Interpreting Accelerometer Data Without Ex-Situ Baseline Data in Ringtails (*Bassariscus astutus*)

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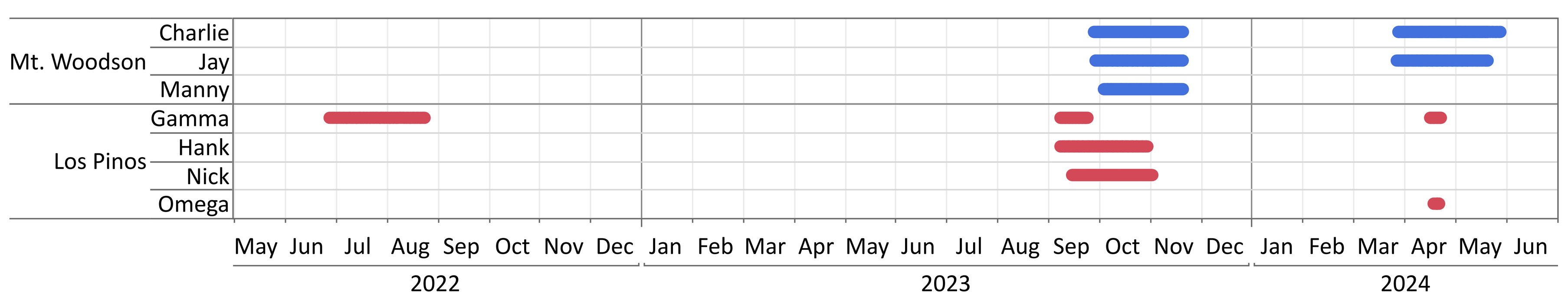
Background

Ringtail (*Bassariscus astutus*)

- 12-17'' body with 12-17'' tail (1.8-2.9 lbs.)
- Nocturnal omnivores found throughout Western North America with a heavy presence in the Southwest US
- They prefer rocky habitats with access to water. These habitats can vary from desert to forest.
- Primarily display solitary behavior
- IUCN Status: Least Concern

Due to identified road killings in the San Diego Area, this study was initiated to investigate behavior around road crossings of local ringtail populations. Across 2022, 2023, and 2024, seven ringtails were fitted with collars which record accelerometer data at a frequency of 1 Hz and GPS fixes and temperature readings every 2 hours. The collars were set to record data from 7pm-7am nightly, with the exception of Omega in 2024 whose data was recorded around the clock.

Though we were able to gather this accelerometer data, we were unable to record ground truth observations of ex-situ collared ringtails. Training data is often acquired when working with accelerometer data to feed to an unsupervised random forest model. These models are then able to classify the movement patterns described by the accelerometer data of the in-situ ringtails. Knowing this barrier, we set the goal of finding a method to classify accelerometer data into categories of "moving" and "not moving".



Methods

1. **Collected training data** by running four collars in stationary positions on a flat surface in four distinct orientations for a period of 30 minutes per orientation for each collar. Our goal in this process was to generate "not moving" data.
2. **Classified accelerometer data** into categories of moving and not moving by comparing the variance of acceleration in our training data to the variance of acceleration in the ringtail data during 5-second moving windows for each point of interest. Since the data was collected at one second intervals, we were able to classify each second of a ringtail night as moving or not moving. We expected to generate a bimodal graph of variance from our ringtail data with one peak for movement behavior and one peak for stationary behavior.
3. **Validated the classification model** by utilizing instances of known activity and daytime accelerometer data to calculate the proportion of time a ringtail was active during these instances according to our classification system. The periods of known activity were identified by camera trap images and videos of collared ringtails. The daytime data collected for Omega in 2024 was used as a period of assumed inactivity due to the ringtail's nocturnal behavior.
4. **Classified temperature data** by using the difference between collar temperature and average outdoor temperature, since collar temperatures are impacted by the body heat of the ringtails. I used k-means clustering where k = 2 over a 7-day moving window for each point of interest. High difference in temperature when no fix was recorded corresponds to a ringtail in its den. When a fix is acquired, the ringtail's location is known and does not need to be re-classified.
5. **Analyzed circadian rhythm** of the ringtails by utilizing the validated classification system to calculate the average proportion of time spent moving during each hour of the day for each ringtail.

Conclusions

Access to ground truth behavioral observations can serve as a barrier in analyzing raw accelerometer values. Though ground truth data can be an immensely powerful training tool in classifying accelerometer data into specific behaviors, it is not available for all study systems. The methods we've developed create an opportunity to interpret raw accelerometer data using a simple training data collection procedure.

The classification of movement and stationary behavior allow us to further refine our analysis of GPS and temperature data collected by the collars. Additionally, it allows us to answer novel questions regarding the biology of the study system. Moving forward, we plan to investigate if movement patterns change between our different study locations and around instances of known road crossings.

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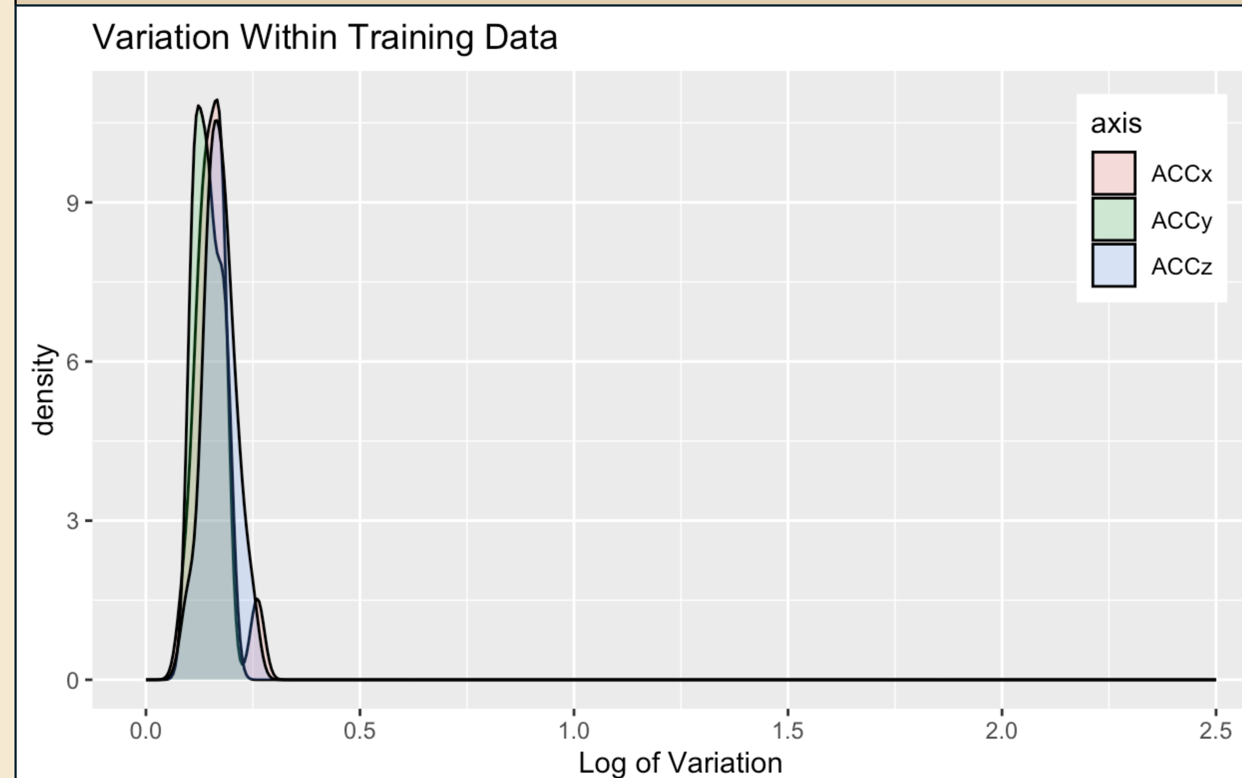
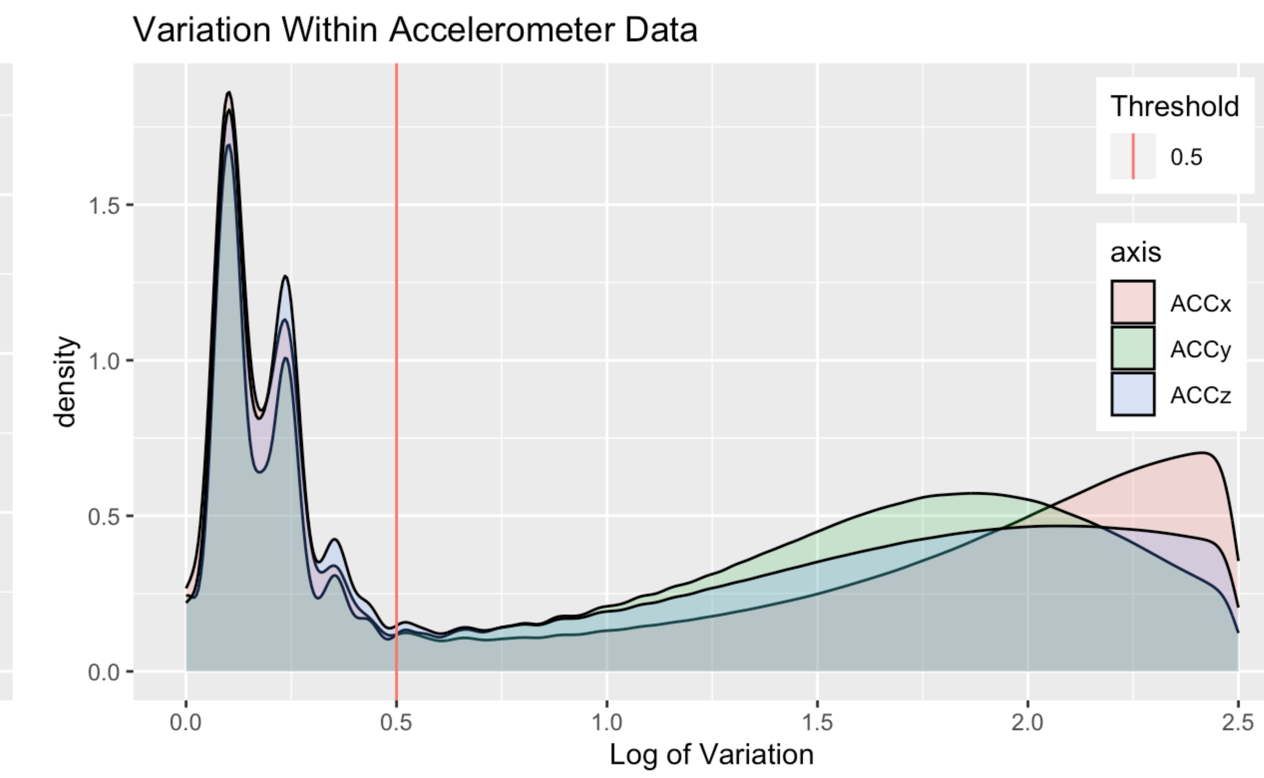
Sources

North American Ringtail (*Bassaricsus astutus*) Fact Sheet. c2013-2019. San Diego (CA): San Diego Zoo Wildlife Alliance; [accessed 2024 Sep 01]. http://ielc.libguides.com/sdzg/factsheets/ ringtail.

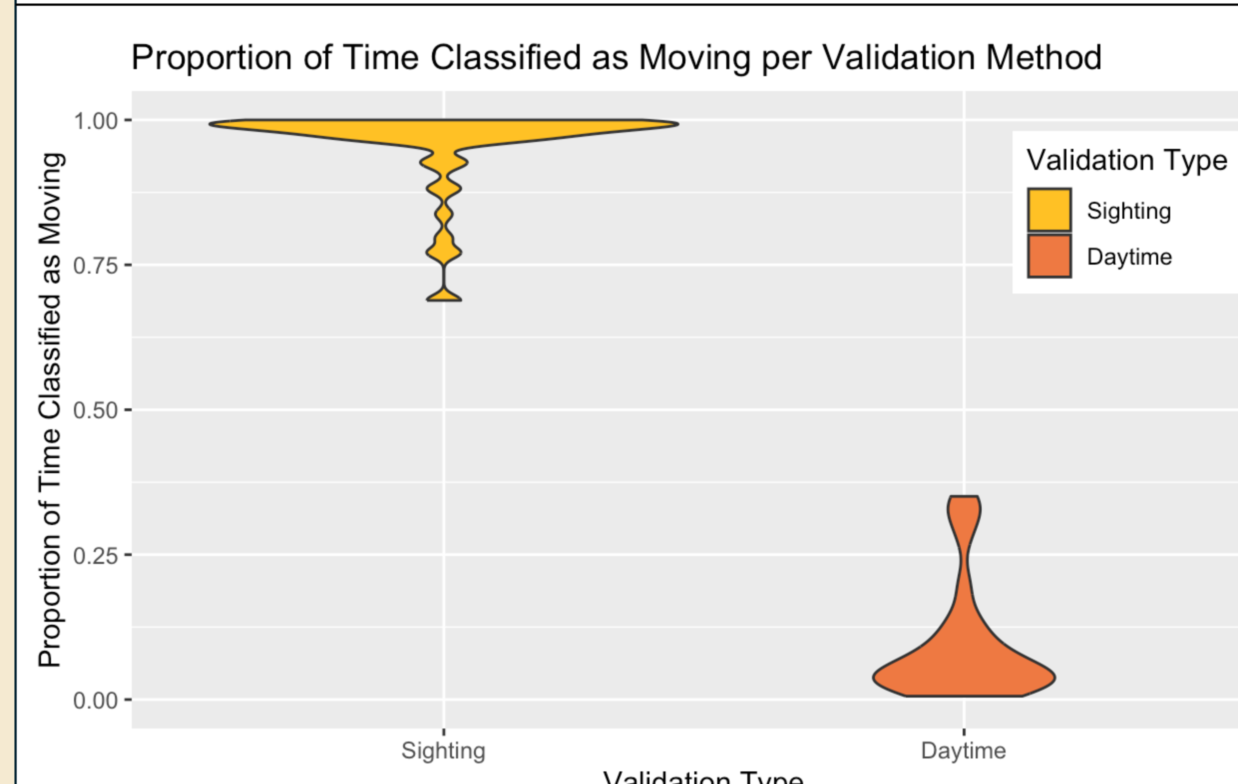
Studd EK, Landry-Cuerrier M, Menzies AK, et al. Behavioral classification of low-frequency acceleration and temperature data from a free ranging small mammal. Ecol Evol. 2019; 9: 619-630. https://doi.org/10.1002/ece3.4786

Results

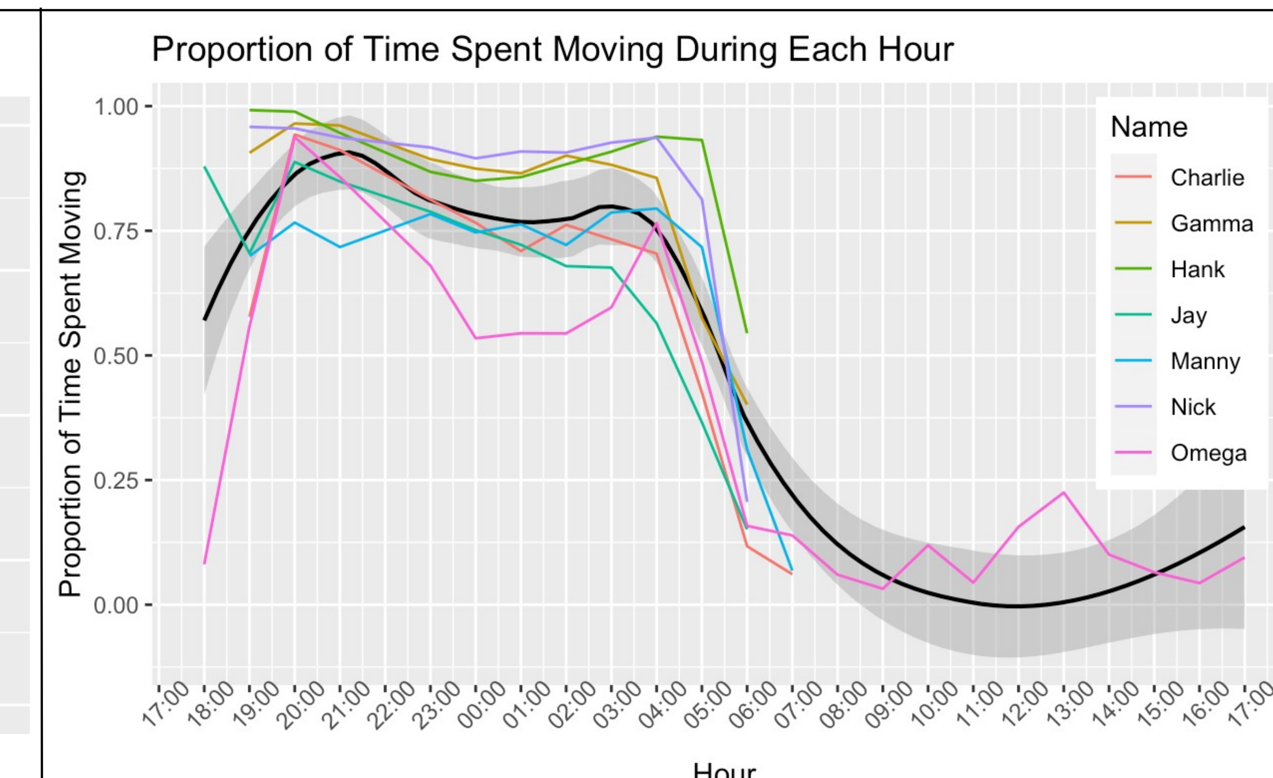




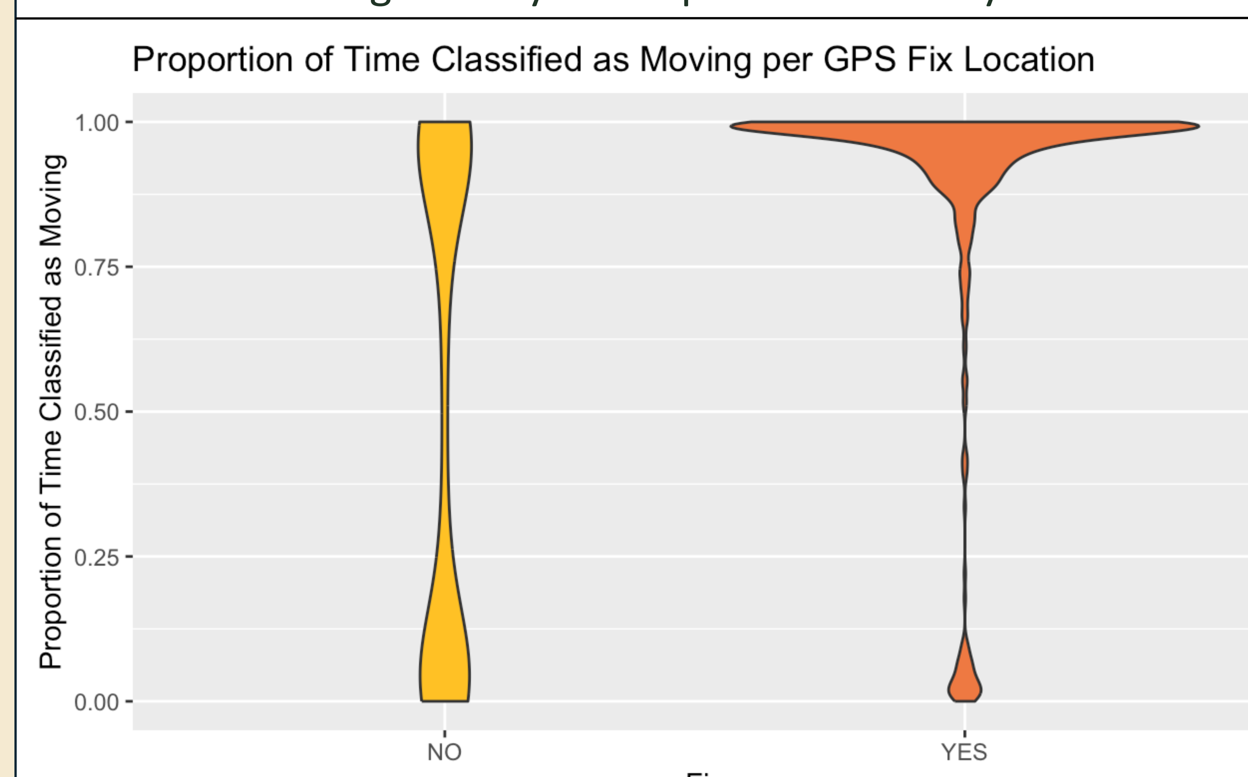
The training data collected from stationary collar positions shows minimal variance. The variance of the ringtail data across all 5-second moving windows has a large range between 0 and 120,000. The bimodal nature of this curve allowed us to identify a threshold for moving and not moving behavior. It is expected that the not-moving behavior of a collared ringtail has higher variation than the training data since the collars likely pick up on movement in breathing.



Movement proportions during known sightings and daytime validate the classification system. Movement during sightings is expected to be high since the ringtails are outside of their dens and active. During the day it is expected that they are inactive.



On average, across individuals, movement peaks at sunset and sunrise. However, there exists meaningful variation in movement patterns between individuals with some showing a steady decrease in activity throughout the night.



Before reclassifying GPS fixes, a missing fix could correspond with a ringtail being within its den or a ringtail out of its den but hidden from satellites (ex. under a large boulder). Once we classified the difference between collar and outdoor temperature into high and low difference, we were able to re-classify the high temperature readings where no fix was recorded as "in den" and validate this approach by confirming that movement was infrequent during fixes classified as "in den".