Ursidae: The Undergraduate Research Journal at the University of Northern Colorado

Volume 5 | Number 3 Article 1

January 2016

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Dominance Hierarchies in Horses: Comparing and Contrasting Different Methods for Assessing Hierarchies

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Understanding animal social structures is imperative when it comes to the care, housing and handling of large herd animals. Knowing how hierarchies are structured, along with environmental and physiological aspects that may affect them, will allow owners and breeders to house and care for their animals. The aim of my study was to better understand two methods used to assess dominance hierarchies in horses, *Equus caballus*, and to predict which method would be more useful for owners housing domestic horses. I designed an experiment where I compared a structured method, the paired feeding test, with behavioral observations from the horses' natural setting. I hypothesized that the structured method would not conclude the same dominance hierarchy as the natural observations. I also hypothesized that traits of the horses, such as size or age, would correlate with the hierarchy ranking within a herd. A herd of six individual horses from a small ranch east of Platteville, Colorado was used to test the two methods. I found that the two methods measured different hierarchies. The paired feeding test showed no correlations to any of the physical measurements, as well as did not provide a hierarchy that was similar to the natural dominance observations of the horses. Natural observations established a more linear hierarchy and had significant correlations with weight and overall body size. The results indicate that the paired feeding test may not be a valid method for establishing dominance hierarchies within domestic horses housed in a small range. I recommend use of natural observations over paired feeding tests for ranchers, breeders or owners trying to understand the dominance hierarchies among their herds.

Keywords: horse dominance, hierarchies, animal behavior

For centuries, horses have played a valuable role in human activities, ranging from work to recreation. Since the horse has been a valuable asset to humans, their behaviors have also been studied to better understand how they not only interact with other individuals in a herd but also how their behaviors affect humans who interact with them. These studies are important for different practical aspects, such as housing horses together, or predicting how they will interact with other individuals in a working or recreational setting.

Dominance hierarchies are established in many different mammals that live in herds (Houpt, 1978; Vries, 1995; Estevez, 2007). Dominance has been defined as "an attribute of the pattern of repeated, agonistic interactions between two individuals, characterized by a consistent outcome and default response rather than escalation of conflict" (Drews, 1993). Within the herd, a hierarchy can be beneficial when foraging for resources, mating, and when eluding predators. The hierarchy provides protection for individuals as well as access to better foraging areas. If there is no hierarchy established then the herd can become chaotic and more susceptible to predation. Wild horses that live in large rangelands must be on constant

look out for predators such as cougars, bears, wolves, and potentially coyotes. Predation is therefore one driving factor behind the evolution of animals establishing herds (Estevez, 2007; Carter, 2009; Houpt, 1978). In the wild, stable hierarchies are important for avoiding predation and in-fighting, as well as finding and sharing resources (Estevez, 2007; Giles, 2015). The benefit of being in the herd and avoiding predation overrides the costs of being in the herd. Within the domestic herd, although predation and foraging pressures are significantly lower, establishing the hierarchy is still an important aspect of horse sociality.

One additional valuable aspect of living within the herd is companionship. Companionship is seen as a basic need in which animals show a willingness to work for access to social benefits (Holm et al. 2002; Hovland, 2005; Estevez, 2007). The social aspect of being in the herd helps to reduce fear in non-harmful situations as well as social facilitation, grooming, thermoregulation and learning opportunities for immature individuals (Estevez, 2007). There are also added costs when living in herds. The cost of confrontation can be high, causing injury to an individual. Such injuries will happen more often if the herd lacks stability in its hierarchy (Estevez, 2007; Giles, 2015). Once a hierarchy is established there is typically less confrontation, leading to less aggression and fewer conflicts (Estevez, 2007; Giles, 2015). Stability in the herd can improve individual fitness and reduce threats to the integrity of the group as a whole (Giles, 2015).

Dominance among horses is established and indicated by a combination of behavioral cues given and/or by aggressive contact (Houpt, 1982; Drews, 1993). Basic aggressive cues or threats are first given, usually in the form of bite or kick threats or lunging and/or chasing an opponent. If those cues are ignored or challenged then the threats are taken further by actually biting, kicking or even rearing up and "boxing" with each other to establish dominance (McDonnell & Hayiland, 1995). Usually the subordinate individual is seen running away with submissive behaviors including a lowered head, tail tucked in, and movement that puts distance between itself and the aggressive individual. Some young, immature individuals have also been observed to use the behavior of submissive snapping (Houpt, 1978). Even the slightest ear or head movement can be a cue to challenge or hint to another to stay away (Houpt, 1978).

There are multiple methods of assessing a hierarchy that earlier scientists have used when observing horses. Natural observation is the most common method used to study and observe the dominance interactions (Vries, 1995; Giles, 2015; Houpt, 1978). This includes sitting in an unobtrusive area where the horses are not affected by your presence and taking note of dominant and submissive behaviors by each horse. This method is informative because the horses are in their natural settings, although this method requires many hours of observations to accurately describe the hierarchy. Another method commonly used is the paired feeding test (Houpt, 1978; Vries, 1995; Giles, 2015). In this test each individual horse is paired with another individual in a fixed setting to observe which is dominant over the other or if they show equal dominance. Many different studies have used "fixed" tests to help measure the hierarchies in the herds they were observing, though some studies have questioned the implications that this method actually holds (Houpt, 1978; Giles 2015; Vries, 1995).

I was curious to see how the two different methods most commonly used compared to each other. Growing up around

horses I've had first-hand experience with different equine behaviors and have observed changes in the hierarchy of my family's own herd of horses. After reading many different studies about establishing hierarchies I decided to put the tests into practice and replicate the studies on my own herd of horses. I set out to study how the paired feeding test would compare to natural observations. My hypothesis was: the structured method for establishing dominance hierarchies would not conclude the same hierarchy as the natural observations. More specifically, I predicted that the paired feeding test would show a more linear hierarchy compared to a natural setting that would produce a more triangular hierarchy. I also predicted that sex and size would correlate with a horse's rank within the hierarchy.

Methods and Materials

The study was conducted at a ranch owned by Troy and Jill Bailey, located roughly ten miles east of Platteville Colorado. The study consisted of 6 horses ranging in age, size and sex. The herd of 6 was housed on a small section of pasture that included two hay feeders, a large water tank, covered shed and area for the horses to run and freely interact (Figure 1). All research was approved by the UNC IACUC committee, protocol number 1521C.

First, to get baseline information, I measured the height and weight as well as the sex and age of each horse (measurement methods following Carter et al. 2009). The owner was not sure of the exact age of each horse but had a rough estimate. On the first day of the study the owner caught each horse using halters, then secured each to a hitching post so we could take measurements (see Figure 2 and Figure 3). For height we used a long, slender PVC pipe to stand from the ground to the top of the horse's withers. I then used a measuring tape to measure from the ground to where the withers stopped on the pipe (see Figure 2). The length of the horse was measured from the middle point of the chest to the rump using a long rope. Then I laid the rope next to a measuring tape to determine its length. The next measurement, called the heart girth, was taken by wrapping a rope around the chest and meeting at the base of the

Figure 1: Enclosed section of pasture where the herd is housed

Figure 2: Height measurements

Figure 3: Heart Girth measurements

withers (see Figure 3). The rope was stretched out and measured using the measuring tape. Once I had the body measurements I used the following calculation to estimate the weight of each horse: ((heart girth) x (heart girth) x (length) / 330) (calculation method following Gibbs. & Householder, 1992). After each horse had been measured it was released back into the sectioned off pasture with the rest of the herd.

In order to quantify natural dominance interactions among the 6 horses I conducted behavioral observations. Each observation consisted of continuous scans for one hour. I conducted 26 observations, with times that ranged throughout the day during two focal periods: 10:00 am to 12pm, or 2pm to 6pm. I started observations in mid-January of 2015 and continued into mid-April of 2015. During observations I found a spot to sit, roughly 12 meters away from the horses, where I was far enough away from the fence that wouldn't affect the horses but in an area where I could see the majority of the fenced in pasture (see Figure 1). I would wait between 5 to 15 minutes for the horses to get adjusted to my presence before beginning each observation period. During the observations all agonistic behaviors were recorded. Agonistic behaviors were classified, using an equine behavior ethogram. I began with an ethogram from a previous study in the *Applied Animal Behavior Science Journal* and then added additional behaviors that I observed in my study subjects (Table 1); (McDonnell & Haviland, 1995). I distinguished "winners/dominant" from "losers/subordinate" by quantifying their learned behavioral signals (Houpt et al., 1978; Houpt et al., 1982). Aggressive

actions occurred when one individual would threaten or displace another causing the other to retreat (Houpt, 1978; Drews, 1993). The horse that performed the dominant behavior towards another individual was determined to be the winner of that one interaction; whereas the horse that retreated was considered to be the loser.

To obtain a more structured method of determining dominance among these horses I used the paired feeding test (Houpt et al., 1978). A large round pen on the Bailey ranch was used for the tests. For the paired feeding test I would place a bucket with grain pellets in the center of the round pen (see Figure 4). The bucket was only big enough for one horse to place its muzzle in, allowing me to observe the interactions between the pair of horses. Each individual horse was paired against each of the other horses, making sure that each horse went only one time in a day.

I acquired the assistance of both of the owners of the ranch to help with haltering and positioning the horses to be released in the pen during the paired feed testing. The horses were walked up to the bucket and allowed to smell the grain, then walked to opposite sides of the pen. Once both of the horses were in place, the owners would un-halter both horses at the same time allowing them to approach the bucket. During approach I recorded which horse was more dominant as well as any agonistic behavior between the pair. During the paired feeding tests, a horse was termed the winner if it spent the most time feeding at the bucket, not allowing the other the chance to feed, and also displaying aggressive threats (Houpt, 1978; Houpt, 1982). During the paired feeding tests I also made notes on the natural behaviors of the rest of the band during the time periods when different pairs were missing.

After all the natural observations were done as well as all the paired feeding tests, I constructed matrices of the wins and losses between each pair of horses on the

Figure 3: Indie vs. Boon paired feeding test

two different tests. I calculated a "win percentage" for each horse in natural interactions as (total wins)/ (total interactions). In the paired feeding test I assigned a "win" as being worth 2 points, a "draw" as being worth 1 point, and a "loss" as being worth 0 points. From there I was able to then construct a "win score" for the paired feeding test. These metrics allowed me to make a hierarchy for each test and allowed me to compare and contrast the linearity of a naturally observed hierarchy versus a test-based hierarchy. I was then able to run a linear regression (fit Y by X) test to determine a line of best fit, allowing me to test for correlations between variables including size and age.

Results

Before any observations were taken, an ethogram of dominant and submissive behaviors was established, and I collected baseline measurements for each horse.

Table 1: Equine Agonistic Ethogram

	Description of behavior:
Alert	Rigid stance with neck elevated and head oriented towards subject. Ears straight, upright position.
Approach	Forward movement to another at any speed. Usually head is lowered, ears back.
Arched neck threat	Neck flexed with muzzle drawn to chest. Can be displayed as part of another behavior: posturing, pawing, investigation, strike threat.
Avoidance/ Retreat	Movement to maintain or increase distance between the agonistic individual. Head is low and ears back.
Bite/ Bite Threat*	Rapid opening and closing of jaw with the teeth grasping on flesh of opponent. Accompanied by pinned back ears and lips retracted. Bite threat is when no contact is made. Neck is stretched back, ears pinned back as head swings toward opponent and deliberately misses to warn opponent. Forward movement such as a lunge toward the hind end of being chased or herded.
Boxing/ Dancing*	Boxing is the action of rearing up and striking out with forelegs. Dancing is when both rear up, interlocking forelegs as well as biting or threatening to bite opponent's head and/or neck.
Bump*	Rapid lateral toss of the head forcefully contacting the opponent's body.
Chase/ Displace*	Displace opposing individual from an area. Ears are pinned back, teeth exposed and bites are made at the opponent's rear. Opponent may kick out with rear leg.
Ears Threat	Ears pressed caudally against the head and neck.
Kick/ Kick Threat*	Extending hind legs backwards towards an opponent with the intent to make contact. The threat is without the actual contact. Leg may be lifted in the ready to strike position. May also back up toward opponent incorporating a tail lash or harsh squeal.
Rearing*	Lifting front limbs off the ground, elevating to a vertical position with intent of strike, box, or stop.
Strike/ Strike Threat*	Forelegs rapidly extend forward making contact with opponent. Using one or both legs. The treat is an abbreviated strike in which foot is lifted off ground mimicking preparation to kick.

Adapted from McDonnell 1995. Behaviors with an asterisk (*) were modified or added to better reflect the behaviors in the study population.

Table 1 shows the ethogram I constructed from a combination of my own behavioral observations as well as other behaviors that past researchers recorded during their studies of horse behavior (McDonnell & Haviland, 1995). Within the herd, I was able to observe all of the agonistic displays listed in Table 1. Although some of the more intense interactions such as actual bites and kicks, as well as rearing up, boxing or dancing were not frequently observed. The only time I observed rearing up/boxing was during social play between the younger horses. Those interactions were not included because it was clear that they were not agonistic in nature.

Table 2 quantifies the number of agonistic behaviors recorded during natural observations. It shows that the majority of aggressive behaviors came from Indie and Badcat, and that most of the behaviors were only to displace or threaten, with very few dangerous contacts such as bites or kicks. Table 2 also indicated which individuals were most submissive by how many times they retreated during an agonistic interaction with another individual.

Each of the six horses had measurements taken of their height, length, heart girth, and weight. Because a large mammal scale was not available, weight was calculated using an equation that used heart girth and length to estimate weight (Carter, 2009). Even though my herd size was small, there was a wide range of sizes (Table 3). Ages of horses ranged from 5 years old to 24 years old. In height, heart girth, and length, there was roughly a 10-inch difference between the smallest and largest of the group. The weight range was from 1,069.4 pounds to 1,497.3 pounds, roughly a 400-pound difference between the smallest and largest. Linear regression indicated that age was not correlated with size, represented by overall weight ($R^2 = 0.19$, $F_5 = 0.92$, $P = 0.39$) (Table 3). The oldest horse was not the largest or heaviest. The same is seen with the youngest horse, he was not necessarily the smallest horse of the herd.

Table 2: Agonistic behavior counts during natural observations

	Ear Threat	Displace / Chase	Bite Threat	Kick Threat	Bite	Kick	Rear up /Box/ Dance	Total Dominant	Total Retreat
Indie	21	18	5	1	2	0	0	47	2
Badcat	19	16	4	1	3	0	0	43	5
Jr	13	4	5	3	5	0	0	30	12
Boon	8	2	4	7	3	0	0	24	18
Frosty	4	0	2	5	2	0	0	13	23
Nike	5	2	0	2	3	0	0	12	22
Total of each	70	42	20	19	18	0	0		

Table 3: Age and size measurements

	Sex:	Age (years)	Height (in)	Heart Girth (in)	Length (in)	Calculated Weight (lbs)
Indie	F	9	64.25	78	74	1,414.3
Badcat	F	9	63	83.5	68.5	1,497.3
Jr	M	24	58.5	76.5	75	1,380.1
Boon	M	7	54.75	75.5	67.5	1,216
Frosty	M	5	56.25	72.5	64	1,069.4
Nike	M	7	62	75.25	70.5	1,259.7

Tables 4 and 5, and Figure 4 represent the two different hierarchy observations of the herd. Table 4 and Figure 4 show the results of the paired feeding test. The results show that there was a definite top ranking horse (Indie) and bottom-ranking horse (Nike), but the middle four horses all ranked similar to each other with two of the horses being equal in the number of wins they had, and similar win scores (Figure 4, red bars). During the paired feeding test I did observe aggressive displays from the more dominant horses, although most of the displays were only threats such as ears pinned back and bite threats. I also observed some interactions where there was no clear winner. Four separate pairs all had ties where neither displayed dominance over the other. During these interactions it was observed that one of the horses wasn't interested in the bucket or they would take equal turns eating out of the bucket. Also, during the paired feeding tests that were conducted later in spring the horses I observed to be more dominant in the natural setting would sometimes not be interested in the grain in the bucket during the fixed test and chose to graze on new vegetation that was sprouting in the round pen. In Table 4 the interactions that have 0 or ties were some of the interactions where the horses I observed as dominant in the natural setting chose to graze instead of eat out of the bucket. The natural setting observation results, seen in Table 5 and Figure 4, show a more linear hierarchy compared to the non-linear hierarchy seen in the fixed setting.

Table 4: Paired Feed Test

	Win(W)					
Loss(L)	Indie	Badcat	Jr	Boon	Frosty	Nike
Indie	X	L	L	L	0	L
Badcat	W	X	L	0	W	0
Jr	W	W	X	0	L	L
Boon	W	0	0	X	L	L
Frosty	0	L	W	W	X	L
Nike	W	0	W	W	W	X

Win or loss indicated for the horse named in the top row relative to opponents in each lower row.

Table 5: Natural Dominance Observations

	Win(W)						Total
Loss(L)	Indie	Badcat	Jr	Boon	Frosty	Nike	Losses
Indie	X	2	0	0	0	0	2
Badcat	3	X	5	0	0	0	8
Jr	9	8	X	4	2	0	23
Boon	8	12	8	X	5	2	35
Frosty	11	12	5	8	X	5	41
Nike	9	11	3	3	2	X	28
Total wins	40	45	21	15	9	7	

The table shows the number of wins for the horse named in the top row relative to opponents in each lower row.

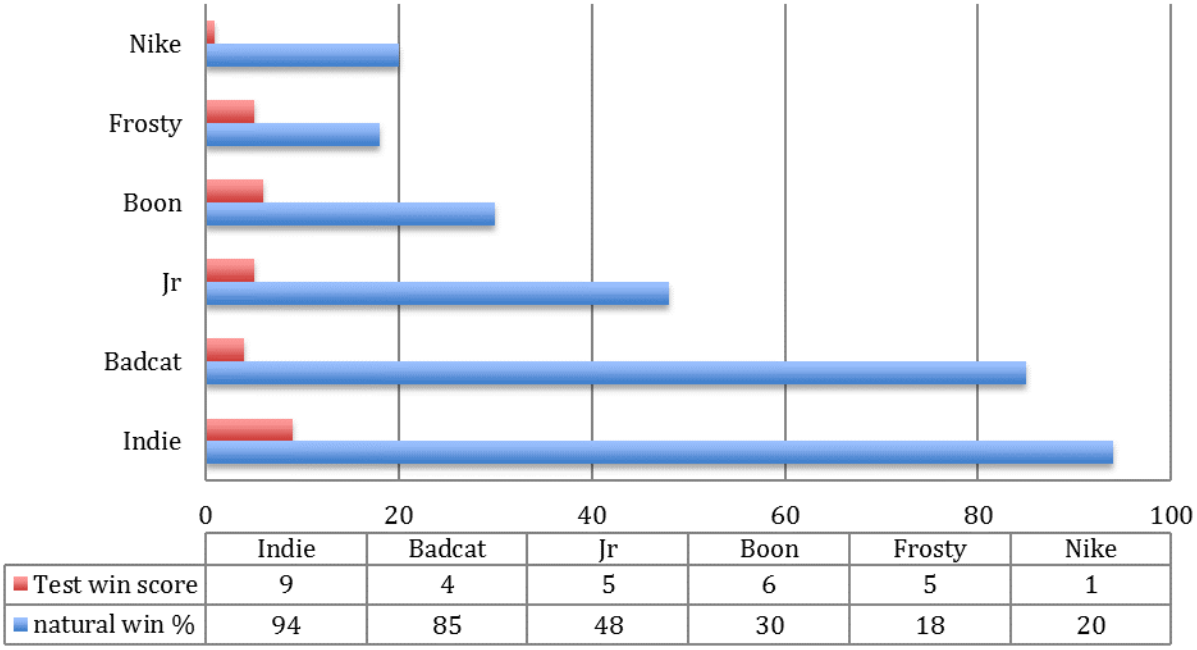

Figure 4: Comparisons of win percentages in the natural condition with the win score in the paired feeding test

Table 6 shows the win percentages of each horse. Interestingly, number of wins did not always perfectly predict win percentage - even though Badcat had more dominance wins (45) than Indie (40) (Table 4), Indie had a higher percentage of wins during those dominance interactions (Table 6). Indie had a high 94% overall wins compared to Badcat's 85%. Jr and Boon for both tests were roughly around the same percentages; they both were near to the middle of the hierarchy for amount of wins and dominance interactions. Neither horse showed extreme dominance nor submission. Nike was seen lower in the hierarchy for the natural observations as well as the paired feed test.

The most dominant horse in both tests was Indie. Badcat was near the top of the hierarchy according to natural interactions, but not according to the paired feeding test. From the two tests, I was able to conclude that there were two options for the most submissive horse: Frosty and Nike (Table 6). Frosty had a higher win score for the paired feeding test, but Nike had a higher natural dominance win percentage (20%). During the paired feeding test Nike didn't have a single win, although he did receive one point for a tied interaction, which is solely based on the fact that neither Badcat nor Nike approached the bucket during their trial. Frosty on the other hand had more wins, one win being against Nike. Natural interactions show a different outcome for the most submissive individual. Frosty had two more wins during natural interactions although he lost more interactions than Nike. It is important to note that Frosty overall had the most interactions, even though he lost majority of them.

After collecting all the data, I used separate linear regression tests for each variable to test for correlations between the win percentages/scores and different physical aspects of each horse. Each body measurement was run against the natural win percentage and paired-feed win scores. Age (Natural observation: $R^2 = 0.03$, $F_5 = .1299$, $p = .7368$) (Paired feed test: $R^2 = .004$, $F_5 = .0177$, $p = .9007$), height (Natural observation: $R^2 = 0.51$, $F_5 = 4.2351$, $p = .1087$) (Paired feed test: $R^2 = .00022$, $F_5 = .0009$, $p = .9777$), and length (Natural observation: $R^2 = 0.25$, $F_5 = 1.305$, $p = .3179$) (Paired feed test: $R^2 = .058$, $F_5 = .2463$, $p = .6458$) did not significantly predict natural dominance percentages. Heart girth on the other hand came very close to showing significance, although the paired feed test values did not show any significance (Natural observation: $R^2 = 0.66$, $F_5 = 7.6480$, $p = .0506$) (Paired feed test: $R^2 = .0038$, $F_5 = .0154$, $p = .9072$). Calculated weight was the only physiological measurement that showed a correlation with the amount of times an individual won a dominance interaction, with the natural setting aggression percentage correlating with calculated weight ($R^2 = 0.74$, $F_5 = 11.39$, $p = 0.0279$). The paired feed test had no correlation between weight and number of wins ($R^2 = .028$, $F_5 = 0.1146$, $p = 0.7520$).

Discussion

I set out to study and observe how dominance hierarchies are structured in herds of horses. Through literature research and review I came to the conclusion that there were different methods of studying hierarchies (Houpt, 1978; Vries, 1995). I was curious to know how the different methods compared. Multiple different reviews used a paired feeding test to establish the hierarchy. In my own experience with horses growing up, I was skeptical that this method actually predicted the hierarchy in a natural setting. I therefore decided to test two of those methods with my own herd to see if I could determine one method that is most accurate.

The first part of my hypothesis was that the two methods for testing dominance would indicate two different outcomes. My results indicated that the two tests in fact do provide different results. I observed that the horses acted differently towards each other during the paired feed tests compared to what I observed in a natural setting. This difference in behavior gave me two different hierarchies, although I can conclude some common results from both. Nike was at or near the bottom of the ranking for both hierarchies that were produced. He was the individual that continuously showed submission to all other horses, with the exception of a few dominant wins over the

two other younger horses. His age and size had no significant correlation to his wins, although he is both older and larger in size compared to the youngest horses. Nike was the individual with the least amount of overall interactions and I observed that he mostly kept to himself during the natural observations. Previous studies have concluded that individual temperament appears to be the most important determinant of dominance in horses (Houpt, 1978). I speculate that Nike's avoidance of other horses keeps him at the bottom of the dominance hierarchy, while Frosty's very up-beat and friendly personality overrides his small size enabling him to not be the most submissive horse.

The two most dominant horses I observed, Indie and Badcat, were at the top of the dominance hierarchy in natural interactions, but Badcat was not dominant in the paired feeding test. In the natural observations, both mares had the highest percentages of wins with much lower numbers of losses and they displayed more aggressive behaviors than any of the other horses. Out of Indie's 47 agonistic interactions she only lost 2 of them, both being to Badcat (Table 5). I observed that Badcat was more dominant during interactions that involved social and spatial resources. Indie became more dominant during interactions that involved food resources, perhaps indicating why Badcat performed poorly on the feed test. The middle placements of individuals switched around for both hierarchies and included Jr, Boon, and Frosty. Overall, my findings assign each horse different placements within the hierarchies, which indicates that the two methods were not equal in determining a set hierarchy.

The second part of my hypothesis stated that the paired feed test would be linear and the natural setting would be a dyad or triangular hierarchy. I conclude that this part of the hypothesis was wrong. According to my data, the natural observations produced a more linear hierarchy, whereas the paired feed test revealed a diamond-shaped hierarchy with several horses clumped in the middle. Although, I can speculate that some of the unexpected results of the paired feed test may be due to other factors, such as the horses acting differently towards food resources or not being hungry before the test. After reviewing Houpt's 1978 study about dominance hierarchies, I realized that he had fasted the horses for 9 hours before performing the feed test (Houpt, 1978). The horses in my study were housed in a large pasture area that had two large circular feed bins that the owner kept full of hay. When conducting my feed tests, the horses were taken directly from their housed area to the round pen with the grain bucket. None of the horses during my test were fasted. This may have contributed to the many ties in my tests. Also, horse dominance can be very context specific, depending on the resources being competed for. An individual that is more dominant in food-related contexts might not be given the same priority or access to other resources such as shelter or social aspects (Kiley-Worthington, 1990)

I can conclude there are no significant correlations between dominance and an individual's height, length, heart girth or age as independent characters. The only correlation observed was for the calculated weight of the individual. Thus, overall size does seem to predict natural dominance, but height and length alone do not. Overall size is indicative of physiological and environmental aspects (Esteves, 2007; Kruger, 2008; Giles, 2015). The two top ranking horses in the herd I observed, Indie and Badcat, were the overall largest horses. They were the largest in height, weight and heart girth (Table 3). Length showed the least correlation to

dominance rank, which makes sense morphologically in how the agonistic actions are carried out. Being longer than the opponent gives no added benefit in accordance to dominance wins, but being taller or heavier gives an advantage. It is also interesting to note that these two most dominant horses are both mares.

According to my data, age had no statistical correlation to dominance rank, although, previous studies have found that age does play a role (Houpt, 1978; Giles, 2015). Horses in the 7-20 year old range are usually the most dominant due to being at prime reproductive age and health, being larger, healthier, and able to forage better (Giles, 2015). Full size and sexual maturity do not peak till after age 6, with higher physiological and reproductive fitness. Badcat and Indie both are reproductively at their peak being 9 years old. Boon and Nike have just reached the reproductive age, though are both geldings which can play into reproductive needs differently (Houpt, 1982). In my herd, Boon, Nike, and Frosty are the three youngest horses and also the lowest ranking. I speculate that since Jr has the longest residency in the herd, he maintains a higher ranking within the hierarchy even though he is the oldest horse. His age and temperament could be indicative as to why he has lost his higher ranking position. It has been observed that herds with lower variations in age and sizes had higher levels of interactivity among individuals in the herd (McGreevey & Burgess, 2005). There is a wide age and size range among Jr, Boon, and Frosty, but they all seem to interact similarly. Decreasing the amount of agonistic interactions increases energy available to foraging and other social interactions (Estevez, 2007; Kruger, 2008).

My study was informative, but does have some limitations. First off I can only conclude that my study and results are indicative of horse dominance hierarchies in a domestic setting where their range is limited to smaller pastures. My results may or may not be applicable to domesticated horses in larger ranges and to wild horses that don't have a limit on their ranges. Nevertheless, I can draw some general conclusions. There are many different types of variables that come into play when determining the dominance hierarchy in horses. Factors such as age, size, temperament, length of residency in the herd, resources available and environment all may play some sort of role. I found that size was the most important factor determining natural dominance in my herd. Behaviors depending on age as well as foraging abilities have a big effect on the size of the individual and the ranking in the hierarchy. Those individuals closer in age will most likely be similar in foraging and size requirements, which can cause more agonistic interactions when it comes to resources (Giles, 2015; Kruger, 2008). I speculate that since resources are spread out within my herd's enclosure, all of the horses get to forage for the most part in equal quantities. Secondly, I believe that since competition for resources is lower as well as the variety of ages and physiological characters, there are fewer agonistic interactions within my herd. Results might be different where resources are limited. Third, the Bailey ranch herd used in my study has been an established herd for 5 years, and results may differ with herds that have been together for different periods of time.

Although the hierarchy among the studied horses isn't as structured as I first initially hypothesized it would be, I can conclude that overall size does correlate to the ranking within the hierarchy. Other aspects such as season, resource availability, and age may also play roles in the hierarchy structure (Kruger, 2008; Estevez, 2007; Giles, 2015). In future studies, to better

understand exactly how horse hierarchies' work, researchers could compare more domesticated herds to more free-range herds. One can obviously conclude that there is a dominance hierarchy within the species but different factors may play different roles depending on the type of herd. Also, it's become apparent that the paired feeding test is not always accurate when studying or assessing hierarchies in animals. In my study, I had no significant correlations between physiological measures and the amount of paired trials an individual won. Houpt states in his own study in 1978 that a weakness of the paired feeding test is that co-dominance is not observed. Another study concludes that the paired feeding method doesn't mirror foraging habits in a natural setting (Giles 2015). During my observations of this method, the behaviors were different for each horse compared to how they naturally act. To make the test accurate there would need to be carefully controlled aspects, such as fasting each horse for a specific amount of time as well as performing the test in an area that had no vegetation growth.

The study may have implications for understanding how effective different methods are in establishing dominance and hierarchical systems in other mammals and animals. The ways that resources are available or distributed can play a major role in determination of rank across animal groups (Estevez, 2007). It is important to remember that methods like the paired feed test do not always measure natural behaviors and hierarchies. This research has value in an agricultural sense as well. Studying the dominance behaviors in domesticated animals can help ranchers, breeders, or owners in keeping and caring for these animals. Being able to correctly assess a hierarchy and understand how the social systems work will help when housing animals together. Instability in the social groups of domesticated animals can lead to increased levels of stress inducing more conflict and harmful fighting (Estevez, 2007). Mixed herds such as the Bailey's herd, that have an established dominance hierarchy show fewer agonistic interactions, which allows owners to have less concern about possible injuries. Quality methods of study can help to improve our understanding of behavioral and social interactions in animals, allowing us to better interact with such helpful, valuable and interesting animals.

Acknowledgments

Special thanks to the Baileys for allowing me permission to work and study their herd of horses. Also to Dr. Lauryn Benedict and the Biology program for allowing me to further my passion in horse behavior and the resources to make this study possible.

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