THE INFLUENCE OF GIRAFFE BEHAVIOR ON PARASITE LOAD: IMPACT OF HUSBANDRY MODIFICATIONS AT BUSCH GARDENS TAMPA BAY

Nancy Ann-Marie Arnold[1], A. Conner Cain*, Robin Rowland, Samantha Steele, PSM, Cara Martel, MS[2], Michael Burton, VMD[2], Heidi Bissell, PhD[2].

[1]Dept. of Health Professions, University of South Florida, 4202 E. Fowler Ave., Tampa FL 33620
[2]Dept. of Zoological Operations., Busch Gardens Tampa Bay, 3605 E. Bougainvillea Ave, Tampa, FL 33612, USA.

Abstract

Haemonchus contortus is a gastrointestinal parasite that lives in the abomasal mucosa of ruminants. Similar to cattle, giraffe housed in warm climates are prone to parasitism by stronglyes such as *Haemonchus contortus*. At Busch Gardens in Tampa, Florida a behavioral study and retrospective parasite survey was conducted to determine if a correlation exists between giraffe behavior, feeding methods, and parasite load. Fifteen giraffe were observed to determine the proportion of observations they spent engaged in risky behaviors (i.e., grazing on the ground) vs. non-risky behaviors (i.e., feeding from elevated feeders). The fecal egg count and proportion of risky behaviors were strongly correlated. However, efforts to alter the proportion of risky behaviors by feeding more browse in a variety of elevated feeders were unsuccessful in changing the overall proportion of risky behaviors. Other techniques to discourage risky behaviors and encourage safe feeding behaviors need to be explored.

Introduction

Giraffe housed in warm climates are prone to parasitism by *Haemonchus contortus*, a gastrointestinal parasite that lives in the abomasal mucosa of ruminants. The parasite causes anemia, edema, and even death in affected animals. *H. contortus* thrives in grassy areas in tropical and subtropical climates. *H. contortus* eggs are excreted in animal feces and can live for up to two weeks without a host. Once the parasite reaches the infective stage (L3), it moves from the feces to the grass (Khatun et al. 2013). Normally browsers such as giraffe would rarely encounter these parasites, which require consumption of these grass-bound larvae near ground-level. However, in the predator-free environment of managed care, many giraffe will lie down on the ground or bend down to graze from the ground, putting them in proximity of these nematodes.

Medicinal anthelmintic treatments can be effective, but like antibiotics, they lose effectiveness over time as parasites become resistant (Garretson et al. 2009), and few new drugs are being developed to replace them. The use of copper wire particles has been attempted and found promising (Moscona 2013), but does not completely eradicate the problem. Non-drug-based methods have been used to control parasites in a number of domestic animals. However, these techniques have varying applicability in the zoological setting. Rotational grazing requires a system of multiple pastures, typically with some remaining empty for periods of time. Few zoological facilities have spare pastures or the ability to maintain empty enclosures. Culling

highly parasitized animals is likewise not considered an option in most facilities, although temporarily relocating heavily parasitized animals to grass-free enclosures is a similar technique that has been used at our institution and others (Garretson et al. 2009).

Other approaches include removing feces daily (scooping or vacuuming), sterilizing the soil with steam, and housing animals on gravel or other substrate rather than grassy exhibits. Finally, husbandry modifications that discourage grazing and encourage elevated feeding have potential. The objective of this study was to determine if ground-directed giraffe behaviors are related to parasite load, and if so, if we could alter giraffe behavior to minimize these potentially problematic encounters between parasites and hosts.

Materials & Methods

Subjects

Subjects included 2 male and 14 female (2015) and 1 male and 13 female (2016) and 12 female (2016 browse feeding trials) reticulated giraffe (*Giraffa camelopardalis*) housed at Busch Gardens Tampa Bay, Florida. The giraffe are housed on a 27-acre veldt which they share with zebra, ostrich, impala, addax, and eland. The veldt consists of mixed grass species, palm trees and elevated feeders for hay and pelleted feeds. A dirt track winds through the area in a loop. During the day, guided groups of park guests tour the area in the back of flatbed trucks every 30-60 minutes and offer lettuce to the giraffe. The giraffe are fed a combination of Mazuri Wild Herbivore Plus (5Z8W) and alfalfa hay along with romaine lettuce offered by guests.

Feeding behavior observations

Giraffe were observed for 60 hours from June 2015 to August 2015. Data were collected between the hours of 7:30 to 16:00, weather permitting. Between the hours of 7:30 to 9:00 data were collected from the cab of a pickup truck driving slowly along the dirt track in multiple large loops. After 9:30 am, data were collected in 30 minute blocks from large safari vehicles that were taking guests on tours.

Scan sampling was used for both types of data collection. From 7:30 to 9:00 behavior was recorded once per circuit as the observers drove past the giraffe. Behavior was recorded for each giraffe seen each time the truck completed a loop on the track. A giraffe identification book was used to identify giraffe via characteristics such as chest patterns. If there was any question about the giraffe's identification then the behavior was not recorded.

All behaviors are defined and listed on the giraffe behavior ethogram (

Table 1). Behaviors with a high likelihood of causing contact with ground-dwelling parasite larvae were categorized as *Risky* and included items such as *Graze Stand* (eating grass while standing, Figure 1), *Graze Rest* (eating grass while lying down), and *Debris* (eating or playing with items that had fallen to the ground). Behaviors with a low likelihood of causing contact with parasites on the ground were categorized as *Safe* and included items such as *Elevated Feed*, *Guest* (feeding on lettuce offered by guests), and *Tree Lick* (licking trees). Two behaviors could arguably be categorized either way. *Graze Wall* was recorded when the animals grazed on an elevated wall with grass growing on top. This grass was considered a low parasite risk because

no animal feces would be up so high to incubate the parasite. Therefore, *Graze Wall* was not considered a *Risky* behavior, even though it involved consuming grass. *Rest* (lying down while not eating) is unlikely to lead directly to consuming parasites. However, it does increase contact with the ground, and animals that are resting have both the parasite larvae and grass close by, and this presumably increases their likelihood of consuming them. For these reasons, we included it in the *Risky* category.

Fecal parasite monitoring

Fecal samples from each giraffe are collected twice monthly as part of the herd's routine monitoring program. Egg counts (derived using the McMaster egg counting technique (Nolan 2006), anthelmintic treatments, dates and dose were obtained from each animal's medical record from August 2012-August 2016. Egg counts were then averaged by animal by month of year, quarterly season (Winter: December-February, Spring: March-May, Summer: June-August, and Fall: September-November), and climate season (rainy season: May-October, dry season: Nov-April), and overall.

Browse feeding observations

During the summer of 2016, browse was provided to the animals at randomized times within three time slots, morning, noon and evening. On evenly numbered dates (e.g., July 14 and 16), browse was put out at noon and during an evening time, and on odd numbered dates (e.g., July 15 and 17), browse was put out in the morning and at noon. Observations sessions lasted for one hour after browse was installed. On average, browse made up 35% of total weekly offered giraffe diet (± 3.2% SD). Browse was not put out if lightning was reported within five miles during the length of a time slot due to safety protocols. Browse was put out every day during the study period. Observations were only conducted on weekdays with the exception of one weekend.

Browse was offered using four different methods which were rotated biweekly. In the *hayrack* option (n=19, Figure 2a), browse was put into tall standalone hayrack on top of whatever hay was left over from earlier feedings. Only one hayrack was used per observation. In the *lattice* option (n=21, Figure 2b), browse was woven through and stuffed in between two plastic lattice fence pieces cut into roughly 4.5x4 foot rectangles and zip-tied together on all sides but the top to form a pocket. Each lattice pocket was then clipped together on the top and clipped to eyehooks drilled into trees on the veldt. Up to four lattice structures could be hanging during a single observation. During the *mix* option (n=19), browse was put into the hayrack and at least one lattice was installed during the same observation session. Up to 4 sources of browse could be available during a mix observation. The *velcro* option (n=5, Figure 2c) was only put out whenever large tree limbs were available, and was only possible during 5 observations. When possible, large sticks (over 1 inch in diameter) were wrapped up in a long strap into a bundle which was velcroed together, and the bundle was attached with a clip to a tree eyehook. Multiple bundles could be put up on multiple trees during one observation session. During each observation session, the lattice and velcro feeders could be installed in three potential locations, which were randomly chosen each session.

Observers categorized giraffe-browse interactions into four distinct behaviors: *Eating*, *Investigate*, *Take Out*, or *No Involvement* (

Table 1) and recorded the individual giraffe, the browse species, and the duration of the behavior by noting start and end times for the behavior. Eating and Take Out were categorized as *Engaged* with the browse, while Investigate and No Involvement were *Unengaged*.

The data were analyzed using ANOVAs to determine the relationship between each animal's proportion of behaviors that were *Risky* with their fecal egg counts measured two ways: the egg count at the time of observation (Instant Egg) and a single 4-year average (Average Egg) for each animal. The impact of offering browse (any feeding method) on proportion of *Risky* behaviors as well as the impact of browse feeder type on the time spent engaged with the browse was also measured using ANOVA in R (Version 3.3.2, Vienna, Austria).

Results

There was a strong, positive, linear correlation between percentage of observations with *Risky* behaviors and average egg count ($df(1,19) = 6.74$, $p < 0.018$, Figure 3) as well as the instant egg count ($df(1,19) = 6.92$, $p < 0.017$, Figure 1). Egg counts did not vary by month, quarterly season, or year. However, egg counts were higher during Florida's rainy season (May-October) than during the dry season (November-April; $df(1,786) = 3.87$, $p<0.05$,

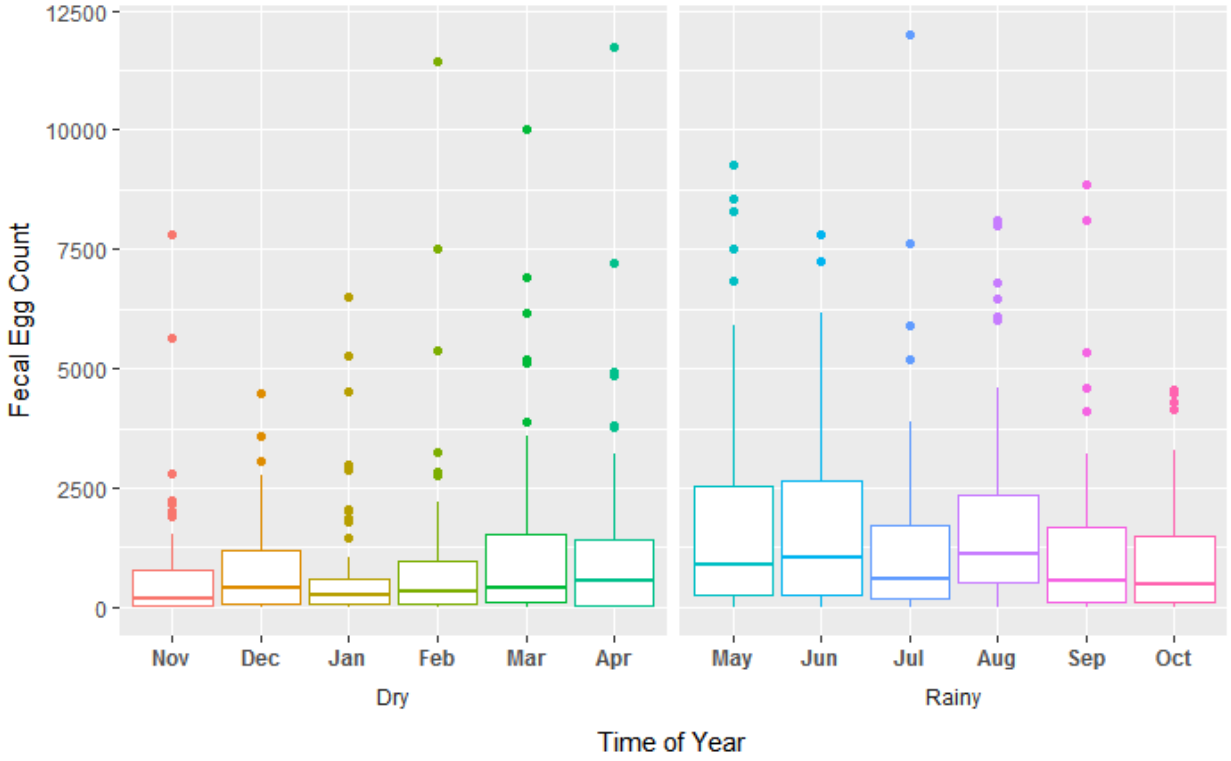

Figure 4).

During the browse feeding trials, there was no difference among the four feeding methods in either the amount of time the giraffe spent *Eating* or *Engaged* or the total number of giraffe present during that session ($p>0.5$). In addition, neither the presence of browse (any presentation) nor any single type of feeder affected the proportion of observations spent engaged in *Risky* behaviors. While some individual giraffe increased the proportion of *Risky* behaviors with the browse provision, others decreased (Figure 5).

Only a small fraction of the giraffe herd approached the browse feeders during the observations. However, other individuals may have fed from them after the period had ended. The type of elevated feeder was not significant, but the specific species of browse provided did have an impact on the number of giraffe feeding from the feeders and was likely a significant source of variation in this study. Some browse species such as tipuana (*Tipuana tipu*), cut grasses, acacia (*Acacia auriculiformis*), and willow (*Salix carolinensis*) were highly preferred. When these species were offered, the amount of time the giraffe herd was engaged with the feeders and the number of giraffe engaged increased.

Discussion

There was a strong correlation between the amount of time spent doing risky behaviors and parasite load. Although our data are merely correlations and do not establish causation, the information we have about how the parasite is transmitted indicates that it is highly likely that increased contact with the ground increases the chances of having a high parasite load. As such, minimizing *Risky* behaviors is a priority, especially when partnered with medical treatments such as anthelmintic drugs, copper wire, and pasture management techniques.

The four different behavioral modifications (different types of elevated feeders) were not universally accepted by the animals, and even for the animals that did engage with the feeders, did not alter their overall proportions of risky behaviors. Thus, providing giraffe with browse and/or elevated feeders may not be sufficient to alter their overall behavioral patterns and reduce the risk of parasite infections. Even preferred browse species were not able alter the behavioral patterns observed.

Conclusions

Based on this study, behaviors that put giraffe in contact with the ground likely play a strong role in determining the extent of their parasite load. However, feeding browse in elevated feeders twice a day did not change the giraffes' feeding behaviors sufficiently enough to cause a change in the proportion of these risky behaviors or their parasite load. In a positive-reinforcement environment, desired foods such as hay, pellets, and browse are some of the strongest tools to encourage giraffe to engage away from the ground. However, this may not be sufficient to deter ground-directed behaviors. Other ways of encouraging safe, elevated behaviors should be investigated beyond just elevated feeders, and other non-behavioral means to reduce parasitic infections should be considered as well.

Literature Cited

Garretson PD, Hammond EE, Craig TM, and Holman PJ. 2009. Anthelmintic Resistant *Haemonchus contortus* in a Giraffe (*Giraffa camelopardalis*) in Florida. J Zoo Wildl Med 40:131–139.

Khatun F, Begum N, Akter S, and Mondal MMH. 2013. In vitro study of environmental and nutritional factors on the hatching and development of eggs of *Haemonchus contortus*. Bangladesh Vet 30:1–9.

Moscona AK. 2013. Copper Oxide Wire Particles Used To Control *Haemonchus* Infections: Efficacy in Giraffe (*Giraffa camelopardalis*) at Busch Gardens Tampa and Potential Mechanism of Action.

Nolan T. 2006. McMaster Egg Counting Technique. VPTH 603 Vet Parasitol.

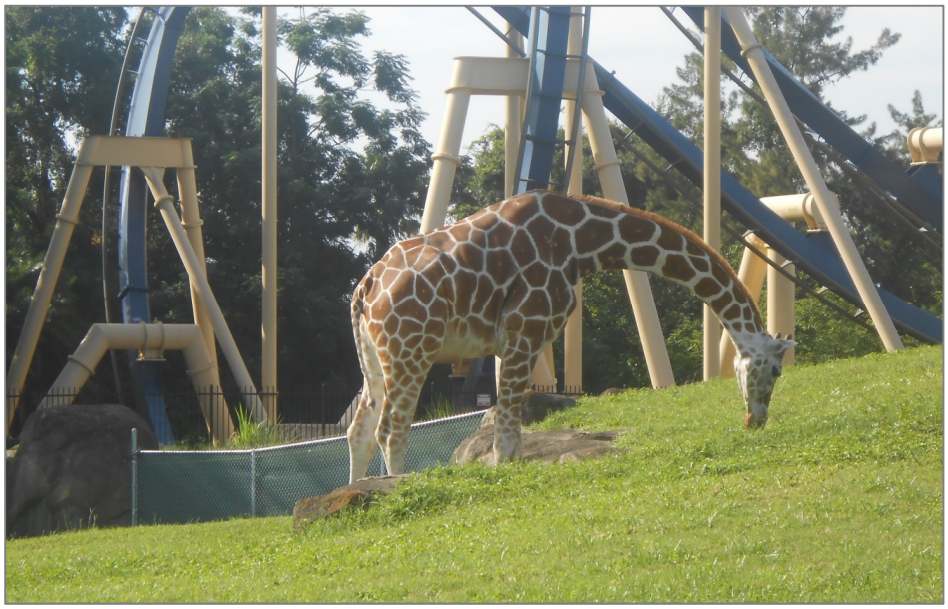

Figure 1. A giraffe engaged in the risky behavior of grazing on grass on the ground.

Table 1. Ethogram of giraffe behavioral observations

Risky: ground-directed behaviors with a high likelihood of parasite transmission (2015 and 2016)	
Debris	Giraffe is eating food, palm fronds or sticks that have fallen to the ground.
Graze Rest	The giraffe is lying on the ground with legs under or close to body with its head lowered and eating grass from ground.
Graze Stand	The giraffe is standing with its head lowered eating grass from ground
Rest	The giraffe is lying down with legs bent and tucked under or close to body on the ground.
Safe: Behaviors not directed at the ground or objects on the ground, low likelihood of parasite transmission (2015 and 2016)	
Elevated Feed	Giraffe eats from the elevated feeders or tree tops with raised head. Does not include eating fallen debris e.g., palm fronds.

Graze Wall	The giraffe is eating grass from an elevated location (wall).
Guest	Giraffe eats romaine lettuce from guest.
Observed	Animal was observed doing something other than the behaviors above.
Tree Lick	Giraffe licks tree bark

Browse-feeding behaviors (2016 only)

Engaged with browse

Eating	Engaging browse with mouth within 2 feet of browse, including chewing and licking
Take out	Eating branch or browse taken from browse source more than 2 feet away from source

Unengaged with browse

Investigate	Giraffe within 5 feet of browse, but not engaged with *Eating* or *Take out*
No involvement	Animal did approach browse or within 5 feet of browse feeders

A. Hayrack

B. Lattice

C. Velcro

Figure 2. Browse feeding methods

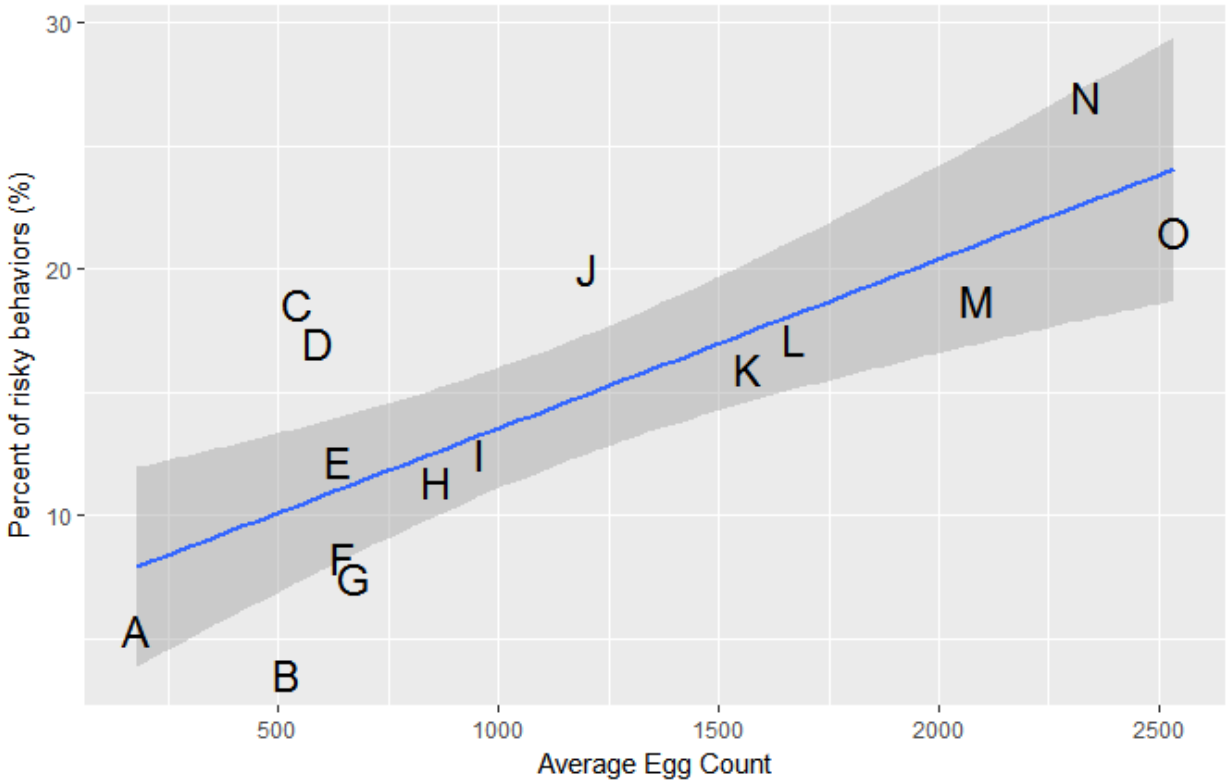

Figure 3. Correlation between fecal egg counts and the percentage of observations the animals performed risky behaviors, such as grazing on the ground. Letters represent individual giraffe.

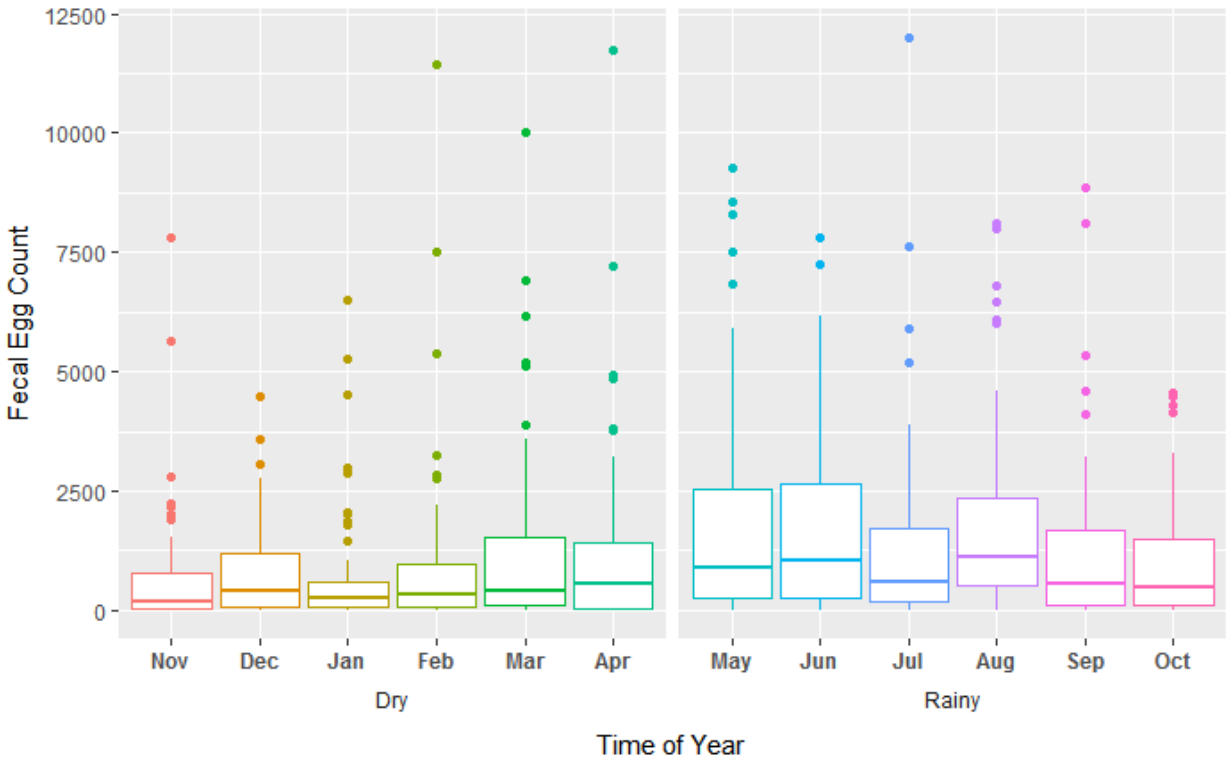

Figure 4. Egg counts were lowest during the dry season and higher in the rainy season in Florida (Four values > 12,500 eggs not shown. Three of these were in the rainy season, one in the dry).

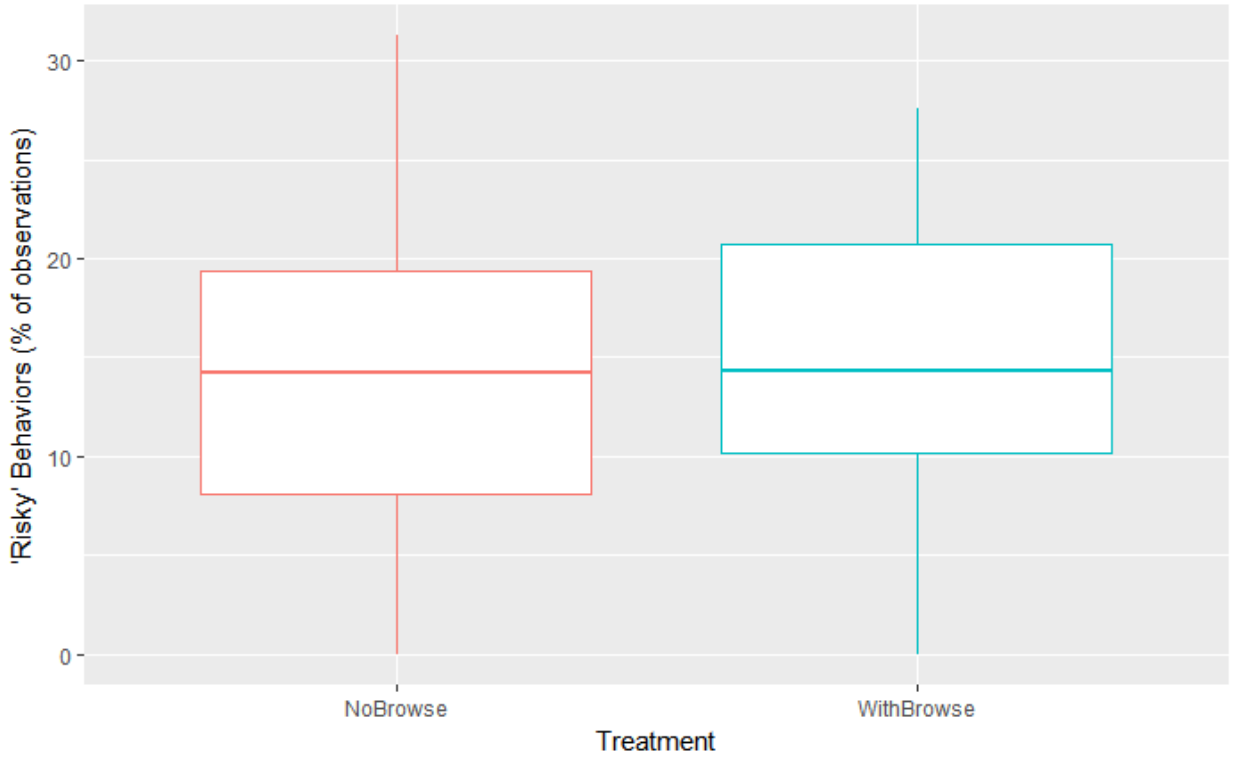

Figure 5. The proportion of risky behaviors did not change after the addition of browse feeding treatments