The Function of Zebra Stripes in Thermoregulation & the Deterrence of Disease-Carrying Biting Flies

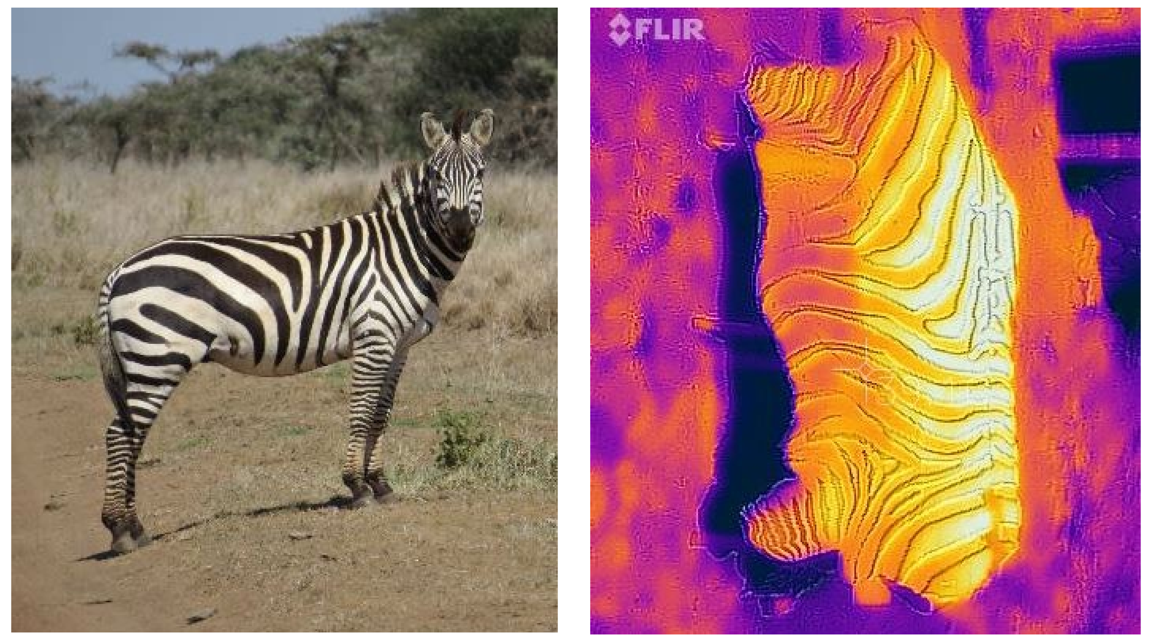
Lily V. Reisinger, 2018, Princeton University Ecology & Evolutionary Biology
Mpala Research Centre, Laikipia, Kenya
Funded by the Center for Health and Wellbeing

Introduction

- Zebra stripes' adaptive significance is still and unsolved puzzle.
- Current data supports hypotheses that stripes promote cohesion, deter predators and disease-carrying biting flies. Observations also shows that zebra maintain a lower (3ºC) external temperature compared to similar sized, unstriped sympatric ungulates.
- Zebras have inefficient equid hindgut fermentation digestion unlike other ungulates on the savannah which ruminate.
- This inefficiency forces zebras to continually graze and spend more time in the open, exposing them to increased pressures; black and white stripes might me the evolutionary response to these selective pressures.

Objective

To pinpoint what selective pressures are predominantly driving stripe evolution and investigate the mechanisms—both independently and synergistically—by which these evolutionary drivers exert their effect.



Left: Plains zebra (*Equus quagga*) with bold black and white stripes. Right: Thermal image of a plains zebra hide showing the temperature differential between the hotter nlack stripes and the cooler white stripes.

Methods

- Data was collected at Mpala Research Center and Lewa Wildlife Conservancy, both in Kenya near the equator
- Record time budgets (30 minutes to 1 hour) of both Grevy's and Plains zebras, noting GPS location, group size and composition, soil type, environmental conditions, age, reproductive status, picture, and direction relative to the sun; fly counts on black versus white zebra stripes were done using photos from the field
- Time budgets and fly counts were also conducted for other herbivores such as waterbuck, hartebeest, and oryx. Collect and determine initial parasite burden in 20 dung samples to place in 4 environmental conditions—exposed, partially exposed, shaded, and shaded with moisture—and take fecal egg counts from each sample every 24 hours
- Conduct fly choice tests with Stomoxys flies in a plexiglass choice chamber with zebra & impala skins
    - Tests run: plains zebra vs. Grevy's zebra, plains zebra vs. impala, Grevy's zebra vs. impala, control
- Conduct heating and cooling experiments with solid black, solid white, and striped water jugs to model how mammals of different colors heat load & heat offload with respect to their orientation towards the sun

Top: The plexiglass chamber used for fly choice experiments with hanging impala & plains zebra hides. Bottom: Water bottles painted for heating and cooling experiments.

Results

- Concrete results remain to be determined as data is raw and has not yet been adjusted
- Preliminary analysis indicates:
    - Zebras displayed lower surface temperature relative to other savannah ungulates
    - Flies were observed more frequently on the black stripes of zebra; solid-peladed herbivores had more flies
    - There was a statistically significant preference of impala skins over both species of zebra skins by *Stomoxys* flies
    - Flies did not have a preference for a specific zebra species and preferentially chose to avoid landing on either
    - When oriented broadside to the sun, zebra bottles cooled significantly faster than either the solid white or black bottles

Discussion

- The avoidance of *Stomoxys* flies towards zebra skins relative to solid-colored skins would serve as a first line of defense against vectored diseases.
- If zebras are able to unload heat faster than other savannah herbivores, they could potentially:
    - Modulate their core temperature to kill flagellates ($LD_{50} \approx 50$ºC) that carry trypanosomiasis (transmitted by biting flies) as a second line of defense
    - The ability to quickly decrease core temperature would prevent both brain & organ damage from induced fever
    - Cool themselves during the hottest time of the day, with the possible creation of convection cooling cells

Further Research

- Replication of heating and cooling experiments during days of complete sun is necessary to ascertain the trends observed hold true Additional data is necessary to obtain a more comprehensive picture of and to strengthen and verify conclusions drawn from the current data set
- Further fly choice tests with tsetse flies, which are the principal vector of African sleeping sickness, should be conducted to see if preference for dun-colored herbivores over zebras hold true for other species of biting flies

Conclusion

- Preliminary conclusions suggest that stripes play an important role in both thermoregulation and disease control by reducing the number of biting flies landing on zebras. At this time it is unclear if a zebra's orientation relative to the sun's azimuth plays a role in the underlying mechanisms that govern these phenomena.
- Additional more nuanced conclusions cannot be appropriately drawn until the data has been adjusted and further analyzed.

Acknowledgements

Thank you to Dr. Daniel Rubenstein, the staff of the Mpala Research Centre, Princeton Center for Health and Wellbeing, Princeton Environmental Institute, and Office of the Dean of Undergraduate Studies.

Left: Three plains zebras trail a male Grevy's zebra (*Equus grevyi*).