Developing Systems to Minimize Heat Stress In Dairy Cattle

John Smith
Mike Brouk
Joe Harner

Effects of Heat Stress
Short Term

- ↑ Respiration Rate
- ↑ Rectal Temperature
- ↑ Water Intake
- ↑ Sweating

- ↓ Rate of Feed Passage
- ↓ Dry Matter Intake
- ↓ Blood Flow to Internal Organs
- ↓ Milk Production

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Effects of Heat Stress
Long Term

- **Future milk production?**
  - **Lower peaks**
- **Poor reproductive performance**
- **Health**
  - **Udder health**
  - **Lameness**

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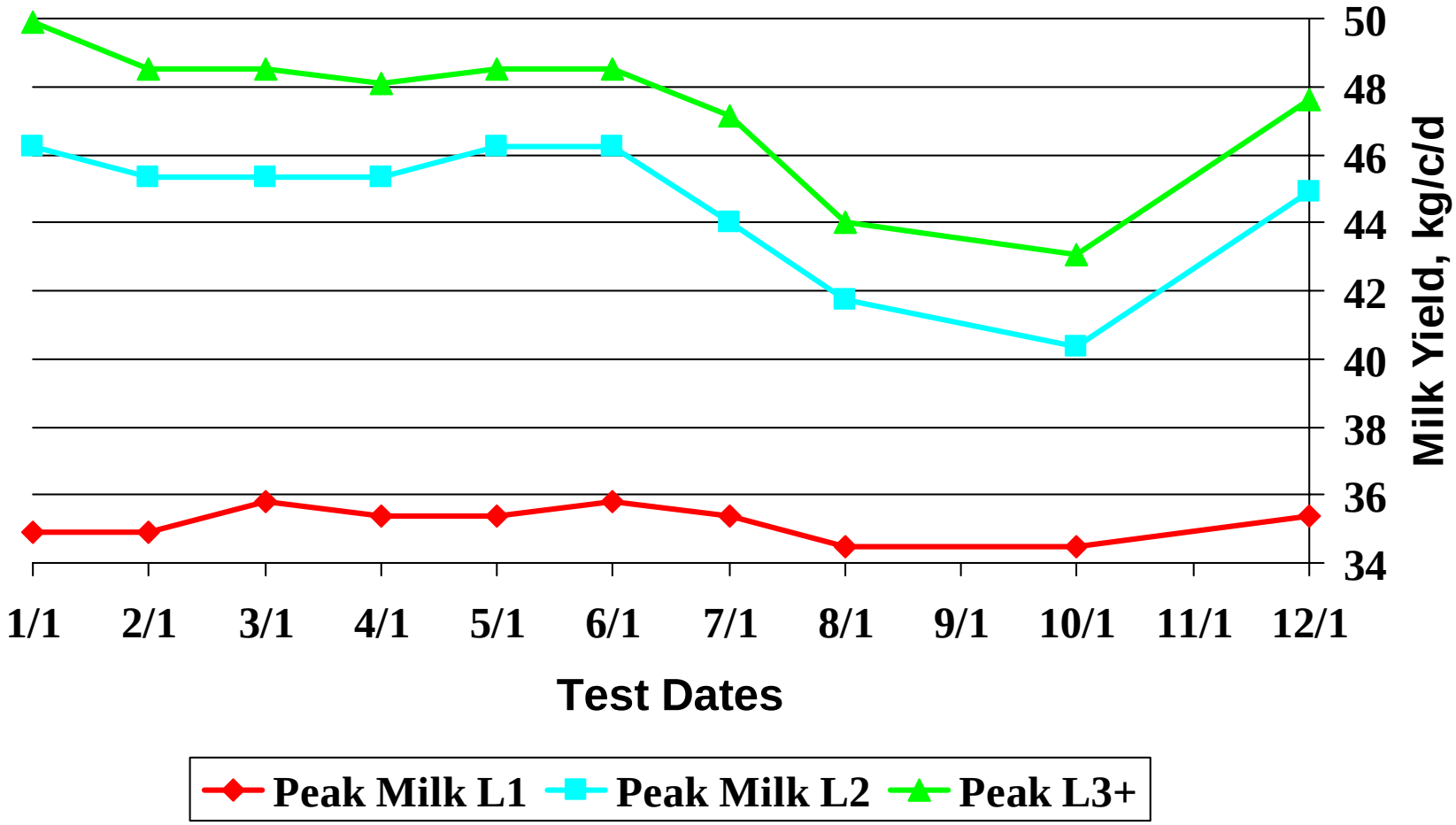
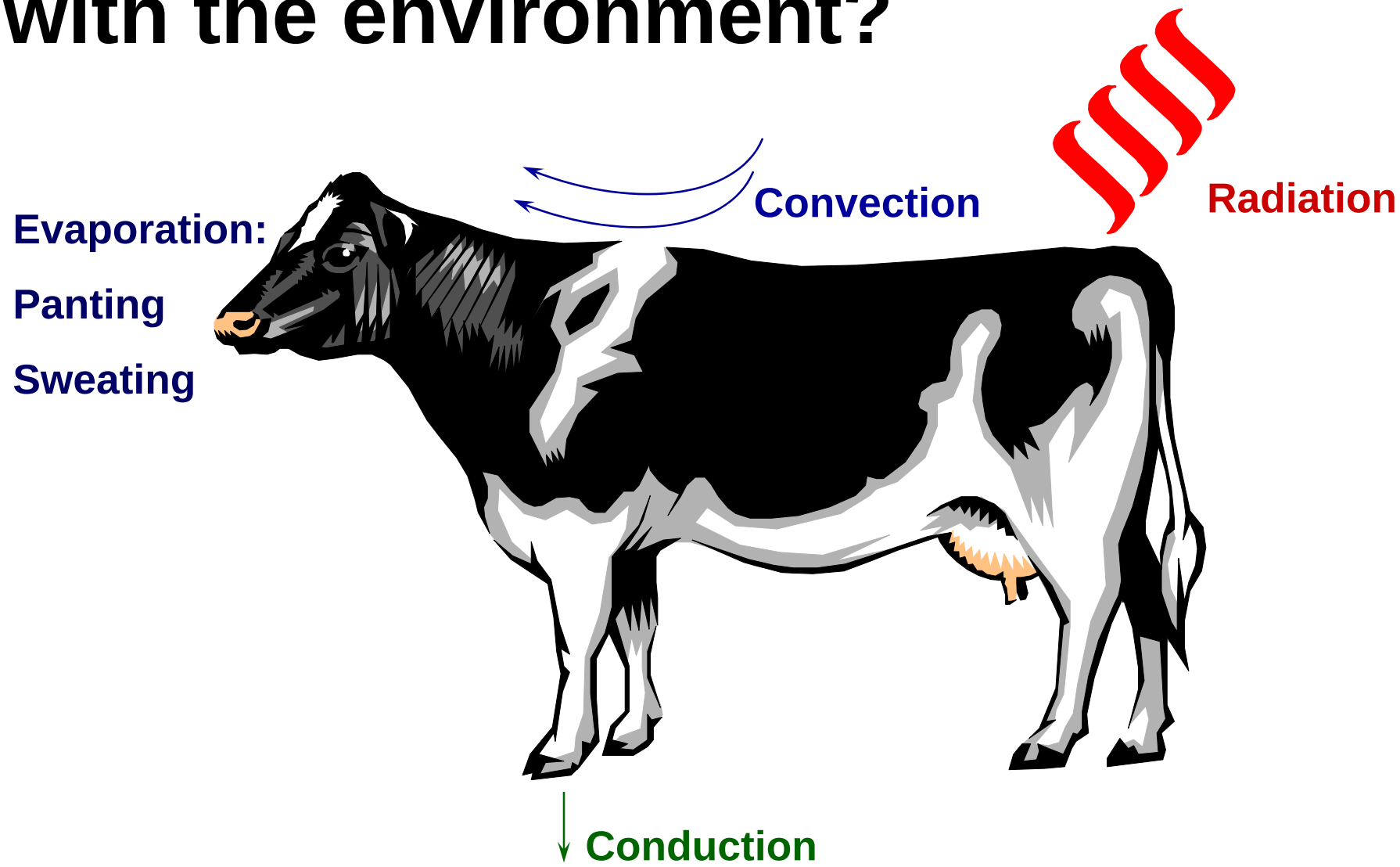
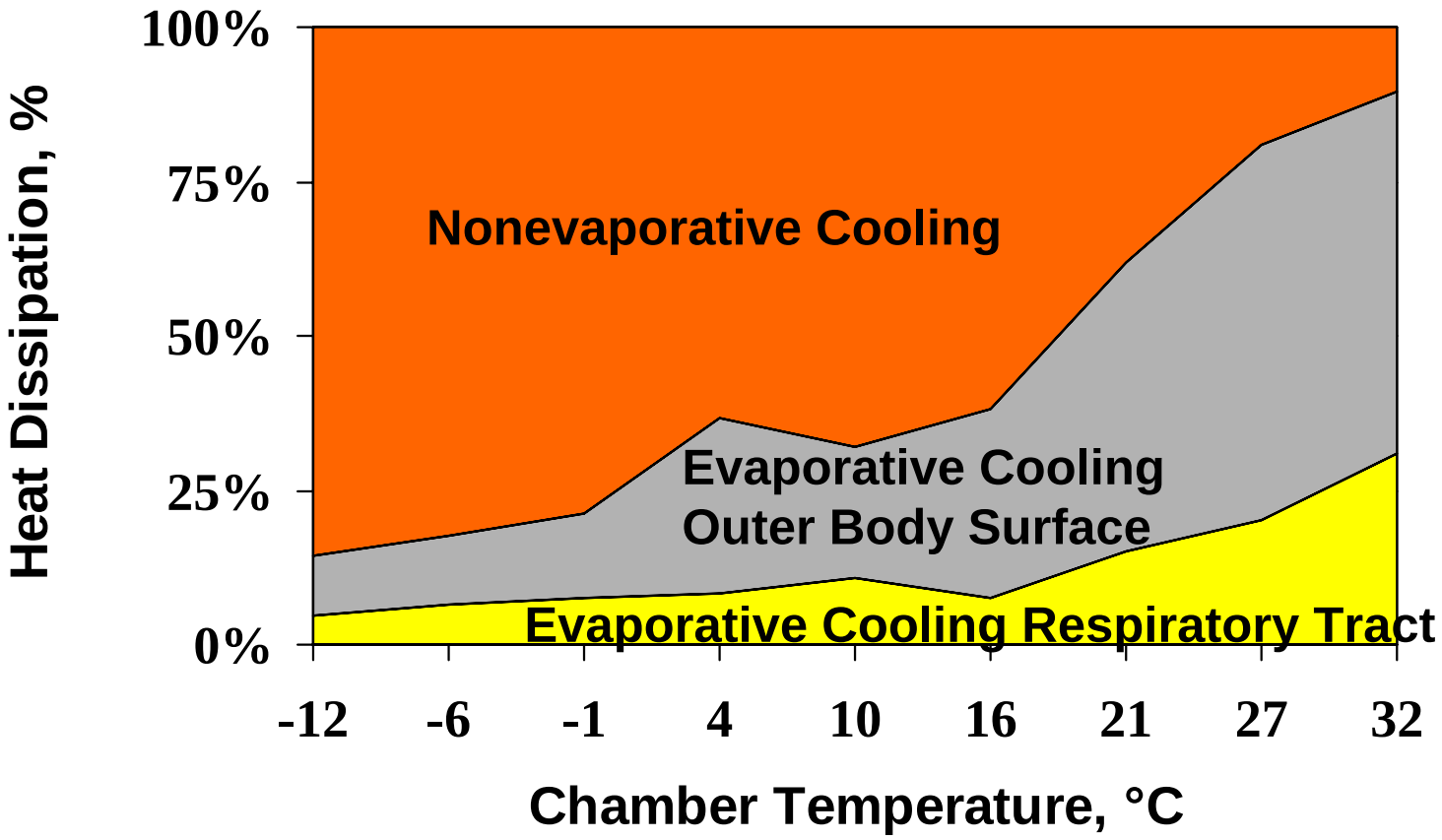
Peak Milk Production in Kansas by Lactation and Month, 1997



How do cows exchange heat with the environment?




Heat Dissipation, %
100%
75%
50%
25%
0%
Nonevaporative Cooling
Evaporative Cooling
Outer Body Surface
Evaporative Cooling Respiratory Tract
-12
-6
-1
4
10
16
21
27
32
Chamber Temperature, °C

Temperature Humidity Index (THI)

- **Calculated value**
- **Accounts for both Temperature and Humidity**
- **THI can never exceed temperature**
- **THI at a certain temperature will increase as humidity increases**

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Temperature Humidity Index (THI)

- **Does not account for shade or wind speed**
- **Heat stress starts at a value of 72**

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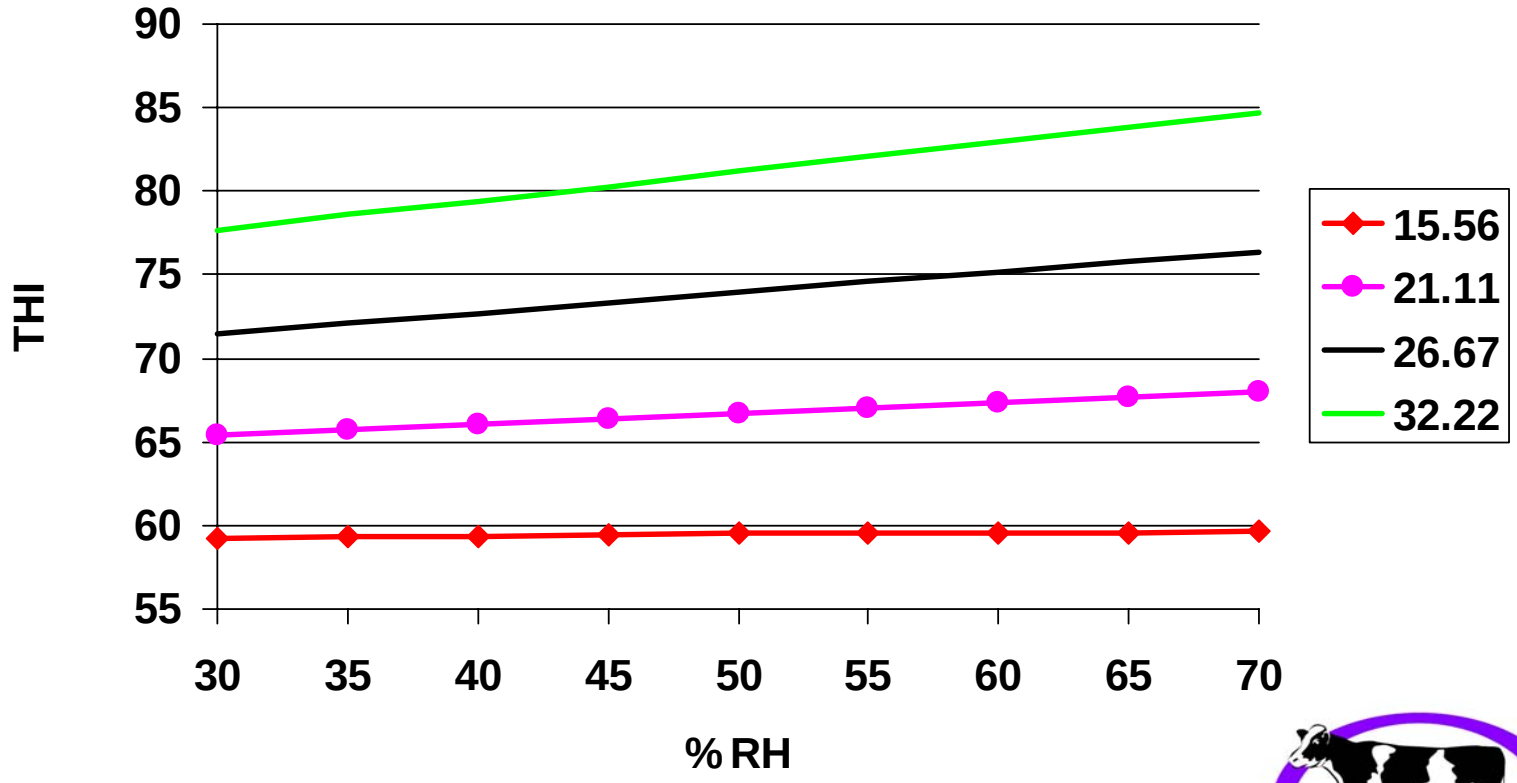
THI Values at Different Temperatures (C) and %RH



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Water Availability

- **Water intake increase 1.2 to 2.0 fold during heat stress!!**

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Recommendations Concerning Access to Water in Housing Areas

- **3.1-9.2 linear cm per cow**
- **Areas with heat stress**
  - **9.2 linear meters for every 100 cows**
- **Multiple locations**

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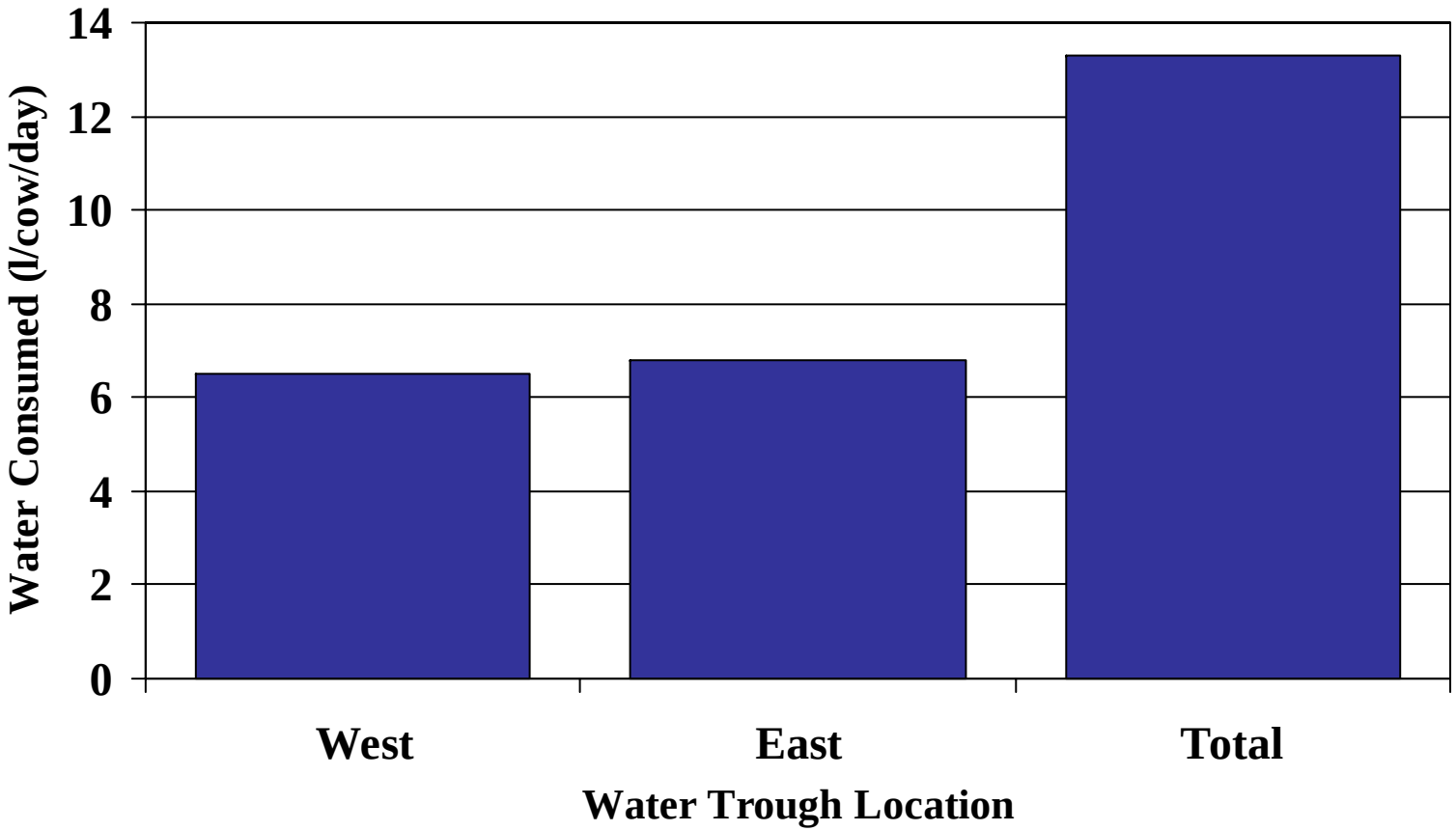
Water Availability in Freestalls

- **Freestall housing**
  - **Water at every crossover**
  - **Distance between crossovers will determine if adequate tank perimeter is provided**
  - **Water troughs can be placed on the outside walls**

Water Consumption at Parlor Exit Lanes



Response to shade

- **1.8 to 4.1 kg of milk/cow/day**

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There are differences in shade material!!

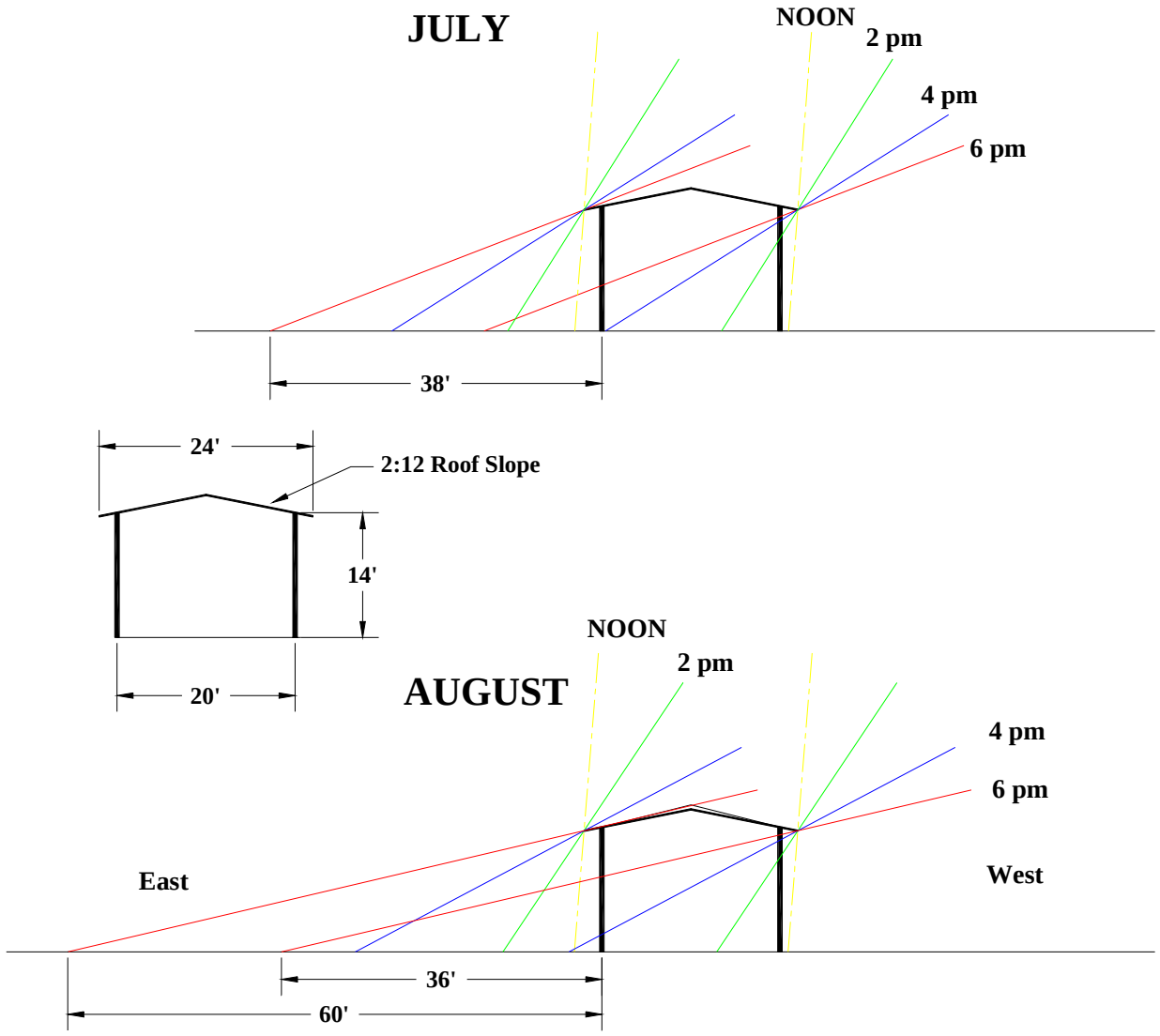
Shade Material Listed in Descending Order of Effectiveness, As Compared With New Corrugated Aluminum

Material	Description	Effectiveness
Hay	15 cm thick	1.203
Wood	Unpainted	1.060
Galvanized Steel	Top white, bottom natural	1.053
Aluminum	Top white, bottom natural	1.049
Neoprene Coated Nylon	White, both sides	1.037
Aluminum	Standard	1.000
Galvanized Steel	Standard	0.992
Asbestos Board	Natural color	0.956
Shade Cloth	90% solid	0.839
Shade Cloth	80% solid	0.819
Slatted Wood	5 cm solid – 5 cm open	0.589

Bond, et al 1961

Shades in Drylot Housing

- **Shade**
  - **4.2 m^2/cow**
  - **North-South orientation**
  - **Minimum 4.3 meters high**


JULY
NOON
2 pm
4 pm
6 pm
38'
24'
2:12 Roof Slope
14'
20'
AUGUST
NOON
2 pm
4 pm
6 pm
East
West
36'
60'

Three Ways to Cool Cows

- **Cool the Cow**
  - **Soakers and fans**
- **Cool the Air**
  - **Evaporative pads**
- **Combination**
  - **Cool the cow**
  - **Cool the air**

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Cooling the Cow

- **Soak the cow and dry the cow**
- **Maximize the number of wet/dry cycles**
- **Combinations of sprinklers and fans**
- **Works in humid and arid climates**

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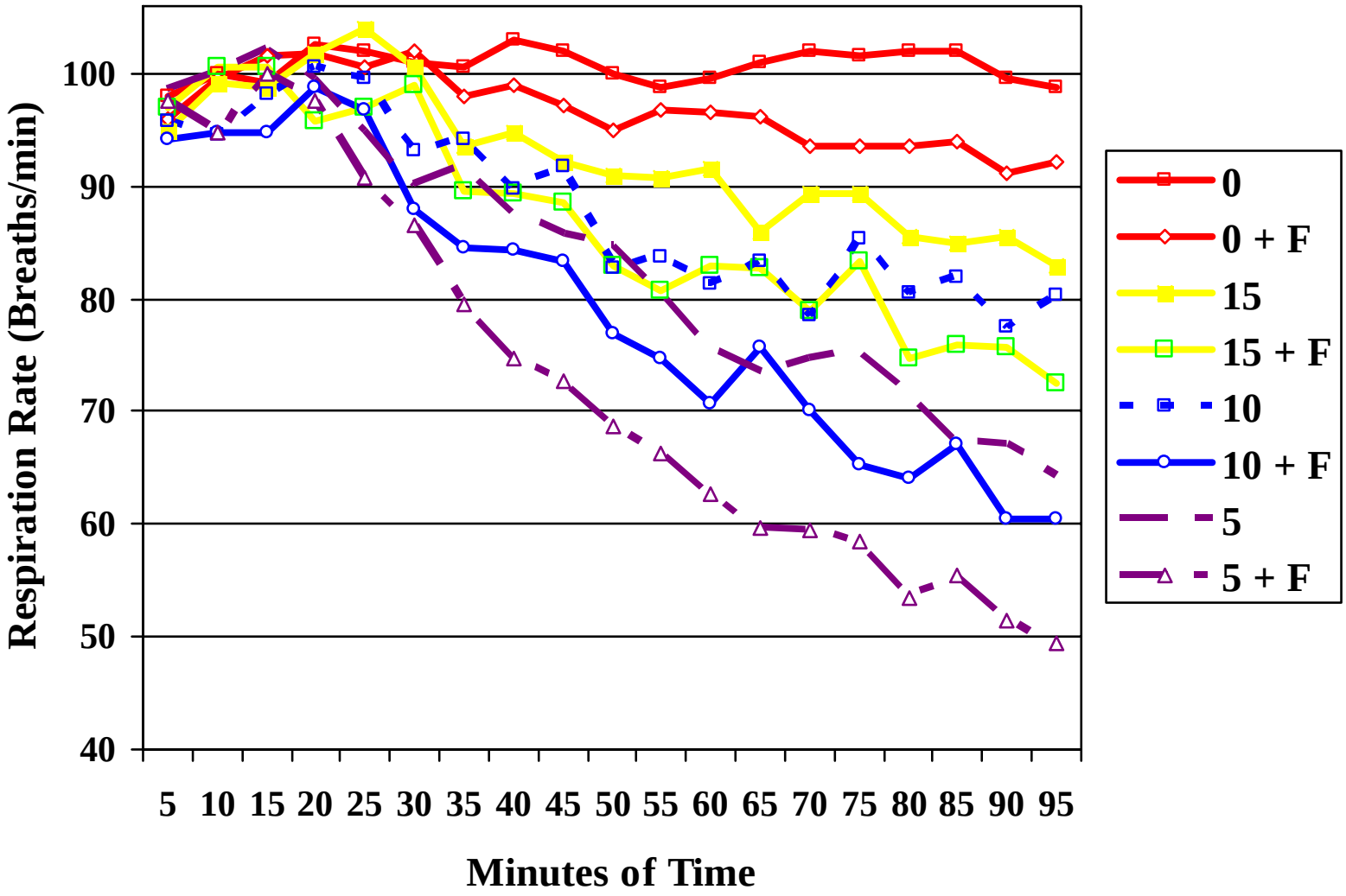
Treatments

1. 0 - Control No Sprinkler or Fan
2. 0 + F - No Sprinkler + Fan
3. 5 - Sprinkler (1 min on & 4 min off)
4. 5 + F - Sprinkler (1 min on & 4 min off) + Fan
5. 10 - Sprinkler (1 min on and 9 min off)
6. 10 + F - Sprinkler (1 min on and 9 min off) + Fan
7. 15 - Sprinkler (1 min on and 14 min off)
8. 15 + F - Sprinkler (1 min on and 14 min off) + Fan

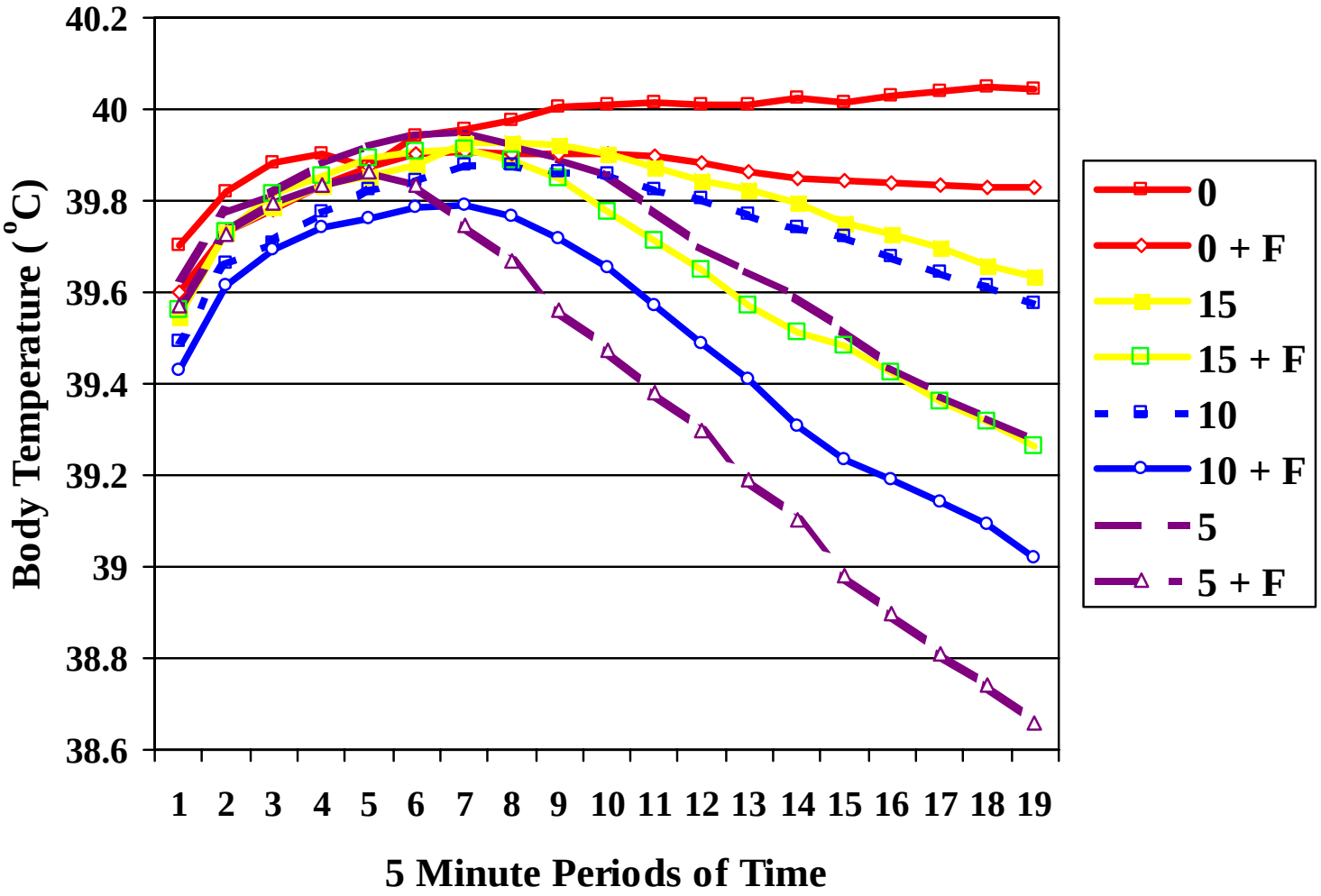
Sprinkler - 3.4 l/min or .17 l/ft^2 Fan – .31 to .33 m^3/second


2771
2771

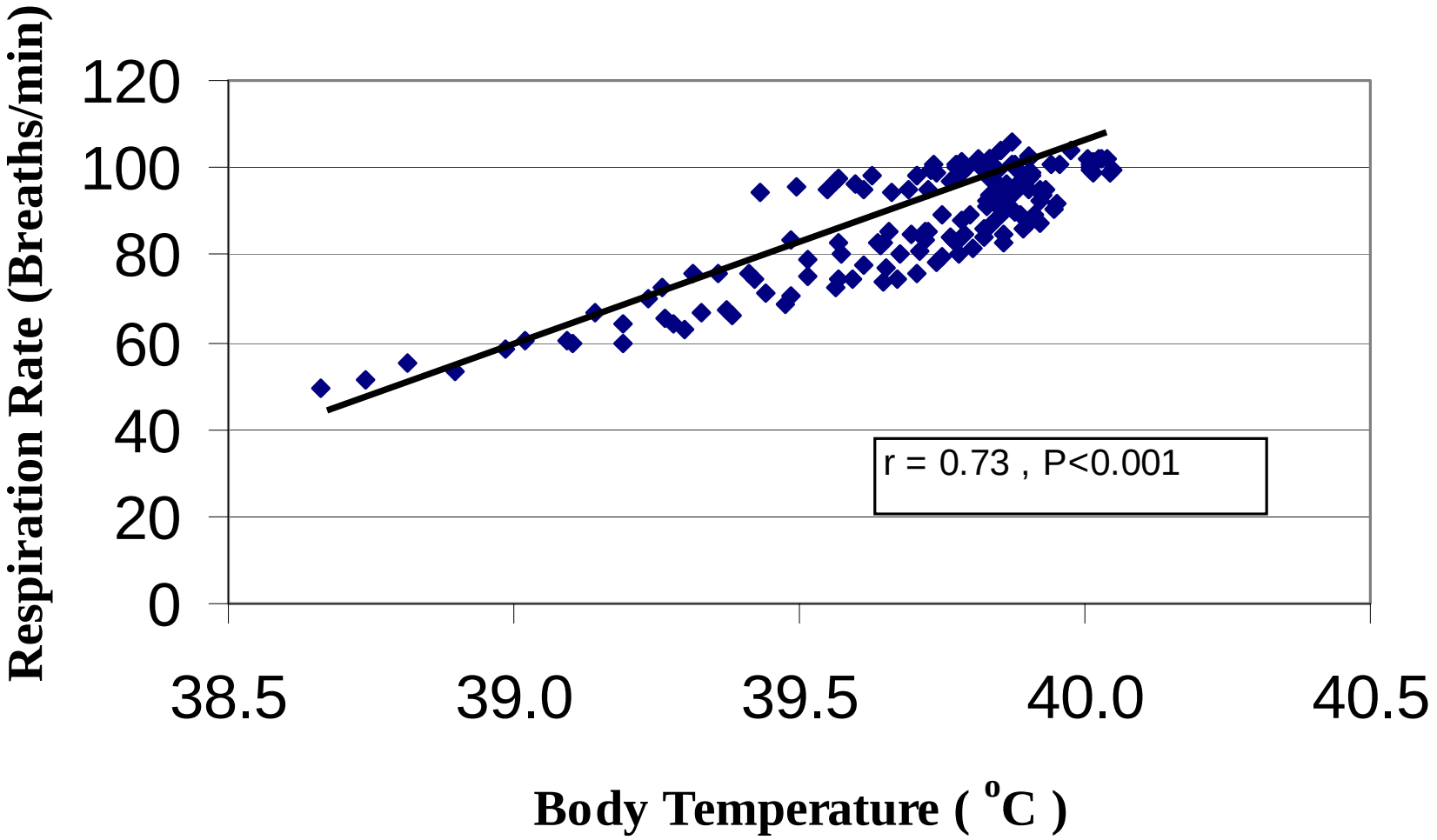
Effects of Cooling Treatments on Respiration Rate over 95 Minutes



Effects of Cooling Treatments on Body Temperature over 95 Minutes



Relationship of Respiration Rate and Body Temperature of Cattle



KS, 2001

Summary

- **Air Alone did not Reduce Respiration Rates**
- **Increasing soaking frequency reduced respiration rate and body temperature**
- **Adding fans on top of the water reduces respiration rate and body temperature**
- **Soak the Cow and Dry the Cow**
- **Water is the Magic!!**

Locations

- **Holding pens**
- **Exit lanes**
- **Feedlines**

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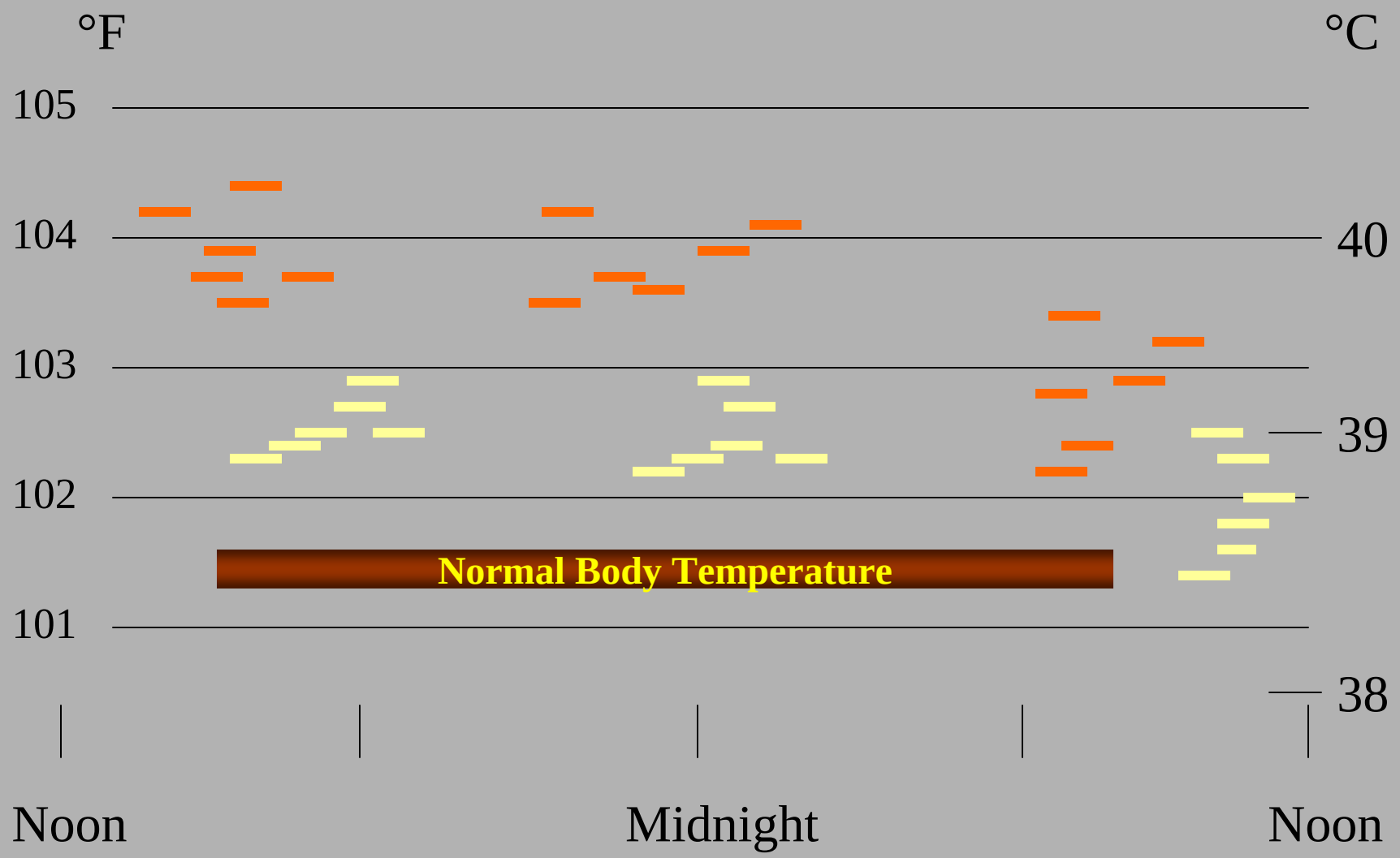
Holding Pen Cooling

Cow Body Temperatures



Holding Pen Cooling

- **AZ data indicates .77 kg of milk/cow/day**

Ventilation!

Adding Fans

Figure 2. Example of fan placement in a holding pen 24 feet or wider. The holding pen shown has an approximate capacity of 80 cows.

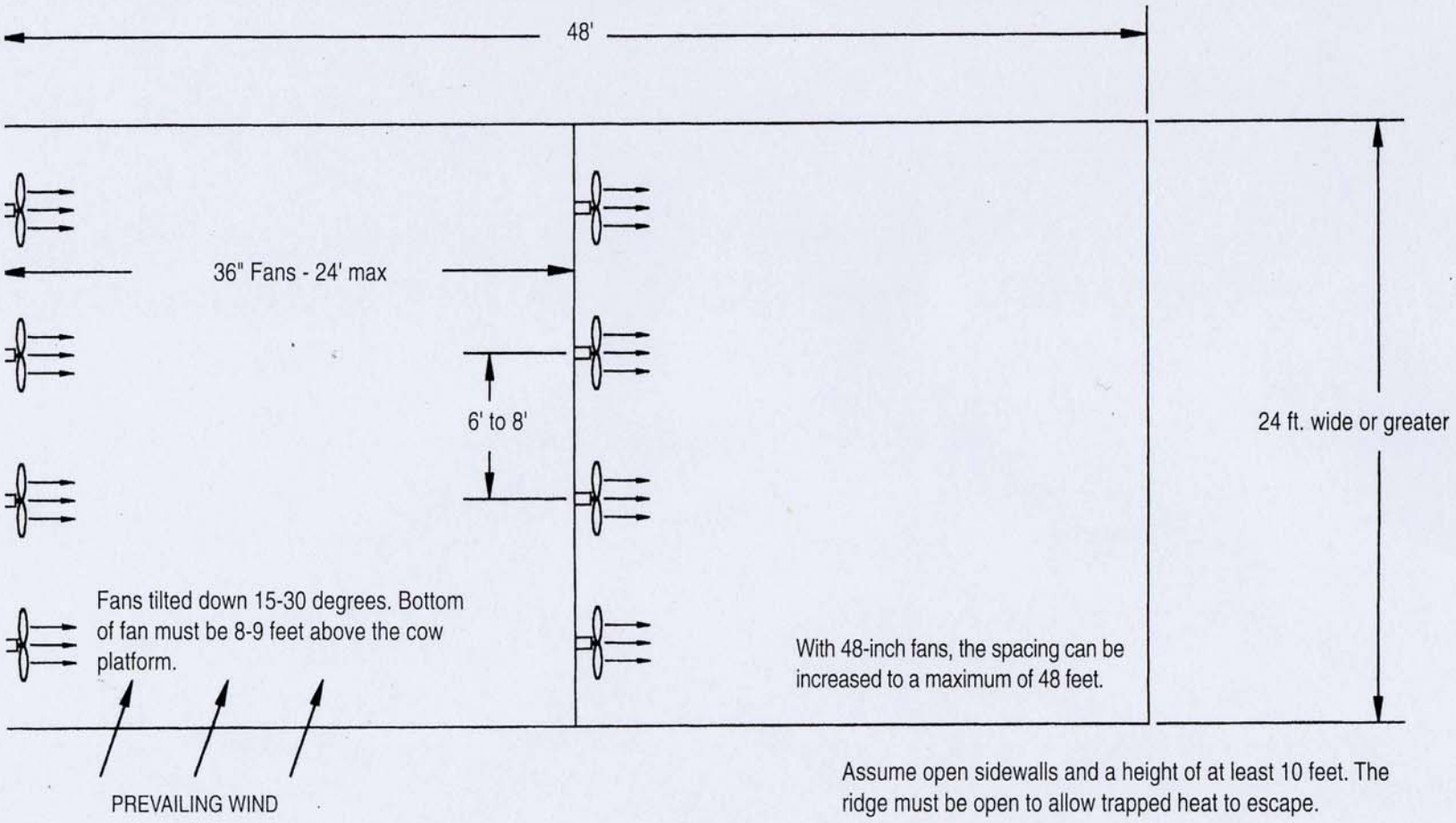
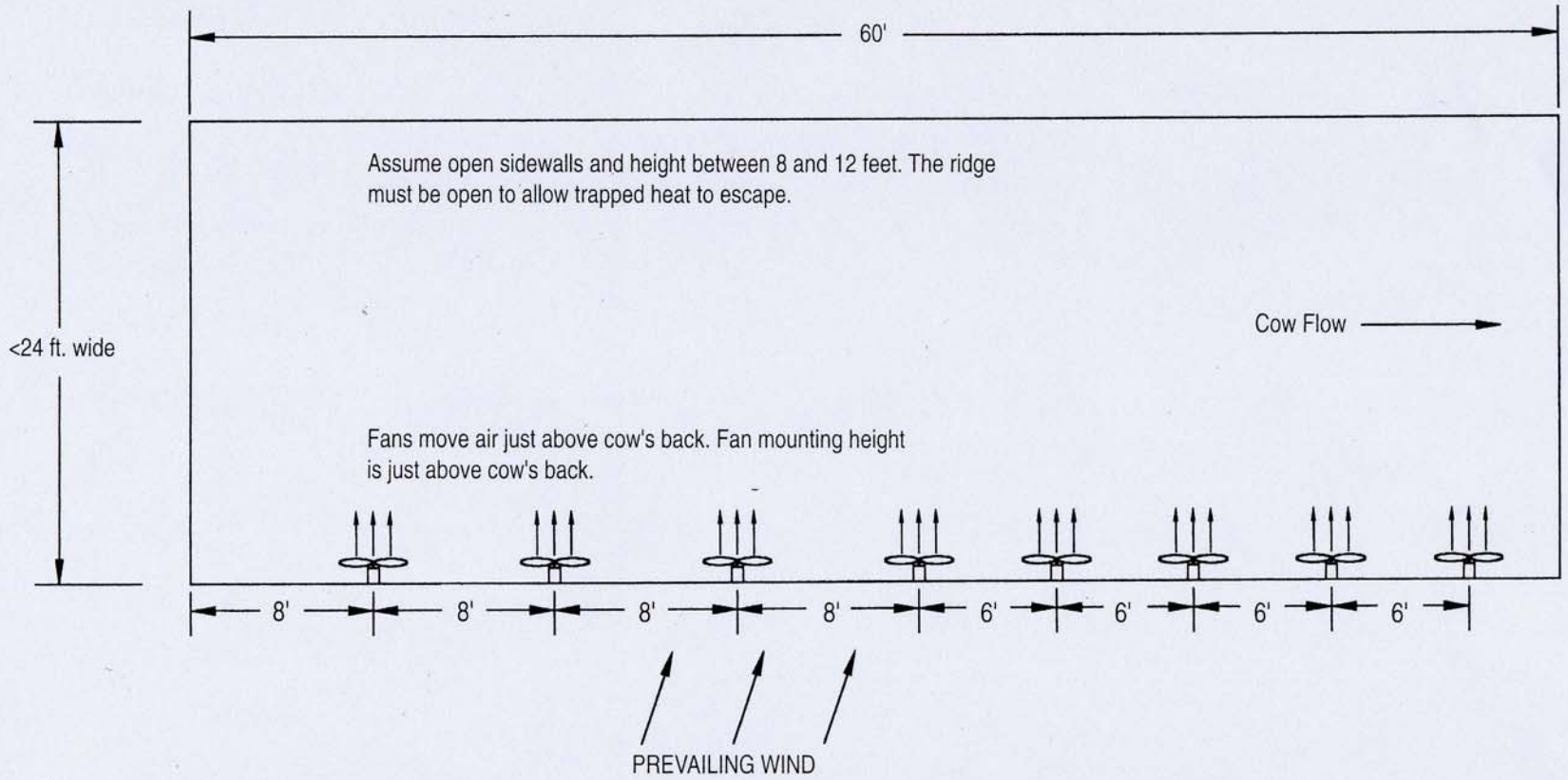
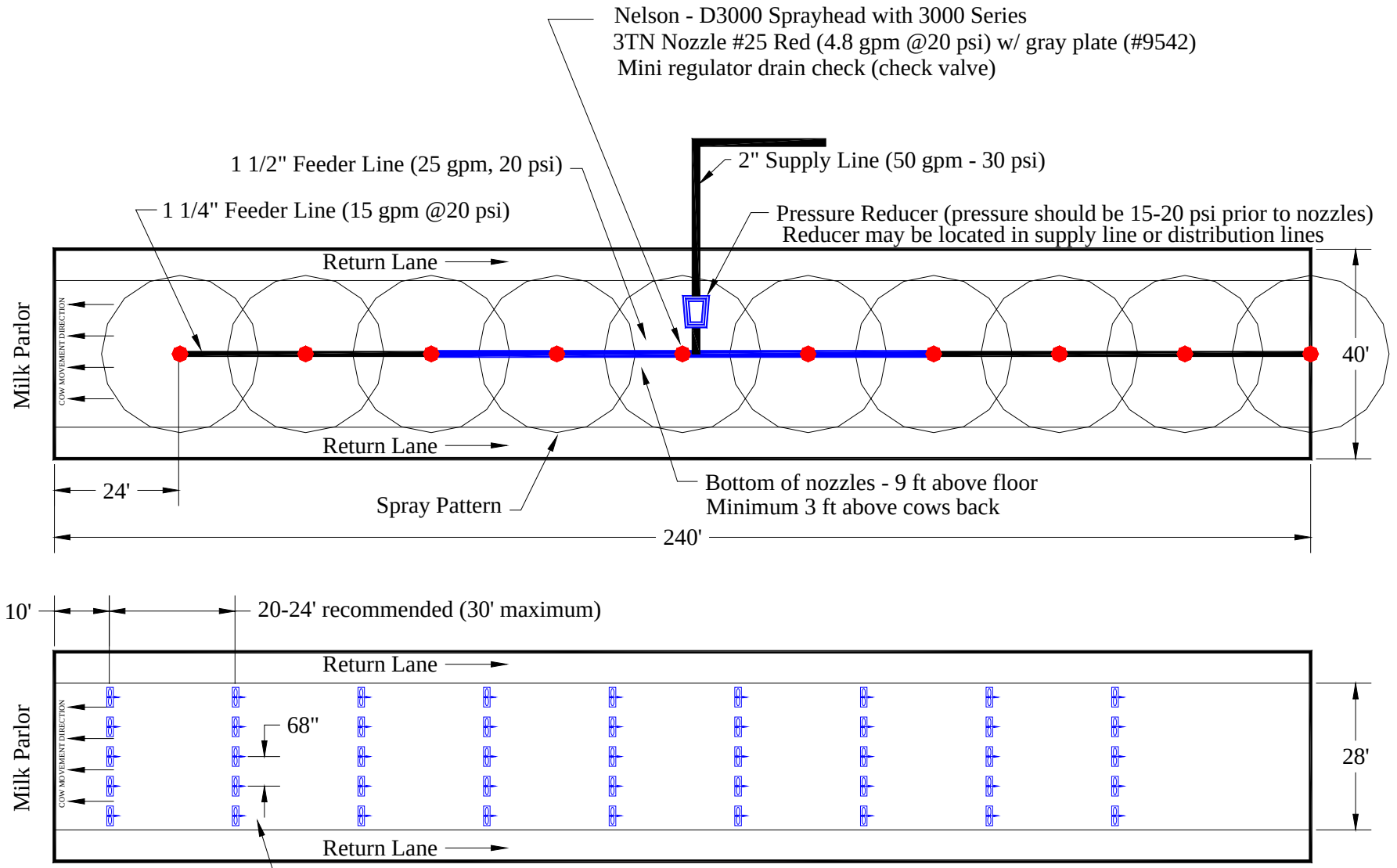


Figure 1. Example of fan placement in a holding pen less than 24 feet wide. The holding pen shown has an approximate capacity of 80 cows.



Adding Water



Holding Pen Guidelines
360 Cow Groups @ 15 sq.ft./cow
25% extra room for 2nd group

Holding Pen Soakers

- **Deliver 12.3 l/m^2/cycle**
- **Soak cows every 5 to 15 minutes**
  - **Soaking frequency is increased with holding pen temperature**

Don’t Cheat!!!

- **Number of fans**
- **Soaker system**
- **There is too much money on the table!!**
- **Holding pen cooling needs to be turned on and off based on the temperature in the holding pen!**

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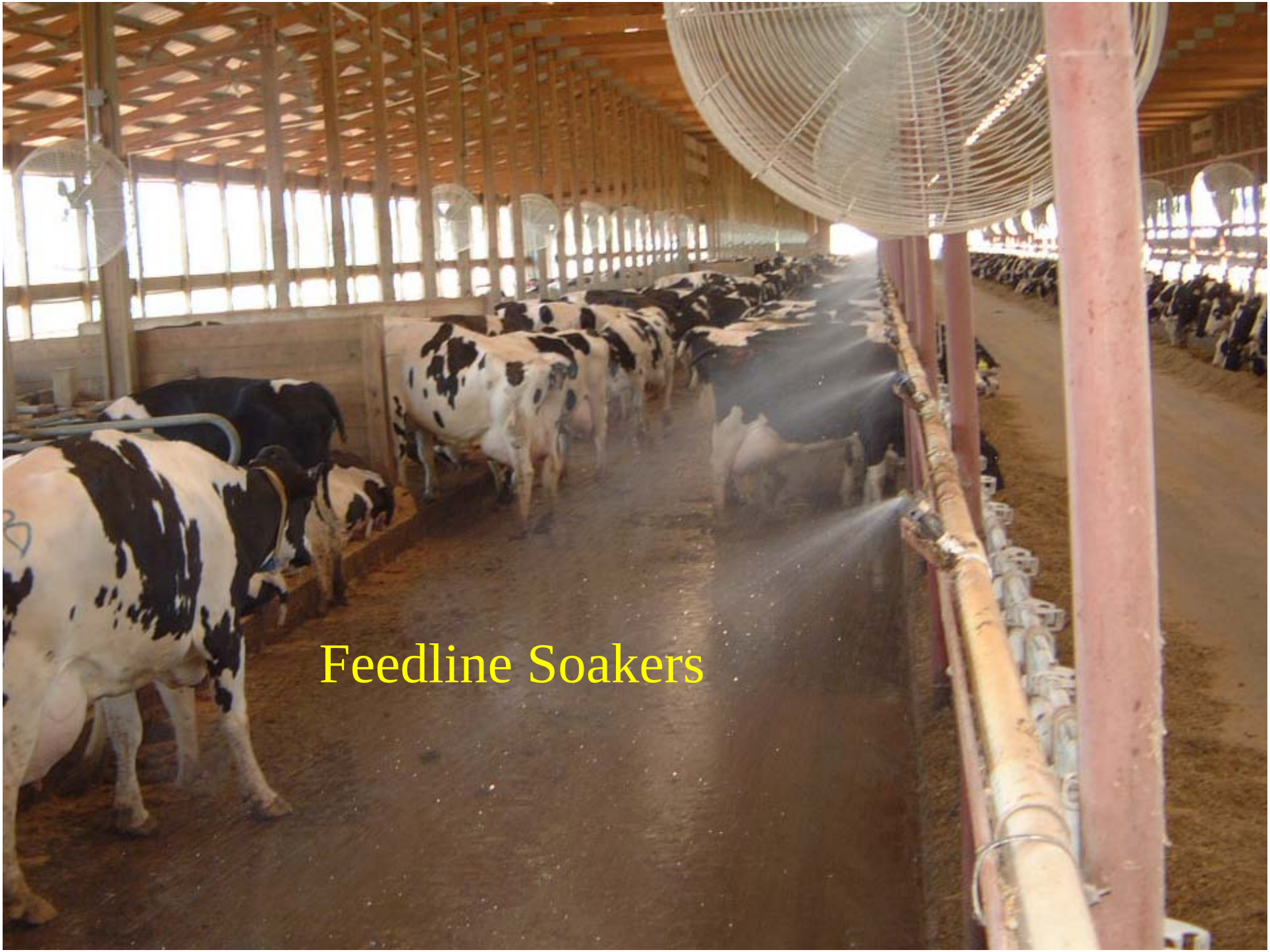
Exit Lane Cooling

- **Nozzles activated by cow**
  - **3 nozzles, 30 liters per minute**
- **Low cost**
  - **$500 - $800**
- **Additional 15-25 min. cooling/milking**


Feedline Soakers

Feedline Soakers

- **Soak and dry the cow**
  - **Never let cows get hot**
  - **Increase wetting frequency with temperature**
    - **21º C = Every 15 minutes**
    - **27º C = Every 10 minutes**
    - **32º C = Every 5 minutes**
  - **On time will be dependent on nozzle size**
  - **Location**
    - **Feedlines in freestalls**
  - **Controllers are available off the shelf**

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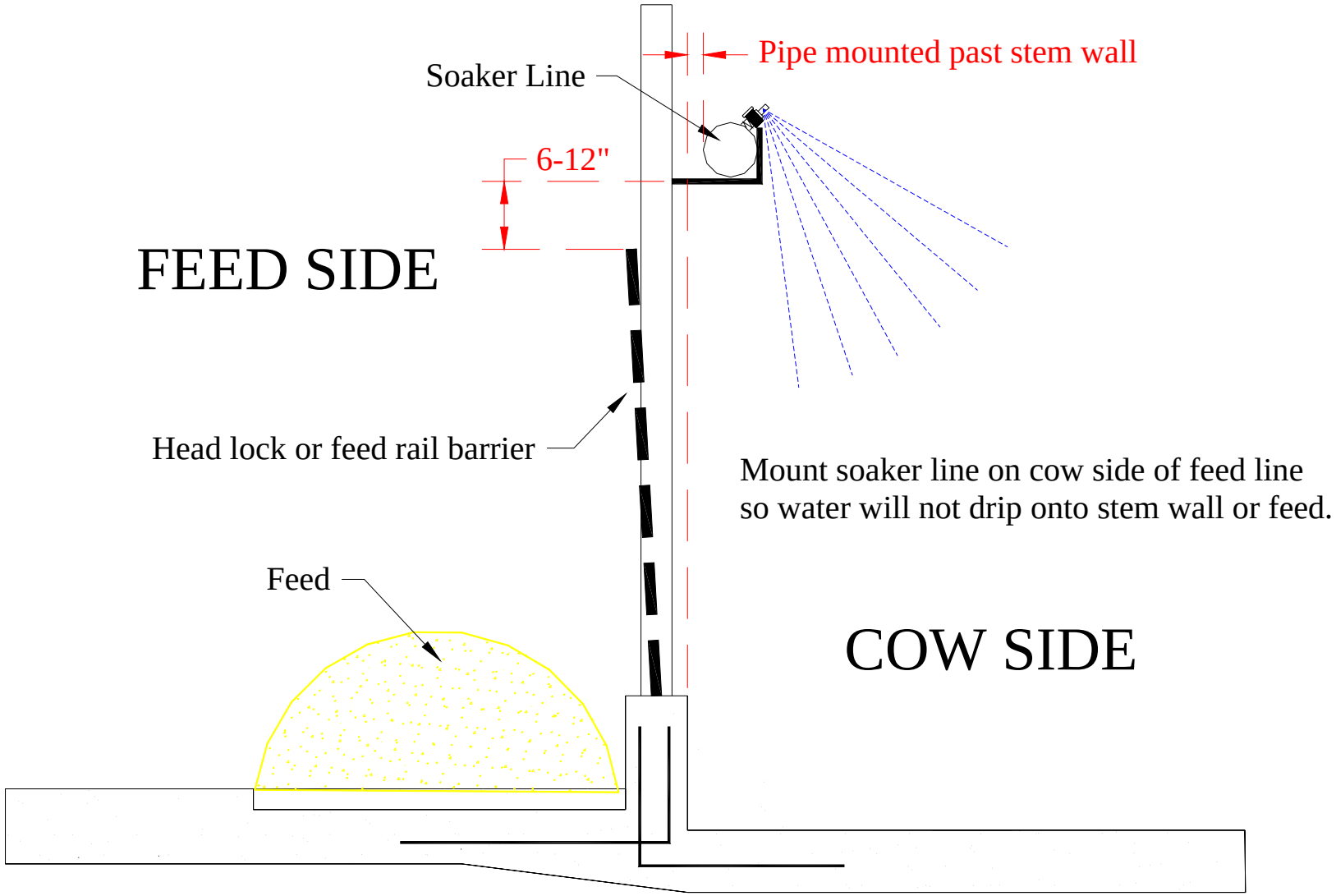
Potential Problems with Soakers

- **Drift**
  - **Larger Droplet Size**
  - **Lower the Water Lines**
- **Sizing Soaker Lines**
- **Water Supply to the Barn**
  - **Inlet water demand**
  - **Sequence Pens**
- **Lagoon Capacity**

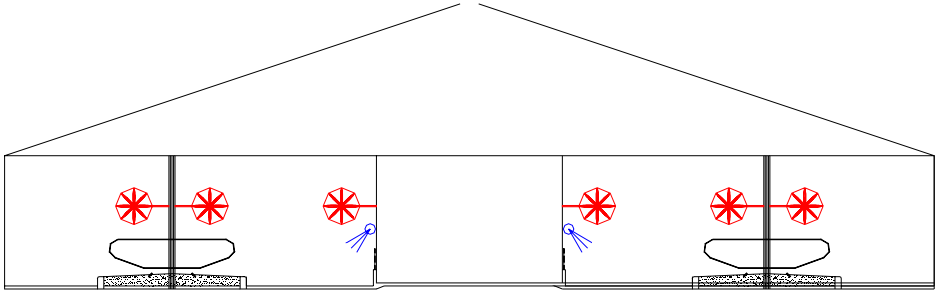
Figure 2. Soaker line location on the feedline.



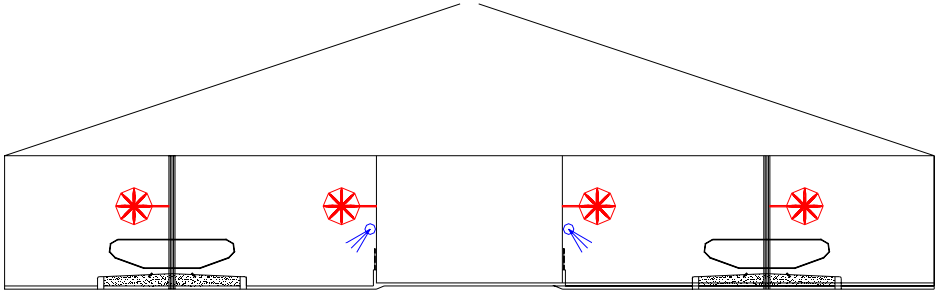
Fan Placement in Freestall Barns

John Smith
Joe Harner
Mike Brouk

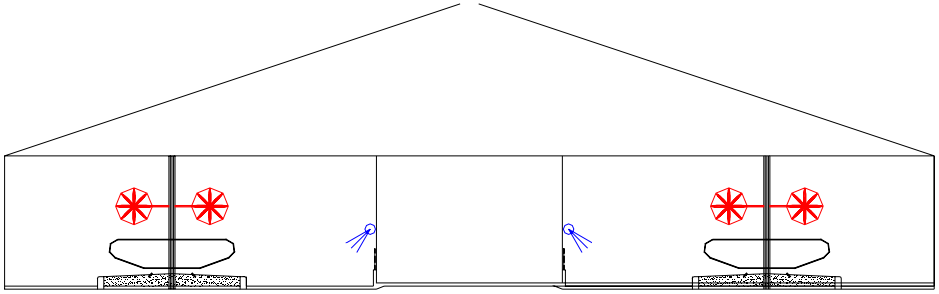
1999 Study



91 cm Fans over stalls & feedline every 7.3 m (F&2S)



91 cm Fans over stalls & feedline every 7.3 m (F&S)



90 cm Fans over stalls every 7.3 m (2S)

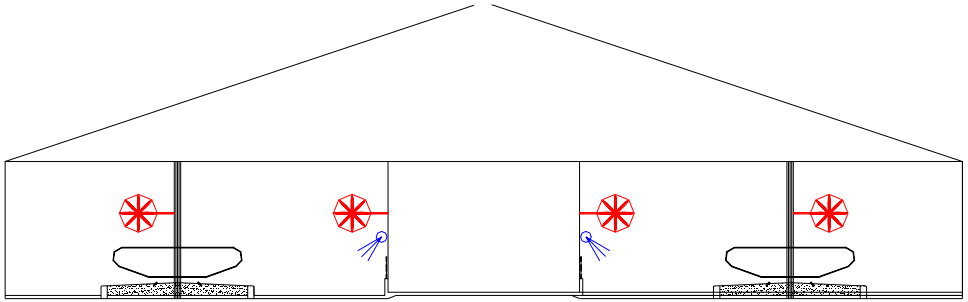
Milk Yield, Body Condition, and Feed Intake of Dairy Cows Housed in a Four-row Freestall Barn with Three Different Cooling Systems

	Cooling System[1]			
Item	**2S**	**F&S**	**F&2S**	**SEM**
Initial milk, kg	51.9	52.4	52.1	1.7
Initial days in milk	131	128	131	10.1
Average milk, kg	42.6[a]	44.8[b]	43.8[ab]	1.1
Dry matter intake, kg	25.2	25.5	25.5	-
Change in body condition	+.52	+.39	+.21	.14

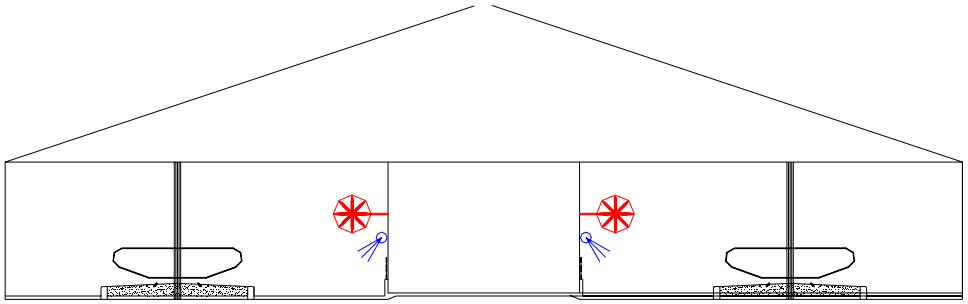
[ab] Means with uncommon superscript differ ($P<0.05$)

What is the Effect of Fans only on the Feedline in 4-row Barns?

2000 Study

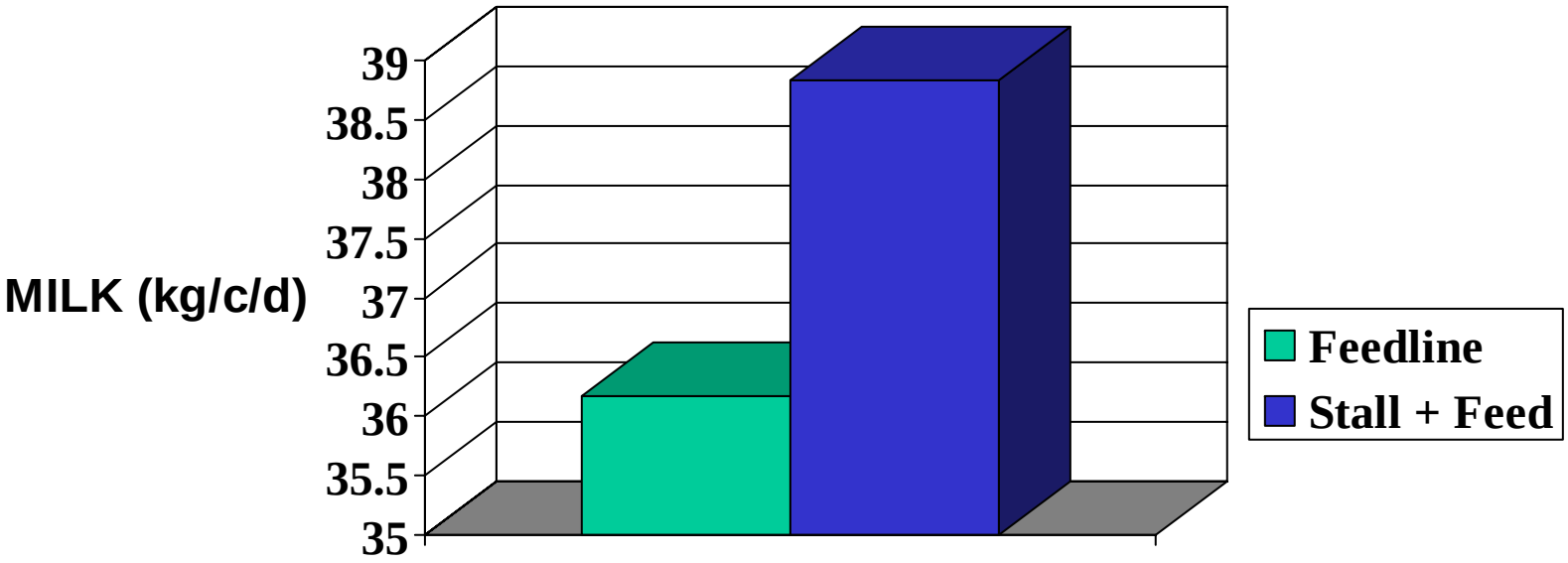


91 cm Fan over stalls & feedline every 7.3 m



91 cm Fan over feedline every 7.3 m

Average Milk Production



Feedline	36.17
Stall + Feed	38.83

P<.01

Recommendations

- **Four-Row Barn**
  - **Fans on Feedline and over Stalls**
    - .91m fans every 6.1-7.3 m
  - **Soakers over feed line**
- **Two-Row Barn**
  - **Fans over Stalls**
    - 1.2 m fans every 12 m
  - **Soakers over feed line**
- **Six-Row Barns??**

Systems to Cool the Air

- **Combinations of high pressure misters and fans**
- **Tunnel or cross ventilation with evaporative pads**

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High Humidity Limits Our Ability to Take Advantage of Using Evaporative Cooling to Cool the Air

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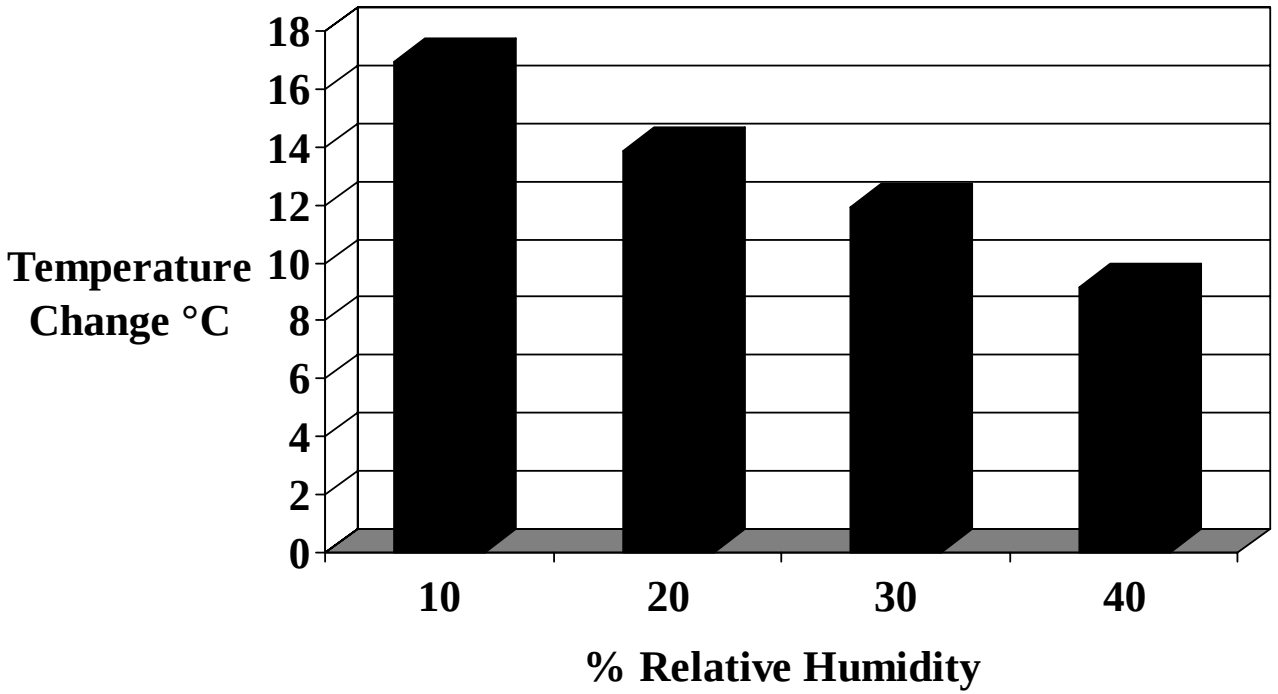
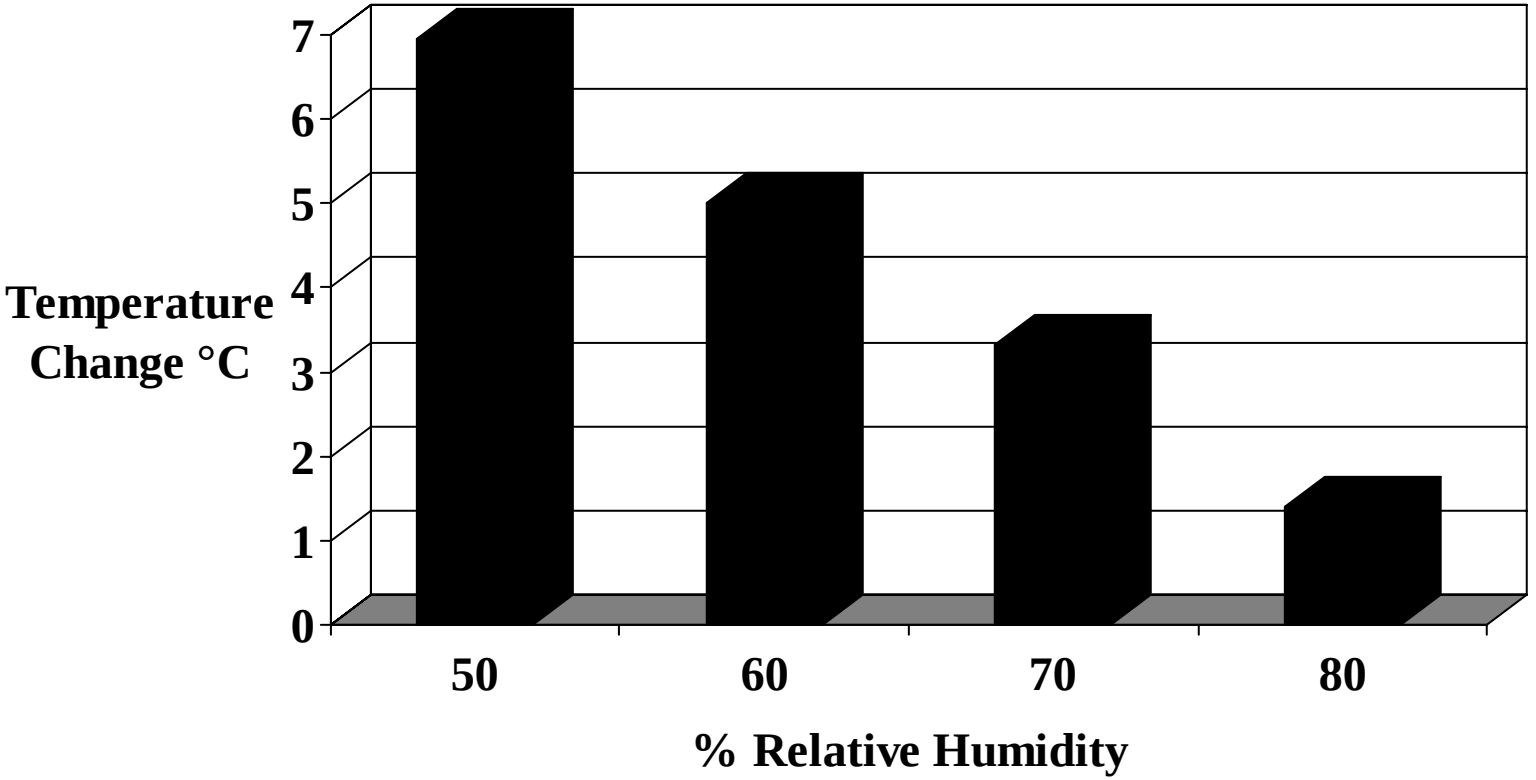
Potential Temperature at 32º C Change Due to Water Evaporation in a Low Relative Humidity Environment

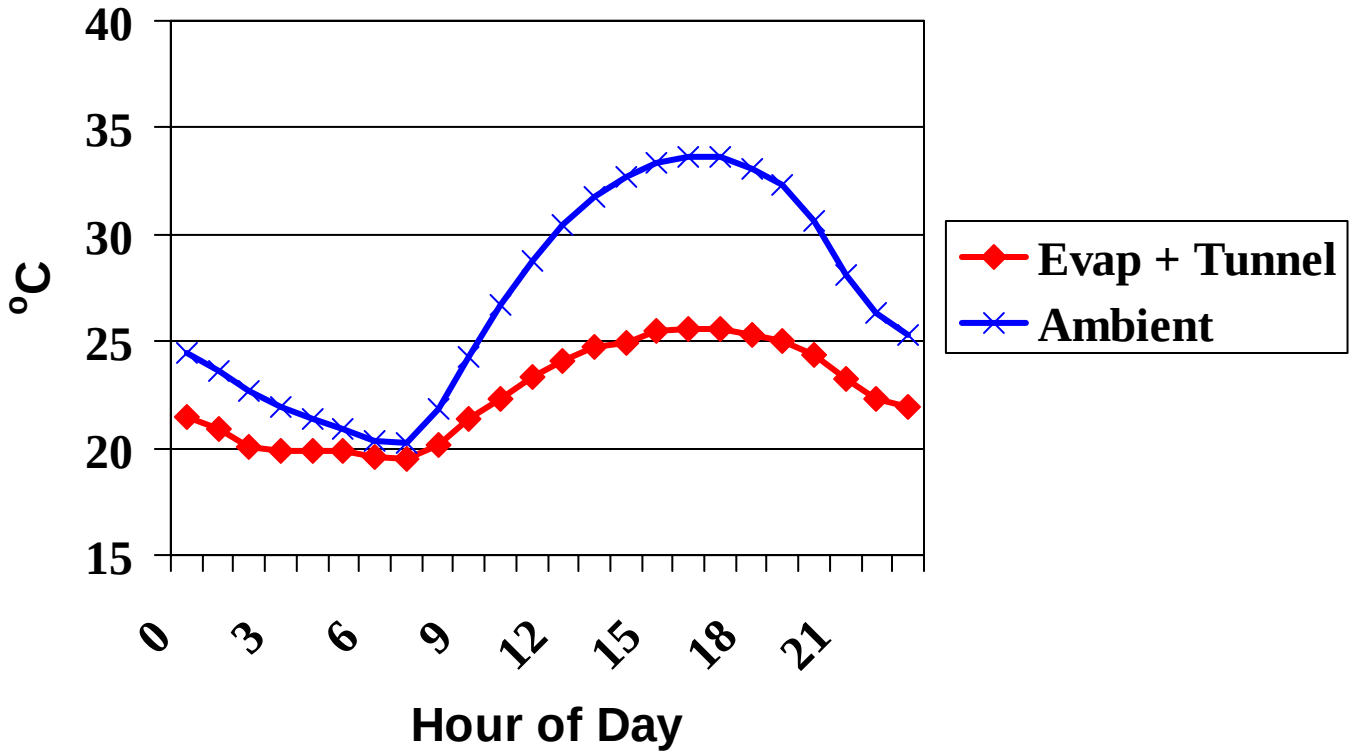


Potential Temperature Change at 32º C Due to Water Evaporation in a High Relative Humidity Environment

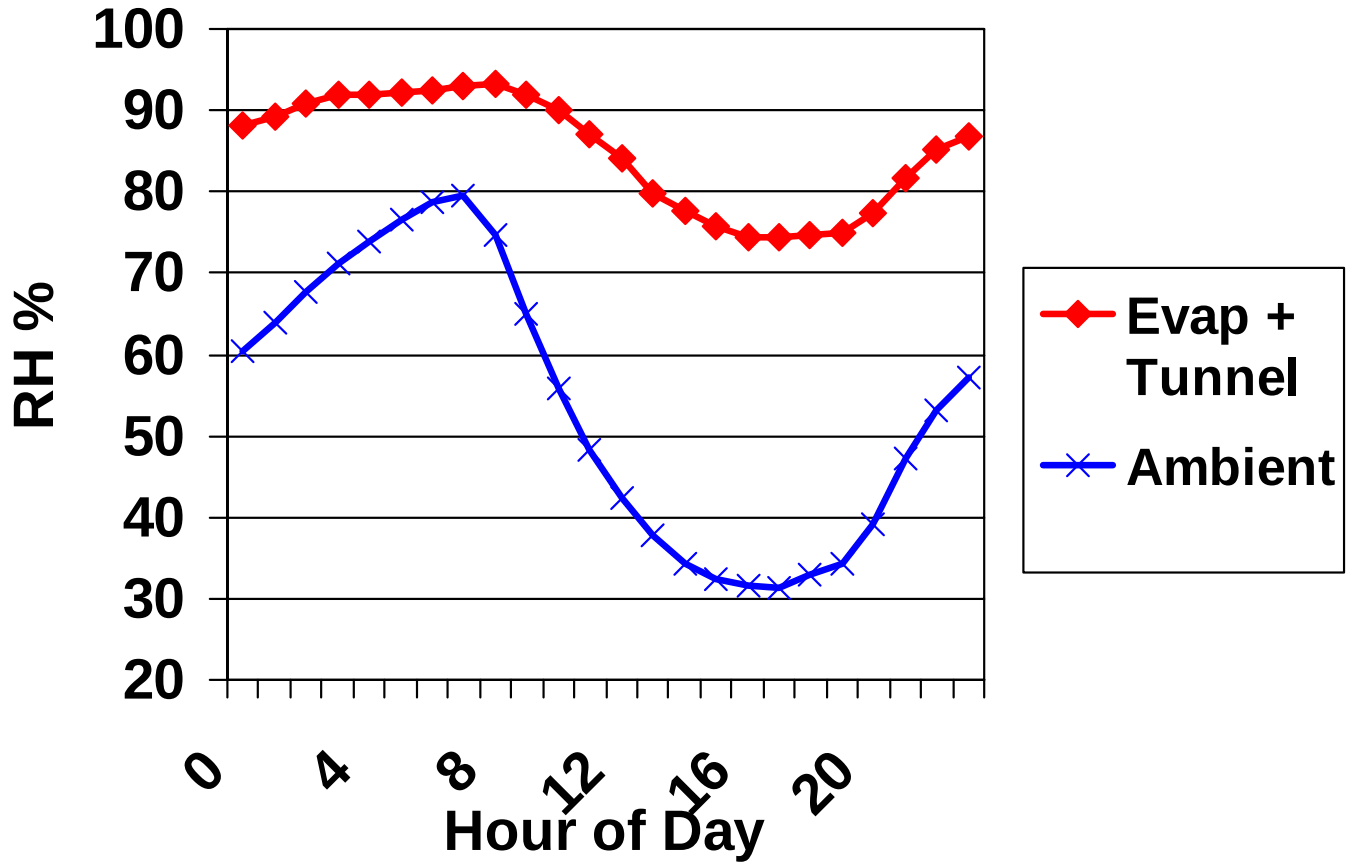


Fully Tunnel Ventilated Freestall Barn, Western Kansas

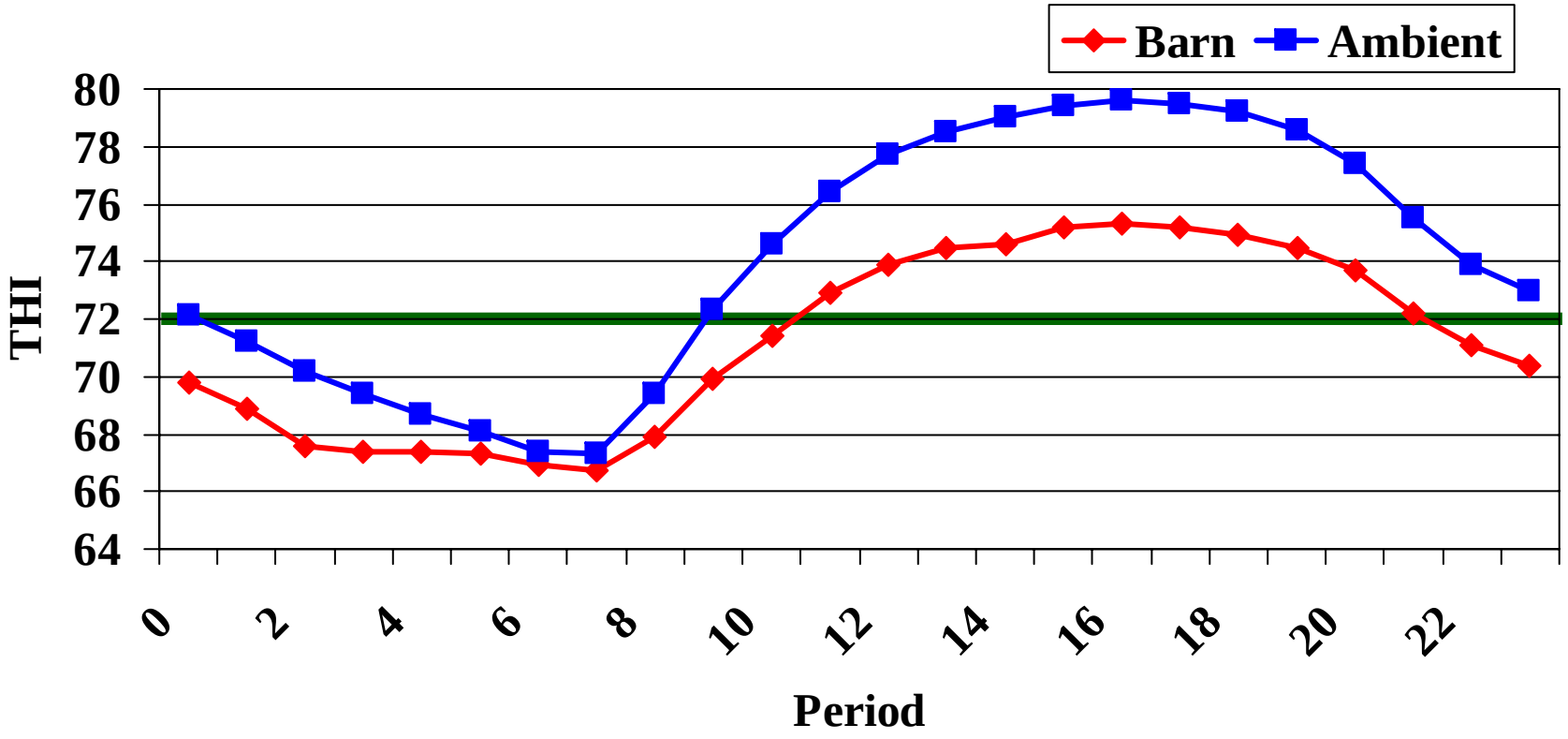
Average Temperature of Evaporative Cooled and Tunnel Ventilated Four Row Freestalls Located in Western Kansas July and August of 2003



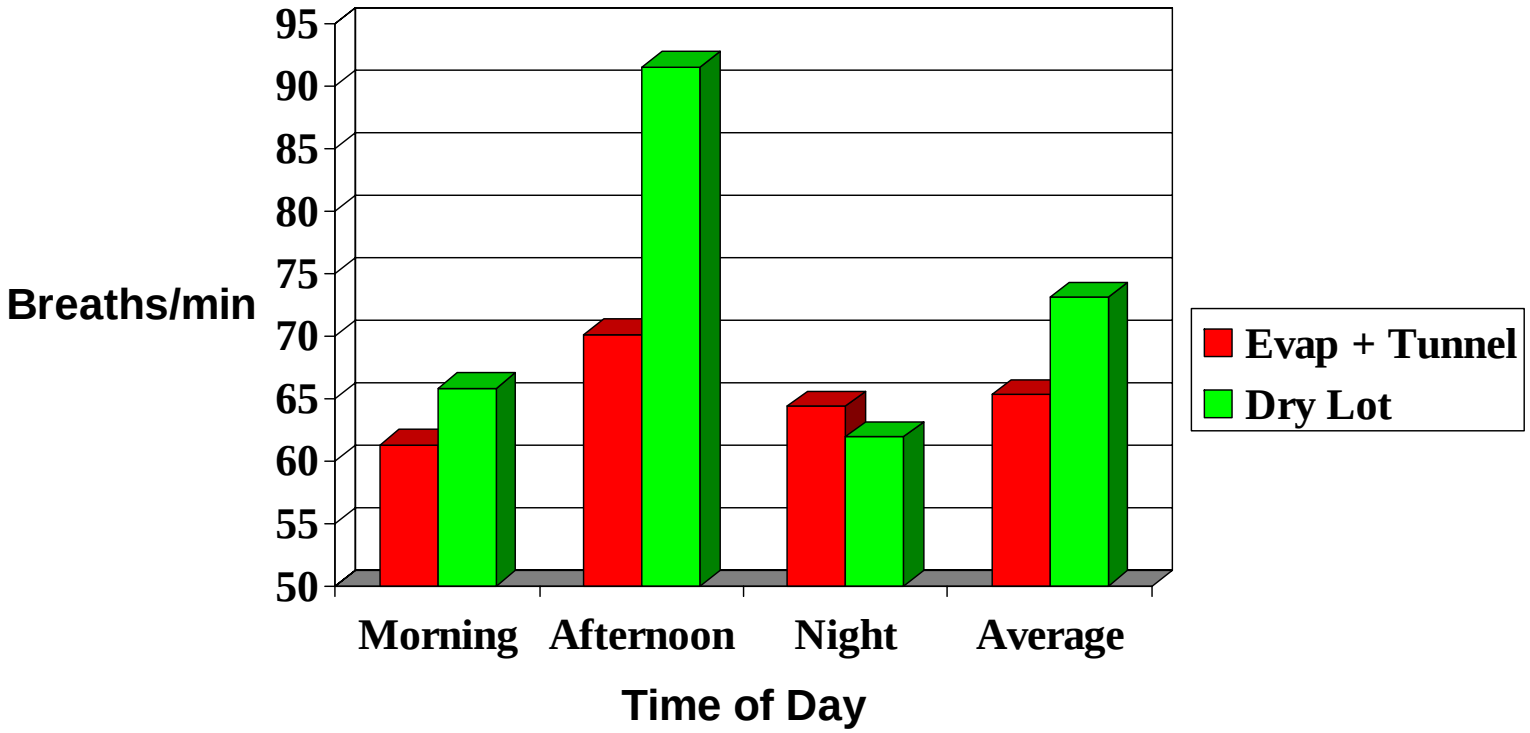
Average Relative Humidity of Evaporative Cooled and Tunnel Ventilated Four Row Freestalls Located in Western Kansas
July and August of 2003



Average THI of Evaporative Cooled and Tunnel Ventilated Four Row Freestalls Located in Western Kansas July and August of 2003

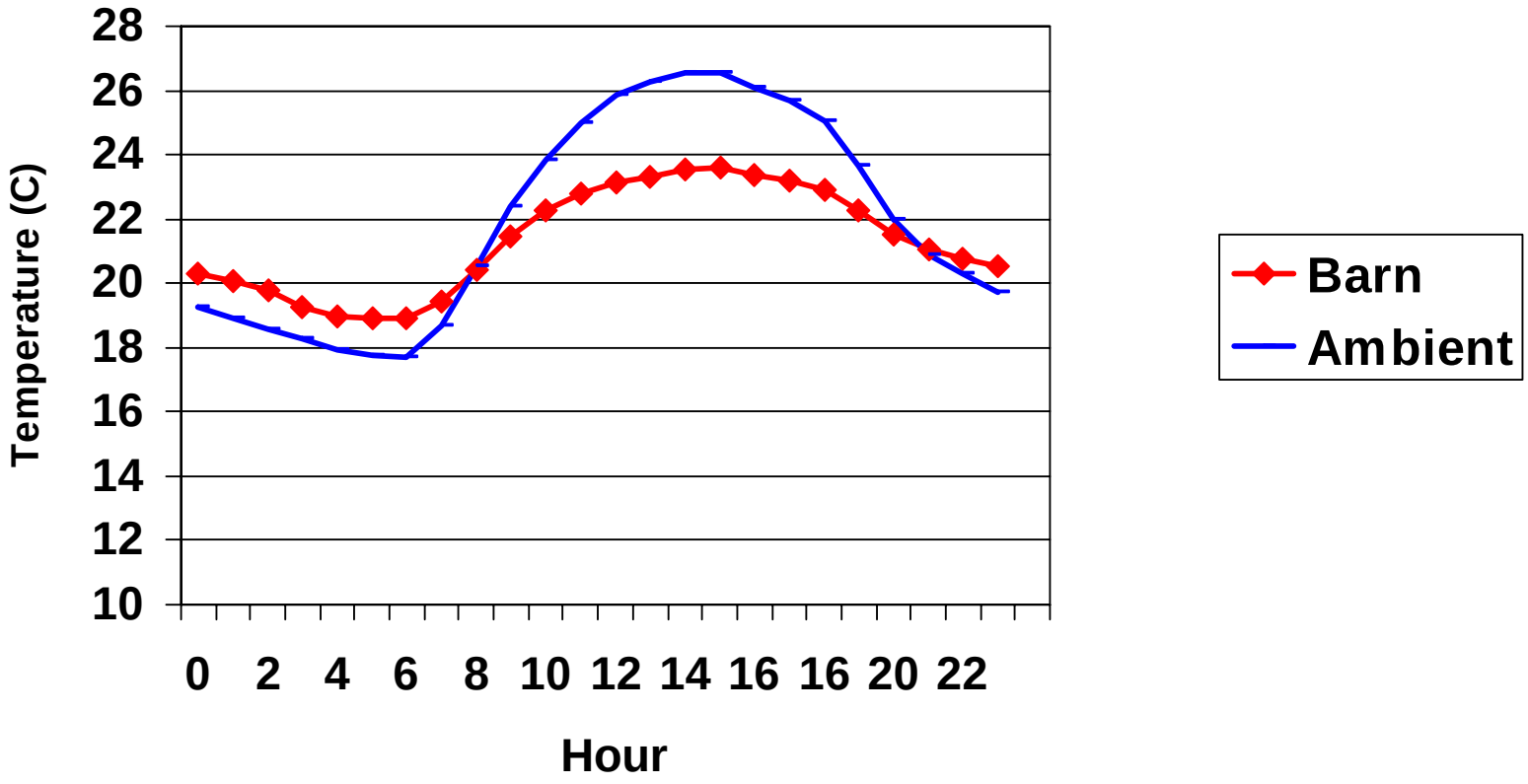


Effect of Cow Cooling on Respiration Rate

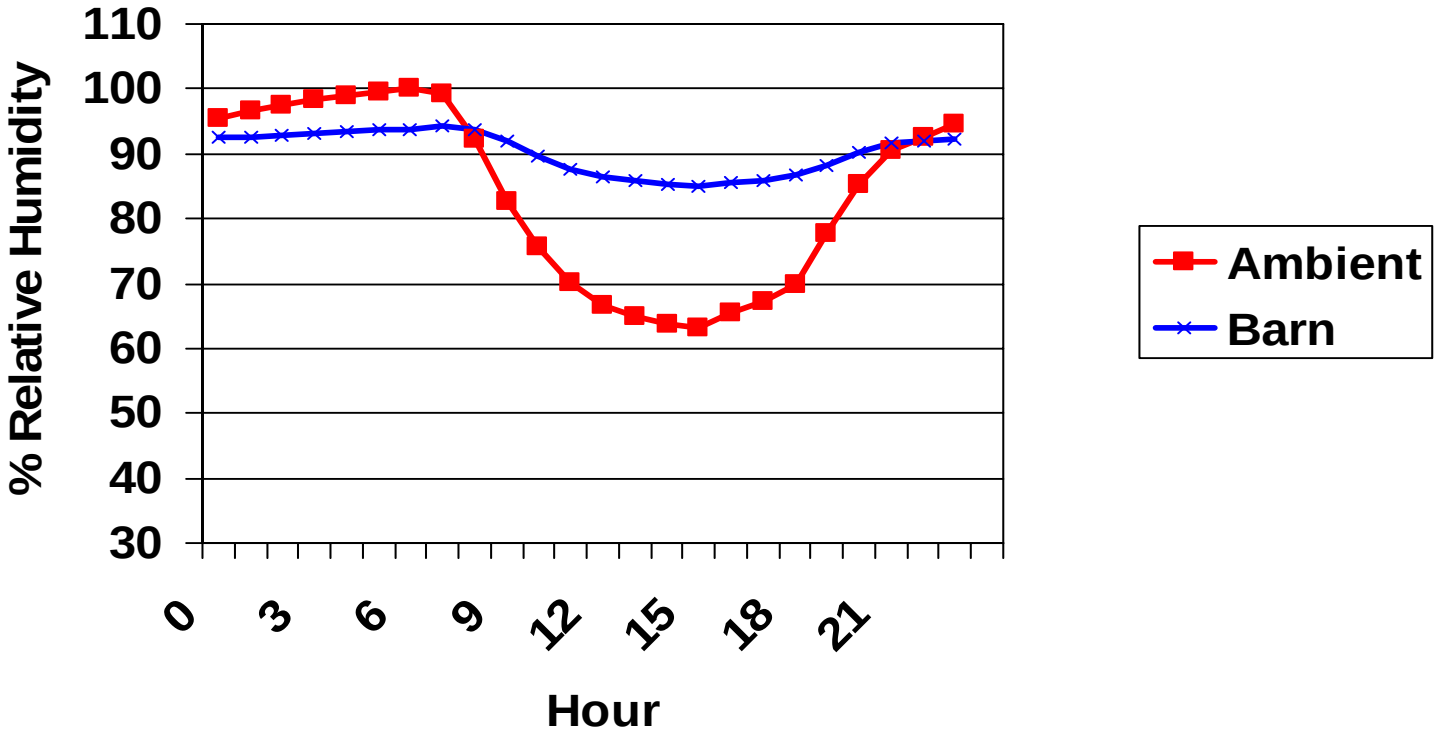


Fully Tunnel Ventilated with Evaporative Pads
Located in Northern Indiana

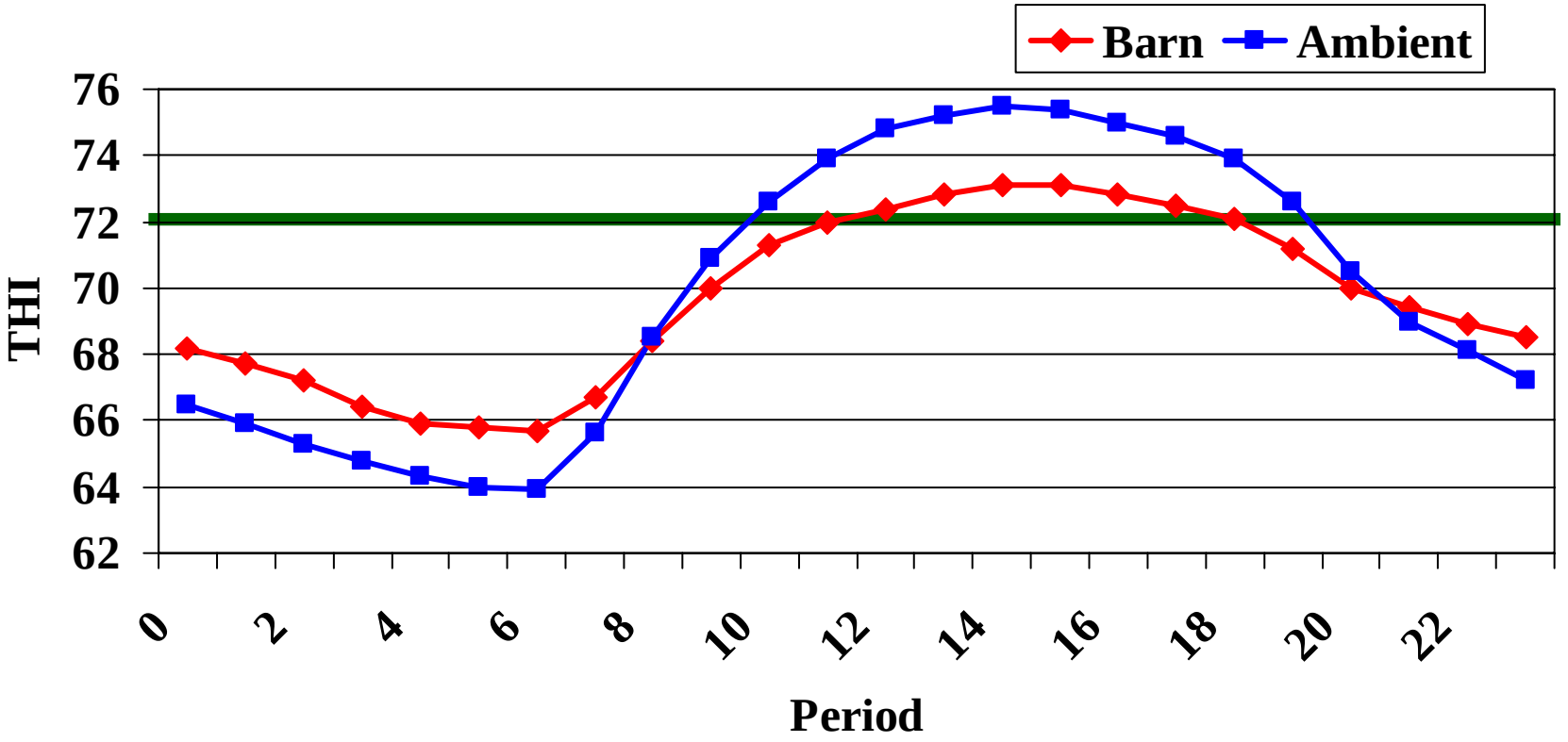
Average Temperature of Evaporative Cooled and Tunnel Ventilated Four Row Freestalls Located in Indiana July and August of 2003



Average Relative Humidity of Evaporative Cooled and Tunnel Ventilated Four Row Freestalls Located in Indiana July and August of 2003



Average THI of Evaporative Cooled and Tunnel Ventilated Tunnel Ventilated Four Row Freestalls Located in Indiana July and August of 2003



Eight Row Cross Ventilated Low Profile Freestall Facilities

John F. Smith, Joe Harner

and Rick Millner

Kansas State University and MCC Dairy

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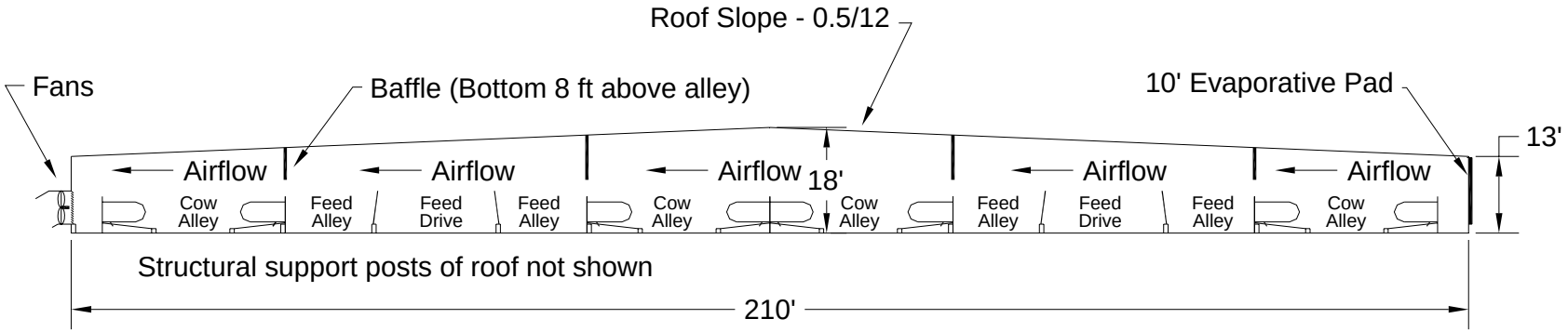
End view of an 8-row low profile cross ventilated freestall building



Source: Joe Harner, K-State

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Is there $ in cooling cows?

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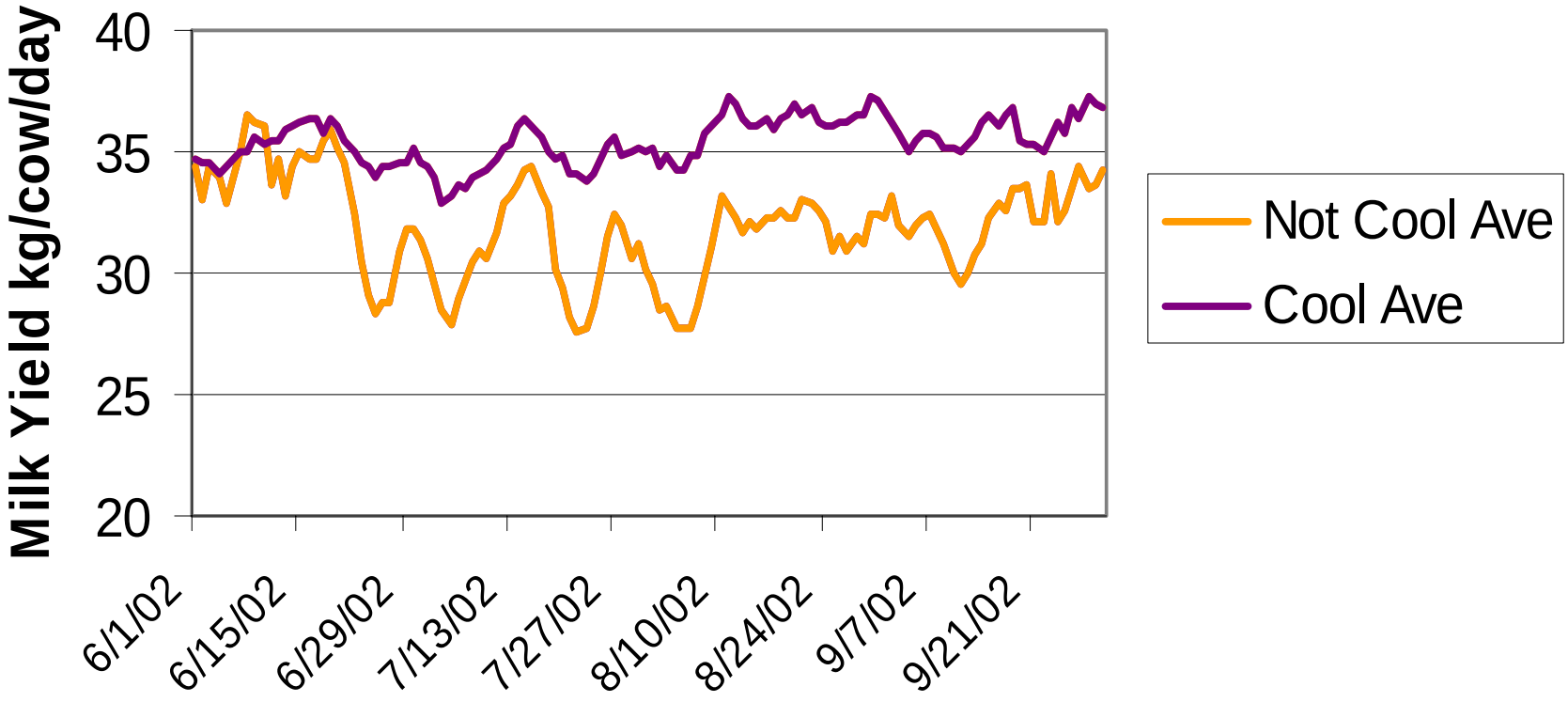
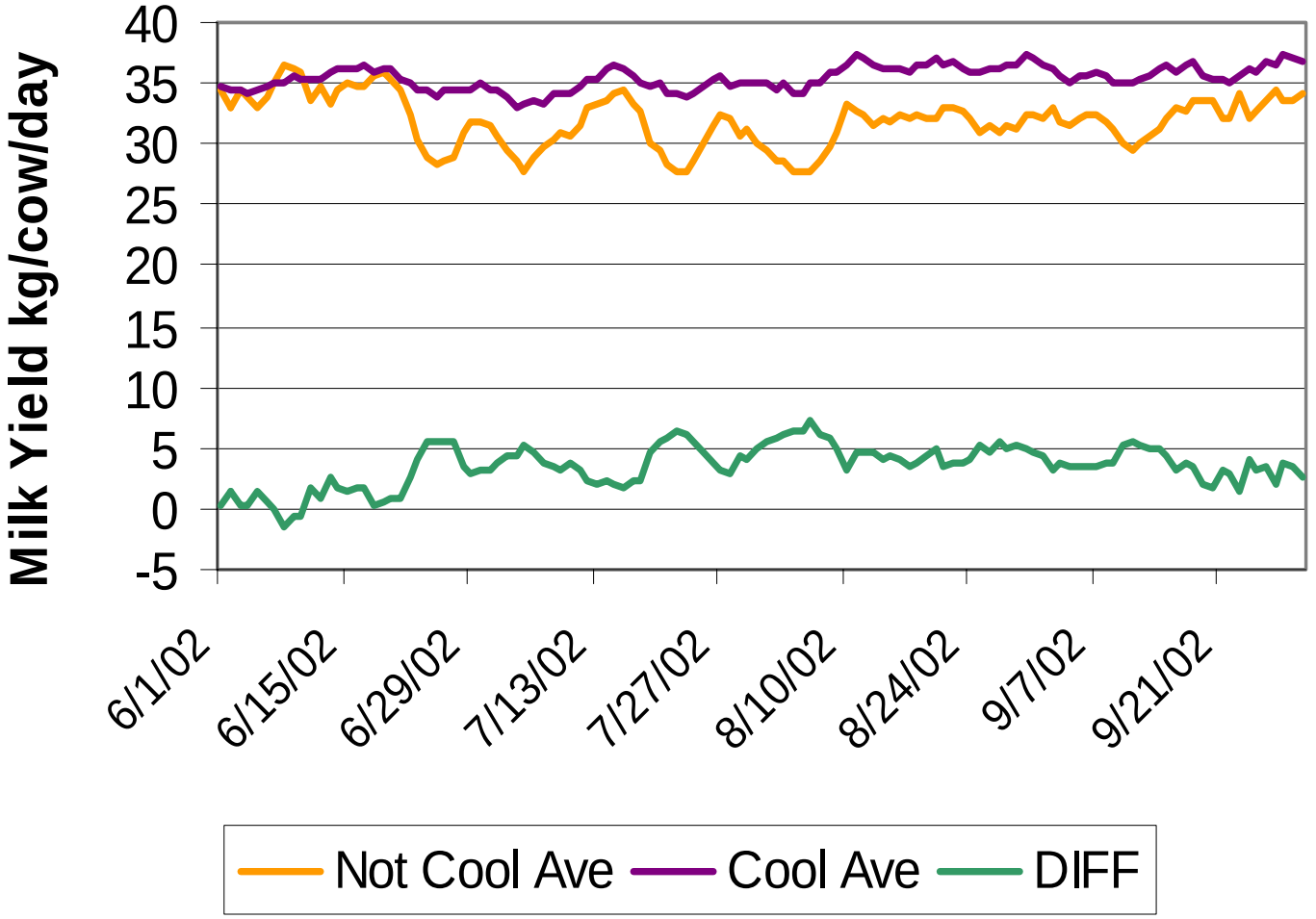
Daily Milk Production (cooled vs. no cooling)



Daily Milk Production and Difference (cooled vs. no cooling)



Economics of Cow Cooling

- **Lost milk production during heat stress**
  - **$1.00 to $1.50 cow/day**
- **Reproduction?**
- **Future milk production?**
- **Health?**
- **Pay back is one year in most cases**

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System Selection

- **Critical factors in system selection**
  - **Type of dairy**
    - **Dry Lot**
    - **Freestall**
  - **Climate**
    - **Temperature**
      - **Maximum temperatures**
    - **Humidity**
      - **Morning**
      - **Afternoon**
  - **What are you cooling?**
    - **Cow or Air**

System Options

- **Low pressure soaking**
  - **Cooling the cow**
  - **Works in arid and humid climates**
  - **Works well in MW climates**
- **Evaporative cooling**
  - **Cooling the air**
  - **Works in arid climates**
- **Combination**
  - **Severe heat and humidity**

Priorities to Reduce Heat Stress (Lactating & Dry Cows)

- **1.Water availability**
- **2. Providing shade in the housing areas and holding pen (Lactating & Dry)**
- **3. Reduce walking distance to the parlor**
- **4. Reduce time in the holding pen**
- **5. Improve holding pen & freestall ventilation**

Priorities to Reduce Heat Stress (Lactating & Dry Cows)

- **6. Add holding pen cooling and exit lane cooling**
- **7. Cool close-up cows (3 weeks prior to calving)**
- **8. Cool fresh cows and early lactation cow housing**
- **9. Cool mid & late lactation cow housing**

Thank You!!!!

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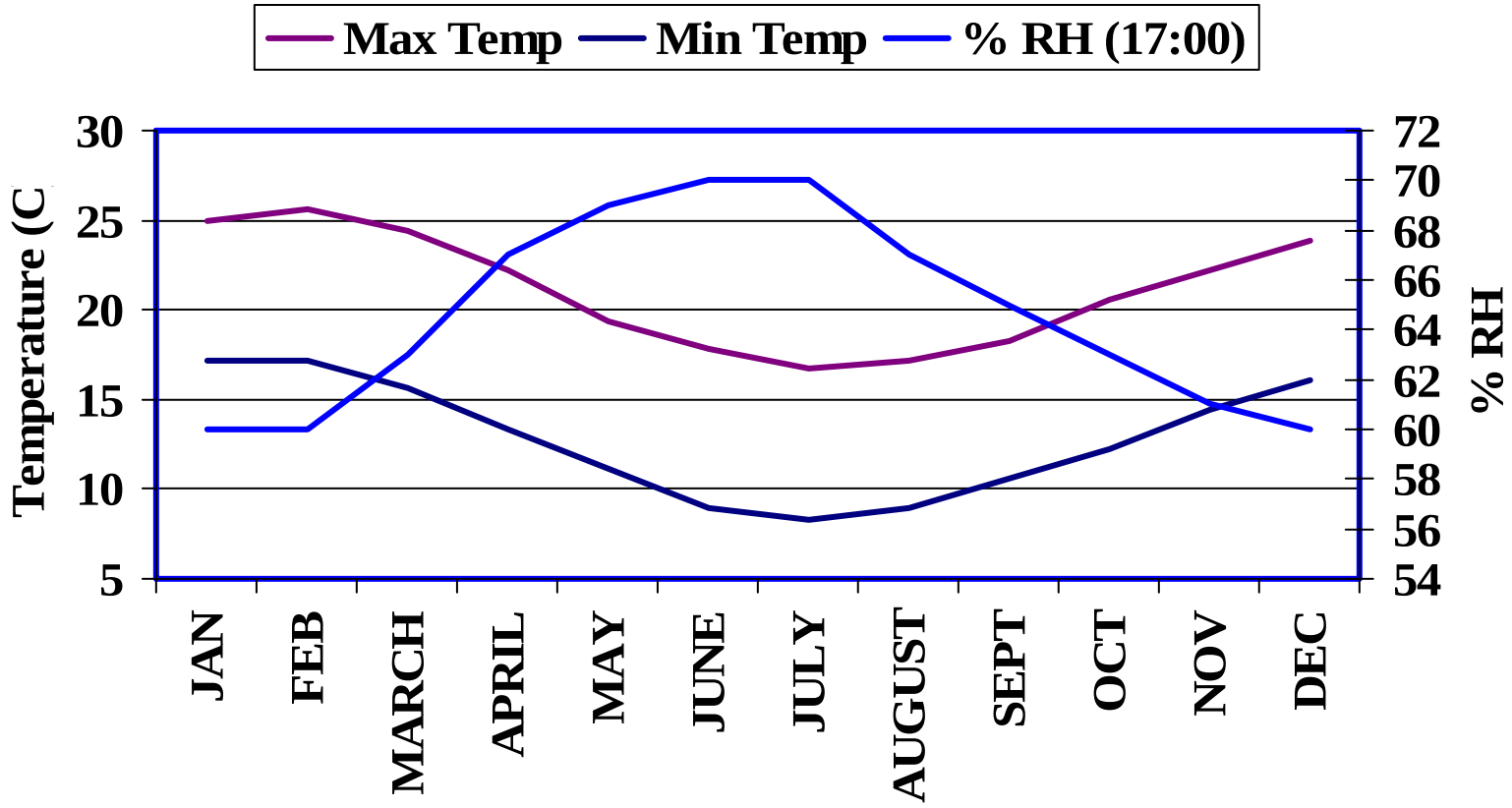
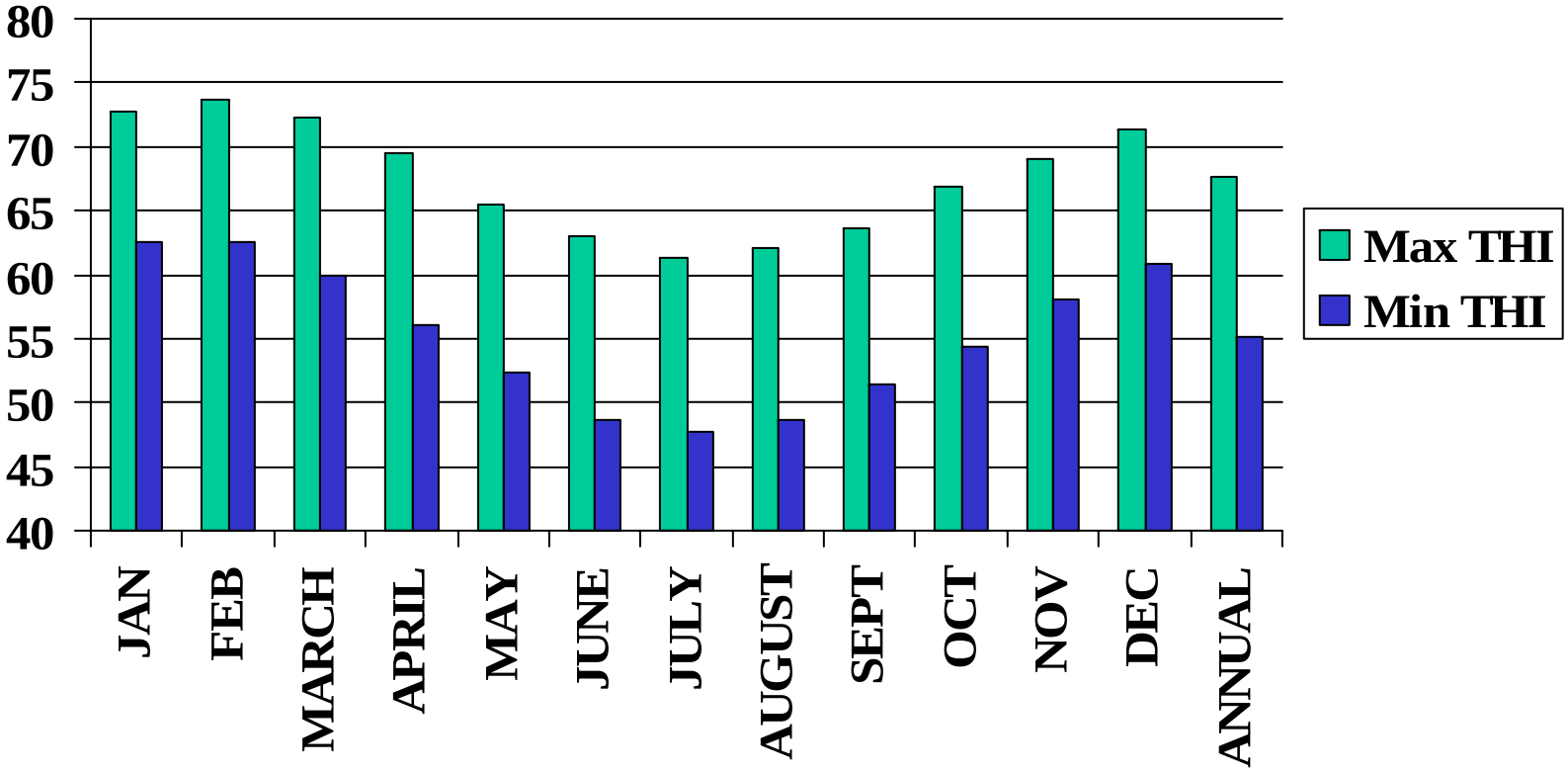
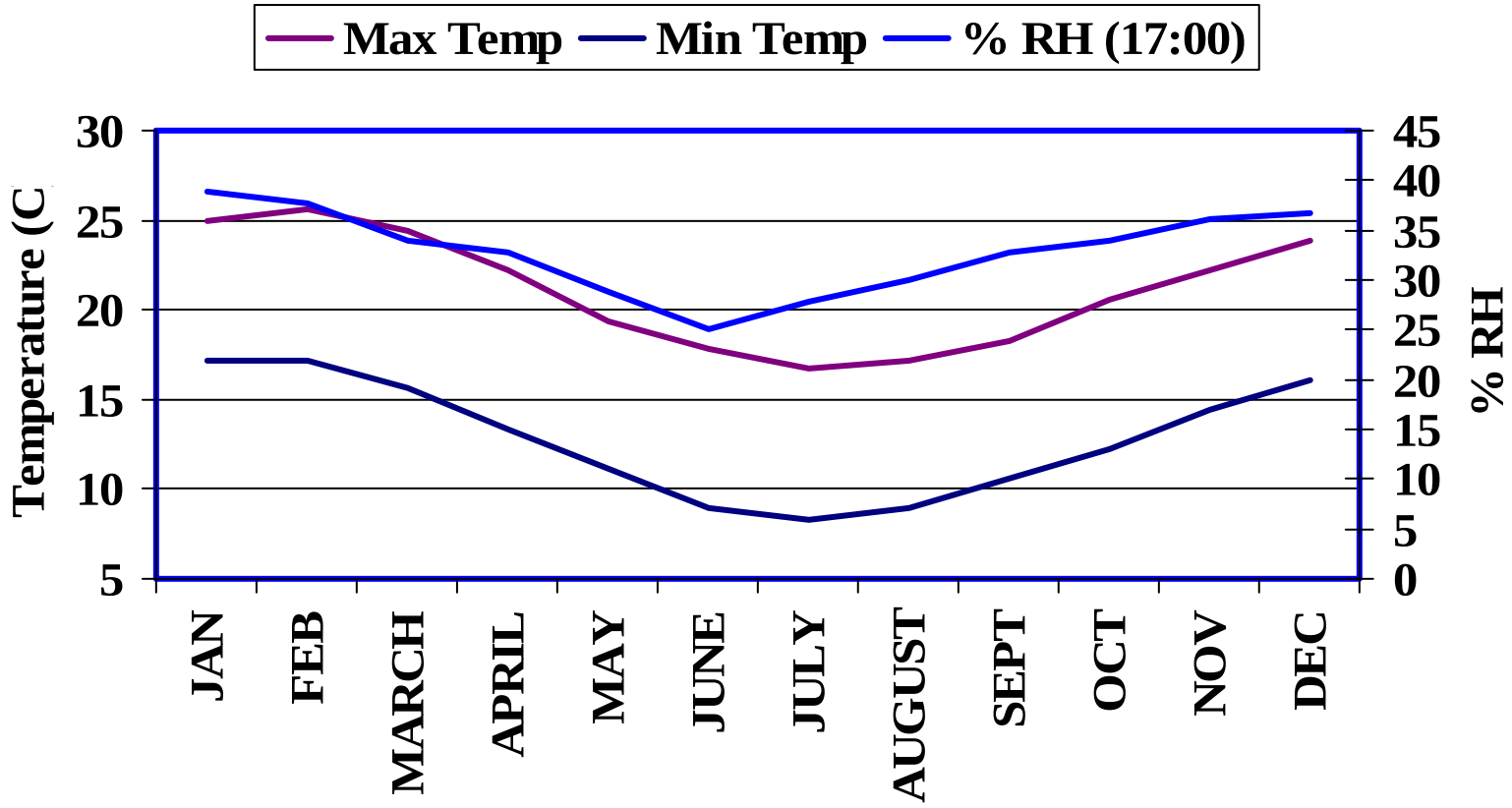
Weather Data (% RH and Temp.)
Cape Town, South Africa



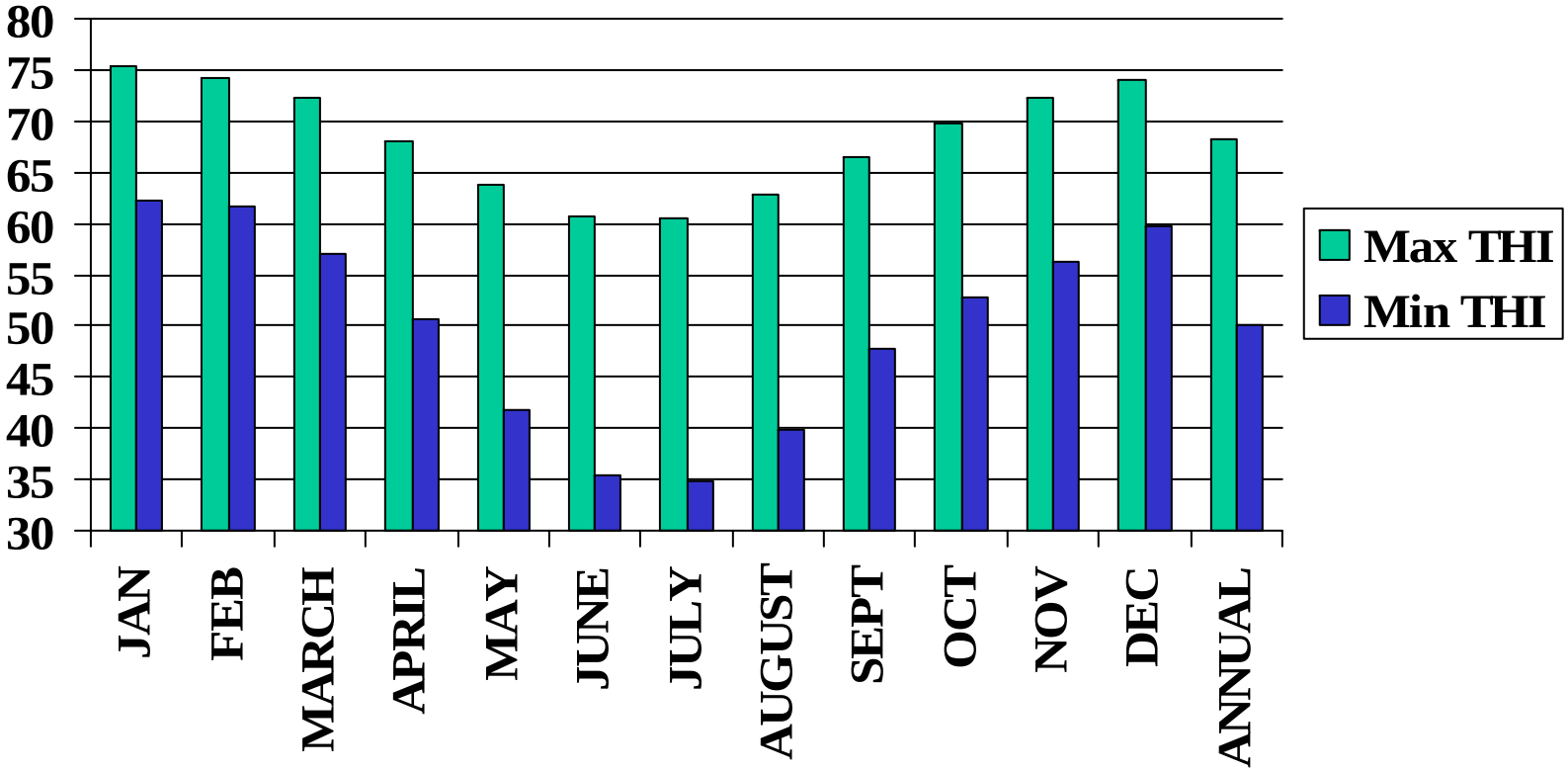
Weather Data (THI)
Cape Town, South Africa



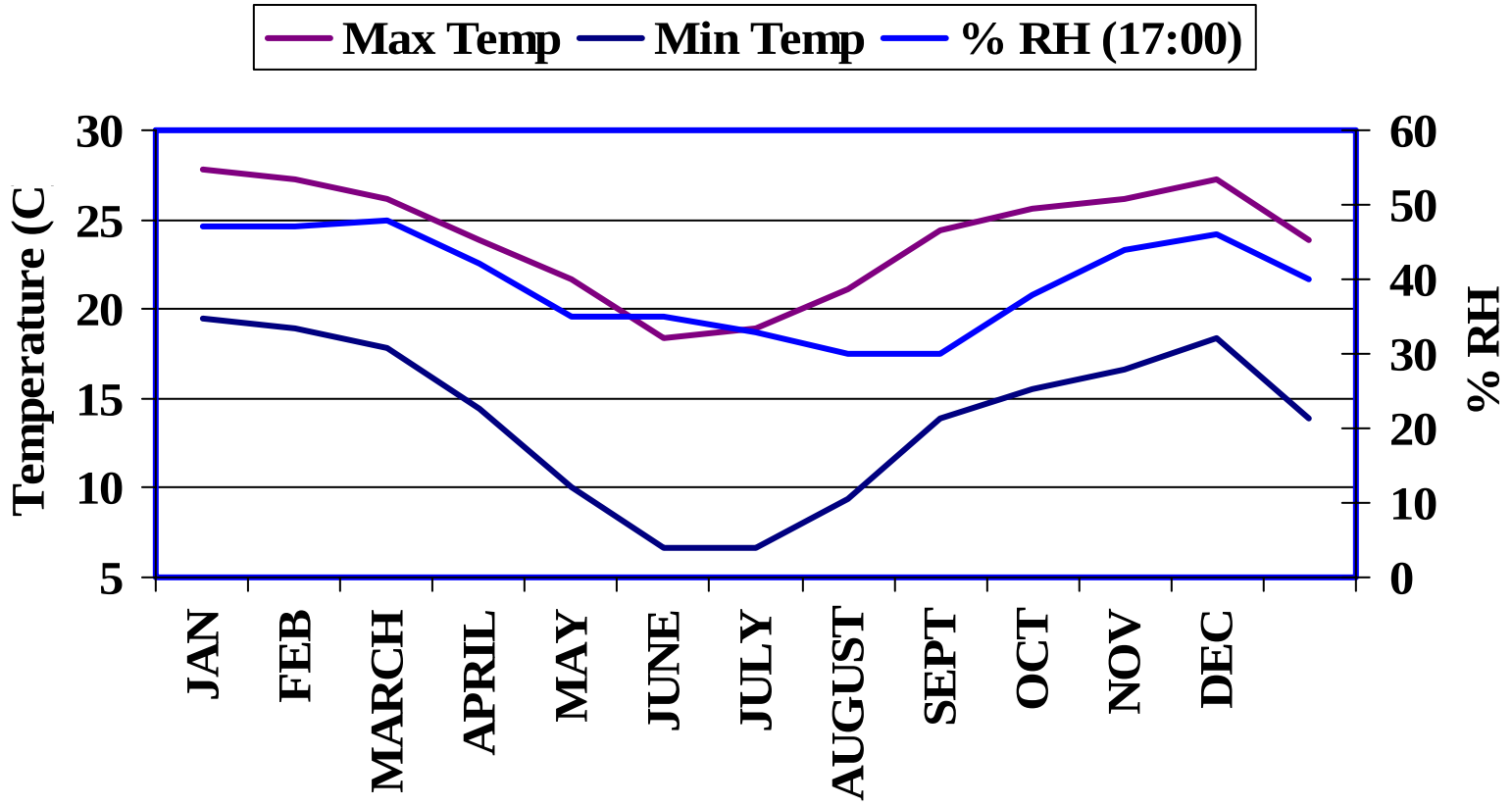
Weather Data (% RH and Temp.) Bloemfontein, South Africa



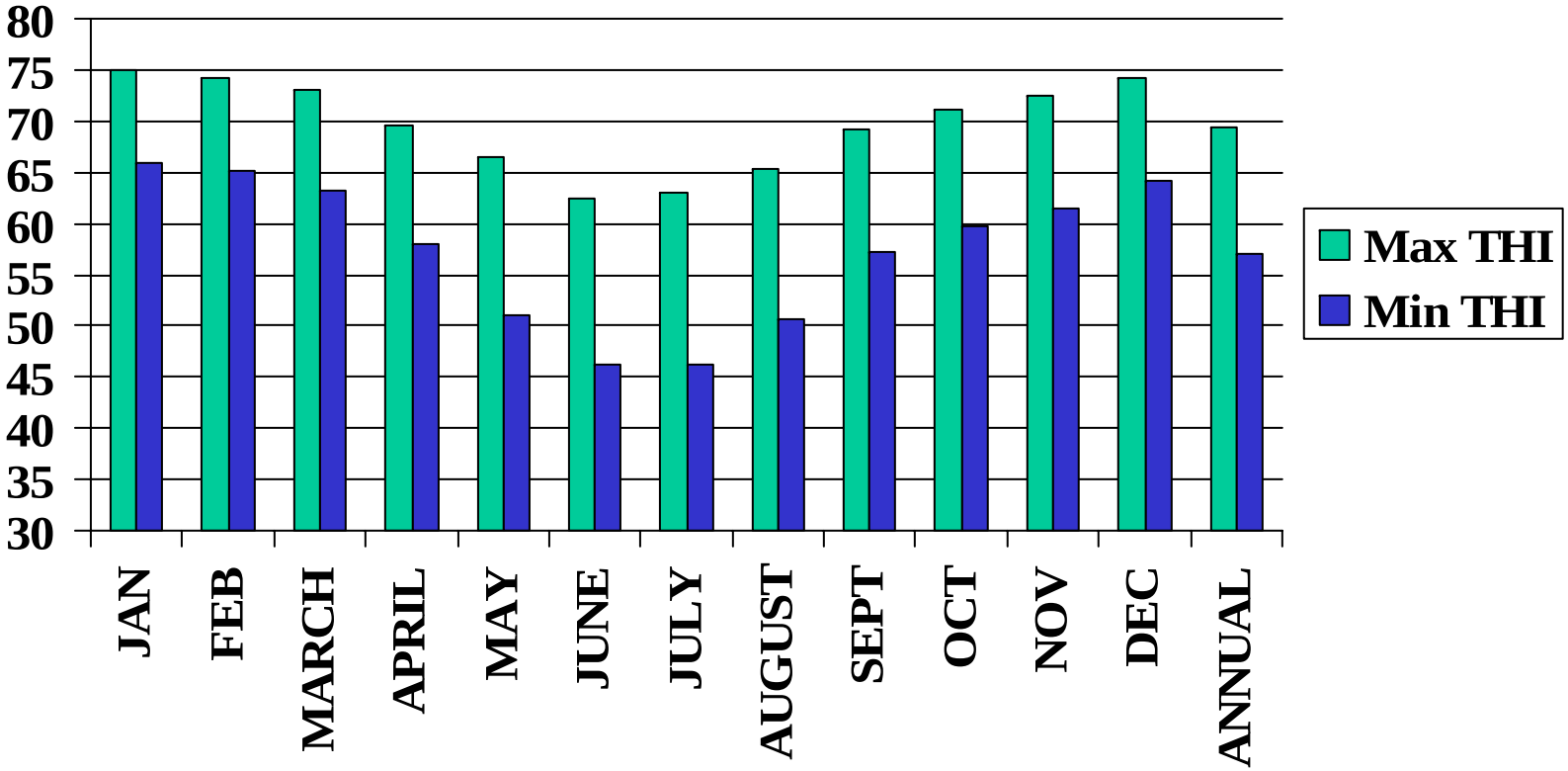
Weather Data (THI)
Bloemfontein, South Africa



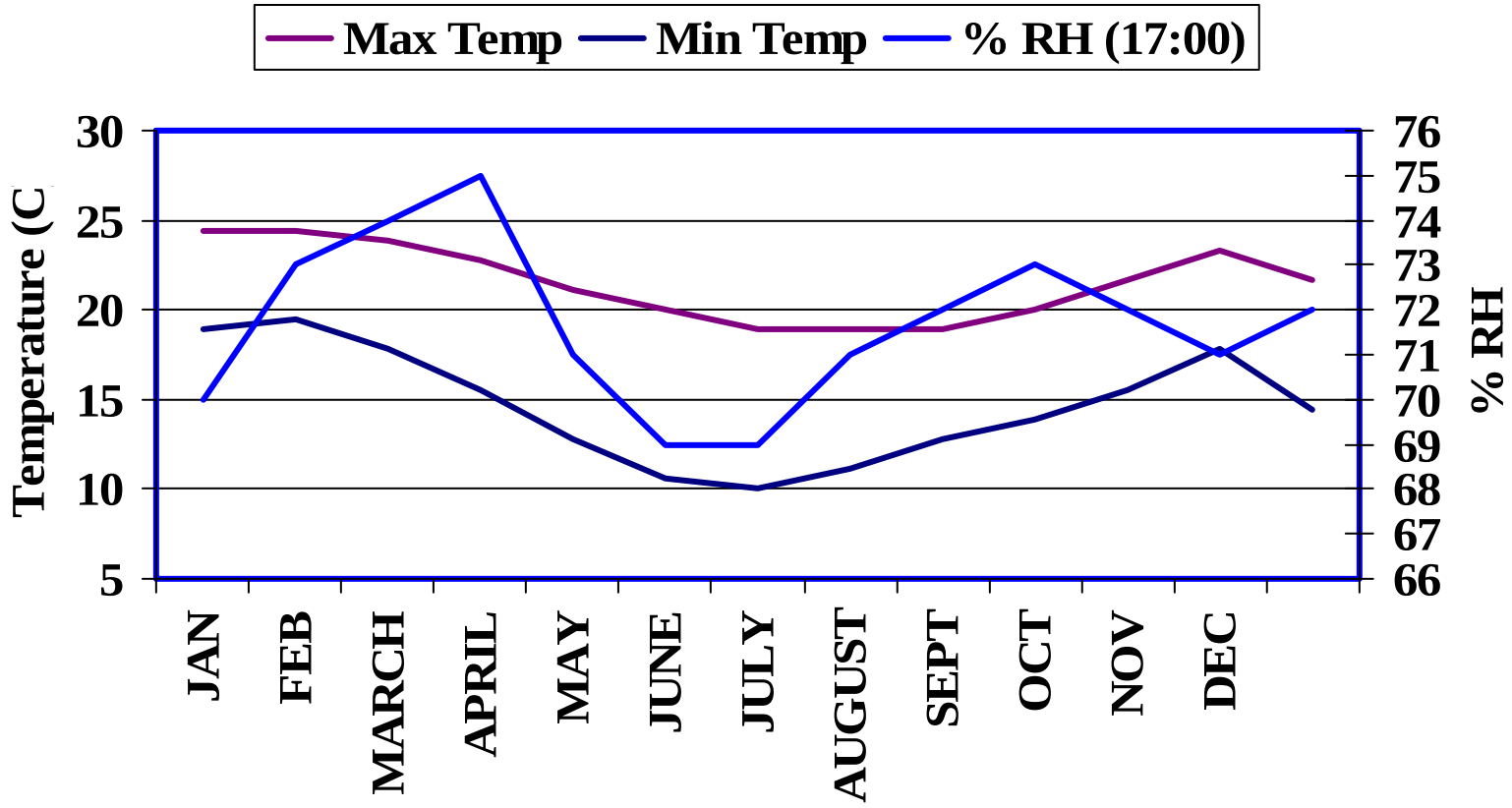
Weather Data (% RH and Temp.)
Pretoria, South Africa



Weather Data (THI)
Pretoria, South Africa



Weather Data (% RH and Temp.)
Port Elizabeth, South Africa



Weather Data (THI)
Port Elizabeth, South Africa