# Hypotheses

H1: Hot weather benefits African wild dogs

H1a) On hot days African wild dogs have fewer, shorter and less intense hunts but compensate for this by increasing the frequency, length and intensity of nocturnal hunts

H1b) African wild dogs find it easier to hunt impala at night

H1bi) Impala congregate in glades at night

H1bii) Wild dogs hunts target glades when hunting at night

H1c) Prey are easier to hunt when it is hot

H1ci) Habitat use by impala and wild dogs is more similar when it is hot

H1cii) Habitat use by dikdik and wild dogs is more similar when it is hot

H1d) Wild dogs are more likely to eat impala when it is hot

H0: Hot weather does not benefit African wild dogs

H0a) On hot days African wild dogs do not compensate for changes to crepuscular hunts by increasing the frequency, length and intensity of nocturnal hunts

H0b) African wild dogs do not find it easier to hunt impala at night

H0bi) Impala do not congregate in glades at night

H0bii) Wild dogs hunts do not target glades when hunting at night

H0c) Prey are not easier to hunt when it is hot

H0ci) Habitat use by impala and wild dogs is not more similar when it is hot

H0cii) Habitat use by dikdik and wild dogs is not more similar when it is hot

H0d) Wild dogs are less likely to eat impala when it is hot

# Results

## Wild dog hunts

African wild dog hunts were most likely to happen in the morning, followed by the evening and then at night (Table 1-3). Temperature was strongly associated with the duration, intensity, start time and stop time of morning and evening hunts, and the occurrence of night-time hunts (Table 1-3). At high temperatures wild dogs had shorter, less intense morning (Table1) and evening hunts, and evening hunts were less likely to occur (Table 2). Night time hunts were more likely to occur following hot days and there a weaker association with length and duration, with hunts following hot days longer and of greater intensity (Table3). There was a strong association between temperature and the start time of morning and evening hunts (Table 1 and 2), and a weak association with the start and stop time of night-time hunts (Table 3). At higher temperatures morning hunts started and ended earlier (Table 1), evening hunts started later (Table 2) and night time hunts started earlier and ended later (Table 3). There was a positive interaction between temperature and rainfall on the duration of morning (Table 1) and evening hunts and the intensity of evening hunts (Table 2).

Levels of moonlight and the time of moonrise were the variables with the strongest influence on all aspects of nocturnal hunts (Table 3). Night time hunts were more likely to occur and were longer and more intense when moonlight levels were higher, starting and ending earlier, with the start time of night time hunts strongly associated with the timing of moonrise (Table 3). The intensity, duration, start and stop times of evening hunts were associated with moonlight - evening hunts were shorter, started and ended later, and less intense when proceeding nights with greater levels of moonlight (Table 2). The occurrence of morning hunts was strongly associated with moonlight the previous night, with morning hunts less likely to occur when the previous night had higher moonlight levels (Table1).

Denning was strongly associated with the intensity and duration of morning and evening hunts, which were longer and more intense during the denning period (Table 1 and 2). Denning was also associated with the start and stop times of morning and evening hunts, with both morning and evening hunts starting and ending later when wild dogs are denning (Table 1 and 2). There was a weak positive association between denning and the likelihood of occurrence of evening hunts (Table 2), and a negative association between denning and the occurrence of night-time hunts (Table 3). There was a positive interaction between the effect of denning and temperature on the duration of morning hunts (Table 1), and a negative interaction between the effect of denning and temperature on the duration of night-time hunts (Table 3). Denning had a small positive interaction with the effect of temperature on the duration of evening hunts but a negative interaction with the effect of temperature on intensity (Table 3). This indicates that evening hunts were shorter when it was hot but less so during the denning period, but were even less intense on hot days during the denning period than outside it.

## Habitat Use

There were significant differences between woody cover use for each of the three species (Kruskal-Wallis chi-squared = 13151, df=2, p<0.001). Dik-diks preferred woodier areas than impala, and wild dogs hunted in areas of significantly denser cover on average than those preferred by either of their prey species.

#### Impala

Impala were found in areas with a lower proportion of woody cover than would be expected at random (W = 3.07 x 1010, p < 0.001). This effect was consistent for crepuscular (W = 1.09 x 1010, p<0.001) and nocturnal hunting periods (W = 4.73 x 109, p<0.001). Impala were also found closer to glades than expected at random (W = 3.62 x 1010, p<0.001). This was true for crepuscular (W = 1.08 x 1010, p<0.001) and nocturnal periods (W = 7.45 x 109, p<0.001). There was a significant difference between probability of being in glades and woody cover use between the morning and evening periods (Table 4).

Time of day had the greatest association with the distance of impala to glades, the likelihood of them being in glades and their use of woody cover. Impala were closest to glades in the day followed by at night (Table 4). They were furthest from glades in the evening, which was also the time period that they were least likely to be found in glades (Table 4). Impala were most likely to be found in glades, and in the lowest levels of woody cover, at night. The highest levels of woody cover were used by impala in the mornings (Table 4). Temperature, rainfall and seasonality both explained some of the patterns observed in distance to glades, with moonlight also associated with distance to glades at night. Temperature was strongly associated with woody cover use by impala in the morning and middle of the day, and somewhat associated with woody cover use in the evening. Impala were closer to glades and in greater levels of woody cover at higher maximum temperatures at all times of day(Table 4). Impala were less likely to be in glades in the morning and evening on hot days and more likely to be in glades on nights following hot days (Table 4).

The probability of impala being found in glades was associated with periods of wet seasonality in all daytime periods, particularly in the middle of the day (Table 4). Following wet seasonal periods impala were further from glades at all times of day other than during the evenings, and impala were more likely to be found in glades in daytime and evening periods following periods of wet seasonality. Wet seasonal periods were associated with woody cover use in the evenings and rainfall was associated with woody cover use at night. In evening periods impala were found in less dense woody cover following periods of wet seasonality (Table 4). Rainfall had a variable relationship with the likelihood of impala being in glades depending on the time of day. The likelihood of Impala glade use was strongly associated with and moonlight at night, with impala less likely to be in glades on nights with more moonlight (Table 4). There was some association between moonlight and distance to glades at night and in the evenings, with impala being found closer to glades at higher levels of moonlight. There was a weak association between the likelihood of impala being found in glades in the mornings and moonlight, with impala more likely to be found in glades in mornings following nights with high levels of moonlight (Table 4).

#### Dikdik

There was no difference between dik-dik use of woody cover and random locations within their home ranges (W = 4.80 x 108, p = 0.1045). This was true for crepuscular (W = 1.38 x 108, p = 0.1029) and nocturnal periods (W = 1.03 x 108, p = 0.5257). Dik-diks were found further from glades than expected at random (W = 1.40 x 108, p<0.001). This was true for crespuscular (W = 4.03 x 107, p<0.001) and nocturnal hunting periods (W = 3.01 x 107, p<0.001). There was no significant between distance to glades, probability of being in glades and woody cover use between morning and evening (Table 5).

Rainfall variables – either seasonal periods of greater rainfall or rainfall on a daily scale – were most strongly associated with dikdik habitat use, with rainfall being strongly associated with distance to glades and season strongly associated with occurrence in glades and levels of woody cover in the day (Table 5). Dikdik were closest to glades when rainfall had been higher in that 24h period at all times of day (Table 5), and less likely to be in glades during seasonal periods with higher rainfall. During wetter seasonal periods dikdik were found in higher woody cover at all time periods other than the middle of the day, when they were found in more open areas (Table 5). There was a weak association between temperature and woody cover use during the middle of the day and in crepuscular periods, and a weak association between temperature and the likelihood of dikdik being found in glades during crepuscular periods (Table 5). At higher temperatures dikdik were more likely to be in glades, and in lower levels of woody cover, during crepuscular periods, and were found in higher levels of woody cover during the day. At night, there was an association between moonlight and habitat use, which was strongest for the likelihood of dikdik using glades (Table 5). Dikdik were found in areas with less woody cover, closer to glades and were more likely to be found in them at night when moonlight levels were higher (Table 5).

#### Wild dogs

Wild dogs hunted in areas with a lower proportion of woody cover than expected at random (W = 2228900, p<0.001). While this effect was strong at night (W = 82250, p<0.001), there was no significant difference in woody cover between crepuscular hunt locations and random points (W = 1454100, p = 0.2744). There was no significant between distance to glades, probability of being in glades and woody cover use between morning and evening (Table 6).

Pack size was associated with distance to glades, particularly during crepuscular hunts (Table 6). African wild dogs hunted closer to glades at bigger pack sizes during both crepuscular periods and at night. Whether the wild dogs were denning was strongly associated with woody cover use(Table 6). When African wild dogs were denning they hunted closer to glades during crepuscular periods but further from glades during the night, and in less woody cover at all times of day. Wild dogs hunted further from glades at higher levels of moonlight. Temperature did not influence the location of wild dog hunts (Table 6).

## Wild dog diet

Wild dogs ate fewer impala at higher temperatures and when they were resident on pastoral land (Table 7)

# Discussion

On hot days African wild dogs have shorter, less intense crepuscular hunts with morning hunts occurring earlier and evening hunts later. Wild dogs were more likely to hunt at night following hot days, however nocturnal and evening hunts were more less likely to occur at lower moonlight levels. Impala selectively spend time in glades across the 24 hour period, and are most likely to be found in glades in the middle of the day and at night. Wild dogs do not appear to target glades when hunting at night, however, as there was no difference in the distance of wild dogs to glades between crepuscular and nocturnal hunts. Both Impala and dikdik both occupied areas of lower woody cover on average than where wild dog hunts occurred. Impala were found in denser woody cover at high temperatures, more similar to that used by wild dogs, however they were also found closer to glades, particularly in the morning and at night, suggesting they are utilising woody cover closer to glades than that utilised most frequently by African wild dogs. Dikdik showed little response to high temperatures, and associations during the periods where wild dogs were hunting brought them into habitats that were less similar to those used on average for wild dog hunts. The results indicate that it is unlikely to be easier for wild dogs to predate on impala when it is hotter, and dietary analysis indicates that impala are less likely to be consumed at higher temperatures.

In line with Hypothesis 1a, temperature was an important determinant of wild dog hunt activity in the morning, evening and at night. During morning and evening periods hunts were shorter and less intense, and morning hunts were earlier, with evening hunts starting later. This is likely because on hot days the period when it is cool enough for wild dogs to hunt is shorter. Whilst wild dogs were more likely to hunt on nights following hot days, this appeared to be restricted by both denning and moonlight, with wild dogs 50% less likely to hunt during the denning period, and nearly 400% more likely to hunt on nights where there were twelve full moon hours as opposed to none. Night time hunts following hot days were longer and more intense. This suggests, in line with previous studies, that wild dogs were at least partially able to compensate for high temperatures by hunting at night.

Hypothesis 1b relates to whether this nocturnal activity meant that it was easier for African wild dogs to successfully hunt impala when engaging in night time hunts. Impala were more likely to be in and near glades at night compared to crepuscular periods and were in lower levels of woody cover, suggesting that impala congregate in glades, particularly during night-time hours. Wild dogs, however, did not appear to selectively target glades at night, as there was no difference in their distance to glades or use of woody cover between crepuscular and night time hunts. This would suggest that wild dogs are not hunting impala selectively at night, and therefore that nocturnal hunts do not increase food intake over and above morning and evening hunts. Larger packs were found closer to glades at all times of day however which may indicate that larger packs selectively target impala more than smaller packs when hunting.

It has been suggested that hot weather may benefit African wild dogs by making prey, in particular prey with larger body sizes, easier to hunt as they overheat more quickly. Hypothesis 1c) suggests another mechanism by which it may be easier for wild dogs to hunt successfully in hot weather, through prey habitat use becoming more similar to wild dog habitat use. Impala moved into habitat with higher levels of woody cover on hot days, however the effect was small, and would not bring average woody cover use by impala in line with that of wild dogs even on hot days. Wild dog woody cover use did not change at high temperatures, again suggesting they do not selectively target impala when it is hotter. Impala used habitat closer to glades more in hot weather, areas that are spatially more dissimilar to those used by wild dogs when hunting. Dikdik habitat use was not greatly influenced by high temperatures, but where it was it was in a way that made habitat use less similar to that used by wild dogs. It would appear that while impala habitat use becomes more similar to the habitat wild dogs hunt in some ways, it becomes more dissimilar in others, and there is little change in the overlap of habitat use between wild dogs and dikdik. It seems therefore unlikely that wild dogs encounter prey at a significantly higher rate in hot weather.

Dietary analysis showed that Hypothesis 1d, that wild dogs consume impala at greater rates following periods of hot weather, was incorrect. Impala were found in a lower proportion of wild dog scats when it had been hotter over the previous 7 days, indicating that wild dogs are eating lower numbers of impala in comparison to dikdik. This reinforces our findings that wild dogs do not appear to be targeting impala during crepuscular periods or at night following periods of hot weather. It suggests alternatively that wild dogs may find it harder to successfully hunt impala during periods of hot weather, which indicates that the increase in nocturnal hunts does not compensate for the decrease in impala consumption due to the decrease in the occurrence, duration and intensity of daytime hunts. Shifts in hunt timings, and potentially prey habitat use, appear to be impacting the diet of African wild dogs.