Paper summaries 27/10/17

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Paper summaries

1. **Valls Fox (2015)** : Elephants behave as central place foragers with multiple foci, periodically returning to water. On longer trips, elephants travel farther from water, as would be expected if speed were constant. In the dry season, the frequency of water trips is increased, as is the distance travelled from water, indicating increased movement rate. Simultaneously, elephants select for areas of low waterhole density, especially later in the dry season. This may represent selection for areas with lower densities of other, competing animals. This is the closest any work has reached to the present study, and posits thermoregulation as the driver of elephant recursion to water sources. Is not yet published (*pers. comm.*), will serve as a strong supplementary work in the intro and discussion.
2. **Kinahan *et al.* (2007)** : GPS loggers on elephants combined with landscape level temperature measurements from weather stations show that elephants select for thermally stable landscapes, ie, with lower rates of temp. change and also for shade. Landscape use may be thermally constrained in the species.
3. **Beest *et al.* (2012)** : Moose *Alces alces* are among the largest temperate ungulates and experience both heat and cold stress. In both winter and summer, moose experience temperatures above critical thresholds, and seek refuge in landscapes with cover, avoiding open areas. Used GPS + temp loggers on moose. Could form part of a compare/contrast with elephants given large size yet very different environment.
4. **Cain *et al.* (2012)** : Zebra *Equus quagga* and sable antelope *Hippotragus niger* in Kruger NP show different movements in relation to perennial water sources during the dry season. Sable need to drink less frequently, and are able to occupy habitats further from water. While this results in higher travel costs between forage and water, and lost foraging time, it likely reduces predation risk at crowded waterholes. Used GPS loggers.
5. **Hirst (1975)** : Monograph on the ecology of African savanna ungulates. Useful for intro.
6. **Owen-Smith & Goodall (2014)** : Three coexisting ungulate species along a body-mass gradient were GPS tagged in Kruger to examine how they coped with changes in rsource availability and predation risk related to seasonality. Buffalo *Syncerus caffer*, the largest of the three, showed the strongest reduction in activity levels with rising temps (proxied by time, assuming max temps at midday), but maintained similar activity levels between day and night. Smaller and more at-risk sable and zebra showed more diurnal than nocturnal activity. During the dry season, both also moved and foraged more than buffalo (lower energy deposits to draw from?). Zebra foraged longer than the others due to their physiology. Sable in a wet habitat showed similar activity levels as in a dry one, but moved more slowly, and did not increase the time spent foraging, likely due to better forage availability.
7. **Fuller *et al.* (2014)** : Review putting forward the idea that water stress leads to increased animal body temps, and that this is the condition under which heterothermy occurs, with large mammals capable of maintaining T_b within a narrow range in arid habitats given access to food and water. Useful for intro, prompts question whether elephant heterothermy is seasonal.
8. **Leggett (2010)** : Desert dwelling elephant males in Namibia were GPS tracked for one year. Daily movement and movement rate were higher in the wet season than in the dry seasons. Peak movement times shifted with the season, with elephants moving faster early in the day in the hot dry season. Useful for intro and discussion.
9. **Giotto *et al.* (2015)** : Asiatic wild ass *Equus hemionus* movement in an arid region reveals a near 24h periodicity in revisits to sites. These sites hold resources in the forms of water, forage, and suitable topography. Territoriality was a social factor that appeared to bear upon revisit rates. Used GPS tags, useful for intro.
10. **Bennitt (2014)** : Fifteen buffalo collared with GPS loggers in the Okavango delta showed contrasting selection for proximity to water sources in the wet season, and areas close to water in the dry (late-flood) season. This contrasts with smaller sable antelope (Cain *et al.* 2012), which spend more time away from waterholes in the dry season, and is related to larger animals' need to remain close to water to thermoregulate, either by drinking or bathing (Owen-Smith & Goodall 2014).

11. **Hetem *et al.* (2012)** : Arabian oryx *Oryx leucoryx* were fitted with GPS loggers and black-globe temp loggers, allowing for the analysis of microclimate selection in the Arabian desert. Oryx selected cooler microclimates, presumably shade, than was found in the sun in all seasons. Oryx activity patterns shifted from largely crepuscular in the cooler months to being mostly nocturnal in the summer months. Useful for intro/disc. Study similar to current work, lacking only waterholes.
12. **Hetem *et al.* (2010)** : Arabian oryx implanted with temperature loggers showed marked heterothermy in the summer, with the amplitude of this heterothermy also significantly higher in the warm dry than in the warm wet season. This points to water-stress as the primary driver of heterothermy in large mammals. Useful for intro/disc.
13. Some general articles linking climate change, especially warming, with species' habitat and distribution changes: Walther *et al.* (2002), and Parmesan (2006).
14. Bowyer & Kie (2009) : Black-tailed deer *Odocoileus hemionius columbianus* select for stands of live oak on warm, windless, dry days in winter to avoid excess heat gain. Used VHF radio-telemetry and static weather sensors.
15. Aublet *et al.* (2009) : Ibex *Capra ibex* show a change in behaviour in summer, with older (and larger) males showing the most change. Peak foraging activity shifts to earlier in the day, probably to avoid high temps and sunshine.
16. Some papers on elephant movement and reliance on water: Boettiger *et al.* (2011), Redfern *et al.* (2003), Redfern (2002), Tshipa *et al.* (2017), and Loarie *et al.* (2009).
17. Schmidt *et al.* (2016) : Muskoxen *Ovibos moschatus* are non-migratory and are restricted to tundra habitats, encountering both heat and cold stress. Muskox movement increases with increasing temperature in summer, but increases with decreasing temperature in winter. Linearity of movement increases with increasing temperatures in winter, but decreases with rising temps in summer. These are very early results and require more context. Used GPS loggers and weather data from stations.
18. Lowe *et al.* (2010) : Moose in Canada were shown to *not* make use of thermal cover in the form of confierous tress, but rather to occupy the landscape as though unaffected by thermal stress. Used GPS collars and static weather data.
19. Stelzner (1988) : Yellow baboons *Papio cynocephalus* probability of being found in shaded or unshaded areas was unaffected by heat stress (proxied by temp/rad metrics). However, the speed of movement through habitats offering more cover was lower than open areas. At the behavioural level, baboons spent more time resting in shaded areas than in open ones, leading to a cumulative slowing of the troupe when in woodland.
20. Cain *et al.* (2006) : A review of thermoregulation in N. Am. desert ungulates, with refs to studies in other species from Asia/Africa.
21. Johnson *et al.* (2002) : Ungulate movements (in caribou, *Rangifer tarandus caribou*) are scale dependent, and intra- and inter-patch movements can be differentiated from tracking data, and also carry different costs, such as predation risks. Used GPS data.
22. Coughenour (2008) : A general chapter on the causes and consequences of the movement of large herbivores through landascapes. Might be useful for intro.
23. Rahimi & Owen-Smith (2007) : Two herds of sable antelope in Kruger tagged with GPS transmitters showed increasing daily displacement during the dry season due to watering trips every few days. Nocturnal activity increased during this time relative to the rest of the year.
24. Nowack *et al.* (2013) : African lesser bushbabies *Galago moholi* use behavioural thermoregulation rather than physiological (torpor) in winter to conserve heat by increasing the intake of high-quality food, using shelter, reducing nocturnal activity, and increasing huddling. This allows them to remain normothermic rather than slip into heterothermy. Used radio-telemetry and static temp/RH loggers. May be useful for intro.
25. Fuller *et al.* (2005) : Eight springbok *Antidorcas marsupialis* fitted with internal temperature loggers showed that heterothermy is scale dependent; while 24h temps track ambient temps, mean daily temps show little variability between seasons, and poor response to ambient temps.
26. Weissenböck *et al.* (2012) : Evidence for heterothermy in Asian elephants *Elephas maximas*. Useful for the intro/discussion; used internal temp loggers, elephants tame.
27. Cain III *et al.* (2008) : Desert living bighorn sheep showed no changes in their movement patterns in response to the removal of artificial(?) water sources. This may have been because of an unusual amount of precipitation which offset the lack of waterholes. Used GPS loggers, useful for discussion.
28. De Beer (2008) : Elephant home range size is determined by landscape heterogeneity and by waterhole density. Useful for intro/discussion.
29. Cromhout (2007) : Buffalo space use in S.Af. in different seasons, includes the idea of nutritional stress in the dry season, but shows that buffalo in the dry season have larger ranges, contradicting Bennitt (2014).
30. Hetem *et al.* (2007) : The use of a small black globe mounted on the dorsal side of a GPS collar can yield good approximations of the thermal microclimate

of an animal. Animal use of thermally favourable microhabitats shown in three ungulates as validation of the device.

31. Shrestha *et al.* (2012) : Further evidence that thermal states in antelope (eland *Taurotragus oryx*, blue wildebeest, and impala) are likely to be dependent on access to water and nutrition.
32. Shrestha (2012) : Thesis on antelope in S.Af., includes Shrestha *et al.* (2012), may be useful for intro.
33. Shrestha *et al.* (2014) : Acitivity of larger ungulates is reduced in the hot dry season, more than that of smaller ones, a trend which continues into spring. Used black globe temperatures as a predictor for activity, with an observed negative correlation. Useful for intro.
34. Cain *et al.* (2008) : Cover in the form of caves and vegetation can be a significant advantage to thermoregulation in bighorn sheep *Ovis canadensis mexicana*. Used temperature loggers in refugia and observations of sheep to posit utilisation. Ambient temps taken as proxy for body temps ("thermal load"). For intro or disc.

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