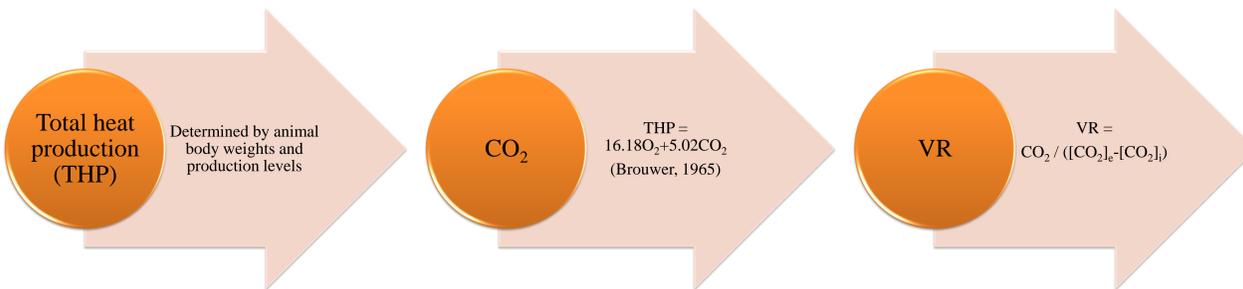


## Introduction

Affordable and reliable means to estimate ventilation rates (VR) of animal house is desirable. A CO<sub>2</sub> balance approach has been proposed to estimate VR based on the metabolic rate data of the animals.



Air emissions from different species were measured as well as VR in environmental rooms at Michigan State University over the course of 15 studies.



Each room (H 2.14 m × W 3.97 m × L 2.59 m) can accommodate:  
 1 steer/lactating cow,  
 6 finishing pigs,  
 20 turkeys,  
 50 broiler chickens,  
 Or up to 80 laying hens.

## Objectives

1. Summarize baseline data on CO<sub>2</sub> emissions from animal operations in these 15 studies and investigate the possible diet effect;
2. Compare the measured CO<sub>2</sub> emissions with CO<sub>2</sub> production rates estimated from the metabolic rate data in literature;
3. Evaluate the performance of the CO<sub>2</sub> balance approach to estimate VR of animal houses for various species.

## Methods

### Animal and diets

- In each study, animals from one of the species were raised in 12 rooms feeding 3 or 4 different diets (4 or 3 reps/diet)
- Different diet CP, DDGs level, feed ingredients ...

### Air Emission Measurements

- Gas concentrations were measured in a sequential manner, first with incoming air, then through each of the 12 rooms' exhaust air for 15 min.
- VR of each room were recorded every 30 seconds using a 15.24-cm orifice plates in the incoming ductwork of each room.

### Estimation of THP

- CIGR, 2002
- THP = 10.62m<sup>0.75</sup> (Broilers)
- THP = 6.28m<sup>0.75</sup> + 25Y<sub>2</sub> (Laying hen)
- THP = 5.6m<sup>0.75</sup> + 22Y<sub>1</sub> + 1.6 × 10<sup>-5</sup>p<sup>3</sup> (Dairy cow)
- ...
- m: body weight
- Y<sub>1</sub>: milk production
- Y<sub>2</sub>: egg production
- p: days of pregnancy

### Data Analysis

- SAS MIXED model
- Forest plot
- Paired t-tests
- Uncertainty analysis

## Results and conclusions

### Diet effect on measured CO<sub>2</sub> emissions

No significant diet effects in 14 of the 15 studies. Lower CO<sub>2</sub> emissions were observed from steers fed diets containing 60% DDGs as compared to that from steers fed the control diets (0% DDGs).

### The CO<sub>2</sub> emissions for each species across different studies

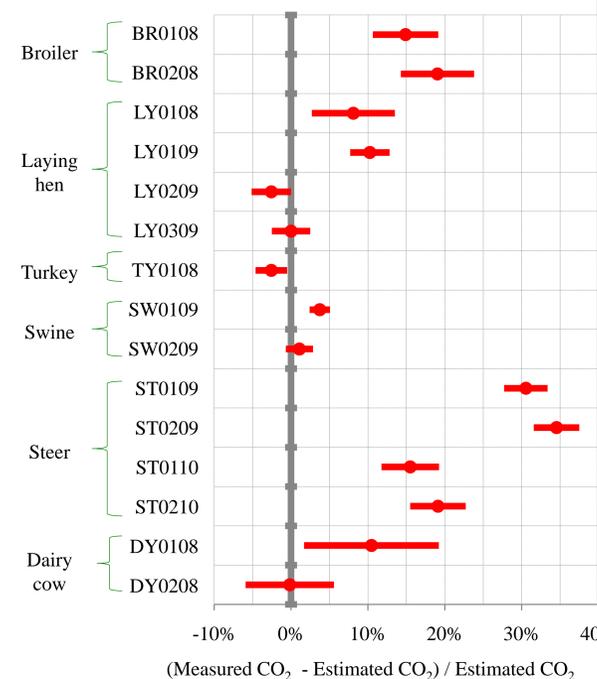
Significant differences were observed across different studies for each species of broiler, laying hen, swine, and steer, possibly due to different stages of production, different weather conditions, or different management practices.

### Comparison of measured CO<sub>2</sub> emissions with estimated CO<sub>2</sub> production rates from THP

Higher measured CO<sub>2</sub> emissions were expected because the total CO<sub>2</sub> emissions should be the sum of metabolic CO<sub>2</sub> production of the animals plus CO<sub>2</sub> generation from other sources (e.g. litter or manure). Since the estimated CO<sub>2</sub> productions were consistently lower than the measured CO<sub>2</sub> emissions in broiler and steer studies; they were multiplied by correction factors of 1.15 and 1.16 respectively to represent the total CO<sub>2</sub> emissions.

### Comparison of directly measured VR with estimated VR using the CO<sub>2</sub> balance approach

Relatively high R<sup>2</sup> were observed in studies of broilers and turkey due to the relatively high variation of VR in these studies.



| Species    | Study ID | Estimated CO <sub>2</sub> production rates (mL s <sup>-1</sup> hd <sup>-1</sup> ) | Exhaust and inlet CO <sub>2</sub> concentration differences (ppm) | Estimated VR (L s <sup>-1</sup> hd <sup>-1</sup> ) | Measured VR (L s <sup>-1</sup> hd <sup>-1</sup> ) | P value of paired t-tests | R <sup>2</sup> | Relative difference between measured and estimated VR (%) |
|------------|----------|---|---|--|---|---------------------------|----------------|---|
| Broiler    | BR0108   | 0.60±0.26   | 115±106   | 5.20±1.39  | 5.05±1.01   | 0.63                      | 0.60           | 6.4±6.9   |
|            | BR0208   | 0.45±0.28   | 220±245   | 2.70±1.87  | 2.69±1.67   | 0.80                      | 0.68           | 11.3±11.8   |
| Laying hen | LY0108   | 0.37±0.00   | 144±147   | 3.17±0.86  | 3.28±0.51   | 0.05                      | 0.20           | 9.5±7.2   |
|            | LY0109   | 0.39±0.00   | 95±35   | 4.17±1.22  | 4.34±0.86   | 0.01                      | 0.31           | 9.6±7.4   |
|            | LY0209   | 0.39±0.00   | 95±28   | 4.55±1.00  | 4.28±0.80   | <0.01                     | 0.18           | 8.8±6.6   |
|            | LY0309   | 0.40±0.00   | 94±26   | 4.40±0.99  | 4.32±0.74   | 0.19                      | 0.25           | 7.3±6.8   |
| Turkey     | TY0108   | 2.26±1.25   | 95±53   | 21.22±12.03  | 20.54±6.72  | 0.01                      | 0.50           | 16.1±15.0   |
| Swine      | SW0109   | 11.34±2.10  | 248±72  | 48.18±9.56   | 47.60±4.27  | 0.03                      | 0.08           | 6.7±5.7   |
|            | SW0209   | 7.38±0.74   | 182±45  | 43.77±12.87  | 42.86±8.16  | 0.12                      | 0.36           | 6.3±6.8   |
| Steer      | ST0109   | 17.62±1.32  | 84±31   | 242.9±40.5   | 265.7±31.4  | <0.01                     | 0.26           | 8.6±5.9   |
|            | ST0209   | 20.29±1.19  | 99±24   | 255.3±62.1   | 284.2±32.0  | <0.01                     | 0.13           | 10.2±6.8  |
|            | ST0110   | 18.70±0.08  | 85±25   | 264.5±60.8   | 254.2±37.8  | 0.09                      | 0.23           | 8.3±5.8   |
|            | ST0210   | 19.35±0.24  | 94±41   | 261.0±71.9   | 256.9±45.8  | 0.85                      | 0.52           | 7.4±5.4   |
| Dairy cow  | DY0108   | 65.09±3.65  | 152±162   | 416.8±322.5  | 331.0±16.0  | 0.01                      | 0.62           | 20.5±14.7   |
|            | DY0208   | 66.74±5.29  | 257±137   | 307.9±156.5  | 261.8±40.0  | <0.01                     | 0.13           | 14.5±12.8   |

Uncertainties in estimated VR in dairy cow studies were relatively large because the relatively large variations in measured CO<sub>2</sub> emissions in these studies were not well represented by the relatively constant estimated CO<sub>2</sub> production values.

### Uncertainties in estimated VR

Using estimated CO<sub>2</sub> productions from THP to represent the total CO<sub>2</sub> emissions in animal houses can result in underestimation of CO<sub>2</sub> emissions and therefore underestimation of VR. The uncertainties in estimated CO<sub>2</sub> emissions can be represented by a constant bias due to unaccounted CO<sub>2</sub> emissions (from sources other than metabolic CO<sub>2</sub> production) and a random error. The constant bias was observed to be as high as 34% (in ST0209).