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Technical Note: Effect of bait delivery interval in an automated head-chamber system on respiration gas estimates when cattle are grazing rangeland[1]

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ABSTRACT

Agricultural methane (CH_4) emissions worldwide account for approximately 43% of all anthropogenic CH_4 emissions, and the majority of agricultural CH_4 emissions are attributed to enteric fermentation within ruminant livestock. Therefore, interest is heightened in quantifying and mitigating this source. The automated head-chamber system (AHCS; GreenFeed, C-Lock Inc., Rapid City, SD) evaluated here can be placed in a pasture with grazing cattle to measure their CH_4 and CO_2 emissions and O_2 consumption. However, improper management of an AHCS might have a significant effect on gas exchange estimates. One factor that may affect the quality of these estimates is the rate that bait is delivered and the length of time an animal has its muzzle in front of the intake manifold for sampling. During both experiments, at each visit to the AHCS an electronic ear tag triggered the delivery of 6-mm alfalfa pellets (bait; 32-g increments) at timed intervals up to 8 times per visit and a maximum of 4 sampling events/d. In Exp. 1, the AHCS was programmed to deliver feed at 18- (n = 2), 21- (n = 4), 24- (n = 4), or 27-s (n = 3) intervals for 73 d; in Exp. 2 the AHCS was programmed to deliver feed at 19- (n = 2), 27- (n = 4), 35- (n = 4), or 43-s (n = 3) intervals for 43 d. The AHCS was programmed to measure CH_4, CO_2, and O_2 (Exp. 2 only) fluxes at each visit during the experiments. Time intervals were analyzed by ANOVA, and least squares means were compared using linear and quadratic contrasts. Carbon dioxide emission estimates were not affected by time interval in either experiment. Methane emission estimates and the ratio of CH_4:CO_2 linearly decreased ($P < 0.01$) with increasing time increment in Exp. 1 but was not different in Exp. 2. Time increment did not affect the O_2 consumption estimate in Exp. 2. Increasing the time increment increased ($P < 0.01$) the time cattle spent in the AHCS but did not affect the amount of bait consumed. Cattle did not respond consistently to increasing time increment for bait delivery, and bait delivery interval had minimal effect on gas emission and consumption estimates.

Key words: carbon dioxide, cattle, methane, oxygen, respiratory quotient

INTRODUCTION

The importance of ruminant livestock as a user of natural resources and a source of livelihood for people in rural communities has received considerable attention in the last decades (McAllister et al., 2011; Vergé et al., 2012; Herrero et al., 2013). Livestock contribute valuable nutrients to crop and grazinglands, supply important protein and micronutrients to the human diet, and provide revenue for rural communities (McMichael et al., 2007), but a duality of the system is that ruminant livestock contribute to anthropogenic greenhouse gas emissions and global climate change (Herrero et al., 2013). The need to respond to global climate change has prompted developed countries to commit to anthropogenic emission reductions (Allwood et al., 2014). Livestock production systems contribute an estimated 14.5% of global anthropogenic greenhouse gas emissions (Gerber et al., 2013).

Because of these issues, technologies are being developed to measure the actual greenhouse gas emissions by ruminant livestock. One such machine is the portable, automated head-chamber system (**AHCS**; GreenFeed; C-Lock Inc., Rapid City, SD) that allows the measurement of CH_4 and CO_2 emission and O_2 consumption by grazing ruminants (Figure 1a). The system has similarities to the open-circuit respiration chamber (McLean and Tobin, 1987), but it must sample the animal's breath multiple times over several days to obtain a quality estimate of emission (Arthur et al., 2017). With the incremental baiting system (32 g/increment) used in the AHCS, the question arises as to how frequently bait should be delivered? Shorter intervals or faster bait delivery might stimulate the interest of the animal so they are more eager to visit the AHCS,

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whereas longer intervals or slower bait delivery might keep the animal's head in the chamber longer, thus improving accuracy. Alternatively, with longer bait delivery intervals (**BDI**), the animal may not visit as often or may not remain in the AHCS long enough to obtain a quality estimate of emissions.

The following experiments were designed to test the hypothesis that with longer increments between bait deliveries, grazing cattle will stay at the AHCS longer and estimates of CH_4 and CO_2 emission and O_2 consumption will be greater and more precise because of a more complete breath-cloud capture, but the CH_4:CO_2 and respiratory quotient (**RQ**) will not differ.

MATERIALS AND METHODS

Both experiments were conducted on a native rangeland site at the Southern Plains Experimental Range of the USDA, ARS near Fort Supply, Oklahoma (36°37′N, 99°35′W; elevation 630 m). Experiment 1 was conducted from November 7, 2014, through January 19, 2015, and Exp. 2 was conducted from February 25 to April 8, 2015. For all animals used in these experiments, the care standards described in the *Guide for Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010) were used. The animal use protocols for each experiment were reviewed and approved by the Southern Plains Range Research Station Animal Care and Use Committee (Protocol number, AUP-005).

Site and Cattle Management

The regional climate at the research site is continental, with an average annual precipitation of 627 mm with 72% of the precipitation falling during the April to September growing season. This region consists of gently rolling and stabilized sand dunes frequently interspersed with areas of heavier textured soils that do not have a well-defined drainage pattern (Berg, 1994). The vegetation is dominated by a mixture of tall, mid, and short native warm-season grasses and forbs, and sand sagebrush (*Artemisia–Andropogon*). The native vegetation of the Southern Plains mixed-grass prairie is within the sandsage–bluestem prairie type described by Küchler (1964). Average mean temperatures were 2.5 and 6.7°C during Exp. 1 and 2, respectively. Minimum- and maximum-recorded temperatures were −14.6 and 30.8°C, and −14.5 and 33.7°C for Exp. 1 and 2, respectively.

The 20-ha pasture was grazed by 13 Red Angus heifers (BW = 364 ± 2.4 kg) for the duration of the experiments. Heifers had been treated in the spring for internal and external parasites with moxidectin (0.5 mg/kg of BW; Cydectin; Boehringer Ingelheim Vetmedica Inc., St. Joseph, MO), vaccinated with a modified live 4-way vaccine for infectious bovine rhinotracheitis, bovine respiratory parainfluenza-3, bovine respiratory syncytial virus, and bovine virus diarrhea (Express 5, Boehringer Ingelheim Vetmedica Inc.), and injected with a 7-way clostridial vaccine (Vision 7 with Spur; Merck Animal Health Intervet Inc., Madison, NJ). To determine BW during the relatively short experimental periods, heifers were gathered in the afternoon and placed in a pen without feed or water until the next morning (approximately 17 h) to control for

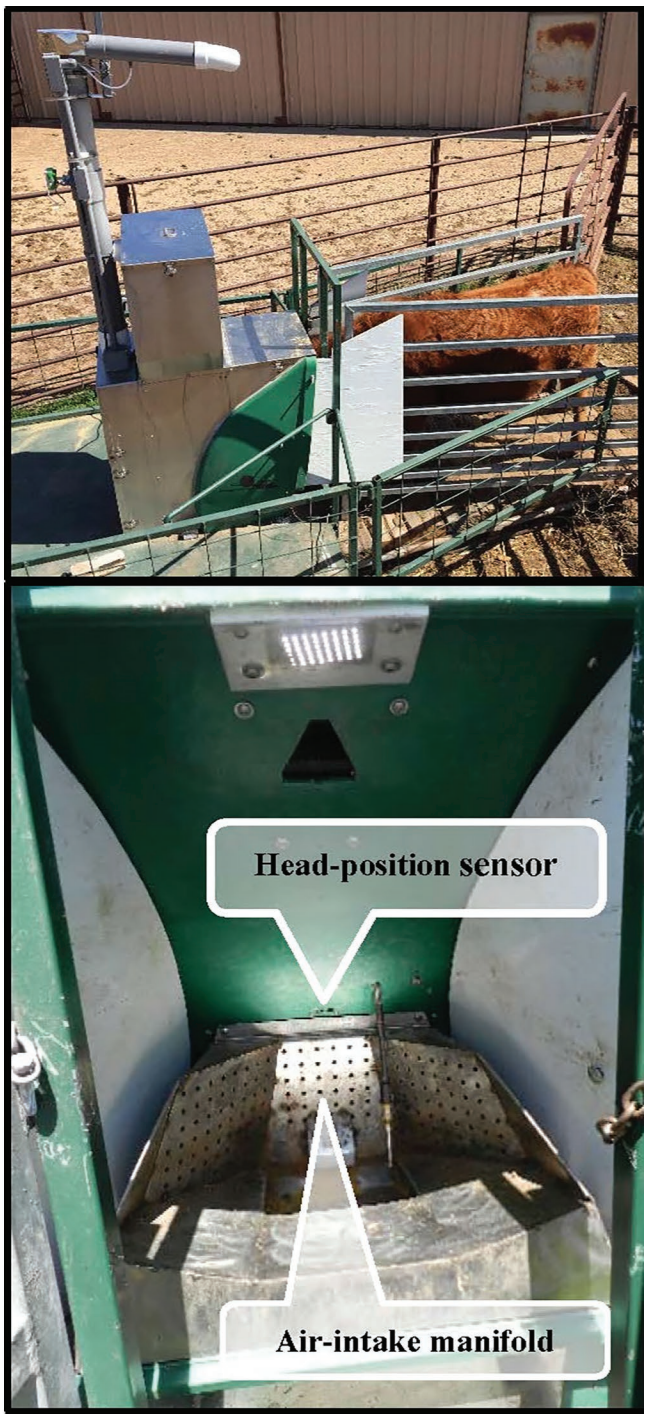

Figure 1. The automated head-chamber system (a) designed to measure methane and carbon dioxide emission by cattle. Air samples are analyzed for the flux of methane and carbon dioxide resulting from the breath of a cow when the cow places its head in the chamber (b) to consume bait. Color version available online.

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