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The occurrence and distribution of bats in Qatar

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ABSTRACT

The distributions of bat species in Qatar have not previously been recorded. We conducted the first nation-wide survey of bats in Qatar. Based on sonogram analysis, we identified Asellia tridens, Otonycteris hemprichii, and Pipistrellus kuhlii. The most commonly recorded species was Asellia tridens, the only species recorded in the northern half of the country. Contrary to our prediction, the likelihood of recording bats was not higher in the northern half of the country where there are many irrigated farms. The distributions of the bat species may result from differences in human land use and disturbance, and from the distance to the main body of the Arabian Peninsula. A key habitat feature for Asellia tridens and Otonycteris hemprichii may be the presence of roosting sites in less disturbed sinkholes/caves, which are therefore crucial for bat conservation.

1. Introduction

Environmental problems, including biodiversity conservation and the prevention of emerging infectious diseases, are at the forefront of many political, societal and economic agendas (Voigt and Kingston, 2016). Bats have recently attracted attention as possible natural reservoirs of coronaviruses responsible for zoonotic diseases. These include the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causing the COVID-19 pandemic (Shereen et al., 2020) and the Middle East respiratory syndrome coronavirus (MERS-CoV) causing MERS (Mohd et al., 2016). One of the first steps towards ensuring the conservation of biodiversity is to determine the presence and distributions of species present (Jennings, 1995), and this surely applies for tackling zoonotic diseases as well. Two species of bats have been previously recorded in Qatar: Geoffroy’s trident leaf-nosed bat, Asellia tridens, and desert long-eared bat, Otonycteris hemprichii (Harrison, 1964, 1981; Madkour, 1986; Harrison and Bates, 1991; Juste and Paunovic, 2016; Monadjem et al., 2017a, b). It appears that the presence of Kuhl’s pipistrelle, Pipistrellus kuhlii, has never been reported, although the distribution range map of the IUCN Red List of Threatened Species includes Qatar in the species range (Harrison, 1964, 1981; Madkour, 1986; Harrison and Bates, 1991; Juste and Paunovic, 2016). Frustratingly, knowledge about bats in Qatar has not been expanded substantially since David Harrison conducted his milestone research on the mammals of Arabia more than half a century ago. A systematic large-scale survey of bats has never been conducted in the country, and all bat records have been made opportunistically. As a result, in the latest version of the IUCN Red List of Threatened Species (Monadjem et al., 2017b), it is considered uncertain whether Asellia tridens still occurs in Qatar. A large-scale nation-wide bat survey in Qatar is a priority for developing the information base for biodiversity conservation and for informing research on emerging infectious diseases.

For the last 50 years throughout the Gulf Region, rapid economic development has resulted in habitat transformations of much of the natural desert into urban and industrial zones, and for agricultural developments through intensive irrigation (Richer, 2009; Abu Baker et al., 2017). This change in land use, along with dramatically increased water availability, has likely influenced the distribution and space use by various wildlife species (Abu Baker et al., 2017; Abdulkarim and Yamaguchi, 2020). Although Qatar is dominated by hyper-arid environments and is one of the few countries in the world where there is not a single natural surface freshwater source available throughout the year, there are now large irrigated areas in the northern half of the country, and especially the north eastern quarter of the country (Shomar et al., 2014). Such high concentrations of irrigated farms may increase resource level (e.g. insects) and create favourable habitats for bats. However, to date, there is no information concerning bat distribution with reference to the different types of land use in Qatar.

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In this study, we document the first nation-wide bat survey in Qatar and aim to provide information on the bat species and their distributions in the country, together with the potential influences on bat distribution of land use changes.

2. Materials and methods

The bat survey was conducted between September 2018 and April 2019. Firstly, we identified possible roosting and activity areas including sinkholes/caves, old water wells, bridges, and farms, with a special emphasis on locating the sinkholes/caves described in Sadiq and Nasir (2002). We visited six sinkholes/caves that were accessible. Whilst we attempted to cover as much of the country as evenly as possible within logistical constraints (56 sites in total), we also interviewed farm workers, livestock keepers, and villagers to identify locations where bats might occur. We arrived at a site before sunset and acoustically surveyed bats using a bat detector (Echo Meter Touch 2, Wildlife Acoustics, Maynard, USA) in and around the site (in most cases, up to c. 500 m × 500 m in area), until approximately 2 h after sunset. We moved the bat detector in and around the site on foot and/or by 4x4 vehicle. Due to the potential risks of zoonotic diseases including MERS, as well as to minimise disturbances to bat colonies, we did not enter potential roost sites.

If we detected any bat call during that period we classified the bats “present”, or otherwise “absent” at that site. We classified a site as a roost when 1) the site had a structure appropriate for bat roost (e.g. cave, sinkhole, or abundant houses), and 2) more than two bats were visibly detected emerging from the structure shortly after sunset. We visited one site per night, unless more than one site were easily covered logistically (e.g. two irrigated farms that can be driven backwards and forwards by a 4x4 vehicle easily within c. 10 min). If necessary, we revisited sites where bat presence was recorded to assess whether the sites were likely to be used as roosts. The effective range of the detector used was c. 20–30m. The detector had reference data bases for North America, Europe and the United Kingdom, Neotropics, and South Africa. Therefore, for bat species identification in the field, we set the auto-ID region to Europe, and selected Turkey, the closest available country to Qatar. Later, the recorded bat calls were analysed using Kaleidoscope PRO software (Wildlife Acoustics) for species identification, based on call characteristics known from other parts of the Middle East were used (Benda et al., 2006, 2008, 2012; Benda and Uhrin, 2019; Hackett et al., 2017). We also recorded the dominant habitat features of each site, which was then classified into one of the following four categories: sinkhole/cave, irrigated farm, open desert, and artificial structure. Differences in bat occurrence between northern and southern halves of Qatar, and habitat features, were tested using the likelihood ratio Chi square test, and the statistical analyses were performed using SPSS 25 (IBM, Armonk, USA).

3. Results and discussion

A total of 287 acoustic ultrasound recordings were collected across Qatar, of which 169 were bat call sequences. We identified the two species that had been previously recorded (Asellia tridens and Otonycteris hemprichii. Asellia tridens (Fig. 1) was the most widely distributed bat species in Qatar (Fig. 2) with 107 calls recorded. The occurrence of A. tridens in Qatar is considered uncertain in the latest version of the IUCN Red List of Threatened Species (Monadjem et al., 2017b). We confirmed its presence. Also, we report the presence of Pipistrellus kuhlii in Qatar for the first time. The sonogram of Asellia tridens (Fig. 3a) has a relatively long constant frequency (CF) component at around 118.0 kHz followed by a rapid downward frequency sweep to 90.0 kHz, with the total length of a call c. 7.90 ms. It has the average Fmax of 118.1 kHz, Fmin of 99.5 kHz, and Fc of 115.1 kHz (Table S1), and is similar to that of A. tridens previously recorded in the Middle East (Benda et al., 2006, 2008; Hackett et al., 2017). Otonycteris hemprichii was the least common of the three species with 14 call sequences recorded, and its call is characterised by Fmax (36.5 kHz), Fmin (20.5 kHz), and Fc (21.0 kHz) (Table S1, Fig. 3b), and is similar to that of O. hemprichii previously recorded in the Middle East (Benda et al., 2008, 2012; Hackett et al., 2017). While O. hemprichii is the quietest of the recorded species and therefore perhaps more likely to have been missed, it also has the lowest frequency calls which attenuate more slowly. As we were recording presence/absence, differences in call frequencies, atmospheric conditions and habitat are unlikely to alter the results substantially. Pipistrellus kuhlii was recorded only in the south of Qatar (Fig. 2). Pipistrellus kuhlii (48 calls recorded) has a FM-QCF call characterised by Fmax (48.8 kHz), Fmin (36.6 kHz), and Fc (37.5 kHz) (Table S1, Fig. 3c) and is similar to that of P. kuhlii previously recorded in the Middle East (Hackett et al., 2017; Benda et al., 2012; Benda and Uhrin, 2019).

All the sinkholes/caves visited were inhabited by bats except one in the capital city Doha (Fig. 2), where the urban disturbance around the site may have made it less attractive as a roost. The majority of irrigated farms in Qatar are located in the area from Doha northward (Abdulkarim and Yamaguchi, 2020). We expected that we would encounter bats more frequently north of Doha as those irrigated farms may produce
more food resources (i.e. insects) which attract bats. However, the opposite was found, with only 11.1% of sites in the north having bats (absent 36, present 4) compared with 27.3% in the south (absent 16, present 6) (Fig. 2) and the difference was marginally statistically significant (likelihood ratio Chi square test: $df = 1, \chi^2 = 3.00, p = 0.084$). Insectivorous bats often show fidelity to specific foraging sites, and hence, bats may be less likely to show fidelity to sites with unpredictable resource availability such as farms with active insect pest control (Kahnonitch et al., 2018). Pesticides are used in irrigated farms in the northern Qatar as part of insect pest control (Abdulrahman, unpublished), and hence these farms may not be as attractive as foraging sites for bats as they might appear. However, we emphasise that our survey was not designed to monitor bat activities, including foraging, throughout the night and was not able to pick up bat calls unless they came within 30 m of the observers. Therefore, our results do not necessarily reject the hypothesis that bats forage in those irrigated farms in the northern Qatar. There was a statistically significant difference in how likely bats are encountered amongst those four habitat categories: sinkhole/cave (present at 5 sites, absent at 1 site), irrigated farm (present 4, absent 18), open desert (present 1, absent 24), artificial structure (present 0, absent 9) (likelihood ratio Chi square test: $df = 3, \chi^2 = 20.12, p < 0.001$). Five sinkhole/cave sites out of six were used by bats as roosting sites. None of the other 56 sites appeared to be used as a roost, suggesting that sinkholes/caves in less disturbed locations are extremely important for bats (at least for Asellia tridens and Otonycteris hemprichii) to survive in this hyper-arid environment, probably by providing less extreme temperatures and higher humidity. Pipistrellus kuhlii is known to roost in small numbers in fissures and holes in aeolianite outcrops in the deserts of the UAE (Gardner, unpublished), and therefore may not be reliant on the presence of sinkholes and caves. In Iran, the species roosts in a wide range of man-made structures as well as crevices (Benda et al., 2012).

Although we found Asellia tridens throughout Qatar, both Otonycteris hemprichii and Pipistrellus kuhlii were found only in the south. We speculate that these distributions may reflect the peninsula effect, first postulated by Simpson (1964), where distance from the main Arabian Peninsula is a factor affecting diversity. The main Arabian Peninsula has a higher bat diversity and greater abundance than found in Qatar (Harrison and Bates 1991). Due to the geographical proximity, bats may colonise southern Qatar from the main Arabian Peninsula more easily than the north of the country. Alternatively, in the north of Qatar, with a high concentration of irrigated farms, the bat populations may be affected by pesticide use. Bats may be more sensitive to pesticide use compared to other mammals (Stahlschmidt and Bähnl, 2012).

Four of the five roost sites appeared to be occupied by a single bat species (either Asellia tridens or Otonycteris hemprichii, based on detection of calls). The single exception was the Mudhlem sinkhole site in the south (see Fig. 2) where two call sequences of Pipistrellus kuhlii were recorded whilst call sequences of Asellia tridens dominated the site. However, we are not certain if the sinkhole is used as a roost site by Pipistrellus kuhlii. This may suggest the possibility of interspecific competition, where the more abundant Asellia tridens limits the range expansion of Otonycteris hemprichii and Pipistrellus kuhlii within Qatar. A similar pattern where one bat species is dominant in a relatively poor bat fauna is observed in Bahrain, where Pipistrellus kuhlii constitutes 96.1% of the 456 bat call sequences recorded, followed by Rhyneptesicus nasutus (3.5%), Otonycteris hemprichii (0.06%), and Taphozous nudiventris (0.01%), while Asellia tridens was not recorded although it is likely to be present (Benda and Uhrin, 2019). suggest that in the relatively poor bat fauna of Bahrain, only one species might have been able to benefit most from the mixed habitat of natural arid environment, irrigated green areas, and urban landscape, despite the possible similar abilities of the other species to utilise such mixed habitat. As Qatar and Bahrain are adjacent to each other with very similar natural habitats and human land uses, the difference in the most abundant species is interesting, and there may be a possibility that biotic (e.g. inter-specific competition) rather than abiotic (e.g. physical environment) factors result in the observed difference. More research is clearly needed for a better understanding of the distribution, behaviour, and ecology of the bats in the Gulf Region to answer the mechanisms resulting in the dominance of particular species in seemingly very similar arid environments, and for tackling bat biodiversity conservation and possible emerging zoonotic diseases in the region.

CRediT authorship contribution statement

Makтом Abdulrahman: Planning research, data collection, Formal analysis, writing draft. Andrew Gardner: Conception of research, planning research, Data analysis, reviewing manuscript. Nobuyuki Yamaguchi: Conception of research, planning research, data collection, data analysis, writing draft.

Declaration of competing interest

The authors declare that they have no known competing financial
interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jaridenv.2020.104379.

**Fig. 3.** Sonograms of bats recorded in Qatar: a) *Asellia tridens*, b) *Otonycteris hemprichii*, and c) *Pipistrellus kuhlii*. Note that scales of both horizontal and vertical axes are different between species.

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