# Glade paper Sections

## Introduction

Second, we hypothesised that predator-prey interactions would be impacted by greater predator nocturnality in hot weather (Table 1). We have shown previously that wild dogs are more nocturnal when daytime temperatures are high (Rabaiotti & Woodroffe 2019). While impala herds are scattered during daylight hours, at night they aggregate in clearings (“glades”) as a form of anti-predator behaviour (Augustine 2004; Otieno et al. 2019), and are therefore predictably located. We predicted that wild dogs would target glades at night to hunt impala, and termed this, Hypothesis 2, the ‘nocturnal prey concentration hypothesis’. We would expect that, if Hypothesis 2 was upheld, increased nocturnal wild dog activity at high ambient temperatures would lead to increased targeting of predictably located impala over less predictably located dikdik, increasing predation risk on impala (Table 1).

## Methods

We used the same habitat map to classify each GPS-collar location in relation to glades. For impala and dikdik, we recorded whether each location fell inside or outside a glade. As <1% of wild dog hunting locations fell inside glades, we recorded the distance to the nearest glade for each wild dog location, using the plugin “*NNJoin*” in *QGIS* (QGIS Development Team 2018).

In the nocturnal prey selection hypothesis (Table 1, Hypothesis 2), we predicted that impala would use glades more at night (Table 1, 2a: nocturnal prey concentration). To test this hypothesis, we calculated the proportion of each impala’s locations falling within glades during the morning, midday, evening, and night periods for each 24-h period. We used mixed effects models with in glade (1) or not (0) as the independent variable and time period (day (morning, evening and midday combined) or night) as the explanatory variable and individual identity and date as random variables to test whether prey species were significantly more likely to be found in glades at night than during the day.

In the nocturnal prey selection hypothesis, we also predicted that wild dogs would be more likely to hunt at night following hot days (Table 1, 2b: increased night-time hunting). To test this hypothesis, we analysed continuous outcome variables describing the duration, start time, stop time, and intensity of hunts occurring between sunset and sunrise, as well as a binary outcome variable describing whether or not a hunt was recorded each night. These outcome variables were compared with the same explanatory variables used in Hypothesis 1 except that, as nocturnal periods span dates, the maximum ambient temperature for the proceeding daytime period was used. As in the models of daytime hunting behaviour (Hypothesis 1), we constructed Generalised Linear Mixed Models (GLMMs), with Gaussian error distribution for the continuous outcome variables and binomial error distribution for the binary outcome variable, for each outcome variable using the package *nlme* (Pinheiro *et al.* 2015) in *R* (R Core Team 2015), and each model included the identity of individual animals as a random effect. Model selection was performed using model averaging in the same way as when investigating daytime hunts (Hypothesis 1).

In the nocturnal prey selection hypothesis, we also predicted that wild dogs would preferentially target glades at night (Table 1, 2c: night-time habitat selection). To test this hypothesis, we calculated the mean distance to the nearest glade for each night-time hunt period. As when investigating prey use of glades, we analysed this outcome variable using. a mixed effects model with time period (day (morning, evening and midday combined) or night) as the explanatory variable and individual identity and date as random variables, in order to test whether wild dogs were significantly closer to glades at night than during the day.

## Results

Similarly, and as predicted under the increased nocturnal prey selection hypothesis (Hypothesis 2), wild dogs were more likely to hunt at night following daytime periods with high ambient temperatures (Table 2). There was also some evidence that the duration and intensity of night-time hunts increased following hot days (Table 2). Nocturnal hunting activity was increased at higher levels of moonlight (Table 2, Table S6), with corresponding reductions in daytime activity on dates with high moonlight indices (Table 2, Table S5, Table S6).

The three species also varied in their use of glades. Consistent with the nocturnal prey selection hypothesis (Hypothesis 2a), impala were significantly more likely to be located in glades at night than in the day (Table 4, Fig. 3c), although there was no such pattern for dikdiks (Table 4, Fig. 3c). In contrast with predictions under Hypothesis 2c, however, wild dogs were significantly further from glades when hunting at night than when hunting in the day (Table 4, Fig. 3b).

## Discussion

Under the nocturnal prey selection hypothesis (Hypothesis 2), we predicted that, when ambient temperatures were high, wild dogs would hunt at night, targeting impala which are predictably located in glades. Although wild dogs hunted more often at night in hot weather (Table 2), and impala were located in glades at night (Table 4, Fig. 3c), there was no evidence that wild dogs targeted impala at night. Wild dogs were no closer to glades at night than at other times of day, were no closer to glades on nights when ambient daytime temperatures had been high (Table 4), and were less likely to consume impala in hot weather (Table 5, Fig. 3e). Hence, patterns of predator behaviour and prey selection were not consistent with Hypothesis 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 1** Hypotheses describing how predator behaviour, prey behaviour, and predation risk might vary with ambient temperatures | | | | |
| **Hypothesis** | **Species** | **Explanation** | **Implication for predator** | **Expected dietary change at high temperatures** |
| Hypothesis 2: Nocturnal prey selection | | |  |  |
| *2a: Nocturnal prey concentration* | Impala | Impala are predicted to gather in glades at night, as described prior to wild dog recolonisation3. | Predators find impala more easily at night as they are predictably located in glades3. | Decreased ratio of dikdik to impala |
| *2b: Increased night time hunting* | Wild dogs | Wild dogs are expected to spend more time hunting at night, because daytime foraging is constrained1. | As a visual hunter active at night, wild dogs may rely on prey which are easily located. |  |
| *2c: Night-time habitat selection* | Wild dogs | Wild dogs are predicted to hunt in or near glades at night, as impala are predictably located there. | Following hot days, wild dogs spend more time hunting at night, targeting glades where they can easily locate impala. | Decreased ratio of dikdik to impala |
| 1(Rabaiotti 2019), 4(Lucas 1983), 3(Augustine 2004); 3 (Ford *et al.* 2014); 4(Ford *et al.* 2014),5(Creel *et al.* 2016). | | | | |

**Table 4** Relationship between time of day (day or night) and **use of glades** by wild dogs, impala, and dikdiks.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Outcome variable |  | Estimate | Lower  95% CI | Upper  95% CI | p |
| impala – probability of being in a glade | Intercept | 0.0586 | 0.0401 | 0.0772 |  |
| Night *vs* day | 0.1878 | 0.1832 | 0.1923 | <0.0001 |
| dikdik – probability of being in a glade | Intercept | 0.0126 | 0.0016 | 0.0237 |  |
| Night *vs* day | 0.0219 | 0.0091 | 0.0349 | 0.09 |
| wild dog - distance to glade | Intercept | 0.0041 | 0.0037 | 0.0043 |  |
| Night *vs* day | 0.0002 | 0.0001 | 0.0003 | 0.001 |

**Figure S2** Distance to glades for wild dogs, impala and dikdiks during morning, day, evening and night time periods. Note that, as dikdik ranges are very small, their distance to glades will be influenced by the locations of home ranges where dikdiks were captured.**A close up of a map

Description automatically generated**

**Table S7** Variables associated with the characteristics of African wild dog hunting periods **at night**. The table presents estimated effects of explanatory variables included in the top model sets (ΔAICc < 2) for each outcome variable. The relative importance of each variable is shown along with the number of models in the top model set in which it was included (n).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Outcome variable | Explanatory variable | | Estimate | Lower 95% CI | Upper 95% CI | Variable importance (n) | |
| Occurrence | Intercept | | -0.414 | -0.522 | -0.305 | | — (2) |
| Temperature | | 0.020 | 0.016 | 0.023 | | 1.00 (2) |
| Moonlight | | 0.031 | 0.029 | 0.033 | | 1.00 (2) |
| Denning | | -0.069 | -0.094 | -0.044 | | 0.52 (1) |
| Duration  (minutes) | Intercept | | 80.2071 | 47.2221 | 113.1922 | | — (3) |
| Moonlight | | 5.5885 | 4.9986 | 6.1783 | | 1.00 (3) |
| Moonrise | | 0.8356 | 0.4175 | 1.2537 | | 1.00 (3) |
| Denning *vs* not | | 106.6300 | -50.2589 | 263.5188 | | 1.00 (3) |
| Temperature (°C) | | 0.7343 | -0.5236 | 1.9921 | | 0.79 (2) |
| Rainfall (mm) | | -0.5488 | -7.7647 | 6.6672 | | 0.52 (1) |
| Rainfall:Temperature | | 0.0042 | -0.2645 | 0.2729 | | 0.52 (1) |
| Denning:Temperature | | -7.4281 | -13.7490 | -1.1071 | | 0.52 (1) |
| Intensity | Intercept | | 28.2814 | 20.3200 | 36.2428 | | — (2) |
| Moonlight | | 0.8649 | 0.7477 | 0.9822 | | 1.00 (2) |
| Moonrise | | -0.0111 | -0.0942 | 0.0720 | | 1.00 (2) |
| Denning *vs* not | | 2.1092 | -0.0491 | 4.2676 | | 1.00 (2) |
| Temperature (°C) | | 0.4325 | 0.1926 | 0.6724 | | 0.52 (1) |
| Start time | Intercept | 15:52:55 | | 09:34:32 | 22:11:08 | | (1) |
| Moonrise | 00:24:22 | | 00:20:30 | 00:24:22 | | 1.00 (1) |
| Moonlight | -00:05:15 | | -00:10:38 | 00:00:08 | | 1.00 (1) |
| Stop time | Intercept | 09:14:33 | | 06:28:31 | 12:00:35 | | (1) |
| Moonlight | -00:24:17 | | -00:20:20 | -00:28:14 | | 1.00 (1) |
| Moonrise | 00:03:22 | | 00:00:31 | 00:06:12 | | 1.00 (1) |