Salmonella in Eggs: Issues and Research

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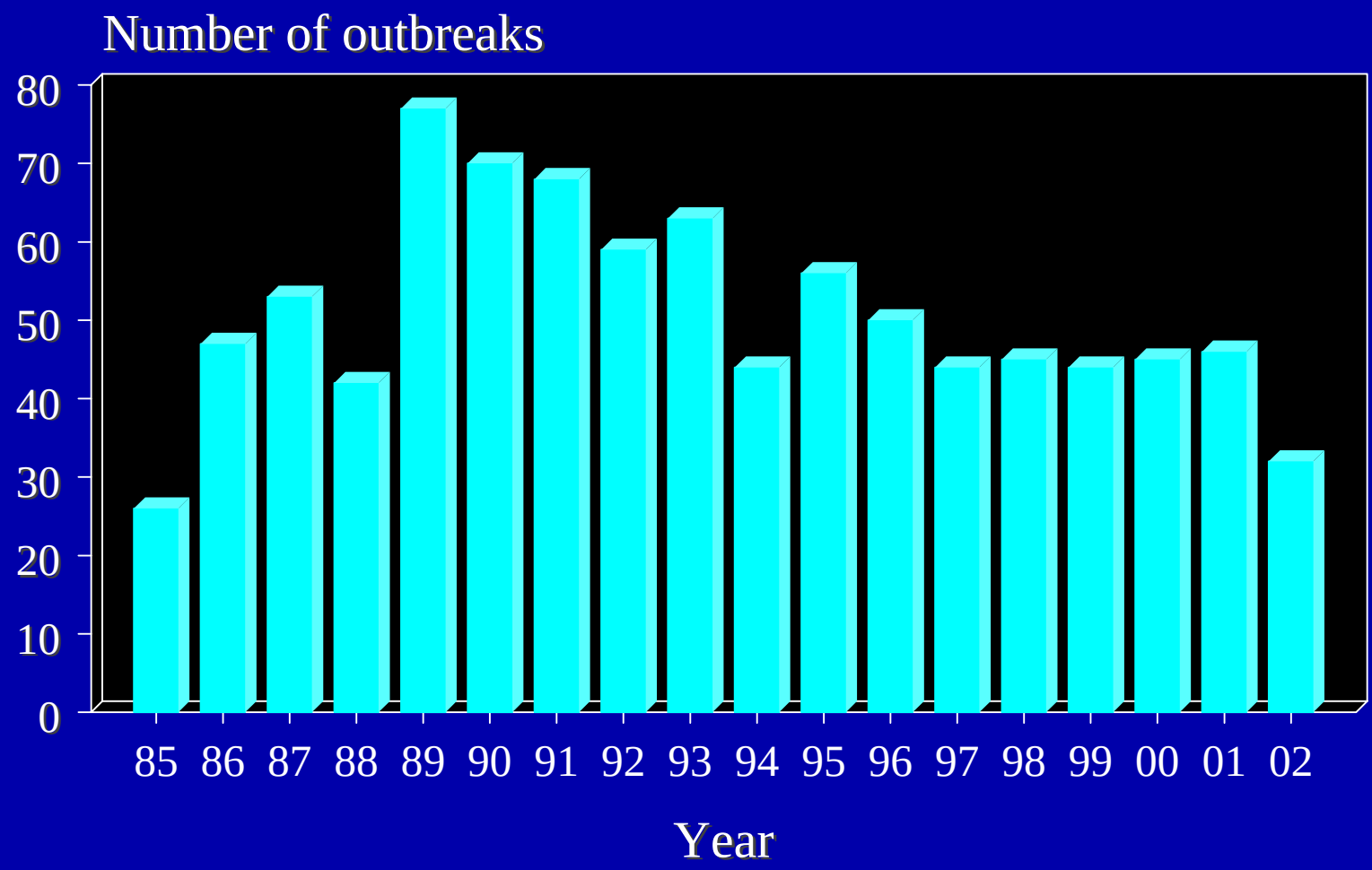
S. enteritidis Outbreaks in the USA

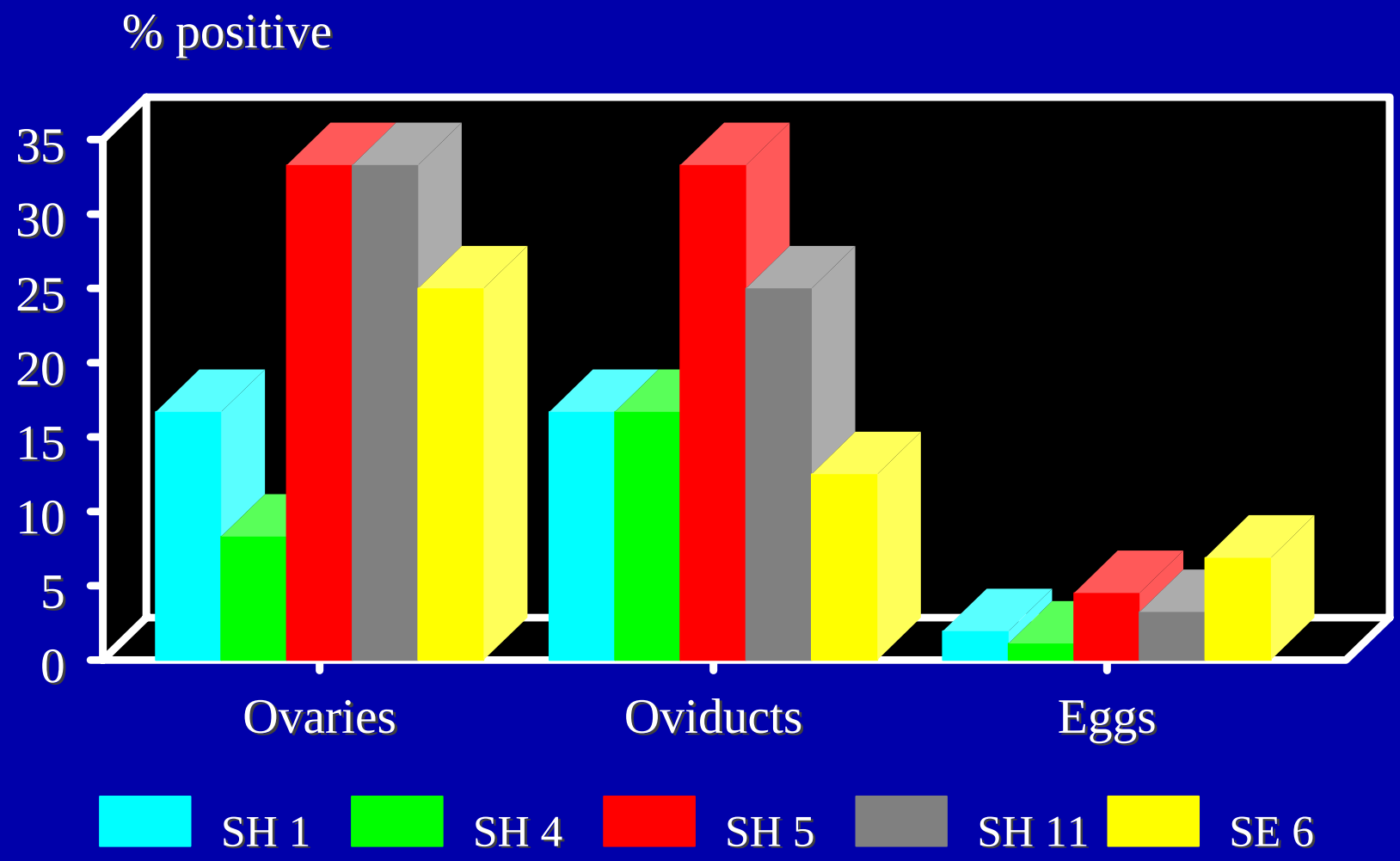


The association of eggs with human *Salmonella enteritidis* and *S. heidelberg* infections:

- 80% of human *S. enteritidis* outbreaks in the USA (1985-1999) for which a food source could be identified were attributed to eggs or egg-containing foods.
- 23% of *S. heidelberg* outbreaks in the USA (1973-2001) were attributed to eggs or egg-containing foods.

The deposition of *Salmonella* in eggs is a consequence of the colonization of reproductive organs, particularly the ovary and upper oviduct, in systemically infected hens.

Salmonella Recovery from Reproductive Tissues and Egg Contents



What is the incidence of *S. enteritidis* infection in laying flocks?

7% of commercial laying houses in the USA were environmentally positive for *S. enteritidis* in a 2000 survey conducted by the USDA National Animal Health Monitoring System.

What is the incidence of *S. enteritidis* contamination of eggs?

- In field studies of environmentally positive flocks in Pennsylvania and California, the prevalence of egg contamination with *S. enteritidis* was approximately 5 in 20,000 (0.025%).
- The 1998 USDA *S. enteritidis* Risk Assessment Report estimated the overall national egg contamination prevalence to be 1 in 20,000 (0.005%).

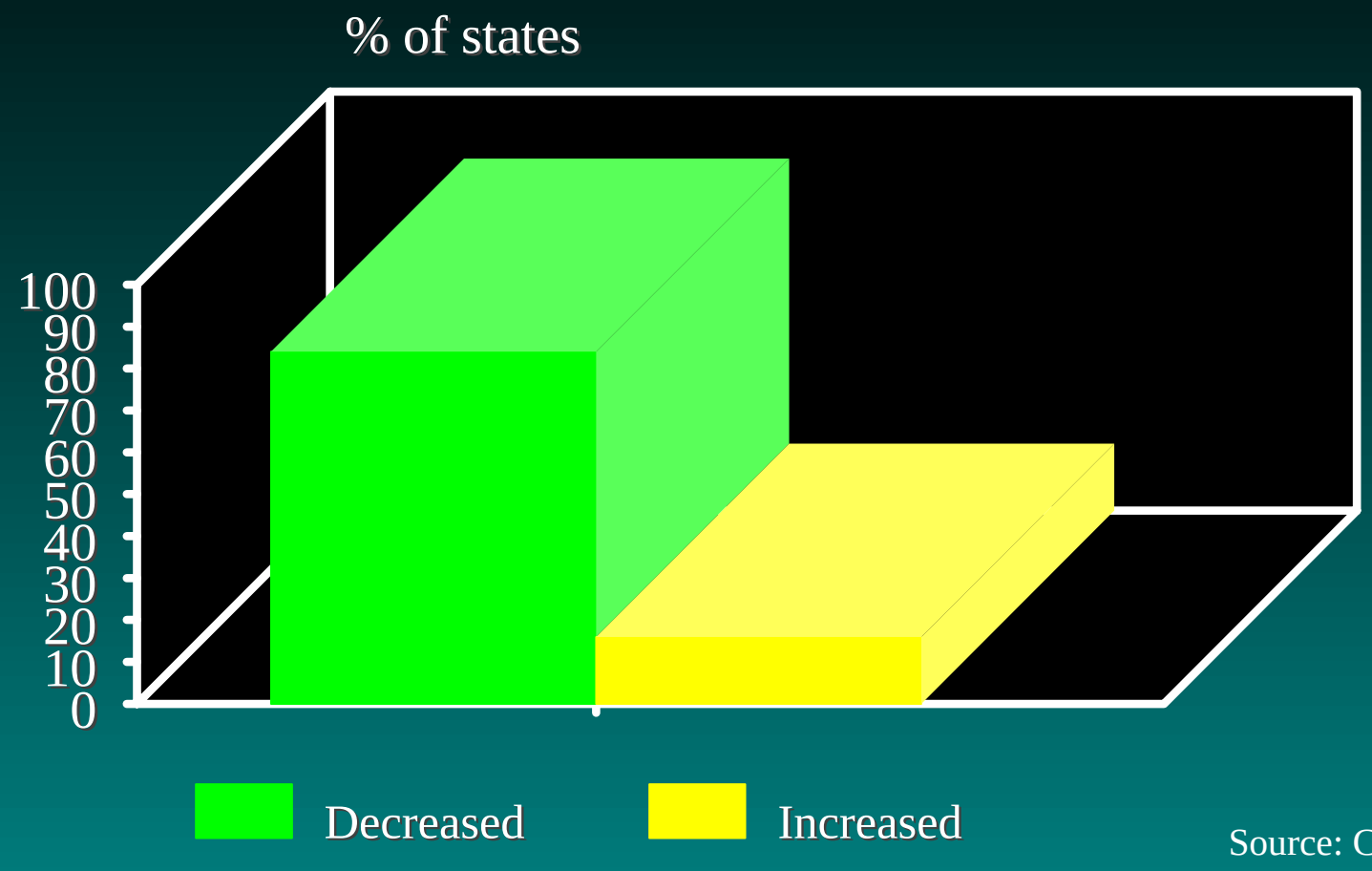
Recent Events in S. enteritidis Epidemiology and Control

- January, 2005: The Risk Assessment Division of USDA-FSIS estimates that 182,060 human illnesses were caused by consumption of *S. enteritidis*-contaminated shell eggs in 2000.
- September, 2004: FDA proposes regulations for shell egg production that include mandatory testing of environmental samples (and eggs, if necessary) from commercial laying flocks.

Common Risk Reduction Practices for S. enteritidis in Poultry Flocks

- Using uninfected chicks
- Effective pest control
- Cleaning and disinfection between flocks
- Heightened biosecurity
- Washing and refrigeration of eggs
- Vaccination

Changes in Human S. enteritidis Incidence in 31 States after Implementation of Egg Quality Assurance Programs

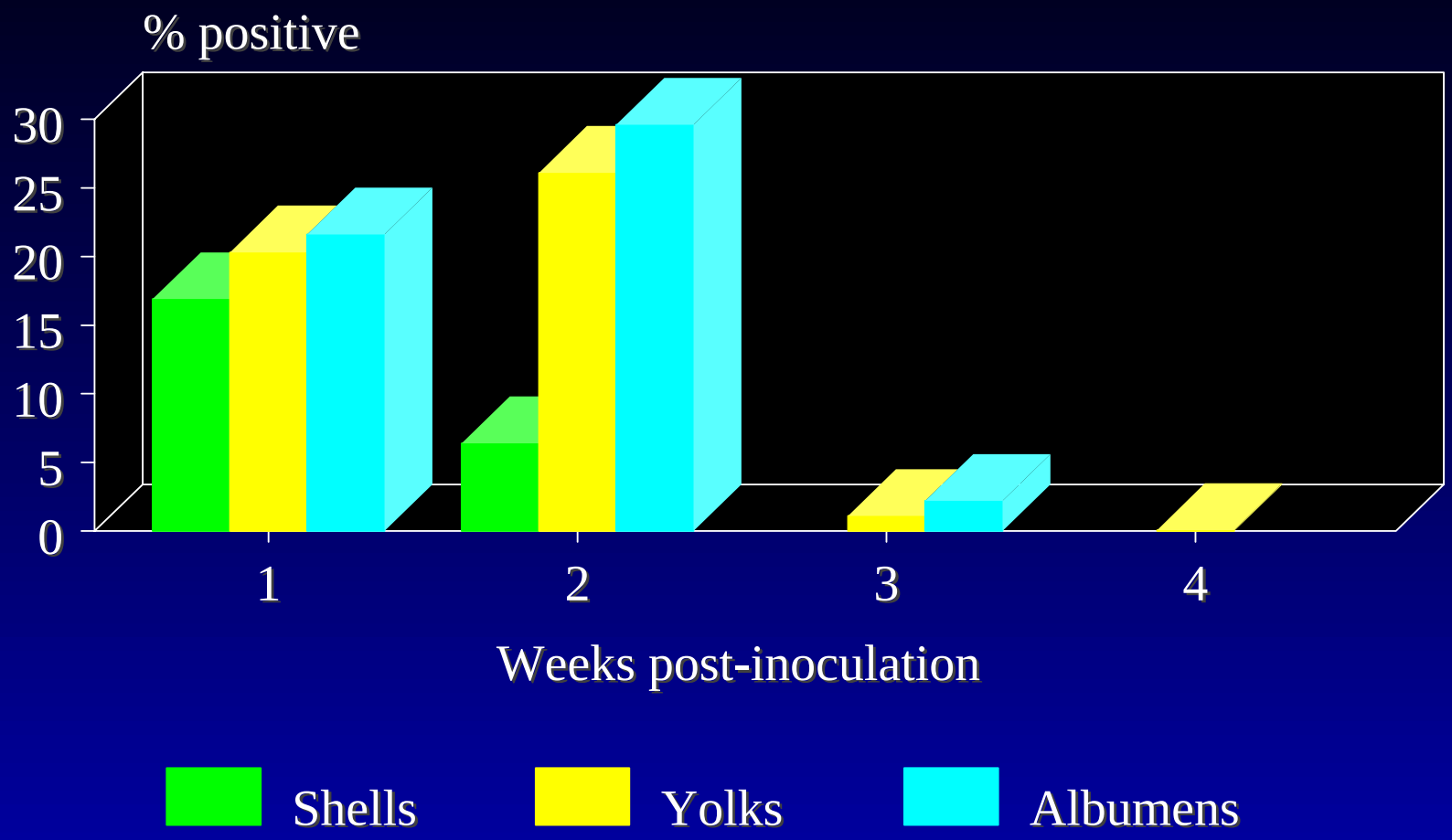


Source: CDC

Proposed FDA Regulations for Shell Egg Producers

- Purchase chicks from uninfected (NPIP-certified) breeder flocks.
- Maintain pest control and biosecurity programs.
- Test laying house environmental samples for *S. enteritidis* at 40-45 weeks of age and after induced molting.
- If environment positive for *S. enteritidis*, clean/disinfect thoroughly between flocks and test eggs. If eggs positive, divert for pasteurization.
- Store eggs under refrigeration at 45° F.

Recovery of S. enteritidis from eggs laid by experimentally infected hens



What are the research needs of regulatory agencies and the poultry industry regarding *Salmonella* in eggs?

Sources of Information:

- 2004 USDA-FSIS Risk Assessment for *Salmonella enteritidis* in Eggs
- Egg Nutrition Center Food Safety Advisory Panel
- American Egg Board Open House

Post-Harvest (Egg Processing) Research Needs

- Prevalence of pathogens on egg shells before and after processing
- Effectiveness of egg sanitizers
- Validation of current and prospective regulatory provisions

Egg Processing Safety, Quality, and Security

Deana Jones – Food Technologist
(Lead Scientist)

Michael Musgrove – Food Technologist

Effects of commercial cool water washing on pathogen detection in shell eggs

- Egg surface temperature was significantly reduced when eggs were washed with a combination of warm and cool water.
- *Enterobacteriaceae* frequency was not different between wash water temperature treatments for offline eggs.
- *Listeria* was detected in cool wash water at the offline facility but not on or in any eggs.
- *Salmonella* and *Campylobacter* were detected within the shells of 3 and 2 (of 384) samples, respectively. All positive samples were from cool water treated eggs.
- More work needs to be conducted to determine the feasibility of cool water washing of shell eggs, including examining detergents designed for cooler temperatures.

Correlation of shell strength and *Salmonella* Enteritidis infection

- Eggshell quality has always been difficult to quantify due to variable nature of eggs
- Advent of more objective detection devices has eliminated much of the testing variability
- A highly invasive inoculation method was utilized, yet it was very difficult to detect SE in the egg. Positive egg contents were only found after pre-enrichment.
- Correlation analysis did not find any strong positive or negative correlations between shell strength and SE contamination within the range of shell strengths detected in the current study

Recovery of *Salmonella* from commercial shell eggs by two methods

- Utilized shell rinse and shell crush and rub
- Monitored for naturally occurring *Salmonella*
- Shell rinse recovered 4.8% positives
- Shell crush and rub recovered 5.3% positives
- Occasionally only one method was positive for *Salmonella* per sample
- Using both methods increased sensitivity, although in most cases, crushing provided more sensitive detection

Impact of commercial processing on the incidence of *Salmonella* on shell eggs

Salmonella	No. of isolates	Sample type
Typhimurium	21	Eggshell
	1	Tap water
Typhimurium (Copenhagen)	4	Eggshell
4-12:i:-monophasic	2	Eggshell
Heidelberg	9	Eggshell
Kentucky	1	Eggshell
	1	Wash water
Total	39	

Pre-Harvest (Egg Production) Research Needs: Stress and Immunity Issues

- Effects of induced molting (by feed withdrawal and alternative methods) on immune responsiveness and susceptibility to *Salmonella* infection
- Stress associated with other management practices and effects on immune responsiveness
- Protection by vaccination and stress effects on vaccine efficacy

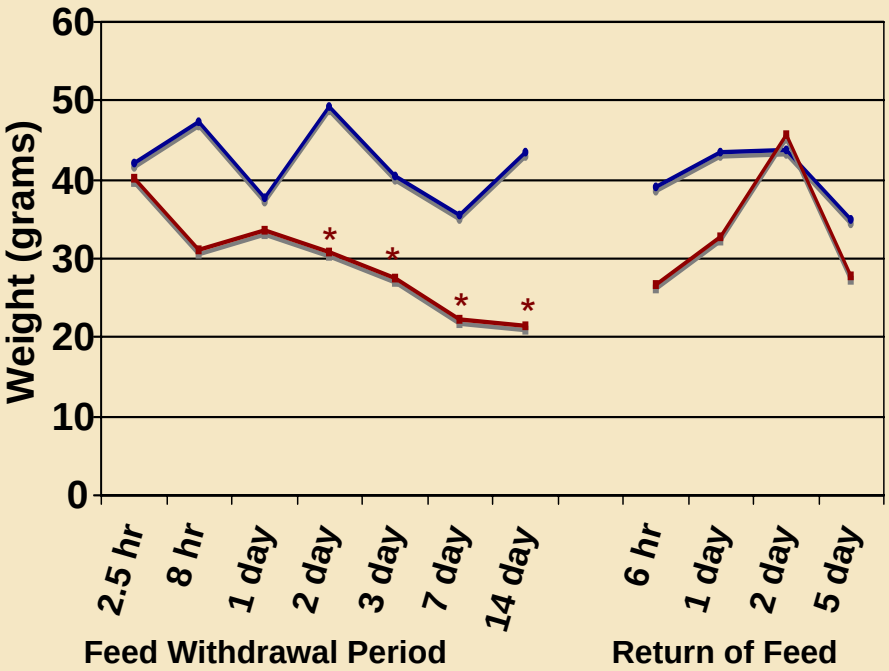
Stress Effects on Immunity and Physiology of Poultry

Peter Holt – Immunologist
(Lead Scientist)

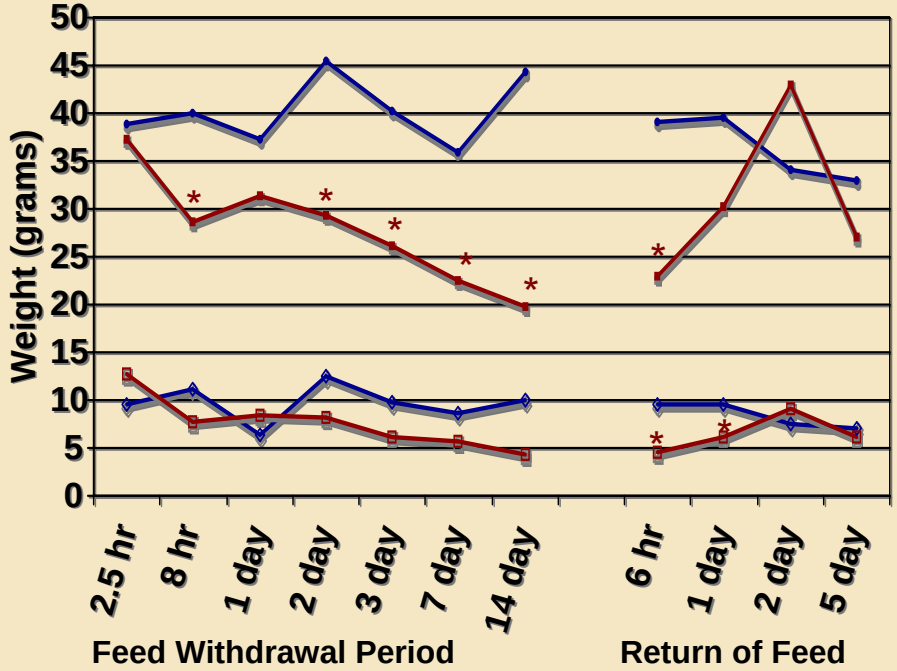
Randle Moore – Veterinarian/Physiologist

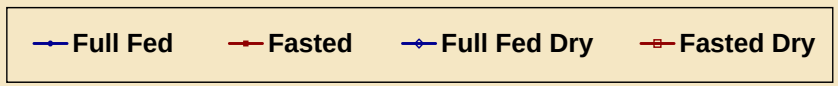
Effect of Feed Deprivation and Recovery from Feed Deprivation Over Time on:

Intestinal Length

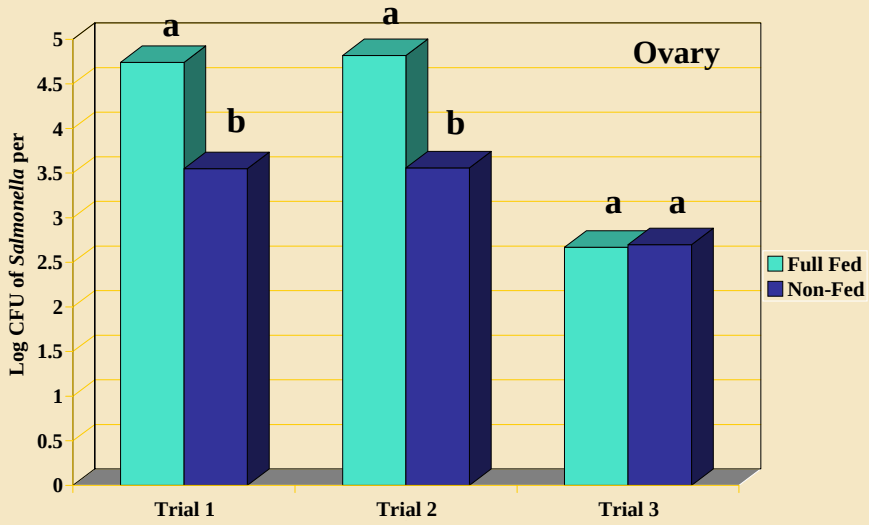


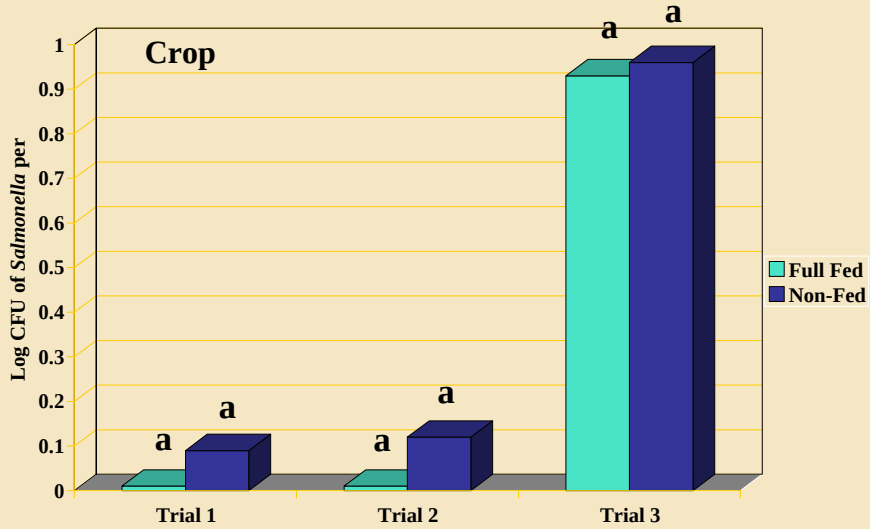
Intestinal Weight

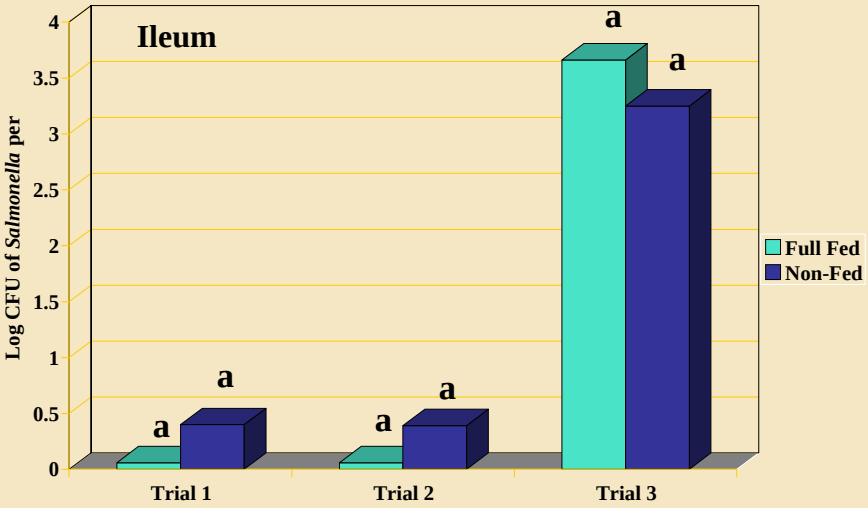


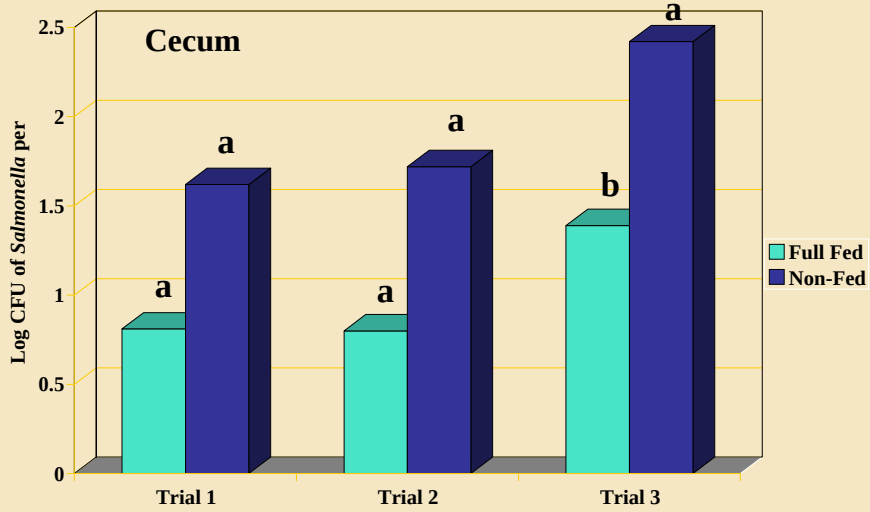


Effect of Feed Deprivation on *in Vitro* Tissue Invasion of *Salmonella enteritidis*



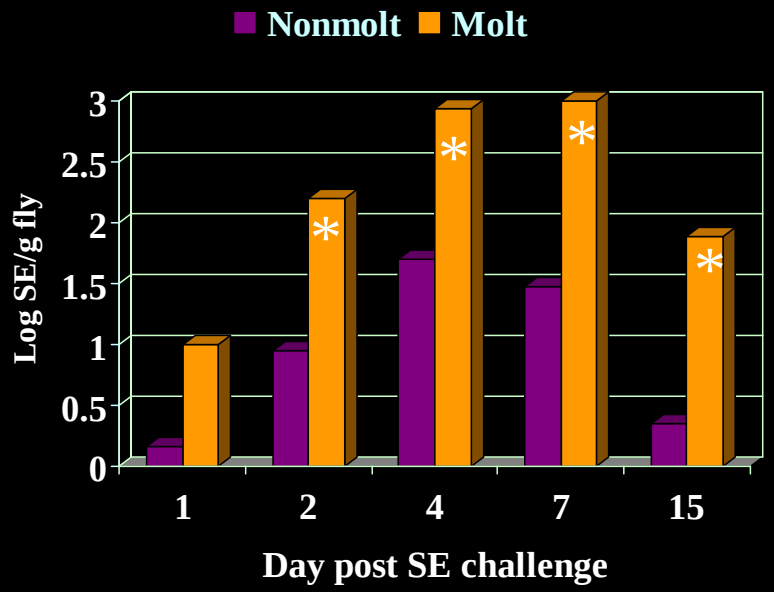




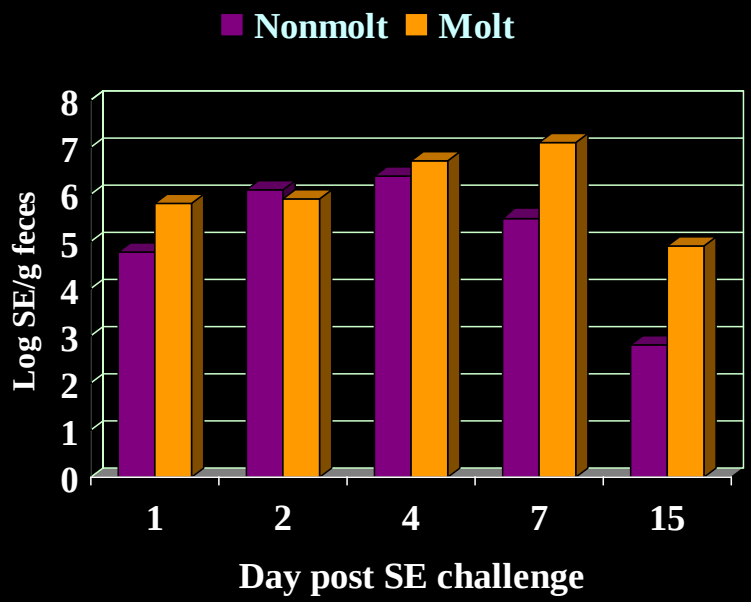


Effect of Induced Molting on Levels of SE in Flies vs on Floor

SE levels in flies



SE levels on floor



Isolation of *S. Enteritidis* from Fly Interior vs Exterior

Treatment	Exterior	Interior
Nonmolt	8/10	9/10
Molt	9/10	9/10

Isolation of *S. Enteritidis* from Internal Organs

Treatment	Sal. Gland	Crop	Gut
Nonmolt	0/10	1/10	10/10
Molt	0/10	3/10	8/10

Pre-Harvest (Egg Production) Research Needs: Pathogenesis Issues

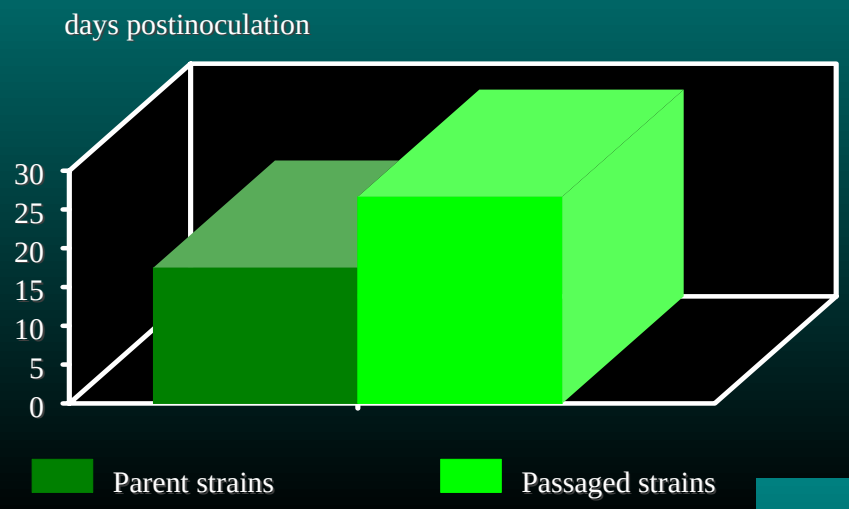
- Prevalence, level, and site of egg contamination; growth kinetics of *Salmonella* in eggs during storage; effects of refrigeration on bacterial growth in eggs
- The evolution (and identification) of *Salmonella* strains able to contaminate eggs
- Genetic differences between *Salmonella* strains that can be used to establish epidemiological relationships (including sources and routes of transmission)

Controlling Egg Contamination with Salmonella enterica by Understanding its Evolution and Pathobiology

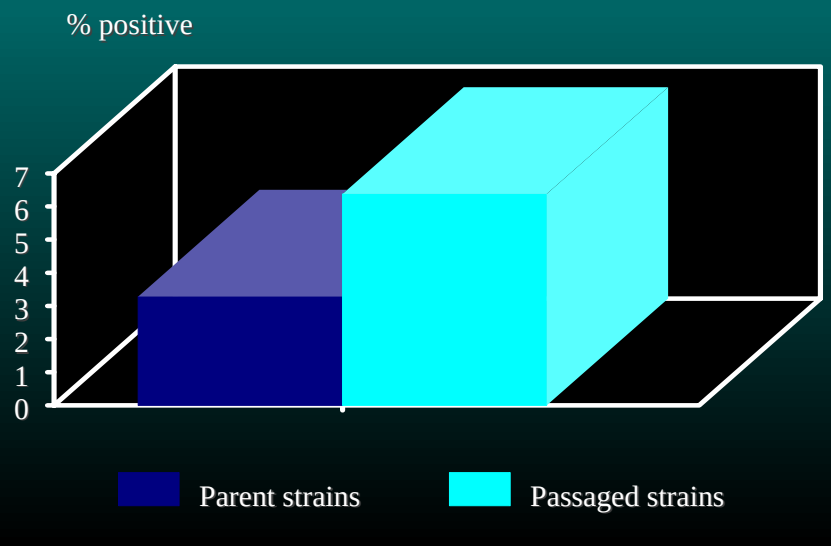
Jean Guard-Bouldin –
Veterinarian/Molecular Biologist (Lead Scientist)

Richard Gast - Microbiologist
(Research Leader)

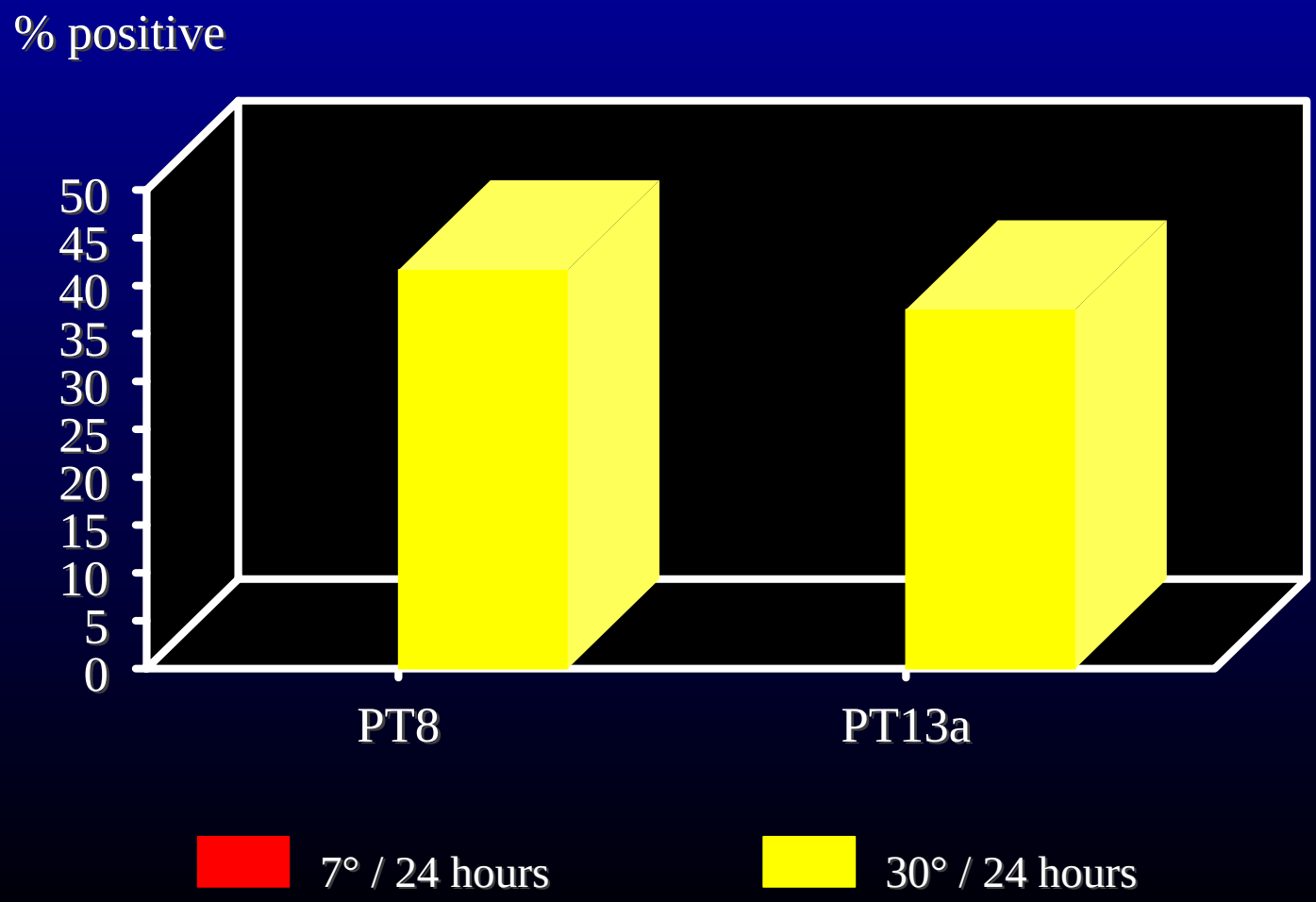
Mean Duration of Salmonella Recovery from Fecal Samples



Salmonella Recovery from Eggs



S. enteritidis penetration into egg yolks

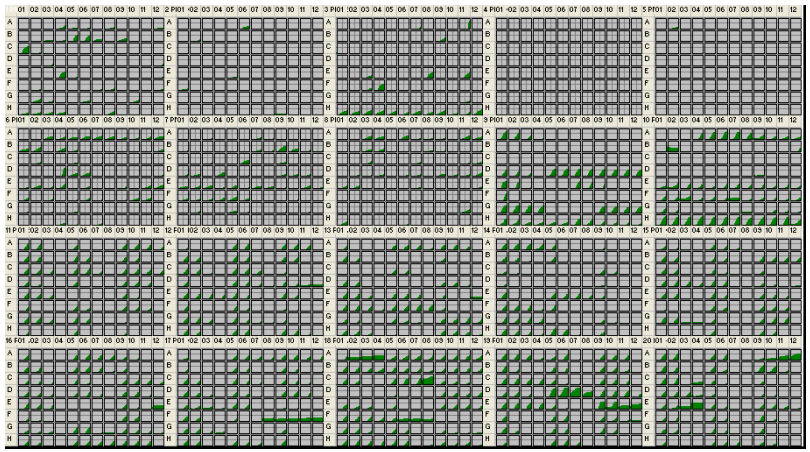


Phenotype can vary dramatically within serotype and phage type

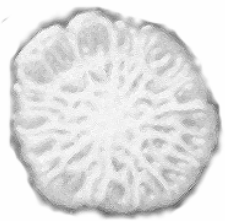
PT13A

= Egg Contamination

biofilm negative



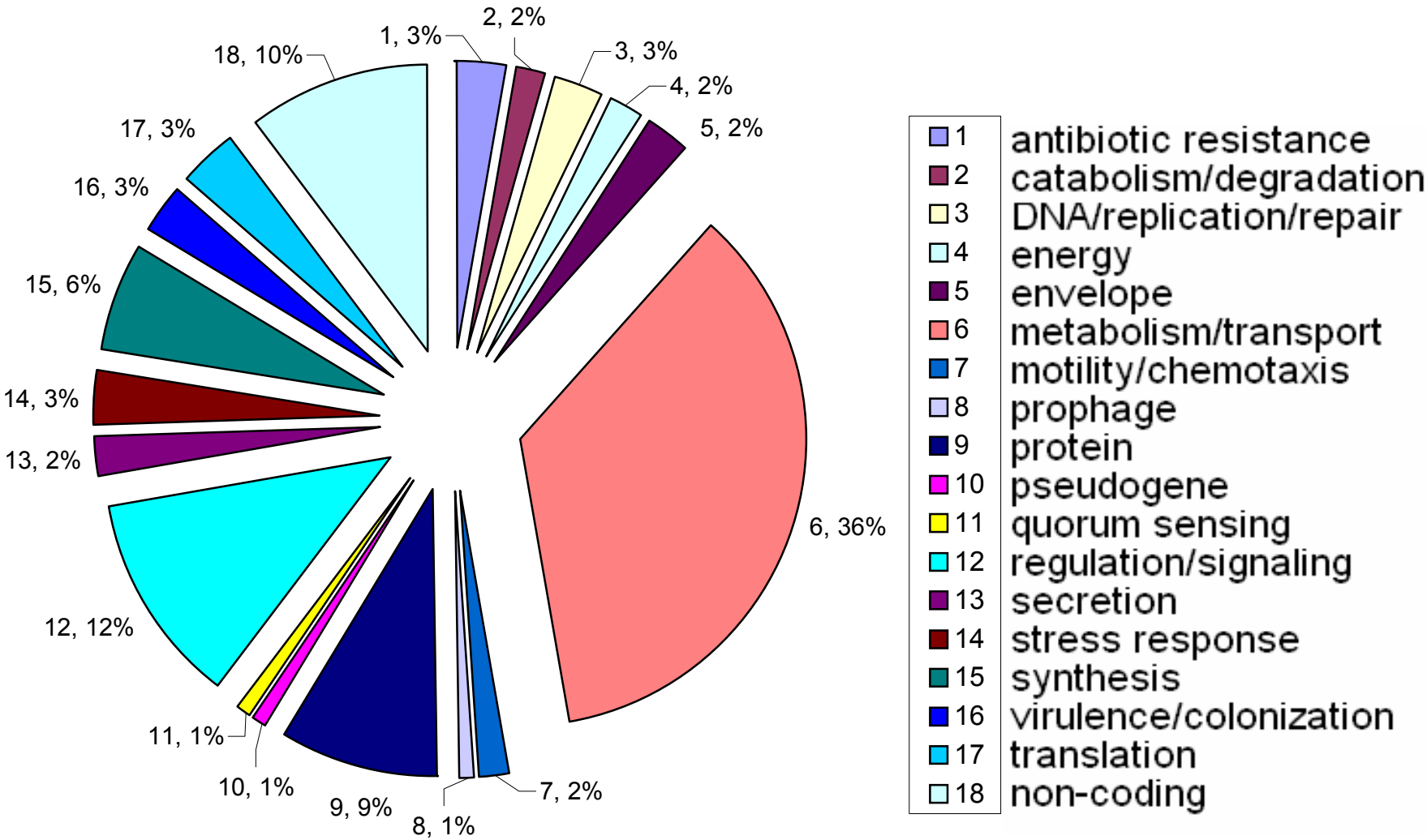
PT13A



≠ Egg Contamination

biofilm positive

SNP portfolio of *Salmonella* Enteritidis



Work in progress from Jean Guard Bouldin, DVM, Ph.D., USDA-ARS-ESQRU, Athens GA

The Future of Salmonella Control in Egg-Laying Chickens?

Detecting and protecting against specific Salmonella serotypes can be essential for responding to urgent or severe threats to public health, but the most cost-effective and sustainable approaches to controlling food-borne disease are based on risk reduction practices that address a broad spectrum of current and emerging pathogens.