

Are juvenile female golden mantle ground squirrels dispersing from their natal burrow due to high-stress levels?

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Abstract:

Many mammals disperse from the area they were born in. Dispersal is done to avoid inbreeding, resources, and mate competition. Dispersal in mammals tends to be male-biased as juvenile males are the ones that often leave their natal burrow, and females do not. The cost of dispersal is expensive as mammals would need to fight for new territory and compete for resources. Females, on the other hand, either stay in their natal burrows or disperse. Females are either kicked out by their mothers or dispersed voluntarily. Many factors contribute to female juvenile dispersal. For instance, avoiding kin competition, resource, and inbreeding. There is also the physiology associated with dispersal in juveniles. Glucocorticoids help regulate energy balances in animals. And cortisol, a stress hormone that could determine if a female juvenile will disperse away from stressful conditions. Stress could also be associated with weight gain as bigger juvenile females tend to disperse while smaller females did not. In this study, we will look at stress's effects on Golden mantle ground squirrels. It will be conducted in the Rocky Mountain Biological Laboratory, located in the East River valley of Gunnison, Colorado.

Introduction:

Dispersal is the movement away from your place of birth and onto another location. (Goossens 2020). Dispersal is a 3-stage process that involves the decision to depart, displacement, and settlement. (Goossens 2020). Most mammals do this to escape antagonistic interactions, inbreeding avoidance, and resource competition (Li & Kokko, 2019). Mobile individuals also have a higher chance of finding a mate and unclaimed territory. Dispersal can be costly, but factors like kin competition and inbreeding can select for it (Li & Kokko, 2019). Mammal dispersal also tends to be male-biased as males almost always disperse as soon as possible, staying no longer than a year (Li & Kokko, 2019). In some species, females tend to disperse less frequently than males. Dispersal is costly, so why do females choose to leave?

Physiology can also play a role in dispersal. Glucocorticoids play an essential role in regulating energy balance in animals, helping them deal with social and environmental challenges (Nunes et al. 2006). Cortisol, the stress hormone, has been studied to determine its role in mammal dispersal. In mammals, GC elevations are high during the last days of gestation as it is critical for maturation in many vital organs like the liver and kidneys (Wada 2018). It also helps conserve energy for hibernation (Nunes et al. 2006). Juvenile ground squirrels (*Spermophilus beldingi*) have elevated cortisol levels during the emergence from their natal burrow as this helps promote learning alarm calls (Wada 2018). In golden mantle ground

squirrels, insulin and glucocorticoids play an essential role in the seasonal regulation of body mass (Boswell 1994). Cortisol especially appears to exert a predominantly anabolic influence on seasonal fattening in golden mantle ground squirrels (Boswell 1994). In a study on Barn Owls, stressful conditions led juvenile female barn owls to disperse further than females under lesser stress (Almasi et al. 2021). There are many studies on how stress can affect dispersal in Aves and reptiles but only a few on small rodent mammals (Vecken 2007).

Golden Mantled Ground Squirrels (*Callospermophilus lateralis*, hereafter “GMGS”) are small mammal species only weighing 230-240 g. (Ferron. J. 1985). The population ranges across Western North America at 1200m elevation or higher (Ferron. J. 1985). They are an asocial species, with juvenile males dispersing during the summer of their birth and some females remaining in the area while others disperse as well. They reach sexual maturity at a year old after hibernation. They emerge from hibernation in May to look for a mate. GMGS then give birth in late June, averaging up to 5 pups a litter (Kneip et al. 2011). Pups are nursed underground for about a month and emerge above ground from their natal burrow in June or July. After two weeks from emergence, pups tend to start dispersing away from their natal area.

The question I want to answer is if stress levels in Juvenile ground squirrels predict movement away from their natal burrow. I believe it does. I predict Juvenile ground squirrels with higher stress levels will move away from their natal burrow.

Study Area:

2023 GMGS site



The data collected and methods conducted were in Rocky Mountain Biological Research Laboratory. This is in the East River Valley of Gunnison, Colorado. The 13-hectare study site has an elevation of 2,900 meters. The site is populated with Golden Mantle Ground Squirrels that are free living. The town has already been mapped and plotted in 7m-by-7m plots around the town of Gothic.

Methods:

The data collected was primarily from GMGS pups. Once GMGS pups emerge from the den, they are immediately safely trapped as soon as they emerge. Once captured, feces and hair were collected. Feces and hair being collected are essential to analyze back in the lab for their Cortisol (stress levels). They are also weighted, and other necessary data was collected. In the span of 14 days, the GMGS pups started to disperse, so they were recaptured, and fecal and other data were collected again. The distance from where they were captured and where they emerged from the burrow was collected. This will calculate distances from the emergence location to the 14-day sampling location. Cortisol samples would take longer to test, so that I will use data from previous years.

To test the relationships between pup cortisol levels and distance moved from the natal burrow, we fit a series of linear models. The cortisol levels from the hair collected during the emergence of the GMGS pups were used as a model. And with the cortisol levels from fecal

collected from emergence. Finally, the cortisol levels from fecal collected when the pups were recaptured.

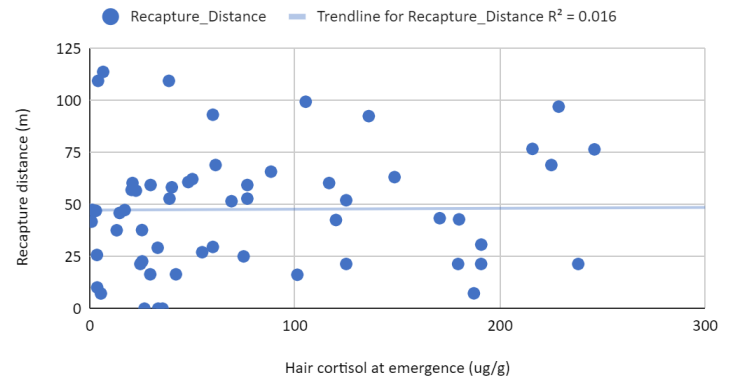
There was an expectation that the relationship between cortisol and distances moved could differ for male vs. female pups. This is the reason the interaction between these two variables in each of the models was included. This was for cortisol levels in hair, emergence fecal, and fecal at recapture.

Results:

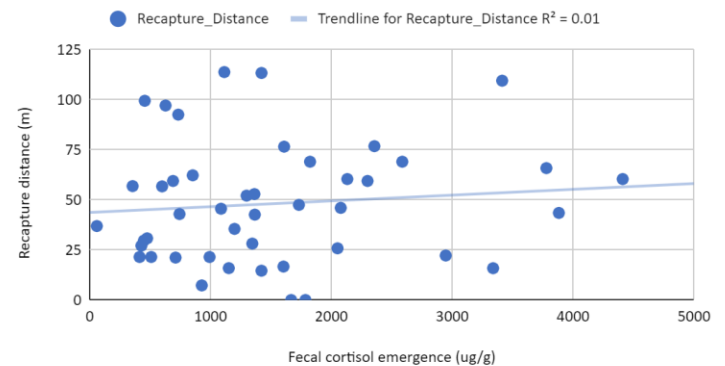
The number of pups sampled was 107 ranging from years 2019 through 2021. The overall distance average was 43.40, and the average growth of 3.24. The minimum distance traveled was 0, and the maximum was 113.86. The minimum growth rate was 1.2, and the maximum was 5.58. Females had an average distance of 43.44, while males had an average distance of 44.64. The average distance moved away from their natal borrow for 2019 was 37.56, with the growth rate being 3.38. For 2020, the average distance was 51.60, with an average growth rate of 3.34. Finally, for 2021, the average distance traveled from their natal borrow was 40.37, with an average growth rate of 3.11.

The data shows that there is very little correlation between stress and distance away from their natal barrow. The recapture distance vs. emergence cort in hair had no correlation with $R^2 = 0.016$. (figure 1) Recapture distance vs emergence cort in fecal had no correlation with $R^2 = 0.01$. Recapture distance vs recapture cort in fecal had no correlation with $R^2 = 0.011$. Recapture distance vs. growth rate had no correlation with $R^2 = 0.023$. Growth rate vs. emergence cort in hair had no correlation with $R^2 = 0$. Growth rate vs. emergence cort in fecal had no correlation with $R^2 = 0$. Growth rate vs. recapture Cort in fecal had no correlation with $R^2 = 0.032$.

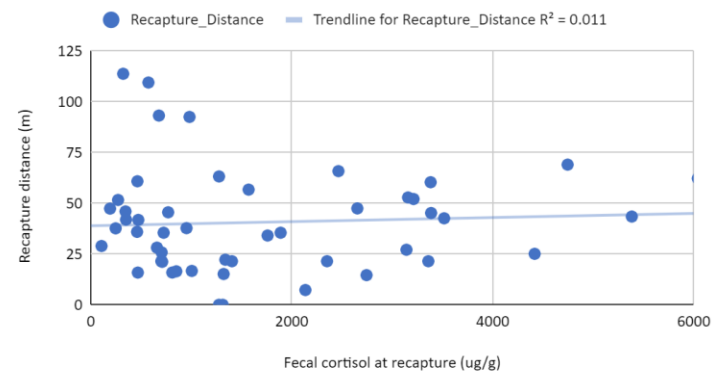
Recapture_Distance vs. Emerge_HairCort



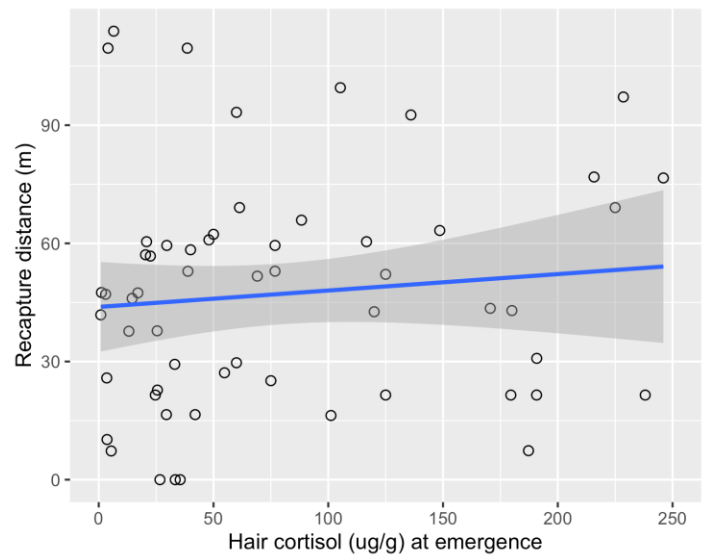
Recapture_Distance vs. Emerge_FecalCort.



Recapture_Distance vs. Recapture_FecalCort



There is not a significant correlation between Cort levels collected from the hair of juvenile GMGS when they first emerged and the distance from their natal burrow to where the GMGS pups were recaptured. Higher hair cortisol levels at emergence from the natal burrow were not associated with longer distances moved at recapture ($\beta = 0.046 \pm 0.06792$, $t = 0.678$, $p = 0.501$). Male pups did not move longer distances than female pups ($\beta = 0.94765 \pm 12.56121$, $t = 0.075$, $p = 0.940$), and there was no interaction between pup sex and hair cortisol levels at emergence on distance moved ($\beta = -0.01231 \pm 0.11433$, $t = -0.108$, $p = 0.915$).



There was no relationship between Cort fecal levels collected when the GMGS pups first emerged with the distance from their natal burrow to where the pups were recaptured. ($\beta = 6.391e-04 \pm 5.283e-03$, $t = 0.121$, $p = 0.904$). There was also no interaction between pup sex and fecal cortisol levels at emergence on distance moved ($\beta = 7.336e-03 \pm 9.724e-03$, $t = 0.754$, $p = 0.455$).

Last, there was no relationship between fecal cortisol levels from when GMGS pups were recaptured from the distance from their natal burrow to where the pups were recaptured. ($\beta = 0.0009028 \pm 0.0015080$, $t = 0.599$, $p = 0.552$). There was also no interaction between pup sex and fecal cortisol levels at recapture on distance moved ($\beta = -0.0002028 \pm 0.0036465$, $t = -0.056$, $p = 0.956$).

Discussion:

Hair cortisol represents pup stress over the course of hair growth during lactation before emergence from the natal burrow. These hair cortisol levels could be elevated either from maternal sources conveyed through milk or from pup internal physiology and social interactions in the natal burrow. Fecal cortisol represents stress levels over the previous few hours. The fecal cortisol levels at emergence that could represent below ground and at recapture were likely from pup aboveground activity. This suggests that prenatal stress levels before emergence had more of an influence on one proxy of natal dispersal (distance moved from natal burrow ~2 weeks after emergence) than did stress levels after emergence from the natal burrow.

Hair cortisol levels made a better prediction in the dispersal of juvenile GMGS. Hair cortisol represented below ground environment, while fecal cortisol from emergence and at

recapture would have direct experiences above ground. This leads to the belief that pups might be “programmed” by perinatal stress levels to move away from their natal burrow.

Similar results were found in Barn Owls that Individuals with a short-term corticosterone increase during the mid-rearing phase delayed the departure from the rearing nest and in females also permanent emigration from the parental home range and then induced females to disperse longer distances (Almasi et al. 2021). This means that during the nestling phase, it had a more considerable effect on their dispersal behaviors.

It was expected that males would have a higher average distance moved away from the natal burrow as males almost always dispersed while females tended to either stay or disperse as well. The results show that there was not much difference between male and female pups in terms of average distance moved and average cortisol levels.

Through this experiment, there was a potential bias in captures found. We found we were less likely to capture pups that had moved further from their natal burrow. This is why the 14-day target is set, which is the time after GMGS disperse after emerging from their natal burrow. We often try to catch the pups before actual natal dispersal. Some other biases found were the pups were easier to capture, usually, those who decided not to disperse.

There were pups that were missing hair and fecal samples so cortisol was missing which excluded that pup from the final data. While conducting the study I also noticed trap logs did not accurately represent the pups' farthest distance moved. Trap logs only contained data when the pup was captured at emergence and recaptured two weeks after where they tended to disperse. The problem is that if a pup emerging at a grid coordinate moves 67 meters away from its natal burrow but when it's time to recapture the pup at two weeks it is only 34 meters away from its natal burrow. The flaw would be that the pup's farthest distance was not truly recorded. I would suggest trackers would be useful to account for this bias and it makes it easier to collect data as a person doing it manually can't be watching them 24/7.

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