Elephant Figures 08

Maria Thaker (1), Pratik R. Gupte (1,2), Abi T. Vanak (2), Rob Slotow (3), Herbert T. Prins (4)

15/01/18

Abstract

Temperature is a major concern for most organisms, with hyperthermia the major risk for large animals. Animals respond to thermal stress through modifications to physiology and/or behaviour. Such behaviour includes movement, and animals moving to avoid overheating select for sites that can act as heat sinks, such as water sources. The movements of the largest land animal, the savanna elephant (Loxodonta africana) have received little attention in the context of water dependence. We tracked African elephants in Kruger National Park and related their temperature, speed, and distance to water. We identified habitually used watering points, and showed that elephants loop back to these points, with most loops lasting 24 hours. Elephants were closest to water during the hottest parts of the day, with the greatest displacement from water at the coolest hours. Elephant speeds were highest in the first and last fifths of loops, i.e., in the approaches to and departures from water. We confirmed our hypothesis that higher temperatures are related to faster movement, indicating that elephants may cover more ground when in search of water than otherwise. This has implications for management decisions that rely on water dependence to control the space use of elephants.

Introduction

Methods

Elephant movement

We collected half-hourly positions of individual (n = 14) free-ranging female African elephants (Loxodonta africana) previously fitted with GPS logger-transmitter collars; each was from a different herd in Kruger National Park, South Africa (24°S, 31.5°E). Elephants were tracked for on average 637 days (range: 436 – 731) between August 2007 and August 2009 (see figure 1 & electronic supplementary material figure S1). To relate elephant movement to their landscape, we gathered the following environmental data: courses of park rivers [cite], locations of active park waterholes [cite].

Elephant temperature

Collar-borne thermochrons reported temperature data (hereon elephant temperature) at each position fix. Seeking to verify that thermochrons accurately reflected the thermal environment of elephants, we also collected ambient temperature data from Skukuza weather station (24.98°S, 31.5°E) [cite], and tested the hourly correlation of ambient temperatures with elephant temperatures.

Visits to water and temperature

We calculated the first passage time through (FPT 200), total time spent within (residence time), and the number of revisits within a 200m radius of each relocation, and sought to identify habitual water points.

We then identified track segments between each visit to water points and investigated the frequency of visits, as well as whether the temperature, speed, and distance to the nearest water source throughout the track. Finally, we used a mixed additive model to test whether elephants moved faster at higher temperatures.

Results

Elephant movement

Elephants ranged on average 4005 km (range: 1854 km – 7074 km) across southern Kruger over the tracking period (figure 1), covering 7.2 km per day (range: 5 km – 9.9 km) at a speed of 398 m/hr (range: 304 m/hr – 470 m/hr); logger fixes placed them within 500m of water 12% (range: 6% – 21%) and 11 % (range: 3% – 17%) of the time in the cool-dry and hot-wet seasons respectively.

Elephant temperature

Collar thermochrons reported identical mean daily temperatures of 27.68°C (range: 6°C – 47°C) and 27.62°C (range: 7°C – 44°C) in the cool-dry and hot-wet seasons. Thermochron data from 3 elephants logged within 10km of Skukuza were well correlated with temperatures from the weather station in both seasons (mean hourly correlation: cool-dry = 0.77, hot-wet: 0.81), with all hourly correlations 0.6.

Visits to water

Elephants ventured beyond 200m of a relocation after 2.5 hours (range: 0.02 hours – 10 hours) on their first visit, returning 5 times (range: never – 86 times), and spent on average 8.65 hours (range: 0.02 – 55 hours) around each point. Using a combination of conservative levels of FPT 200 (< 2 hours), residence time (> 10 hours), and the number of revisits (> 10 times) 6,711 of 47,186 (14%) relocations within 500m of water sources were classified as habitual water points.

The interval of visits to water points had a multi-modal distribution, with 19% (n = 1292) having an interval.

Elephants moved faster with increasing temperatures (X^2 = 4668, p < 0.01), and also in the hot-wet season (X^2 = 361, p < 0.01); woody density had a negative effect (X^2 = 2347, p < 0.01).

References

Figures and Tables

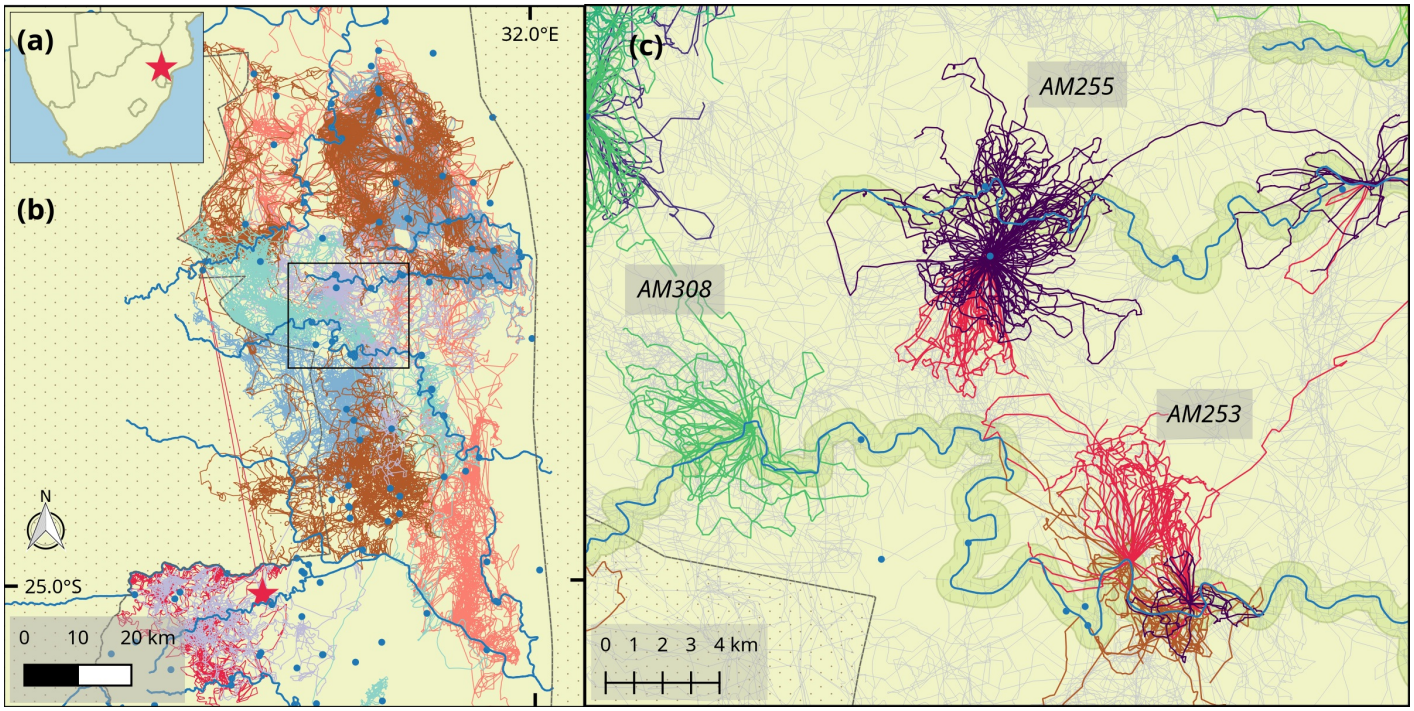

Figure 1: (a) Study site in Kruger National Park, South Africa (red star), showing (b) park boundary (dashed grey line), weather station at Skukuza (red star), major rivers (solid blue lines), open waterholes (blue dots), and raw elephant tracks (coloured lines, n = 14). (c) Inset showing identified 24-hour looping behaviour centred on water sources (blue dots and lines), coloured by elephant shown (see labels, n = 3), with remaining tracks in the background (grey lines). 500m riparian zone along rivers is shaded green.

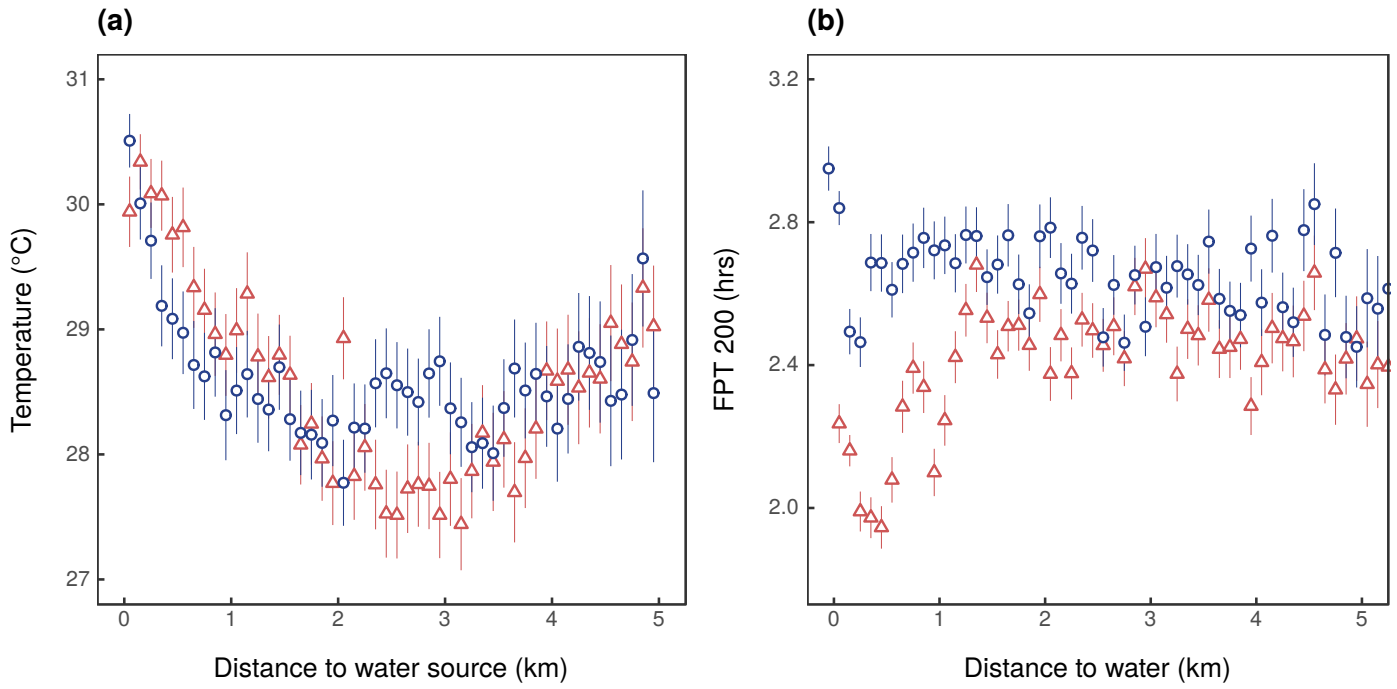

Figure 2: (a) Temperature of moving elephants, and (b) first passage time out of radius of 200m (points) at 100m distance intervals from the nearest water source in each season (cool-dry: blue circles, hot-wet: red triangles). Vertical lineranges represent 95% confidence intervals.

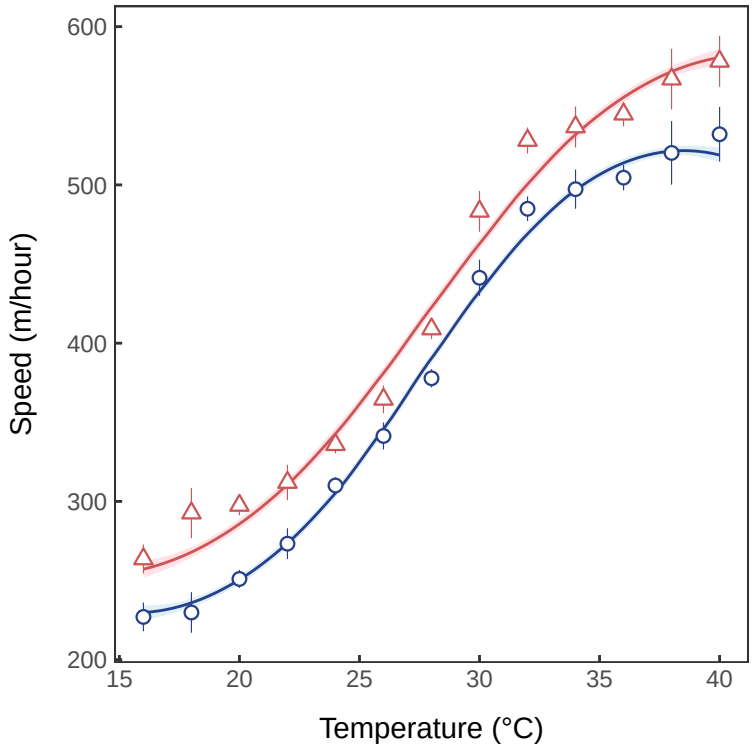

Figure 3: Mean steplength (points) at 2°C temperature intervals in each season (cool-dry: blue circles, hot-wet: red triangles). GAMM fit (lines), data error intervals (lineranges), and fit error intervals (shaded areas) are shown.

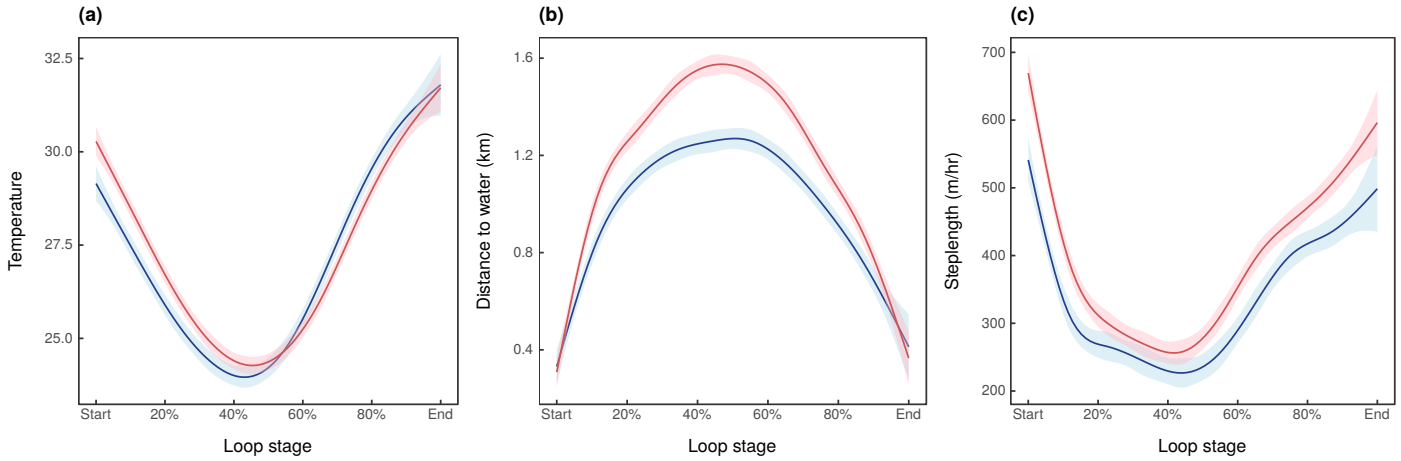

Figure 4: Elephants shuttle to water. GAM smooths coloured by season (cool-dry: blue, hot-wet: red) of (a) temperature, (b) distance to the nearest water source, and (c) steplength at stages in elephant revisits to water sources. Elephants are furthest from water at low temperatures, and move fastest in the initial and final 20% of a loop, i.e., when departing and approaching water sources. Only 24-hour loops considered.

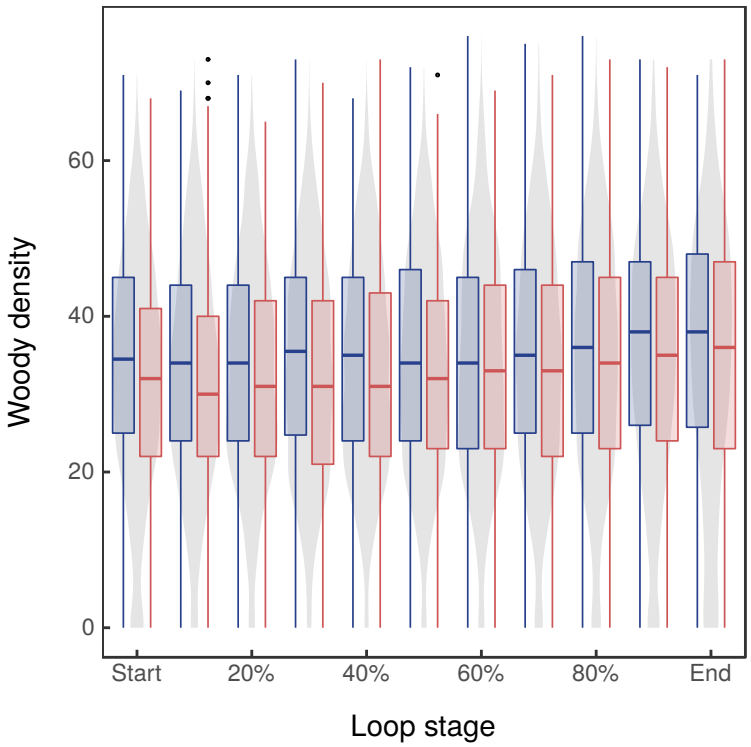

Figure 5: Elephant shuttling is not driven by woody density. Boxplots (coloured by season, cool-dry: blue, hot-wet: red) overlaid on violin plots (grey, background, pooled over seasons) of the woody density along the stages of elephant revisits to water. Only 24-hour loops considered.

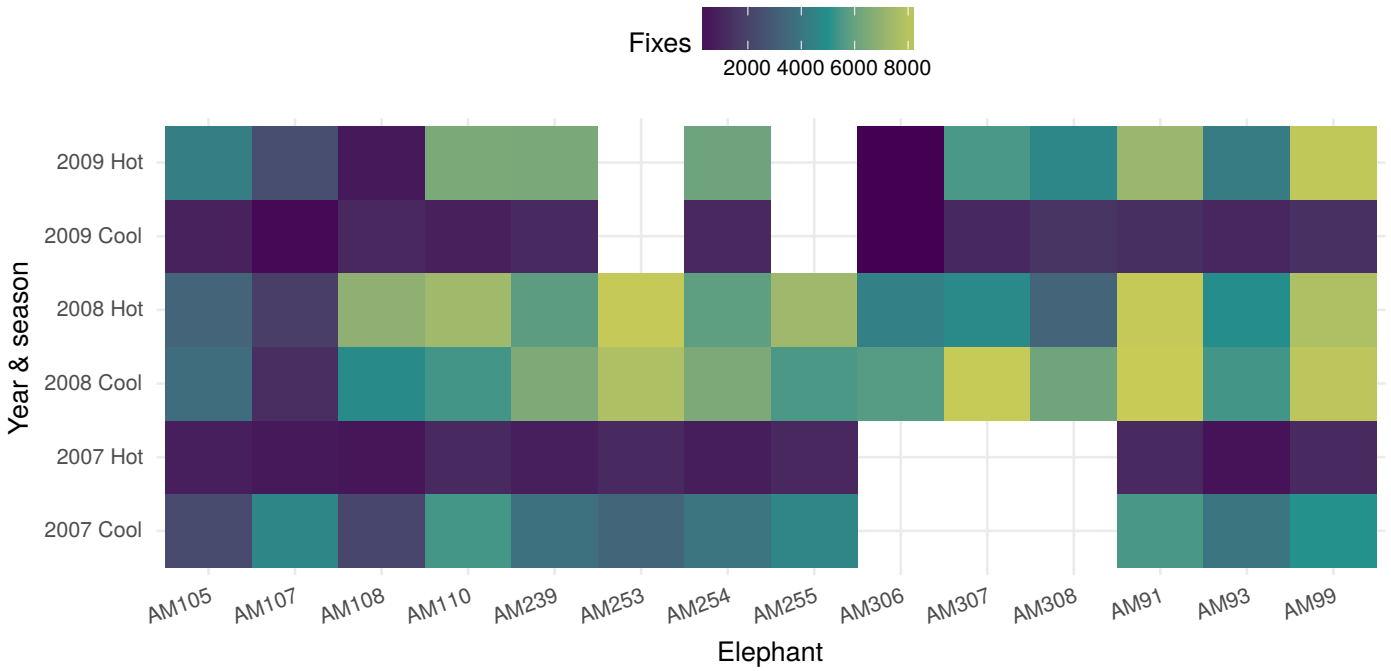

Figure 6: Supplementary material. Heatmap of fixes per individual, grouped by season and year.

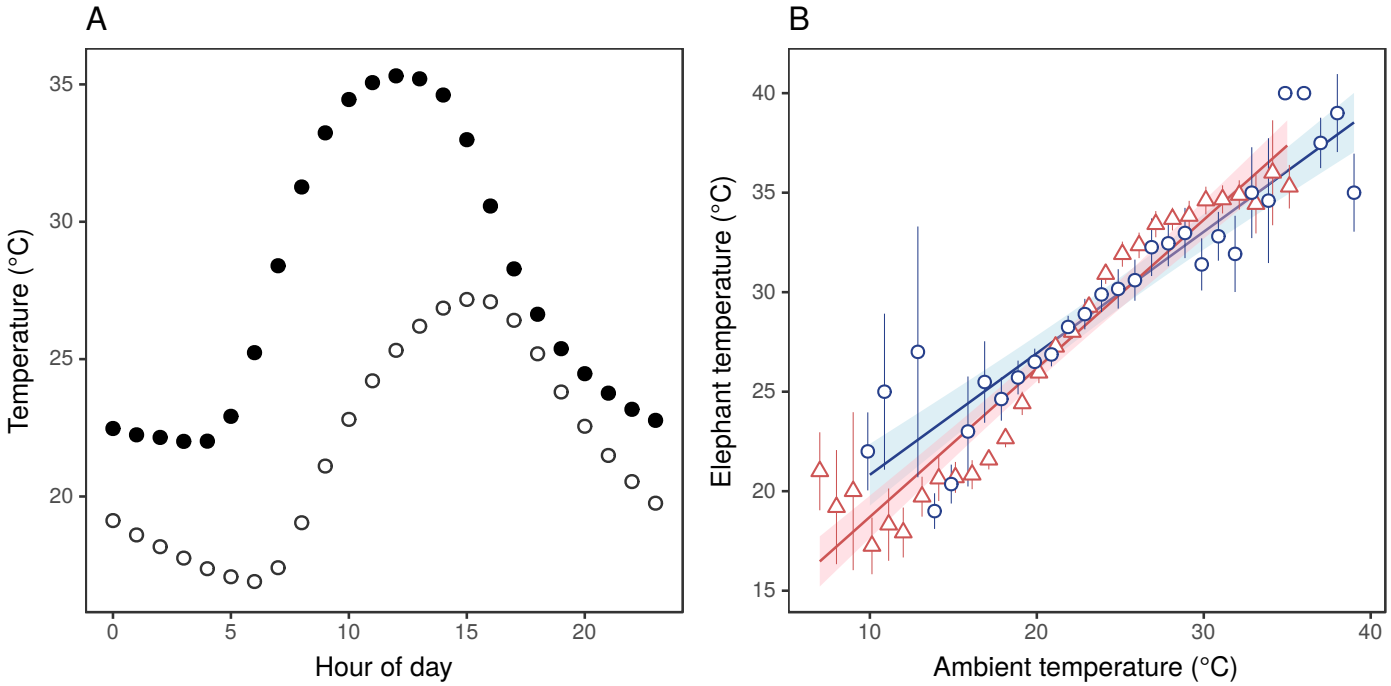

Figure 7: Supplementary material. Mean thermochron temperature (points) at measured ambient temperature, and GLM fits (lines) in each season (cool-dry: blue circles & lines, hot-wet: red triangles & lines). Vertical lineranges and shaded areas (coloured by season) indicate 95% confidence intervals at each point.

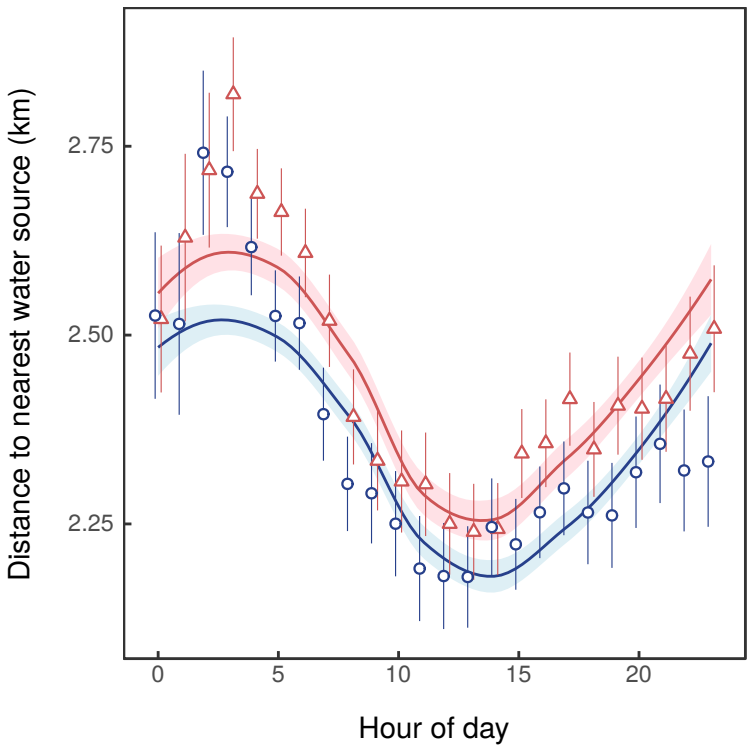

Figure 8: Supplementary material. GAMM fit (lines) and mean distance to the nearest water source in each season (point) through the day in each season (cool-dry: blue circles & lines, hot-wet: red triangles & lines). Vertical lineranges and shaded areas (coloured by season) indicate 95% confidence intervals at each point. Only moving elephants included.

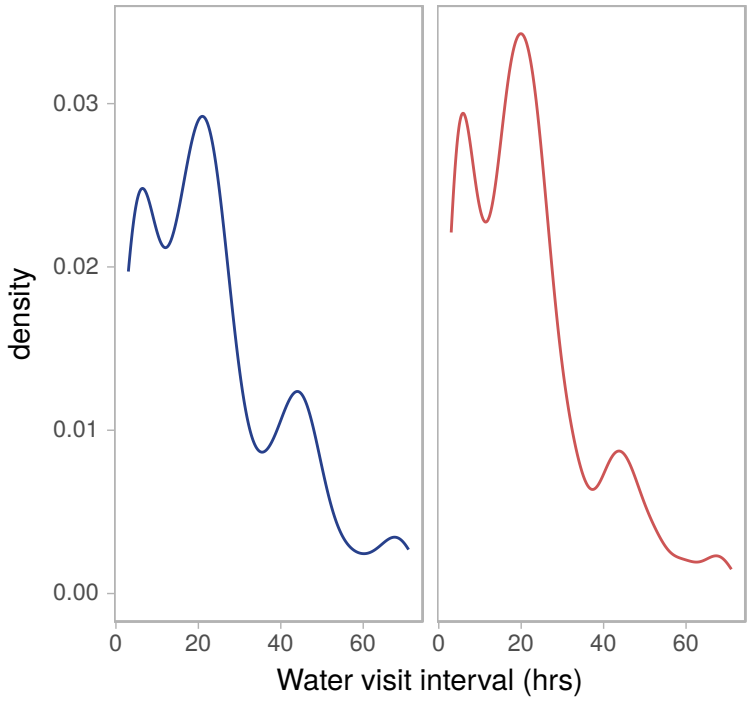

Figure 9: Supplementary material. Distribution of intervals between elephant revisits to water sources.

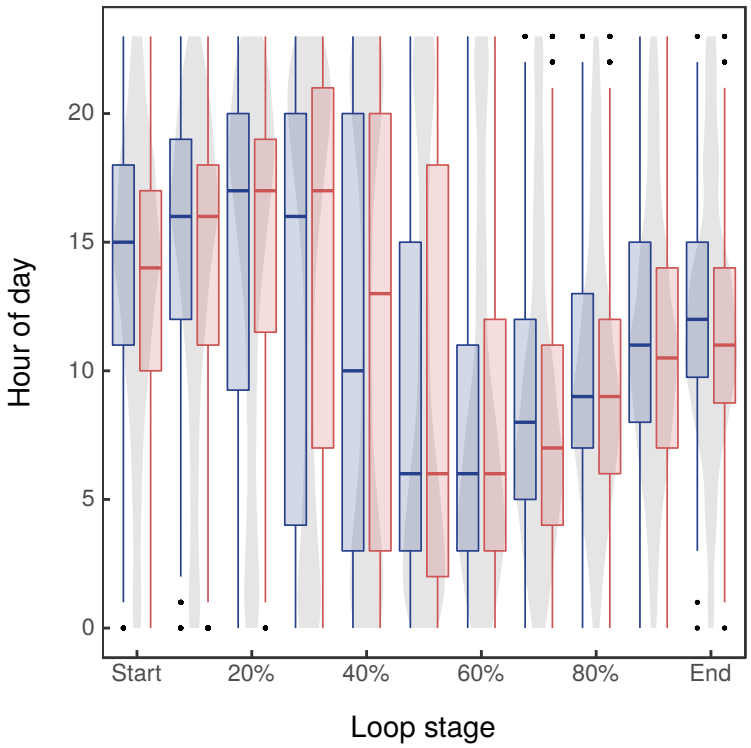

Figure 10: Supplementary material. Elephants loop at all times. Boxplots of the hour of day at stages of elephant looping behaviour, coloured by season (cool-dry: blue, hot-wet: red). Each loop begins and terminates at a water source. Violin plots of the probability distribution of hour of day at each stage in the loop, pooled over seasons are shown in the background.

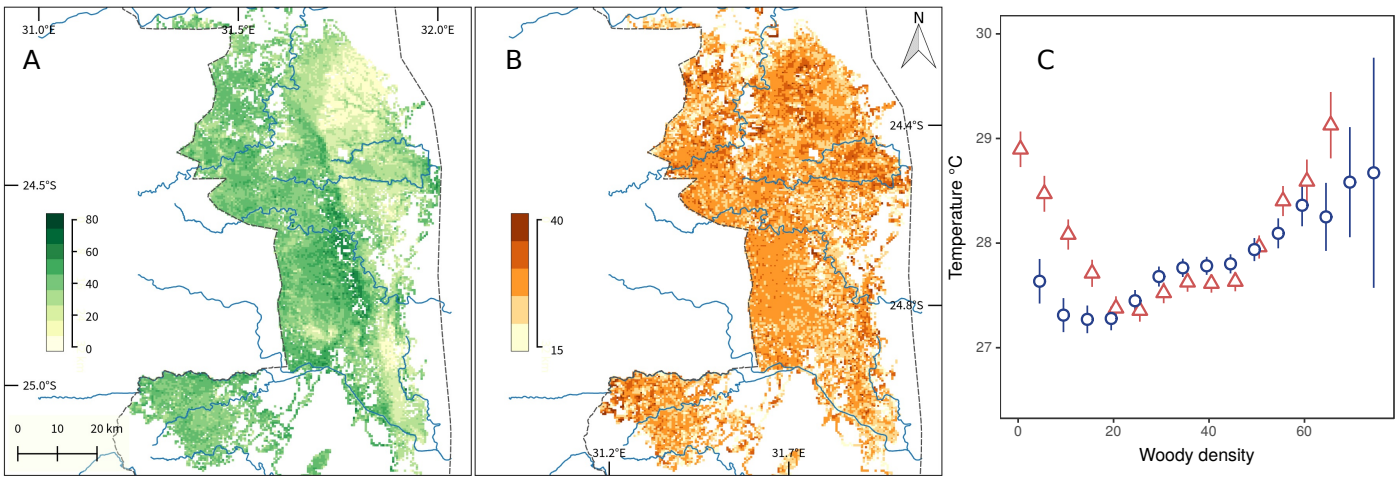

Figure 11: Supplementary material. (A). Woody density, and (B). Elephant temperature at relocation sites. Values shown are 500m^2 pooled means. (C). Mean elephant temperatures at woody densities in increments of 5, separated by season (cool dry: blue circles, hot wet: red triangles), showing 95% confidence intervals (lineranges coloured by season.). Rivers (light blue lines) and Kruger boundary (dashed black line) are shown.

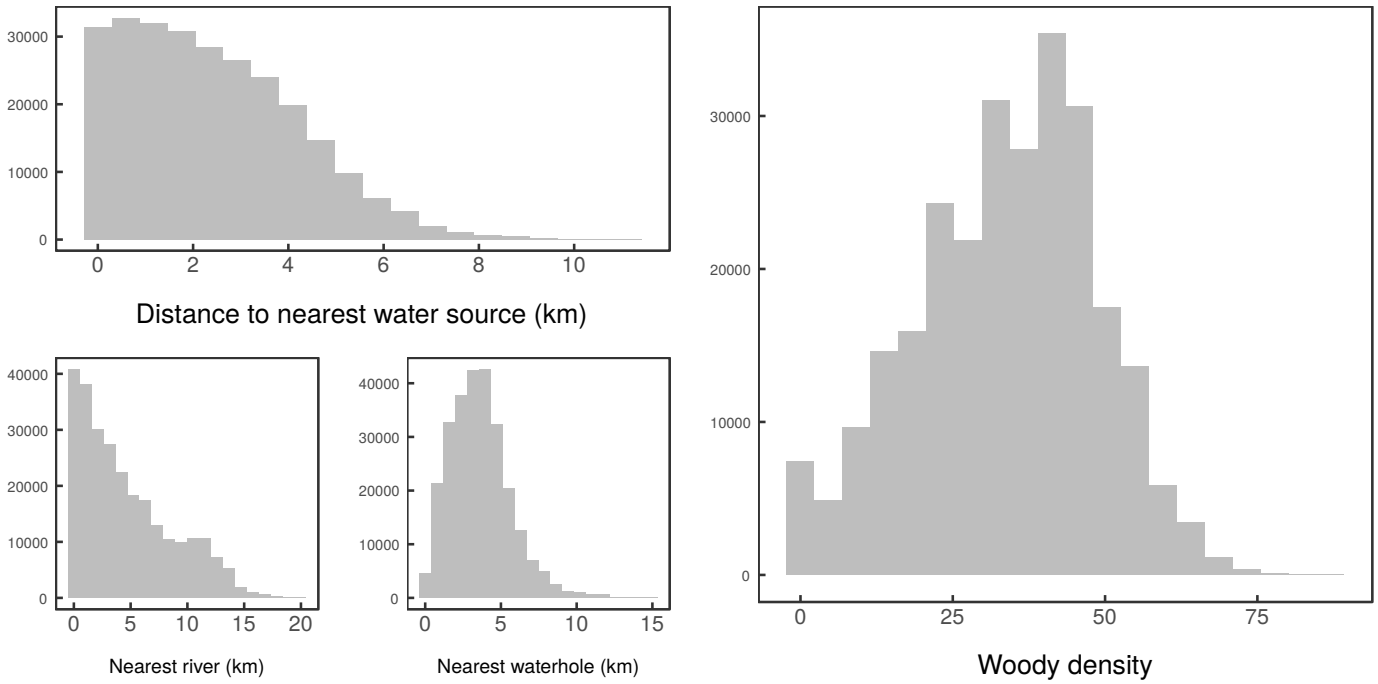

Figure 12: Supplementary material. (a). Frequency distributions of distance to the nearest water source (waterhole or river, see separate histograms below), and (b). Frequency distribution of the woody density encountered by elephants.