

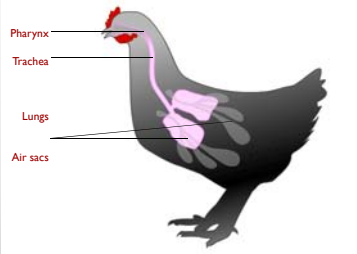
## Air Quality and Bird Health/Production

Brian Fairchild  
The University of Georgia

Australia Workshop 2014

### Avian respiratory system

The avian respiratory tract consists of the pharynx, trachea, lungs, and air sacs.




▶

### Air sacs



▶


### Airsacculitis



▶

### Minimum ventilation


▶ Why do we have to bring in fresh air into a house during cold weather?



▶

### Air quality parameters



- ▶ Ammonia
- ▶ Carbon Dioxide
- ▶ Carbon Monoxide
- ▶ Oxygen
- ▶ Dust
- ▶ Relative Humidity



▶



### Poor air quality

- ▶ Air sacculitis
- ▶ Keratoconjunctivitis
- ▶ Poor litter quality
- ▶ Increased dermatitis issues
- ▶ Decreased performance
  - ▶ Reduced growth
  - ▶ Poor feed conversion
  - ▶ Increased mortality



### Oxygen (O<sub>2</sub>)

- ▶ Air is 20% O<sub>2</sub>
- ▶ Less than 6% is lethal for chickens



### Burning Fuel

- ▶ Burning 1 gallon of propane (C<sub>3</sub>H<sub>8</sub>)
  - ▶ Produces 92,000 BTU's of heat
  - ▶ Produces 108 ft<sup>3</sup> (3.1m<sup>3</sup>) of CO<sub>2</sub>
  - ▶ Produces 0.82 gallons (3.1 L) of H<sub>2</sub>O
  - ▶ Consumes O<sub>2</sub> (850 ft<sup>3</sup> (24 m<sup>3</sup>) of air)
- ▶ If brooder/furnace is properly maintained, very little CO will be produced

### Chick's oxygen requirements (one-week-old)

- ▶ 0.01ft<sup>3</sup> (.0003m<sup>3</sup>) per hour
- ▶ Air is 20% oxygen
  - ▶ Fresh air requirements = 0.05 ft<sup>3</sup> (.0001m<sup>3</sup>)/hr
- ▶ 40' X 500' house with 20,000 chicks
  - ▶ Fresh air = 20,000 X 0.05 ft<sup>3</sup> (.0001m<sup>3</sup>)/hr = 1,000 ft<sup>3</sup> (28.3m<sup>3</sup>)/hr
  - ▶ Or ..... = 16 ft<sup>3</sup> (.45m<sup>3</sup>)/min


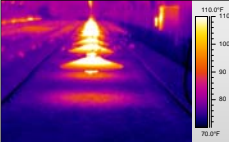

### Timer fan settings for 16 ft<sup>3</sup> (0.45 m<sup>3</sup>)/min of air ....

- ▶ 48" fan (20,000 cfm or 32,000 cmh)
  - ▶ 60 seconds on
  - ▶ 86,340 seconds off
  - ▶ (86,400 seconds in a day)
- ▶ 36" fan (10,000 cfm or 17,000 cmh)
  - ▶ 120 seconds on
  - ▶ 86,280 seconds off
- ▶ Computer fan (50 cfm or 84 cmh)
  - ▶ 4 out of 10 minutes





### What about the oxygen used by the brooders?

- ▶ Burning propane requires oxygen ...
- ▶ Operating heaters increases minimum ventilation rates.


Burning one gallon of propane...

- ▶  $C_3H_8 + 5 O_2 \rightarrow 3 CO_2 + 4 H_2O + \text{Heat}$
- ▶ Consumes the oxygen in 850 ft<sup>3</sup> (24 m<sup>3</sup>) of air



Fresh air requirement for oxygen with all brooders operating ....

- ▶ Birds = 16 ft<sup>3</sup>/min (30 m<sup>3</sup>/hr)
- ▶ Brooders = 50 ft<sup>3</sup>/min (84 m<sup>3</sup>/hr)
- ▶ Total = 66 ft<sup>3</sup>/min (114 m<sup>3</sup>/hr)

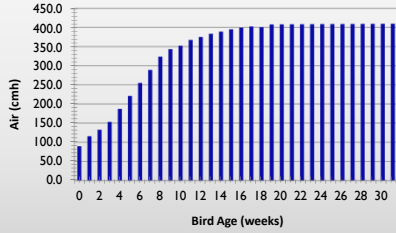


Oxygen


- ▶ What about older birds?



Minimum ventilation based on oxygen requirements  
(20,000 birds + heating system)




Bird Age (weeks)	Air (cmh)
0	100
2	150
4	200
6	250
8	300
10	350
12	380
14	400
16	400
18	400
20	400
22	400
24	400
26	400
28	400
30	400




Oxygen

- ▶ Though not something we really have to ventilate for, low oxygen levels can still be a problem...
- ▶ Blood oxygen levels



One cause of low blood oxygen

- ▶ Carbon monoxide (CO)



### Carbon monoxide (CO)

- ▶ Hemoglobin affinity is 200 times greater than that of O<sub>2</sub>
- ▶ Dependent on concentration & exposure time
  - ▶ 600 ppm for 30 min – distress
  - ▶ 3000 ppm lethal in 2 hours
  - ▶ 70 ppm linked to ascites
- ▶ Goal: keep below 50 ppm



### CO toxicity symptoms (poultry)

- ▶ Uneasiness
- ▶ Stupor
- ▶ Drowsiness
- ▶ Labored breathing
- ▶ Wobbling gait
- ▶ Blood and tissues appear bright pink



### Carbon monoxide (CO)

- ▶ France Study (Breurec et al, 1999)
  - ▶ Workers wore CO detectors
  - ▶ 1994-1998 - 25 people affected by CO concentrations greater than 50ppm
  - ▶ Chickens were less affected
    - ▶ One incident resulted in ~3,500 dead birds around the radiant heaters
- ▶ Conclusions of the study
  - ▶ Accidents occurred in new tight buildings during coldest months of the year
  - ▶ Poor maintenance of heating equipment biggest factor



### All brooders/furnace produce some carbon monoxide!



### Carbon monoxide is more likely to become a problem if...

- ▶ High fuel prices
- ▶ Cold weather
- ▶ Tight house
- ▶ Fresh litter or litter treatment
- ▶ Little or no ventilation
- ▶ **Poorly maintained brooders**



### How do you know if you have a carbon monoxide problem?

- ▶ Soot on brooder canopies and/or yellow flames are a sure sign of CO production.
- ▶ But the best way to recognize high CO is ...

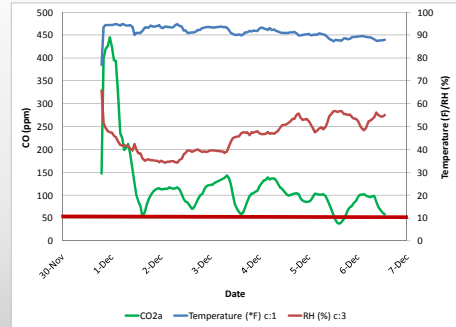


### Using a carbon monoxide meter

- ▶ Check for CO prior to chick placement
  - ▶ In the morning,
  - ▶ cold weather.
- ▶ Check individual brooders.



### CO Can Be a Problem



### Carbon Monoxide

- ▶ Is not a ventilation problem...
  - ▶ The more you ventilate to get rid of it, the more the heating system will operate ....and the more CO will be generated!
- ▶ It is a maintenance problem!

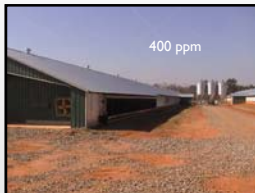


### If we are not ventilating for oxygen then what are we ventilating for?

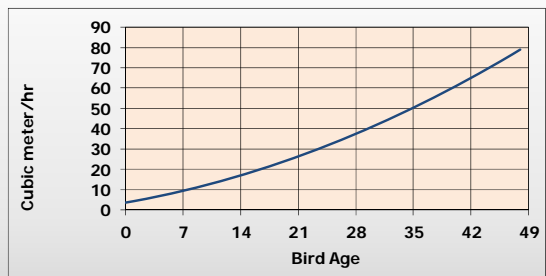
- ▶ Carbon dioxide (CO<sub>2</sub>) is far more likely to be a problem than is oxygen.



### Normal outdoor CO<sub>2</sub> concentration



### Carbon Dioxide Production (20,000 birds)



### Study: CO<sub>2</sub> and broiler performance

(0 - 4 wks: different CO<sub>2</sub> levels; none: 4 - 7 wks)

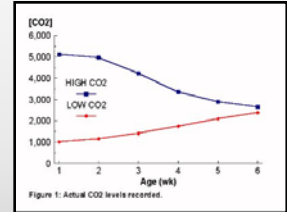
- ▶ 3,000 ppm
  - ▶ no effect
- ▶ 6,000 ppm
  - ▶ no effect
- ▶ 12,000 ppm
  - ▶ 4 wks weights 8%
  - ▶ 7 wks weights 16%



### Broiler performance

(Alberta – agriculture, food, and rural development)

- ▶ Four week weights:
  - ▶ High CO<sub>2</sub> = 1,297 grams
  - ▶ Low CO<sub>2</sub> = 1,276 grams
- ▶ Six week weights:
  - ▶ No difference in weights
  - ▶ Did note some differences in the heart of the birds.

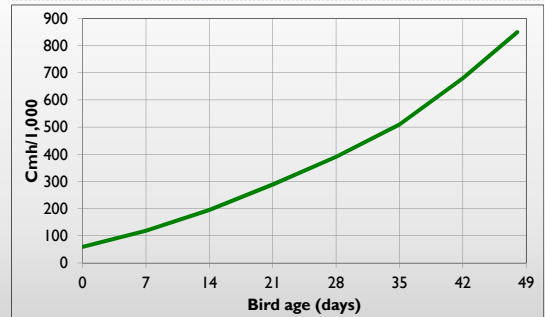


### Carbon Dioxide

- ▶ Target 3,500 ppm



### Minimum ventilation rate to limit carbon dioxide...



But keep in mind, heating systems consume O<sub>2</sub> and produce CO<sub>2</sub>




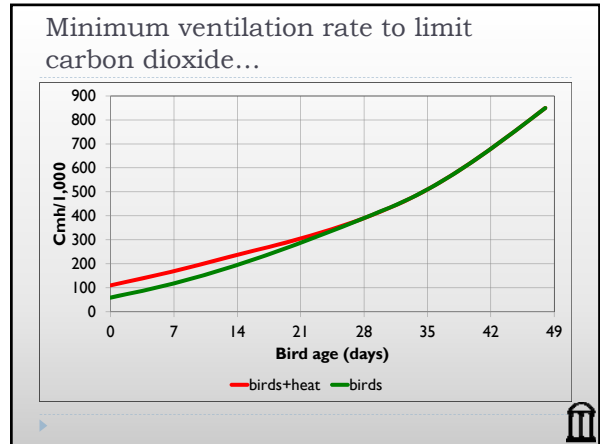
### Burning one gallon of propane...

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- ▶ If brooder/furnace is properly maintained, very little CO will be produced




### Brooding

- During cold weather a house heating system typically produces 2 to 3 times the amount of CO<sub>2</sub> than do the birds.


### To truly determine if Carbon Dioxide is a problem you have to measure it

- Good for spot checking and can be connected to data logger for long term monitoring.




### Carbon Monoxide/Dioxide

- Typically only a potential issue in broiler/pullet houses during the first few weeks.
- Really never an issue for older birds




### Dust/Air Particulates



### Dust/air particulates

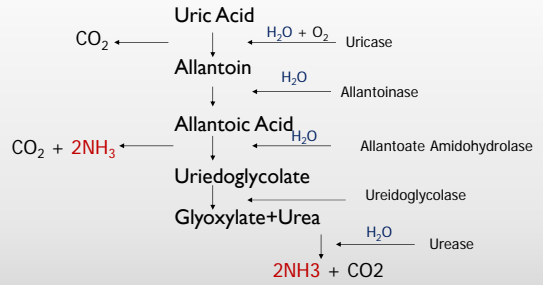
- Affect equipment**
  - Fan shutters
  - Light bulbs
- Increased respiratory issues**
  - Air sacculitis
  - Viral infections
  - Bacteria (E. coli Salmonella)
- Sources**
  - Feathers
  - Skin
  - Down
  - Litter
  - Manure



### Ammonia in poultry houses



### Uric acid aerobic degradation

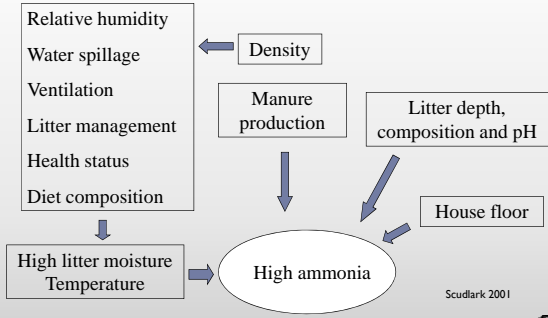


Bongaerts and Vogels, 1976  
Bachrach, 1957

### Ammonia concerns

- ▶ Bird Performance
- ▶ Bird Health/Welfare
- ▶ Farm workers' Health
- ▶ Lower fertilizer value of litter
- ▶ In the future: Poultry House Emissions
  - ▶ Role in atmospheric chemical processes
  - ▶ Rxn with sulfuric and nitric acids to form fine particulates
  - ▶ Fine particulates are of concern to public health
  - ▶ Fine particulates diminish visibility; public concern in pristine areas of country

### Factors affecting ammonia production

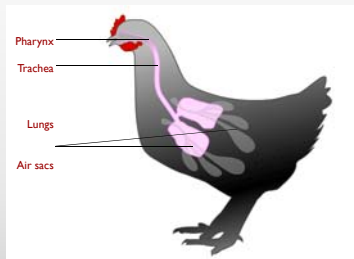


Scudlark 2001

### How does ammonia affect the birds?



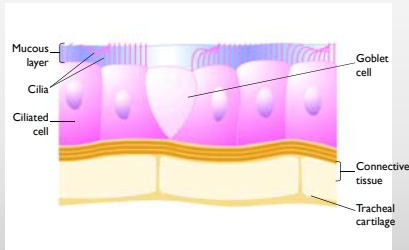
### First, let's review the respiratory tract



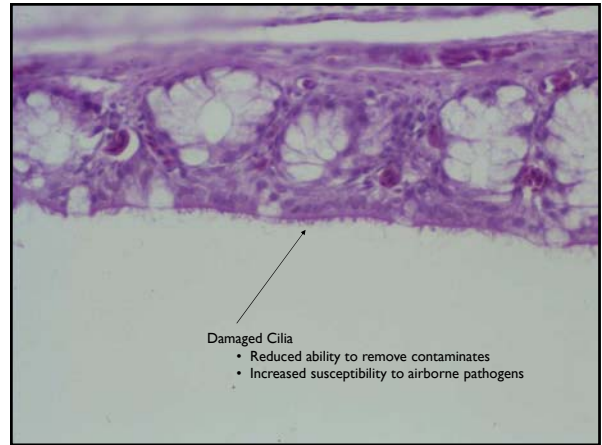
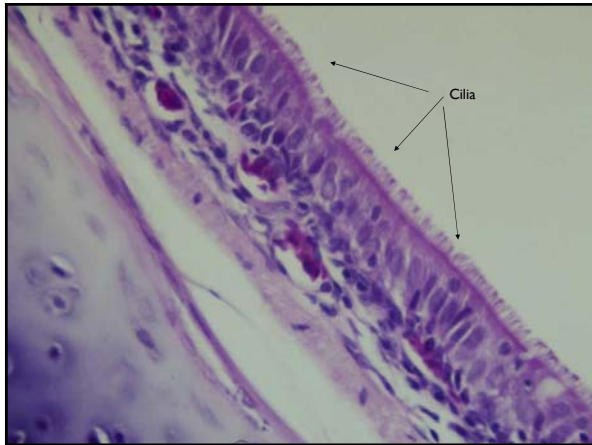
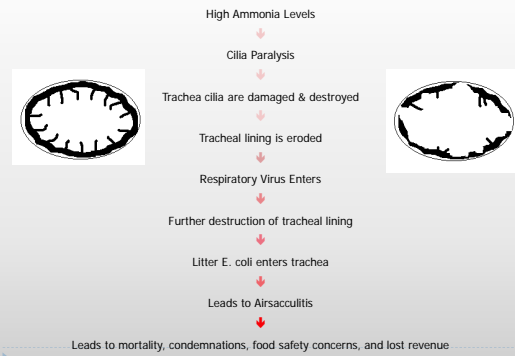


### Normal respiratory tract epithelium

The mucosa of the trachea, bronchi, and air sac is lined by ciliated epithelial cells, simple mucous glands, and goblet cells.



### How ammonia leads to respiratory disease



### Bird Health

- ▶ Reduced weight gains
- ▶ Reduced feed efficiency
- ▶ Adverse effects on bird health
  - ▶ Snicking
  - ▶ Trachea irritation
  - ▶ Air sac inflammation
  - ▶ Conjunctivitis
  - ▶ Reduced resistance to disease challenges



### Keratoconjunctivitis

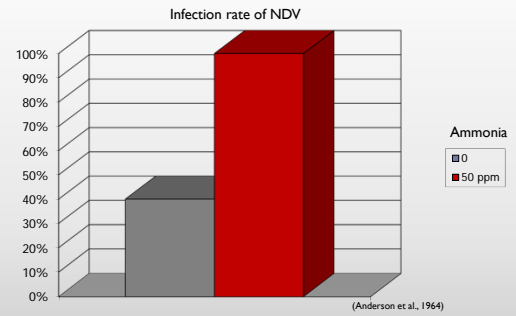
- ▶ Inflammation of the cornea.
- ▶ Signs: rubbing of eyes, tearing, light sensitive.
- ▶ Difficult for the bird to locate feed and water.



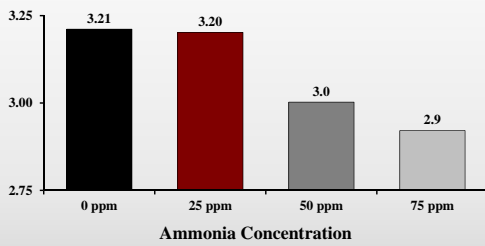
Ammonia levels too high



Increased ammonia concentrations increase disease susceptibility

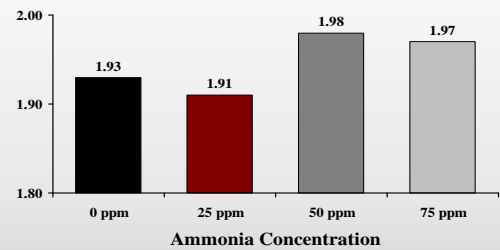


Live Weight (kg), 49 Days



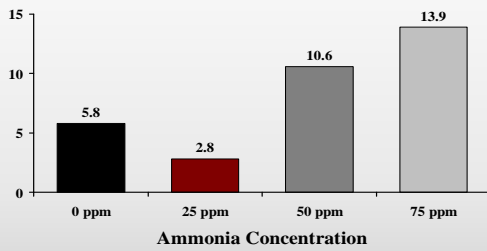
Miles et al., 2004

Feed/Gain, 49 Days



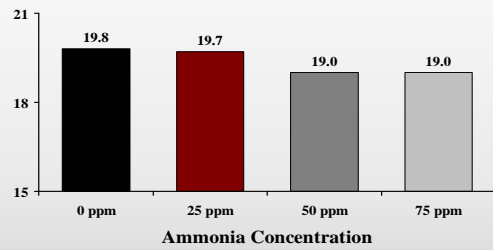
Miles et al., 2004

Mortality (%)



Miles et al., 2004


Breast Meat Yield (%)



Miles et al., 2004

Ammonia and body weights of 49 day old birds by

- ▶ 25 ppm for four weeks
  - ▶ Reduces weights between 3 to 4%
- ▶ 50 ppm for four weeks 70 to 90 g
  - ▶ Reduces weights between 6 and 10%
- ▶ 75 ppm for four week 136 to 227 g
  - ▶ Reduces weights between 8 and 12%



These numbers could be easily be higher...

- ▶ 25 ppm for four weeks
  - ▶ Reduces weights between 3 to 4%
- ▶ 50 ppm for four weeks 70 to 90 g
  - ▶ Reduces weights between 6 and 10%
- ▶ 75 ppm for four week 136 to 227 g
  - ▶ Reduces weights between 8 and 12%

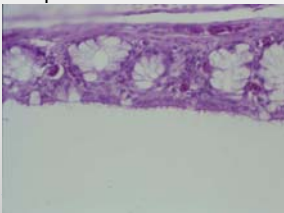
Most houses do not have 0 ppm from week 4 - 7

Minimum welfare standards for poultry

Recommendation	NH3 ppm
▶ American Humane Society	▶ 10 - 25
▶ Australian Code of Practice	▶ 20
▶ RSPCA Standards	▶ 15
▶ McDonalds	▶ 25
▶ National Chicken Council	▶ 25
▶ Wendy's	▶ 25
▶ United Egg Producers	▶ 25


Summary

- ▶ Avian respiratory tract is susceptible to damage by both environmental factors and pathogenic organisms.
- ▶ Respiratory disease often develops following the interaction of multiple factors




Summary

- ▶ Ammonia is one of the most important environmental factors for initiation of respiratory disease.
- ▶ Moisture removal by ventilation is the primary means of ammonia control.



What happens when there is a power loss and no ventilation?



### Is it Really Suffocation?

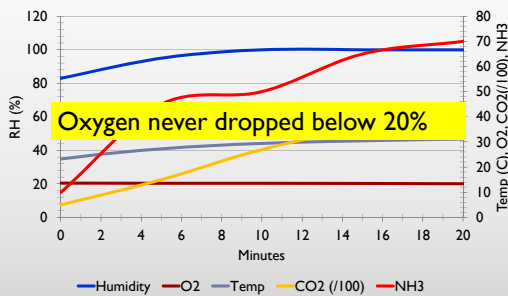


### Demonstration background

- ▶ Fall of 1991
- ▶ Outside temperature 50F (10 C)
- ▶ Inside temperature 73F (22.8 C)
- ▶ 20,000 birds @ 6 weeks of age
- ▶ Shut the fans off for 20 minutes
- ▶ Monitored
  - ▶ Temperature
  - ▶ RH
  - ▶ Ammonia
  - ▶ Oxygen
  - ▶ Carbon Dioxide
  - ▶ Bird behaviour

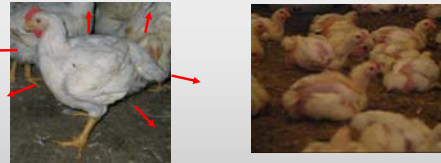


### Suffocation?



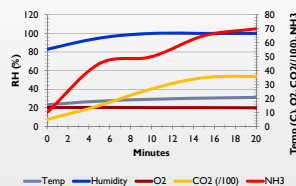
### Bird behavior and response

- ▶ Blood volume is increased
- ▶ Vasculature in the extremities dilates
- ▶ Search out cooler area
- ▶ Wings held away from body
- ▶ As air gets warmer, birds lose less heat



### No fans for 20 minutes

- ▶ Oxygen
  - ▶ Negligible change
- ▶ Carbon Dioxide
  - ▶ 250 ppm per minute
- ▶ Ammonia
  - ▶ 4 ppm per minute



- ▶ House temperature increased rapidly
  - ▶ 0.6 C per minute
- ▶ Relative humidity increased rapidly
  - ▶ 2 % per minute



poultryventilation.com