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Mammalian activity at artificial water sources in Dana Biosphere Reserve, southern Jordan

Sarah Edwards [a], Malik Al Awaji [c], Ehab Eid [c, d], Omar Attum [b, *]

[a] Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa
[b] Dept. of Biology, Indiana University Southeast, 4201 Grant Line Rd., New Albany, IN 47150, USA
[c] Eco Consult, Amman, Jordan
[d] The Royal Marine Conservation Society, Amman, Jordan

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ABSTRACT

Desert conditions such as high ambient temperatures and scant rainfall result in water being a rare and essential resource for many species, and consequentially artificial water sources are often installed in such environments. Permanent water has the potential to influence multiple aspects of a species' ecology, such as movement, activity, predation and thermoregulation. Given the importance and potential impact of artificial water sources, this study used camera traps to record mammal presence and activity at two artificial water sources in Dana Nature Reserve, Jordan. Seven mammal species, each with distinct activity patterns, were recorded at the water sources, including Nubian ibex, a species of conservation concern. Evidence of temporal resource partitioning was recorded between all species, with the exception of porcupine and striped hyena. Due to the small size of the water sources, temporal partitioning between species may be used as a means of avoiding drinking in close proximity to other species, including potential predators.

1. Introduction

Desert environments are generally characterised by high ambient temperatures, intense solar radiation, scant rainfall and low primary productivity (Ostrowski et al., 2002). As a result, water has a significant impact on the ecology of species inhabiting such environments (Shmida et al., 1986), which are especially challenging for thermoregulation and water balance (Cain et al., 2006). In arid ecosystems, water can influence the spatial ecology of wildlife (e.g. Leggett, 2006), as water availability may limit the daily distances wildlife are able to move in search of food (Chamaillé-Jammes et al., 2007).

Aggregations of numerous species occur around permanent water holes when surface water is scare, which often results in the waterholes becoming potential sites for competition, as well as high risk areas for predation (Valeix et al., 2009). Although larger and permanent water sources are non-depleting and hard to defend, small water sources may allow only a few animals to drink at once, meaning close proximity between species when using the resource at the same time. This may be problematic, especially between potential predators and prey, and species may use temporal partitioning to avoid such close and/or direct encounters, and promote species coexistence (Schoener, 1974).

Given the potential for artificial water sources to influence the presence and activity patterns of local wildlife, this study used camera traps to examine mammalian visits to two artificial water sources in Dana Biosphere Reserve, southern Jordan. Presence and activity patterns of mammals at water points were recorded, and the degree of overlap between species pairs calculated, as well as tests for temporal resource partitioning performed.

2. Materials and methods

2.1. Site description

The study was conducted at Dana Biosphere Reserve, southern Jordan. The reserve (320 km^2) is home to wildlife species of conservation concern, such as Nubian ibex and striped hyena *Hyaena hyaena* (Near threatened). The reserve contains approximately 60 permanent and semi-permanent water sources (Attum et al., 2016), with an average annual rainfall of 61 mm. Reserve management

* Corresponding author.
E-mail address: oattum@ius.edu (O. Attum).

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installed three permanent water sources in the core zone of the reserve, which is believed to hold the highest biodiversity within the reserve and is consequently a focus area for conservation action (Attum et al., 2016).

3. Methods

Mammal activity was recorded at two artificial water sources, 460 m apart, located within the reserve's core zone, Site B (30.6887° N, 35.58327° E) built in June 2003 on a flat plateau, and Site C (30.6873° N, 35.5787° E) built in 2010 at a plateau edge. Water sources were small, being approximately 1 m in diameter and less than 12 cm deep. Data collection at Site B ran from June to November 2011, representing hot summer months (April to October). At Site C, two data collection periods were used, the first being from January to September 2011, containing both winter and summer months, and from April to November 2012 at Site C, representing summer months only. A single Scoutguard SG560 (HCO Outdoors, Norcross, GA, USA) was installed at each water point, at a distance of 6–7 m from the water, set to be active 24 h a day, with medium sensitivity, a minute interval between triggers, with one photo per trigger.

Data were analysed separately for each site, with data from 2011 (winter and summer months) analysed separately from 2012 (summer months only) data for Site C due to potential seasonal effects on waterhole use patterns as observed in Nubian ibex (Wakefield et al., 2008). Mammal records were identified to species level and classified into independent events using a criterion of 30 min or more between consecutive records of the same species (O'Brien et al., 2003). Events were viewed as a random sample taken from an underlying continuous temporal distribution, describing the probability of an event occurring at any particular time (Ridout and Linkie, 2009). Package 'overlap' version 0.2.6 (Meredith and Ridout, 2007) in R 3.1.1 (R Development Core Team, 2014) was used to non-parametrically estimate and plot the probability function of the distribution (as detailed in Ridout and Linkie, 2009), to give a visual representation of activity pattern. Coefficients of overlap between species pair were also calculated using the 'overlap' package, using estimator Δ_1, as suggested for sample sizes of <50 (Ridout and Linkie, 2009). Coefficients of overlap ran between 0 and 1, with 0 representing no overlap, and 1 representing a complete overlap. Confidence intervals for coefficients of overlap were calculated using 500 bootstraps.

Activity patterns at the water points were compared using circular Mardia-Watson-Wheeler tests (MWW), to test the null hypothesis of activity patterns being identical for each species pair, using the program Oriana (Kovach Computing Service, Pentraeth, Isle of Anglesey, UK; Kovach Computing Services, 2013). Not all large mammal species could be analysed, as the test requires a sample size of $n \geq 10$. Oriana was also used to calculate the mean vector, which is equivalent to the mean activity time.

4. Results

Seven mammal species were recorded; Indian crested porcupine *Hystrix indica*, Cape hare *Lepus capensis*, caracal *Caracal caracal*, striped hyena, Arabian wolf *Canis lupus arabs*, red fox *Vulpes vulpes* and Nubian ibex during a total of 605 camera trap nights (168 Site B and 437 Site C). Additionally, unidentified snakes, lizards and bats were recorded. A total of 703 independent events occurred in which mammals were recorded; porcupine ($n = 73$), Cape hare ($n = 6$), caracal ($n = 39$), striped hyena ($n = 283$), Arabian wolf ($n = 22$), red fox ($n = 8$) and ibex ($n = 272$). Due to low sample sizes red fox and Cape hare were not included in analyses. All species, with the exception of ibex, were present at Site B which was not considered suitable habitat for ibex, whilst only porcupine, striped hyena and ibex were recorded at Site C. All species had nocturnal or dawn mean activity times, with porcupine showing a mean vector time between 01:32 and 02:30 across sites and years, caracal had a mean vector at 00:56, striped hyena mean vector varied between 01:20 and 02:46, wolf mean vector was 04:49 and ibex mean vector time ranged from 05:05 to 06:44 (Figs. 1 and 2). Detection probability, defined as the average number of events per 100 trap nights varied between species; being lowest for Arabian wolf at 1.31 events/100 trap nights, and highest for striped hyena at site B with 105.26 events/100 trap nights (Figs. 1 and 2).

Porcupine activity showed a peak between midnight and sunrise, with a sharp decline in activity around midday, across both sites and years. Caracal showed activity throughout the day, with a decline in activity around midday, with bimodal peaks, the first being between midnight and sunrise and the second being after sunset. Striped hyena activity peaked between midnight and sunrise, with a decline in activity around midday for both sites and years. Arabian wolf activity showed bimodal peaks at sunrise and mid-afternoon, with a decline in activity around midday. Ibex also showed bimodal peaks just after sunrise and just after sunset, with a decline in activity around midnight and midday for both years.

Mardia-Watson-Wheeler tests showed significant differences in temporal activity patterns between all species pairs with the exception of striped hyena and porcupine at both sites ad years (Table 1). A significant difference in activity patterns was detected for ibex between the 2011 and 2012 data for Site C ($W = 12.99$, $P = 0.002$), therefore the data were analysed separately between years. At Site C for both years, only porcupine and striped hyena showed no significant difference in activity patterns. Overlap between species pairs ranged from 0.11 (95% CI's 0.01–0.25) for porcupine and ibex at site C 2011, to 0.85 (95% CI's 0.65–1.00) for porcupine and striped hyena at site C 2011 (Table 1).

5. Discussion

This study is the first to examine species presence and activity at artificial water holes in the arid environments of Jordan. A diverse community of seven mammalian species were recorded visiting two artificial water sources, all species are believed to be water dependent species or species that utilize waterholes regularly. Activity patterns of mammals differed between species, but species activity patterns were similar across sites and years. Evidence of temporal partitioning was seen for all species pairs, with the exception of striped hyena and porcupine. Due to the small size of the water source, we believe temporal partitioning occurs to minimize species drinking in close proximity to other species.

Artificial water sources have the potential to open up areas for exploitation by species that require regular access to drinking water (Knight, 1995), such as Nubian ibex, which was recorded at site C. Ibex require daily access to drinking water (Wakefield et al., 2008), and the species was recorded with a detection probability of 47.39 events/100 trap nights in 2011 and 69.44 events/100 trap nights in 2012, suggesting less than daily use of this particular water source. Differences in detection probability between years may arise from factors such as population fluctuations and availability of water elsewhere. Whilst previous studies have investigated ibex activity at waterholes with camera traps (e.g. Wakefield et al., 2008), the number of independent events was not reported, making comparisons unreliable. However, this study confirms the findings of Wakefield et al. (2008) who recorded peaks of activity at water around sunrise and sunset for Nubian ibex in Saudi Arabia.

Regular presence of ibex at artificial waterholes could attract predators or scavengers, such as Arabian wolf and striped hyena, both of which were recorded using the artificial water sources.