The discovery of endophyte-grass associations in tall fescue \([Lolium arundinaceum]\) (Schreb.) Darbysh. syn. \(Festuca arundinacea\) Schreb.] and perennial ryegrass \([Lolium perenne\) L.] has improved the understanding of fescue toxicosis, ryegrass staggers, and other related syndromes. These two forage species are of major importance in temperate grazing systems, and the presence of alkaloid toxins in many varieties produced by endophytic fungi (from the \(Epichloë\) and \(Neotyphodium\) genera) has led to poor animal performance and great economic losses. About 8 million beef cows in the United States graze tall fescue sometime during the year, and there are also significant numbers of dairy cattle, horses, and small ruminants present in the fescue belt. Total economic loss as a result of adverse effects on growth rate, reproduction, and milk production exceeds $1 billion/yr (Roberts and Andrae, 2010).

Recent development and commercialization of tall fescue infected with an endophyte that does not produce toxic alkaloids (e.g., MaxQ, Pennington Seed, Madison, GA) represents the first use of endophyte technology to enhance the agronomic performance of a grass (i.e., Jesup tall fescue). Initial research demonstrated that agronomic characteristics of tall fescue infected with nontoxic endophytes were better than endophyte-free tall fescue and not different from tall fescue infected with wild-type (i.e., toxic) endophyte. Furthermore, animal performance was similar for endophyte-free and nontoxic-endophyte-infected tall fescue, both of which supported improved performance vs. tall fescue infected with wild-type endophyte (Parish et al., 2003). Questions remained about how long-term persistence of the nontoxic-endophyte-infected tall fescue would compare with wild-type-infected tall fescue. Two long-term studies have been published recently (Vibart et al., 2008; Drewnoski et al., 2009a,b; Franzluebbers et al., 2009) that confirmed the beneficial effects of the nontoxic endophyte on animal performance and also showed that long-term yield and persistence were improved compared with endophyte-free fescue and were nearly equal to tall fescue infected with wild-type endophyte.

Subsequent releases of tall fescue and perennial ryegrass varieties infected with nontoxic endophytes have provided new tools for producers developing temperate grazing systems. However, the adoption of the technologies has been slow because of high seed cost, poor understanding of the real cost of toxic endophytes to the grazing systems, and the climatic adaptation of grasses infected with toxic endophytes.

This symposium, held July 16 at the 2012 Joint Animal Meeting in Phoenix, Arizona, was designed to enhance the understanding of the positive and negative implications of endophyte ecology, the implications of endophyte–tall fescue associations on sustainability of pastures in a changing climate, experiences with endophyte technology in Australia and New Zealand, mechanisms by which cattle adapt to exposure to ergot alkaloids from toxic tall fescue, and approaches to managing endophyte toxicosis to achieve acceptable animal and agronomic performance in a tall fescue–based forage system. Three of the speakers combined their presentations into a single manuscript for publication in this series (Young et al., 2013), whereas Aiken and Strickland (2013) provided a second paper.

Young et al. (2013) discuss the biology of endophyte-grass associations, the importance of endophyte...
infection on the sustainability of pasture systems in a warming climate, and the distribution and pathogenicity of endophyte-infected tall fescue and ryegrass primarily in the United States, New Zealand, and Australia. Their paper explores the history of the discovery of endophyte-grass associations, the discovery and commercialization of nontoxic fescues, and the genetic mutations that lead to these naturally nontoxic endophytes. Infection with endophyte is considered essential for long-term persistence of tall fescue. Studies in Tennessee and Kentucky (Young et al., 2013) have shown that infection with endophyte increases soil carbon and nitrogen and enhances survival of tall fescue in stands as environmental temperature rises. Whereas infection rate of tall fescue did not increase over time during heat exposure, wild-type endophyte-infected fescue expressed increased toxin levels in response to higher environmental temperatures. Nontoxic endophytes were screened and collected from around the world and selected in breeding programs in association with improved varieties of fescue and ryegrass. The releases of nontoxic ryegrasses (primarily in New Zealand) and tall fescues (primarily in the United States) are the first example of commercialization of endophyte technology. The understanding of the specific genetic defects leading to low or nonexistent ergot alkaloid production will aid in screening of additional strains of endophytes and may lead to novel applications of endophytes in other agronomic crops.

Aiken and Strickland (2013) discuss specific effects of ergot alkaloids in pasture-based livestock production systems and strategies to mitigate their negative effects on livestock. There are a number of ergot alkaloids that are present in endophyte-infected forages, but until recently, the potency and activity of each compound have not been well understood because of the lack of a well-accepted model to study them. A myograph system recently developed at the University of Kentucky (Klotz et al., 2010) and the ability to measure peripheral blood flow in vivo (Aiken et al., 2007) has greatly advanced understanding of one of the effects of alkaloids on the peripheral circulatory system. The same technology is currently being used to explore effects on vasculature in other tissues.

Tall fescue and ryegrass infected with toxic wild-type endophytes are present across large areas of the temperate world and will continue to provide great challenges to livestock producers that use them. However, advancement in the understanding of the mechanisms leading to toxicosis and improved understanding of the biology of nontoxic endophytes promise multiple new strategies for minimizing or eliminating toxicoses in cattle consuming such forages.

**LITERATURE CITED**


