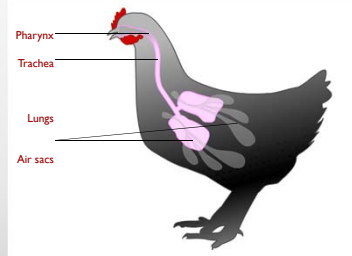


Air Quality and Bird Health

Brian Fairchild
The University of Georgia

Avian respiratory system

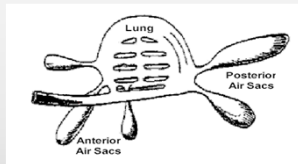
The avian respiratory tract consists of the pharynx, trachea, lungs, and air sacs.



How Do Birds Breathe?

So, how does air flow through the avian lungs and air sacs during respiration?

1. **On first inhalation**, air flows through the trachea & primarily into the posterior (rear) air sacs
2. **On first exhalation**, air moves from the posterior air sacs & into the lungs
3. **With the second inhalation**, air moves from the lungs & into the anterior (front) air sacs
4. **With the second exhalation**, air moves from the anterior air sacs back into the trachea & out



Minimum Ventilation

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



Poor Air Quality

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

Air Quality Parameters

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



Burning Fuel

- ▶ Burning 1 gallon of propane (C_3H_8)
 - ▶ Produces 92,000 BTU's of heat
 - ▶ Produces 108 ft³ of CO_2
 - ▶ Produces 0.82 gallons (3.1 liters) of H_2O (3.1 kg)
 - ▶ Consumes O_2 (850 ft³ of air)
- ▶ If brooder/furnace is properly maintained, very little CO will be produced



O_2

- ▶ Air is 20% O_2
- ▶ Less than 6% is lethal for chickens



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

- ▶ 0.01 cubic feet per hour
- ▶ Air is 20% oxygen
 - ▶ Fresh air requirements = 0.05 ft³/hr
- ▶ 40' X 500' house with 20,000 chicks
 - ▶ Fresh air = 20,000 X 0.05 ft³/hr
 - ▶ = 1,000 ft³/hr
 - ▶ Or = 16 ft³/min



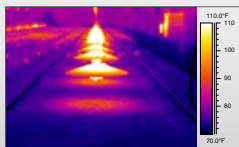
Timer fan settings for 16 ft³/min of air

- ▶ 48" fan (20,000 cfm)
 - ▶ 60 seconds on
 - ▶ 86,340 seconds off
 - ▶ (86,400 seconds in a day)
- ▶ 36" fan (10,000 cfm)
 - ▶ 120 seconds on
 - ▶ 86,280 seconds off
- ▶ Computer fan (50 cfm)
 - ▶ 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 ft³ of air



Fresh air requirement for oxygen with all brooders operating

- ▶ Birds = 16 ft³/min
- ▶ Brooders = 50 ft³/min
- ▶ Total = 66 ft³/min

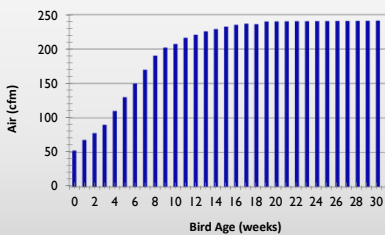


Oxygen

- ▶ What about older birds?



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



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 levels is carbon monoxide (CO)



Carbon Monoxide (CO)

- ▶ Hemoglobin affinity is 200 times greater than that of O₂
- ▶ 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



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



Carbon monoxide and human health

CO level (ppm)	Exposure Time	Signs and Symptoms
200	2 – 3 hrs	Mild headache
400	1 hr	Headache, muscle weakness, nausea
800	45 min	Headache, dizziness, nausea
1,300	45 min	Cherry-red skin, violent headache
1,600	0.5 2 hrs	Headache, dizziness, nausea Irreversible damage – death
2,000	1 hr	Irreversible damage – death
3,200	5 – 10 min	Immediate head – dizziness
6,400	10 min	Irreversible damage - death

CO Toxicity Symptoms

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

All brooders produce some carbon monoxide!

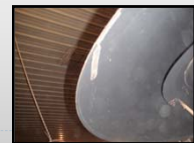


Carbon monoxide is more likely to become a problem if...

- ▶ 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 ...
- ▶ use a CO meter!

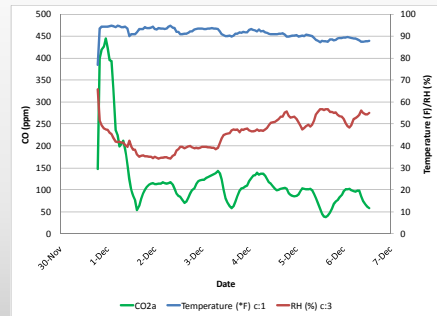


Using a carbon monoxide meter

- ▶ 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 operateand the more CO will be generated!
- ▶ It is a maintenance problem!

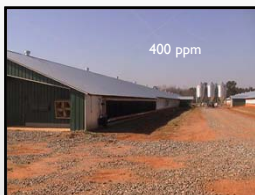


If we are not ventilating for oxygen then what are we ventilating for?

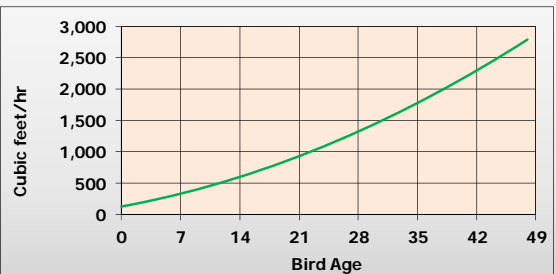
- ▶ Carbon dioxide (CO₂) is far more likely to be a problem than is oxygen.



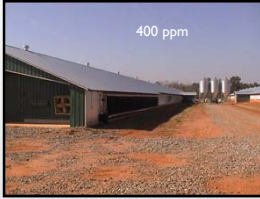
Normal outdoor CO₂ concentration



Carbon Dioxide Production (20,000 birds)



Normal outdoor CO₂ concentration



Study: CO₂ and broiler performance

(0 - 4 wks: different CO₂ levels; none: 4 - 7 wks)

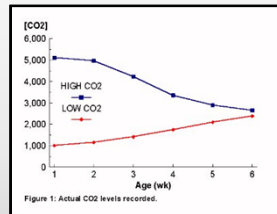
- ▶ 3,000 ppm
 - ▶ no effect
- ▶ 6,000 ppm
 - ▶ no effect
- ▶ 12,000 ppm
 - ▶ 4 wks weights 8%
 - ▶ 7 wks weights 16%



Broiler performance

(Alberta – Agriculture, Food, and Rural Development)

- ▶ Four week weights:
 - ▶ High CO₂ = 1,297 grams
 - ▶ Low CO₂ = 1,276 grams
- ▶ Six week weights:
 - ▶ No difference in weights
 - ▶ Did note some differences in the heart of the birds.

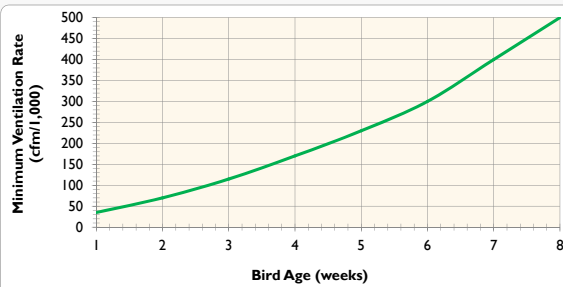


Carbon Dioxide

- ▶ Maintain CO₂ less than 5,000 ppm



Minimum ventilation rate to limit carbon dioxide...



But keep in mind, heating systems consume O₂ and produce CO₂



Burning one gallon of propane...

- ▶ $C_3H_8 + 5 O_2 \rightarrow 3 CO_2 + 4 H_2O + \text{Heat}$
- ▶ Consumes:
 - ▶ oxygen in 850 ft³ of air
- ▶ Produces:
 - ▶ 91,893 Btu's of heat (92,000)
 - ▶ **108 ft³ of carbon dioxide**

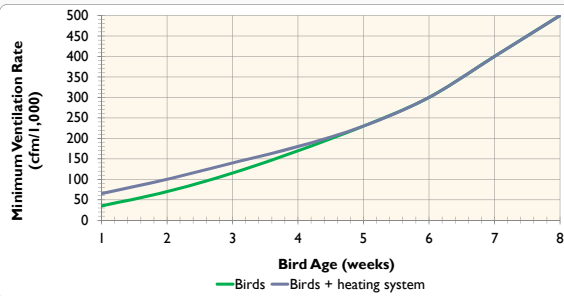


Brooding

- ▶ During cold weather a house heating system typically produces 2 to 3 times the amount of CO₂ than do the birds.



Minimum ventilation rate to limit carbon dioxide...



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



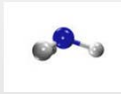
Ammonia in Poultry Houses

- ▶ Ammonia introduction
- ▶ Effects on Performance
- ▶ Reduction Strategies
- ▶ Monitoring

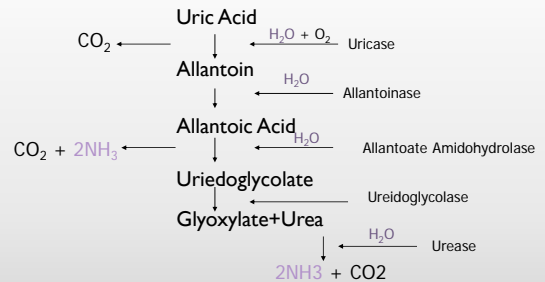


Ammonia (NH₃)

- ▶ Gas
- ▶ Colorless
- ▶ Water soluble
 - ▶ Mucus linings
 - ▶ Eyes
 - ▶ Dust
 - ▶ Litter
- ▶ Sharp odor
- ▶ Toxic to mammalian Cells



Uric Acid Aerobic Degradation



Bongaerts and Vogels, 1976
Bachrach, 1957

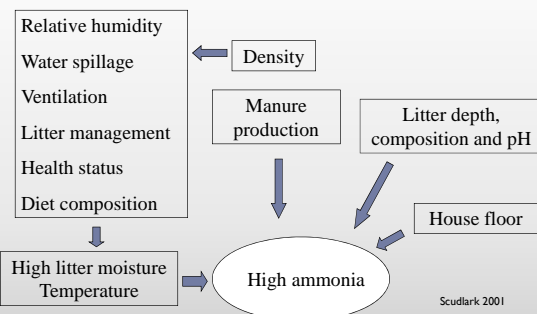
Ammonia Concerns

- ▶ 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

Minimum welfare standards for poultry

Recommendation	NH ₃ ppm
▶ American Humane Society	▶ 10 - 25
▶ McDonalds	▶ 25
▶ National Chicken Council	▶ 25
▶ Wendy's	▶ 25
▶ United Egg Producers	▶ 25

Factors affecting ammonia production

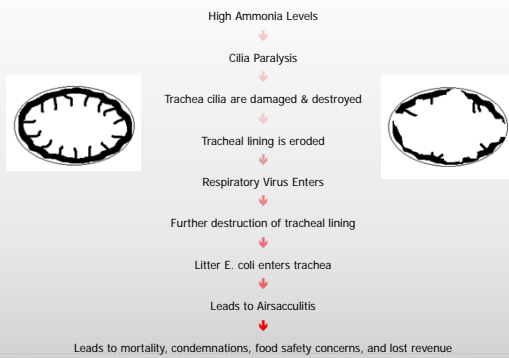


Adverse Effects of Ammonia

- ▶ Damaged respiratory system & Increased susceptibility to disease
 - ▶ As low as 10 ppm
- ▶ Poor body weights, feed efficiency & condemnation rates
 - ▶ Levels that exceed 25 ppm

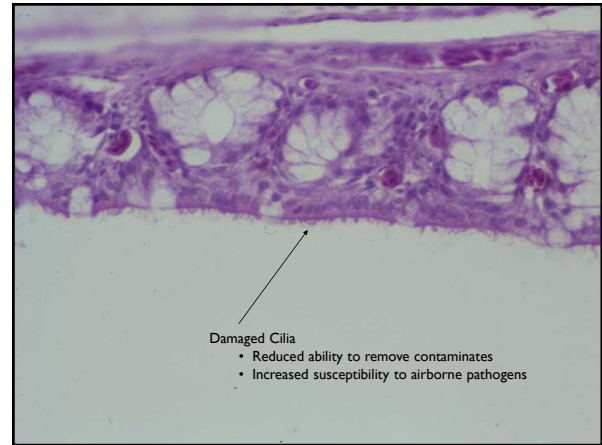
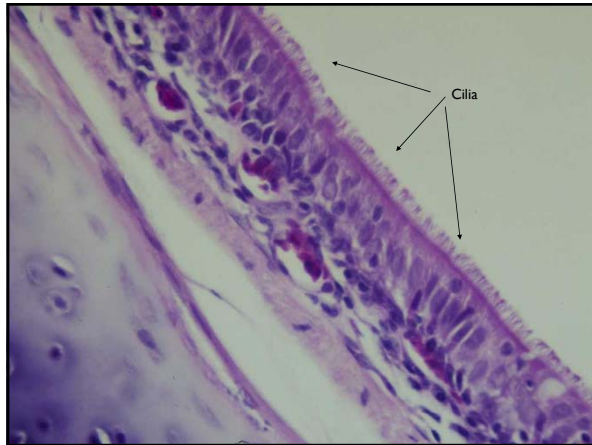
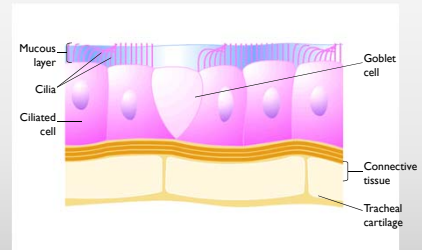


How Ammonia Leads to Respiratory Disease



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.



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



Contributing Factors to Ammonia

Ventilation mis-management

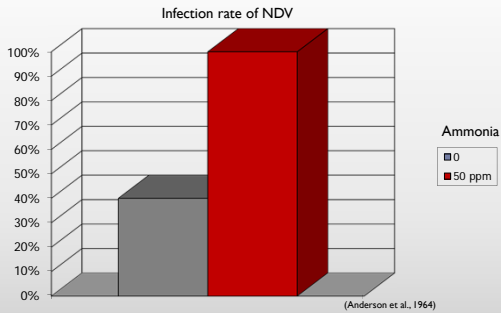
- Inadequate time
- Competing timers & sensors

House preparation mis-management

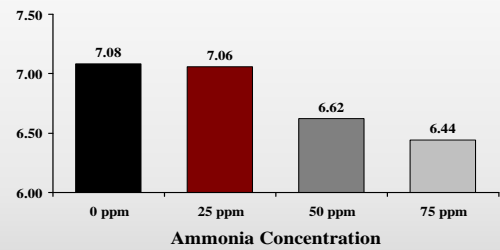
- Inadequate cake-out
- Tilling
- Inadequate pre-heat



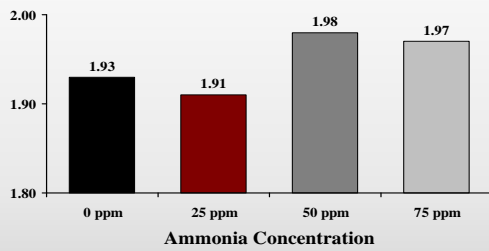
Increased Ammonia Concentrations Increase Disease Susceptibility



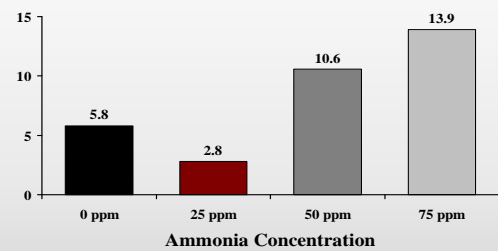
Live Weight, 49 Days

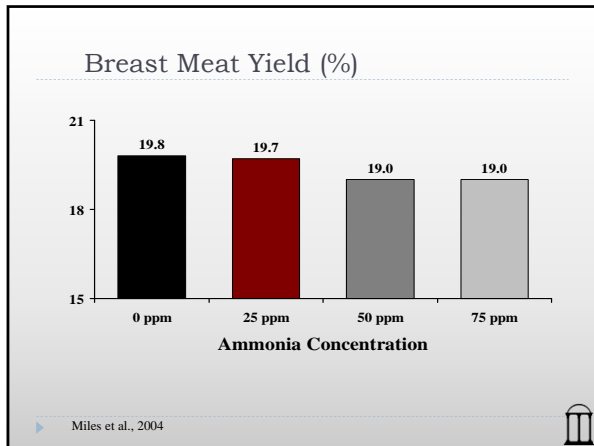


Feed/Gain, 49 Days



Mortality (%)





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 0.15 to 0.20 lbs
 - ▶ Reduces weights between 6 and 10%
- ▶ 75 ppm for four week 0.30 to 0.50 lbs
 - ▶ Reduces weights between 8 and 12%

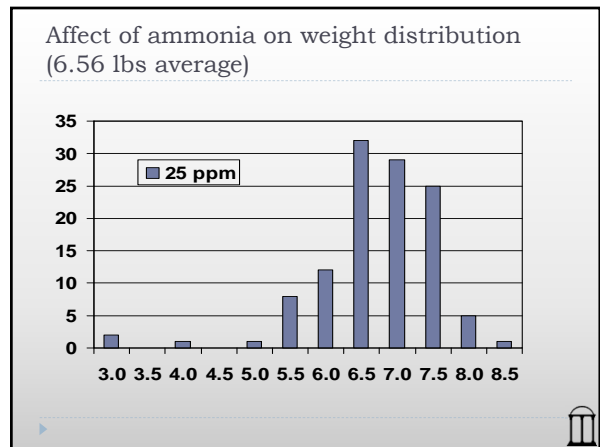
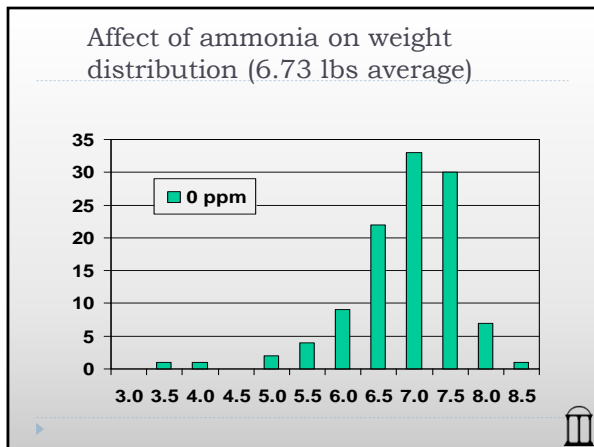
These numbers could be easily be higher...

- ▶ 25 ppm for four weeks
 - ▶ Reduces weights between 3 to 4%
- ▶ 50 ppm for four weeks 0.15 to 0.20 lbs
 - ▶ Reduces weights between 6 and 10%
- ▶ 75 ppm for four week 0.30 to 0.50 lbs
 - ▶ Reduces weights between 8 and 12%

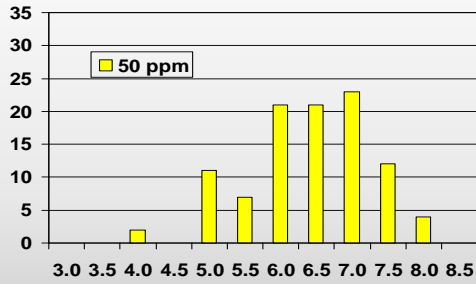
Most houses do not have 0 ppm from week 4 - 7

Ammonia

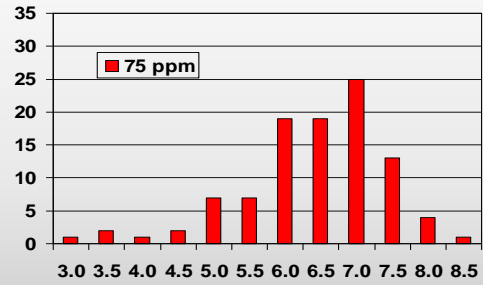
- ▶ Bird weights
- ▶ Feed conversion
- ▶ Bird uniformity



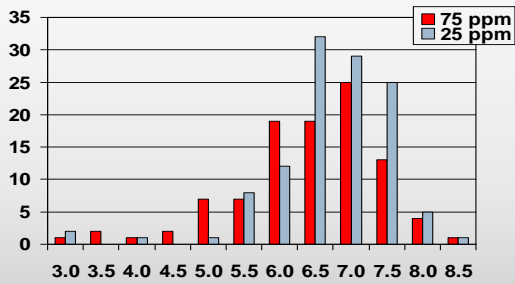
Affect of ammonia on weight distribution
(6.25 lbs average)



Affect of ammonia on weight distribution
(6.23 lbs average)



Affect of ammonia on weight distribution



Ammonia

- ▶ Bird weights
- ▶ Bird uniformity
- ▶ Yield
- ▶ Bird health
 - ▶ Cornea lesions



Eye Irritation and Damage



(A): 19-day-old broiler. Eyelids are swollen, reddened and closed shut. (B), (C): 26-day-old broilers. Eyelids are swollen, deformed and almond shaped in (B) and they are tightly closed in (C).

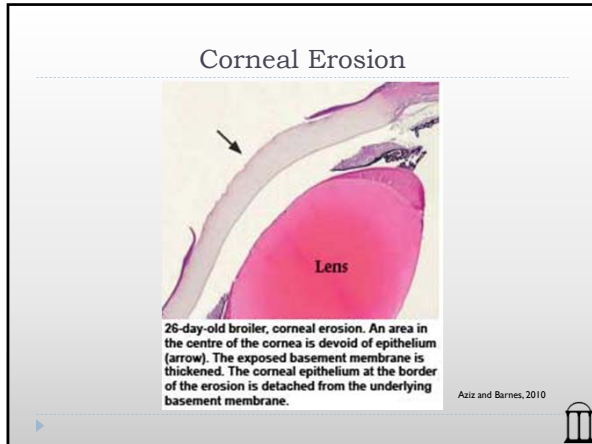
Aziz and Barnes, 2010

Corneal Lesions



15-day-old broiler, corneal erosion. The erosion in the centre of the cornea appears as circular, white-grey, opaque, rough-looking area. This is a severe lesion. Both eyes were affected and the bird was blind.

Aziz and Barnes, 2010



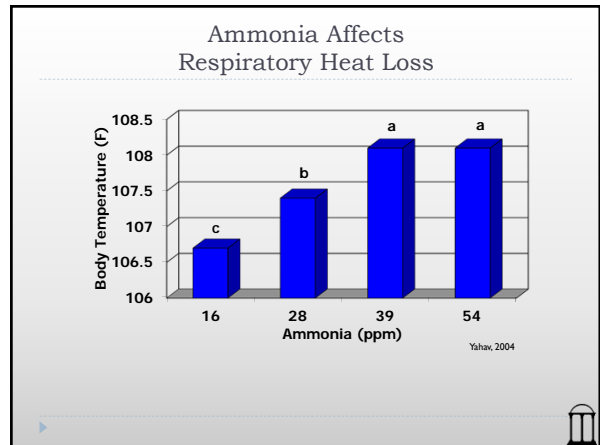
Cornea lesions score (Lott 2002)

- ▶ 0 = normal
- ▶ 1 = corneal edema (75%)
- ▶ 2 = ulcer
- ▶ 3 = deep ulcer

Effect of ammonia on cornea lesions

Week	0 ppm	25 ppm	50 ppm	75 ppm
1	0	0.04	1.6	1.2
2	0	0.1	2.6	2.4
3	0	0.6	2.9	2.3
4	0	0.4	2.9	2.2
7	0	0.02	2.1	1.4

▶ 0 = normal, 1 = corneal edema (75%), 2 = ulcer, 3 = deep ulcer
(Lott 2002)



Minimum welfare standards for poultry

Recommendation	NH3 ppm	NH3 ppm
▶ American Humane Assoc.	▶ 10 - 25	▶ 25
▶ McDonalds	▶ 25	
▶ National Chicken Council	▶ 25 - 50	▶ 25
▶ National Turkey Federation		▶ 25
▶ Wendy's	▶ 25	
▶ United Egg Producers	▶ 25 - 50	▶ <10 - 25

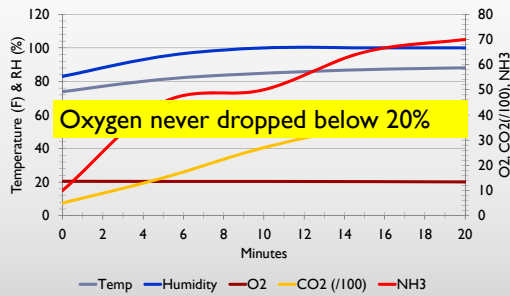
- ### Summary
- ▶ Avian respiratory tract is susceptible to damage by both environmental factors and pathogenic organisms.
 - ▶ Respiratory disease often develops following the interaction of multiple factors

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

Is it Really Suffocation?

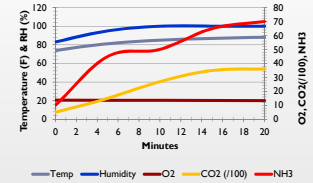


Suffocation?



No Fans for 20 Minutes

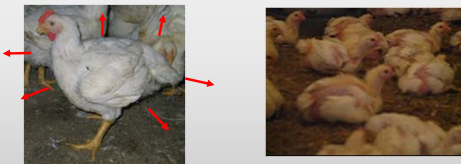
- ▶ Oxygen
 - ▶ Negligible change
- ▶ Carbon Dioxide
 - ▶ 250 ppm per minute
- ▶ Ammonia
 - ▶ 4 ppm per minute



- ▶ House temperature increased rapidly
 - ▶ 1 F per minute
- ▶ Relative humidity increased rapidly
 - ▶ 2 % per minute

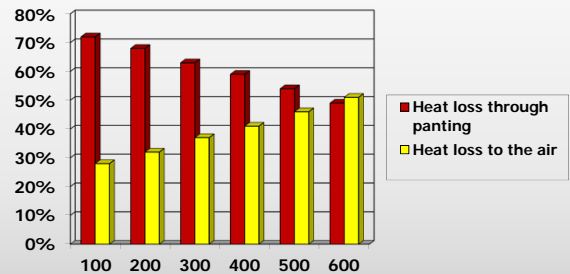
Bird Behavior and Response

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



Five pound birds 85°F

Simmons & Lott 1981



Bird Behavior and Response

- ▶ Begins to pant
 - ▶ Humidity of 50% - Temperature 85 F (29.4 C)
 - ▶ Rate is influence by both temperature and humidity
 - ▶ Panting becomes less efficient as air moisture level reaches saturation (100% RH)
 - ▶ As less heat is lost – body temperature increases
 - ▶ Acid-base balance is disturbed



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.



Minimum ventilation rate to reduce ammonia

- ▶ How is ammonia reduced?
 - ▶ How do we decrease ammonia by half?
 - ▶ Increase ventilation rate
 - ▶ Double it

- ▶ Prevention of ammonia volatilization is key



Two Ways to Handle Ammonia

1. Control Moisture
2. Utilize litter treatments



- ▶ Controlling heat and moisture are the primary concern

