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FEEDING PREFERENCES AND CHANGES IN MASS OF CANADA GEESE GRAZING ENDOPHYTE-INFECTED TALL FESCUE[1]

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In the late 1940s and 1950s, southern farmers began planting a newly-discovered tall fescue cultivar (Kentucky-31), which was much hardier and more productive than other cultivars. Unknown at the time, this cultivar was infected with the endophytic fungus *Acremonium coenophialum.* By the 1970s, there were over 14 million ha of tall fescue pastures in the U.S., mostly in the southern and south-central states, and most were infected with the fungus (Shelby and Dalrymple 1987, Stuedemann and Hoveland 1988). The total infected area may have increased recently, because tall fescue has been the predominant grass seeded in Conservation Reserve Program plantings in the central and southern states (Osborn et al. 1992, as cited by Barnes et al. 1995).

This fungus, which grows subcutaneously in leaves, stems and seeds, produces ergopeptine alkaloids, notably ergovaline (Yates et al. 1985, Yates and Powell 1988, Thompson and Stuedemann 1993). The fungus makes the grass more hardy (Arachevaleta et al. 1989) and more toxic to insects and nematodes (Johnson et al. 1985, Latch et al. 1985, Clay 1988, Kimmons et al. 1990).

Reproductive impairment has been observed among laboratory rats (Zavos et al 1986, Varney et al. 1987, 1988) and mice (Zavos et al. 1987, 1988a, 1988b, 1990; Godfrey et al. 1994) fed infected fescue seed. Cattle fed fungus-infected tall fescue (hereafter call infected fescue), especially in hot weather, exhibited poor appetites, lower weight gains, reduced conception rates, suppressed milk production, and hyperthermia (Aldrich et al. 1993, Schmidt and Osborn 1993). Nonetheless, these problems can largely be avoided by proper husbandry, thus allowing infected fescue cultivars still to be recommended for year-around grazing pastures (Bouton et al. 1993).

Madej and Clay (1991) found that Dark-eyed Juncos (*Junco hyemalis*) fed infected fescue seed lost slightly more mass than Juncos fed uninfected fescue seed, but the differences were not statistically significant. Whether avian herbivores that graze infected grass will suffer ill effects is unknown. Also unknown is whether avian herbivores can discriminate between infected and uninfected fescue. These questions are addressed in the current study using Canada Geese (*Branta canadensis*) as grazers. During winter and migration, Canada Geese feed primarily by gleaning waste grain and grazing in green grain fields and pastures (Bellrose 1980), including tall fescue pastures (Conover, pers. observ.).

METHODS

These experiments were conducted from June 1992 until October 1993. Twelve adult Canada Geese (six males and six females) were collected in June 1992 from a nuisance flock in Reno, Nevada and then transported to Utah State University's Green Canyon Ecology Center at Logan, Utah. They were weighed, sexed through a cloacal examination, and given a uniquely-numbered neck collar. Three males and three females were selected and assigned to a "fungus geese" group and placed on a diet of fungus-infected fescue. The other three males and three females were assigned to the "control geese" group and fed uninfected fescue. During this study, one control goose was killed by a raccoon, and two others (one control and one fungus goose) died of unknown causes. Hence, sample sizes consisted of four control geese and five fungus geese, none of which attempted to breed during this study.

Fungus geese were placed in one of six caged turf plots that ranged in size from 5 × 10 m to 21 × 45 m. Control geese were placed in paired turf plots of the same size. Each fungus-goose plot had been planted in the previous year with a fungus-infected tall fescue cultivar (Kentucky 31 genotype DN-15, Titan, or Shenandoah). Each control-goose plot was planted with the same cultivars and seed batch as its paired fungus-goose plot, but few plants in the control-goose plots were infected. Fungus in the seed was killed before planting by cooking seeds at 58°C in a water bath for 20 minutes (Siegel et al. 1984, Williams et al. 1984). Microscopic examination of the leaves indicated that this treatment was effective in killing the fungus, because over 80% of the grass in the fungus-infected plots was infected while infection rates were less than 10% in the control plots.

Turf plots were mowed bi-weekly and were heavily fertilized with 10-10-10 (a fertilizer with 10% nitrogen, 10% phosphate, and 10% potassium). Geese were moved to a new plot after they had harvested most of the grass in a plot (most leaves were less than 5 cm in height). Control geese and fungus geese were always moved simultaneously so that they remained in paired plots. Turf plots provided almost all of the food for the geese during April–September; geese also were provided approximately 100 g of wheat grain each week.

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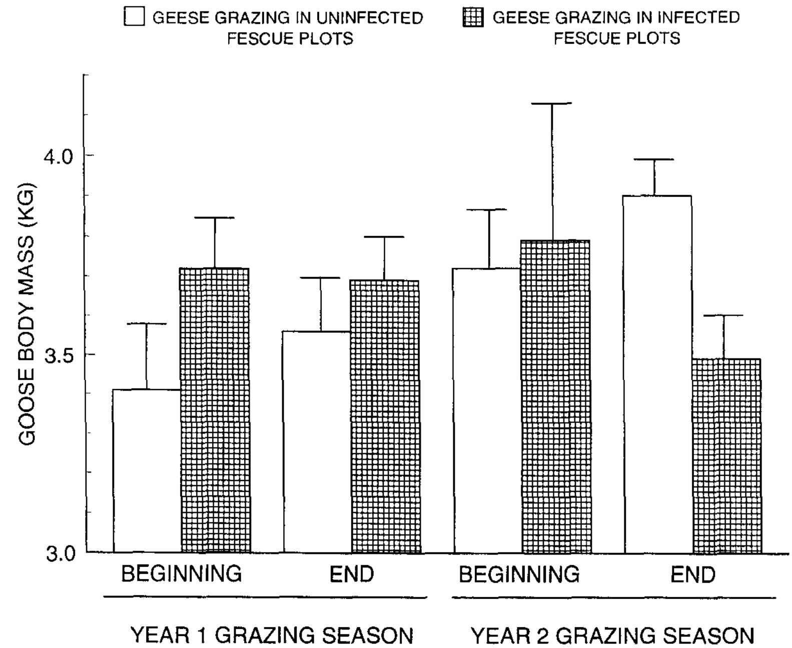

FIGURE 1. Mean body mass of Canada Geese at the beginning and ending of each grazing season when they foraged in plots of tall fescue infected with the endophytic fungus *Acremonium coenophialum* or plots containing uninfected tall fescue. The line above each bar represents the standard error.

They also were provided with water and a source of calcium ad libitum. During fall and winter when grass production was no longer sufficient to maintain geese, geese were moved to a 10 × 10 m cage and provided a diet of wheat, corn, and Intermountain Farmer's (IFA) commercial goose feed.

Geese were weighed each spring when moved to the fescue turf plots. Body mass was analyzed with a two-way repeated-measures ANOVA to assess whether there was a significant difference in mass between control geese and fungus geese before each year's experiment began. Each goose also was weighed at the end of each year's grazing season. This value was subtracted from the goose's mass at the beginning of the season to determine its change in mass during the grazing season. A two-way repeated-measures ANOVA was conducted on these changes in mass to assess whether fungus geese gained less mass than control birds.

To assess preferences for grazing infected and uninfected fescue plants, we conducted a choice feeding test when the geese were first obtained and 16 months later when the experiment ended. For these tests, we removed fences separating fungus and control plots to create plots containing both infected and uninfected plots. We then conducted a scan sample once per hour and noted the position of every goose and whether it was feeding. These tests lasted several weeks during which geese were placed in small groups (2 to 4 individuals). Every 2 to 3 days, each goose was moved to a new group and plot so that data could be collected on each individual while it was part of several groups and plots and for at least three days. All foraging observations were summed for each goose to determine the proportion of time it spent grazing in the infected plots (each goose was observed for at least 30 hours). A chi-square test was then conducted to assess whether these proportional data differed from the expected proportion of 0.5. Similarly non-foraging observations were summed for every individual and tested using a chi-square test to assess whether geese preferred one side to the other when not foraging.

RESULTS

At the beginning of the experiment, the mean mass (± SE) of control geese was 3.41 ± 0.18 kg; fungus geese weighed 3.62 ± 0.32 kg (Fig 1). When the geese were moved from their winter pen and placed out on the fescue plots for the second grazing season, the control geese had a mean mass of 3.72 ± 0.16 kg, and the mean mass of fungus geese was 3.79 ± 0.33 kg. Body mass of control geese and fungus geese did not differ at the beginning of the grazing seasons ($F_{1,7} = 0.13$, $P = 0.73$) nor was there a difference between years ($F_{1,7} = 4.06$, $P = 0.08$).

By the end of their first season of grazing fescue, control geese had gained mass ($\bar{x} = 0.15$ kg), whereas fungus geese had lost mass ($\bar{x} = -0.03$ kg). By the end of the second grazing season, control geese again gained mass ($\bar{x} = 0.17$ kg), whereas fungus geese again lost mass ($\bar{x} = -0.30$ kg). The change in mass between control and fungus geese during the grazing seasons was statistically significant ($F_{1,7} = 6.30$, $P = 0.04$).

When initially given access to plots of both infected and control grass, Canada Geese divided their foraging time equally ($\chi^2 = 6.1$, df = 10, $P = 0.8$); 53% of the grazing occurred in infected fescue plots and 47% in control plots. After foraging on tall fescue plants for 15 months, the geese spent significantly more time (86%) grazing in the control plots than they did (14%) in fungus-infected plots ($\chi^2 = 36.2$, df = 7, $P < 0.001$). This preference for uninfected fescue was exhibited by both control and fungus geese. When not grazing, geese spent equal amounts of time (53%) in the fungus plots and in the control plots (47%).

DISCUSSION

Our results indicate that Canada Geese that grazed in plots of tall fescue infected with *Acremonium coenophialum* lost mass while those grazing in control fescue plots gained mass. Hence, the former may be less able to survive periods of food deprivation. When put on a grain diet during the winter, fungus geese regained their lost mass, indicating that the ill effects of grazing infected fescue can be reversed.

We were unable to evaluate whether grazing on infected fescue plants caused any reproductive problems for Canada Geese because no fungus goose or control goose attempted to breed. Zavos et al. (1993) reported a 10% fertility reduction in Japanese Quail (*Coturnix japonica*) fed a diet of 45% infected fescue seed. Conover and Messmer (1996) found that consuming infected fescue seeds did not affect the ability of Zebra Finches (*Taeniopygia guttata*) to either maintain mass or to reproduce when ambient temperatures were 21°–23°C, but it did affect their ability to survive when temperatures were increased to 31–34°C. Other studies showed that eating infected fescue caused a reduction in reproductive performance in livestock (Aldrich et al. 1993, Schmidt and Osborn 1993), laboratory rats (Zavos et al. 1986, Varney et al. 1987, 1988) and laboratory mice (Zavos et al. 1987, 1988a, 1988b).

Upon first exposure to fescue, Canada Geese did not discriminate between infected and uninfected grass. After consuming fescue for several months, Canada Geese showed a preference for grazing control plots over fungus-infected ones during choice tests. This fungus produces alkaloids which have a bitter taste, but the birds' delay in developing an aversion to infected fescue suggests that this aversion may be based more on post-ingestion feedback than on a disagreeable taste. This aversion was exhibited by both fungus and control birds indicating that opportunities to forage on fescue plants were important for this discrimination, but not necessarily experience with infected ones. Conover and Messmer (1996) observed that naive Zebra Finches preferred infected seed, but birds experienced with eating fescue seed preferred uninfected seed. Madej and Clay (1991) also reported that avian seed predators captured from fields containing infected tall fescue plants (presumably experienced fescue seed foragers) exhibited an aversion to infected fescue seeds. Such an aversion should help protect avian species from the adverse impacts of grazing infected fescue if alternate food supplies are available. It also suggests that birds are most vulnerable prior to their development of an aversion or in situations where alternate foraging opportunities are limited.

Prior to 1950, large populations of Canada Geese wintered in all southern coastal states, with some of the largest populations residing in North Carolina, Florida and Louisiana (Crider 1967, Hankla and Rudolph 1967). Since the 1950s, however, these populations have declined (Trost et al. 1986, Hestbeck and Malecki 1989, Hestbeck et al. 1991). Reasons for the decline include short-stopping, which occurs when birds are lured to more northern wintering sites (Trost et al. 1986, Hestbeck and Malecki 1989) and lower survival rates among southern geese than those in more northern latitudes, perhaps because southern populations suffer heavier hunting pressure (Hestbeck et al. 1991). Based on the findings of this study, we hypothesize that grazing infected fescue also may have contributed to the decline of these southern populations by putting them at a nutritional disadvantage to geese that wintered further north where tall fescue pastures were less common (Shelby and Dalrymple 1987, Stuedemann and Hoveland 1988). Certainly the timing of events is correct for this hypothesis—southern farmers began planting pastures with infected fescue in the 1940s and 1950s (Shelby and Dalrymple 1987, Stuedemann and Hoveland 1988), and southern goose populations began to decline after that. However, this is only a hypothesis, the critical experiments to test it have not been conducted.

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