

# Foraging Behavior of European Starlings: Implications for Mitigating Their Impact on Native Species<sup>1</sup>

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## Abstract

European starlings (*Sturnus vulgaris*) are a remarkably successful invasive species known to compete with native bird species for nest sites. The objective of this study was to understand why starlings avoid ungrazed pastures and provide recommendations to help mitigate the impacts of starlings on native bird species. I used aviary trials to examine the effects grazing and mowing practices on starling foraging behavior. In experiment 1, I examined the effects of grass height and litter. Starlings preferred to forage in short grass without litter. In Experiment 2, I modified the treatments to more closely simulate actual grazing and mowing practices. Results further confirmed avoidance of areas with tall grasses. Starlings entered all three of the mowed treatments more than the control treatment. No preference was found for the treatment representing long-term exclusion of grazing, therefore a single year of exclusion from grazing or mowing appears sufficient to deter foraging by starlings. Short grass and lack of litter likely facilitate increased mobility, increased ability to detect and capture prey, and increased visibility to see potential predators. Recommendations include leaving moderate or high levels of forage in areas where starlings prefer to forage, such as moist swales and level, open woodlands. Because distance to foraging sites has been found to be negatively correlated with nesting density, competition with native species for nest cavities may be decreased by reducing the quality of foraging habitat. Rotational grazing that creates a mosaic of varying grass heights might offer opportunities for reducing starling densities. In exurban areas, avoidance of extensive mowed and watered lawns that attract starlings is recommended. Further research is needed to investigate thresholds of grass height at which starlings are discouraged from foraging. A species as numerous as the starling almost certainly has impacts beyond the guild of cavity-nesting birds. Interspecific relationships among ground-foraging insectivores should be investigated in areas where native bird species co-occur with starlings.

*Key words:* birds, European starlings, grazing, invasive species, mowing, wildlife

## Introduction

Invasive species are one of the largest threats to native wildlife around the world. They have caused dramatic changes in ecological systems and have profoundly altered communities and ecosystems. Approximately 42 percent of threatened and endangered species are placed at an increased risk by non-native, invasive species (Pimentel and others 2005). In addition, economic losses associated with invasive species and their control total approximately \$120 billion each year in the United States (Pimentel and others 2005). Solutions to the invasive species problem based on sound science are needed.

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The European starling (*Sturnus vulgaris*) is one of the world's most numerous and successful birds. It is a species of temperate regions and has a wide breeding range extending from Western Europe to central Asia, and from Iceland to northern India (Feare 1984). In addition, starlings have been introduced and established populations in North America, South Africa, Australia, New Zealand, and several West Indies and Pacific islands (Feare 1984, Lever 2005). In North America, starlings have been remarkably successful. About 100 individuals were released in New York's Central Park in 1890 by the American Acclimatization Society, whose chairman Eugene Schieffelin had determined that every bird species mentioned in Shakespeare's work should be introduced to North America (Lever 2005). From there, starlings spread rapidly and their range now extends from the east to the west coasts and from the Arctic in Alaska to the tropics in Mexico. Starlings in North America now comprise about a third of the world's total population of starlings and are among the most abundant species of birds in North America (Feare 1984). Starlings first appeared in California in 1942 (Jewett 1942) and are now likely the most abundant bird in the state (Small 1994).

Starlings are aggressive competitors and are known to usurp cavities of native cavity-nesting birds, whose nest sites are commonly assumed to be limiting (Short 1979, Troetschler 1976, Weitzel 1988). Cavity-nesting birds, and particularly secondary cavity nesters, comprise a high proportion of the bird species found in oak woodland bird communities (Purcell 2011, Verner and others 1997). Starlings use nest cavities similar in size and shape to those used by native species, raising concerns about nest site availability for these species (Purcell 2011) and behavioral experiments have confirmed that native bird species recognize the presence of starlings at their nest sites as a threat (Olsen and others 2008).

Starlings are often associated with livestock and are often found foraging in grazed pastures. Research has shown that starlings nesting in the foothill oak woodlands of the Sierra Nevada avoid ungrazed areas (Verner and others 1997). Starlings forage on the ground on soil arthropods found in moist soil. Tall grass in ungrazed areas presumably limits maneuverability and therefore foraging efficiency, but results also suggest that plant litter depth may also explain the avoidance of ungrazed areas (Purcell and others 2002). Mowed and watered lawns are also attractive foraging areas. Residents of foothill oak woodlands are encouraged to remove biomass around their homes to reduce fire risk, and often modify the landscape by planting lawns that require watering, providing ideal foraging habitat for starlings.

Starlings have the potential to affect the diversity and resilience of oak woodlands, yet we have a poor understanding of their habitat needs in this ecosystem. The aim of this study was to provide insights into how starlings have been able to successfully invade oak woodlands and to understand why starlings avoid ungrazed pastures, with the goal of providing recommendations for grazing management and mowing practices on rangelands that may help reduce the impacts of starlings on native bird species. In an effort to achieve these objectives, I used aviary trials to study the foraging behavior of starlings in relation to grass height and litter depth.

In the first set of experiments, I attempted to tease out whether grass height, litter, or both were important in foraging habitat selection. If poor mobility is the reason ungrazed pastures are avoided, this could be due to either tall grass or litter impeding movement. The second set of experiments was designed to more closely simulate actual grazing and mowing practices with the goal of providing recommendations for ranchers and rural homeowners interested in reducing starling nesting density on their land. In these experiments, treatments involved mowing plots and leaving or

removing the clippings to simulate grazing and weedeating or mowing, and mowing and raking all dead biomass from plots to simulate multiple years of grazing.

## Study area

This research was done at the San Joaquin Experimental Range (SJER) in Madera County, California in the foothills of the western Sierra Nevada. The SJER is 1875 ha in size and ranges in elevation from 215 to 520 m. Vegetation consists of a sparse woodland overstory of blue oak (*Quercus douglasii*), interior live oak (*Q. wislizenii*), and foothill pine (*Pinus sabiniana*). An understory of scattered shrubs includes wedgeleaf ceanothus (*Ceanothus cuneatus*), chaparral whitethorn (*C. leucodermis*), Mariposa manzanita (*Arctostaphylos viscida mariposa*), holly-leaf redberry (*Rhamnus ilicifolia*), and coffeeberry (*R. tomentella cuspidata*). In some areas the overstory is primarily blue oak with an open understory. Soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus diandrus*), Mediterranean barley (*Hordeum geniculatum*), wild oat (*Avena barbata*), annual blue grass (*Poa annua*), broadleaf filaree (*Erodium botrys*), popcorn flower, (*Plagiobothrys nothofulvus*), common fiddleneck (*Amsinckia menziesii intermedia*), and others dominate the annual grassland understory. The SJER has been moderately grazed by cattle since about 1900 except for a 29 ha Research Natural Area and a few smaller ungrazed pastures that have been ungrazed since 1935. The climate at SJER is characterized as Mediterranean with cool, wet winters and hot, dry summers. Most precipitation falls as rain.

Starlings were first recorded at SJER in the late 1960s and by 1970 SJER several nesting pairs occupied cavities around the buildings. They have been abundant breeders throughout SJER since around the mid-1980s (Purcell and others 2007). Abundance appears to have stabilized since 1995 (Purcell and others 2002).

## Methods

Starlings were captured at nests (Stanback and Koenig 1994) or in drop-in traps using decoy birds as attractants (Zajanc and Cummings 1965). Birds were aged and sexed and each bird received an aluminum U.S. Geological Survey leg band and three colored plastic bands (two bands per leg), creating a unique color combination to allow identification of birds in the field to ensure they were tested only once. The research complied with all U.S. Department of Agriculture, Forest Service requirements for animal welfare. Housing for birds retained in captivity adhered to appropriate standards of care and provided for their safety, health, and well-being (Fair and others 2010). Birds were fed crushed dog food, poultry mash, or other high protein feed, along with meal worms and fruit, and provided water ad libitum. Birds were released following trials. Research was done under U.S. Fish and Wildlife Service banding permit 21859 and California Department of Fish and Wildlife Scientific Collecting Permit 5479.

In Experiment 1, done in 2006, three treatments and a control were tested: 1) mowed to simulate short grass, 2) raked to simulate tall grass without accumulated litter, 3) mowed and raked grass to simulate short grass without litter, and 4) a control treatment that was unmowed and unraked. Raking removed both the current year's growth that was dead and unrooted (which would become residual dry matter) and previous or accumulated growth (litter). Fifteen trials were completed.

Experiment 2 was done in 2010 and 2011. The treatments tested were: 1) mowed, with clippings removed to simulate grazing or mowing with a grass catcher, 2)

mowed, with clippings left on the ground to simulate weedeating or mowing without a grass catcher, and 3) mowed and raked, with clippings removed to simulate consecutive years of grazing or mowing with a grass catcher, and 4) control. Eighteen trials were completed in 2010 and 20 in 2011, for a total of 38 trials.

Experiments were done in sites that had been ungrazed for several years to ensure the presence of accumulated plant litter. We used an open-bottom enclosure constructed of PVC painted green and chicken wire with a central perch, assembled by connecting the sides and top with zip ties. Side length of the enclosure was 1.87 m, area of each treatment within the enclosure was 0.88 m<sup>2</sup>, and total volume was 6.77 m<sup>3</sup>. Ropes were placed on the ground to delineate the quadrants, treatments were randomly assigned to each quadrant, and the treatments were applied. We recorded average grass height in each quadrant and then placed the enclosure on the experimental plot.

Starlings were placed one at a time in the enclosure. A video camera (JVC digital camcorder) on a tripod was set up to achieve a downward view of the four treatment plots and on one side and slightly off center. We always selected a side opposite the control plot so the foraging bird would not be blocked from view by tall grass. After the bird was placed in the enclosure we left the area. We returned after 25 to 30 minutes and removed the bird from the enclosure. Up to three starlings were tested in a morning, all using the same experimental setup. All trials were done in May except for one trial in 2010 that was done in late April.

We recorded each bird's foraging behavior by viewing the video tape. After allowing 5 minutes from the time researchers were out of the area to allow the bird time to acclimate to the enclosure and for the initiation of normal foraging behavior, we recorded two response variables during the following 20 minutes: the number of times a starling landed in or walked into a quadrant (number of entries), and the total number of seconds a starling spent in a quadrant (seconds).

### **Statistical analysis**

For both experiments, differences in the number of seconds starlings spent in each treatment were tested using Proc Mixed (SAS Institute Inc. 2012), with individual included as a block (random effect) as each individual was subjected to each of the four treatments. The mean time (seconds) starlings spent in each quadrant was square-root transformed, which resulted in residuals being approximately normally distributed. Differences in the number of times a starling entered a treatment were tested using GLIMMIX (SAS Institute Inc. 2012), using a negative binomial distribution with a log link function. Individual was again included as a random effect. Tukey's studentized range test was used to control for Type I experimentwise error rates, with an overall significance level of 0.05.

### **Results**

Results from Experiment 1 showed that starlings preferred to forage in short grass without litter. The overall tests for total seconds spent in each treatment and the number of entries into each treatment were both significant ( $P < 0.001$  for both) and the adjusted  $P$  values for comparisons revealed that the rankings of the treatments for both variables were  $MR > M > R = C$ , where  $MR$  = mowed and raked,  $M$  = mowed,  $C$  = control and  $R$  = raked (figs. 1a and b). The mowed and raked treatment was preferred and both of the tall grass treatments were avoided.

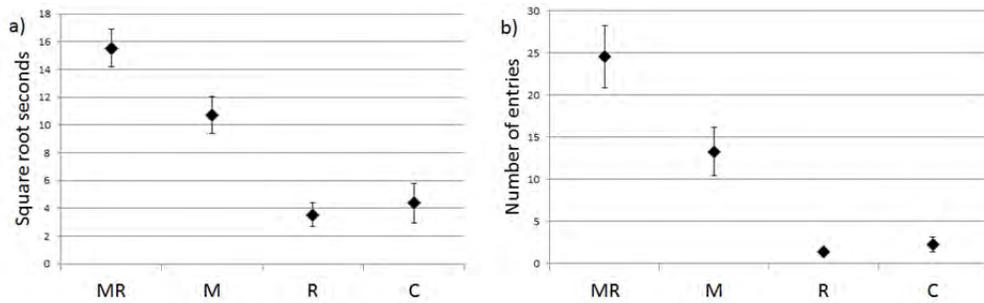


Figure 1—Results of European starling foraging experiments done in May 2006 at the San Joaquin Experimental Range, CA. a) Mean time (square root seconds) that starlings spent in each treatment. b) Mean number of times a starling landed in or walked into a quadrant with each treatment type. Treatments were MR = mowed and raked, M = mowed only, R = raked only, C = control. Error bars represent one standard error.

Results from Experiment 2 further confirmed avoidance of areas with tall grasses. The overall tests for both time spent in treatments and the number of times starlings entered a treatment were again significant ( $P = 0.03$  for square root of seconds and  $P < 0.001$  for number of entries). Starlings spent more time in the mowed treatment with the clippings left on the ground compared to the control treatment (ML > C; adj.  $P = 0.038$ ; fig. 2a). None of the other comparisons was significant. Starlings entered all three of the mowed treatments more than the control treatment (ML = MR = MRD > C; adj.  $P$  values all  $< 0.004$ , fig. 2b). The treatment simulating long-term exclusion of grazing (MRD) did not differ from the other mowed treatments.

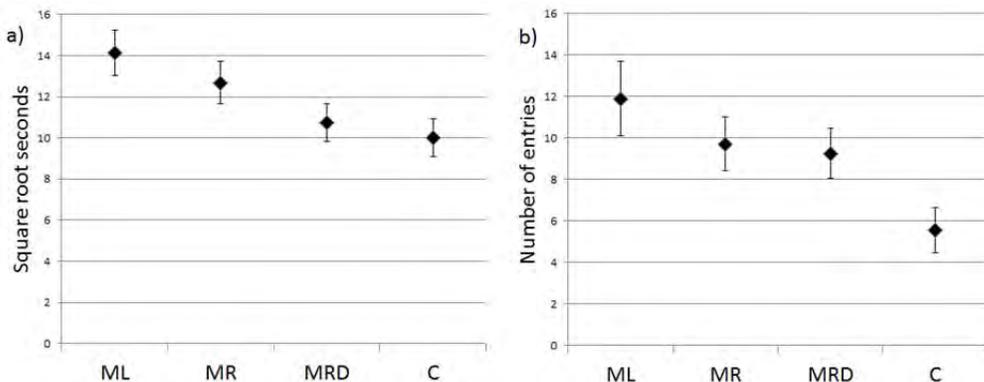


Figure 2—Results of European starling foraging experiments done in 2010 and 2011 at the San Joaquin Experimental Range. a) Mean time (square root transformed) that starlings spent in each treatment. b) Mean number of times a starling landed in or walked into a quadrant with each treatment type. Treatments were ML = mowed with clippings left, MR = mowed with clippings removed, MRD = mowed with clippings removed, then raked, C = control. Error bars represent one standard error.

The inability to distinguish among the treatments in Experiment 2 as finely as in Experiment 1 may have been due to the relative differences in grass heights among treatments. Average differences in grass heights between the mowed and unmowed treatments was 44.7 cm in Experiment 1 compared to only 36.0 cm in Experiment 2 (for Experiment 1, average grass height for mowed treatments was 8.8 cm and for control plot was 53.5 cm; for Experiment 2, average grass height for mowed

treatments was 12.4 cm and for unmowed plots was 48.4 cm). Starlings entered and spent more time in control plots in Experiment 2, perhaps as a result of the lesser relative differences between mowed and control treatments.

## Discussion

Our study adds to a growing list of studies that have shown that pastures with shorter grass are preferred by starlings (Atkinson and others 2005, Buckingham and others 2006, Devereux and others 2004, Whitehead and others 1995, Whittingham and Devereux 2008, Williamson and Gray 1975). Interestingly, the majority of these studies were spurred by concerns over decreases in farmland birds, and specifically starlings, in northern and western Europe.

Prey abundance is not believed to be the factor driving foraging choices for short grass (Atkinson and others 2005, Devereux and others 2004) and tall grasses have been shown to have greater abundance and diversity of arthropods (Morris 2000). Habitat structure was clearly important, and clearly more important than botanical composition (Buckingham and others 2006). Several studies have suggested the functional explanation for this response is that tall grass impedes movement and that prey is easier to detect and capture in short grass. Starlings moved more rapidly and walked more steps in short grass (Brownsmith 1977, Devereux and others 2004), allowing them to search more efficiently. I found that both tall grass and litter were avoided, suggesting that litter may also impede movement.

Shorter grass may also provide lower perceived predation risk for foraging birds. Short grass likely provides increased visibility to detect potential predators approaching. Starlings feeding on invertebrates in tall grass were more vigilant, had reduced feeding rates, and were slower to respond to a model hawk compared to those feeding on short grass (Brownsmith 1977, Devereux and others 2004, Whittingham and Devereux 2008). Starling densities were also higher in fields with feeding areas further from hedges where predators may lurk (Whitehead and others 1995).

No studies have directly addressed questions related to biomass removal vs. grass clippings left on the ground. In experiment 1, starlings preferred the raked plots where the previous year's biomass was removed. In experiment 2, although I found no significant differences between plots with clipped leavings and treatments other than controls, starlings clearly didn't avoid these treatments (fig. 2) and they appeared to be attractive to starlings, perhaps offering interesting foraging opportunities that did not inhibit their mobility. Previous studies have shown that starlings prefer recently mown pastures (Devereux and others 2006, Whittingham and Devereux 2008), suggesting the effect of clippings left on the ground may be ephemeral.

I detected no effects of long-term grazing, as measured by starling response to the mowed and raked plots with clippings removed (fig. 2, MRD compared to ML and MR). A single year without grazing is apparently sufficient to deter starlings from foraging. I know of no other studies that have directly addressed long-term grazing. Buckingham and others (2006) found that recent grazing was a strong predictor of field usage, but no studies to date have suggested that removing pastures from grazing for multiple years has any lasting effect on starling foraging behavior once they are returned to grazing.

Eradication of starlings is clearly not feasible, but with improved knowledge of starling habitat requirements, starling numbers may be reduced, minimizing their impacts on native bird species in California's oak woodlands. The distribution of

foraging habitat relative to nest sites could be useful in limiting starling numbers and their impacts. Starling breeding density is limited by nest site availability where foraging habitat is readily available, maximizing nest-site competition with native cavity-nesting species. Bruun and Smith (2003) found that when high quality foraging habitat was limited, starlings flew longer distances to forage, thereby enlarging their home ranges and reducing density. When starling density is reduced, competition for nest sites will be relaxed.

Recommendations to reduce the impact of starlings on cavity-nesting birds for rangelands include leaving moderate or high levels of residual dry matter when possible, especially in the areas where starlings prefer to forage. Purcell and others (2002) found that starlings were found in level, open woodlands with fairly well-developed soils such as the moist swales also preferred by grazing livestock. Rotational grazing, where pastures with both short and tall grass occur simultaneously, may be a useful tool for reducing starling densities but this needs to be tested experimentally. Rotations that create a mosaic of different grass heights will require some starlings to fly longer distances to forage and result in lower starling density. The spatial scale of this heterogeneity requires consideration; patch sizes should probably be fairly extensive, as small-scale heterogeneity could benefit starlings by providing both beneficial conditions for starling foraging and reservoirs for their prey (Devereux and others 2004). Where starlings are present in suburban and exurban areas, avoiding extensive mown and watered lawns will help avoid attracting starlings. Urban environments likely serve as habitat reservoirs in the drier months when starlings leave the oak woodlands in search of moist soils for foraging, and there are important opportunities to reduce starling numbers there as well.

Further research is needed to investigate thresholds of grass height at which starlings are discouraged from foraging. We collected data on grass height and biomass for each of our experiments but results were confounded by application of the experimental treatments. Our goal was to test responses to treatments, not responses to specific grass heights. Grass heights tested have varied widely among studies, with 'short' grass treatments ranging from 3 to 9 cm and 'long' grass treatments from 6 to 19 cm. Future experiments should refine the specific grass heights at which starlings hesitate to forage in order to identify less attractive foraging habitat. Recommendations from such studies would be useful not only for livestock management, but understanding on how best to protect rural households from fire risk.

Differences between mowing and grazing treatments as they relate to foraging habitat for starlings and other ground-foraging birds also need a more thorough examination. Grazing differs from mowing in that livestock are selective in the species and locations they graze, and grazing occurs over a longer time period. Cattle also compact the soil, and dung has its own rich invertebrate fauna, which starlings are known to exploit (Morris 2000). While starlings are known to associate with livestock, the relationships are not clearly understood.

From the first sightings of starlings in California in 1942 to becoming one of the most abundant, if not the most abundant, bird species in California (Small 1994), concerns have been raised about competition with native species for nesting cavities. However a species so numerous has almost certainly also affected other ground-foraging species, particularly those that feed on soil arthropods. Western meadowlarks (*Sturnella neglecta*) have decreased over the last 27 years at SJER (Purcell and Mori, n.d.) and Breeding Bird Survey (BBS) data show declines in both California and the Western BBS region (Sauer and others 2014). Causes for declines are unknown. Meadowlarks feed on the ground in open areas and eat soil

invertebrates (Davis and Lanyon 2008) and overlap with starlings in feeding habits. As a group, grassland bird species show consistent declines across North America (Brennan and Kuvlesky 2005, Knopf 1994, Vickery and Herkert 2001). Inter-specific relationships among the guild of ground-foraging insectivores should be investigated in areas where native species co-occur with starlings.

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