Estimation of energy expenditure of grazing ruminants via accelerometry

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Summary

Understanding the physiological and behavioral differences between grazing farm animals and housed farm animals is essential for the efficient management of these animals. In particular, the estimation of the energy expenditure (**EE**) of grazing animals is of great importance for the efficient management of animals on pasture. A few techniques have been used to estimate the EE of grazing animals, but these methods have limited applications in the field. Therefore, a new method that is appropriate for estimating the EE of free-ranging animals is highly desired. In recent years, miniature animal-attached data-logging devices have been increasingly used in the study of wild animal ecology to obtain information on the physiological and behavioral status of free-ranging animals that are hard to trace by direct observations. One such device, the accelerometer, is used as a powerful tool for quantifying animal behavior, and it has been recently applied for the estimation of EE of free-ranging animals across varied species by using a simple acceleration index, referred to as dynamic body acceleration (**DBA**). However, to our knowledge, it has not yet been fully demonstrated whether accelerometry can be applied to grazing ruminants such as cattle, goats and sheep to estimate the EE. This thesis highlights the investigation of the application of accelerometry to estimate the EE of grazing ruminants.

Following the introduction chapter (Chapter 1), Chapter 2 gave an outline of the conventional methods to estimate the EE of ruminants under constrained and free-ranging conditions in the form of a literature review. In addition, it provided the findings of accelerometry for estimating the EE of animals, based on reports on wildlife and human studies. Although both conventional methods (i.e., the isotopic method and

heart rate method) and new methods (i.e., those based on locomotion information and accelerometry) can be applied to the estimation of EE of animals in pastures, each have their advantages and disadvantages in taking appropriate measurements, especially in field situations, and thus they are not always applicable to the estimation of EE in every situation. Therefore, it is necessary to select the most appropriate method for the experimental purpose, design and situation. Thus, we sought to validate the use of accelerometry in experiments on farm ruminants.

Chapter 3 investigated the potential of DBA as an index for EE estimation of grazing ruminants through a comparison with heart rate, a conventional substitute for EE. The results of the simultaneous measurement and comparison of body acceleration and heart rate of animals on pastures showed a significant relationship between the two parameters. This indicated that DBA could be a good proxy for estimating heart rate and thereby the EE of grazing animals. Although the relationship between DBA and heart rate was different between the species and breeds as well as between individuals, the difference could be explained by variability in body weight. Thus, a common relationship across species, breeds, and individuals may be established by normalizing the body weights. Furthermore, this common relationship could be extended to diverse animal species that belong to different animal types (bipeds, quadrupeds, aquatic, terrestrial, etc.) in the future.

Chapter 4 proposed and tested a new and simple method for the estimation of EE of animals on pastures via accelerometry by combining DBA with a conventional animal energy requirement system. In this method, DBA was used to quantify the increase in physical activity during grazing and subsequently to calculate the activity-specific EE as the activity allowance according to the conventional Agricultural and Food Research Council (**AFRC**) energy requirement system. When both the accelerometry method and the heart rate method were applied to farm ruminant species, higher DBA and heart rate values were obtained under grazing management, resulting in greater EE values using both methods than those under housing management. While the EE estimated from DBA was within the appropriate range of values, it was different from that estimated from the heart rate. These differences may have been partly due to the effects of physiological, psychological, and environmental factors, in addition to physical activity, on the heart rate measurements. There is evidence that the conventional energy system can use accumulated data from energy metabolism research to predict fasting metabolism and activity-specific EE of housed animals, while DBA can quantify physical activity separately from other factors in pasture animals. Therefore, the use of the DBA appears to be a more precise way to predict activity-specific EE under grazing conditions. Furthermore, incorporating acceleration index data with a conventional energy system can be a simple and useful method for estimating EE in farm ruminants on pastures.

Final chapter (Chapter 5) summarized the thesis and concluded that accelerometry, using DBA, can be applied to the estimation of the EE of grazing ruminants as well as that of other animal species. Because of the lack of calibration with calorimetry and direct comparison with conventional estimation methods, it is still uncertain whether the accuracy of the accelerometry method for estimating EE of animals is superior to that of the conventional estimation methods. Nevertheless, the utility and simplicity of the acceleration logger or sensor could enable the widespread use of the accelerometry method as a better option for estimations of EE in pasture animals, especially in field-research and commercial farms. Thus, we believe that when calibration or validation experiments with concomitant methods are adequately conducted, the accelerometry method will contribute to determining the EE of grazing farm animals, and the information gained from these measurements would be an invaluable resource for farmers in the form of reports on energy requirements in several feeding standards.