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Review

Bat Diversity and Conservation in Jordan

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Abstract: The diversity and conservation of bats in Jordan were reviewed based on field work and specimen collections. The bat fauna of Jordan consist of 24 species. Zoogeographical affinities of the bats of Jordan are reviewed. Threats to and human impact on current populations are discussed. Recommendations for implementing conservation measures and future bat research avenues in Jordan are highlighted.

Key Words: Bat, diversity, conservation, Jordan, threats

Introduction

Within the past 2 decades, our knowledge of the bats of Jordan expanded significantly (Qumsiyeh, 1980; Amr and Disi, 1988; Qumsiyeh et al., 1992 and 1998, Darweesh et al., 1997; Al-Omari et al., 2000). Yet, these studies also point out significant shortcomings in our knowledge, especially with regard to the ecology and conservation of the bat fauna of this country.

Although Jordan is a small country, the bat fauna is diverse, with 24 species representing 8 families. Jordan is situated at a crossroad between 3 continents and has diverse habitats (Mediterranean, Saharo-Arabian, Irano-Turanian, and Afro-tropical); thus, the list of species reported is probably an underestimate of the actual number of potential records. Our observations, based on fieldwork and study since 1978, have added several species to the recorded bat fauna, and also suggest that the degradation of natural habitats has taken its toll on all aspects of Jordan's wildlife, including bats. The accelerated development in Jordan within the past 30 years may be the cause for significant changes in natural habitats, water resources, and agricultural practices. These changes may have, in turn, affected the well-being of several species of animals, including bats.

This paper reviews the diversity, zoogeographical affinities, threats, and human impact on current bat populations in Jordan.

Taxonomic and Ecological Studies on the Bats of Jordan: A Review

Studies on the bats of Jordan were neglected for many years. The first scientific attempt to study the Chiroptera of Jordan was initiated by Atallah (1966) when he took part in the International Jordan Expedition in 1965. He reported on the bats of Azraq Nature Reserve, then he outlined the bats of Jordan in his landmark contribution Mammals of the Eastern Mediterranean: Their ecology, systematics, and zoogeogaphical relationships (Atallah, 1977 and 1978).

Qumsiyeh (1980) included new records to the bats of Jordan, and later published a paper on the karyotype of some bats from Jordan (Qumsiyeh et al., 1986). Perhaps the most comprehensive treatments of the bats of Jordan were those of Qumsiyeh et al. (1992 and 1998), in which detailed ecological notes were included.

Additional records to the bats of Jordan confirmed the presence of 2 more species (Darweesh et al., 1997;

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Al-Omari et al., 2000). Other older records appeared in Harrison (1959), Nader and Kock (1983), and Bates and Harrison (1989). Only one article dealt with flies associated with the bats of Jordan (Amr and Qumsiyeh, 1993).

Qumsiyeh (1996) and Amr (2000) discussed cumulative records and notes on the ecology, systematics, and biology of the bats of Jordan, with a preliminary proposal for the conservation of the mammals of Jordan.

Diversity of the Chiroptera of Jordan

The Chiroptera of Jordan constitutes of about 31% of the total known mammalian species in Jordan; consisting of 24 species belonging to 8 families (Pteropodidae, Rhinopomatidae, Nycteridae, Emballonuridae, Rhinolophidae, Vespertilionidae, Hipposideridae, and Molossidae) and 13 genera.

Fruit bats are included in one family (Pteropodidae) with a single species, *Rousettus aegyptiacus*. This is an African species that succeeded in penetrating north along the mountain ranges of Jordan into Syria, eventually reaching Turkey (Harrison and Bates, 1991). It prefers humid enclaves along the eastern mountains of Jordan, and avoids dry deserts (Amr, 2000).

The Mouse-tailed bats (Rhinopomatidae) are exemplified by a single genus, *Rhinopoma*, and 2 species. Both species have a wide range of distribution extending from Morocco westwards to India, and eastwards across Arabia. So far, their occurrence in Jordan is confined to caves and crevices within the Mediterranean mountains (Qumsiyeh et al., 1998).

The family Nycteridae is represented by one species, *Nycteris thebaica*. This is an African species, having its most northern range of distribution in Jordan and Palestine.

In Jordan, Emballonuridae, the Sheath-tailed bats, consist of 2 species, *Taphozous perforatus* and *Taphozous nudiventris*. Both species have a wide range of distribution from Africa to India. The known distribution for both species is limited to the southern Jordan Valley, where humidity and water are abundant (Darweesh et al., 1997).

Rhinolophidae is represented by 6 species belonging to one genus (*Rhinolophus*). Species of this family are found in the dense oak and pine forests in northern Jordan (*Rh. ferrumequinum, Rh. blasii, Rh. Euryale*, and *Rh. hipposideros*) or in deserts (*Rh. clivosus* and *Rh. mehelyi*) (Qumsiyeh et al., 1998).

The family Hipposideridae has a single species in Jordan, *Asellia tridens*. This species is a desert-adapted species and is known to dwell in caves close to open water in Wadi Araba (Qumsiyeh et al., 1998).

Vespertilionidae is well-represented in Jordan, where 7 genera (*Myotis, Hypsugo, Pipistrellus, Eptesicus, Otonycteris, Plecotus,* and *Miniopterus*) with a total of 11 species are recorded. *Myotis* and *Pipistrellus* include 2 and 3 species for each genus respectively, while the other genera are represented by a single species. Members of this family have a wide range of distribution and can be found in various habitats, including forests, extreme deserts, and moderate habitats (Qumsiyeh et al., 1998).

Tadarida teniotis is the only species representing Molossidae in Jordan. This is a widely distributed species inhabiting all types of habitats.

Within the Middle East and Egypt, a total of 56 bat species are known. The bats of Jordan comprise about 47% of the total species recorded in the area (Table 1). Iran has the highest bat diversity (39), followed by Turkey (36), Palestine (33), then Saudi Arabia, Egypt, and Syria, with 23, 22, and 21 bat species, respectivelly (Hutson et al., 2001; Benda et al., 2003). Perhaps the limited number of faunal studies in Syria and Egypt can explain the low number of recorded bat species.

Rousettus aegyptiacus, *Rh. hipposideros*, *A. tridens*, *P. kuhlii*, *O. hemprichii*, *P. austriacus*, *M. schreibersii*, *E. bottae*, and *T. teniotis* are widespread throughout the area.

Zoogeographical Analysis of the Chiroptera of Jordan

The zoogeography of the Chiroptera in the Middle East is not well discussed. Lack of specimens and extensive field studies are the main obstacles that hinder a comprehensive assessment of this matter.

The analysis of bat distribution in Jordan is based on locality records reported in the literature, specimens collected in the Jordanian natural history museums, and field notes. This analysis revealed the following tendencies:

Table 1. Distribution of bats in the Middle East.

Family/Species	Jordan	Palestine	Syria	Iraq	Turkey	Arabia*	Iran
Pteropododae							
Rousettus aegyptiacus	•	•	•		•	•	•
Eidolon helvum						•	
Rhinopomatidae							
Rhinopoma hardwickii	•	•		•		•	•
Rhinopoma microphyllum	•	•				•	•
Rhinopoma muscatellum				•		•	•
Emballonuridae							
Taphozous nudiventris	•	•	•	•	•	•	•
Taphozous perforatus	•	•			•	•	•
Coleura afra						•	
Rhinolophidae							
Rhinolophus ferrumequinum	•	•	•	•	•		•
Rhinolophus clivosus	•	•				•	
Rhinolophus hipposideros	•	•	•	•	•	•	•
Rhinolophus euryale	•	•			•		•
Rhinolophus mehelyi	•	•	•	•	•		•
Rhinolophus blasii	•	•			•	•	•
Nycteridae							
Nycteris thebaica	•	•					
Hipposideridae							
Asellia tridens	•	•	•	•	•	•	•
Hipposideros caffer						•	
Triaenops persicus						•	•
Vespertilionidae							
Myotis blythii		•	•	•	•	•	•
Myotis bechsteinii					•		•
Myotis brandtii					•		
Myotis daubentonii					•		
Myotis emarginatus	•	•	•	•	•		•
Myotis capaccinii	•	•		•	•		•
Myotis myotis		•	•		•		
Myotis mystacinus					•		•
Myotis aurascens					•		

Table 1. continued

Myotis nipalensis					•		
Myotis nattereri	•	•	•	•	•		•
Myotis schaubi							•
Myotis bocagii						•	
Pipistrellus ariel	•	•					
Pipistrellus kuhlii	•	•	•	•	•	•	•
Pipistrellus nathusii					•		•
Pipistrellus pipistrellus		•	•	•	•		•
Pipistrellus pygmaeus					•		
Pipistrellus rueppellii		•		•		•	•
Hypsugo bodenheimeri	•	•				•	
Hypsugo arabicus						•	•
Hypsugo savii		•	•	•			•
Nyctalus noctula		•			•		•
Nyctalus leisleri					•		•
Nyctalus lasiopterus					•		•
Eptesicus bottae	•	•	•	•	•	•	•
Eptesicus serotinus		•	•		•		•
Eptesicus nasutus				•		•	•
Otonycteris hemprichii	•	•	•	•	•	•	•
Barbastella barbastellus		•			•		
Barbastella leucomelas							•
Plecotus auritus					•		
Plecotus austriacus.	•	•	•	•	•	•	•
Plecotus kolombatovici					•		
Plecotus macrobullaris					•		
Miniopterus schreibersii	•	•	•	•	•	•	•
Nycticeinops schlieffeni						•	
Scotophilus leucogaster						•	
Vespertilio murinus					•		•
Molossidae							
Tadarida teniotis	•	•	•	•	•	•	•
Tadarida aegyptiaca						•	•
Tadarida midas						•	
Tadarida pumila						•	
Tadarida nigeriae						•	

* Arabia = Arabian Peninsula.

This matrix is based on DeBlase (1980), Qumsiyeh (1985, 1996), Harrison and Bates (1991), Benda and Horáček (1998), Benda et al. (1999a,b), Sachanowicz et al. (1999), Amr (2000), Benda and Tsytsulina (2001), Spitzenberger et al. (2002), Benda et al.(2003) and, Hulva et al. (2004).

1. Mediterranean species: *Rhinopoma microphyllum*, *Rhinolophous ferrumequinum*, *Rh. clivosus*, *Rh. hipposideros*, *Rh. euryale*, *Rh. blasii*, *M. emarginatus*, *M. capaccinii*, *M. nattereri*, and *M. schreibersii*.
2. Afro-Tropical (Sudanian): *R. aegyptiacus*, *T. nudiventris*, *T. perforatus*, *Rh. mehelyi*, *A. tridens*, *N. thebaica*, and *P. ariel*.
3. Saharo-Arabian: *Hypsugo bodenheimeri*, *E. bottae*, and *P. austriacus*.
4. Widespread: *P. kuhlii* and *T. teniotis*.

Atallah (1978) gave a zoogeographical summary for mammals of the eastern Mediterranean. He listed *Rh. ferrumequinum*, *Rh. hipposideros*, *Rh. euryale*, *M. emarginatus*, *M. capaccinii*, *M. nattereri*, *P. kuhlii*, and *P. austriacus* as characteristic species of the Mediterranean region. *Rhinopoma microphyllum*, *Rh. hardwickii*, *A. tridens*, *H. bodenheimeri*, and *O. hemprichii* were considered as Saharo-Sindian bats. Ethiopian elements (Sudanian or Afro-Tropical) included *R. aegyptiacus*, *T. nudiventris*, *N. thebaica*, and *Rh. clivosus*. He considered *Rh. blasii* and *M. schreibersii* as pluriregional species that can be found in 2 of the main zoogeographical regions.

Qumsiyeh (1985) presented an analysis of the mammals of Egypt, including bats, utilizing a matrix that showed the distribution of mammals over 20 areas, extending from southern Spain across northern Africa, and to Afghanistan in the east. He concluded that *R. aegyptiacus*, *T. perforatus*, *N. thebaica*, and *Rh. clivosus*, were of Sudanian (Afro-Tropical) affinities. Moreover, *Rh. mehelyi* was confined to the Mediterranean region, while *Rh. hardwickii*, *Rh. microphyllum*, *A. tridens*, *E. bottae*, and *O. hemprichii* were distributed within the Saharo-Sindian ecozone. *Rhinolophus hipposideros*, *P. kuhlii*, and *T. teniotis* were widespread.

A further zoogeographical analysis of the bats of Iran (DeBlase, 1980) showed 75% of the bat fauna of Iran was similar with that of the Levant (Lebanon, Palestine, western Syria and Jordan, Sinai, and Hatay Province in Turkey), compared to 64% with Mediterranean Europe.

At least 4 species of African origin (*Rousettus aegyptiacus*, *N. thebaica*, *Rh. clivosus*, and *A. tridens*) penetrated eastwards into the Arabian Peninsula and northwards into Jordan and Syria. *Rhinolophus ferrumequinum*, *Rh. hipposideros*, *Rh. mehelyi*¸ *Rh. euryale*, *M. capaccinii M. emarginatus*, *M. nattereri*, and *M. schreibersii* are considered of Palaearctic origin, with a wide distribution in Europe and around the Mediterranean basin (Corbet, 1978).

None of the bats of Jordan can be considered endemic. *Hypsugo bodenheimeri* is the only species confined to southern Palestine and Jordan, Arabia, and Sinai (Harrison and Bates, 1991).

Rhinolophus ferrumequinum, *Rh. mehelyi*¸ *Rh. euryale*, *M. capaccinii M. emarginatus*, *M. nattereri*, and *M. schreibersi* are mainly distributed in the northwestern part of Jordan, while *A. tridens* and *E. bottae* can be considered as southern species.

Global and Regional Interests in Bat Conservation

Historically, bats did not receive significant attention in conservation circles in many parts of the world, including Jordan. In Jordan, conservation was mostly focused on carnivores and ungulates (Qumsiyeh et al., 1993 and 1996; Bunaian et al., 2001), with minimal interest in bats and other relevant themes.

Recently, bat conservation received the attention and concern among several researchers and national and international conservation agencies (Mickleburgh, 2001; Mickleburgh et al., 2002). Previously, Stebbings (1995) and Fenton (1997) gave excellent accounts of the need for protecting bats.

The International Union for the Conservation of Nature (IUCN) Species Survival Commission published the results of the first comprehensive review of bat conservation in 2 studies (Mickleburgh et al., 1992; Hutson et al., 2001). These documents included reviews on the biology and ecology of bats, and conservation issues, along with recommendations for a conservation action plan that can adopted in other countries.

We will limit our review to bat conservation efforts in Europe and the Middle East. In Europe, several studies were entirely dedicated to bat conservation; Northern Ireland (Russ and Montgomery, 2002), Italy (Russo et al., 2002), Lithuania (Pauza and Pauziene, 1998), England (Mitchell-Jones et al., 1986, 1993), Belgium (Marie-Odile, 1996), while few researchers took the initiative to report on bat conservation in the Middle East; Iran (Sharifi et al., 2000), Palestine (Carmel and Safriel, 1998; Korine et al., 1999), and Turkey (Furman and Özgül, 2002).

All these studies pointed out declining bat populations, identified major threats, and proposed conservation measures. Public awareness and education on the biology of bats, their life histories, and role in the environment were suggested as conservation measures.

Threats affecting the Chiroptera of Jordan

Insecticides

The uncontrolled use of insecticides is perhaps one of the main threats affecting the population of bats in Jordan. Since the establishment of the Kingdom, extensive amounts of DDT and other organophosphorous insecticides were used for the control of malaria and *Leishmania* vectors all over the country, especially the Jordan Valley. Caves were sprayed unintentionally to eradicate resting mosquitoes and sandflies. In my experience with the Ministry of Agriculture, bats were not targeted as pests; yet, several populations of the Egyptian Fruit Bat, *R. aegyptiacus*, declined sharply. In 1978, a cave over looking the Yarmouk River used to be a haven for bat enthusiasts, where thousands of bats were roosting. Unfortunately, on our last visit (2001) to the same cave, only a few hundred remained. Extensive spraying of Deltamethrin was carried out in this cave due to an outbreak of leishmaniasis in the neighboring villages in 2001.

Also, several insect populations declined as a result of various insecticides employed in agriculture. This is the case in the Jordan Valley, where agricultural projects are extensive, and is an area that used to harbor the highest diversity of bats.

Habitat alternation

Deforestation

Several bat species occurring in Jordan are found within the limited natural forests. *Rh. ferrumequinum*, *Rh. blasii*, *Rh. euryale*, *M. emarginatus*, *M. capaccini*, *M. nattereri*, and *M. schreibersii* are forest inhabitants. Human activities including logging, vacationing, and clearing private forests for agricultural or housing projects are major threats to bat populations. These activities deprive bats of roosting and feeding, causing a substantial decline in their populations.

Urbanization

The population of Jordan increased 7.7-fold during the past 45 years. In 1952, the population of Jordan was about 600,000, whereas in 1997, it was 4,600,000. This increase created a great burden for the natural habitats of Jordan. Cities, towns, and villages all expanded greatly at the expense of wild habitats all over the country. The most important factor that affected bat populations was the changes in construction style. Houses in villages were usually constructed of mud or stone, with galleries and storage areas that were suitable for bat roosting. These old houses were demolished and replaced by modern houses. Bats populations are still surviving in vacant old houses in deserted villages. This is true for the Larger Horseshoe bat, *Rh. ferrumequinum*, and large colonies are still active in uninhabited old villages. Similarly, bat roosts can be explored in old houses of wooden construıction and mud-hay domes.

In addition to changes in construction style, noise and heavy traffic in cities and towns disturbed many species of bats that are sensitive to human activity. In 1959, *Rh. ferrumequinum* was a common bat in Swialeh, a township close to Amman (Harrison, 1959); however, it is completely absent now due to expanded urbanization and population increase.

Agricultural Expansion

The population of Jordan grew very sharply within the past 50 years as a result of natural population growth and mass deportation of refugees from Palestine during 1948 and 1967. Agricultural practices increased intensely to meet the demand of the Jordanian consumers, as well as to create a source of revenue. Exploitation of land for intensive agriculture caused severe depletion of natural habitats for wildlife in the Jordan Valley, eastern mountains, Wadi Araba, and the Eastern Desert. For example, several caves and ledges in Wadi Araba were inhabited by bats in 1978, and when agricultural projects began to expand, bat populations declined, and some disappeared completely (e.g. *Rh. blasii*) (Qumsiyeh et al., 1998). Other examples were witnessed by the author in the Eastern Desert and Jarash area, where caves that used to be frequented by bats in the 1980's have now been abandoned. Large colonies of *P. kuhlii* that used to be common in the Eastern Desert are very scarce.

The Egyptian Fruit Bat was considered an agricultural pest in Palestine. Fumigation and sealing of caves inhabited by this bat resulted in mass killing along with other insectivorous bats (Makin and Mendelssohn, 1986).

Road Construction

The network of highways and roads across the country increased immensely within the past 20 years. The rocky terrain of the eastern mountains offers suitable habitats for many bat species of Jordan. Caves and caverns were demolished while constructing highways linking major cities along the Mediterranean stretch of the eastern mountains.

Tourism and Vacationing

Local tourism and other outdoor activities in wild habitats (e.g. Wadi Rum, Zobya, and Dibbin Forests) disturbed the roosting populations of several bat species. For example, large colonies of *R. ferrumequinum* are absent in the northern forests, and only a few individuals are present now. Hiking and tourism in Wadi Ram might have a considerable contribution in declining populations of *E. bottae*.

As indicated earlier, the Egyptian Fruit Bat populations declined from several sites where bats used to be found in abundance. A cave near Al Hemma, located on the Yarmouk River, used to harbor thousands of bats. In my latest visit to this cave, only a few hundred of the fruit bats were present. Similarly, a cavern in Wadi ben Hammad, near Karak, lost most of its population of the Egyptian Fruit Bat.

Status of the Chiroptera of Jordan

Table 2 shows the status of bats in Jordan and the surrounding countries. Nine of the 24 bat species recorded in Jordan are listed in the IUCN Red Data Book (Red Data Book, 2000), which constitutes about 40% of the total known species. *Miniopterus schreibersii, Rh. blasii*, *Rh. ferrumequinum*, and *H. bodenheimeri* are in the low risk category, while *M. capaccinii*, *M. emarginatus*, and *Rh. hipposideros* are vulnerable. However, the remaining species, with the exception of *R. aegyptiacus* and *Pipistrellus kuhlii*, are considered vulnerable and require further assessment.

This analysis shows the urgent need to assess the existing bat population in Jordan, taking into consideration the alarming decline in bats observed in their natural habitats. Further studies of the ecological requirements and habitat selection for the bats of Jordan are needed. Such studies will provide base-line data to implement conservation strategies for each species.

Table 2. Red Data Book Conservation Categories for the Bats of Jordan and Surrounding Countries

Species	IUCN status	Jordan	Palestine	Saudi Arabia	Syria	Lebanon	Iraq
M. schreibersii	LR/nt	•	•	•	•	•	•
M. capaccinii	VU A2c	•	•			•	•
M. emarginatus	VU A2c	•	•	•		•	
M. myotis	LR/nt		•		•	•	
H. bodenheimeri	LR/nt	•	•		•		
Rh. blasii	LR/nt	•	•		•		
Rh. ferrumequinum	LR/nt	•	•	•	•	•	•
Rh. hipposideros	VU A2c	•	•	•		•	•
Rh. euryale	VU A2c	•	•		•	•	
Rh. mehelyi	VU A2c	•	•			•	•
E. nasutus	VU A2c			•			•
Total		9	10	5	6	8	6

Bat Conservation and Protection

A legal framework for animal protection in Jordan was initiated in 1973 with enactment of laws regulating hunting and trapping of wild animals. Jordan subsequently signed a number of international treaties for protection of wildlife. The most significant with regards to bats was the Convention on Migratory Species, which Jordan ratified on January 3, 2001. In May 1992, with help from the IUCN, a team of over 180 Jordanian specialists were asked to develop a strategy of environmental protection combined with sustainable development. It was entitled "National Environment Strategy for Jordan." The document offered over 400 recommendations and outlined 5 strategic initiatives for facilitating and institutionalizing long-term progress in the environmental sphere:

1. Construction of a comprehensive legal framework for environmental management;
2. Strengthening of existing environmental institutions and agencies, particularly the Department of Environment and the Royal Society for the Conservation of Nature (RSCN);
3. Providing an expanded role for Jordan's protected areas;
4. Promotion of public awareness of and participation in environmental protection programs;
5. Giving priority to water conservation and slowing Jordan's rapid population growth.

This plan seems reasonable, but resources devoted to enforcement and actual implementation are extremely limited. In the case of bats, despite the presence of a legal framework designated to protect wild animals in Jordan, no article has specifically referred to the protection of bats per se, and no program has been implemented to actually protect them. The RSCN, a non-governmental organization, with the legal and logistical support of the government of Jordan, was assigned the role of managing nature reserves and wildlife conservation and protection; however, no attention was given to bat conservation.

From a cultural point of view, bats are disliked. This attitude is due to the lack of understanding of the ecological role and importance of bats. Bats are not deliberately killed, either for food or traditional medicine; however, misconceptions and superstitions about them make them vulnerable to attack when encountered.

These issues are not unique to Jordan and are faced by all scientists dealing with bat conservation in other countries.

Thus, the role of the RSCN and other national agencies involved in nature conservation is, first and foremost, to educate the public about the importance of bats in controlling agricultural pests and vectors of some endemic diseases in Jordan (Malaria and *Leishmania*). Further actions are needed to enforce bat conservation through enforcement of existing legislation.

Recommendations on Future Bat Research and Conservation in Jordan

Research should be constructed on the following subjects

1. Additional records of bats that are suspected to exist in Jordan, such as *Pipistrellus pipistrellus, P. rueppellii, Nyctalus noctula, Eptesicus serotinus*, and *Tadarida aegyptiaca*.
2. Habitat preference of bats in the main biogeographical regions of Jordan.
3. Feeding habits of endangered species and inter-specific competition of associated species.
4. The reproductive biology of some selected species.
5. A comparison of population densities in nature reserves and unprotected areas.
6. Identify, quantitatively and qualitatively, the impacts of various man-made changes and threats to the existing bat population.
7. Identify and mapping the most important roosting sites.
8. Identify the main threats (current and potential) to key roosting sites.

Education and Conservation

1. For better promotion of bat conservation, a task force affiliated with the RSCN and/or other local nature conservation societies should be formed. This task force should consist of nature enthusiasts, academics, and conservation specialists. Adequate training of RSCN staff based

on bat conservation in countries with prior experience in this field should be formulated.

2. We suggest an educational campaign in collaboration with the Ministry of Education targeting public schools in Jordan. The aim would be to increase awareness of the need for conservation in general, and of bats in particular.
3. Work must be initiated to expand enforcement efforts regarding existing laws and expand the legal framework for bat conservation. This can be along the lines of the recommendations made in 1992 by the "National Environmental Strategy for Jordan".

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