



# Salmonella

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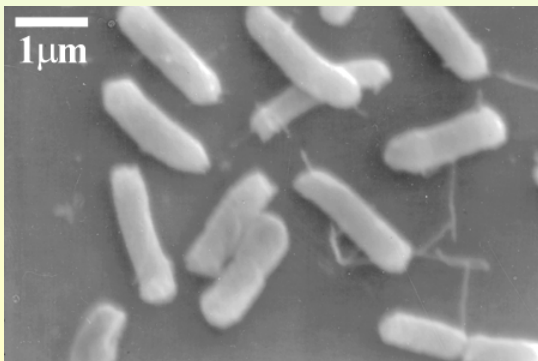
# What's Salmonella ?

- Salmonella is a **bacteria**
  - ◆ Rod shaped
  - ◆ Appears pink to red when stained with Gram's stain (**Gram-negative**)
  
  - ◆ Belongs to a family; *Enterobacteriaceae* (intestinal bacteria)
    - ◆ Salmonella (genus)
      - ◆ enterica ( species)
      - ◆ serotype ( over 2200 serotypes)

Light Microscope



Electron Microscope

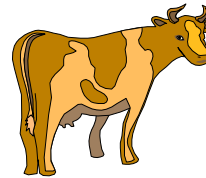


Example: *Salmonella enterica* serotype Dublin  
S. Dublin

# Where does Salmonella come from ?

■ Inhabitant of intestinal tract of

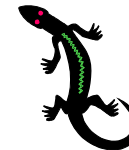
◆ animals



◆ birds



◆ reptiles



◆ insects



## Host adapted

Human: *S. Typhi*

Cattle: *S. Dublin*

Poultry: *S. Pullorum*

Pigs: *S. Choleraesuis*

## Non host adapted

*S. Typhimurium*  
and others



# What's Salmonellosis ?

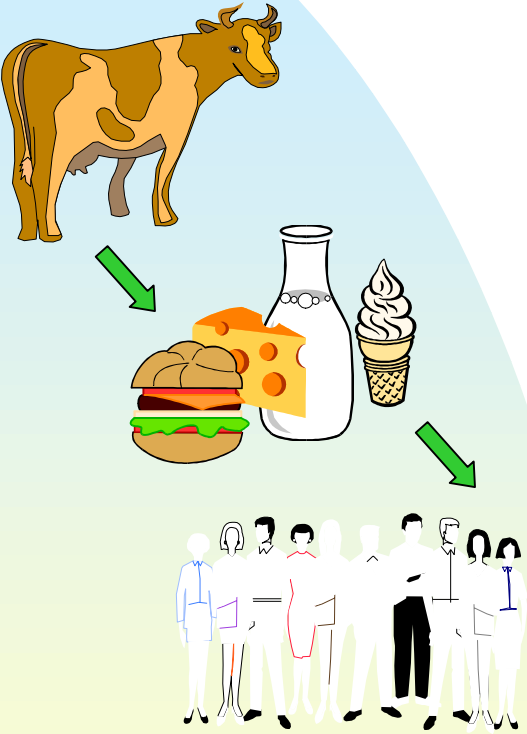
- clinical illness in animals or human beings caused by *Salmonella* sp.

## Is *Salmonella* communicable between animals and humans ?

**YES !**

- Human outbreaks of Salmonellosis in the United States are frequently associated with food products of animal origin including eggs, meat, milk and milk products

**38 Outbreaks, 14 (37%)  
traced to products of  
bovine origin !**





# Salmonella in Cattle

## Salmonella in raw milk



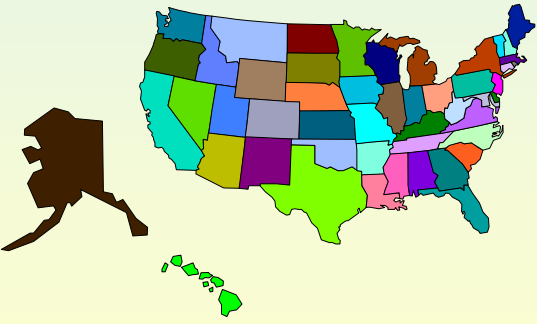
**Wisconsin --- 4.7%**  
**Tennessee --- 8.9%**  
**South Dakota - 6.1%**

- **Magnitude of the problem**
  - ◆ National survey
    - ❖ 2.1% fecal samples from 7.4% of farms
  - ◆ Cull dairy cows
    - ❖ 4.6% of cull cows (Washington State)
  - ◆ Neonatal calves
    - ❖ Ohio- 4.8% farms; California- 16 % farms
  - ◆ Missing information
    - ❖ Estimates of economic losses
      - calf and adult cattle
      - milk production
      - contaminated raw bulk tank milk



# Bovine Salmonellosis

- Common serotypes isolated from cattle in the United States
  - ◆ **S. Dublin** - ( group 'D') -----
  - ◆ **S. Typhimurium** - ( group 'B') --- } **Most common**
  - ◆ **S. Newport** - C
  - ◆ **S. Muenster** - E
  - ◆ **S. Saintpaul** - B
  - ◆ **S. Anatum** - E
  - ◆ **S. Kentucky** - C
  - ◆ **S. Montevideo** - C



# How does Salmonella enter a farm ?

**Most important sources of infection**



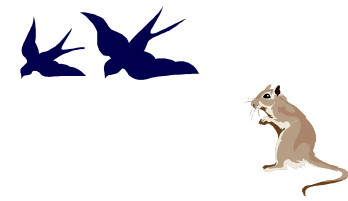
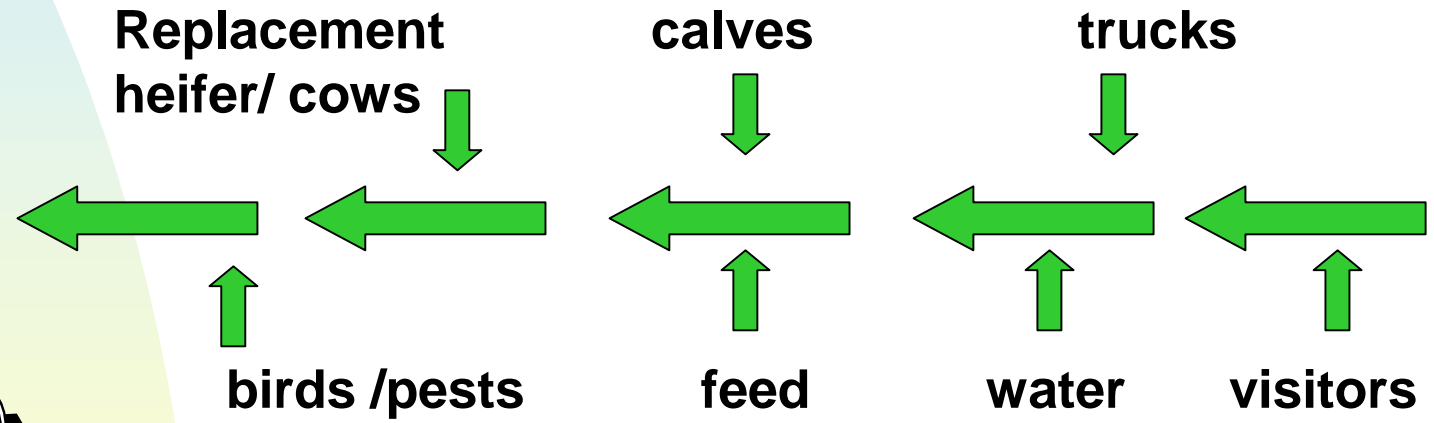
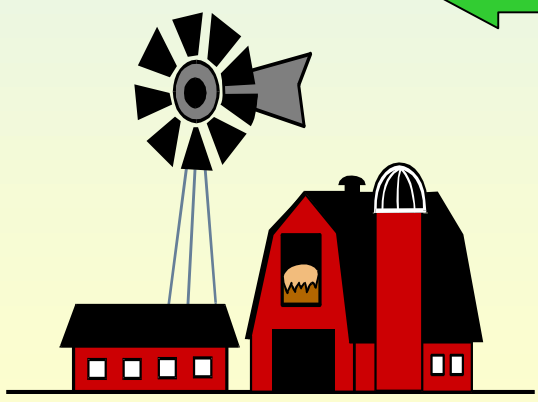
**Replacement heifer/ cows**



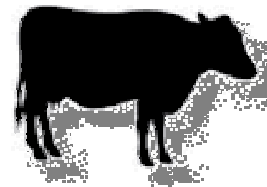
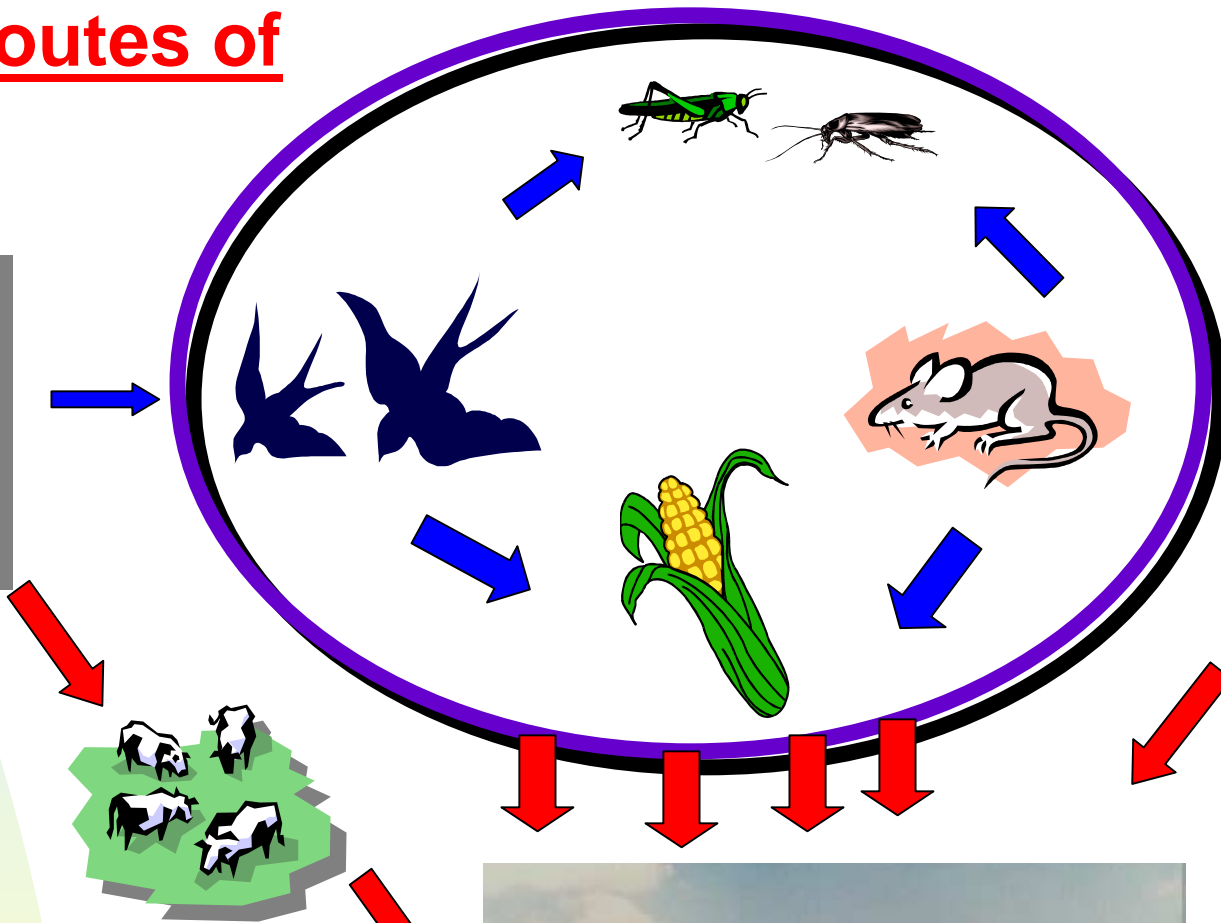
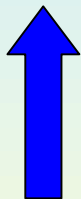
**calves**



**trucks**



# Other routes of entry





# Salmonella & host interaction

**Contaminated**



feed



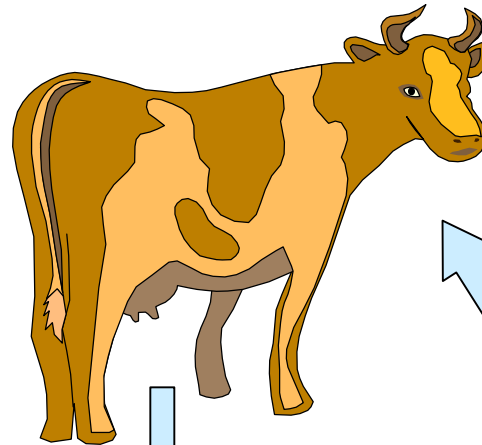
water



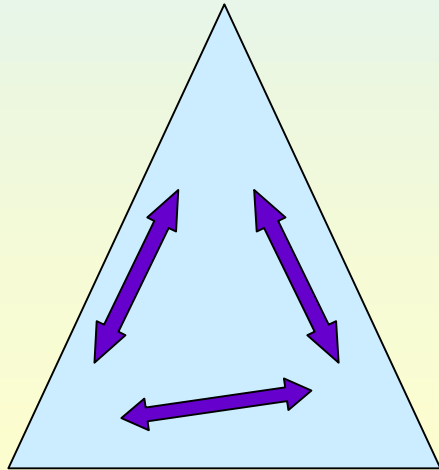
feces



colostrum / milk



**Animal**



**Salmonella      Environment**

**Intestine**

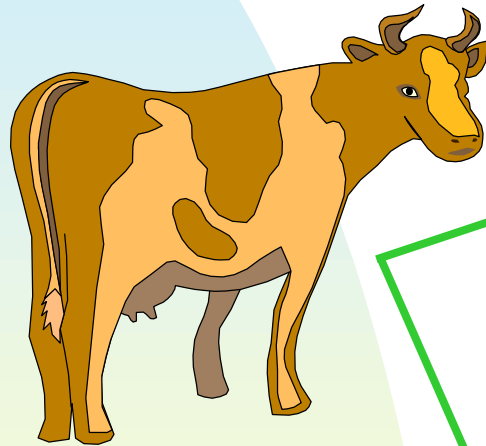


**Microscopic picture of small intestine**

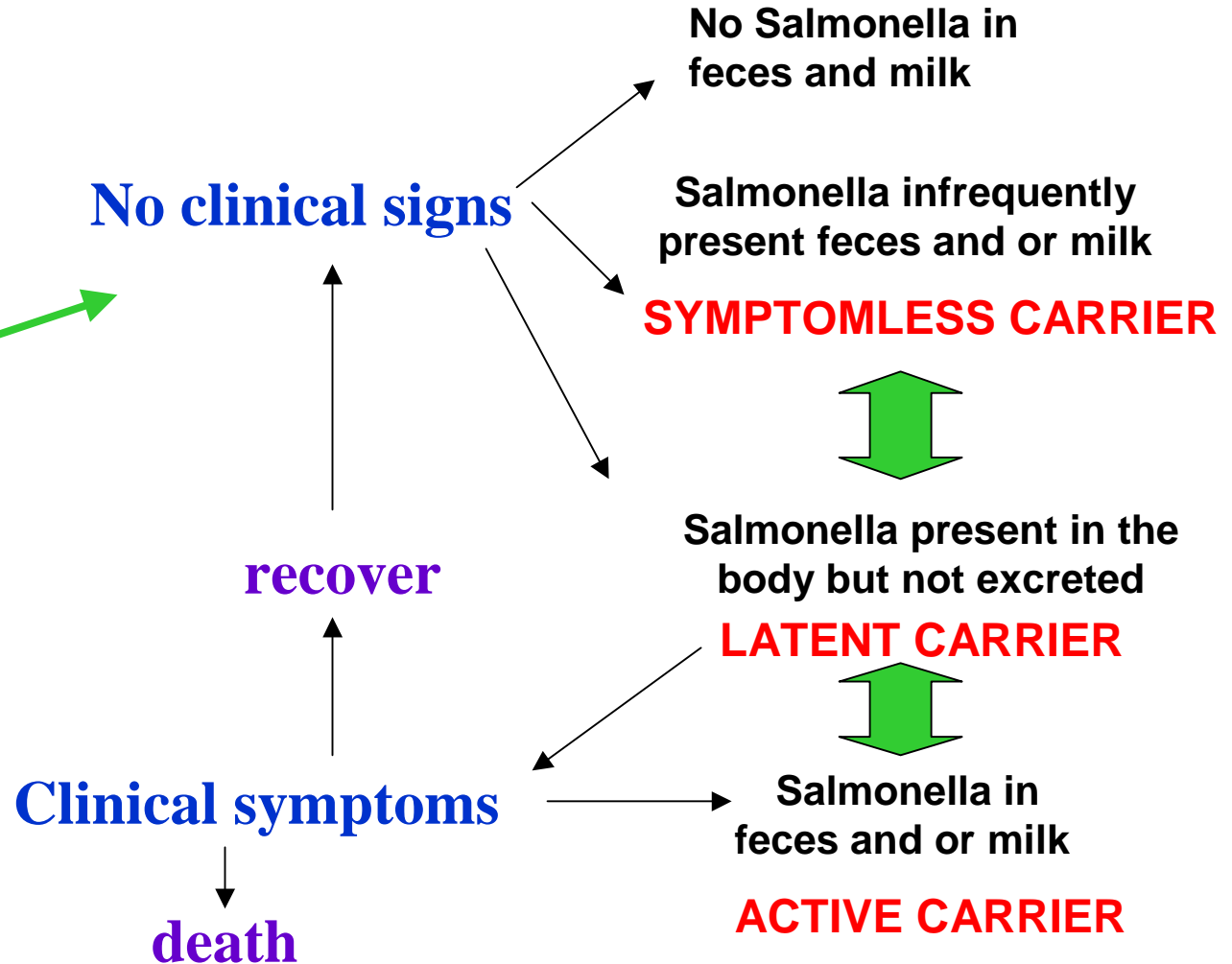


**OUTCOME ?**

# Outcome of an Salmonella infection ....



Fever, diarrhea, bloody stool, dehydration, anorexia/ emaciation rapid breathing, sloughing of skin from extremities





# Salmonella carriers ?

- Animals with Salmonella infection that **appear healthy** and show no signs of disease make

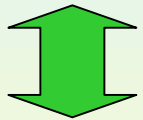
**detection**

**diagnosis**

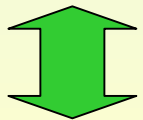
**prevention and control**

one of the **most difficult tasks** to achieve and provide the **greatest challenges** to the animal health industry.

**ACTIVE CARRIER**



**LATENT CARRIER**



**SYMPTOMLESS CARRIER**



# Salmonella Infection

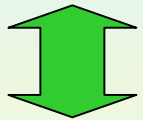
## ■ Detection

- ◆ isolation from pooled samples from high risk individuals
- ◆ repeated sampling to detect subclinical carriers

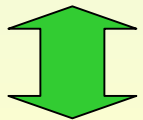
## ■ Diagnosis - culture based

- complete typing of isolates
- Serology limited except for S Dublin carriers and to determine exposure to other serotypes

ACTIVE CARRIER



LATENT CARRIER



SYMPTOMLESS CARRIER



# "Characteristics of Salmonella and Salmonellosis --- points to remember"\*

**ONE** : Infection on a farm is maintained primarily by transmission of Salmonella from feces of infected animals to mouths of susceptible animals.

**ACTION:** Break the links in the chain by minimizing opportunity for fecal contamination of feedstuffs, feeding surfaces, water troughs and equipment

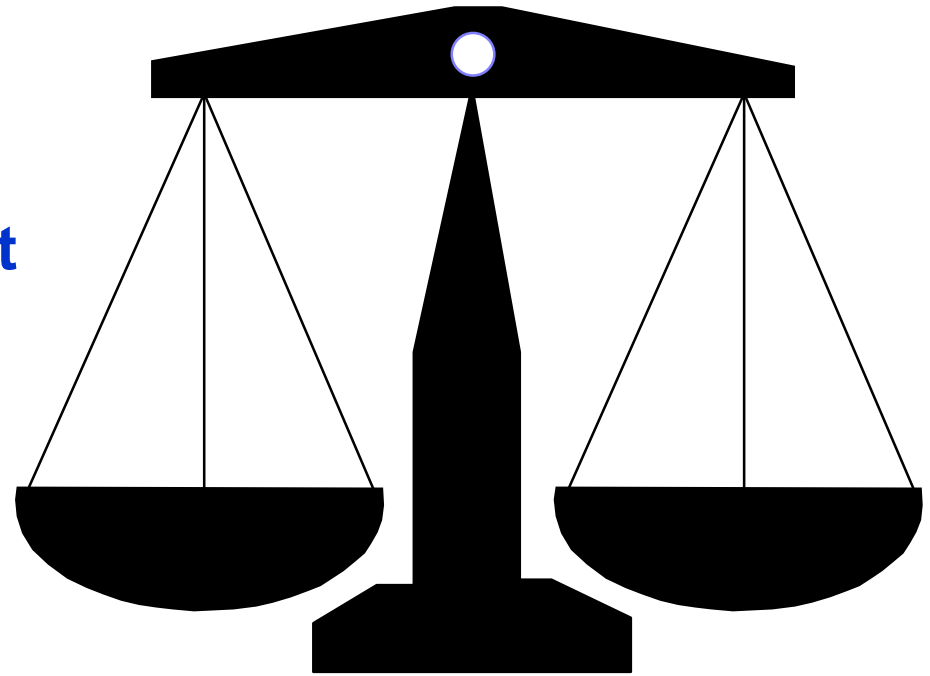
\* Partly taken from:  
John M. Gay,  
Bovine Herd Salmonellosis  
<http://www.vetmed.wsu.edu/courses-jmgay/fdiuherdsalmonella.htm>





## **TWO:** Salmonella infection & subsequent clinical disease is a result of :

- **ACTION:** Maximize host resistance by paying careful attention to the transition of susceptible animals (periparturient cows, newborn calves).



### **Organism**

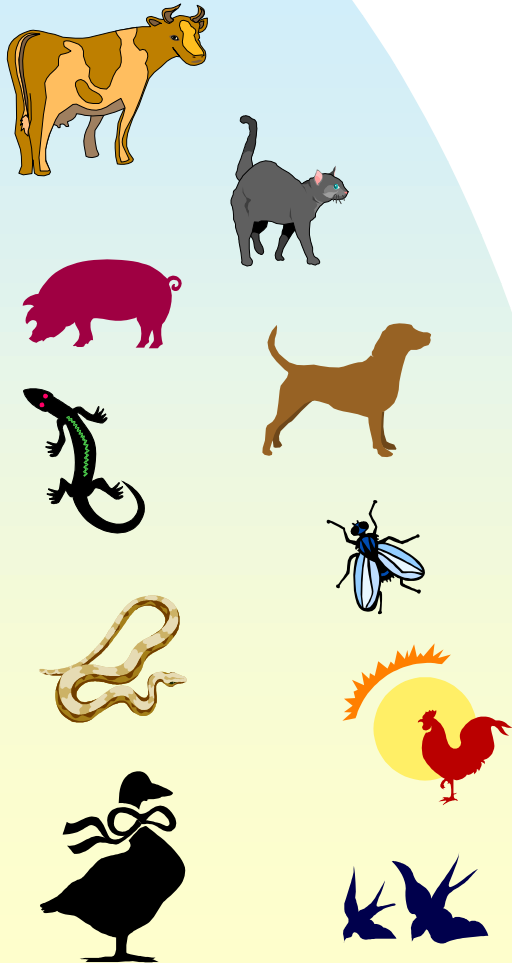
- \* serotype
- \* virulence
- \* No. of organisms

### **Animal**

- \* age
- \* immunity
- \* nutrition
- \* prior exposure
- \* stress



**THREE:** Salmonella infects anything in the livestock environment that has an intestinal tract:



**ACTION:** Initiate control programs

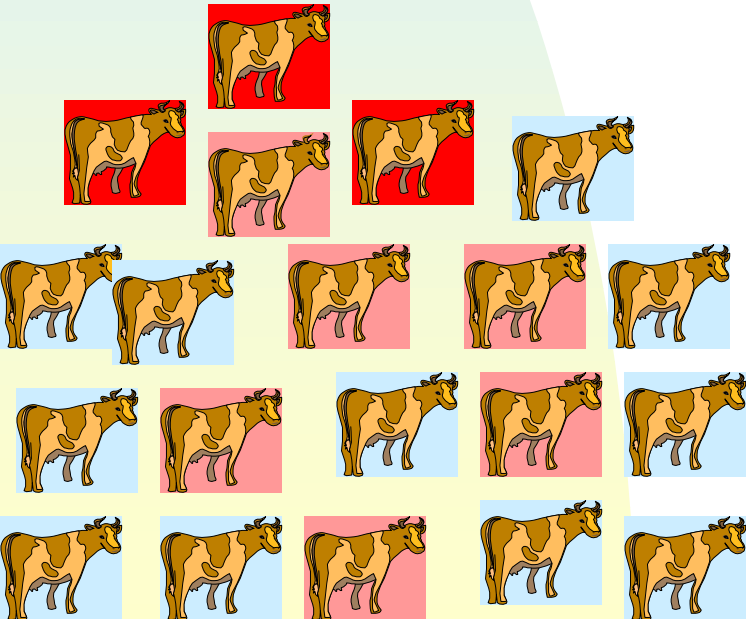
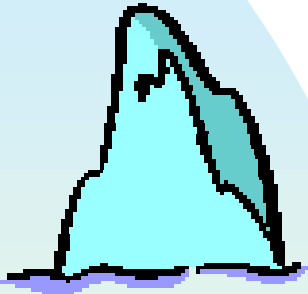
1. Rodent proof and bird proof feed storage
2. Remove nesting and roosting opportunities
3. Restrict access by pets and feral cats

# ICEBERG EFFECT

**FOUR:** Majority of Salmonella infections in a herd over a period of time are symptomless

Clinical infections are only the tip of the iceberg, even during clinical outbreaks of disease

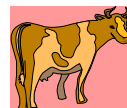
**ACTION:** in an outbreak handle all animals as if they were shedding not just the sick ones. Reduce water and feed contamination.



Clinical



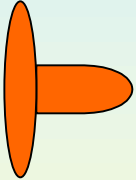
Normal



Subclinical



## **FIVE :** Septicemic animals shed **Salmonella** through saliva, nasal secretions, urine, milk and feces without enteric signs



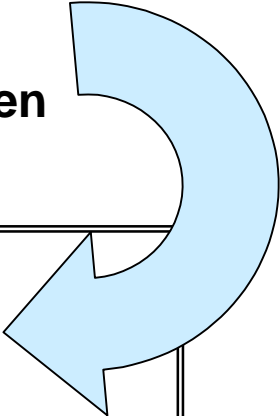
- Such animals **pose a great threat** in controlling spread of **Salmonella** infection as they contaminate
  - ◆ water bowls
  - ◆ nipples
  - ◆ oral treatment equipment (balling guns, esophageal feeders)
  - ◆ human hands
- **ACTION:** Clean all equipment with Chlorhexidine ( 3 oz. / gal) and other items such as boots and mats with orthophenylphenol.



1. **Normal Dry Matter Intake**
2. **Normal VFA level**
3. **No Growth of Salmonella in rumen**

1. **Lowered Dry Matter Intake**
2. **Lowered VFA level**
3. **Increase in number of Salmonella in rumen**

**SIX:**  
Salmonella are usually killed by exposure to the volatile fatty acids of fully functional normal rumens

- 
1. Don't have regular access to feed
  2. During transport
  3. Parturition
  4. Subclinical ketosis
  5. Hypocalcemia
  6. Sudden ration changes
  7. Ration maladaptation
  8. Inadequate bunk space and pen space
  9. Mixing submissive heifers with dominant cows at parturition

**ACTION:** Maximize rumen function by maximizing a consistent dry matter intake in periparturient and early fresh cows



## **SEVEN:** Salmonella survives for long periods under conditions common on the livestock farm

- **Colostrum**
  - ◆ 30 C, 2 to 5 weeks.
  - ◆ 5 C to 11 C, for ~ 10 days, low pH will reduce the number of Salmonella
  
- **Pasture and soil** ---- 200 days
- **Garden soil** ---- 251 days
- **Liquid manure** --- 27 days ( S. Dublin), --- 286 days ( S. Anatum)
- **Slurry** - 84 to 250 days
- **Infected feces stored in cans** - 159 days ( S. Dublin)



# **EIGHT:** People who are at risk of illness

## ■ **Farm workers and Visitors**

- ◆ **Expectant mothers handling sick animals**
- ◆ **Working with sick calves and cows**
- ◆ **Poor personal hygiene**
- ◆ **Consuming raw bulk tank milk**
- ◆ **Avoid fecal and salivary contact!**

## ■ **Public - Consumers**

- ◆ **Consuming raw milk, fresh cheese made of raw milk.**

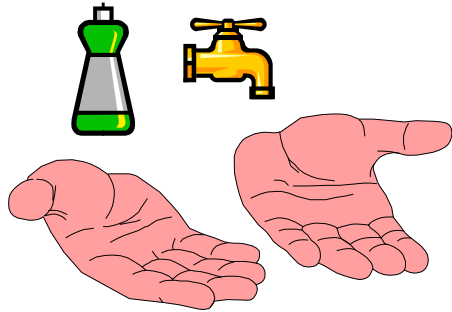


# **NINE:** Personal hygiene practices on farm

## Wash hands with soap and water

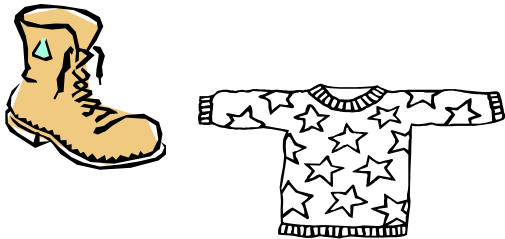
A **must** before and after:

1. Attending sick calves and animals
2. Milking cows ( also wear gloves)
3. Manure handling

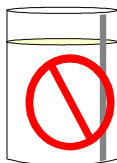


## Dress and boots

1. Change into farm boots on the farm
2. Wash farm boots regularly
3. Leave farm boots on the farm
4. Wash and disinfect farm clothes



**IF available: shower before leaving the farm**



**DO NOT drink raw milk**



# Salmonella Typhimurium DT 104

- Emerging foodborne pathogen
- Detected in several countries
- Why is DT 104 of concern ?
  - ◆ Multiple antibiotic resistance
    - ◆ Ampicillin
    - ◆ Chloramphenicol
    - ◆ Streptomycin
    - ◆ Sulfonamides
    - ◆ Tetracycline
- DT 104 has been isolated from;
  - ◆ poultry, swine, **cattle** and wild animals



## United States

### ◆ Humans

- ◆ **S. Typhimurium: 8510 (1990) ----- 9510 (1996)**
- ◆ **S. Typhimurium DT 104: 766 (1990) ----- 3138 (1996)**

### ◆ Cattle ( Northwest)

- ◆ **DT 104: No isolations till 1986**
  - 13% --- 1986 to 1991
  - 64% ---1991 to 1996

### ■ Outbreaks ( human) in the US:

- ◆ 4 ( 3 - west coast, 1- east coast)
  - ◆ **ALL 4 OUTBREAKS LINKED TO UNPASTEURIZED DAIRY PRODUCTS**
  - ◆ **SOURCE OF DT 104 IN TWO OUTBREAKS, TRACED TO DAIRY FARMS**



- No unique control methods available for *S. Typhimurium* DT 104 in animals.
- Control measures that are effective against other types of *Salmonella* will reduce the likelihood of transmission of *S. Typhimurium* DT 104.





# Risk factors for Salmonella Typhimurium DT 104



- **Cattle in dealer premises** were at increased risk of disease (**Odds ratio 14.25**)
- Introduction of **newly purchased cattle** ( 4 weeks after purchase) to the farm increases the risk of disease (**OR 2.51**)
- Purchase **via dealers** was at high risk **as compared** with purchasing stock directly from **other farms** (**OR 3.90**)

Evans S., and R. Davies. 1996. Case control study of multiple - resistant Salmonella typhimurium DT 104 infection of cattle in Great Britian. Vet. Rec. 139 :557:558.



# Risk factors for Salmonella Typhimurium DT 104



- **Persistently contaminated buildings** may be a source of infection **(OR 2.48)**
- **Lack of isolation facilities** for ill animals was associated with an increased risk of disease
  - ◆ In particular; if cows calved in buildings that previously housed diseased stock **(OR 1.51)**
- A **high population density of cats** around the farm increased the risk of infection **(OR 1.35)**
- Evidence of **access to cattle feed stores by wild birds** was associated with an increased risk of disease **(OR 1.67)**



# Risk factors for Salmonella Typhimurium DT 104



**Risk factors over which the dairy producer can exert control:**

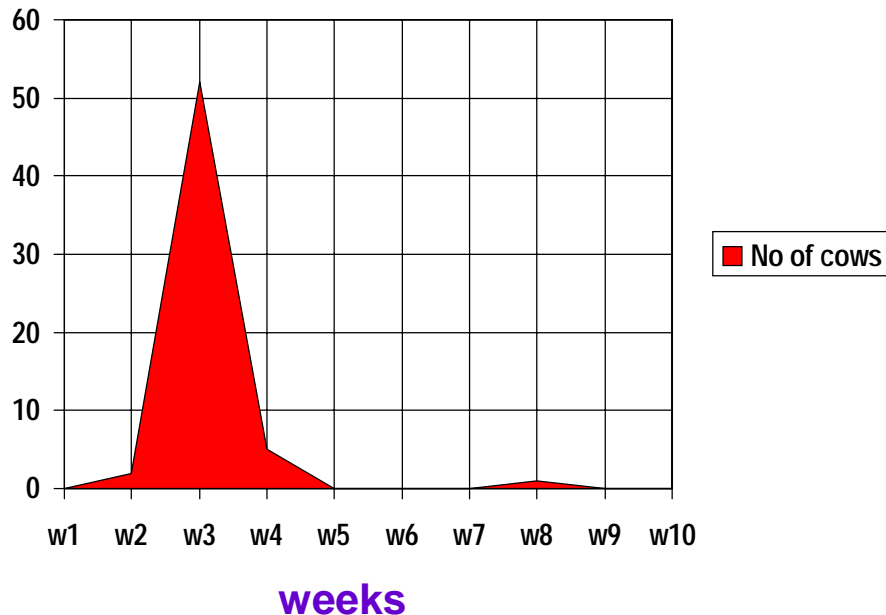
1. **Purchasing replacement stock** from direct sources rather than a dealer
2. **Quarantine of purchased cattle** for a 4 week period
3. **Housing sick animals** in dedicated isolation areas
4. **Preventing wild bird access** to cattle feed stores
5. **Vaccination**



# Typical Scenario-1



No of animals

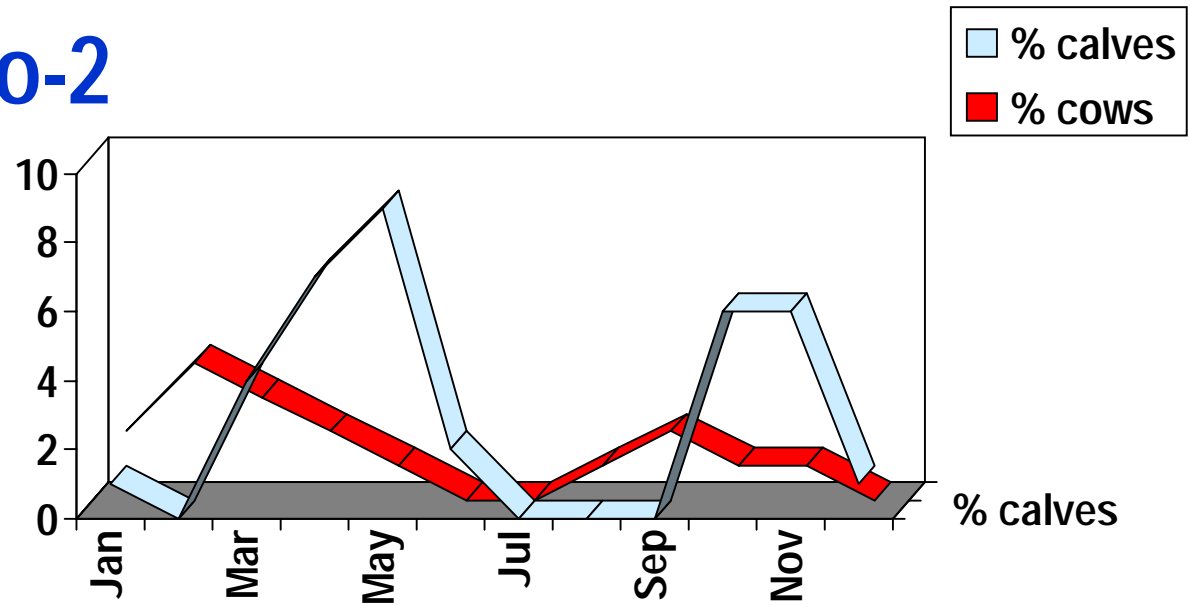


## OUTBREAK

- Newly assembled herd, animals from unknown source, or from a dealer
- High morbidity ( at least 40 - 60% in the herd infected)
- Drop in milk production, ~ 10 %, high risk of bulk tank milk contamination
- Typically observed with *S. Typhimurium*, lasts 2-4 weeks
- Samples taken during outbreak show extensive herd contamination
- Samples collected 4-6 weeks later, most of which test negative
- Subsequent outbreaks or infections may be sporadic, or may go unnoticed



# Typical Scenario-2



## ■ Recurrent Salmonella infection in calves and cows

- ◆ Cycling of Salmonella in a herd
- ◆ Typically seen with Salmonella group D and group E
- ◆ Presence of animal reservoir or extensive environmental contamination
- ◆ **Hot spots:** Maternity area, calf housing areas, watering troughs
- ◆ Identify carriers, massive environmental cleanup, put in place appropriate management practices.



# Other Scenarios...

**Pre-fresh and or  
fresh cows sick**

**Calves and cows you  
recently sold caused  
Salmonellosis**

**Salmonella detected in  
milk filters and  
bulk tank milk**

**Family member  
diagnosed with  
Salmonellosis after  
drinking raw milk**

**Recurrent diarrhea and  
loss of calves**

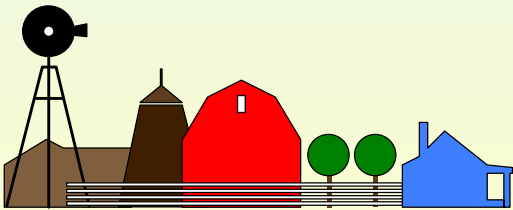


# Strategies for Prevention and Control of Salmonellosis



# Principles of Salmonella Control on Dairy Farms

- Reduce exposure
  - ◆ Biosecurity - incoming animals and between groups
  - ◆ Prevent fecal -oral and salivary transmission
  - ◆ Avoid use of waste milk for calves
  - ◆ Feed and water biosecurity
  - ◆ Rodent and bird control







# Principles of Salmonella Control on Dairy Farms

- Maximize immune status
- Minimize stressors
- Maximize feed intake in the periparturient period.
- Implement a sound general herd vaccination program



# Principles of Salmonella Control on Dairy Farms

- **Control measures during a Salmonella outbreak**
  - ◆ **Identify and isolate sick animals**
  - ◆ **If possible, identify source of bacteria, and eliminate**
  - ◆ **Institute hygiene measures (fecal-oral, salivary, milk spread)**
  - ◆ **Vaccination ?**
  - ◆ **Treatment of infected animals ?**



# Control measures during a Salmonella outbreak

- **Human health precautions during a Salmonella outbreak**
  - ◆ Avoid exposure of young, old, or immune compromised people
  - ◆ Limit number of people handling sick animals
  - ◆ Avoid having same people handle sick and well animals
  - ◆ Hygienic measures
    - ◆ **foot bath**
    - ◆ **handwash**
    - ◆ **separate clothes/footwear for sick animal handling**
  - ◆ Prevent pet animal exposure to cattle
  - ◆ **DON'T DRINK RAW MILK FROM AFFECTED FARM**



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# END

NYSCHAP gives a special thanks to **Bhushan Jayarao from Penn. State University** for use of these slides.

(with some modifications by Stehman and McDonough, Cornell)