

The Effects of Lycosoid Spider Density within Trophic Cascades

Diana Saintignon*, Erica Kistner

Environmental Research Center - West, University of Notre Dame

School of Environment and Natural Resources, The Ohio State University

In a trophic cascade an organism can indirectly have a beneficial impact on another organism by directly impacting an intermediate organism. This idea is useful in conservational practices because these organisms, known as keystone predators, can be used to control the populations lower down on the food chain, ultimately benefiting producers. In the grasslands of western Montana, grasshoppers are considered pests by local farmers. In this experiment, we tested whether Lycosoid spiders play the role of a keystone predator within this ecosystem by preying on early developmental stage grasshoppers. This project also looked into how the grasshoppers reacted to the Lycosoid spider presence, and if a potentially resulting trophic cascade had a positive effect on plant biomass. Data was collected at the National Bison Range, MT at an undisturbed grassland in July. Ten early-stage grasshoppers were placed in wire mesh cages with 0, 1, or 2 Lycasoid spiders and observations were recorded over an eleven day period. Results showed that while early developmental stage *Melanoplus sanguinipes* and *Melanoplus femurubrum* exhibited risk behaviors in the presence of Lycosoid spiders and that the number of individuals practicing these behaviors increased with the number of spiders added, no tropic cascade resulted.

Introduction

Ecosystems consist of abiotic and biotic components that interact with one another forming complex and interwoven communities. Any change in these community structures has the potential to alter ecosystem function through direct or indirect effects between populations. Communities can be broken into different trophic levels where primary producers support primary consumers who are fed on by secondary consumers, or predators. An upper-level predator can indirectly affect producers by directly or indirectly affecting primary consumers; this is referred to as a trophic cascade. Through the decrease or elimination of a keystone predator, the prey species (i.e., primary consumers) experience higher survival rates. This in-

creased survival and thus increased density of organisms means more stress on the next trophic level down (i.e., the primary producers). For example, pond-side plants have higher reproductive success if the pond is populated by fish that feed on dragonfly nymphs. Because these fish reduce the number of nymphs that would have become adult dragonflies, they reduce the number of pollinators that would have fallen prey to the dragonflies (Knight et al. 2005).

The effects on trophic levels can be decreased or amplified in both direct and indirect ways. For example, birds feeding on grasshoppers would directly reduce grasshopper population size (Belovsky & Slade 1993). An indirect effect would be the prey exhibiting a "risk behavior" such as slowed or reduced movement, less time spent feeding, or presence of a diet



Diana Saintignon is a senior at The Ohio State University majoring in forestry, fisheries, and wildlife with a specialization in forestry and wildlife management. Diana is applying to the Peace Corps and hopes to do work involving environment preservation.

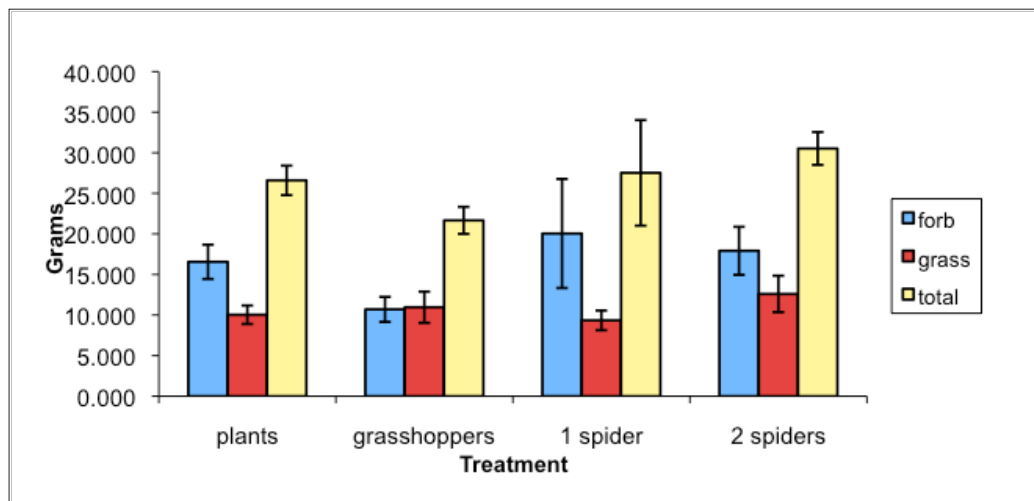


Figure 1. Comparisons of forb, grass, & total biomass between plant-only, grasshopper, one and two lycasoid spider treatments.

shift. There are multiple hypotheses as to why grasshoppers may switch from grasses to forbs, with the simplest explanation being that forbs are more structurally complex and provide better refuge from predators. Secondly, the adaptive foraging theory expects prey to switch to food, such as forbs, that will fill their gut faster, due to their high water content, to reduce the amount of time they are exposed to predators. Lastly, it is thought that the effectiveness of predator avoidance could depend on the amount of information the hunted has about the hunter's location, meaning that the predator may be easier to spot in some areas over others, clueing in the prey (Schimtz & Suttle 2001). Schimtz et al. (1997) found that both predatory spiders and risk spiders (those with disabled feeding ability) caused behavior shifts in the grasshoppers indicating that predator presence affects prey behavior regardless of whether there is active preying.

Knowing how trophic cascades work is beneficial to navigating conservation efforts. The density of the top predator may affect the magnitude of a trophic cascade's impact and by decreasing or eliminating a keystone predator, which in turn may increase the prey's survival rates, introducing more stress on the next trophic level down. In a study conducted by Estes et. al. (1989) it was found that the local extinction of sea otters resulted in a large enough increase in benthic organisms (notably sea urchins), no longer being consumed by the otters, to over-graze kelp forests. Keystone predators like these otters prevent exploitive competition so one species of primary consumer is less likely to over take an ecosystem (Estes et. al 1989). If prey abundance depends on predator density then we would want to see how we affect that densi-

ty and realize its role in controlling the prey. In systems where the grasshoppers are under too much stress from being hunted more dominant grasses may overcome less hardy grasses in systems without grasshoppers or in systems where grasshoppers are practicing risk behaviors. If the grasshoppers have feeding preferences that include rapid growing or dominate grasses, their absence could lead to an uncontrolled increase of those such grasses, negatively affecting other more

recessive vegetation. However, predators like Lycosoid spiders are necessary for decreasing pest numbers like those of the grasshoppers (Prieto-Benítez & Méndez 2011) potentially decreasing the need for pesticides.

In this project we will be measuring the effect that wolf spider density has on grasshopper fatality and the resulting grass and forb density. With use of controlled experiments we wish to determine 1) if varying numbers of wolf spiders affect the density of the local vegetation and what percentages of that vegetation are grasses and forbs, 2) if there is less consumption per spider in cages with higher predator densities, and 3) if spider or grasshopper numbers decrease along a transect at the study site once controlled testing begins. While in the field we will examine 1) spider and grasshopper densities along transects over time and vegetation density at the beginning and end of the project, 2) how spider and grasshopper densities affect grass and forb biomass, 3) if avoidance behaviors are exhibited by spiders or grasshoppers in high spider density areas, and 4) if predation rates increase in high spider density cages. We hope our results will reiterate the benefits these predators have on the surrounding vegetation.

For the trophic cascade field study we would predict that there will be 1) low vegetation density in the two-trophic system level treatment. 2) A decrease in grasshopper activity and therefore an increase in vegetation as the number of spiders increases & 3) Fewer grasshoppers consumed per spider in the cages with multiple spiders. If there is a lower density of vegetation in the two-trophic level test (vegetation and grasshoppers) rather than the single-level (vegetation) or triple level

tests (vegetation, grasshoppers, & spiders) due to grasshoppers feeding in the absence of predators and their preference of grasses over forbs unless exhibiting risk behavior, then it is expected that forbs will experience some decrease in biomass as a result. Since risk behavior in grasshoppers results in a decrease in activity and because feeding makes up a fair part of a grasshopper's routine, then activity can be measured in plants consumed (via. biomass measurements). However, it will be important to take weather conditions into account; a typical day includes sun basking & avoidance behaviors mostly but feeding tends to take place after grooming around when temperatures hit 81 degrees F and seek cover at 90 degrees F. There is also very little feeding if wind speed is greater than 15 mph or on cool cloudy or rainy days. If activity is decreasing then biomass for each of the tests containing predators will be greater than the biomass of the two-level system. On a side note, we are interested how spiders will interact with each other when competing in a confined space. We would expect grasshoppers consumed per spider will decrease. Lycosoid spiders will avoid conflict with each other and frequent encounters may decrease time spent hunting. Wolf spiders are also scavengers and preying on another's leftovers may occur (Nosek & Rovner 1984).

For the field surveys, we hypothesize that there will be a decrease in non-captive spider & possibly grasshopper populations around test site after cages are stocked. Local invertebrates that feel threatened by spider predation (including other spiders) will frequent the area less (measured by surveys using pit traps & catching effort and compared to surveys taken prior to experimentation) and as a result, vegetation density of these areas may increase according to what invertebrates remain.

Methods and Materials

Study Site

Research was conducted during the month of July at the National Bison Range located in Sanders and Lake Counties, Montana. This part of the experiment was run in "the triangle" within the National Bison Range. Not far from "the triangle" transects will be set up along parts of North Road in

the palouse prairie where the landscape is dominated by Cheat grass (*bromus* sp.), wheat grass (*elymus* sp.), yarrow (*Achillea millefolium* sp.), white prairie aster (*Aster falcatus*), & fleabane (*Erigeron* sp.). Treatments were randomly assigned to the pre-existing cages arranged in rows of eight. Each cage is 0.1m² and assembled of wire mesh, with a buried aluminum-flashing base held in by wooden stakes.

Controlled Trophic Cascades

Each cage in "the triangle" represents a different number of trophic levels; 1) A single-level consisting only of plants, 2) a double level consisting of grasshoppers & plants. 3) a three level system consisting of vegetation, grasshoppers, and a single spider, and 4) a three level system consisting of vegetation, grasshoppers, and two spiders. There are 5 cages representing each treatment randomly assorted across 3 rows of the cages described above. Each were stocked with 0, 1, or 2 Lycosoid spiders reaching a body length of at least 0.7 cm. Additionally, 10 grasshopper nymphs being of 1st-3rd instar were added to their assigned cages at the beginning and were restocked daily to reach numbers of at least 5 individuals. Grasshopper nymphs were chosen because younger grasshoppers have a lower survival rate in presence of spiders than older, much larger grasshoppers (Belovksy & Slade

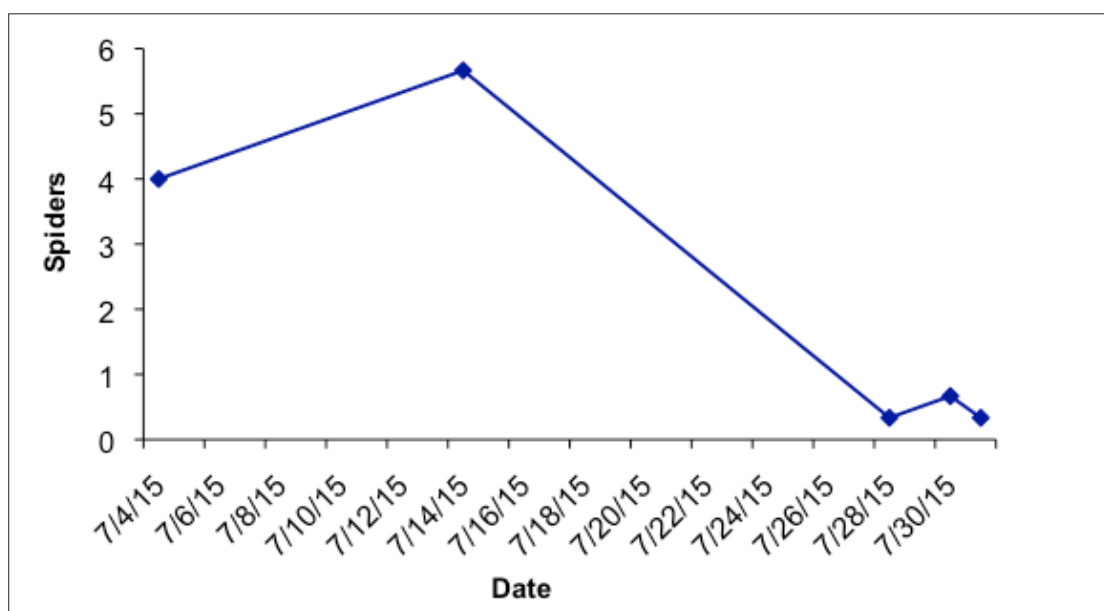


Figure 2. Change in number of captured wolf spiders from the beginning to the end of the month of July

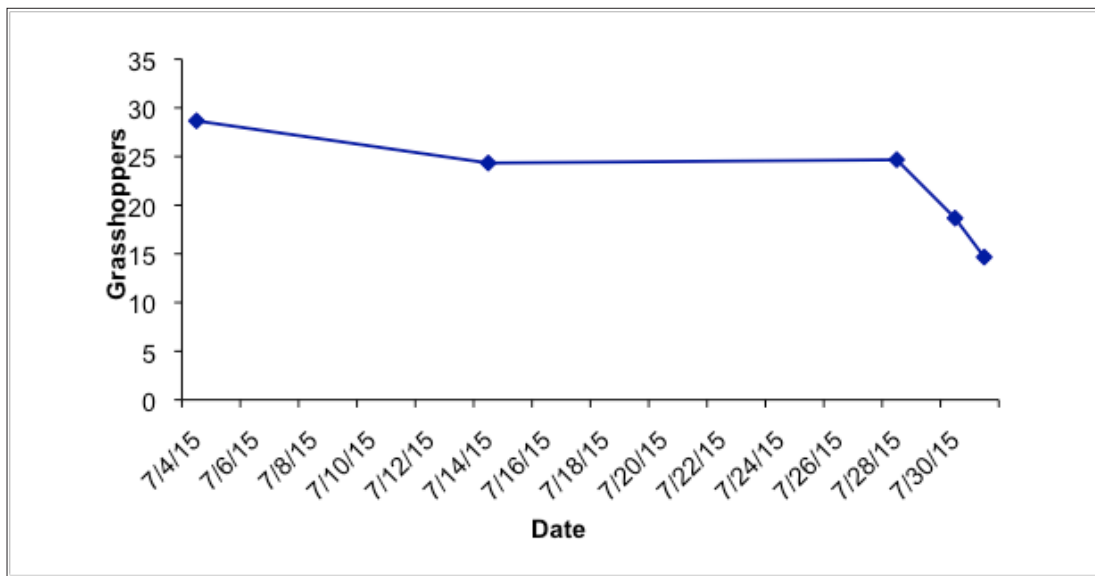


Figure 3. Change in number of grasshoppers captured from the beginning to the end of the month of July

1993). *Melanoplus sanguinipes* and *Melanoplus femurubrum* were used because of how common they are on the Bison range, their hardiness, and because these grasshoppers, notably 3rd instars (Bradford & Joern 2003), have been found to practice risk behaviors in the presence of Lycosoid spiders (Laws et al 2009). Lycosoid spiders are to be used because they are a common grasshopper predator (Belovsky & Slade 1993). The hope was to increase the number of grasshoppers to be used in the 0.1m² cages over natural numbers to get more drastic results within a shortened period of time. The cages were visited every day and grasshopper & wolf spider numbers, locations, fatalities, and appearance of the corpse were recorded. At the end of each count grasshoppers were restocked to at least 5 individuals. Special attention was paid to grasshoppers consumed per spider in the cages with multiple spiders to determine the intra-specific competition levels. After the experiment ran for 11 days the grasshoppers and spiders were released, the

cages pulled up, and the vegetation within each cage clipped. The clipped vegetation was sorted and stored in paper bags by cage number and whether they were grasses or forbs. They were then taken back to the lab and placed in a drying oven overnight. The next day dry masses were recorded to determine any effects the inhabitants might have had, since previous projects found that

while engaging in risk behaviors grasshoppers are more likely to feed on these less nutritious but more filling forbs due to the adaptive foraging theory and the more complex cover they provide (Schmitz & Suttle 2001) rather than grasses which is their preferred food (Schmitz et. al. 1997).

Transect Surveys

Meanwhile, open-system surveys were conducted to determine if the presence of the captive individuals had an indirect effect on the outside grasshopper and spider pop-

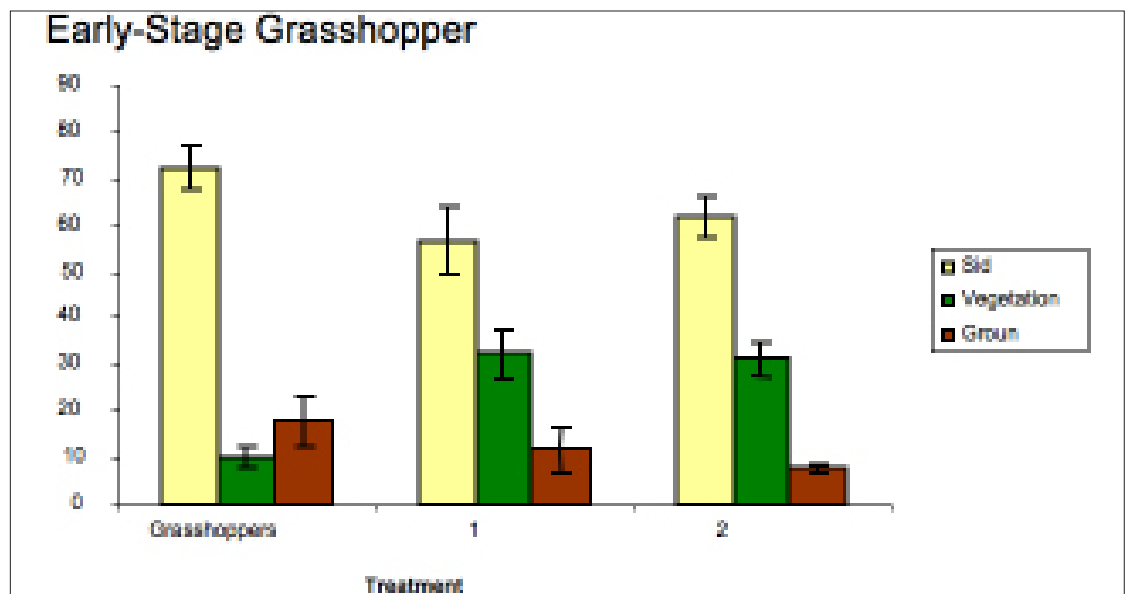


Figure 4. Number of early developmental stage grasshoppers spotted on the ground decreased with the addition of each spider while the number of early developmental stage grasshoppers spotted on the vegetation increased with spider presence.

ulations. This will help determine if they will naturally spread out to avoid such competition since caged stock numbers will be higher than field dispersion. There were three transects, one along the test site and two others along North road. Non-captive grasshoppers were surveyed by the catching effort technique (Belovsky & Slade 1993). Non-captive spider densities were measured by pitfalls set up every meter for 15 meters along each transect. Vegetation density was measured every 5 meters along the 15 meter transect measuring 2 yards outwards.

Statistics

All data was inputted and organized in Microsoft Excel and statistics were done in SYSTAT 11 & 13. ANOVAs were run to test grasshopper and spider densities along the three transects. A t-test was used to determine differences in plant composition and density at each survey site while another ANOVA determined differences across the survey sites. A 2x2 ANOVA was used to assess the effects of grasshopper absence versus presence, and predator density on each of my dependent variables: total biomass, grass biomass and forb biomass. A 3 dimensional chi-square (Figure 4) was used to analyze the different trophic cascade levels and age of the grasshopper on grasshopper position within the cages over the course of the experiment. An ANOVA test was attempted to analyze grasshopper mortality within the cages (Figure 5), but because of the limited observations of grasshopper death overall the test was not useful.

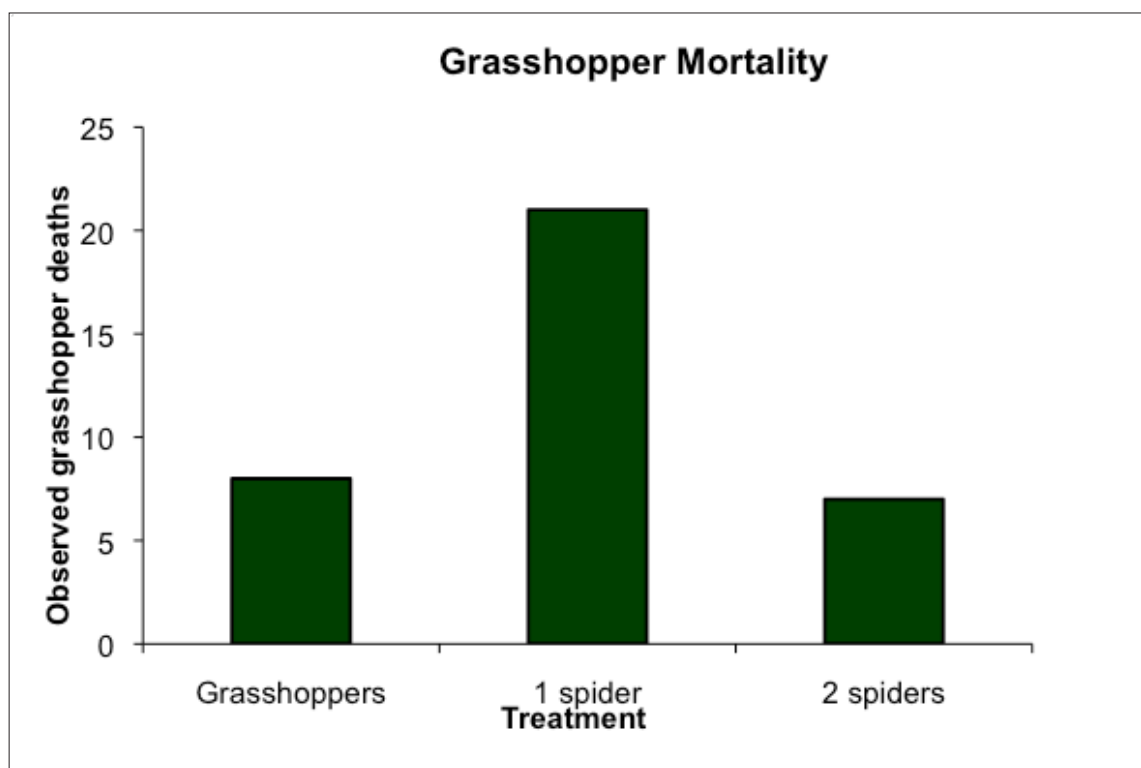


Figure 5. Visual representation of grasshopper mortality between treatments: Grasshoppers, 1 spider, 2 spi-

Results

The ANOVAs ran on spider and grasshopper densities both returned insignificant results between transects or transects over time and significant results simply over time. Total biomass values returned insignificant ($p = 0.32$) and remained insignificant when comparing grass and forb biomasses between treatments. The chi-test ran on grasshopper location returned significant results ($p < 0.001$) between treatment and location and when age was taken into account it was found that the early developmental stages of grasshoppers were significant with location ($p = 0.003$) but location with late developmental stages of grasshoppers were insignificant ($p = 0.065$). The last test ran involved grasshopper mortality between treatments, which returned an insignificant p-value of 0.15.

Discussion

In conclusion we found that at the field study site 1) there was no significant lower vegetation density in the two-trophic system level treatment, 2) there was a significant change in younger grasshopper instar activity even if it did not cause a significant trophic cascade, and 3) there was no significant evidence of fewer grasshoppers consumed per spider in the cages with multiple spiders. By analyzing

the collected data using the methods above it was found that there were significant results found for the decrease in spider density over time at the transects. This could be due to a decrease in spider activity as temperatures rise making them less likely to be caught in a pitfall. The significant results for the decrease in grasshoppers over time is likely a result of the natural field numbers dying off as the season passes.

The insignificance of total and separate grass and forb biomass between transects suggests that no trophic cascade affecting the vegetation was experienced as a result of direct and indirect effects of wolf spider presence on grasshoppers (Figure 1). There was some evidence however to show that their presence did affect the grasshoppers behavior if not in the way that was expected. The quantity of early grasshoppers choosing vegetation or cage sides over the ground between treatments increased as the number of spiders increased significantly (Figure 4).

This trend was not observed in late instar grasshoppers. Grasshopper mortality was also recorded and analyzed but unfortunately there were not enough deaths to return any significant results even if a bar graph shows a trend for higher death in single spider treatments than in 2 spider treatments.

Researchers wishing to perform a similar procedure would benefit from starting earlier in the season and stocking more grasshoppers. Other areas of interest for future research include studying any additional increases in the number of grasshoppers responding with risk behavior to larger quantities of spiders as seen in the grasshopper location analysis in young instars grasshoppers. Our last area of interest would be the idea that wolf spiders may display some kind of risk behavior when encountering other wolf spiders or potential predators and how the prey population is impacted as a result.

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