TECHNICAL NOTE: A simple back-mounted harness for grazing dairy cows to facilitate the sulfur hexafluoride tracer gas technique

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ABSTRACT

We describe here a cattle harness to attach a gas collection vessel to facilitate the sulfur hexafluoride tracer gas (SF_6) technique. The harness consists of 2 major components, i) a light-weight, robust body, fabricated from an equine surcingle or lunge roller with padded thoracic trapezius pressure points, a bespoke shaping shaft for spine support and adjustable buckles on both sides, and ii) an elastic flank-strap to prevent the harness from dislodging. The spine support consists of stainless steel laminated with carbon fiber. This support minimizes animal skin contact area, relieves the spine area of pressure and it creates free flow of ambient air below the platform reducing sweat accumulation, hence avoiding any skin lesions. The harness weighs approximately 1.2 kg, allows for attachment of 2 gas collection vessels (animal and background sample), and is cost-effective.

Key words: SF_6, methane measurement, enteric CH_4, equipment

Technical Note

Enteric methane emissions from individual grazing ruminants can be measured using the sulfur hexafluoride tracer gas (SF_6) technique developed by Zimmerman (1993) and first adopted by Johnson et al. (1994). Since 1994, various implementations of the original technique have been published in more than 120 peer-reviewed papers. In an attempt to standardize the SF_6 technique, a few guidelines on the use thereof have been made available over time (Johnson et al., 2007; Berndt et al., 2014; Williams et al., 2016), with the latest modification for dairy cattle described in detail by Deighton et al. (2014). These guidelines concentrated profoundly on the fundamental elements of the SF_6 technique, such as the slow-release device (permeation tube), sampling line with flow restrictor and gas collection vessel (sample and background). The gas collection vessel changed from a stainless steel sphere suspended by a neck strap, attached to the halter apparatus (Johnson et al., 1994), to the V- or U-shaped neck yoke molded from polyvinyl chloride (PVC) pipe (Johnson et al., 2007) and most recently to a stainless steel or PVC cylinder fitted to the animal's back (O'Neill et al., 2011; Deighton et al., 2013, 2014). Mounting position of the gas collection vessel is mainly dependent on the species and breed (size and temperament) as well as the operating environment (extensive or intensive) and available resources to manufacture the vessel. For example, the neck position for the gas collection vessel will function for most extensive animals, whereas it is dysfunctional in a milking parlor or feed stall equipped with a baling system. It appears that detailed description of back-mounting options for the gas collection vessel is, however, usually covered superficially, not always cost-effectively and not standardized. In our opinion, the position and quality, in terms of support and minimal skin contact area and pressure points of the mount on the animal, is critical as this will impact animal welfare and the number of representative gas samples lost.

This note presents a cost-effective, but robust back-mounted harness with minimum skin contact area for grazing dairy cows that facilitates the SF_6 technique for measurement of enteric methane emissions. We hypothesize that grazing dairy cows equipped with this novel harness, to facilitate the SF_6 technique in methane measurement, will not show signs of skin lesions on the spine area or behind the thoracic limb. Although the harness described in this note applies to dairy cows, the apparatus could be adapted for use in other ruminants as well. Institutional animal care and use was obtained from Western Cape Department of Agriculture (Admin Building, Muldersvlei Road, Elsenburg 7607, Western Cape, South Africa) before commencement of the study and unnecessary discomfort to the animals was avoided at all times.

The harness consists of 2 major components, i) a light-weight, robust body, fabricated from an equine surcingle or lunge roller with padded thoracic trapezius pressure points, a bespoke shaping shaft for spine support and adjustable buckles on both sides, that acts as a platform for gas collection vessel attachment, and ii) an elastic flank-strap to prevent the harness from sliding over the neck of the animal. The padded surcingle used is commercially available and is specifically designed to relieve pressure on the spine and to avoid sideways movement of the harness. The surcingle is also equipped with attachment rings running from the ribcage up to the spine area and usually has a girth range of 160 to 220 cm. Nylon is recommended over leather as material, due to the lighter weight and enhanced breathability keeping sweat accumulation to a minimum. The trapezius padding is covered by perforated neoprene material to ensure breathability and comfort (Figure 1). We found that the standard padded surcingle did not relieve sufficient pressure on the spine due to the pointed thoracic spinous process of the Jersey cow, which is more profound in a grazing system compared with a TMR system where energy-supply is not limiting and body condition is improved. As observed in previous unpublished SF_6 trials, more than 40% and 20% (n = 72) of pasture-

based Jersey cows equipped with the standard padded surcingle without protective felt wrapping, covering an average distance of 800 m twice daily around milking for 6 consecutive days, showed signs of skin lesions on the spine area and behind the thoracic limb, respectively, ranging from slight to severe cases. Unfortunately, exact values of skin lesion incidences from other research establishments for comparison purposes are difficult to obtain due to the sensitive nature thereof.

Figure 1: Harness-body showing the perforated neoprene padding with built-in support shaft to ensure breathability and comfort to the trapezius area of the cow while acting as a platform for attachment of the gas collection vessel.

To alleviate the problem, a U-shaped trapezoidal support shaft was crafted from stainless steel rod (6 mm diameter) laminated with 1 layer of stringed carbon fiber per side to create a flat area with rounded edges. The lengths of the sides are 170 mm, the top base 70 mm, and the width of the laminated shaft 40 mm (Figure 2). The weight is approximately 177 g. The

inner base angle of the support shaft can range from 120° for cows with BCS <2.5 to 150° for cows with BCS >3.0. The BCS system used was the 5-point scale developed by Wildman et al. (1982). The shape and size of the support shaft was based on a gypsum mold of the thoracic vertebrae area of a Jersey cow with a BCS of 2.0. The support shaft is inserted within the surcingle between the 2 nylon layers, above the trapezius padding and stitched secure. This support relieves the spine area of any possible base pressure imposed by the weight of the gas collection vessel, minimizes the skin contact area alleviating skin lesions, creates free flow of ambient air below the base reducing sweat accumulation that attract flies, and creates a platform for attachment of the gas collection vessel.

Figure 2: The U-shaped trapezoidal support shaft crafted from stainless steel rod laminated with stringed carbon fiber.

In order to prevent the harness-body dislodging and sliding over the neck of the animal, a single elastic band (dimensions: 25 to 40 mm width, 1 to 2 mm thick and approximately 2 m long unstretched dependent on the girth and length of the cow) is connected caudally via attachment rings to the mid-rib area on both sides of the harness-body. The elastic band is connected at 30% stretch and should run over the flank area of the animal under the tail (Figure 3). The harness-body is fitted so that the adjustable buckles are at equal heights, >70 mm above the olecranon tuber area of the thoracic limb minimizing skin lesions (Figure 4a). The harness-body should be tightened to prevent excessive sideways movement, but at the same time allowing restricted hand movement under the body of the harness-body in the mid-rib area. To further preclude the possibility of skin lesions, we wrapped the adjustable buckles with a double layer of felt material fixed with elastic band (Figure 4b).

Figure 3: A Jersey cow equipped with a simple back-mounted harness for gas collection vessel attachment to facilitate the sulfur hexafluoride tracer gas technique. Adjustable buckles and elastic band over the flank avoid dislodgment of the harness.

Figure 4: (a) Placement of the adjustable buckles >70 mm above the olecranon tuber area of the thoracic limb (b) wrapped with double layer of felt material to minimize skin lesions.

Figure 5: The gas collection vessel is attached with two double sided Velcro (2 Kingdom Street, 6th Floor, Paddington, London, W2 6JP, United Kingdom) strips via a cable-tie looped through one of the attachment rings available on the harness-body facilitating quick replacement of the vessel.

The gas collection vessel is positioned recumbent, parallel to the animal's spine on the platform created by the harness-body. The vessel is fixed with 2 double sided Velcro (2 Kingdom Street, 6th Floor, Paddington, London, W2 6JP, United Kingdom) strips, cranially and caudally, via a cable-tie looped through 1 of the attachment rings available on the harness-body (Figure 5). The double sided Velcro strips complement quick replacement of gas collection vessels, while providing a robust, cost-effective attachment.

This novel harness has recently been implemented in two unpublished SF_6 trials that in combination consisted of 68 pasture-based, lactating Jersey cows covering the same distance for the same duration under similar conditions as the previously mentioned unpublished SF_6 trials. During the trial none of the harnesses dislodged and after completion of the trial no signs of skin lesions on both the spine and thoracic limb area were detected. Hence, we accept our hypothesis that this novel harness will avoid skin lesions in grazing dairy cows.

The complete harness, excluding the gas collection vessel, weighs approximately 1.2 kg and could cost less than USD 70.00. This harness allows for attachment of 2 gas collection vessels, therefore allowing for individual on-cow background sampling. It is recommended to equip the animal with the harness without the collection vessel at least 2 days prior to the sampling period to allow the animal to acclimatize to the harness. This harness has been developed over a series of SF_6 trials to a point where it functions successfully while avoiding any skin lesions, hence focusing on animal welfare.

ACKNOWLEDGEMENTS

This research was supported and funded by the Western Cape Department of Agriculture and the Western Cape Agricultural Research Trust. A special thanks goes out to Franette Botha, a

medical orthotist prosthetist (practice no 0544744), and her team for developing and manufacturing the support shaft. The financial assistance of the National Research Foundation (NRF) towards this research is hereby also acknowledged. Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the NRF.

REFERENCES

Berndt, A., T. M. Boland, M. H. Deighton, J. I. Gere, C. Grainger, R. S. Hegarty, A. D. Iwaasa, J. P. Koolaard, K. R. Lassey, D. Luo, R. J. Martin, P. J. Moate, G. Molano, C. Pinares-Patiño, B. E. Ribaux, N. M. Swainson, G. C. Waghorn, and S. R. O. Williams. 2014. Guidelines for use of sulphur hexafluoride (SF_6) tracer technique to measure enteric methane emissions from ruminants. Pages 166. M. G. Lambert, ed. New Zealand Agricultural Greenhouse Gas Research Centre, New Zealand.

Deighton, M. H., B. M. O'Loughlin, S. R. O. Williams, P. J. Moate, E. Kennedy, T. M. Boland, and R. J. Eckard. 2013. Declining sulphur hexafluoride permeability of polytetrafluoroethylene membranes causes overestimation of calculated ruminant methane emissions using the tracer technique. Anim. Feed Sci. Technol. 183:86–95.

Deighton, M. H., S. R. O. Williams, M. C. Hannah, R. J. Eckard, T. M. Boland, W. J. Wales, and P. J. Moate. 2014. A modified sulphur hexafluoride tracer technique enables accurate determination of enteric methane emissions from ruminants. Anim. Feed Sci. Technol. 197:47–63.

Johnson, K. A., H. H. Westberg, J. J. Michal, and M. W. Cossalman. 2007. The SF_6 tracer technique: Methane measurement from ruminants. Pages 33–67 in Measuring Methane

Production from Ruminants. H. P. S. Makkar and P. E. Vercoe, ed. Springer, Dordrecht, the Netherlands.

Johnson, K., M. Huyler, H. Westberg, B. Lamb, and P. R. Zimmerman. 1994. Measurement of methane emissions from ruminant livestock using a SF_6 tracer technique. Environ. Sci. Technol. 28:359–362.

O'Neill, B. F., M. H. Deighton, B. M. O'Loughlin, F. J. Mulligan, T. M. Boland, M. O'Donovan, and E. Lewis. 2011. Effects of a perennial ryegrass diet or total mixed ration diet offered to spring-calving Holstein-Friesian dairy cows on methane emissions, dry matter intake, and milk production. J. Dairy Sci. 94:1941–1951.

Wildman, E. E., G. M. Jones, P. E. Wagner, R. L. Boman, H. F. Troutt Jr., and T. N. Lesch. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65:495–501.

Williams, S. R. O., P. J. Moate, and M. H. Deighton. 2016. The modified SF_6 technique for the determination of methane emissions from dairy cows. Notes for a workshop held at Ellinbank, Victoria, Australia 10-11 February 2016. Pages 56. Department of Economic Development, Jobs, Transport and Resources, Melbourne, Victoria, Australia.

Zimmerman, P., inventor. 1993. System for measuring metabolic gas emissions from animals. Univ. Corp. for Atmospheric Research, assignee. US Patent No. 5265618.