Forages and Pastures Symposium: Impact of Fungal-Endophytes on Pasture and Environmental Sustainability

75 Fungal endophytes: Forage friend or foe? C. Young,* *Noble Foundation, Ardmore, OK.*

The epichloae (sexual *Epichloë* and asexual *Neotyphodium* species) are endophytic fungi that systemically infect many cool season grasses, including the common forage grasses tall fescue and perennial ryegrass. The success of endophytes, such as *N. coenophialum* (tall fescue endophyte) and *N. lolii* (perennial ryegrass endophyte), within the host is due to a lifestyle strategy where the fungus systemically infects the aerial parts of the plant without causing disease and is subsequently transmitted in the seed where this association is maintained over successive generations. In modern monoculture-based agriculture, the presence of asexual *Neotyphodium* species has been shown to enhance persistence of the host plant by providing protection from biotic and abiotic stresses. Some known host fitness attributes provided by the endophyte arise from the production of bioactive alkaloids. Lolines and peramine provide beneficial anti-insect properties, while the ergot alkaloids and lolitrem B cause toxicity to grazing livestock that result in production losses. It is well documented that ergot alkaloids produced by the endophyte are the causative agent of fescue toxicosis that presents with numerous detrimental effects such as fescue foot, reproductive disorders, and reduced milk production and weight gains. Similarly, lolitrem B produced by some *N. lolii*-infected perennial ryegrass was found to cause ryegrass staggers. The genes required for the biosynthesis of each alkaloid have been cloned and characterized and this information can now be used to understand alkaloid diversity across the epichloae. To overcome endophyte-related toxicity problems, endophyte-free cultivars were established but despite the improvement in animal quality and production, pasture persistence significantly decreased. Inclusion of "livestock-friendly" endophytes in forage grasses is now considered important in forage grass breeding due to the beneficial properties they impart on the host. Cultivars with endophytes that ameliorate detrimental livestock effects yet retain host fitness benefits are now in use to overcome the problems of livestock toxicity.

Key Words: fescue toxicosis, endophyte, alkaloids

76 Impact of tall fescue—Fungal endophyte associations on sustainability of pastures under current and future environmental conditions. R. McCulley,* J. Iqbal, J. Siegrist, G. Brosi, and J. Nelson, *University of Kentucky, Lexington.*

Tall fescue (*Schedonorus arundinaceous*) is often infected with a fungal endophyte (*Neotyphodium coenophialum*) that, depending on the strain, is capable of producing alkaloids that can affect grazing animal health and pasture ecosystem structure and function. While the above-ground ecological effects of fescue symbiosis with the common toxic form of the endophyte have been well-documented, less is known about below-ground responses or effects of fescue symbiosis with other "novel" strains of *Neotyphodium*. Given that endophyte symbiosis confers abiotic stress tolerance to tall fescue and that the climate and atmosphere are changing, there is a need to understand how tall fescue, the endophyte symbiosis, and the production of toxic alkaloids will be affected by future climatic conditions. Here, we summarize results from 4 studies that explore these topics. Across a range of sites in the southeastern US, tall fescue stands infected with the common toxic strain of the endophyte consistently had greater soil organic carbon and nitrogen than adjacent endophyte-free stands, suggesting that endophyte infection has the potential to increase carbon sequestration in pastures of this region. In central Kentucky, stands of tall fescue infected with the novel endophyte 'AR-542' had higher soil-to-atmosphere fluxes of CO_2 and N_2O than adjacent stands of endophyte-free fescue or fescue infected with the common toxic or other novel endophyte 'AR-584,' illustrating that root and rhizosphere processes were influenced by endophyte genotype. In Tennessee, we found that 5 years of exposure to elevated atmospheric CO_2 concentrations promoted endophyte-infected tall fescue, but contrary to expectations, endophyte infection frequency did not change under drought conditions or with warming. In Kentucky, warming increased mortality of endophyte-infected vs. –free tillers, and in both experiments, warming significantly increased alkaloid concentrations in infected fescue. These studies demonstrate that endophyte infection is likely important for the sustainability of southeastern US tall fescue pastures both now and in the future.

Key Words: *Neotyphodium*, pasture ecosystems, biogeochemistry

77 Lessons from "down-under" in New Zealand and Australia: The critical role of endophyte in pasture quality and production. D. E. Hume,* *AgResearch, Palmerston North, New Zealand.*

The *Neotyphodium* fungal endophytes of ryegrass and tall fescue are essential for the survival and productivity of these grasses in a large proportion of the pastures in the moderate to high rainfall temperate zones of New Zealand and Australia. This is primarily due to the insect protection these endophytes impart to the grass plant through alkaloid production. This is most evident in New Zealand, with some endophyte strains protecting the grass plant from up to 5 different insect species. The most widespread strains of endophyte are toxic to grazing livestock, resulting in a dilemma for livestock farmers as to whether to choose endophyte-free or endophyte-infected grass seeds. This is of greatest concern for perennial and hybrid ryegrasses, as the market size for tall fescue is relatively small and the majority of tall fescue cultivars over the last century have been sold as endophyte-free. The main disadvantage for farmers is the animal toxic endophyte strains result in ill health of grazing livestock, primarily heat stress, ryegrass staggers (ryegrass only) and fescue foot (tall fescue only). While these symptoms are visually apparent, research has shown there are also reductions in liveweight gains, milk production, reproductive performance and immune function, and in sheep fecal soiling in the breach area resulting in increased fly strike. There are several options for dealing with advantages and disadvantages of endophyte in ryegrass. The most effective solution is the use of selected novel endophytes to manage pasture pests and animal productivity. Industry uptake of this technology has been rapid for the endophytes AR1 and AR37, with AR1 now the industry standard, with other strains also providing options. Greater use of the MaxP/MaxQ novel endophyte in tall fescue is likely to increase the use of this grass species as this endophyte is safe for sheep and cattle and improves grass production and persistence. Further novel endophyte developments are likely to present even more options for the farmer in the future.

Key Words: endophyte, quality, production

78 Phases of physiological adaptation to heat stress and fescue toxicosis. D. E. Spiers,* B. A. Scharf, J. S. Johnson, and P. A. Eichen, *University of Missouri, Columbia.*

Consequences of consuming tall fescue (*Lolium arundinaceum*) infected with the endophyte *Neotyphodium coenophialum* are well known, along with the fact that simultaneous exposure to heat stress (HS) enhances the negative effect. Less information is available about adaptation to these stressors. Studies were performed using cattle in field and chamber environments to identify the components of physiological adaptation to HS and fescue toxicosis. Exposure of Angus cattle to HS in environmental chambers results in an increase in respiration rate (RR) that remains elevated and unchanged for up to 2 weeks of HS. In contrast, rectal temperature (Tre) exhibits a biphasic response, with an initial increase followed after a few days by a greater rise under constant cycling HS. Over the same period, the initial heat-induced rise in sweat rate decreases. Acclimation to HS over a month on pasture decreases both RR and core temperature responses to heat. In a separate study, Angus cattle were maintained on endophyte-infected (E+) and uninfected (E-) tall fescue pastures for 2 mo into mid-summer, then tested in environmental chambers, followed by return to identical pastures for another 2 mo (late-summer) and retesting after this time. Feed intake (FI) and sweat rate were depressed in E+ treated cattle exposed to HS in the chambers with no change from mid- to late-summer periods showing no signs of adaptation. In contrast, Tre of E+ animals exhibited a progressively greater HS response from mid- to late-summer periods with no biphasic pattern as in controls. However, this hyperthermia merged with controls after a few days of HS. Likewise, E+ animals displayed an increase in RR, which quickly returned to control level after several days of HS to suggest adaptation. Despite evidence of thermoregulatory adjustment to these stressors, some thermal responses characteristic of fescue toxicosis (i.e., skin temperature) still show increased sensitivity to a change in air temperature. These results demonstrate that thermoregulatory and non-thermoregulatory responses to the combined stressors of heat stress and fescue toxicosis exhibit different long-term patterns of change.

Key Words: bovine, acclimation, thermoregulation

79 Managing the fungal endophyte/forage symbiosis for optimum forage-animal production. G. Aiken,* *USDA-ARS, FAPRU.*

Tall fescue (*Lolium arundinaceum* L.) is widely utilized for grazing in the eastern half of the USA. The grass is productive and persistent under low management, which is attributed to alkaloids produced by a fungal endophyte (*Neotyphodium coenophialum*) that infects most tall fescue plants. Unfortunately, the endophyte also produces ergot alkaloids that can induce fescue toxicosis in cattle. Symptoms of the malady include rough hair coat during the summer, elevated body temperature, labored respiration, and decreased serum prolactin. Ergot alkaloids bind biogenic amine receptors in peripheral vasculature that can reduce the animal's ability to dissipate body heat and make them vulnerable to severe heat stress at onset of high ambient temperature. Calf weight gain can be very low on toxic tall fescue, particularly in warm environments, which has limited the use of fescue for stocker production. Although the grass is primarily used for cow-calf production, calving percentages, milk yields, and weaning weights can be reduced on toxic endophyte-infected tall fescue. Further, there is concern of carry-over effects of ergot alkaloids on performance of calves consuming finishing rations in the feedyard. Management technologies have been developed that demonstrate potential in alleviating or mitigating the adverse effects of fescue toxicosis on cattle performance, physiology, and well being. Evaluations of these technologies will be reviewed and the advantages and disadvantages of each will be presented.

Key Words: tall fescue, ergot alkaloids, fescue toxicosis