The Animal Arm of the National Antimicrobial Resistance Monitoring System – Enteric Bacteria (NARMS)

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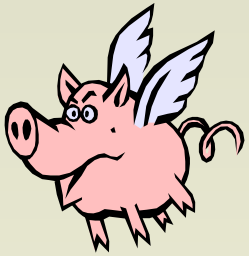
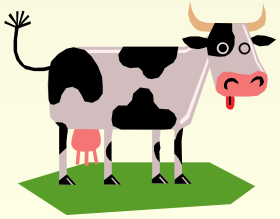
Acknowledgements



- Dr. Mark Englen
- Dr. Charlene Hudson
- Dr. Jeff Gray
- Dr. Bob Kraeling
- Dr. Jeanetta Tankson
- Jennifer Murphy
- Takiyah Ball
- Carolina Hall
- Scott Ladely



- Leena Jain
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- Jovita Hermosillo
- Eric Adams
- Sandra House
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- Rosie Minish
- Lari Hiott
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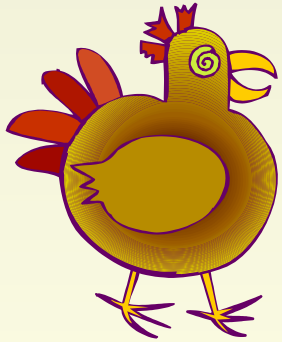

Acknowledgements

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FDA-OR

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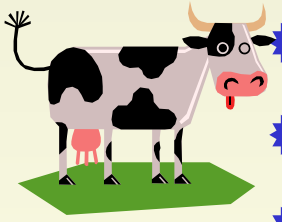
- Bob Walker



CDC – Human NARMS

- Dr. Fred Angulo
- Dr. Tom Chiller

USDA-APHIS

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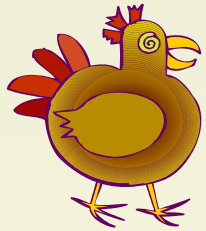

USDA-FSIS

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- Dr. Neena Anandaraman
- Bonnie Rose

Non-federal partners

- Vet diagnostic labs

Goals and Objectives

- To provide descriptive data on the extent and temporal trends of antimicrobial susceptibility in *Salmonella* and other zoonotic enteric organisms from human and animal populations
- Identification of resistance as it arises
- Timely information
- Prolong the lifespan of approved drugs
- Identify areas for more detailed investigation and guide research

Bacterial Isolates and Sources

Animal Isolates

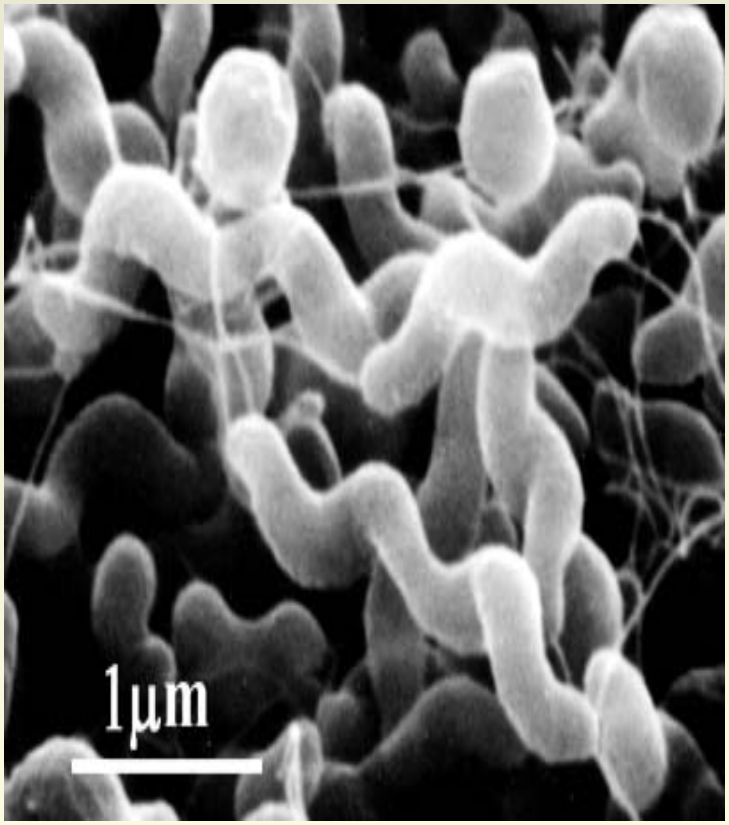
- Non-Typhi *Salmonella*
- Generic *E. coli*
  - 0157:H7 when available
- *Enterococci*
- *Campylobacter*
- *Listeria* [2004]

Animal Sources

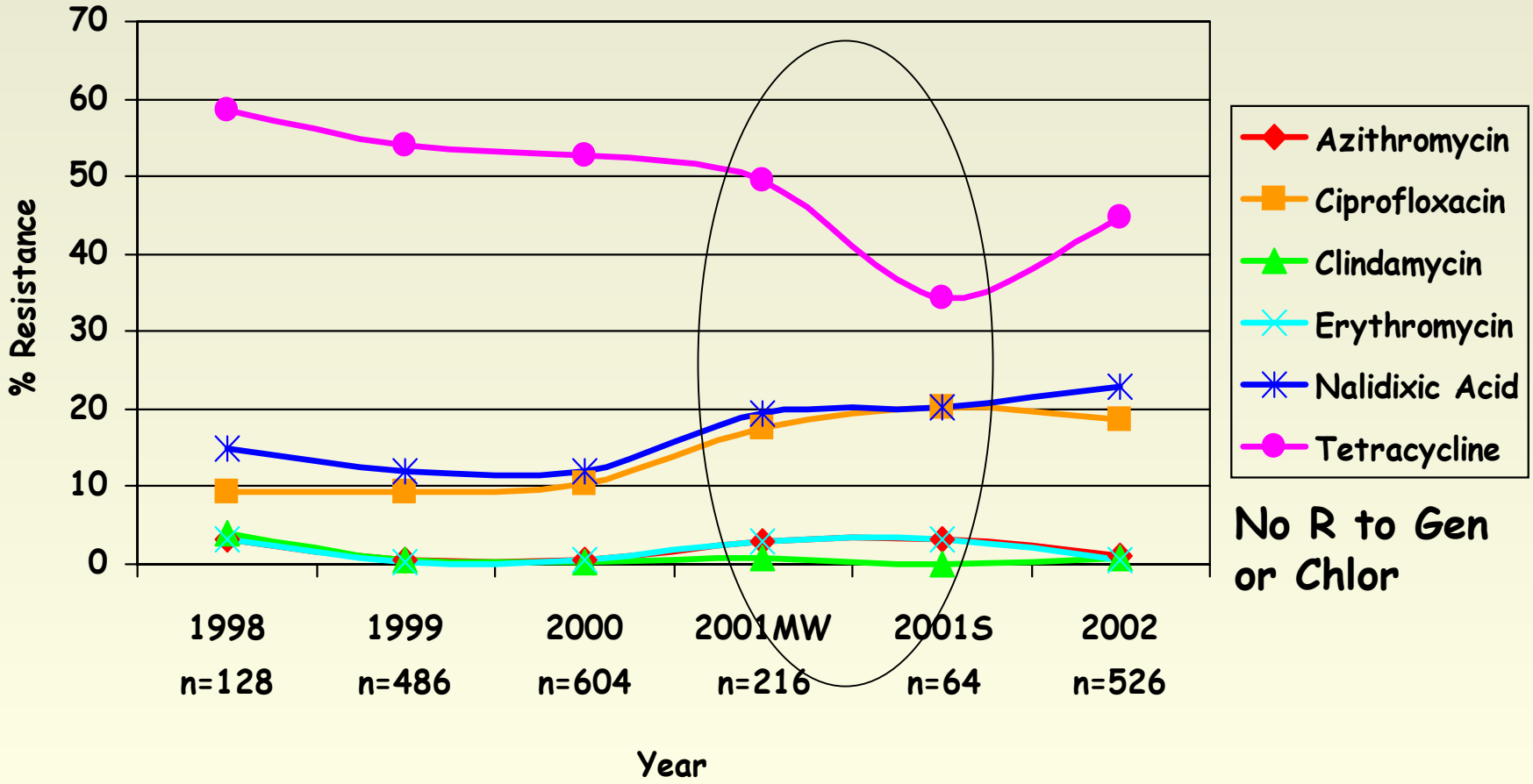
- Diagnostic; *Salmonella, E. coli*
  - NVSL, Vet Diagnostic Labs (Sentinel Sites)
- Non-diagnostic; *E. coli, Salmonella, Campy, Enterococci*
  - Raw product from federally inspected slaughter and processing plants
  - Focused studies

Campylobacter

- Added in 1998
- 1998 through 2000 Campy obtained by FSIS methods
  - NA used in screening
  - Underestimated % R to Quinolones, FQs
- 2001 method changed
  - More accurate reflection of resistance in the total population

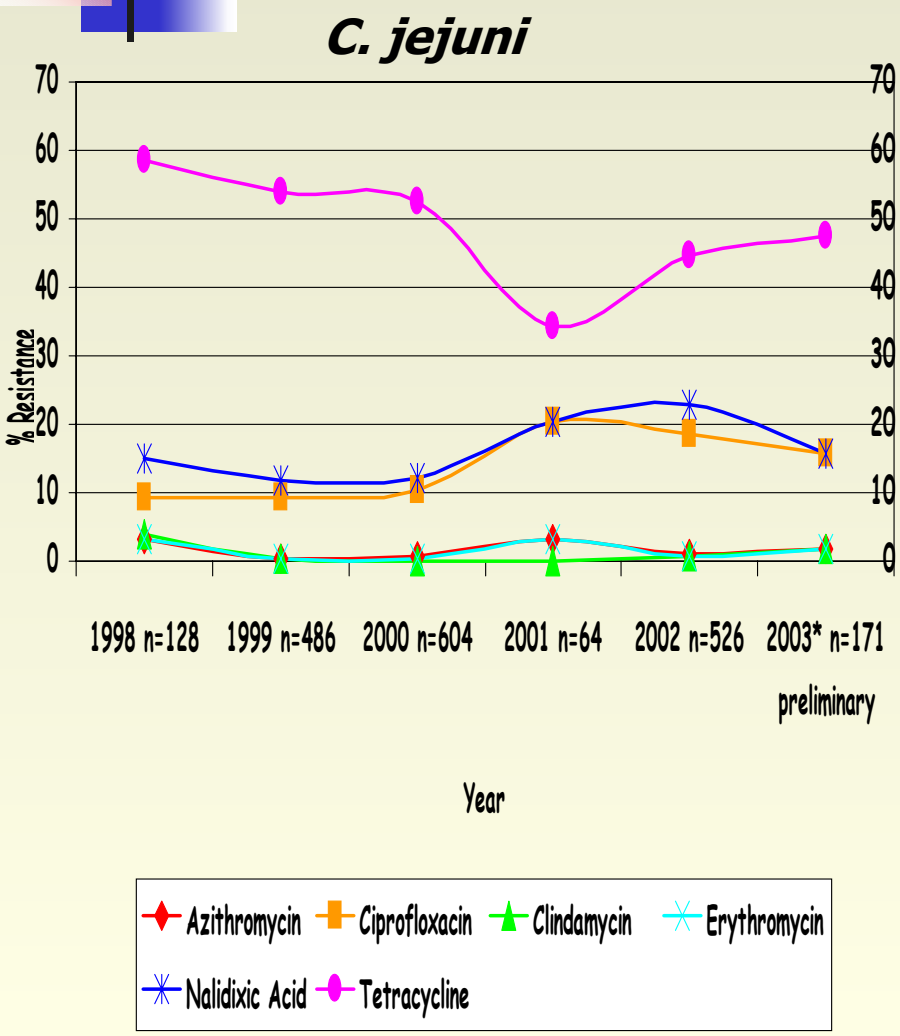


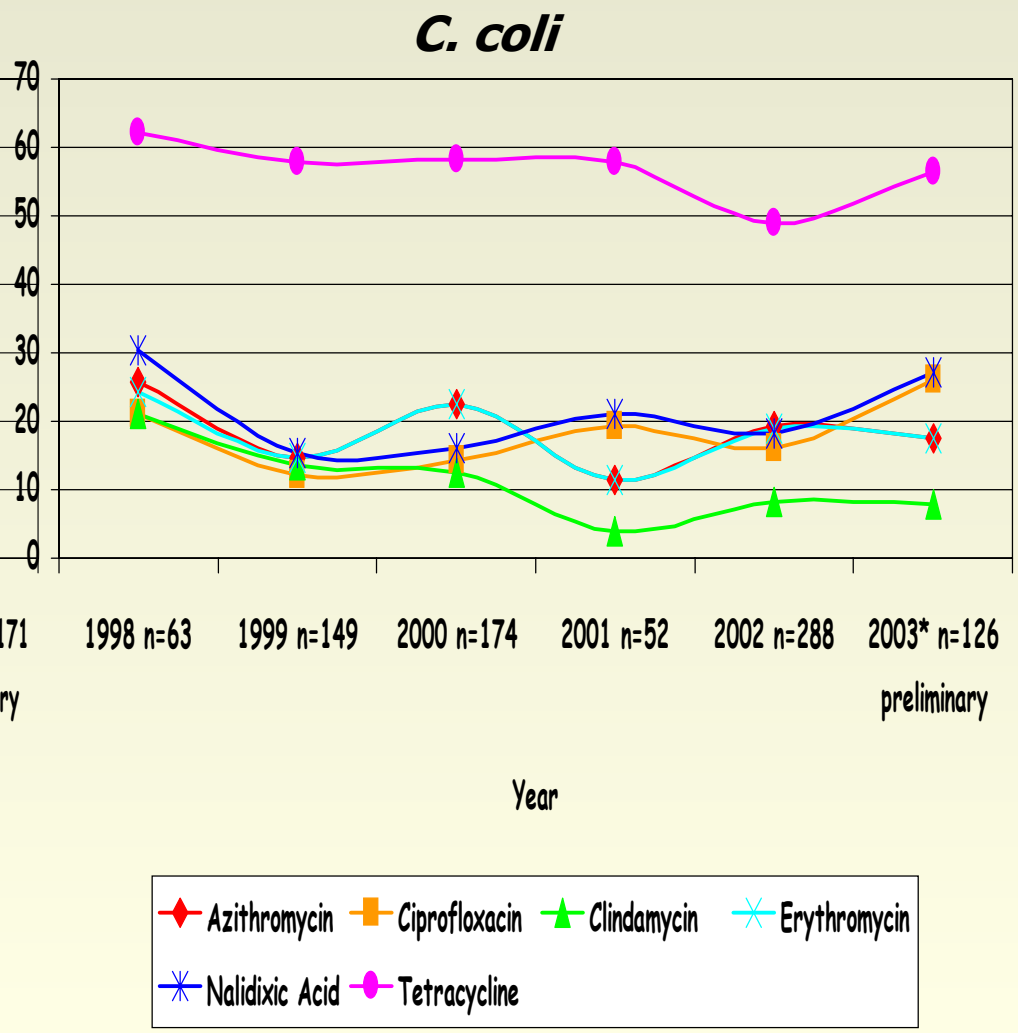
Campylobacter jejuni 1998-2002



No R to Gen or Chlor

C. jejuni and *C. coli* 1998-2002

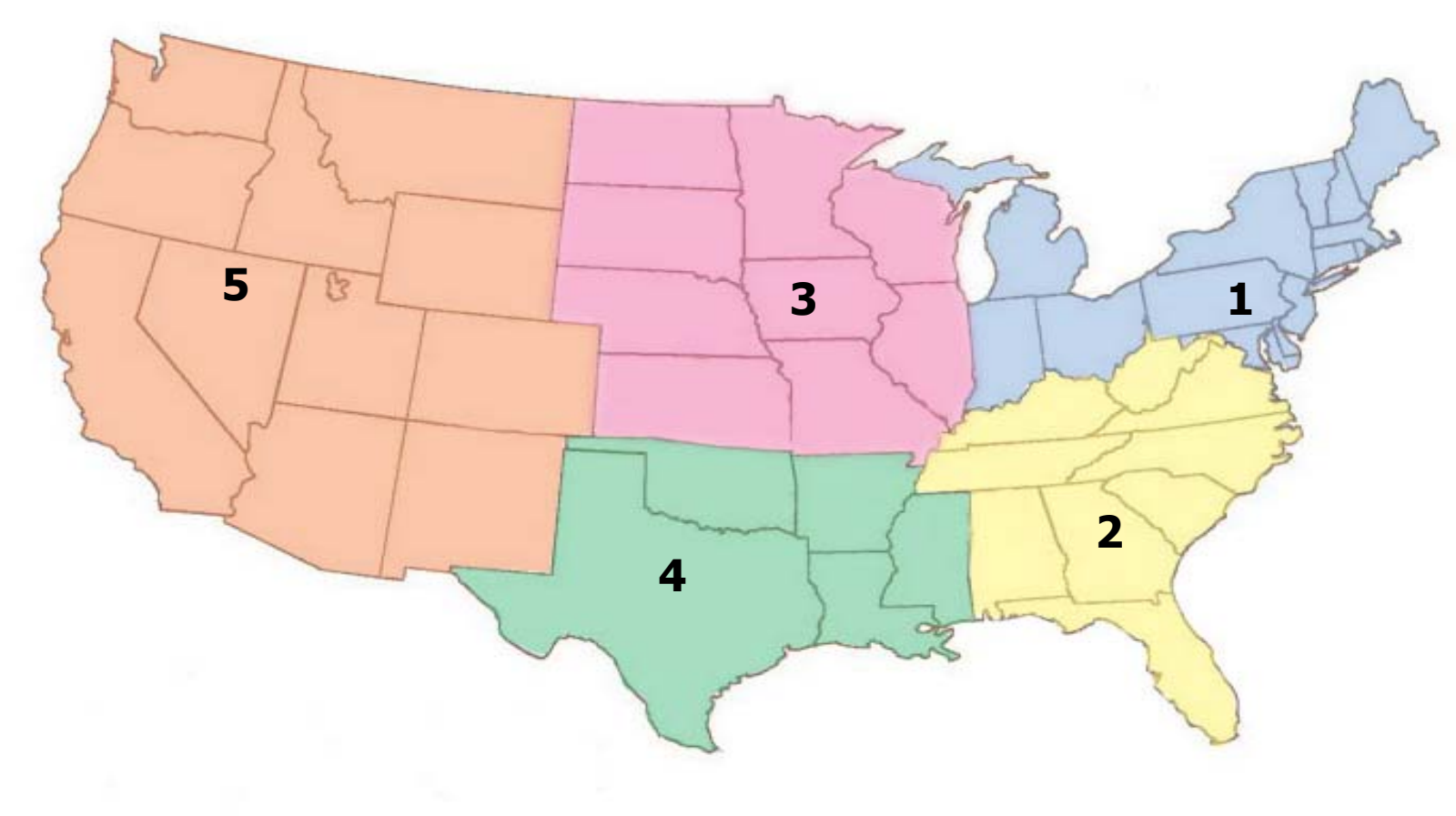




% Total Resistance Broilers By Quarter - 2000

	C. jejuni				*C. coli*			
	1st Qtr.[a]	2nd Qtr.[b]	3rd Qtr.[c]	4th Qtr.[d]	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
n =	38	35	9	12	6	7	3	2
Azithromycin	5	0	0	0	0	28	33	0
Ciprofloxacin	15	11	0	0	0	14	0	0
Chloramphenicol	0	0	0	0	0	0	0	0
Clindamycin	2	0	0	0	0	0	0	0
Erythromycin	5	0	0	0	0	28	33	0
Gentamicin	0	0	0	0	0	0	0	0
Nalidixic Acid	21	11	0	0	0	14	0	0
Tetracycline	55	45	33	50	66	71	0	50

Regional Analysis



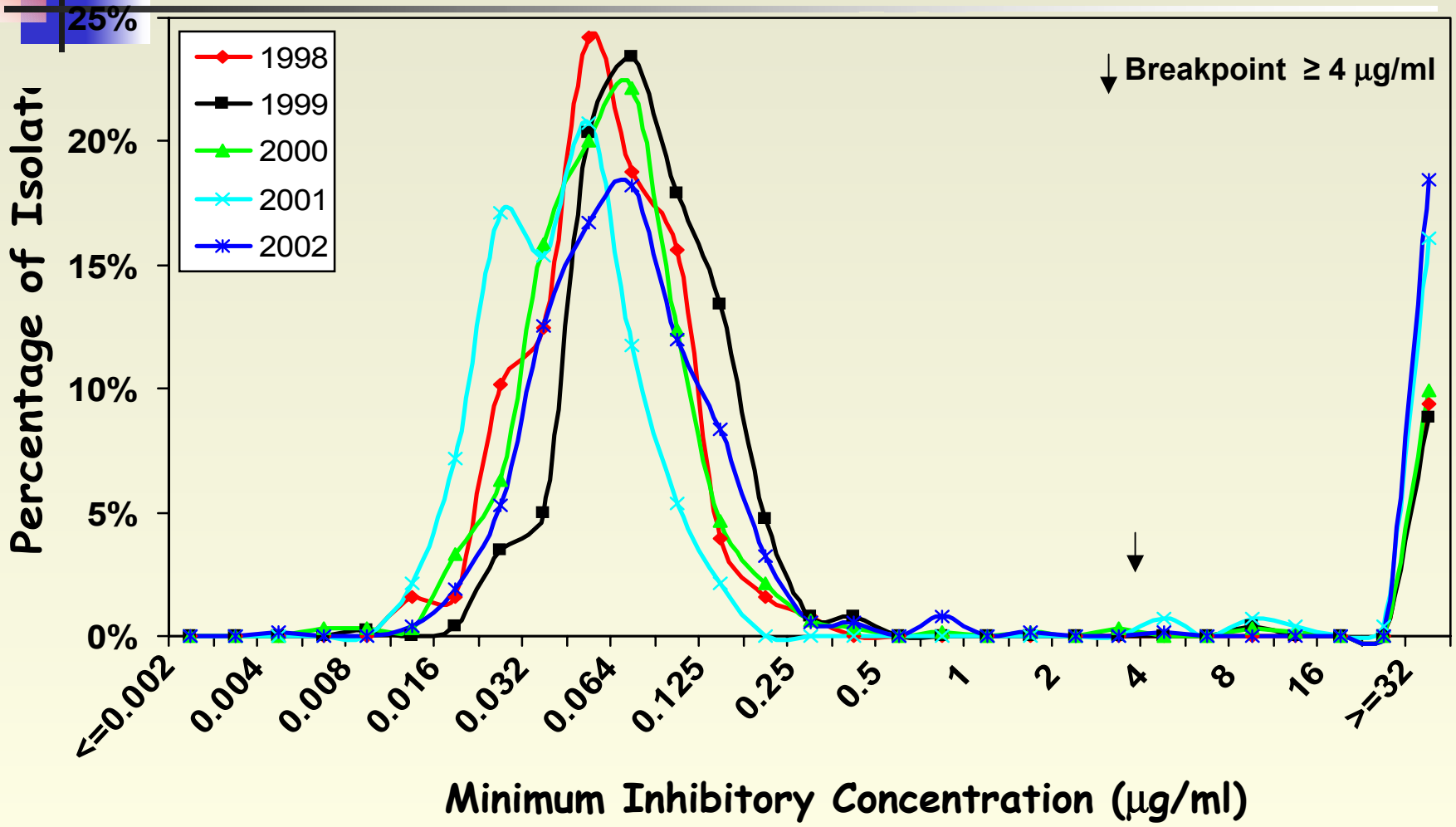
Regional Numbers - Broilers 2000

Antimicrobial	C. jejuni					C. coli				
	R1 9	R2 39	R3 6	R4 29	R5 7	R1 1	R2 10	R3 0	R4 5	R5 0
Azithromycin	1	1	0	0	0	0	1	0	2	0
Ciprofloxacin	2	4	1	1	2	0	1	0	0	0
Clindamycin	0	1	0	0	0	0	0	0	0	0
Erythromycin	1	1	0	0	0	0	1	0	2	0
Nalidixic Acid	2	5	1	2	2	0	1	0	0	0
Tetracycline	4	18	2	16	4	1	5	0	2	0

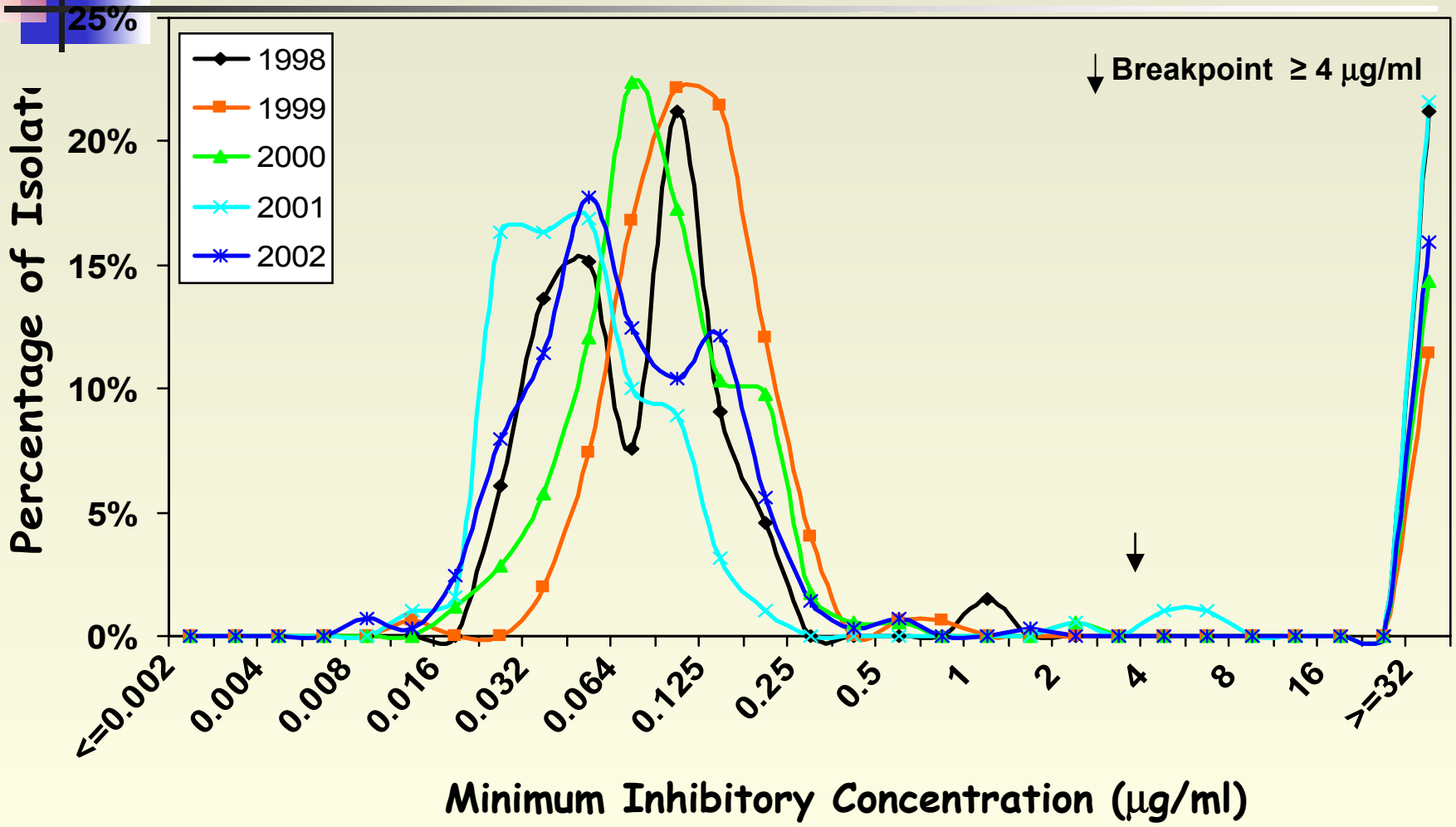
Resistant Patterns by Region - 2000

Region	C. jejuni		C. coli	
	# isolates	R patterns	# isolates	R patterns
R1	2	Tc	1	Tc
	1	Az Em		
	2	Ci Na Tc		
R2	13	Tc	5	Tc
	1	Na Tc	1	Ci Na
	1	Az Cm Em	1	Az Em
	4	Ci Na Tc		
R3	1	Tc		
	1	Ci Na Tc		
R4	14	Tc	2	Az Em Tc
	1	Na Tc		
	1	Ci Na Tc		
R5	4	Tc		
	1	Ci Na		
	1	Ci Na Tc		

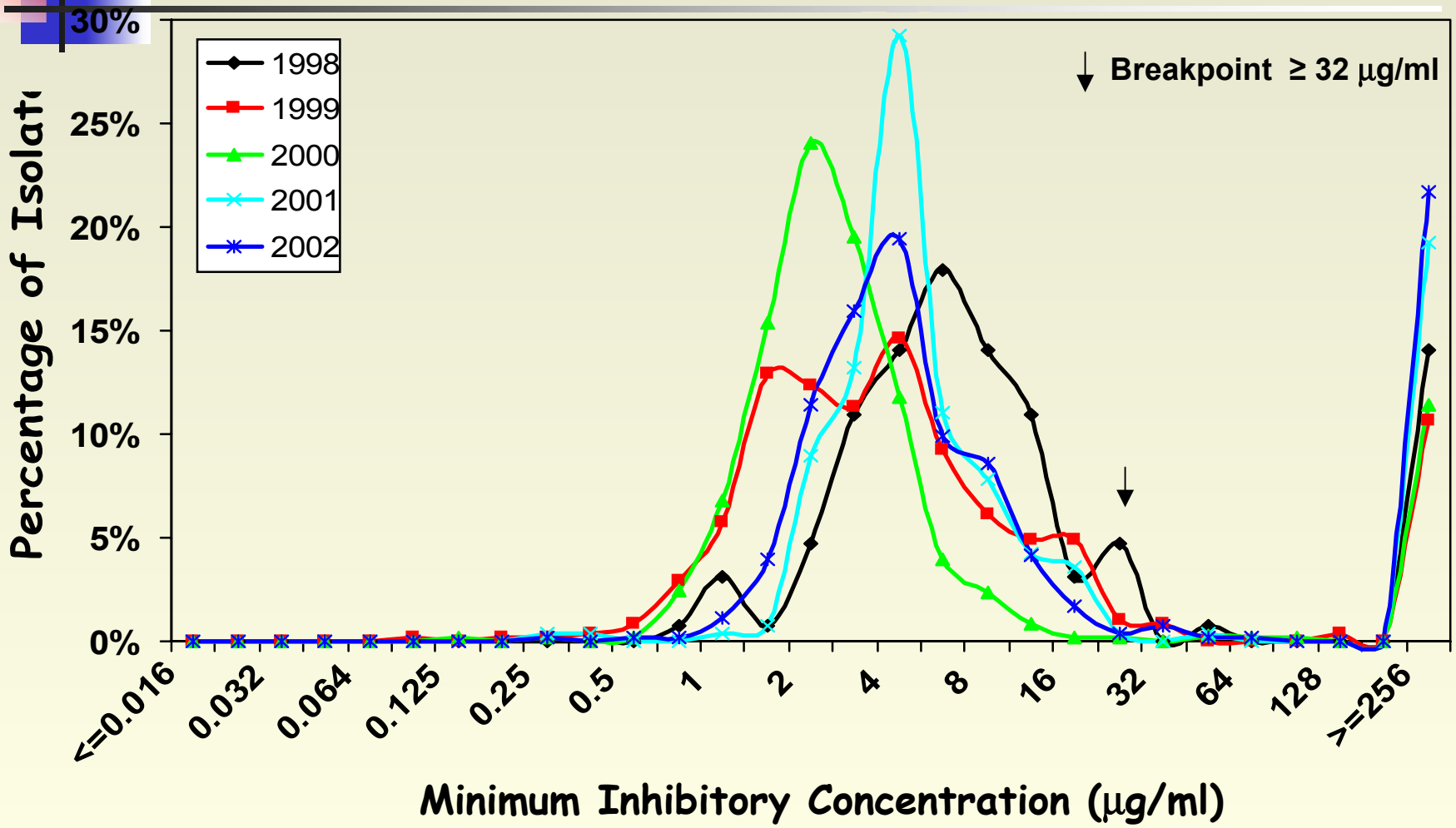
C. jejuni 1998-2002 Ciprofloxacin MICs



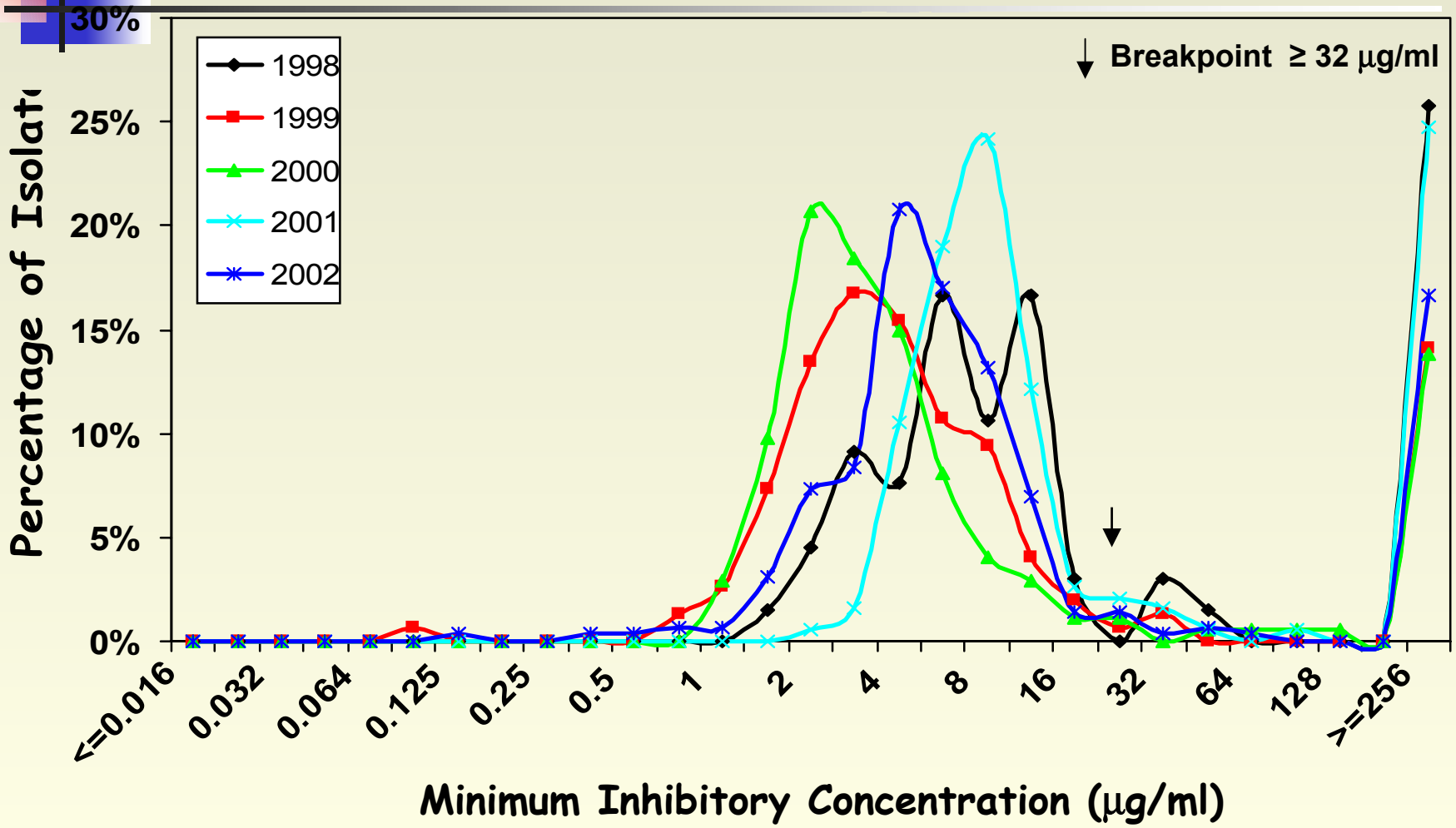
C. coli 1998-2002 Ciprofloxacin MICs



C. jejuni 1998-2002 Nalidixic Acid MICs



C. coli 1998-2002 Nalidixic Acid MICs



Most Frequent R Patterns *C. jejuni* 1998-2001

R Profile	1998 n=128 (%)	1999 n=486 (%)	2000 n=604 (%)	2001 n=280 (%)
Pan S	44 (34.4)	197 (40.5)	246 (40.7)	125 (44.6)
Tc	58 (45.3)	220 (45.3)	277 (45.9)	90 (32.1)
Ci, Na, Tc	8 (6.3)	30 (6.2)	39 (6.5)	34 (12.1)
Na, Tc	6 (4.7)	7 (1.4)	7 (1.2)	4 (1.4)
Ci, Na	-	15 (3.1)	23 (3.8)	17 (6.1)
Az, Cm, Em	-	-	-	4 (1.4)

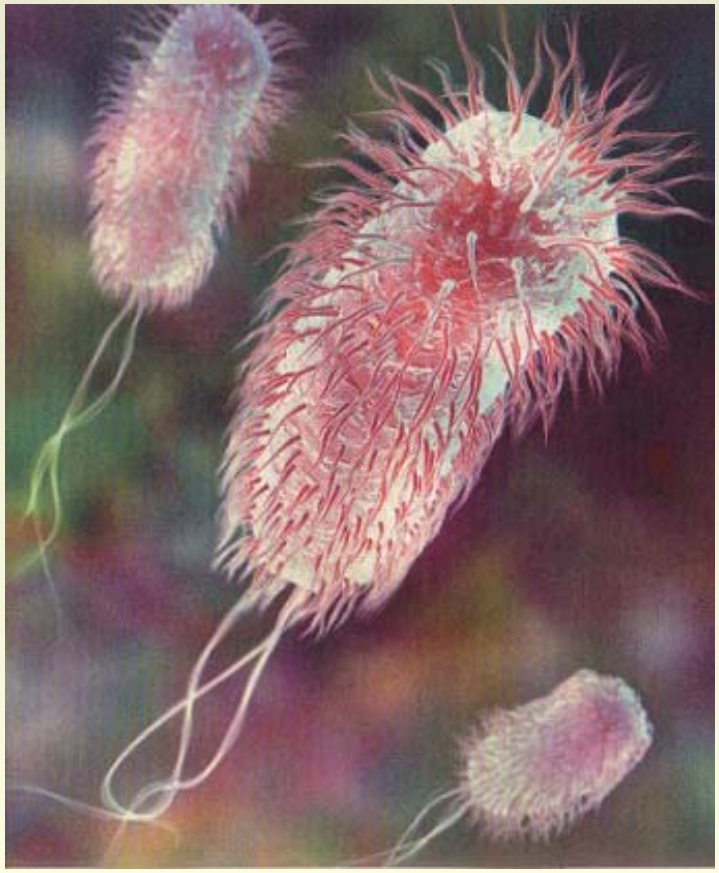
Most Frequent R Patterns *C. coli* 1998-2001

1998 n=63 (%)		1999 n=149 (%)	
Pan S	12 (19.0)	Pan S	50 (34.0)
Tc	17 (27.0)	Tc	57 (38.0)
Ci, Na, Tc	10 (15.9)	Az,Cm,Em,Tc	12 (8.1)
Az,Cm,Em,Tc	8 (12.7)	Ci, Na	7 (4.7)
		Ci, Na, Tc	5 (3.4)

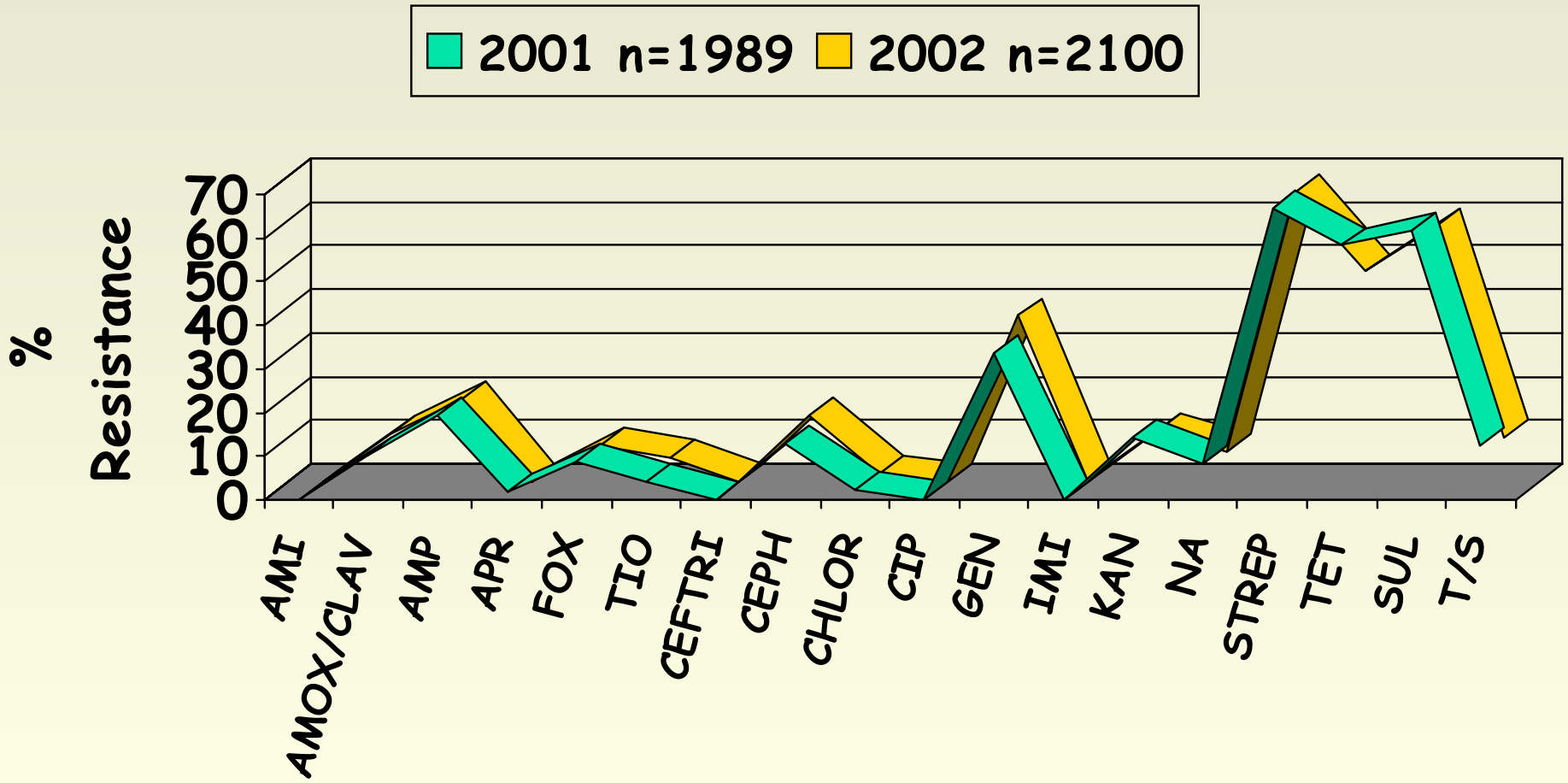
2000 n=174 (%)		2001 n=190 (%)	
Pan S	47 (27.0)	Pan S	56 (29.5)
Tc	65 (37.4)	Tc	51 (26.8)
Az,Cm,Em,Tc	14 (8.0)	Ci, Na, Tc	28 (14.7)
Ci, Na, Tc	13 (7.5)	Az, Em, Tc	10 (5.3)
Az, Cm, Em	7 (4.0)	Ci, Na	9 (4.7)

E. coli

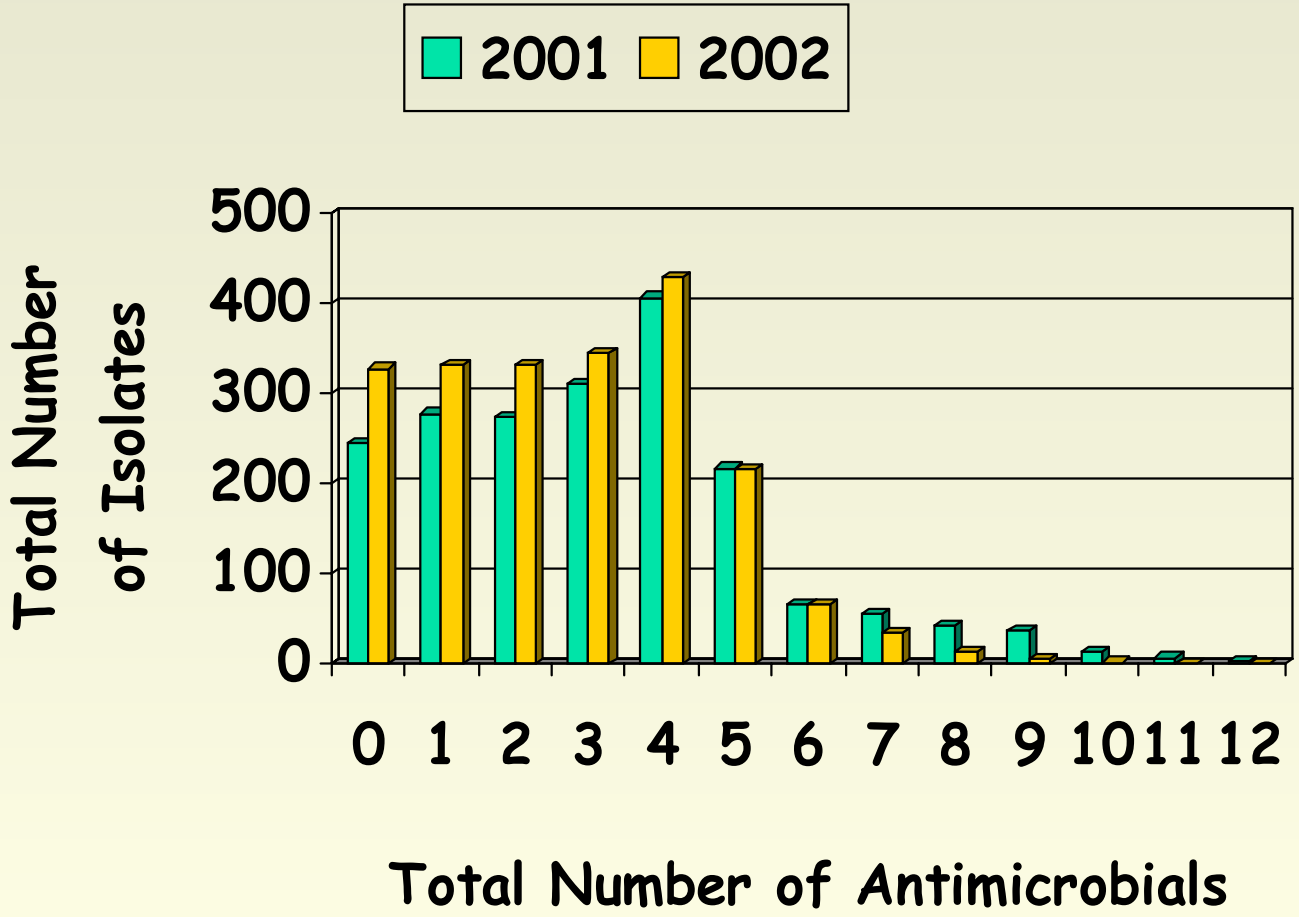
- Generic *E. coli*
- Started in 2001
- The majority of samples originate from poultry rinsates



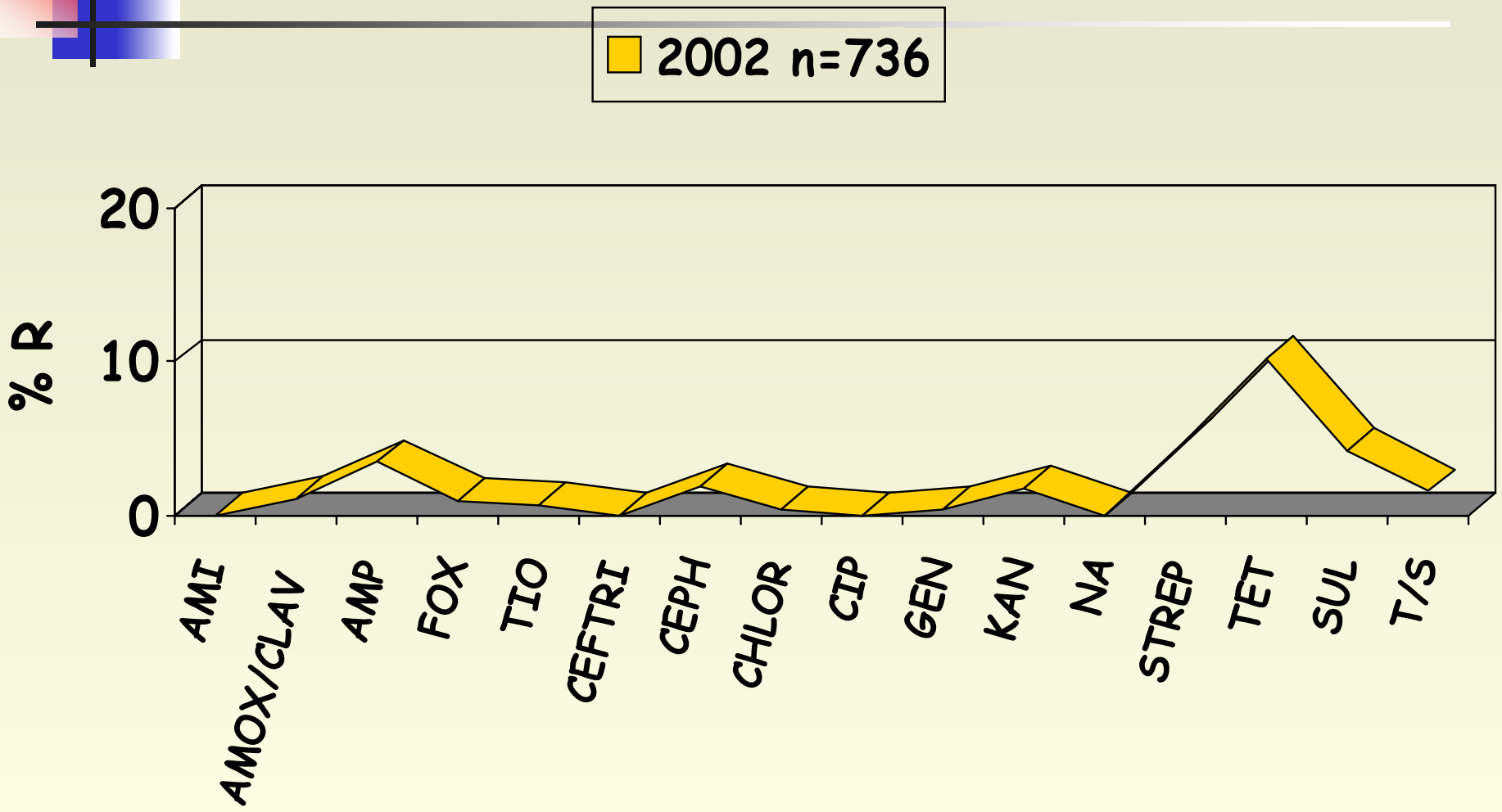
E. coli Chicken Slaughter Resistance 2001 - 2002



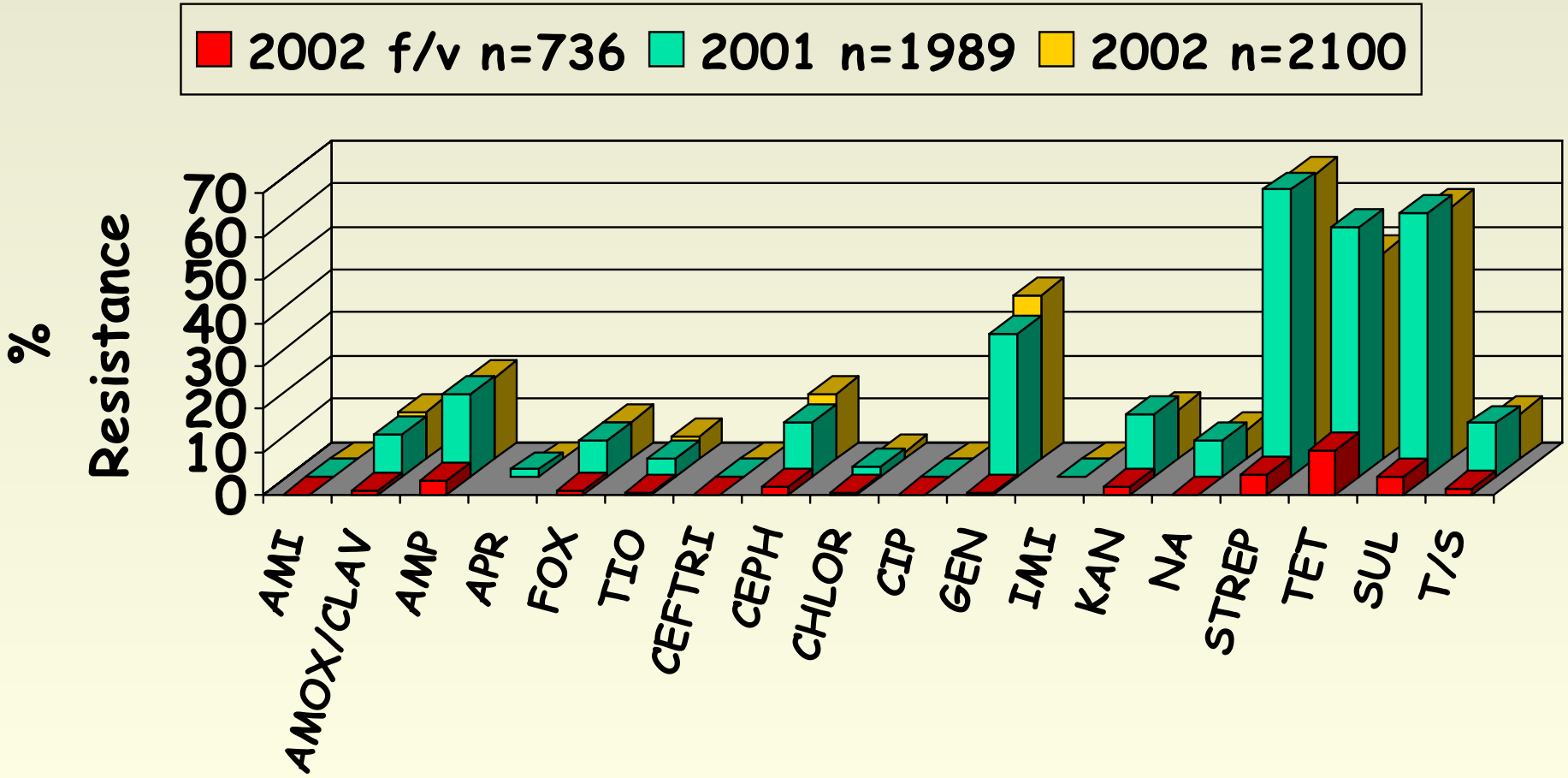
Multiple Resistance *E. coli* from Chickens



E. coli Fruits & Vegetables Resistance 2002



E. coli Chicken Slaughter Resistance 2001 - 2002



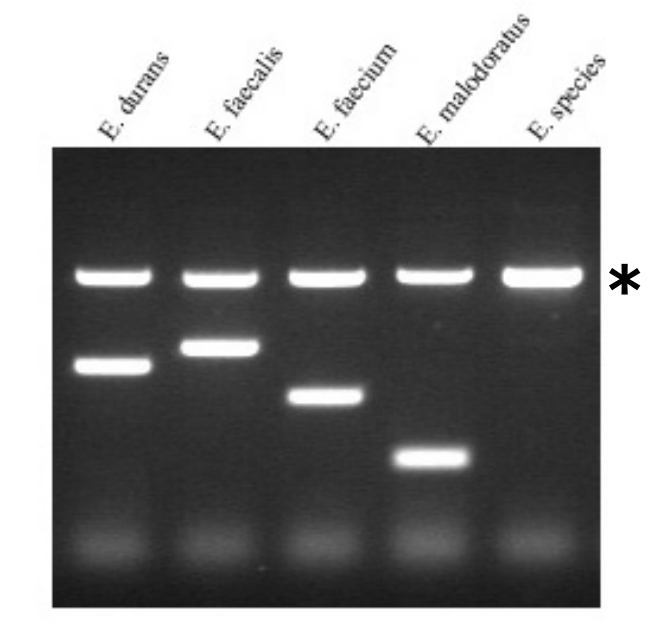
Enterococci

- Started in 2000
  - 2001 aggregates noticed
- PCR started in 2002 for speciation
- 2002 media study conducted
  - Serotype recovery affected by temperature
- Data is being analyzed

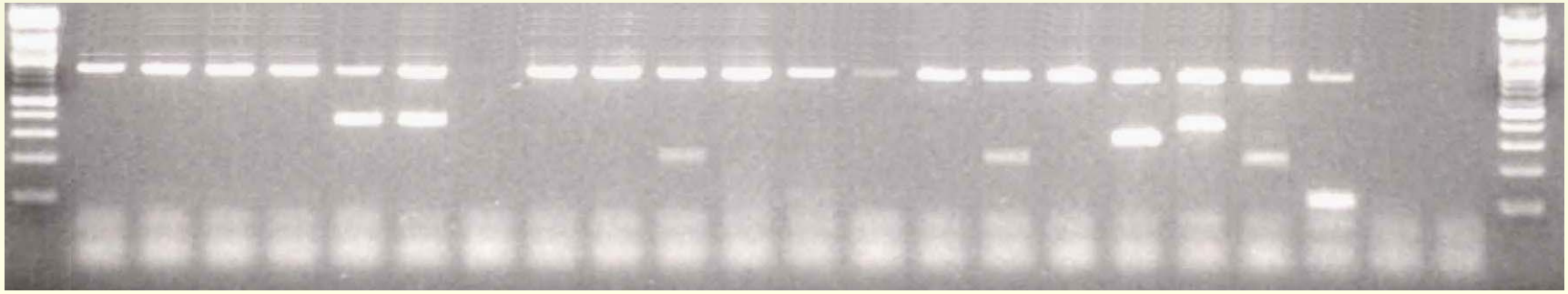
Genus and species identification of enterococci

Group 1:
Faecalis-360 bp
Durans-295 bp
Faecium-215 bp
Malodoratus-98 bp

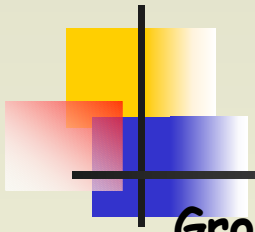
Genus primer:
16s rDNA-733 bp



*Genus primer from Deasy, B.M. et al. 2000. System. Appl. Microbiol. 23: 510-522.



Enterococcus speciation PCR



Group 1:
Faecalis-360 bp
Durans-295 bp
Faecium-215 bp
Malodoratus-98 bp

Group 2:
Solitarius-371 bp
Casseliflavus-288bp
Gallinarum-173 bp
Mundtii-98 bp

Group 3:
Saccharolyticus-371 bp
Dispar-284 bp
Pseudoavium-173 bp
Gilvus-98 bp

Group 4:
Flavescens-284 bp
Sulfureus-173 bp
Raffinosus-98 bp

Group 5:
Avium-368 bp
Columbae-284 bp
Pallens-160 bp
Seriolicida-100 bp

Group 6:
Cecorum-371 bp
Hirae-187 bp

Group 7:
Asini – 365 bp
Porcinus – 280 bp
Ratti – 98 bp

Genus primer: 16s rDNA-733 bp

Enterococci by Serotype

	Avium	Casseliflavus	Cecorum	Durans	Faecalis	Faecium	Gallinarum	Hirae	Solitarius	ND
2000	26	89	0	482	437	336	7	81	2	130
2001	2	42	2	63	778	373	34	81	3	89

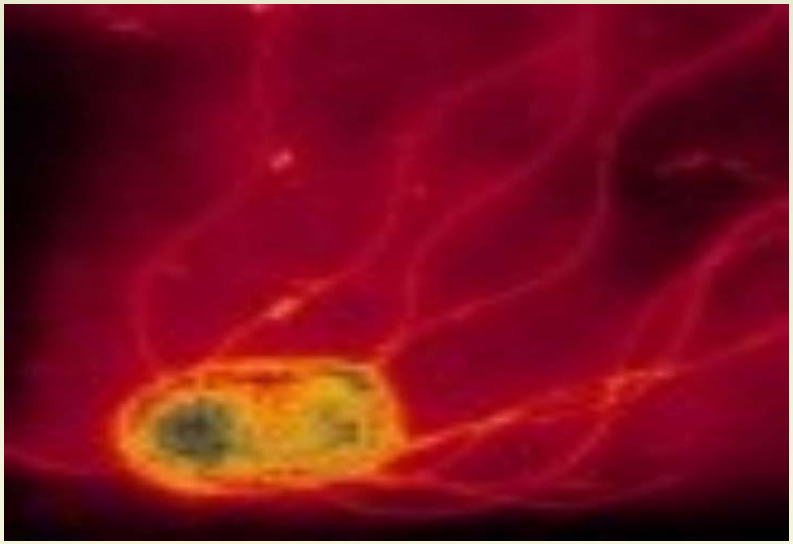
Enterococci Analysis

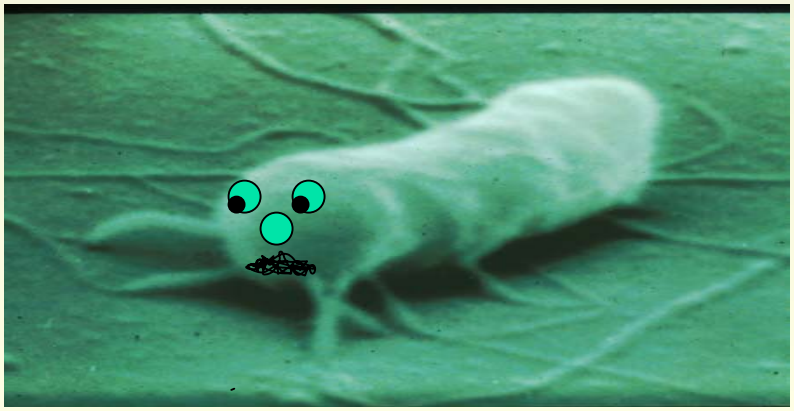
- Analyzed by
  - Serotype
  - Source

- Serotype will affect outcome

Salmonella

- Over 30,000 isolates tested since 1997
- Serotypes
  - Vary over time
  - Vary by source



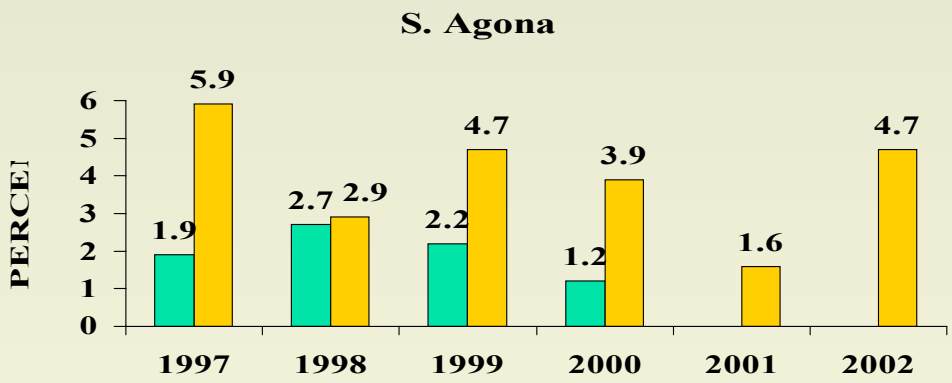


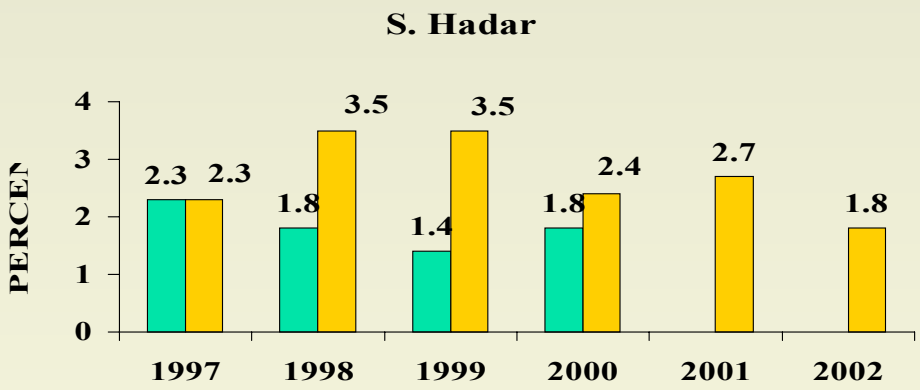
Salmonella

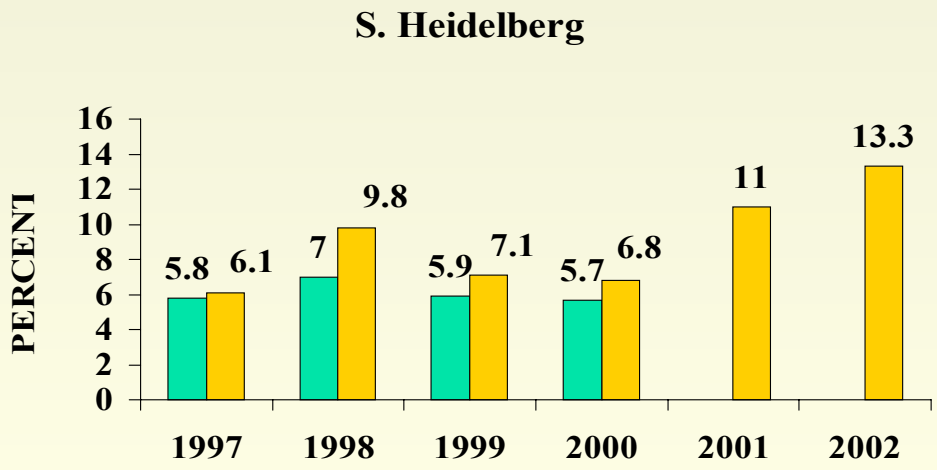
	1997	1998	1999	2000	2001	2002*
Total No. Tested	2391	3318	8508	7834	5739	6582
Total No. Serotypes	98	120	125	138	125	127

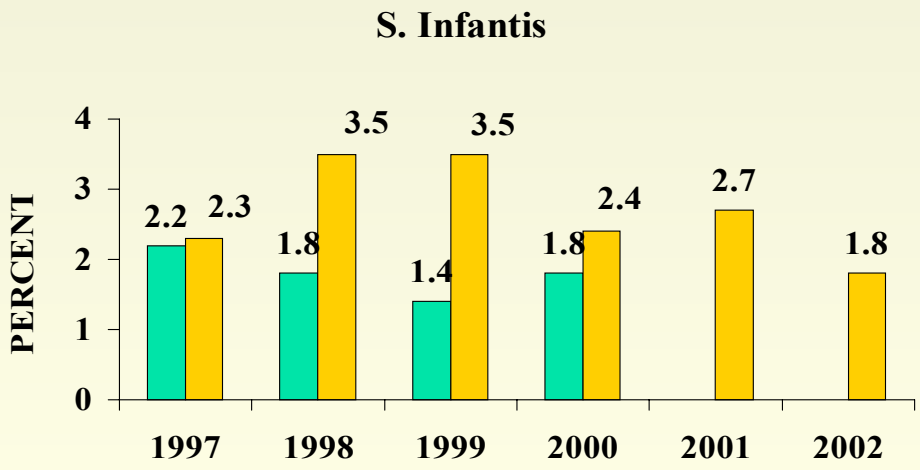
*** Preliminary**

Human vs Animal *Salmonella* Serotypes

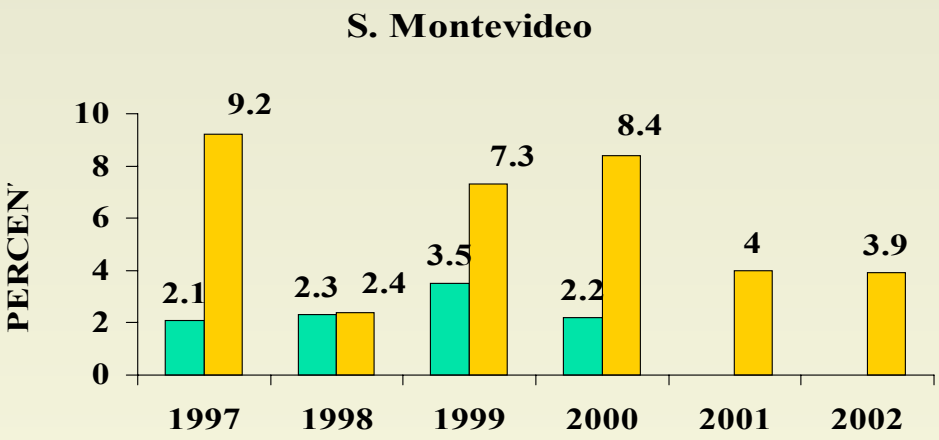




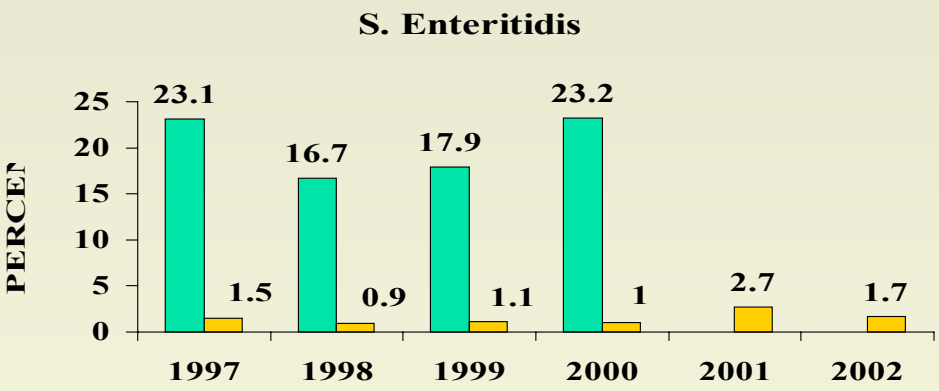


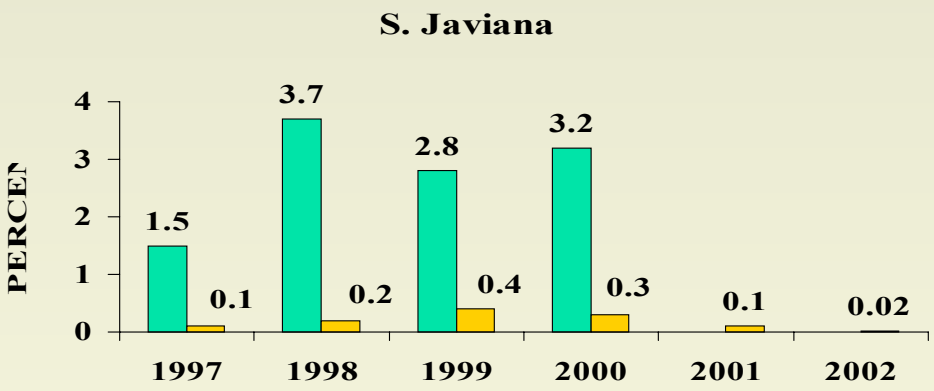


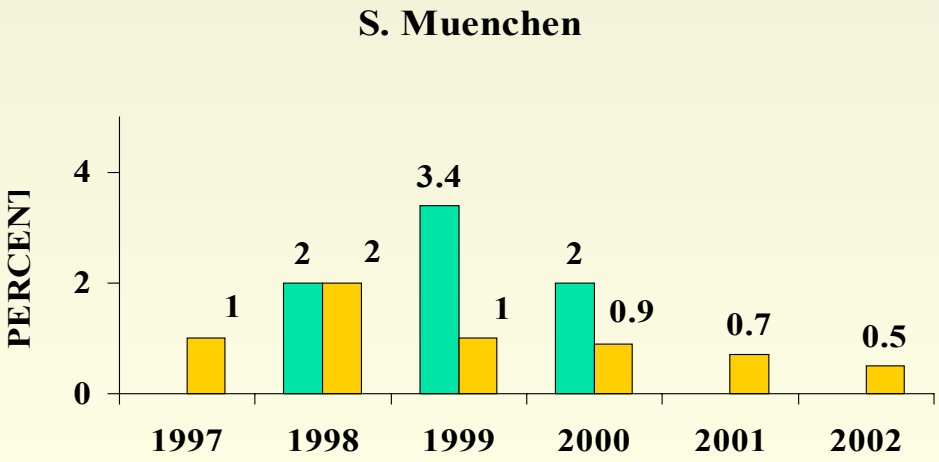
Human vs Animal *Salmonella* Serotypes

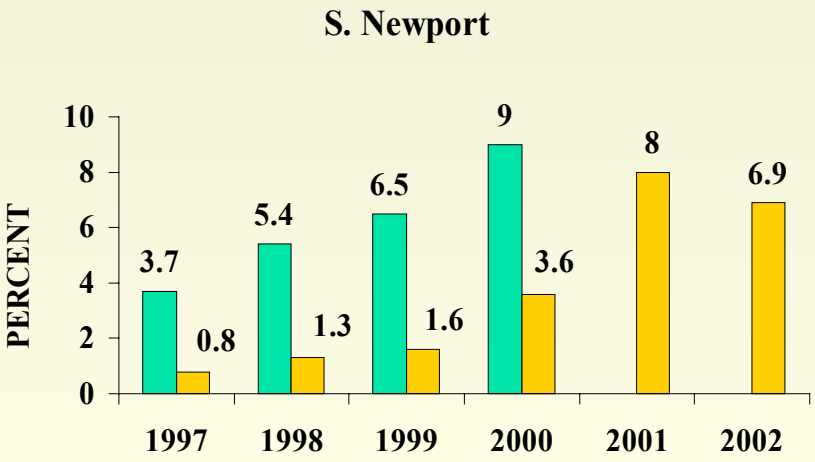


Human vs Animal *Salmonella* Serotypes

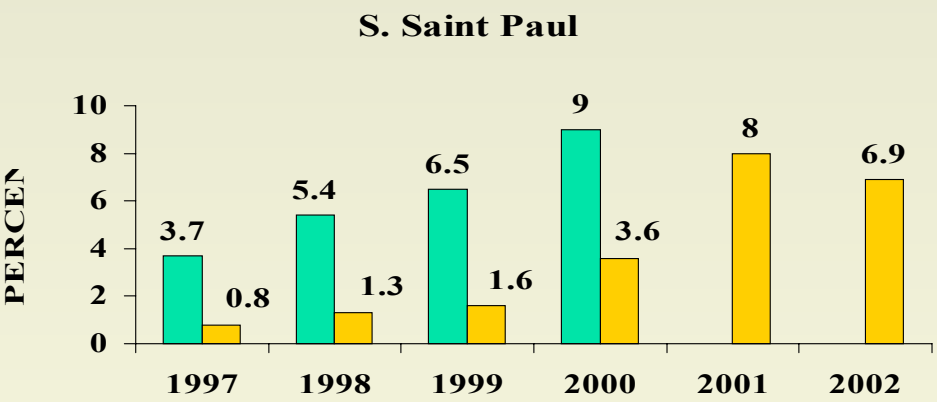


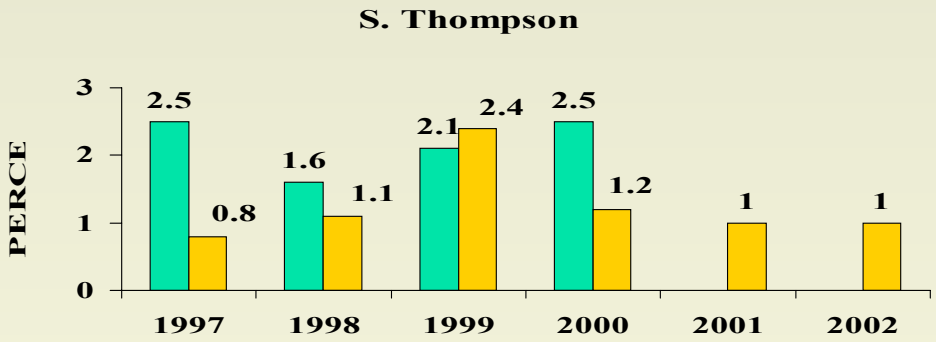


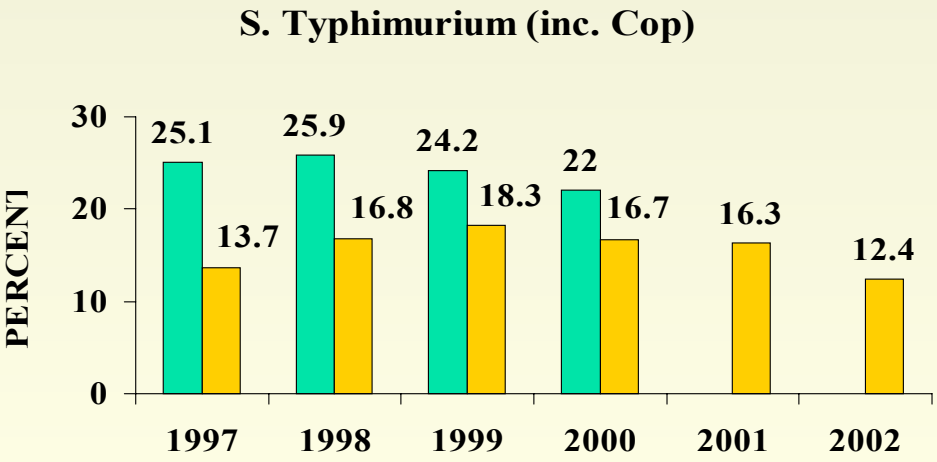




Human vs Animal *Salmonella* Serotypes



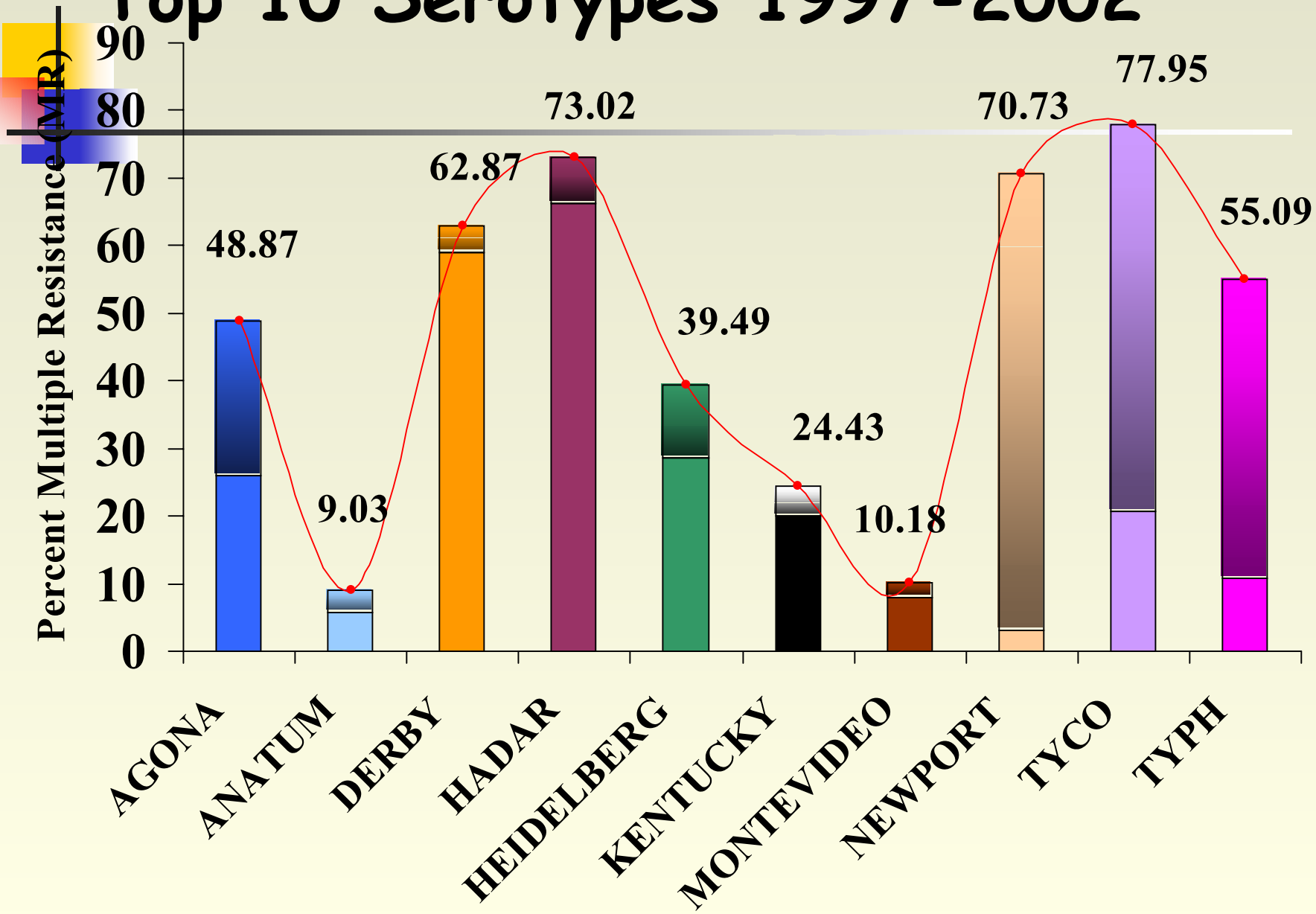




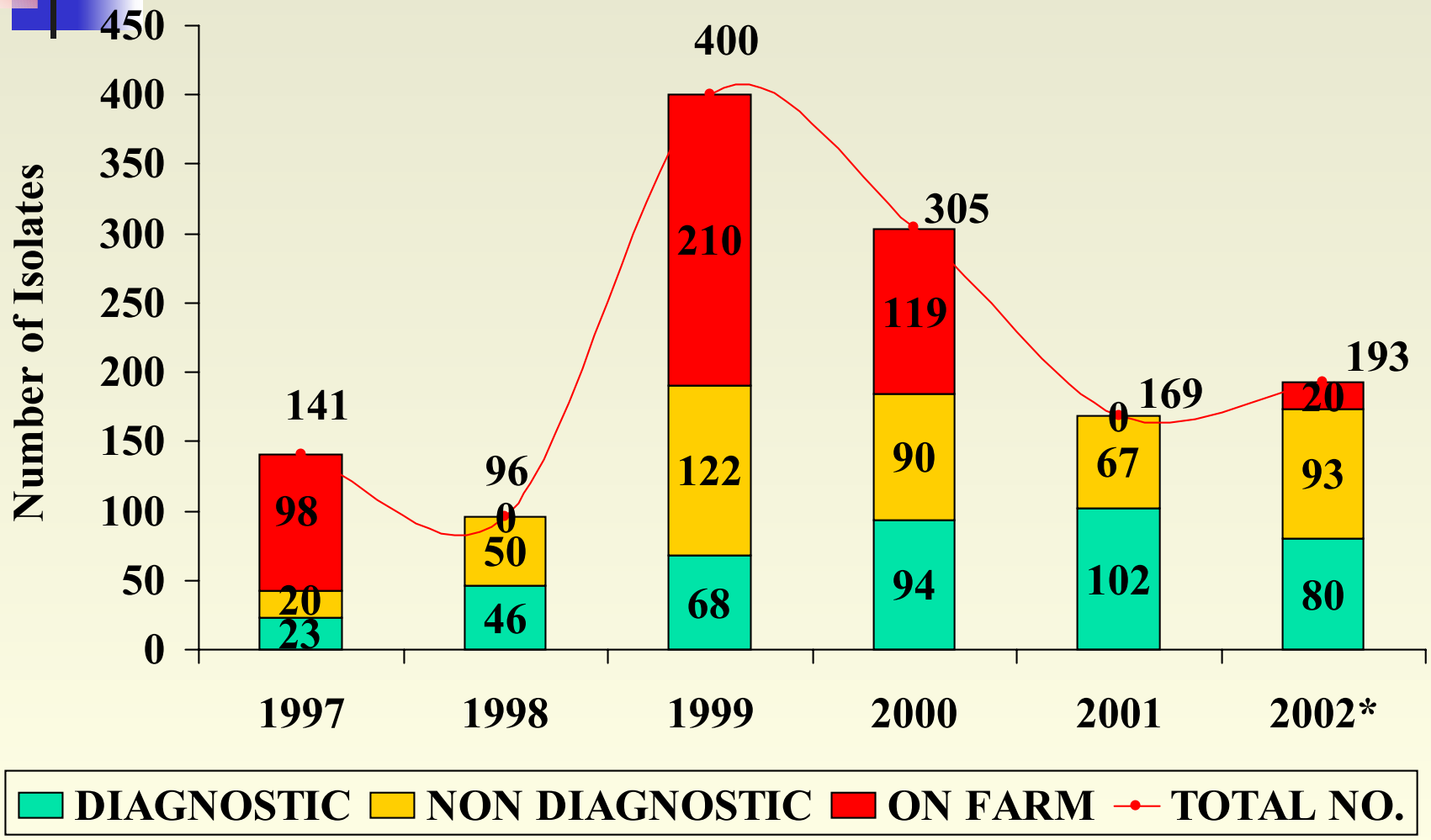
Top 10 Serotypes by Rank 1997-2002*

RANK	SEROTYPE	TOTAL NO.	TOTAL %	CUMULATIVE %
1	S. heidelberg	3117	9.07	9.07
2	S. kentucky	2951	8.58	17.65
3	S. typh var Co	2812	8.18	8.18
4	S. typhimurium	2690	7.82	16.00
5	S. montevideo	2062	6.00	39.65
6	S. derby	1581	4.60	44.25
7	S. anatum	1407	4.09	48.35
8	S. newport	1387	4.03	52.38
9	S. agona	1304	3.79	47.11
10	S. hadar	934	2.72	58.89

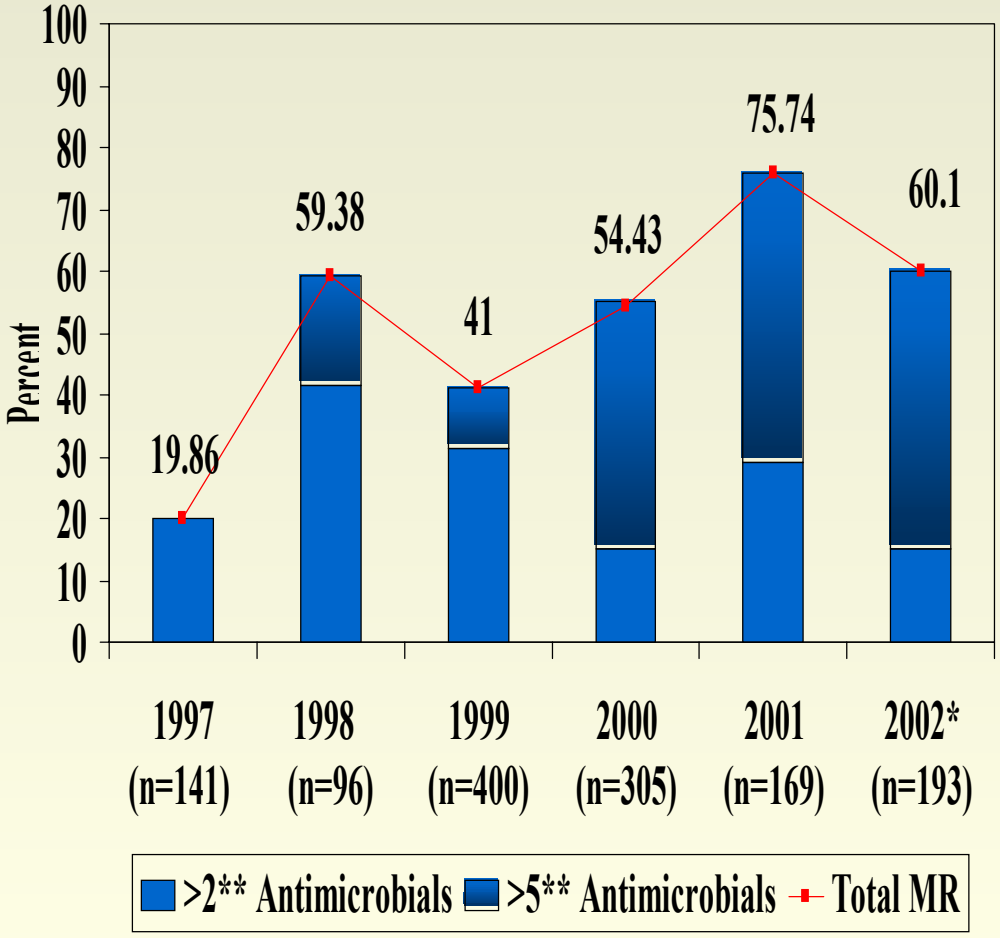
Multiple Resistance Among Top 10 Serotypes 1997-2002*

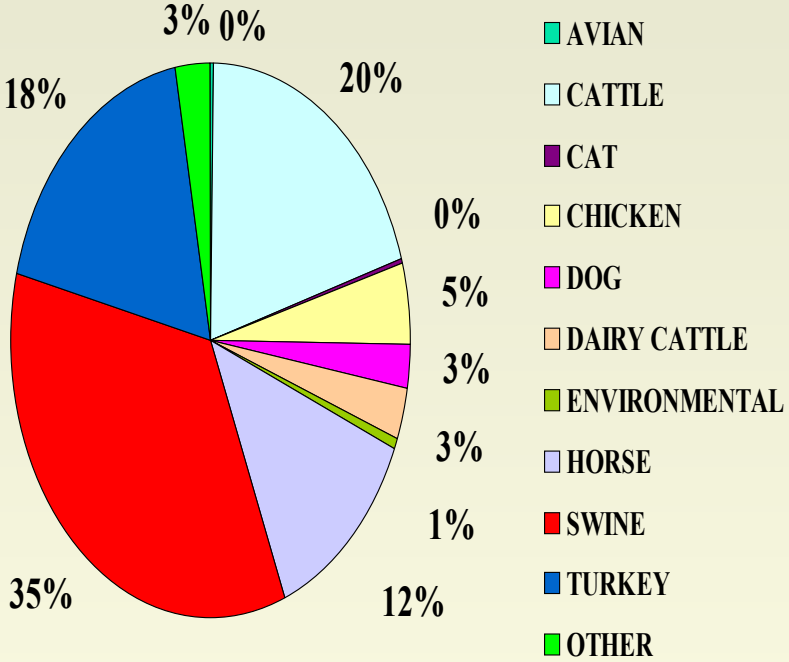


Total Number *S. Agona* Year and Clinical Status



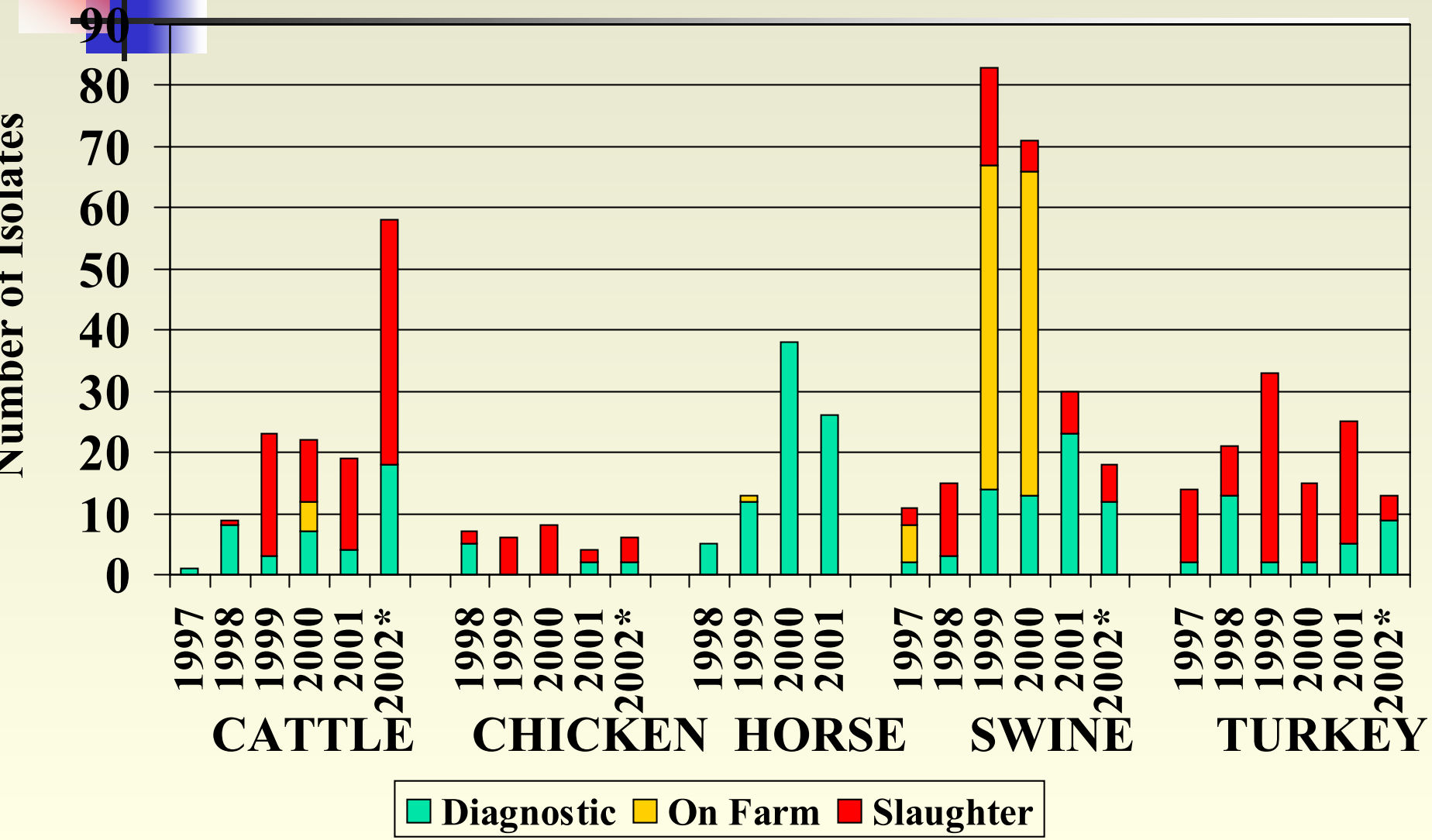
S. Agona n=1111



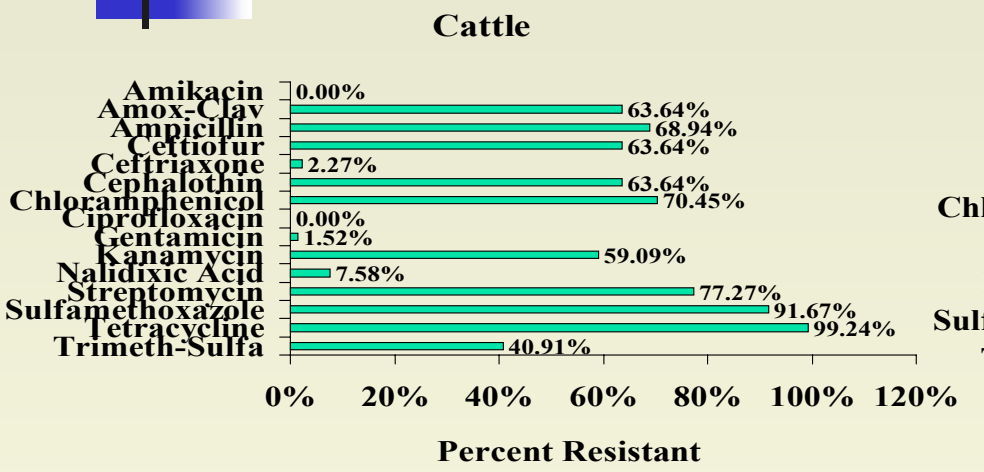


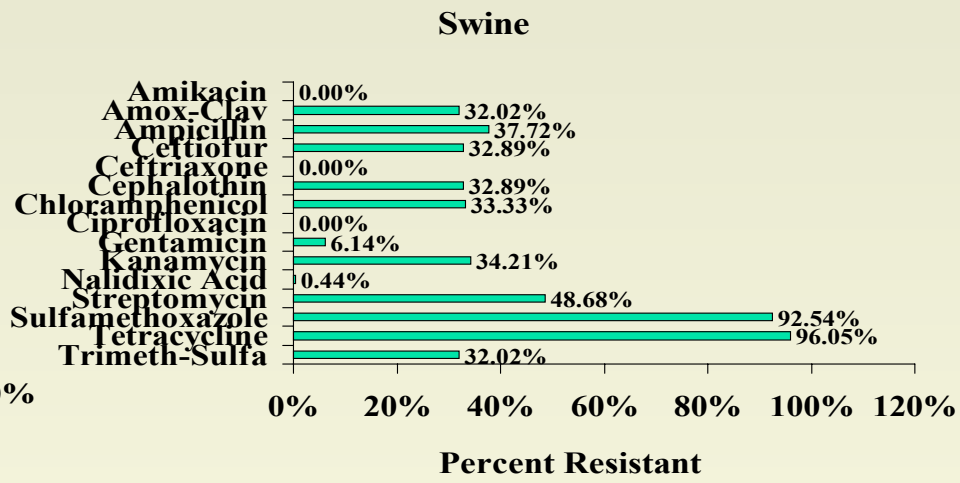
MR isolates from swine, turkey, cattle, chicken and horse = 90%

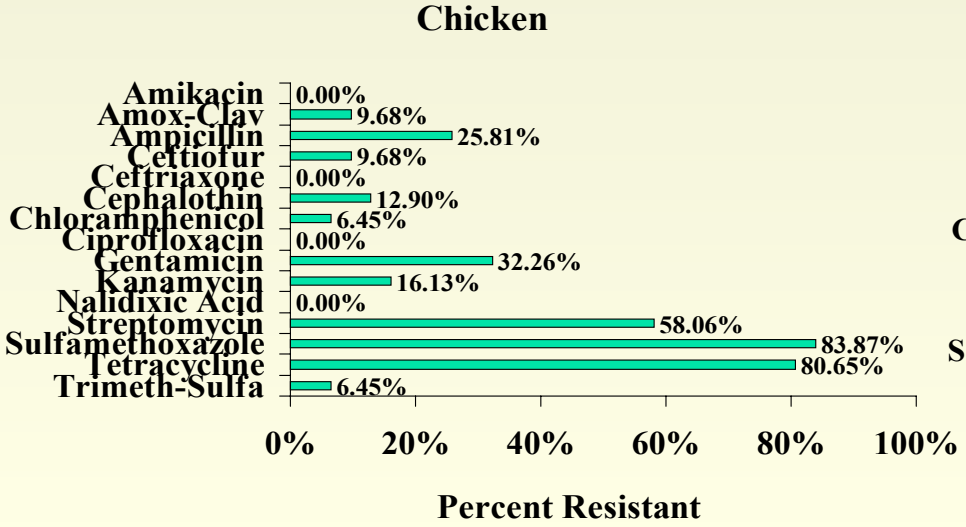
Top Sources for MR *S. Agona* by Year and Clinical Status

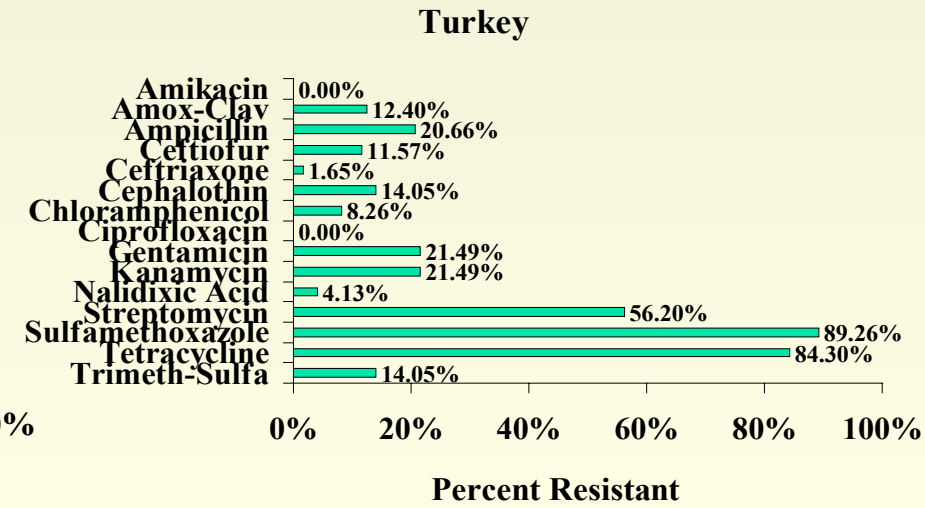


MR S. Agona %R

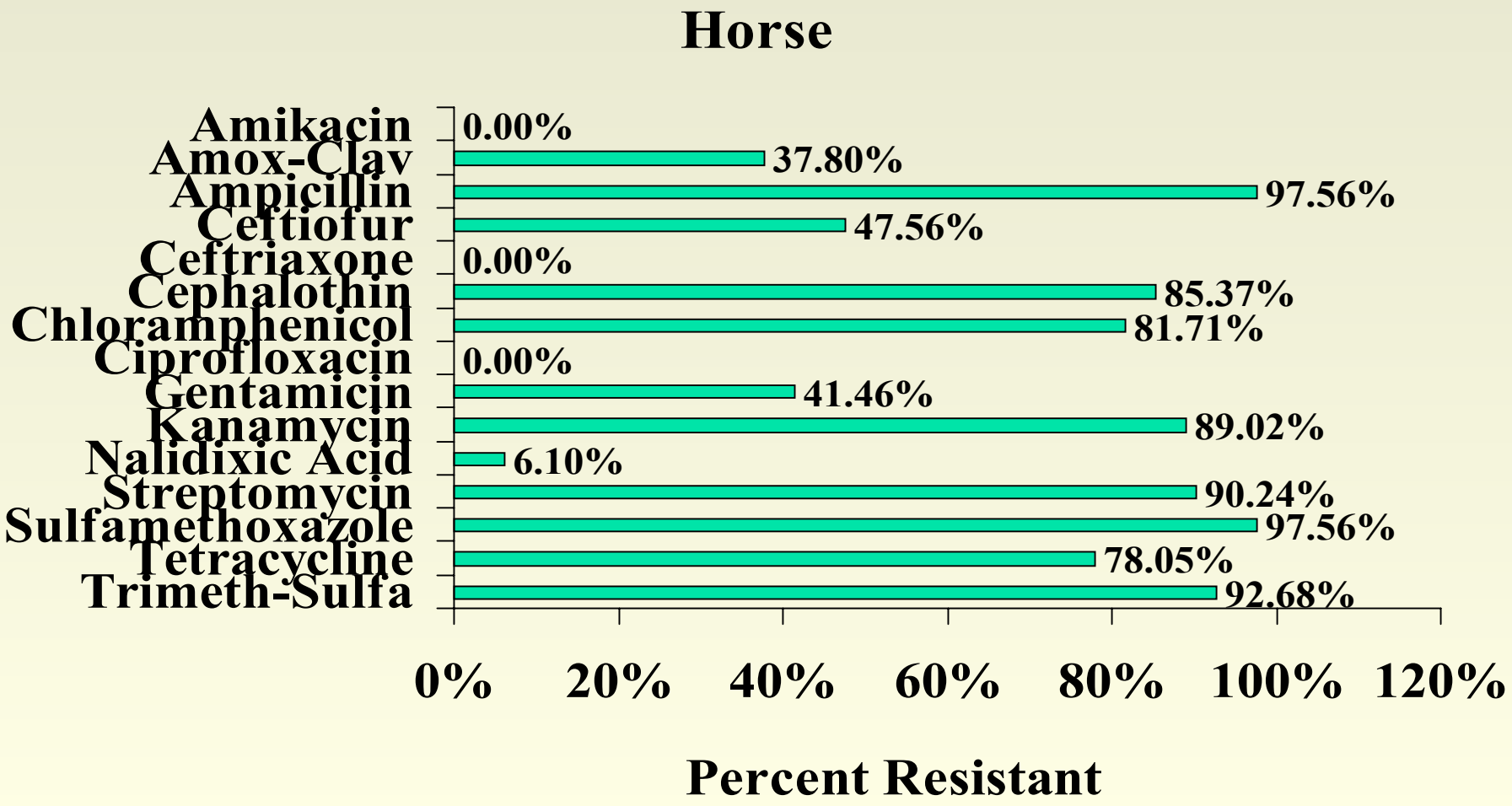

Cattle
Amikacin 0.00%
Amox-Clav 63.64%
Ampicillin 68.94%
Ceftiofur 63.64%
Ceftriaxone 2.27%
Cephalothin 63.64%
Chloramphenicol 70.45%
Ciprofloxacin 0.00%
Gentamicin 1.52%
Kanamycin 59.09%
Nalidixic Acid 7.58%
Streptomycin 77.27%
Sulfamethoxazole 91.67%
Tetracycline 99.24%
Trimeth-Sulfa 40.91%
0% 20% 40% 60% 80% 100% 120%
Percent Resistant


Swine
Amikacin 0.00%
Amox-Clav 32.02%
Ampicillin 37.72%
Ceftiofur 32.89%
Ceftriaxone 0.00%
Cephalothin 32.89%
Chloramphenicol 33.33%
Ciprofloxacin 0.00%
Gentamicin 6.14%
Kanamycin 34.21%
Nalidixic Acid 0.44%
Streptomycin 48.68%
Sulfamethoxazole 92.54%
Tetracycline 96.05%
Trimeth-Sulfa 32.02%
0% 20% 40% 60% 80% 100% 120%
Percent Resistant

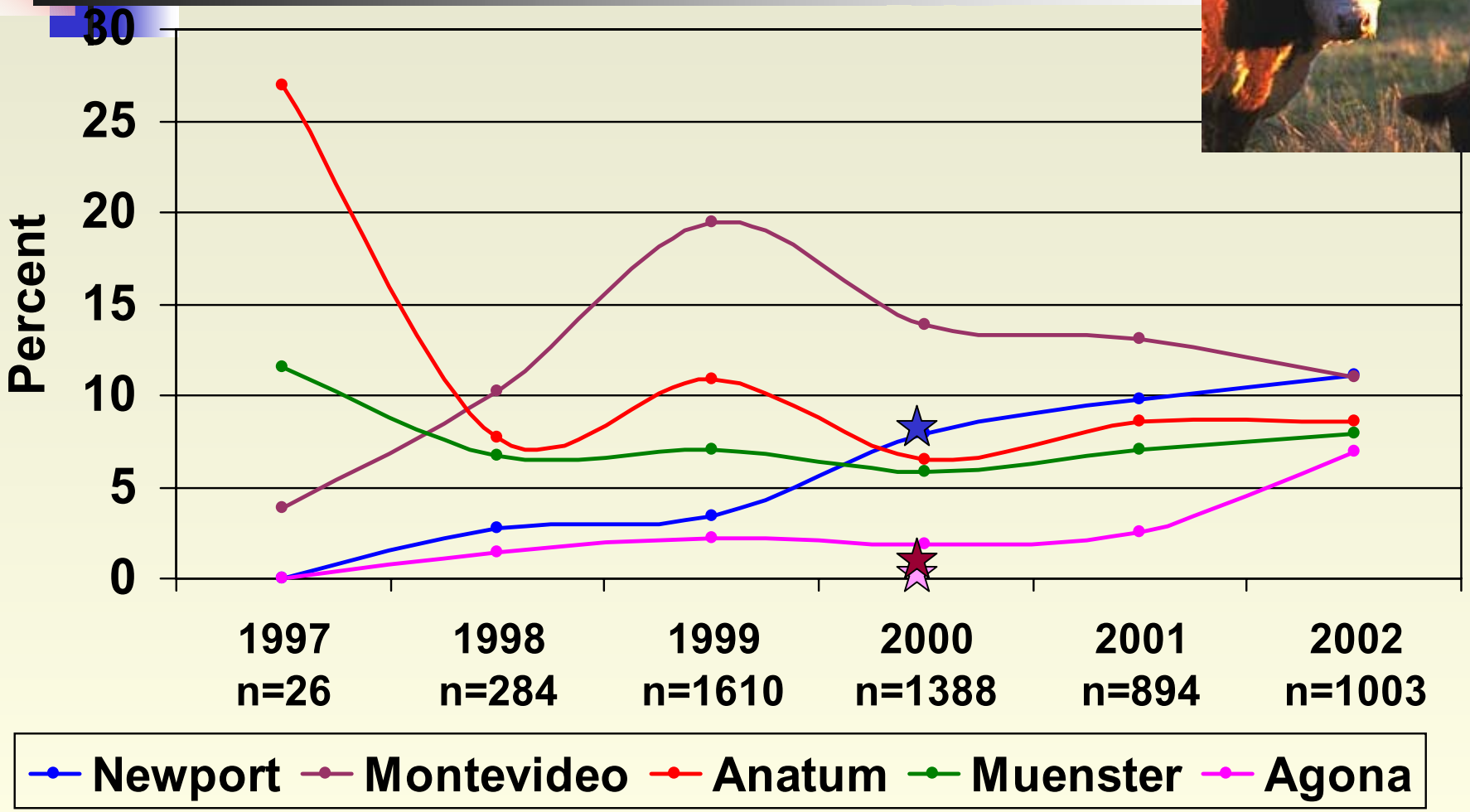

Chicken
Amikacin 0.00%
Amox-Clav 9.68%
Ampicillin 25.81%
Ceftiofur 9.68%
Ceftriaxone 0.00%
Cephalothin 12.90%
Chloramphenicol 6.45%
Ciprofloxacin 0.00%
Gentamicin 32.26%
Kanamycin 16.13%
Nalidixic Acid 0.00%
Streptomycin 58.06%
Sulfamethoxazole 83.87%
Tetracycline 80.65%
Trimeth-Sulfa 6.45%
0% 20% 40% 60% 80% 100%
Percent Resistant


Turkey
Amikacin 0.00%
Amox-Clav 12.40%
Ampicillin 20.66%
Ceftiofur 11.57%
Ceftriaxone 1.65%
Cephalothin 14.05%
Chloramphenicol 8.26%
Ciprofloxacin 0.00%
Gentamicin 21.49%
Kanamycin 21.49%
Nalidixic Acid 4.13%
Streptomycin 56.20%
Sulfamethoxazole 89.26%
Tetracycline 84.30%
Trimeth-Sulfa 14.05%
0% 20% 40% 60% 80% 100%
Percent Resistant

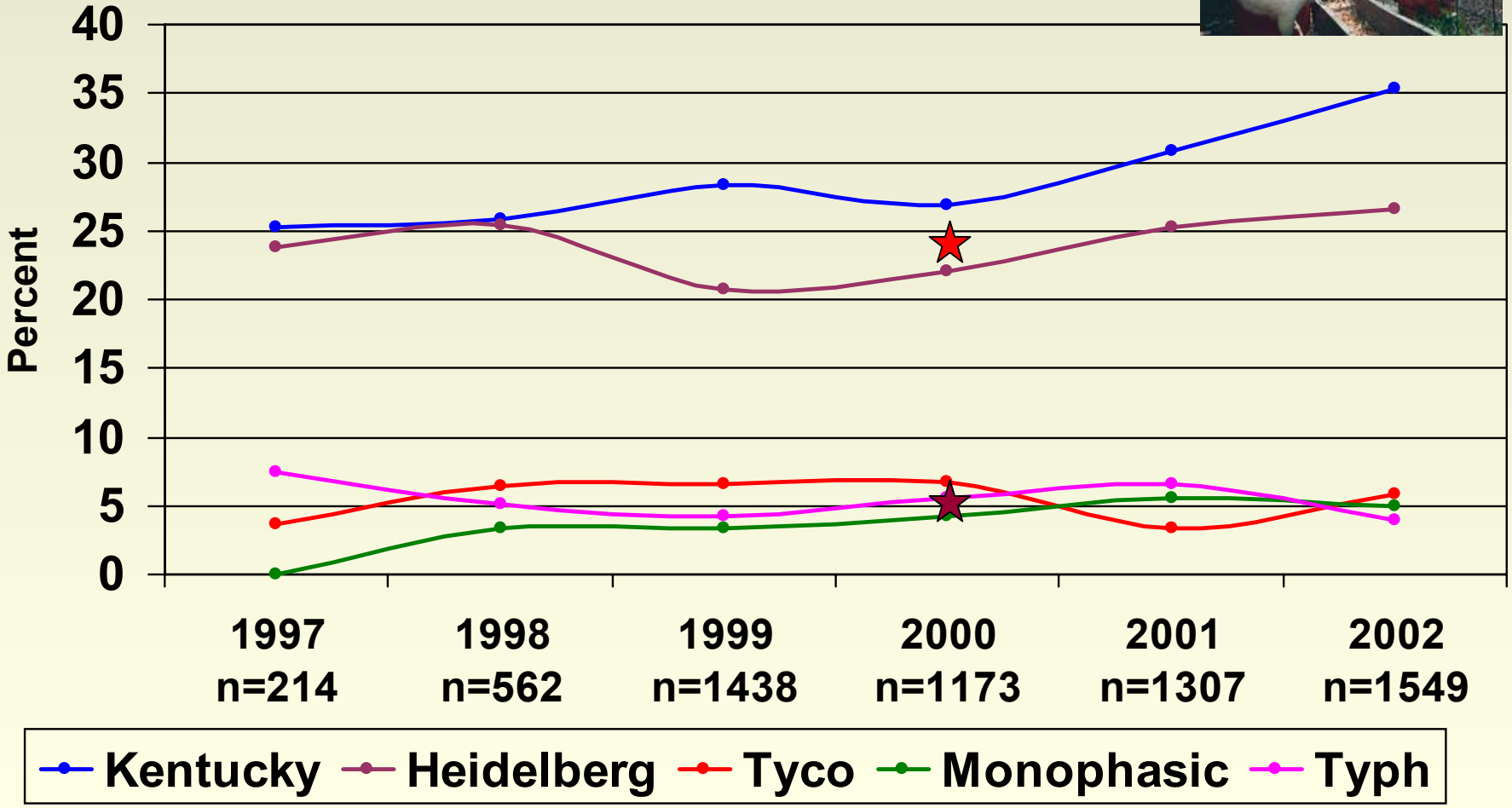
MR *S. Agona* %R


Horse
Amikacin
Amox-Clav
Ampicillin
Ceftiofur
Ceftriaxone
Cephalothin
Chloramphenicol
Ciprofloxacin
Gentamicin
Kanamycin
Nalidixic Acid
Streptomycin
Sulfamethoxazole
Tetracycline
Trimeth-Sulfa
0.00%
37.80%
97.56%
47.56%
0.00%
85.37%
81.71%
0.00%
41.46%
89.02%
6.10%
90.24%
97.56%
78.05%
92.68%
0%
20%
40%
60%
80%
100%
120%
Percent Resistant

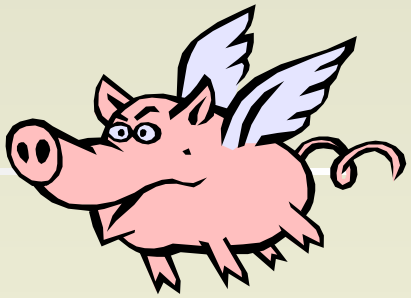
Salmonella Serotypes for 2002 Non-Diagnostic Cattle

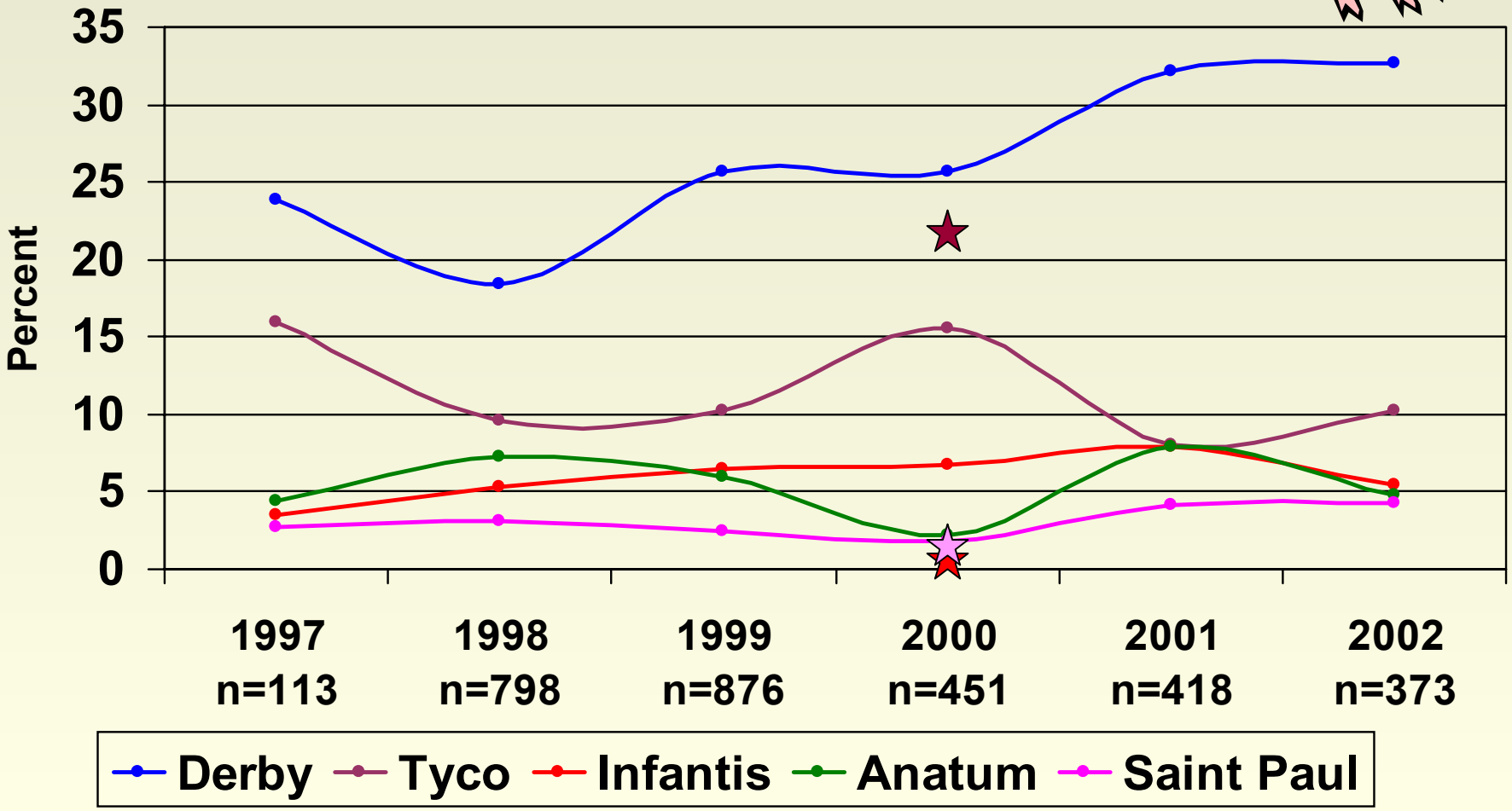


Salmonella Serotypes for 2002 Non-Diagnostic Chicken

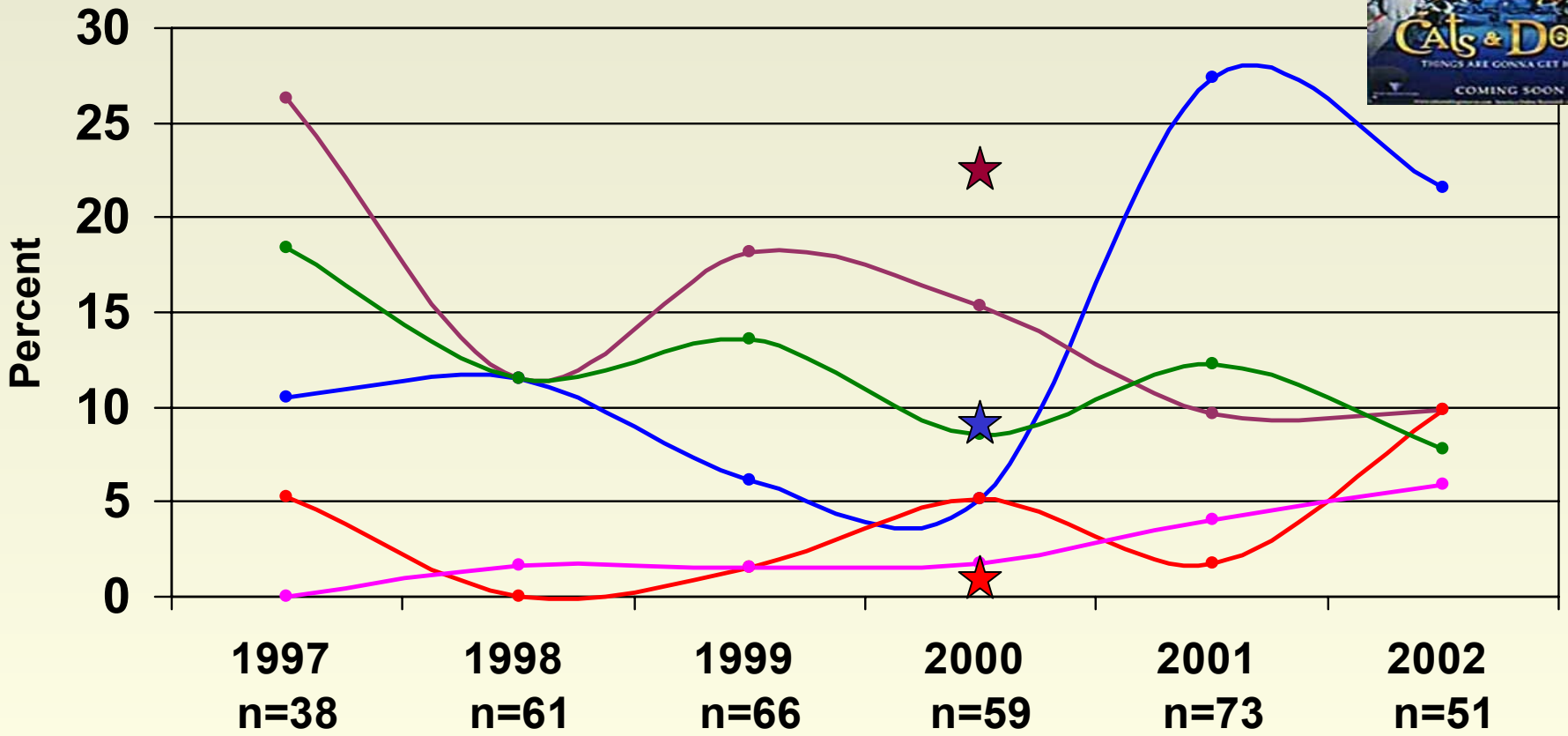


Salmonella Serotypes for 2002 Non-Diagnostic Swine



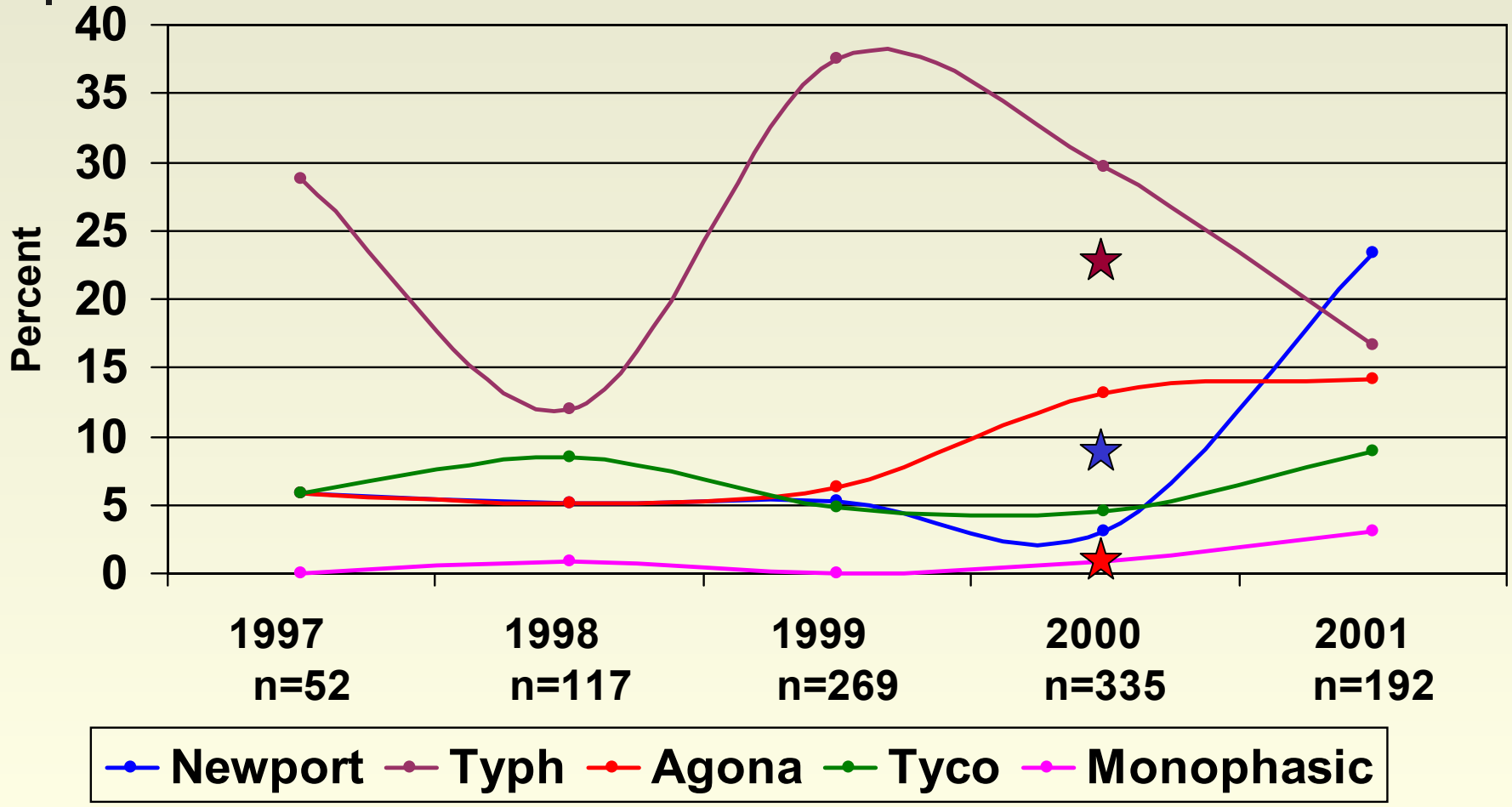


Salmonella Serotypes for 2002 Diagnostic Dog

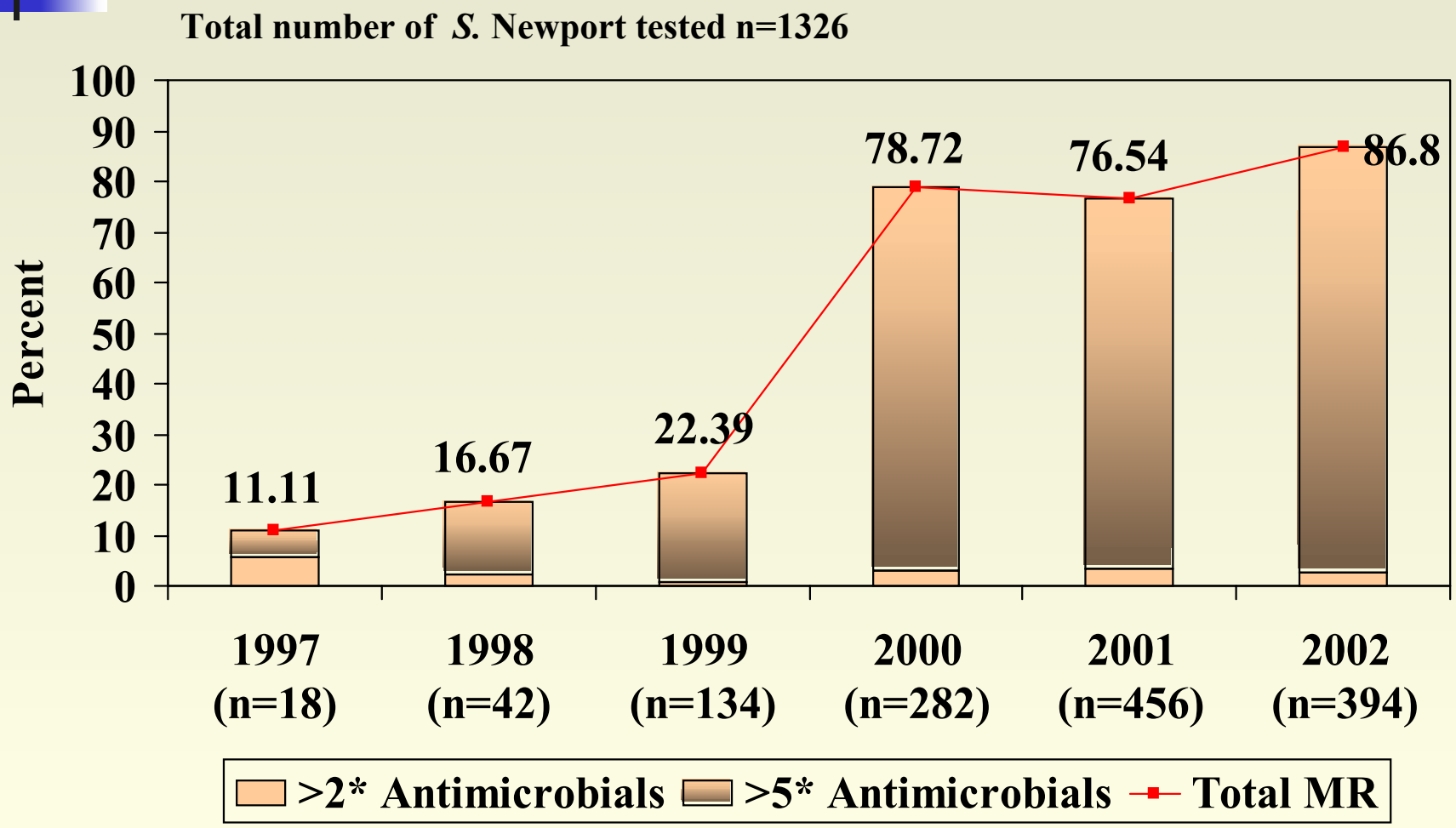


Newport Typh Agona Tyco Oranienburg

Salmonella Serotypes for 2002 Diagnostic Horse

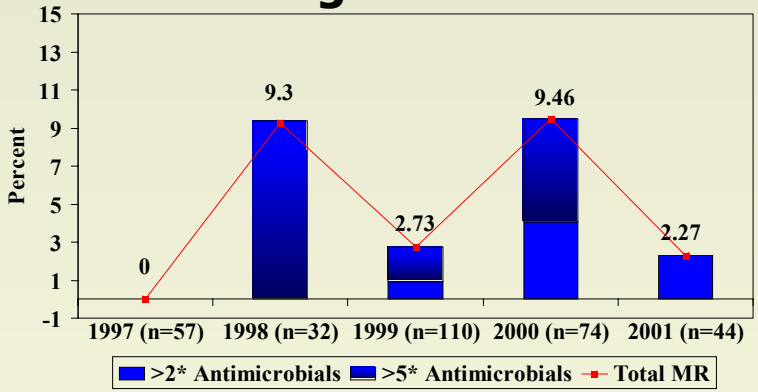


Percent Multiple Resistance – *S.* Newport

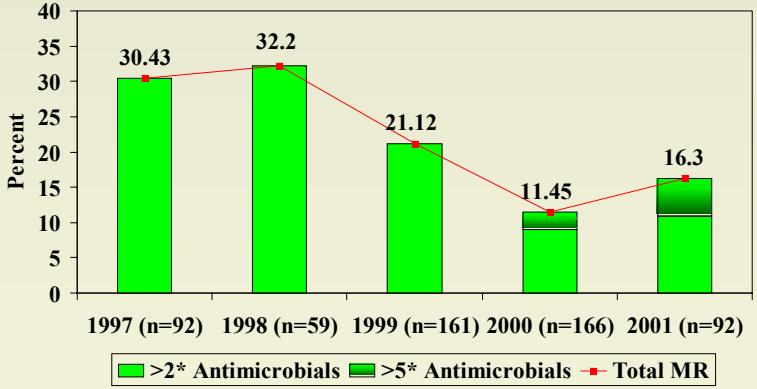


MR Variations

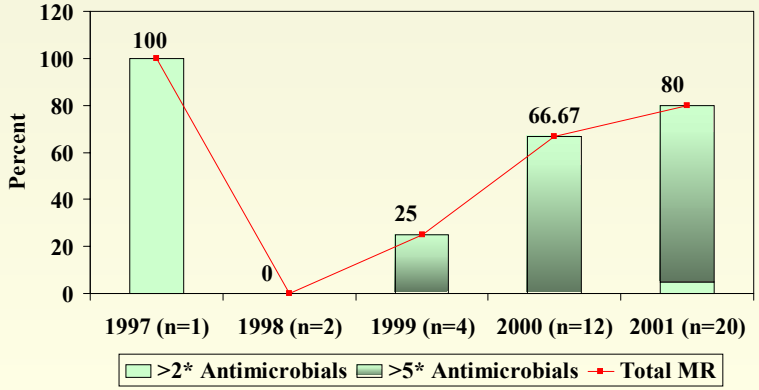
S. Meleagridis n=317



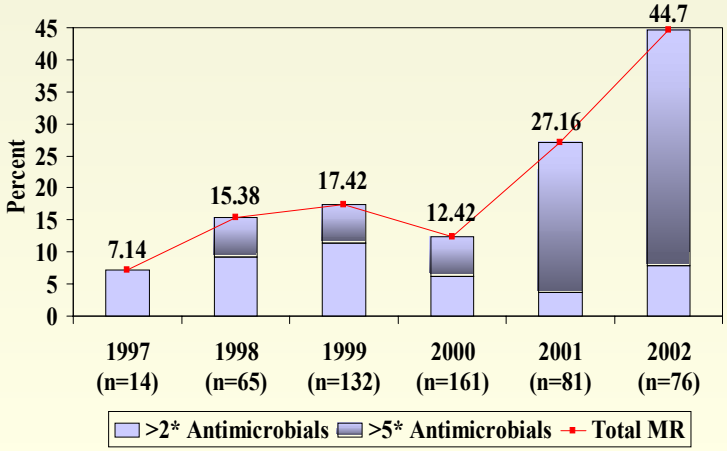
S. Mbandaka n=570



S. Bardo n=39

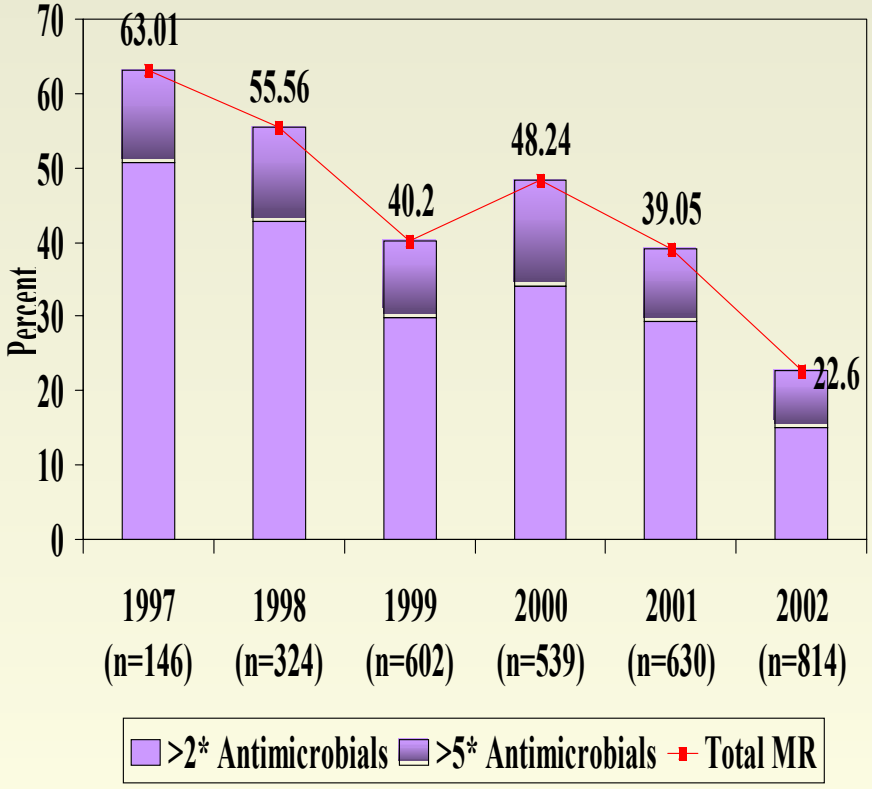


S. Reading n=529

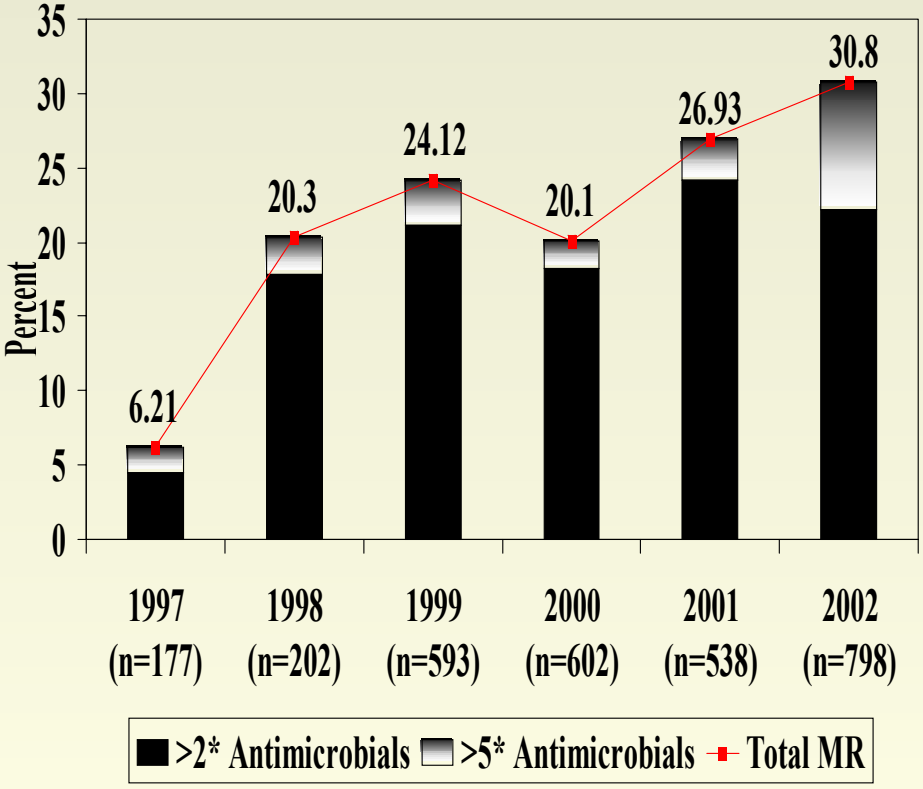


MR Chicken Isolates

***S.* Heidelberg n=3055**



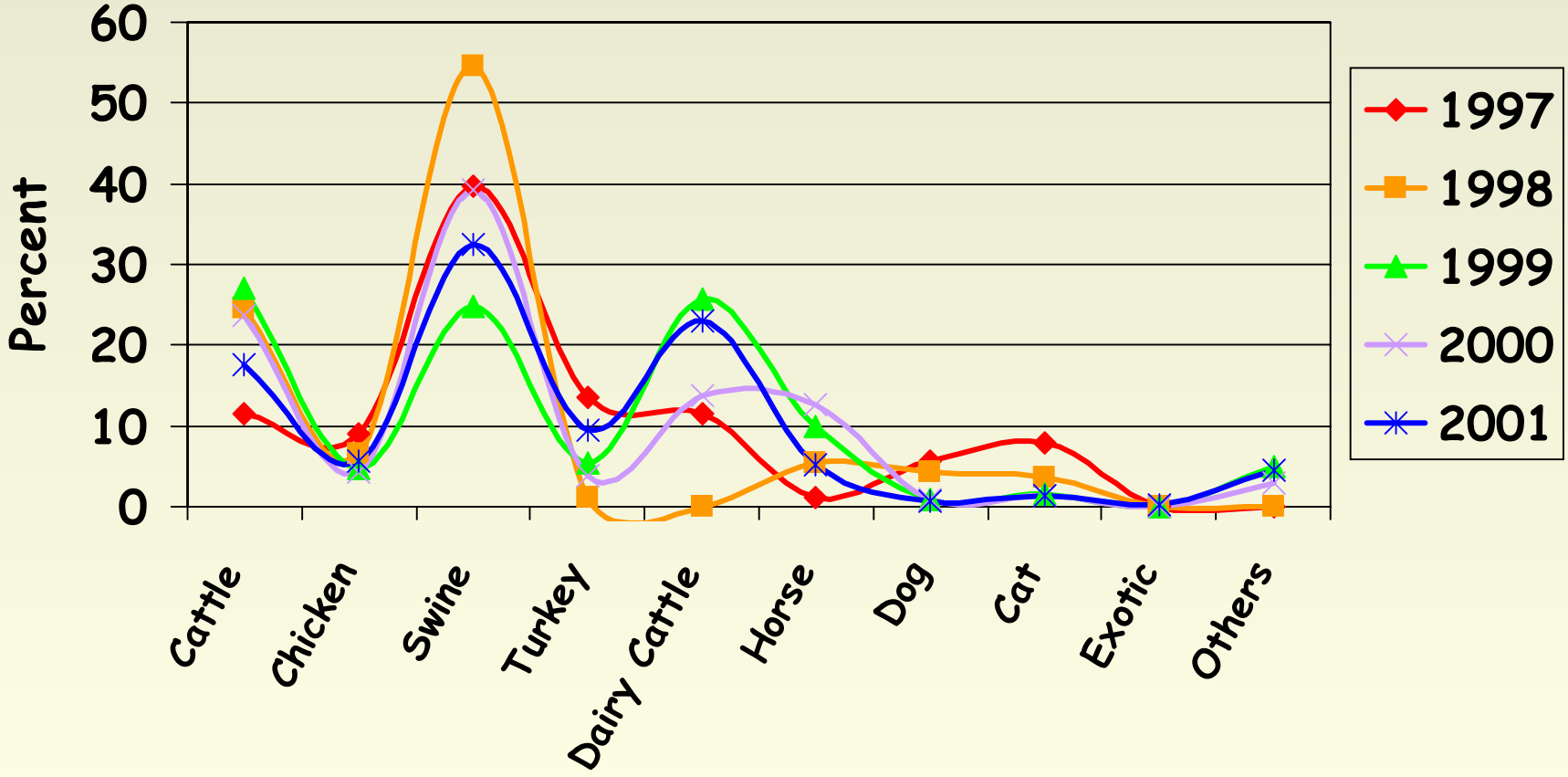
***S.* Kentucky n=2910**



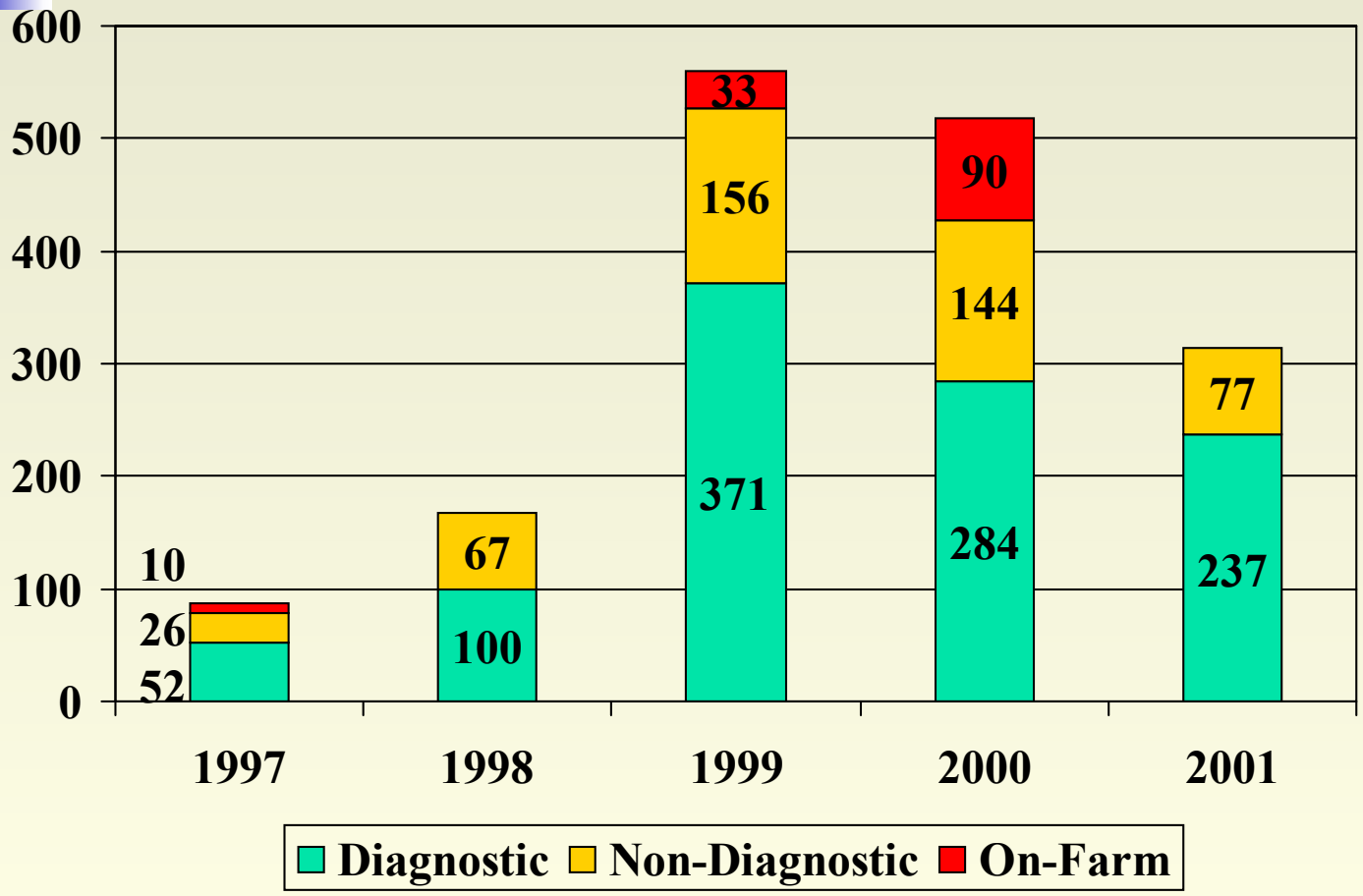
DT104 Perspective

	1997	1998	1999	2000	2001	Total
Total No. Tested	2391	3318	8508	7834	5739	27790
Tot. Typh/co	328	557	1562	1308	933	4688
% of Total	13.7	16.8	18.4	16.7	16.4	16.9

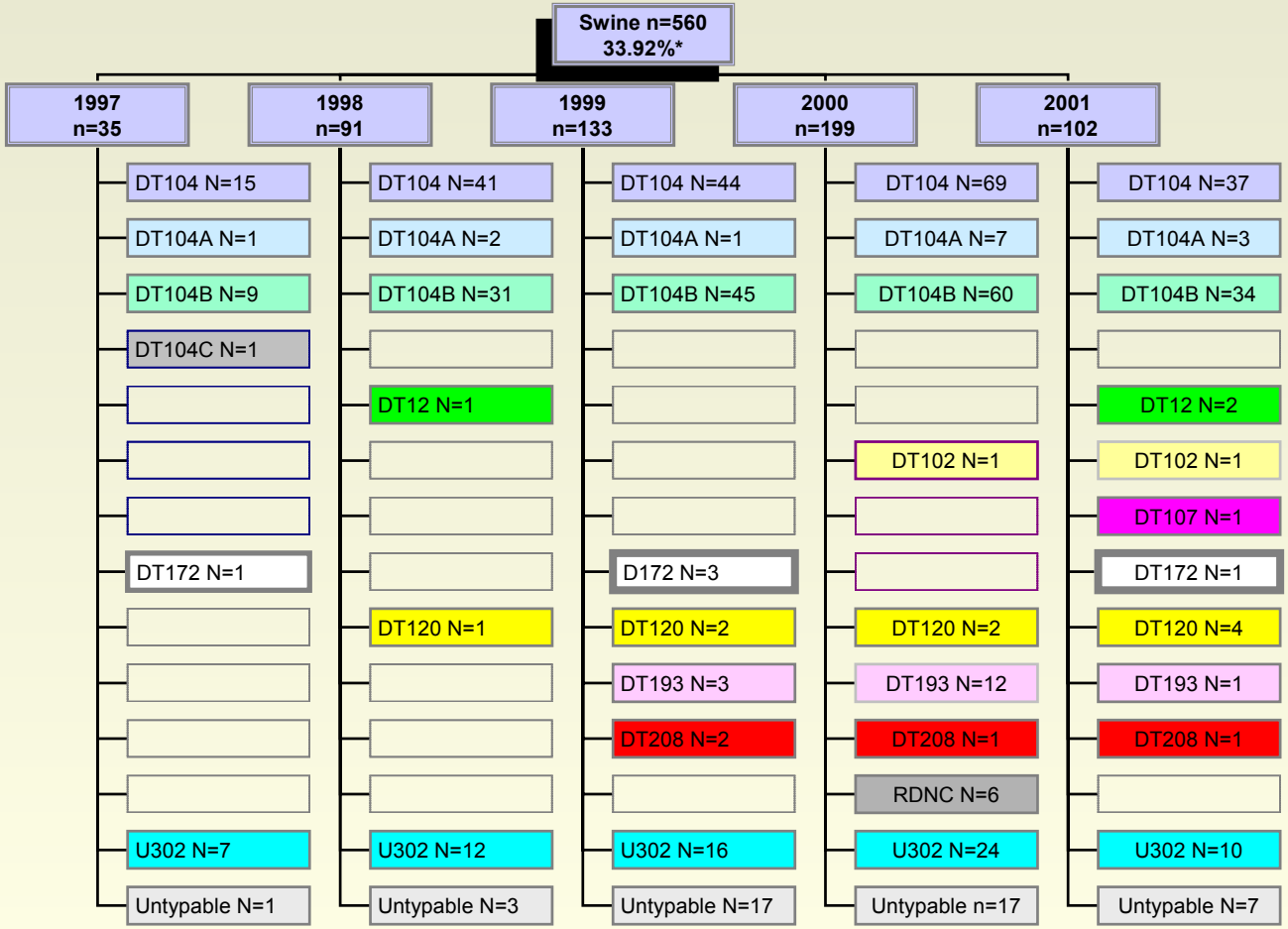
% Typhimurium by Year and Source with Penta R Pattern



Typhimurium by Year and Source with Penta R Pattern



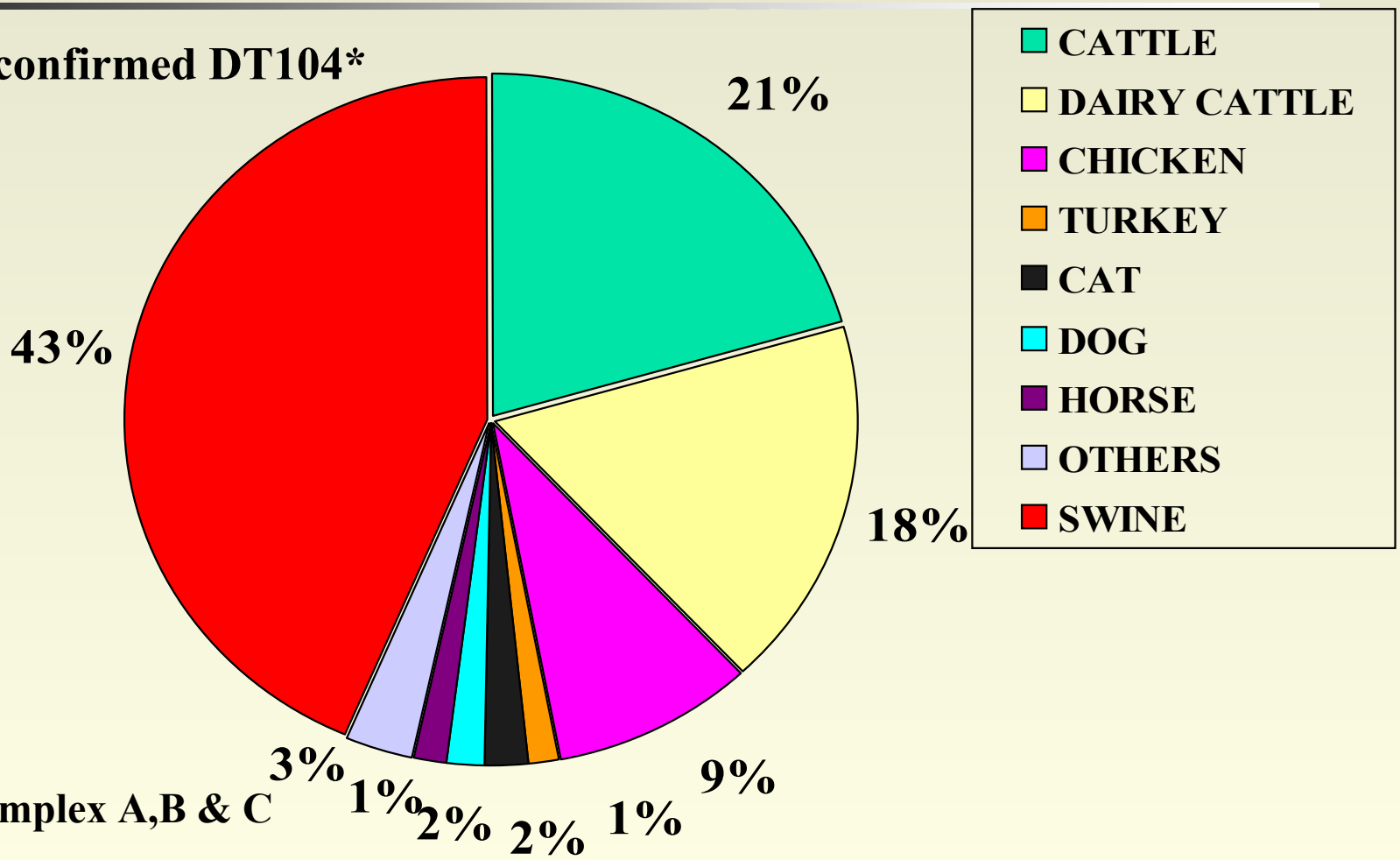
Phage Types – Swine 1997-2001



*% of total DT104 suspects submitted for phage typing

Total Confirmed DT104* by Source 1997-2002**

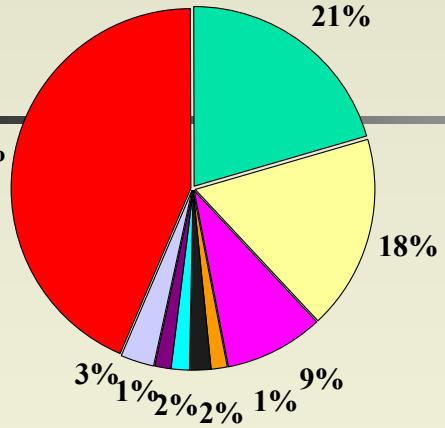
Total =1063 confirmed DT104*

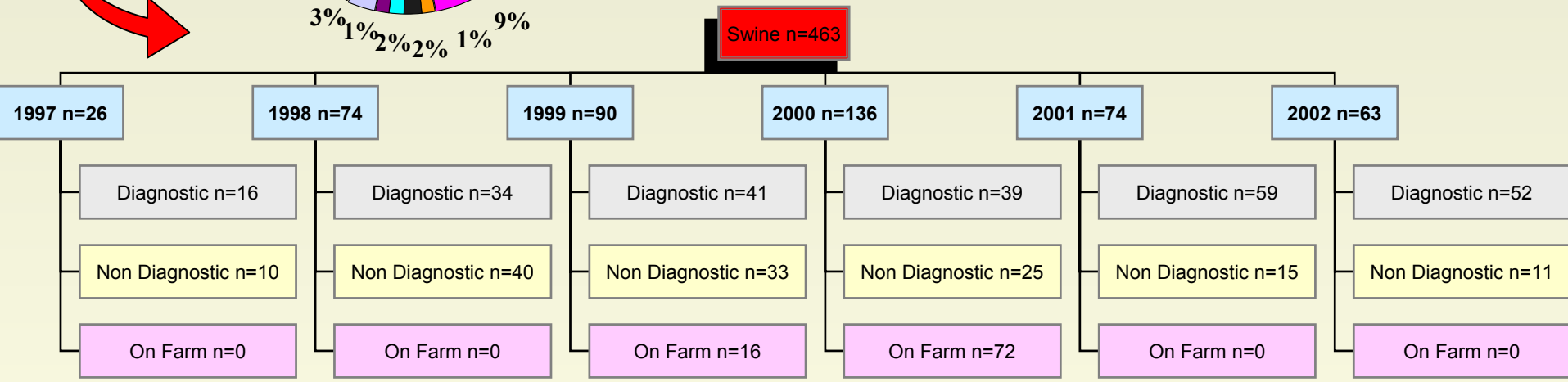


*DT104 + complex A,B & C

**Preliminary data

Confirmed DT104* - Swine





*DT104 + complex A,B & C

**Preliminary data

Totals

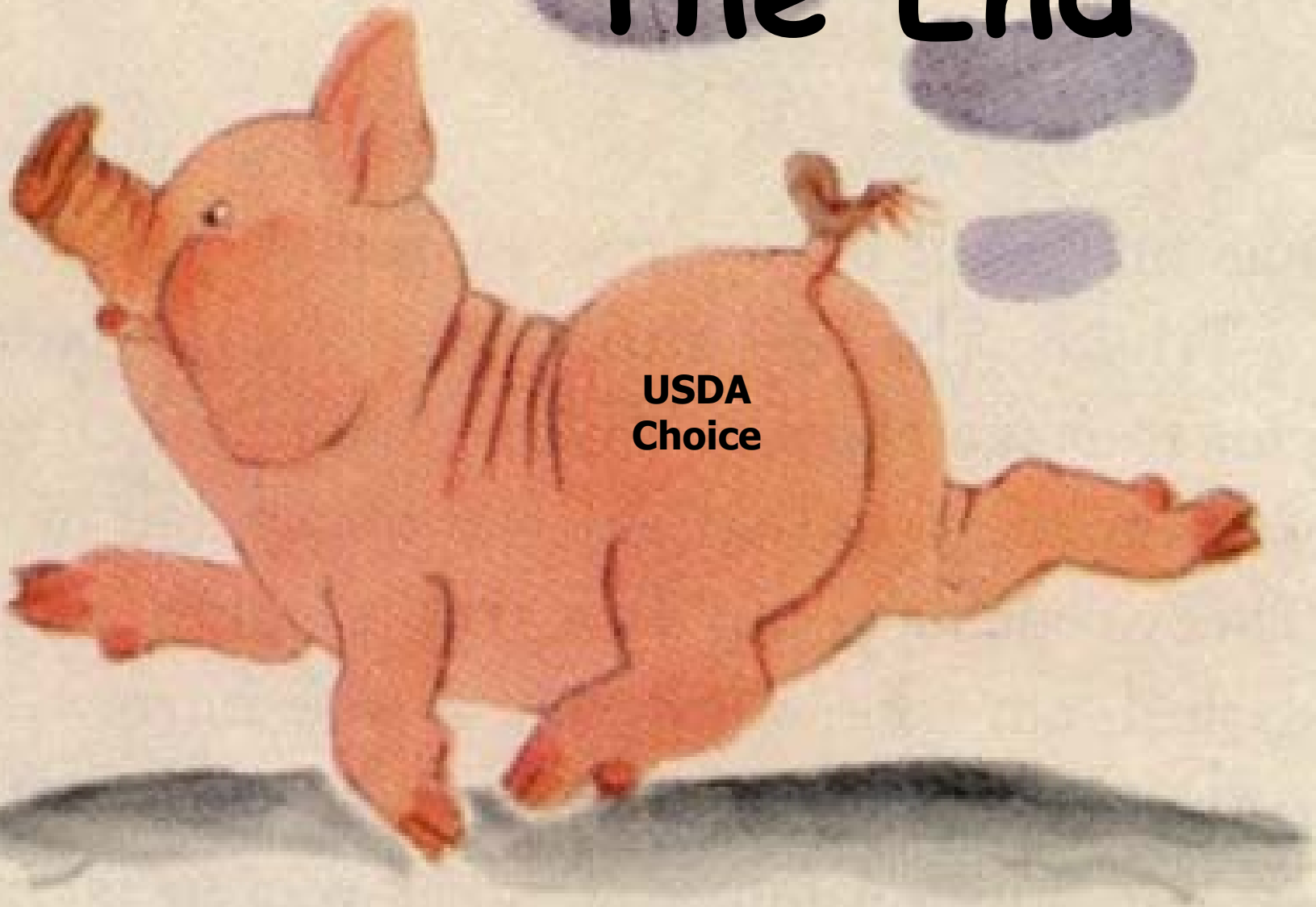
Diagnostic= 246 **Non Diagnostic= 134** **On-Farm=83**

Comments

- Analysis must be by species/serotype
  - Many serotypes found in the same environment
- Why do they come and go over time?
- Why are some serotypes more likely to acquire multiple resistance?
  - What is the next important serotype??????
- Starting the animal arm of PulseNet

All Things Are Possible!!

The End



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