Grasshopper Egg Mortality Explained by Laying Strategy and Fire Intensity

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Problem: Few studies have examined if rangeland fire can be used to help manage pest grasshopper species. Grassland fires appear capable of having positive or negative effects on grasshopper populations, with the timing and intensity of a fire playing important roles. Grasshopper species laying shallow egg pods appear to be negatively affected by late-summer or fall rangeland fires, but the mechanisms responsible for this pattern are unknown. For example, populations of the white-whiskered grasshopper declined following fall fires in both Oklahoma and western North Dakota. Most grasshopper species in the northern Great Plains lay egg pods in late summer and overwinter as eggs before hatching the following spring. Since the size of egg pods and the depth and orientation they are laid in the soil varies between grasshopper species, soil temperatures in the vicinity of egg pods during a fire should differ between species and with the intensity of a fire. In addition, soil temperatures and the duration of heat during rangeland fire increase with the amount of standing biomass. Therefore, the amount of plant biomass could be a determining factor in whether a given fire kills grasshopper eggs in the soil. We examined the effects of simulated grassland fire intensities on egg survival and hatching using a pest grasshopper species laying shallow egg pods (whitewhiskered grasshopper) and a pest species laying deeper, vertically-oriented egg pods (migratory grasshopper) in a laboratory experiment. The whitewhiskered grasshopper lays small egg pods of 3 to 5 eggs close to the surface, typically in the top ¼ inch of soil. In contrast, the migratory grasshopper, which is often the most abundant grasshopper in eastern Montana, lays egg pods in a vertical orientation, with the midpoint of the egg pod typically ¾ of an inch below the soil surface. The purpose of this experiment was to examine if exposure to heat during rangeland fires was the mechanism responsible for observed reductions in populations of the whitewhiskered grasshopper following fire. The direct effects of soil temperature regimes occurring during rangeland fires on the mortality of grasshopper eggs have not been previously examined. The experiment will help determine conditions for which fire can be used as a management tool to reduce pest grasshopper species.

Procedures: Four-inch diameter, intact soil cores were collected from the field and placed in plastic containers. Adult whitewhiskered and migratory grasshoppers were caught at a native mixed-grass prairie site in August 2004. Individuals of each species were placed in screen cages containing approximately 20 soil core containers for egg pod laying. After egg pod laying was complete, fire was simulated using a propane heater placed above the soil surface. Fire treatment levels were chosen to be representative of surface temperatures during rangeland fires over a range of fuel loads typically found in grasslands. Three temperature treatments and a control treatment with no fire were used for each species, with 10 replicate soil cups in each treatment (Fig. 1). Times used for treatments were 0 seconds (control), 9 seconds (1850 lbs/acre of standing biomass), 23 seconds (2700 lbs/acre of standing biomass), and 46 seconds (4200 lbs/acre of standing biomass). Following the simulated fire, soil core containers were watered and placed in a refrigerator for 3 months to cold diapause the eggs. The containers were then placed in a warm environmental chamber and hatchling grasshoppers were counted daily until all hatching ended. After hatching was complete, all remaining unhatched eggs were removed from the soil and counted. The proportion of eggs hatched in each cup (number hatched/total number of eggs) was used for the statistical analysis of treatment effects.

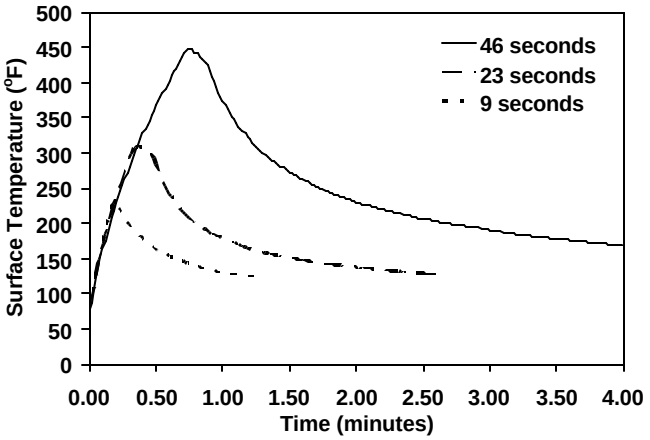

Figure 1. Soil surface temperature over time when exposed to heat treatments of 46, 23, and 9 seconds.

Results: Fire intensity did not have large effects on egg mortality in the migratory grasshopper (Fig. 2). The midpoint of egg pods of the migratory grasshopper is approximately ¾ of an inch below the soil surface. The soil temperature at this depth increased above the ambient temperature only in the 46-second fire treatment, indicating that the migratory grasshopper egg pods are well protected from the effects of rangeland fires even when standing biomass is abundant.

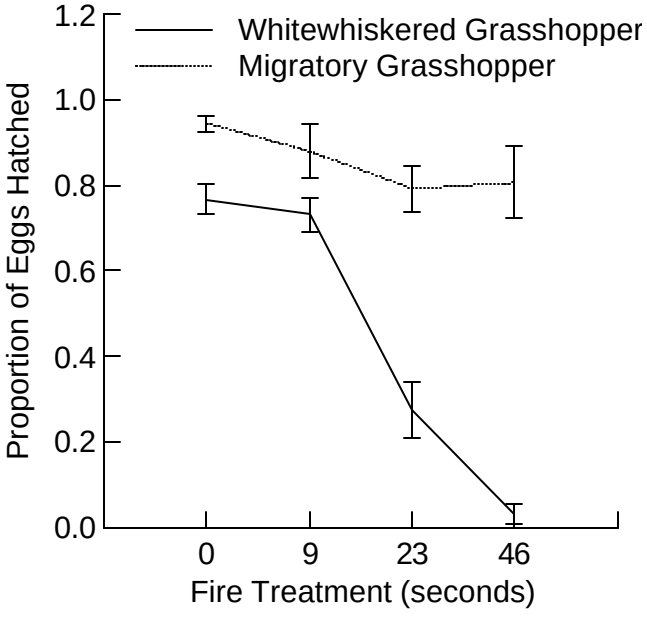

Figure 2. Proportion of eggs hatched by treatment for each grasshopper species.

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In contrast, the proportion of whitewhiskered grasshopper eggs that hatched was strongly reduced at the two highest fire intensity levels (23 and 46 seconds) (Fig. 2). At the moderate biomass fire intensity (23 seconds), the proportion of eggs hatched was reduced by two-thirds. In the highest fire intensity treatment, no eggs hatched in 12 of the 14 containers, indicating that high biomass fires would nearly eliminate the whitewhiskered grasshopper in the year following a fall fire. An average of 35% of unhatched whitewhiskered grasshopper eggs in the highest fire intensity treatment were visibly charred, a further indication that the simulated fire was the direct cause of egg mortality. The horizontal orientation and shallow location of whitewhiskered grasshopper egg pods likely results in high temperatures for all eggs in a given egg pod during intense fires. The proportion of eggs hatching was not affected by the lowest fire intensity treatment (9 seconds), when soil temperatures ¼ of an inch below the surface remained lower than 100°F. Grasshopper species that lay egg pods at somewhat deeper than the whitewhiskered grasshopper could be controlled by fires if they preferentially lay egg pods in clumps of plants. Grasshopper species that lay eggs primarily in areas of bare ground would be less likely to be affected by fire even when egg pods are near the soil surface. Furthermore, wildfires are heterogeneous and do not burn all areas evenly. However, the results indicate that fires occurring in areas with at least 2450 lbs/acre of standing biomass would selectively control populations of the whitewhiskered grasshopper.

Implications: This study is the first that has linked field observations of grasshopper populations following a fire to the mechanisms responsible for the observations. This study suggests that fire may be useful as a management tool for some, but not all pest grasshopper species. By examining other pest grasshopper species that lay shallow egg pods, we can determine how often burning could be used to help control grasshopper populations in the northern Great Plains. In addition, we are conducting field experiments to examine other direct and indirect effects of rangeland fire on grasshopper populations.

Related Publications:

VERMEIRE, L.T., R.B. MITCHELL, S.D. FUHLENDORF, AND D.B. WESTER. 2004. Selective control of rangeland grasshoppers with prescribed fire. Journal of Range Management 57:29-33.

Figure 3. Scorched grasshopper and smoldering sagebrush during an August prescribed fire at Fort Keogh.