Animal Magnetism: A study of captive grey wolves at rest and their orientation relative to Earth's magnetic field

Max Yasgur, John Jay High School

Acknowledgements

This research was conducted with the help of my mentor, Ms. Rebecca Bose. She aided this research through elucidation of common wolf behavior as well as the possible procedures in captive wolf imaging, which was the primary method of data collection. My mentor also allowed access to observe the wolves. My teacher, Ms. Anne Marie Lipinsky, reviewed my paper and my forms.

Table of Contents

Topics

Tables and Figures

Abstract

The field of magnetoreception studies animals and their sensitivity to Earth's magnetic field. Over the past 50 years, the roster of magnetically-sensitive animals has grown significantly, but one animal has yet to make the list: the grey wolf (*Canis lupus*). This study attempts to determine if the captive grey wolf orients along a consistent directional axis during rest. The literature suggests that other higher order mammals with similar physiology show signs of magnetoreceptive behaviors at rest, but little is known about the wolf in this regard. In this study, four captive grey wolves were observed (n = 107 observations) over the course of five weeks using a camera-compass iOS application. After sampling was complete, the data was sorted for each wolf and circular statistical analysis was done for each animal and for the pooled totals. The pooled data show that the overall population rests along a highly significant (Rayleigh Z; $p < 10^{-12}$) North-South axis (mean vector = 175.3°/355.3°). These findings provide further evidence for the existence of magnetoreception in larger mammals and possible conclusions relating to canid senses and behaviors. A deeper understanding of magnetoreceptive behaviors allows biologists and environmental conservationists to better understand and predict the navigational tendencies of animals, including the endangered, wild grey wolf.

Introduction

Do animals have a "sixth sense?" In the standard context, "sixth sense" means a neurophysical response to intangible stimuli (e.g. imminent weather, magnetic fields, gazes from behind). The closest real-world example of a "sixth sense" is known as magnetoreception, or a sensitivity to Earth's magnetic fields (Wiltschko & Wiltschko, 2005). Magnetoreception is a weak sensation; the animals which respond to this force are not conscious of the magnetic influence on their bodies; other primary senses can easily overpower a sensation of specific magnetic alignment (Johnsen & Lohmann, 2008). Behavioral tendencies are the only form of macroscale evidence that magnetoreception is a real phenomenon.

Since it was postulated in 1957 by Hans Fromme, magnetoreception has been confirmed across several animal taxa, including migratory birds, sharks, dolphins, sea turtles, cattle, deer, bats, and some canid species (Wiltschko & Wiltschko, 2005, Johnsen & Lohmann, 2008, Tyson, 2003, Nießner et al., 2016, Begall et al., 2008, Červený et al. 2010, Holland et al., 2008, Hart et al., 2013). A common theory which has been proposed is that magnetoreception is important for migratory and homing behavior, as can be seen in many of the of the taxa listed previously. Animals which show such patterns have been researched in order to locate a specific mechanism to explain these magnetically inclined behaviors.

The two most prominent theories surrounding the magnetoreception mechanism are (i) a magnetite based "compass" comprised of nanoscale ferrimagnetic crystals (Jezek, 2006) of iron oxide (Fe_3O_4) (Eder et al. 2012, Kirschvink et al. 1992, Kirschvink et al. 2001) and (ii) a radical pair-based "compass" relying on photochemical signals from a flavoprotein, Cryptochrome 1, in the retina of several animal taxa, including birds, bears, and canids (Nießner et al., 2016). The most compelling theory is the magnetite "compass", due to its ability to be studied on the cellular level (Eder et al. 2012).

Because magnetoreception is a relatively weak sensation, it is most strongly expressed during periods of inactivity and low external stimuli. Domestic dogs (*Canis lupus familiaris*) have been found to align with the North-South axis during elimination, a behavior which requires the body's relaxation (Hart et al., 2013). This magnetically inclined behavior was categorized as axial, meaning that a northward orientation vector is equivalent to a southward orientation vector. Similarly, cattle, red deer, and roe deer were observed to align during grazing and resting, both low activity behaviors. The researchers found that cattle showed a strongly magnetic orientation (definite preference for N-S axis) while resting. Roe deer and red deer showed similar, highly N-S axis preferential grazing behaviors. Interestingly, when cattle strayed to the edges of their pens, near high voltage power lines, they aligned parallel with those power lines (Begall et al., 2008).This further suggests the validity behind the magnetoreception phenomenon because the power lines produce an electromagnetic field of their own which can disrupt the animals' natural alignment with the Earth.

An examination of grey wolf (*Canis lupus*) resting patterns is necessary to determine whether the Earth's magnetic fields affect their orientation of rest. The majority of grey wolf resting periods, or periods of inactivity, last 15-30 minutes. Less than 30% of rest periods last for longer than one hour (Theuerkauf et al., 2003). Rest in wolves typically begins once the animal has lied down in either the "sphinx-like" position or "side-lay" position (Mech et al., 1998, Peterson, 1995).The "sphinx-like" position entails lying with forepaws outstretched and hind-legs tucked to the animal's sides. The head can either remain upright or be resting on the paws with ears neutral or back (i.e. not forward, as this is a display of aggression). If the wolf gets more comfortable and is in a non-threatening environment, a common sleeping position is the "side-lay" wherein the animal rolls around his/her axis of rotation and begins to relax with extremities outstretched and spine straight (Mech et al., 1998, Peterson, 1995). Either of these is acceptable in the definition of a resting position because the axis of rotation has been conserved. Many studies have used an animal's thoracic spine (between scapulae) pointing towards the head as the axis of rotation for said animal allowing for total control of orientation and alignment (Hart et al., 2013, Červený et al. 2010).

On the spectrum of domesticated dogs to free-roaming wolves, ambassador wolves occupy a middle ground. Ambassador wolves are a pack of wolves which are born and raised in captivity with the sole purpose of representing free wolves and teaching and exposing wolves to the public. Physiologically, ambassadors are identical to wild wolves, though with fewer ailments due to their controlled environment. These wolves are human-fed on an irregular schedule known as the "feast-or-famine" method of feeding, a simulation of wild consumption behavior. Free grey wolves have a typical range of 60-600 square miles (150-1550 sq km) (Jedrzejewski et al., 2001). In an enclosure, ambassadors could have anywhere from 1-6 acres (0.004- 0.024 sq km) of land to explore, mark, and navigate. Behaviorally, ambassador wolves differ slightly from free wolves. Both animals possess an innate pack mentality and predatory instinct, but captivity removes two defining characteristics from the free wolves: their need to hunt for food and their natural fear of humans. Since ambassadors are on exhibition for people and are fed by people their entire lives, they develop a comfort and dependence on people that is uncommon and dangerous in the wild. Innate behaviors, such as sleeping in close proximity to other packmates, resting for over 50% of the day (Theuerkauf et al., 2003), howling to communicate and strengthen the bond between other wolves in the pack, and competing for food, are not lost in the captivity-raising process, making ambassador wolves acceptable subjects for studying natural wolf behavior.

Statement of Purpose

The purpose of this study was to determine if the ambassador grey wolf will align itself parallel to a common axis of orientation or direction based on the Earth's magnetic fields. The hypotheses are twofold: (i) Ambassador grey wolves will align along a consistent axis, and (ii) the ambassador grey wolf will align closely with the North-South axial vector because similar animals have been found to orient themselves with a predominantly North-South axial vector.

Materials & Methods

The resting orientations of four captive ambassador wolves--one Arctic Grey Wolf (*Canis lupus arctos*; male) and three Northwestern Grey Wolves (*Canis lupus occidentalis*; two male)--were observed for five weeks (July-August 2017) between the hours of 1300-1900, as to coincide with their crepuscular resting cycle of maximum activity at dawn and dusk and minimum activity towards midday. The minimum rest duration, as observed in these wolves was one minute, due to external stimuli which could have interrupted resting periods. No upper bound was placed on wolf rest duration as to not limit natural resting length.

The Arctic Grey was given the denomination "Wolf 1" and the Northwestern Greys were labelled accordingly with names "Wolf 2-4" for this study. The wolves are separated by species and live in 1.5 acre enclosures. Close to ten years prior to this study, Wolf 1 was moved to his own enclosure due to particular possessive and aggressive behaviors which were deemed dangerous to the other wolves. He was not separated solely for this study.

Using the National Oceanic and Atmospheric Administration's (NOAA) Magnetic Field Strength, Inclination, and Declination calculators, the observation environment was analyzed to factor shifts in magnetic field orientation into the results. These calculators use the World Magnetic Model (WMM) to generate an accurate representation of the Earth's magnetic field. The WMM uses a spatial scale representation of the Earth meaning that strength and fluctuations in the magnetic field are estimated according to previously collected data.

The iOS application Theodolite was used to record the rest periods of wolves and measure the wolves' alignment during such time. This is a camera application with a built-in heads-up-display including a magnetic compass (accurate to ±1°), altimeter, clock, and crosshairs, for centering subjects in photographs. This application allowed pictures to be taken of the four wolves with a compass direction present. To ensure the highest level of accuracy during data collection, the crosshairs were aligned parallel with the wolves' thoracic spine and shoulder blades. This location on the wolf body was adapted from the similar work of (Hart et al., 2013) on dogs. The thoracic spine was found to be the axis of rotational motion and could be used to define the orientation of the animal.

The small population of wolves (n=4) meant that a larger sample size (n=107 total observations, at 90% confidence level with 8% margin of error) was necessary to supplement the significance value of the study within the timeframe.

First-order directional statistics were used to analyze the data. This included Mean Axis Determination (azimuth, μ) and Angular Dispersion (r), which is similar to standard deviation but only ranges from 0-1. Second-order statistics were run at a later date. This included the Rayleigh Z test, a method for organizing and presenting non-uniform data points in a circle as well as testing the significance of the mean axis determined, and Rao's Spacing Test, a test for the data's uniformity and directionality around the circular plane.

Results

Body axes of four ambassador grey wolves (*Canis lupus*) were measured using a camera-compass application with 24-hour clock. Rest durations were also measured. Wolf 1 lived in a separate enclosure from Wolves 2-4. The table below shows the average rest orientation and rest duration of the four wolves as well as the pooled data (Table 1). Standard deviations are found adjacent to both categories in the table below (Table 1).

Wolf #	Rest Orientation (degrees)	SD_o	Rest Duration (minutes)	SD_d
1	198.5°/18.5°	22.6°	15.081	11.593
2	163.3°/343.3°	34.7°	13.947	13.597
3	163.5°/343.5°	22.7°	13.296	9.537
4	167.5°/347.5°	17.5°	14.125	13.401
Pooled	175.3°/355.3°	29.4°	14.215	11.959

Table 1. Mean Rest Orientation (degrees) and Rest Duration (minutes). This table shows mean resting orientation in degrees and resting duration in minutes for all 4 wolves and the pooled data. Standard deviation for orientation is denoted as SD_o and standard deviation for duration is denoted as SD_d. SD_d contains values near average rest duration since rest duration during observations had a lower limit of 1 minute with no upper limit to mark the end of a rest period. Mean resting orientation values are provided as XX°/XX° in S/N format.

With 180 degrees signifying due South, individually, the wolves rested within a range of -12.5° to 18.5° (Wolves 4 and 1, respectively) from the South-North axis. Negative values signify orientations less than 180°/360°, whereas positive values signify orientations greater than 180°/360°. In pooled data, the wolves rested on average within 5 degrees of the South-North axis (pooled data: 175.3°/355.3° ± 29.4°).

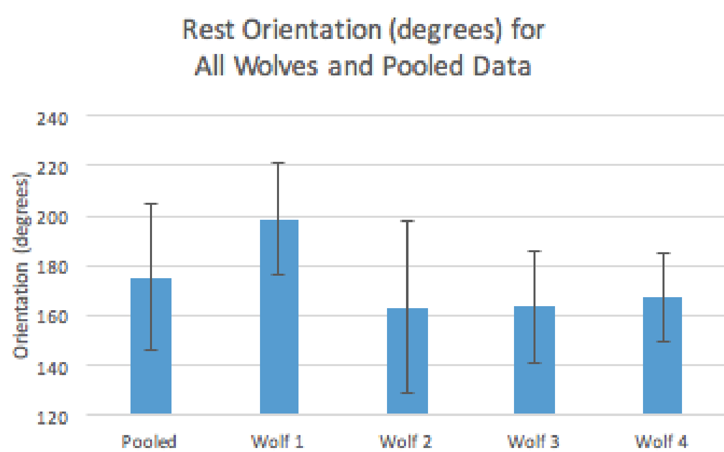
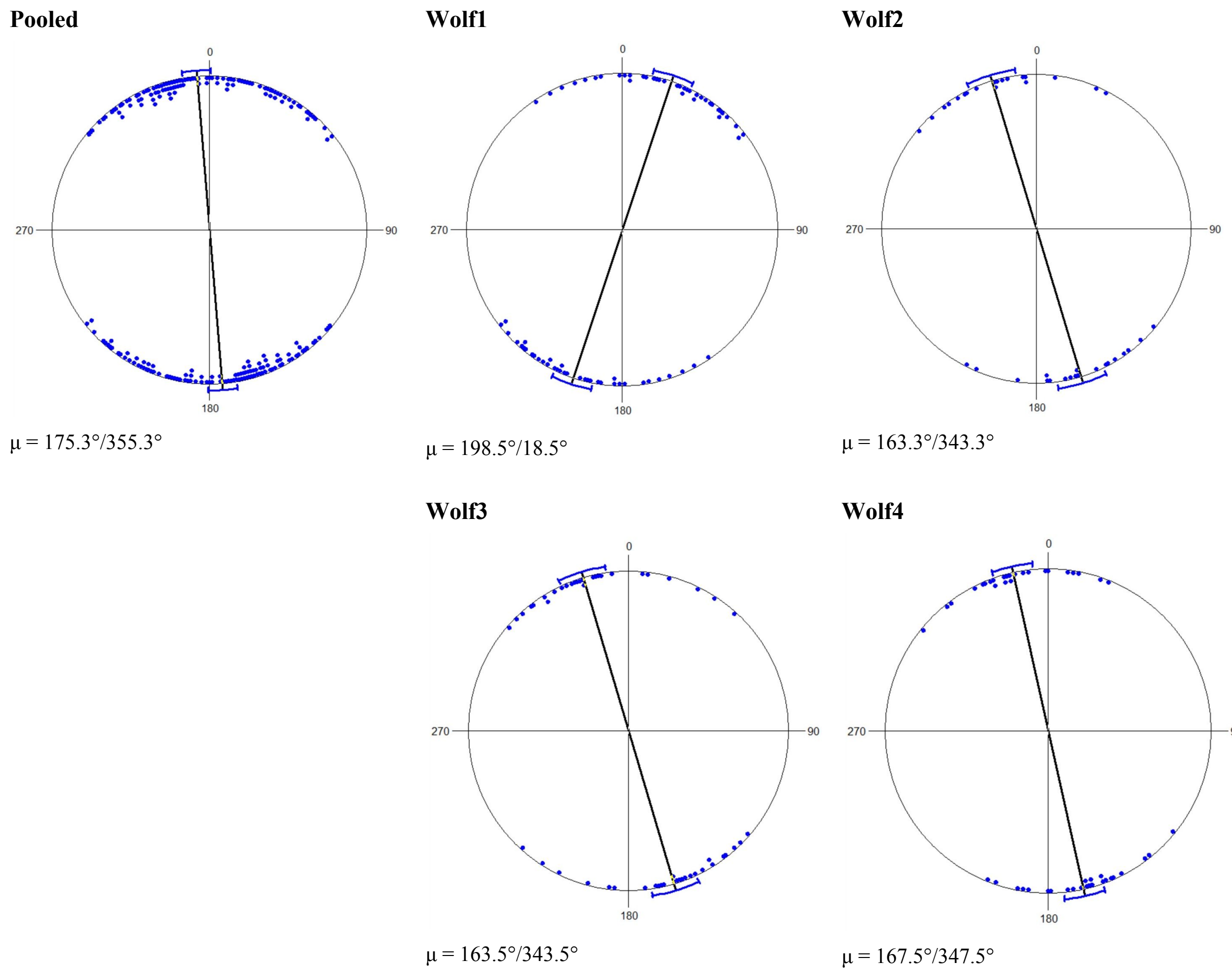


Figure 1. Rest Orientation for All Wolves and Pooled Data. On a range from 120 to 240 degrees (±60° from Due South, 180°/0°) are the mean rest orientations for all four wolves, as well as the orientation for the pooled data (n=107 observations). The error bars show standard deviation (Table 1, Column SD_o). All values are in degrees and can be found in Table 1.

Circular analysis was performed on each of the four wolves, as well as the combined dataset. The Rayleigh Z test, which examines the data against the null hypothesis that there is no sample mean direction, determines if a significant axial vector is present within a set of circular data. Analysis of the resting pooled recordings revealed a significant axial preference for North-South alignment during rest (μ = 175.3°/355.3° ±9.5° (mean vector orientation; 95% confidence interval), r = 0.649 (mean vector length), Rayleigh test: n = 107, $p < 10^{-12}$, Z = 45.073; Figure 1). Analyses of individual wolf data showed significant axial preferences for North-South (Wolf 1: μ = 198.5°/18.5° ±25.8°; Wolf 2: μ = 163.3°/343.3° ±7.8°; Wolf 3: μ = 163.5°/343.5° ±8.1°; Wolf 4: μ = 167.5°/347.5° ±5.5°; Table 2, Figures 2-5). Direct observations revealed that the majority of wolf resting positions face southward (angular data: 175.8°, r=0.886, n=107 observations). Due to the fact that axial behavior was studied, particular initial directions, such as South, are less important to final conclusions than total axis of resting orientation because South (180°) is equivalent to North (360°) on an axial measure.



Figures 2-6. Mean Axis Determination Graphs of wolf resting orientation for Wolves 1-4 and pooled data. Direction of the thick bar and arrows represents the mean vector of axial data (μ) on the Cartesian plane. Error bars show the variance of 8% in the axial determination. Mean axis values are provided under each graph as XX°/XX° in S/N format. Blue points represent individual data points. Stacking of the points shows the select data frequency.

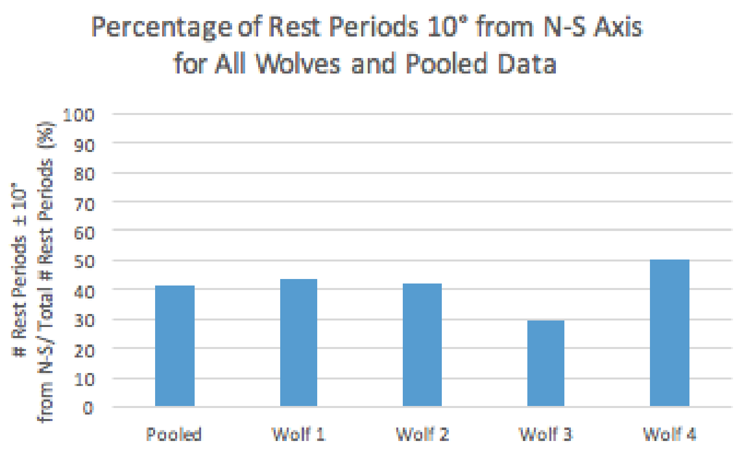


Figure 7. Percentage of Rest Periods 10° from N-S Axis for All Wolves and Pooled Data. Values in the graph were calculated by dividing the number of observations which were within 10° of the N-S axis (350-10°/170-190°). This gives a representation of density of the points, but this is localized around a set value (0°/180°) with set variance (10°). The data in this graph can also be seen in Figures 2-6.

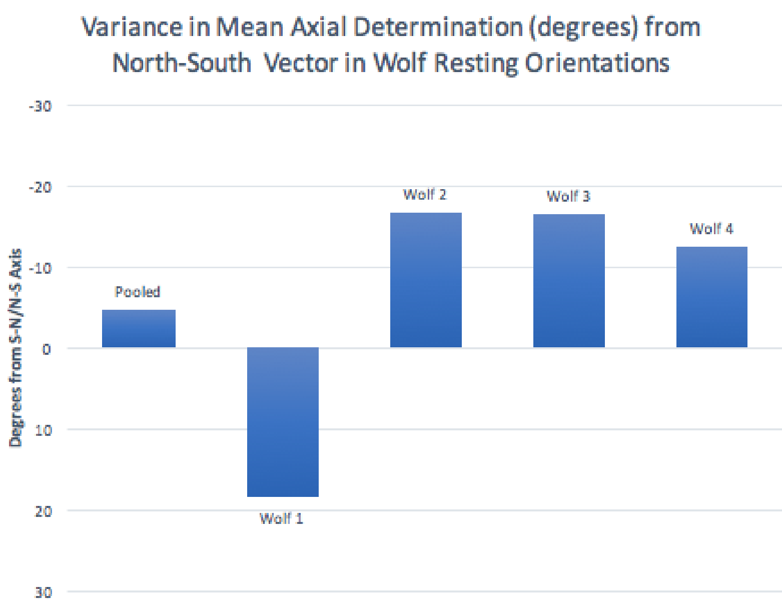


Figure 8. Variance in Mean Axial Determination (in degrees) from North-South Vector in Wolf Resting Orientations for Pooled Data and Wolves 1-4 Individually. This graph shows the minimal variance from the magnetic N-S vector, which would read as 0° in the graph. In order from "Pooled" to "Wolf 4," the values for the 5 bars read [-4.7°, 18.5°, -16.7°, -16.5°, -12.5°]. All data besides "Wolf 1" are negative because 180°, or due South, reads 0° and a lesser value would fall below this 0° reading, resulting in a negative value.

Variable	Pooled		Wolf 1		Wolf 2		Wolf 3		Wolf 4	
Data type	angular	axial	angular	axial	angular	axial	angular	axial	angular	axial
Number of observations	107	107	37	37	19	19	27	27	24	24
Mean vector (μ)	175.8°	175.3°/ 355.3°	197.4°	198.5°/ 18.5°	159.2°	163.3°/ 343.3°	165.2°	163.5/ 343.5°	167.6°	167.5°/ 347.5°
Length of mean vector (r)	0.886	0.649	0.925	0.726	0.867	0.783	0.925	0.735	0.954	0.828
Circular standard deviation	28.2°	26.6°	22.7°	22.9°	30.6°	20.0°	22.7°	22.5°	17.5°	17.6°
95% Confidence interval (-/+) for μ	-	170.2°/ 180.5°	-	11.1°/ 25.8°	-	154.4°/ 172.2°	-	155.1/ 171.9°	-	160.5°/ 174.5°
99% Confidence interval (-/+) for μ	-	168.6°/ 182.1°	-	8.8°/ 28.1°	-	151.6°/ 175.0°	-	152.4/ 174.5°	-	158.3°/ 176.7°
Rayleigh test (Z)	83.969	45.073	31.631	19.488	14.283	11.653	23.079	14.574	21.854	16.470
Rayleigh test (p)	<1E-12	<1E-12	<1E-12	2.37E-9	2.63E-7	1.12E-6	4.3E-10	1.16E-7	1.44E-9	4.76E-8
Rao's Spacing Test (U)	253.178	188.617	264.27	186.162	249.105	203.158	255.667	190.000	272.000	214.000
Rao's Spacing Test (p)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 2. Basic circular statistics for angular and axial directions of captive grey wolves. This table shows all statistics which were calculated in this study. It shows both the axial and angular data for the individual wolves, as well as the pooled data. The difference between axial and angular data is that angular data is the average of orientations with respect to the facing directions, whereas axial data is the average of orientations with respect to the facing and tail directions. The mean vector is characterized by its angle (μ) and its length (r).

Discussion

The purpose of this study, which was to determine if grey wolves orient along a consistent axis, more specifically the North-South axis, was met. This study was conducted because literature on magnetoreception and its effect on other canids (dogs and red foxes) has been published, and grey wolves are the progenitors of both species (Hart et al., 2013, Červený et al. 2010). This would suggest that grey wolves are the originator from which both independent species received this sense. Grey wolves showed behaviorisms which many other magnetically sensitive animals possess, including being migrational predators (following prey up to 30 miles daily and returning home) and having a large natural range (60-600 sq mi), yet no studies have been published determining if the grey wolf is another species to add to the long roster of magnetically sensitive animals. Furthermore, the addition of another higher order mammal to the list of magnetoreceptive animals could further suggest the existence of a human magnetoreception response due to similarities in physiology.

In this study, four captive grey wolves were observed during rest, and their orientations were measured relative to the thoracic spine to determine if wolves rest according to a consistent direction. Through the use of a camera-compass application and circular analysis, it was determined that grey wolves do significantly orient along a North-South vector while resting. Magnetoreception is a weak sense where organisms are able to be influenced by the Earth's magnetic field (Johnsen & Lohmann, 2008). Being so weak, these magnetically sensitive behaviors are most strongly expressed during times of low excitement and low stress. Previous studies demonstrated that animals tend to orient with a large vector of N-S while engaging in restful and low stress activities (i.e., resting, grazing, eliminating) (Begall et al., 2008, Hart et al., 2013). This report is consistent with the finding that grey wolves will lie in accordance with the N-S axis. In one contrary report, researchers found that red foxes will orient NE while hunting, which is a stressful activity (Červený et al. 2010). Despite this, the researchers proposed that the foxes were listening to their prey, mice which show the magnetoreceptive tendencies, and acclimating to the prey's behavior, instead of possessing magnetoreception themselves. Either this is the case or a resting state may be independent of the magnetoreceptive behaviors.

Though no other parameters were measured in this study, there were intriguing findings. The first finding is the similarity between the Mean Axis Determination graphs of Wolves 2-4. As stated in the Materials and Methods, Wolves 2-4 live in the same enclosure, and have for the last 5 years. A probable explanation for the graphical similarity is the idea of pack behavior, where in a group of wolves will become a pack, therefore becoming more closely attached and producing similar behaviors, such as resting orientation (Figures 4-6). During the observation period in data collection, we found that the wolves tended to lie within 5 meters of the fenceline on their enclosures. As these are ambassador wolves, they are accustomed to humans, but interestingly one study has found that wild wolves will also rest by man made structures, even if their dens are as far from humans as possible within a wooded area. Since this behavior has been found in the wild, it is unlikely that this affected the results.

As a behavioral study in the field, there are many limitations and error sources in this research. The first limitation was the use of in-person data collection instead of a constant camera feed with which data could be collected remotely and for all hours of the day. As such, it is likely that the results were influenced by the human presence despite the attempt to prevent the wolves from pointing at the person before lying down, essentially mitigating the bias. Another design flaw includes the separation of (or lack thereof) the wolves in the enclosures. A possible fix could be isolating the wolves into separate enclosures so that they are less affected by pack behavior. Wolf 1 was isolated based on past complications and his results are therefore not biased by any social behavior. The last limitation was the uneven terrain within the wolf enclosures. There were shallow pits, slopes, and shrubbery where the wolves lied that resulted in few inconsistent data points due to the prevalence of spinal twists and torsions and overall lack of visibility on such terrain. One way we overcame this difficulty was by limiting the orienting rest periods to ones where the thoracic spine was clearly visible and clear of any terrain or vegetation obstructions.

In the future, we would like to continue this study and collect more data and update the results or conduct this research again but only after addressing each limitation described above. Another possible future study could be the observation of free, wild wolves and their resting orientation trends to compare how comfort with humans affects wolf resting behavior. Such a study would need to be conducted remotely for the safety of the humans and animals involved. A final possible study could test how other canid species respond to the Earth's magnetic field during rest or similar restful activities to determine if magnetoreception can be defined as a canid sense, not including the various other animals from across the taxonomic spectrum in which magnetoreception has already been found.

Conclusions & Significance

In summary, captive grey wolves do significantly rest in accordance with the N-S directional axis. Despite similar animals being studied, this research is the first connection made between wolves and magnetic sensitivity. The findings further the progress towards concluding that magnetoreception is a sense possessed by many higher order organisms by the addition of another mammal to the list. Additionally, the findings support the theory that magnetoreception is an evolutionary sense which can be found in animals across the taxonomic spectrum. Since the findings relate to captive wolves, future research will need to be conducted on free wolves to make the appropriate final conclusion that grey wolves are magnetically sensitive.

References

1. Begall, S., J. Cerveny, J. Neef, O. Vojtech, and H. Burda. **Magnetic alignment in grazing and resting cattle and deer.** *Proceedings of the National Academy of Sciences* 105.36 (2008): 13451-3455. Web. 14 Feb. 2017.
2. Cerveny, J., S. Begall, P. Koubek, P. Novakova, and H. Burda. **Directional preference may enhance hunting accuracy in foraging foxes.** *Biology Letters* 7.3 (2011): 355-57. Web. 14 Feb. 2017.
3. Eder, Stephan H.k., Hervé Cadiou, Airina Muhamad, Peter A. Mcnaughton, Joseph L. Kirschvink, and Michael Winklhofer. **Magnetic characterization of isolated candidate vertebrate magnetoreceptor cells.** *Proceedings of the National Academy of Sciences* 109.30 (2012): 12022-2027. Web. 19 Jan. 2017.
4. Hart, Vlastimil, Petra Nováková, Erich Malkemper, Sabine Begall, Vladimír Hanzal, Miloš Ježek, Tomáš Kušta, Veronika Němcová, Jana Adámková, Kateřina Benediktová, Jaroslav Červený, and Hynek Burda. **Dogs are sensitive to small variations of the Earth's magnetic field.** *Frontiers in Zoology* 10.1 (2013): 80-92. Web. 8 Jan. 2017.
5. Holland, Richard A., Joseph L. Kirschvink, Thomas G. Doak, and Martin Wikelski. **Bats Use Magnetite to Detect the Earth's Magnetic Field.** *PLoS ONE* 3.2 (2008): n. pag. Web. 24 Apr. 2017.
6. Jedrzejewski, Wlodzimierz, Krzysztof Schmidt, Jörn Theuerkauf, Bogumila Jedrzejewska, and Henryk Okarma. **Daily movements and territory use by radio-collared wolves (Canis lupus) in Bialowieza Primeval Forest in Poland.** *Canadian Journal of Zoology* 79.11 (2001):1993-2004. Web. 8 May 2017.
7. Jezek, Geno. **Types of Magnetism.** *Types of Magnetism | What is Magnetism?* N.p., 2006. Web. 9 Jan. 2017.
8. Johnsen, Sönke, and Kenneth J. Lohmann. **Magnetoreception in animals.** *Physics Today* 61.3 (2008): 29-35. Web. 12 Feb. 2017.
9. Kirschvink, Joseph L., Atsuko Kobayashi-Kirschvink, Juan C. Diaz-Ricci, and Steven J. Kirschvink. **Magnetite in human tissues: A mechanism for the biological effects of weak ELF magnetic fields.** *Bioelectromagnetics* 13.S1 (1992): 101-13. Web. 23 Jan. 2017.
10. Kirschvink, J. **Magnetite-based magnetoreception.** *Current Opinion in Neurobiology* 11.4 (2001): 462-67. Web. 21 Apr. 2017.
11. Mech, L. David. ***The Wolves of Denali***. Minneapolis: U of Minnesota Press, 1998. Print.

12. Nießner, Christine, Susanne Denzau, Erich Pascal Malkemper, Julia Christina Gross, Hynek Burda, Michael Winklhofer, and Leo Peichl. **Cryptochrome 1 in Retinal Cone Photoreceptors Suggests a Novel Functional Role in Mammals.** *Scientific Reports* 6 (2016): 21848-1855. Web. 11 Jan. 2017.
13. Theuerkauf, Jörn, Sophie Rouys, and Wlodzimierz Jedrzejewski. **Selection of den, rendezvous, and resting sites by wolves in the Bialowieza Forest, Poland.** *Canadian Journal of Zoology* 81.1 (2003): 163-67. Web. 6 May 2017.
14. Theuerkauf, Jörn, Włodzimierz Jędrzejewski, Krzysztof Schmidt, Henryk Okarma, Ireneusz Ruczyński, Stanisław Śnieżko, and Roman Gula. **Daily Patterns And Duration Of Wolf Activity In The Białowieża Forest, Poland.** *Journal of Mammalogy* 84.1 (2003): 243-53. Web. 10 May 2017.
15. Tyson, Peter. **Animal Magnetism.** *PBS*. PBS, 18 Nov. 2003. Web. 17 Jan. 2017.