginatus* (photo by NCW).

Previous records: Raydah escarpment and Taif [24].

Recent records: Al Soudah area and S of Raydah Protected Area. (Personal observation based on recordings by Jacky Judas, 2022.)

Remarks: The Notch-eared Bat is widely distributed in S Europe, north to the Netherlands and S Poland, Crimea, Caucasus, and east to Uzbekistan and E Iran, the Middle East, North Africa, and Afghanistan [66]. *Myotis emarginatus* is a cave-dwelling species [34]. In the Al Soudah area, there are many small caves, and the bat detector was placed on a tree stand close to the rocky walls. Most of its activity was recorded between 3 and 4 A.M. *Myotis* species are very difficult to distinguish; however, *M. emarginatus* has been recorded in neighboring Yemen. This species has a specialized diet, primarily feeding on spiders, aerial feeding from webs, and sometimes gleaning from vegetation.

Nycticeinops schlieffeni (Peters, 1860) (Figure 26)



Figure 26. The Schlieffen's Twilight Bat, *Nycticeinops schlieffeni* (photo by A. Reiter).

Previous records: Wadi Yiba, SE Al Qunfida, and Qanuna [49].

Remarks: The Schlieffen's Twilight Bat is distributed in SW Saudi Arabia, Yemen, and Egypt to Djibouti, Somalia, Mozambique, Mali, Botswana, South Africa, and Namibia, and Mauritania and Ghana to Sudan and Tanzania.

This species is associated with low-lying savannas and riparian vegetation along rivers and drainage lines in Africa. It roosts in crevices in trees and in houses [67]. No details on its habitat preference are available from Saudi Arabia and Yemen [35]. This bat feeds on aerial insects such as Coleoptera, Diptera, Lepidoptera, Trichoptera, and Hymenoptera. Females give birth to up to three young at a time [67].

Otonycteris hemprichii Peters, 1859 (Figure 27)



Figure 27. The Desert Long-eared Bat, *Otonycteris hemprichii* (Photo by Z. Amr).

Previous records: Hufuf [1], Anaiza, Hail [2], Taif [15], Riyadh [34], and That Al Haji [26].

Recent records: Abha and Al Ehsa.

Remarks: The Desert Long-eared Bat occurs in Morocco and Niger through Egypt and Arabia to Tadzhikistan, Afghanistan, and Kashmir [68]. This is a desert-adapted species known from arid regions in the Middle East. It was collected from deserted houses near

Tabuk [26]. It is distributed in open deserts with close-by mountain ridges, deserted forts, and houses. Its diet consists of tenebrionids, Blattoidea, and Orthoptera. Pregnant females usually have two embryos. More details on its biology and behavior are provided by Gharaibeh and Qumsiyeh [68].

Pipistrellus kuhlii (Kuhl, 1817) (Figure 28)



Figure 28. Kuhl's Pipistrelle, *Pipistrellus kuhlii* (photo by A. Shehab).

Previous records: Hufuf [1], Marrat [7], Abha-Raydah escarpment, Riyadh [34], Al-Qassim [25], Bisha, Unaizah, and Riyadh [38].

Recent records: Al Asfar Lake, Ibqiq, Abha, Jeddah, Neom, and Hard.

Remarks: Kuhl's Pipistrelle is known to occur in S Europe through the Caucasus to Kazakhstan and Pakistan; SW Asia; most of Africa and the Canary Islands. This is a widespread species inhabiting a variety of habitats ranging from forests to arid and urban areas. It is considered one of the most common species. It frequents houses, small caves, and crevices around human habitation [61]. Alagaili et al. [25] gave a detailed account of the timing and pattern of molt for this species. They found that both adults and juveniles undergo one molt over a five-month period during late April until September. The majority of both sexes molt in July and terminate the molt almost simultaneously. Molting begins on the dorsum and then spreads to the ventral side when the dorsal molt is completed.

Plecotus christii Gray, 1838 (Figure 29)



Figure 29. A colony of Christie's Big-eared Bat, *Plecotus christii* (photo by A. Aloufi).

Previous records: Misfera [18] and Albogaz Tunnel [26].

Recent records: Neom.

Remarks: Christie's Big-eared Bat distribution extends from Sinai, Libya, and Sudan to the Middle East. A colony of about forty bats was observed in Al Bogaz tunnel [26]. This species can be found in caves, mine shafts, and old castles [61]. This bat is well adapted to "hovering" flight. While resting, its long ears are held back close to its body. Among other distinctive features of this bat is that it flies with its ears in an erect posture. Harrison [49] observed a female with a single small fetus in March.

Scotophilus dinganii (Smith, 1833) (Figure 30)



Figure 30. The Yellow-bellied House Bat, *Scotophilus dinganii* (photo by A. Reiter).

Previous records: Abha-Raydah escarpment [22] and NE of Jizan [69].

Remarks: The Yellow-bellied House Bat occurs from Mauritania, Senegal, and Gambia to N Kenya and Ethiopia, reaching Yemen and SW Saudi Arabia [67]. Five individuals were mist-netted above a water tank at Abha-Raydah escarpment [22]. This African species prefers humid habitats with tree cover. The feeding behavior of this species was studied in

Zimbabwe. It foraged mainly over floodplains for less than one hour at dusk and roosts in small tree cavities. It feeds on hemipterans and coleopterans [70].

Arabian populations of the genus *Scotophilus* Leach, 1821, were assigned to *S. nigrita* (Schreber, 1774) or *S. leucogaster* (Cretzschmar, 1830). Benda et al. [35] placed the Arabian population of this genus under *S. dinganii* based on the taxonomic revision by Robbins et al. [71]. Benda et al. [35] suggested that *Scotophilus dinganii* (Smith, 1833) inhabits the entire area of southwestern Arabia. They considered all records from Saudi Arabia and Yemen to belong to *S. dinganii*.

Family Miniopteridae

Miniopterus pallidus Thomas, 1907 (Figure 31)



Figure 31. Pale Bent-wing Bat, *Miniopterus pallidus* (photo by A. Shehab).

Previous records: Abha [9], near Taif, Abha-Raydah escarpment, and Ablah [34].

Remarks: This species has a wide distribution range, extending from southern Europe, Morocco to Turkey, and northwest of the Middle East [66]. It is usually found in large colonies in caves along with other species [61]. It avoids extreme desert and is mainly associated with forested areas such as Abha-Raydah escarpment in southwestern Saudi Arabia. Nader [9] collected two specimens from an apartment in Abha.

It was reported as *Miniopterus schreibersii* from Saudi Arabia [9,34]. The taxonomic status of this species is not clear in the Middle East. Benda et al. [29] referred to some populations of this species in Jordan as *Miniopterus pallidus* Thomas, 1907. In this treatment, we considered all previous records for *M. schreibersii* as *M. pallidus*.

Zoogeographical affinities of bats in Saudi Arabia

Evidently, the bats of Saudi Arabia represent a mixture of faunal elements of several affinities. At least eight species (26.6%) are of Afrotropical origin, including two fruit-eating bats: *Eidolon helvum* and *Epomophorus labiatus*; two vespertilionids: *Nycticeinops schlieffenii* and *Scotophilus dinganii*; three molossids: *Chaerephon nigeriae*, *Chaerephon pumilus*, and *Mops midas*; and one from the family Hipposideridae: *Hipposideros tephros*. These species also occur in Yemen as well [35].

Species with Saharo–Sindian distribution include *Rhinopoma cystops*, *Asellia tridens*, and *Hypsugo ariel* (10%), while *Rousettus aegyptiacus*, *Rhinolophus clivosus*, *Taphozous perforatus*, and *Nycteris thebaica* are considered to be of Afrotropical–Palearctic affinities [35]. Three species with a wide range of distribution throughout the Afrotropical–Palearctic–Oriental range are represented by *Taphozous nudiventris*, *Pipistrellus kuhlii*, and *Tadarida aegyptiaca*.

Palearctic species are represented by four species (*Myotis emarginatus*, *Miniopterus schreibersii*, *Tadarida teniotis*, and *Eptesicus bottae*), reaching their most southern range in the Arabian Peninsula. *Plecotus christii* can be considered as a North African species with an extension of its range to the Middle East.

Rhyneptesicus nasutus was considered as a Middle East endemic species with distribution confined to Iraq, Iran, and Afghanistan, and reaching as far as western Arabia [35]. *Barbastella leucomelas* is considered as an oriental species, reaching its most western distribution in Sinai, Jordan, and northwestern Saudi Arabia. *Rhinopoma microphyllum* and *Otonycteris hemprichii* can be described as an Afrotropical–Oriental species with distribution in Sub-Saharan Africa, reaching as far as the Indian subcontinent. *Asellia patrizii* stands as an endemic species known only from Eretria, Ethiopia, and Farasan Island in Saudi Arabia.

Species richness of bats in Saudi Arabia

Figure 32 shows the species richness of bats across Saudi Arabia. The southwestern corner of Saudi Arabia covering Asir, Jazan, and Najran plateaus extending further into Al Sarawat mountains hosts the highest number of bat species (16 species). This includes all bats of Afrotropical affinities: *E. helvum*, *E. labiatus*, *N. schlieffenii*, *S. dinganii*, *C. nigeriae*, *C. pumilus*, *M. midas*, and *H. tephros*; and species of other affinities: *R. aegyptiacus*, *R. cystops*, *R. microphyllum*, *T. nudiventris*, *T. perforatus*, *Nycteris thebaica*, *T. aegyptiaca*, *Rhyneptesicus nasutus*, *E. bottae*, *M. emarginatus*, *O. hemprichii*, and *P. kuhlii*. This area represents the Afromontane element characterized by rich vegetation cover, relatively high humidity and rainfall, and an abundance of permanent waterbodies. Fruit-eating bats have plentiful food resources including fruits, palm, figs, and berries. On the other hand, insectivorous bats enjoy feeding on a wide range of insects that are highly diversified and common in such habitats.

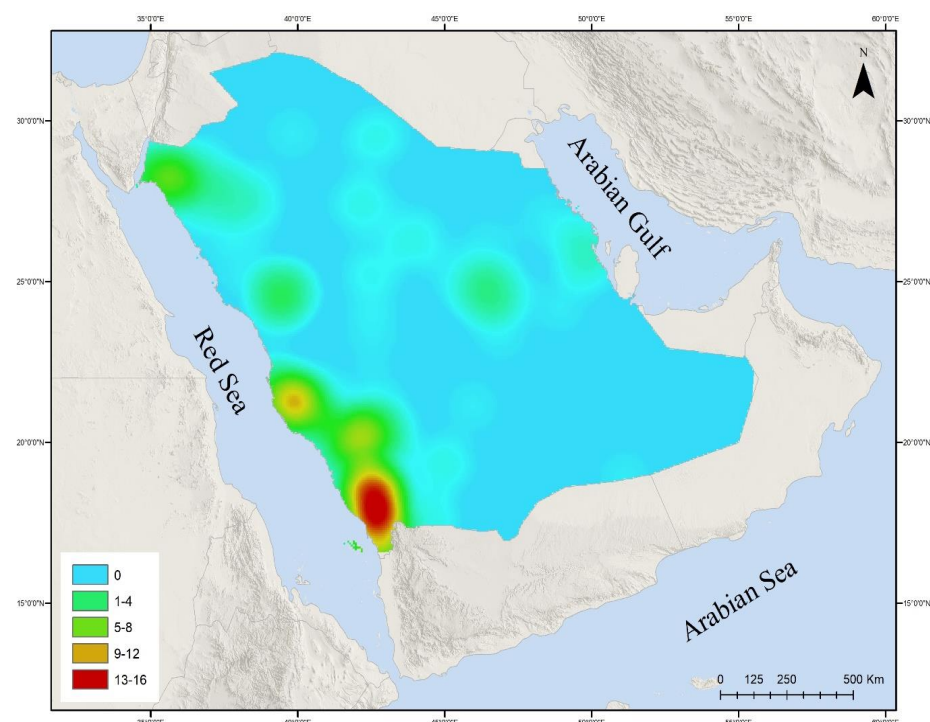


Figure 32. Heat map showing bat species richness in Saudi Arabia.

Species richness starts to decline to the north along the Red Sea mountains, whereas vegetation cover decreases along with increased temperatures. Similarly, species diversity reaches its minimum in most of the country due to less-favorable habitats for bats and a lack of field studies.

Conservation status of the bats of Saudi Arabia

The conservation status of the bat fauna of Saudi Arabia according to the IUCN global status and the IUCN Mediterranean status [72] is shown in Table 2. Twenty-five species are considered as of Least Concern, two as Data-Deficient, one as Near-Threatened, and two species as Vulnerable. According to the IUCN Mediterranean status, eleven are of Least Concern, five are Data-Deficient, and three are Near-Threatened (Table 1). Now, we are in the process of evaluating the national status. The preliminary analysis of the national status of the bats of Saudi Arabia suggests that at least 14 species are Data-Deficient (DD) due to lack of distributional data, while the remaining 16 species were listed as of Least Concern.

Table 2. IUCN global, Mediterranean and national statuses for the bats of Saudi Arabia.

Family	Species	IUCN Global	IUCN Mediterranean	IUCN National
Pteropodidae	<i>Eidolon helvum</i> (Kerr, 1792)	NT		LC
	<i>Epomophorus labiatus</i> (Temminck, 1837)	LC		DD
	<i>Rousettus aegyptiacus</i> (Geoffroy, 1810)	LC	NT	LC
Rhinopomatidae	<i>Rhinopoma cystops</i> (Thomas, 1903)	LC	LC	LC
	<i>Rhinopoma microphyllum</i> (Briinnich, 1782)	LC	LC	LC
Rhinolophidae	<i>Rhinolophus clivosus</i> (Cretzschmar, 1828)	LC	DD	LC
	<i>Rhinolophus hipposideros</i> (Bechstein, 1800)	LC	NT	LC
Emballonuridae	<i>Taphozous nudiventris</i> (Cretzschmar, 1826)	LC	LC	DD
	<i>Taphozous perforatus</i> (E. Geoffroy, 1818)	LC	LC	LC
Nycteridae	<i>Nycteris thebaica</i> (E.Geoffroy Saint-hilaire, 1813)	LC	DD	LC
Hipposideridae	<i>Asellia patrizii</i> (De Beaux, 1931)	LC		DD
	<i>Asellia tridens</i> (Geoffroy, 1813)	LC	LC	LC
	<i>Hipposideros tephros</i> (Cabrera, 1906)	LC	DD	LC
	<i>Hipposideros megalotis</i> (Heuglin, 1861)	LC		DD
Molossidae	<i>Chaerephon nigeriae</i> (Thomas, 1913)	LC		DD
	<i>Chaerephon pumila</i> (Cretzschmar, 1826)	VU		DD
	<i>Mops midas</i> (Sundevall, 1843)	LC		DD
	<i>Tadarida aegyptiaca</i> (E.Geoffroy, 1818)	LC	LC	DD
	<i>Tadarida teniotis</i> (Rafineque, 1814)	LC		LC
Vespertilionidae	<i>Barbastella leucomelas</i> (cretzschmar, 1830)	LC		DD
	<i>Eptesicus bottae</i> (Peters, 1869)	LC	LC	LC
	<i>Rhyneptesicus nasutus</i> (Dobson, 1877)	LC		LC
	<i>Hypsugo ariel</i> (Thomas, 1904)	DD	DD	LC
	<i>Myotis emarginatus</i> (E.Geoffroy, 1806)	LC	LC	DD
	<i>Nycticeinops schlieffeni</i> (Peters, 1860)	LC		DD
	<i>Otonycteris hemprichii</i> (Peters, 1859)	LC	LC	LC
	<i>Pipistrellus kuhlii</i> (Kuhl, 1817)	LC	LC	LC
	<i>Plecotus christii</i> (Gray, 1838)	DD	DD	DD
	<i>Scotophilus dinganii</i> (Smith, 1833)	LC		DD
Miniopteridae	<i>Miniopterus pallidus</i> (Thomas, 1907)	NT	NT	DD

Threats affecting the bats of Saudi Arabia

The threats that are affecting bats in Saudi Arabia have virtually never been addressed. In the Middle East, several forms of threats that impacted bat populations in Jordan were identified, including deforestation, urbanization, tourism and vacationing, mining, wind

power projects, folk medicine and other practices, and the use of bats caves as animal barns [73,74].

Based on our field observations, several threats were identified that can affect the bats in Saudi Arabia. Mining is one of the activities that most affected the bats in Saudi Arabia. Phosphate mining in the northern part of the country resulted in the demolition of caves and rocky areas that are utilized by bats. Phosphate mining is a large-scale activity that will result in the habitat destruction of many desert-dwelling bats such as *R. cystops*, *R. microphyllum*, *R. clivosus*, *R. hipposideros*, *N. thebaica*, *A. tridens*, *E. bottae*, *O. hemprichii*, and *P. kuhlii*.

In general, bats are disliked animals in Saudi Arabian culture, especially after the spread of viral diseases implicating bats. Today, and more than ever, bats are controlled around human habitations, especially in the southwestern parts of Saudi Arabia where three species of fruit-eating bats occur. During the spread of the Middle East Respiratory Syndrome (MERS) in 2013, the Egyptian Fruit Bat, *R. aegyptiacus*, was the primary suspect for hosting the virus [38]. It was collected for detecting the presence of the virus and many of its populations were controlled.

During the past decade, wind farms became popular with the establishment of four projects in Dumat Al-Jandal wind farm with 99 turbines. Two further projects to generate 1 GW from 167 wind turbine generators in Shagra and Al Dawadmi Wind Power Plants are expected to be installed in 2027. This requires attention by the authorities to implement a strategy for monitoring bat populations that may be affected by such projects, by conducting environmental impact assessments and long-term monitoring.

About 1826 caves and underground caves are known in Saudi Arabia [75]. The underground caves are more common and locally known as “dohols”. They are quite common in the northern and eastern provinces, and mostly are karstic. In the black lava desert, “dohols” are common around Al Madinah Al Munawwarah and have a round opening that leads to the underground cave with extensive branching. These underground caves, as well as natural caves, are suitable habitats for bats, and are frequently visited by cave explorers, causing disturbances to populated caves. Hikers and tourists exploring caves have negatively affected some bat populations and forced them to desert their caves or underground caves. Videos of such activity seen on social media have presented documentations of disturbance.

Habitat disturbance in the southwestern part of the country through agricultural and urban expansion and tourism activities has taken its toll on cave-dwelling species such *R. aegyptiacus*, *R. cystops*, *R. microphyllum*, *R. clivosus*, and *R. hipposideros*.

At least two species are considered agricultural pests and are under control through the eradication of their population by the locals. *Rousettus aegyptiacus* and *E. helvum* are under attack in many parts of the country where palm plantations occur.

Other suspected bat species that may occur in Saudi Arabia

Based on Benda et al. [35], at least six bat species (*Rhinolophus blasii* Peters, 1867, *Coleura afra* (Peters, 1852), *Neoromicia guineensis* (Bocage, 1889), *Miniopterus natalensis* (Smith, 1834), *Plecotus* cf. *balensis* Kruskop and Lavrenchenko, 2000, and *Triaenops persicus* Dobson, 1871) are suspected to occur in southwestern Saudi Arabia. All these species were reported from western Yemen about 300–400 km from the Saudi borders to the north.

Species of Afrotropical affinities include *Coleura afra* known to occur in Sudan and Somalia to the east of its range as well as Yemen in the Arabian Peninsula, *Plecotus balensis* was described from Ethiopia [76] and subsequently found in Yemen [35], *Neoromicia guineensis* has a distribution range extending from Senegal across the Congo, reaching east to Sudan, Ethiopia, and Yemen, and *Miniopterus natalensis*, with a wide distribution extending from South Africa and reaching as far as Sudan and Yemen to the east. *Rhinolophus blasii* has a patchy distribution in the Middle East, North Africa, Greece, Yemen, and Ethiopia in eastern Africa.

4. Discussion

The bat fauna of Saudi Arabia is considered rich compared to neighboring countries, with 30 known species. It constitutes about 40% of the terrestrial mammals of Saudi Arabia. In total, 19 species of bats have recorded from Iraq [28], 26 from Jordan [29], 4 from Bahrain [30], 3 from Kuwait, 3 from Qatar [32], 9 from United Arab Emirates [33], 17 from Oman [34], and 31 from Yemen [35].

The present study showed the urgent need to conduct further studies on the bats of Saudi Arabia. Most of our knowledge is based on papers published more than 30–40 years ago. Only one relatively recent study focused on the bats of Tabuk, northwestern Saudi Arabia [26]. The Afromontane region and the Saudi islands in the Red Sea offer a huge opportunity to explore the status and habitat requirements for species reported based on single records (e.g., *E. labiatus*, *H. megalotis*, and *A. patrizii*). Such data are needed to understand the conservation status for the different species to develop conservation strategies. Although threats affecting bat populations were indicated, more efforts should address current threats with a quantitative approach. An action plan for the protection of bats in Saudi Arabia is among the priorities for the NCW, along with further measures to protect these little-explored mammals in the country.

More studies on the caves of Saudi Arabia as a refuge for bats should receive high research priority. In Saudi Arabia, about 1826 caves and underground caves are mapped [75]. Tanalgo et al. [77] addressed the need for conservation priorities for cave-dwelling bats worldwide, and they showed high-priority caves compared to fine-scale prioritization within the Arabian Peninsula.

Furthermore, echolocation call patterns for species in Saudi Arabia should be recorded to compare patterns with different populations in Saudi Arabia and the surrounding countries. As discussed earlier, the zoogeographical affinities of the Saudi bats are mainly of Afrotropical origin, as well as affinities representing the surrounding regions. This showed that the hotspot of species richness is confined to the Afromontane region of the country.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Locality	N	E
Abha	18°14'48.94"	42°30'24.34"
Ablah	25°48'00.00"	43°47'60.00"
Abu Al Sala'a	17°14'17.67"	35°49'42.62"
Ahad Rufaida	18°11'42.72"	42°49'13.84"
Ain Abo Dheba'a	18°17' 34.51"	42°22'25.51"
Ain Al Hamah	25°44'51.00"	39°15'37.00"
Al Asfar Lake	25°31'30.88"	49°48'31.35"

Locality	N	E
Al Ays	25°03'36.00"	38°06'00.00"
Al Bad'a	28°28'43.62"	35°01'12.88"
Al Baha	20°01'18.27"	41°28'16.58"
Al Disah	27°36'07.65"	36°25'51.69"
Al Frawaha Cave	19°41'39.78"	45°12'02.88"
Al Hajeb	18°15'00.00"	42°20'00.00"
Al Jowa	16°51'51.08"	43°04'12.56"
Al Jubail	26°57'35.18"	49°34'07.47"
Al Madinah Al Munawwarah	24°31'28.76"	39°34'09.06"
Al Maski	18°02'14.14"	42°43'23.52"
Al Mendasah	24°38'08.46"	39°19'49.26"
Al Menshar	24°58'00.00"	40°02'00.00"
Al Moatham	27°44'27.00"	37°30'31.00"
Al Mothra	18°25'35.14"	42°35'50.80"
Al Muatadel Cave	26°39'00.00"	38°00'00.00"
Al Naji	18°10'00.00"	42°40'00.00"
Al Othaeb Farms	26°44'00.00"	26°44'00.00"
Al Qaseem	26°08'00.47"	43°38'46.84"
Al Qunfida	19°11'17.54"	41°10'12.66"
Al Shugayri	17°08'00.00"	42°49'00.00"
Al Soudah	18°16'43.05"	42°22'59.59"
Al Ula	26° 37'20.13"	37°56'25.30"
Alagan	28°23'00.00"	36°33'00.00"
Alagan-Algtar	28°52'31.00"	35°30'47.00"
Al-Aytaliah	26°31'00.00"	47°07'00.00"
Albogaz Tunnel	28°06'21.00"	37°04'02.00"
Ara'ar	30°57'03.63"	40°50'25.46"
Bajdah-Alsero	28°20'58.00"	35°48'14.00"
Ben Rasheed cave	24°57'35.67"	46°01'13.08"
Ben Yeshden	18°25'00.00"	42°36'00.00"
Bisha	19°58'34.87"	42°35'24.60"
Buraiman	21°38'00.00"	39°13'00.00"
Dir'iyah	24°44'53.23"	46°32'10.80"
Durma	24°36'20.00"	46°07'08.27"
Far'a Alradadi	24°19'00.00"	39°18'00.00"
Farasan	16°42'39.14"	41°59'10.29"
Hail	27°30'03.85"	41°37'03.00"
Hard	24°09'33.14"	49°04'49.49"
Hufuf	25°23'00.64"	49°34'33.58"
Ibex Reserve	23°25'16.84"	46°46'18.57"
Ibqiq	25°55'57.53"	49°39'50.47"
Jabal Tuwaiq	24°31'06.14"	46°27'31.13"
Jazan	16°56'51.80"	42°40'35.56"
Jeddah	21°32'21.16"	39°33'10.31"
Khamis Mushayt	18°19'52.83"	42°49'13.74"
Maghair shoaib	28°29'17.42"	35°00'11.65"
Makkah	21°25'44.99"	39°56'01.18"
Marrat	25°18'00.00"	45°15'00.00"
Midian	26°51'53.19"	37°59'02.47"
Misfera	18°20'04.72"	42°29'51.25"
Muhayil	18°33'09.22"	42°03'17.72"
Muleh Farms	28°23'56.00"	34°44'47.00"
Muwailih	27°49'00.00"	35°30'00.00"
Najran	17°35'28.30"	44°15'33.91"

Locality	N	E
Naqi	20°14'40.88"	42°42'30.81"
Neom	28°04'24.87"	35°15'19.78"
Qanuna	19°15'00.69"	41°24'40.37"
Ras al Abkhara	27°24'01.30"	49°14'08.47"
Raydah escarpment	18°11'58.28"	42°24'33.29"
Riyadh	24°41'33.51"	46°32'12.85"
Sabihah	16°51'43.51"	42°37'47.75"
Sabya	17°08'07.31"	42°38'35.23"
Sharma-Tor Qunibi	27°58'21.00"	35°13'14.00"
Tabuk	28°20'30.34"	36°31'48.93"
Tabuk Sewage Treatment	28°34'43.00"	36°36'33.00"
Taif	21°16'28.53"	40°24'53.34"
Taima-Al Hamra farms	27°38'10.00"	38°32'49.00"
Thee Ain	19°55'49.83"	41°26'30.29"
Unaizah	26°05'26.63"	43°59'15.16"
Usfan	21°54'58.94"	39°10'54.08"
Wadi Ad Dawasir	20°25'02.98"	44°47'13.23"
Wadi Al Aqeeq	24°22'01.20"	39°33'05.21"
Wadi Al Jouf	18°11'26.40"	42°55'06.80"
Wadi Jazan Dam	17°02'52.20"	42°58'04.87"
Wadi Khadhrāh	23°07'00.00"	23°07'00.00"
Wadi Khaytan	19°45'00.00"	41°40'00.00"
Wadi Sawawin	27°57'00.00"	35°47'00.00"
Wadi Yiba	19°00'00.00"	41°30'00.00"
Wargan	23°57'00.00"	39°13'00.00"
Yanbu Al Nakhel	24°19'22.78"	38°25'56.67"

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