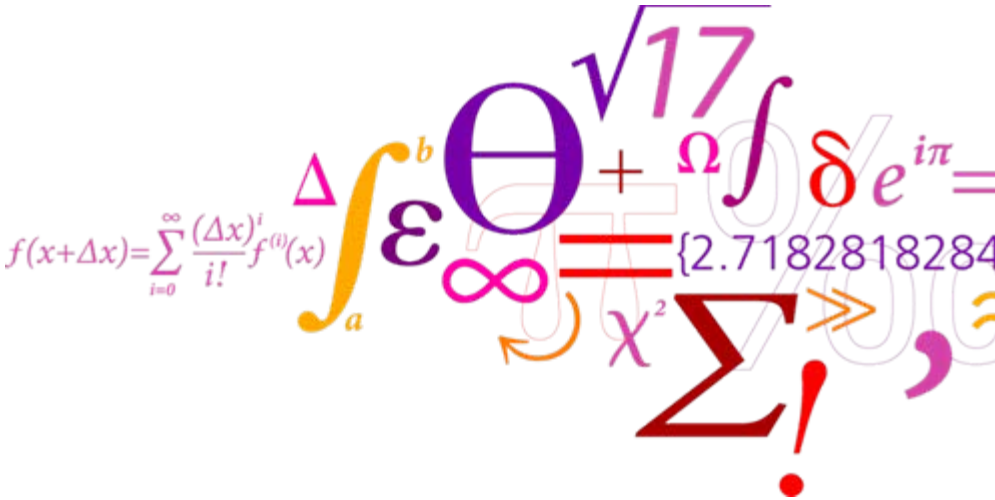
The Danish experience in *Salmonella* Enteritidis control - in layers

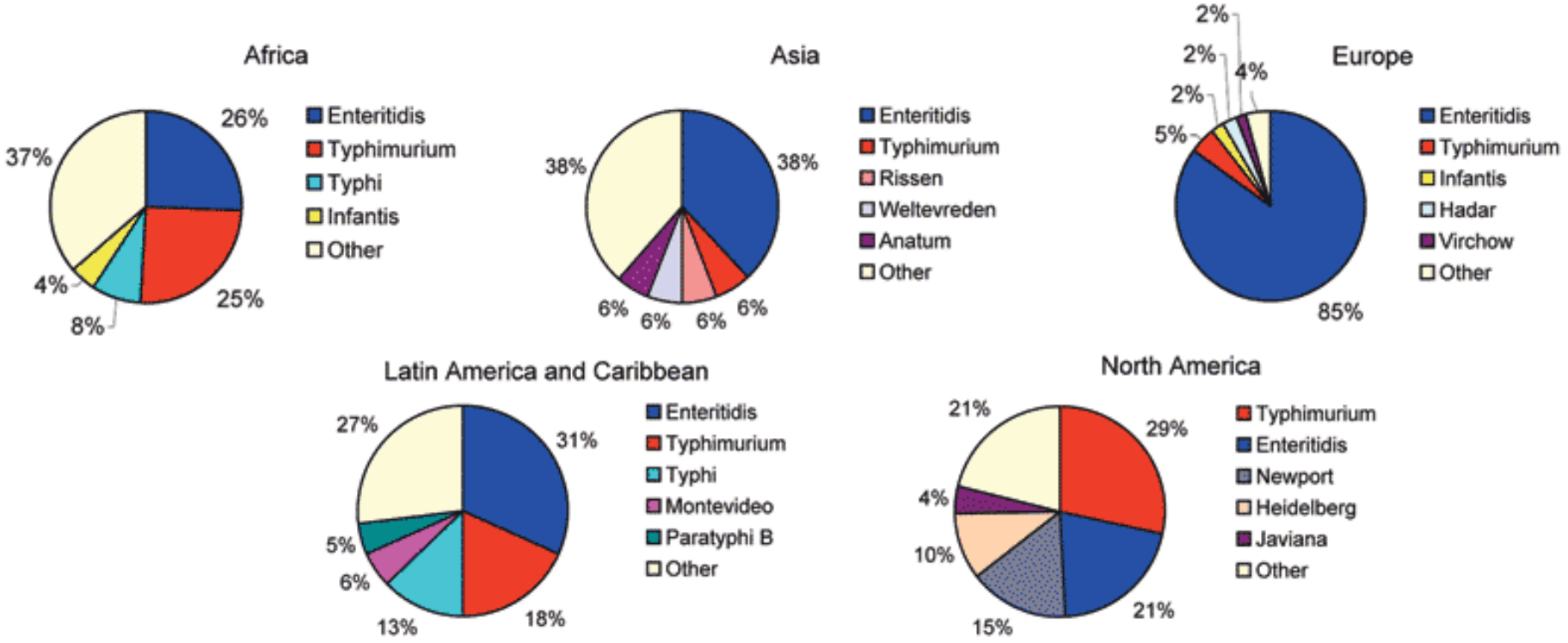
Henrik C Wegener



DTU Food
National Food Institute

SE is the most commonly occurring salmonella in human disease globally

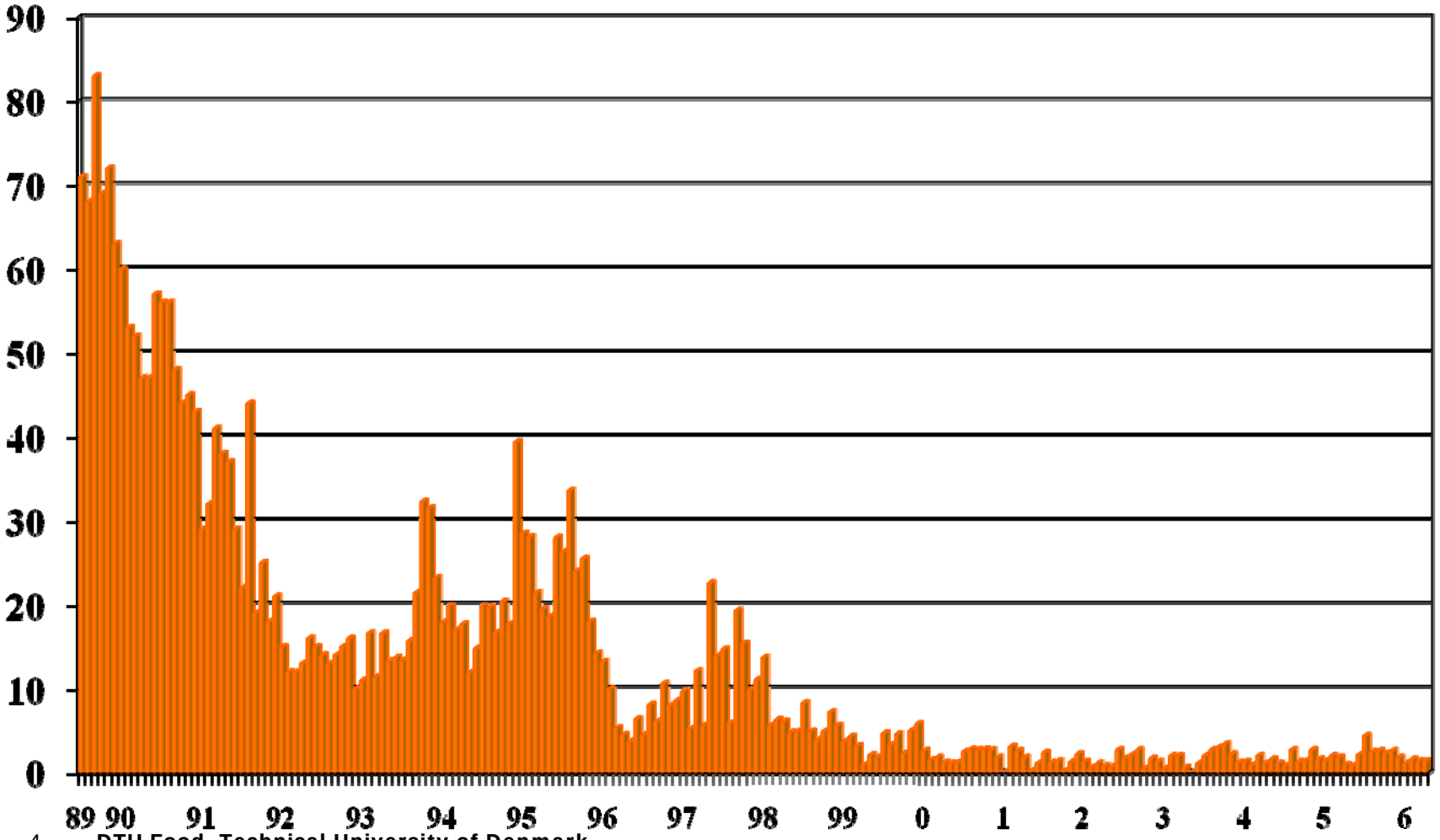
WHO Estim. > 100 million cases of human disease each year



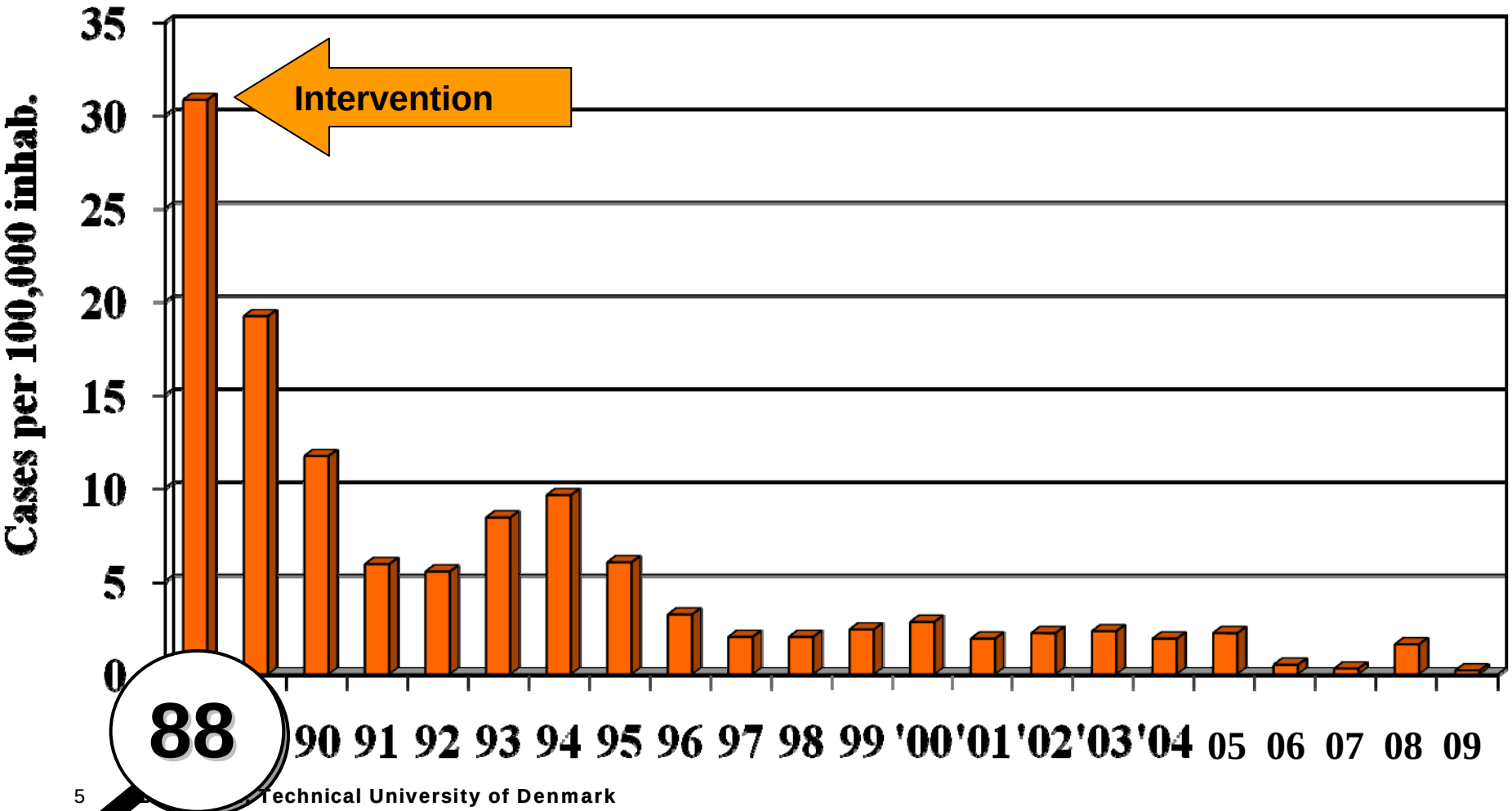
Galanis E., et al. EID 2006

Salmonella can be effectively controlled

Prevalence of *Salmonella* infected Danish broiler flocks



Incidence of human salmonellosis attributable to broilers in Denmark

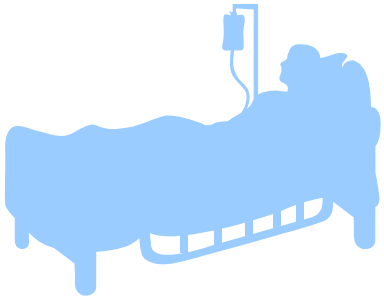


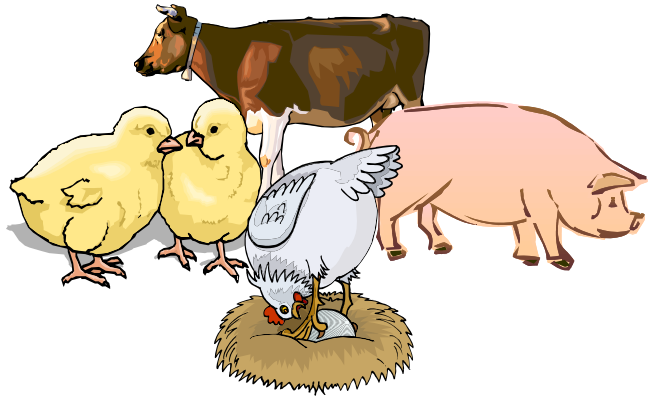
Linking diseases and food / animal reservoirs

Principle of the Danish Salmonella Source Attribution model

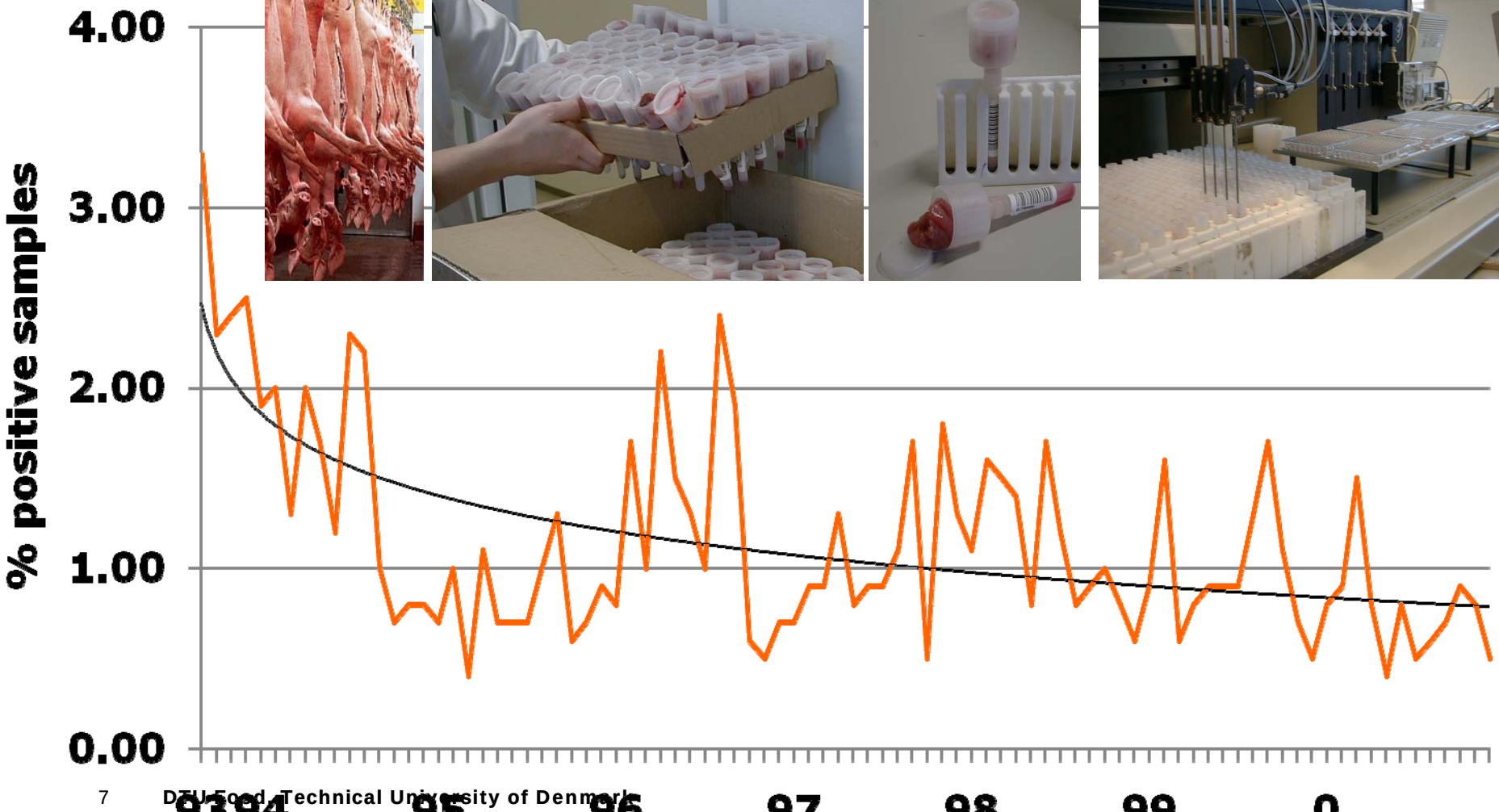
Compare the number of (reported) human cases caused by different *Salmonella* subtypes

with the distribution of *Salmonella* subtypes isolated from the various food (-animal) sources

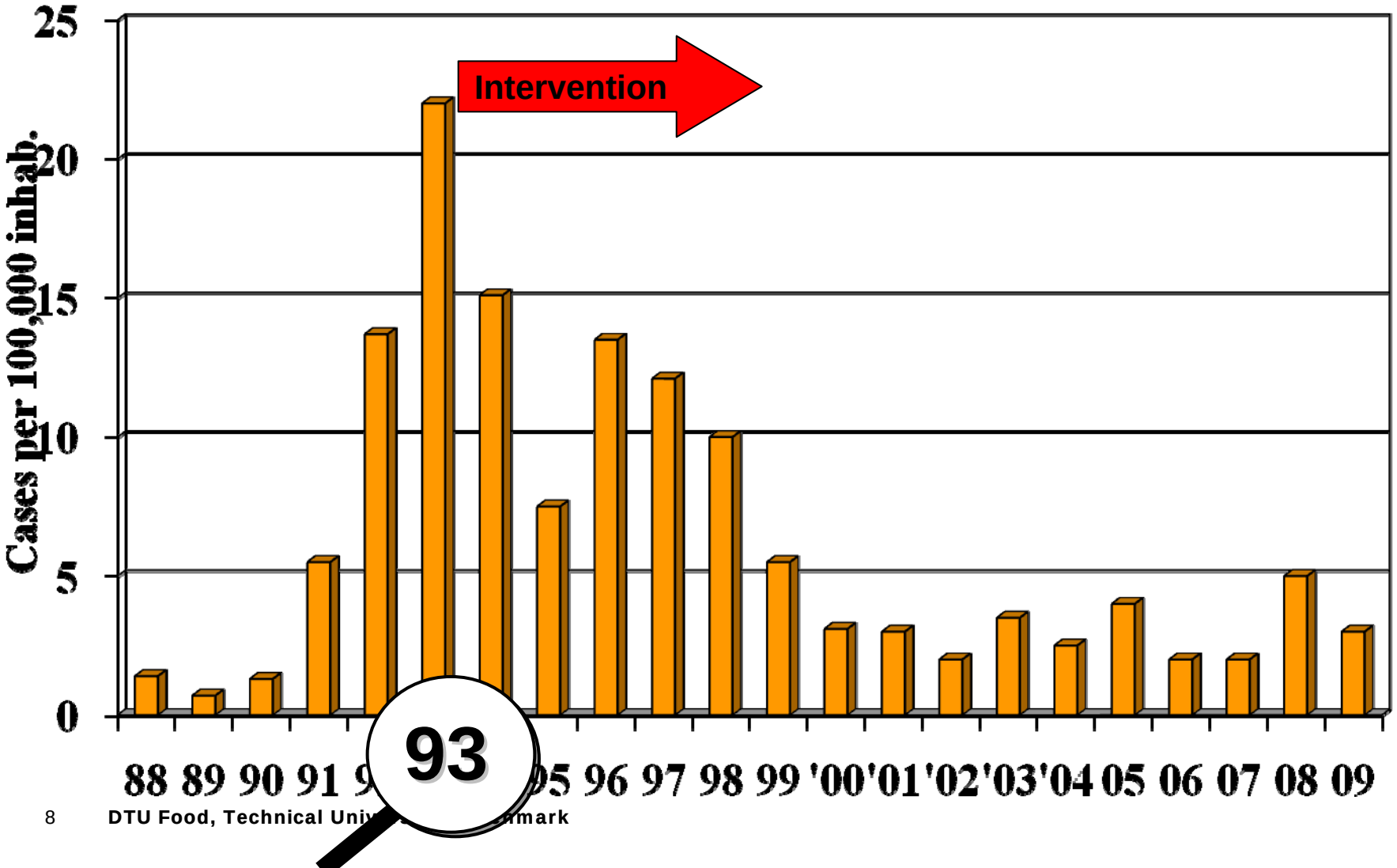




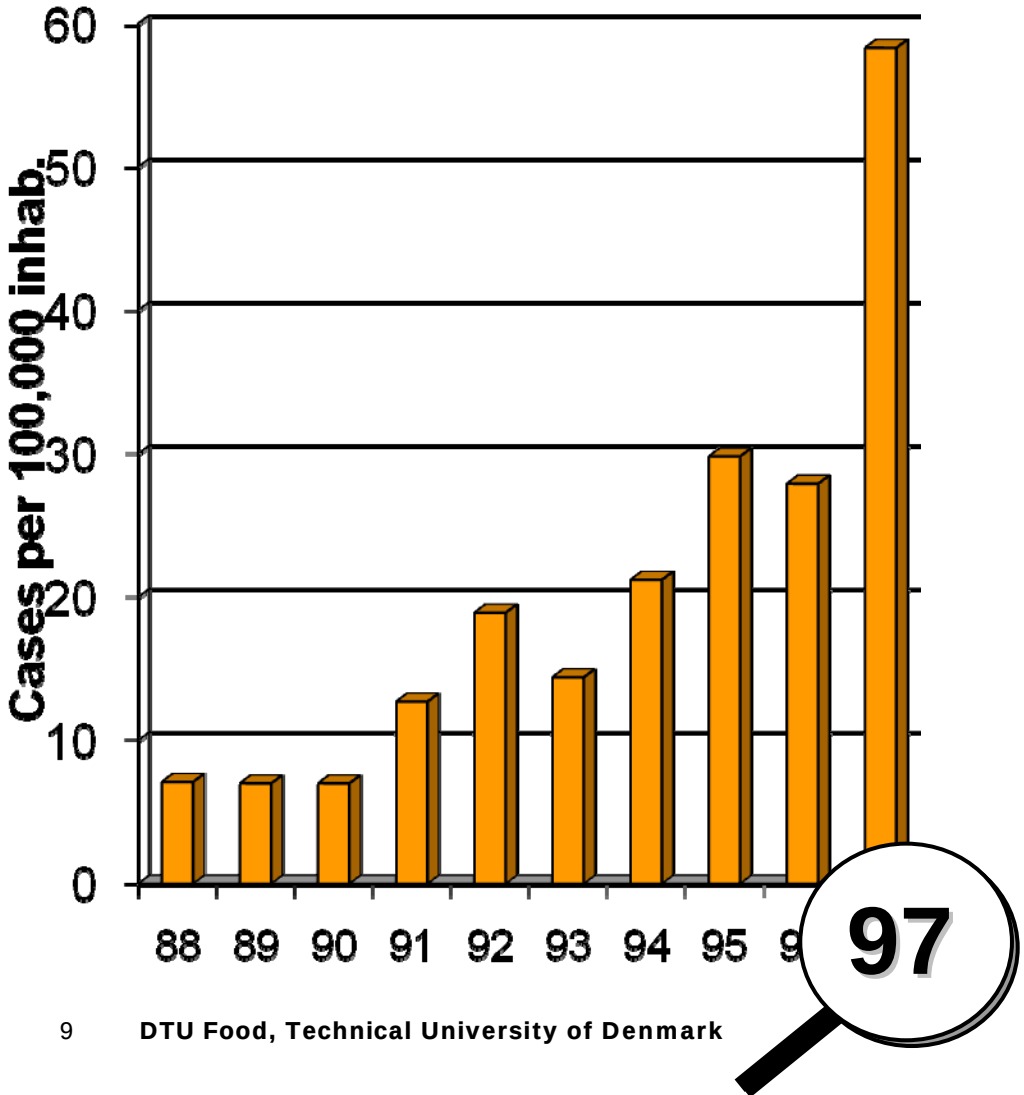
Salmonella prevalence in fresh pork – introduction of serology



Pork associated human salmonellosis in Denmark



Egg associated human salmonellosis in Denmark, 1988-1997



The table egg production pyramide

- When a good thing turns bad

Layer industry structure

Genetic Improvement

Pedigree Selection

GGP

Grandparent Stock

Parent Stock

Commercial layers

Processing/Retailers

Consumers

Thousands

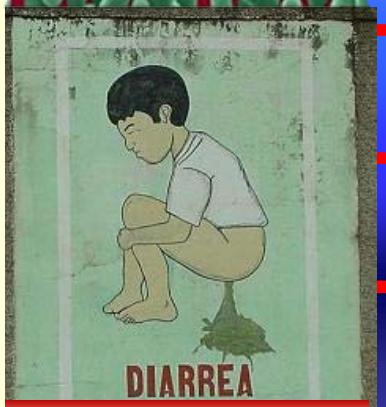
Tens of thousands

1,000,000

50,000,000

5,400,000,000

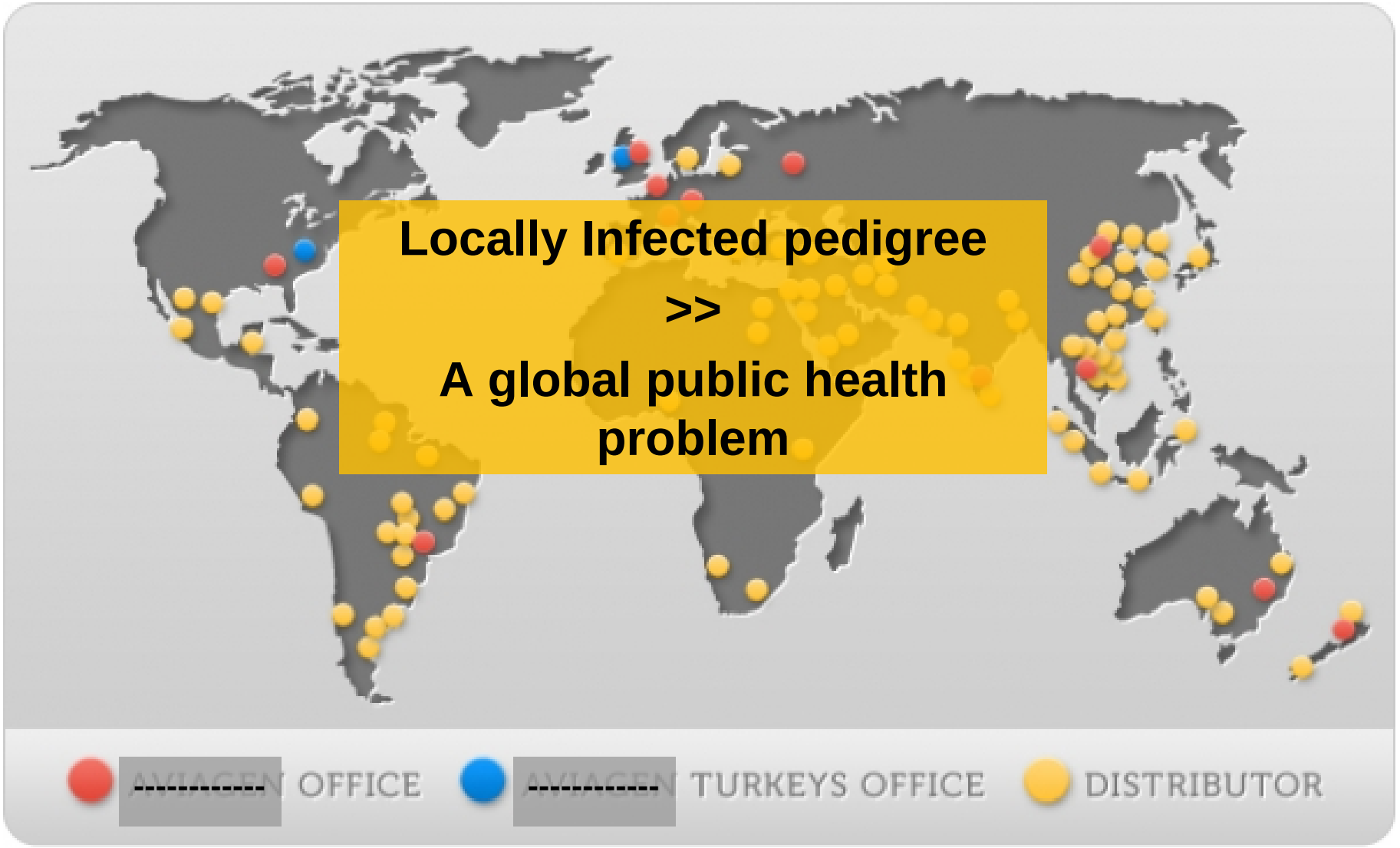
1,000,000,000,000 eggs



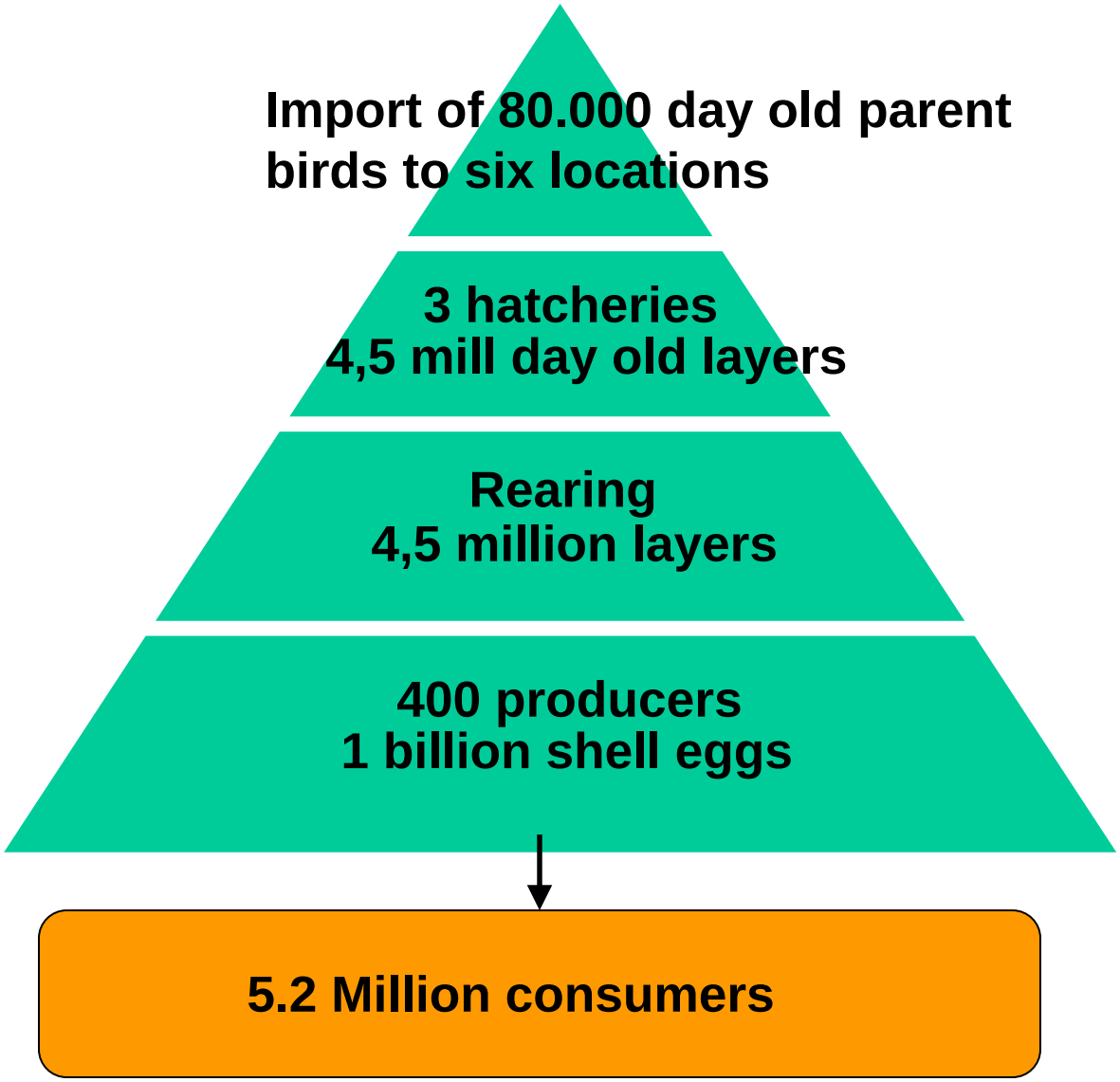
Hundreds of thousands of cases

”think globally, act locally”

– begin by eradicating SE from all pedigree!



Danish shell-egg production system



Danish SE eradication strategy

Top Down Eradication Strategy

- Test and destroy infected imports of day old layer breeders
- Monitor and destroy infected breeding flocks
- Test and destroy infected layer flocks, alternatively decontaminate table eggs (heat treat)
- Cleaning and disinfection of infected premises
- All Danish producers involved
- All serotypes, but special emphasis on *S.* Typhimurium and *S.* Enteritidis

Table-egg control programme - Technical task force

- **Equal representation of industry and public sector**

- **Responsibility for technical aspects, e.g.**
  - sampling plans,
  - detection techniques,
  - sanitation,
  - training,
  - improvements

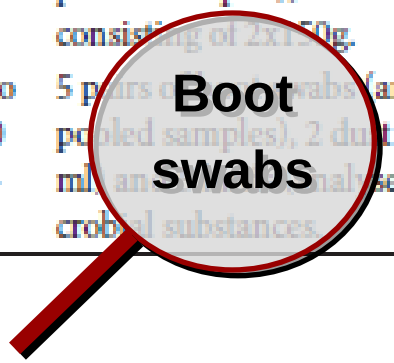
The Danish salmonella surveillance programme of table-egg production (2009)

Table A31. Salmonella *surveillance programme for the rearing flocks and adult flocks of the grandparent and parent generation of the broiler and table egg production, 2009*

Time	Samples taken	Material	Material
Rearing flocks		*Grandparent generation*	*Parent generation*
Day-old[a,b]	Per delivery	5 transport crates from one delivery: crate liners (>1m² in total) or swab samples (>1m² in total). Analysed as one pool.	5 transport crates from one delivery: crate liners (>1m² in total) or swab samples (>1m² in total). Analysed as one pool.
1st & 2nd week[b,c]	Per unit[d]	-	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.
4th week[a,b]		5 pairs of boot swaps (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.
8th week[b,c]	Per unit	2 pairs of boot swabs (analysed as one pooled sample). Cage birds: 60 samples of fresh droppings (1g). Analysed as one pool.	2 pairs of boot swabs (analysed as one pooled sample). Cage birds: 60 samples of fresh droppings (1g). Analysed as one pool.
2 weeks prior to moving[a,e]	Per unit	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.

Table A31. Salmonella surveillance programme for the rearing flocks and adult flocks of the grandparent and parent generation of the broiler and table egg production, 2009

Time	Samples taken	Material	Material
Adult flocks		*Grandparent generation*	*Parent generation*
Every two weeks[b] (Every 16th week[d])[f]	Per flock	Hatcher basket liners from 5 baskets (>1m² in total) or 10g of broken egg-shells from each of 25 hatcher baskets (reduced to 25g sub-sample). Analysed as one pool.	Hatcher basket liners from 5 baskets (>1m² in total) or 10g of broken eggs-hells from each of 25 hatcher baskets (reduced to 25g sub-sample). Analysed as one pool.
After each hatch[b]	Per hatch	Wet dust samples. Up to four hatchers of the same flock can be pooled.	Wet dust samples. Up to four hatchers of the same flock can be pooled.
Every week[b]	Per unit	-	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60g.
0-4 weeks after moving, 8-0 weeks before slaughter[e]	Per unit	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150g.
After positive findings[c]	Per unit	5 pairs of boot swabs (analysed as two pooled samples), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances.	5 pairs of boot swabs (analysed as two pooled samples), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances.



a) Sampling requirements set out by Regulation (EC) 2160/2003.
b) Samples collected by the food business operator.
c) Order no 1259 of 15/12/2008.
d) A unit (house) may harbour part of a flock or more than one flock, depending on the size of the unit.
e) Samples collected by the Regional Veterinary and Food Control Authorities.
f) When eggs from a flock exceed the capacity of one incubator, each incubator should be sampled as described.
Source: Danish Veterinary and Food Administration

A Danish speciality - ”boot swabs”

A highly sensitive sampling method for bacteriological detection of salmonella in poultry houses

Skov et al., J. Applied Microbiol. 1999, 86:695-700.

Table A33. Salmonella surveillance programme for the pullet-rearing, table egg layer and barnyard/hobby flocks in the table egg production, 2009

Time	Samples taken	Material
Pullet- rearing		
Day-old[a,d]	Per delivery	5 transport crates from one delivery: Crate liner (> 1 m^2 in total) or swab samples (> 1 m^2 in total) (Analysed as one pooled sample).
4 weeks old[b,d]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces samples of 60 gram.
2 weeks before moving[a,c]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces samples of 60 gram. 60 blood samples (serology).
Table egg layers (Production for certified packing stations)		
24 weeks old[a,c]	Per flock	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample consisting of 2x150 gram. 250 ml (100 g) dust and 1 pair of boot swabs. 60 eggs[b] (serology).
Every 9 weeks[d,e]	Per flock	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample consisting of 2x150 gram. 60 eggs[b] (serology).
Barnyard and hobby flocks		
Every 18 weeks[d]	Per folck	Egg samples.

Sero-logy

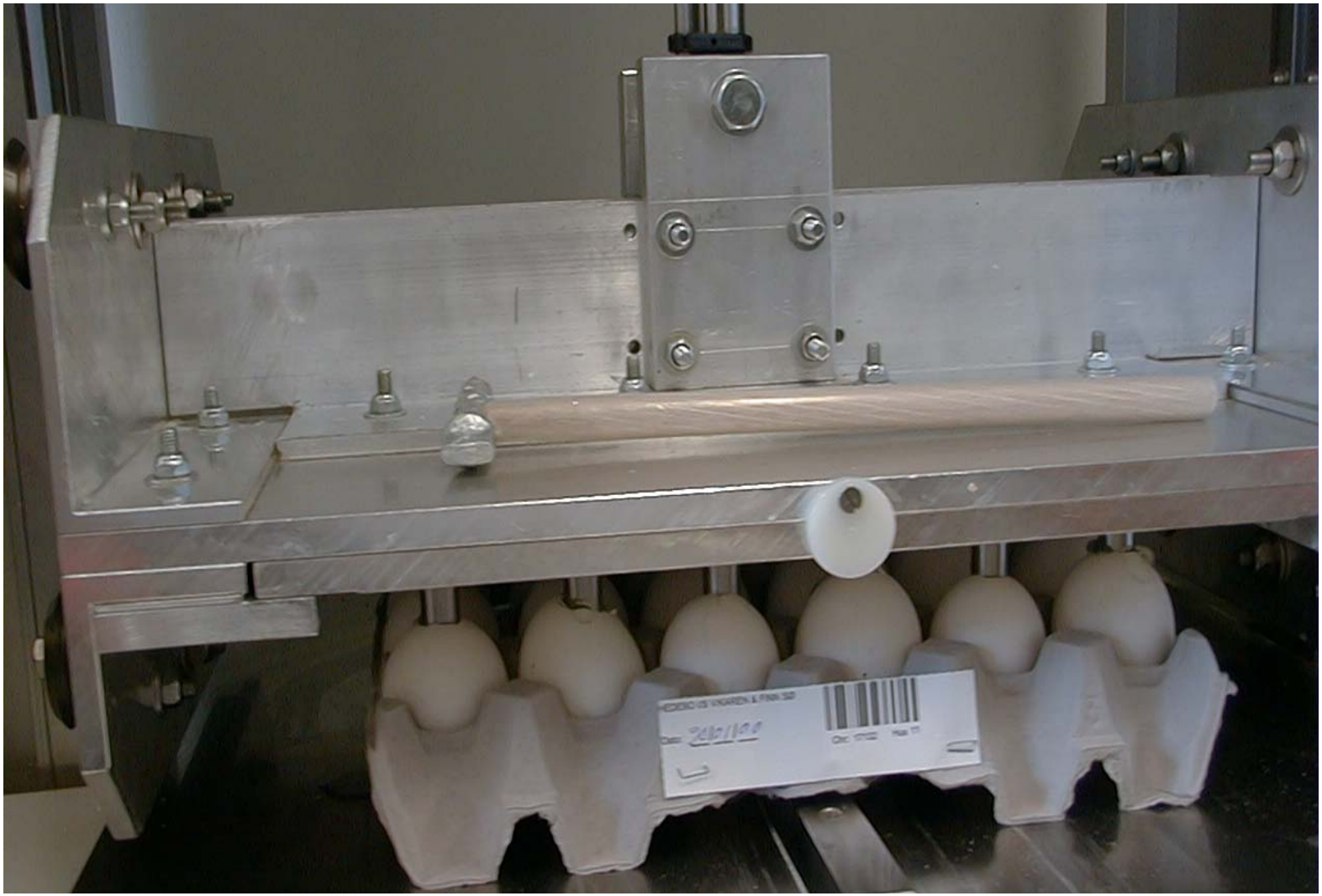
a) Sampling requirements set out by Regulation (EC) 2160/2003.
b) According to Order no 1260 of 15/12/2008.
c) Samples collected by the Regional Veterinary and Food Control Administration.
d) Samples collected by the food business operator.
e) According to Regulation (EC) 2160/2003 sample collection must be carried out every 15 weeks as a minimum.
Source: Danish Veterinaty and Food Administration

Serological testing of egg yolk - the key to succes

- Mix-ELISA using LPS from *S*. Enteritidis and *S*. Typhimurium
- Samples are defined as seropositive if the calculated OD% > 40; specificity = 0.999
- Flocks are defined as seropositive if two or more samples are seropositive; specificity = 0.997

Receipt and registration in laboratory

Punching a hole (so the tip can get in)



Drawing egg yolk

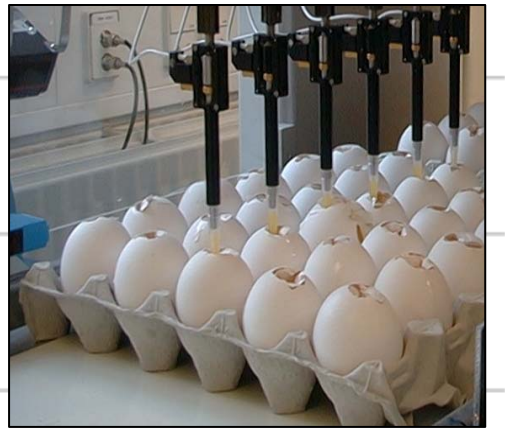
ELISA testing

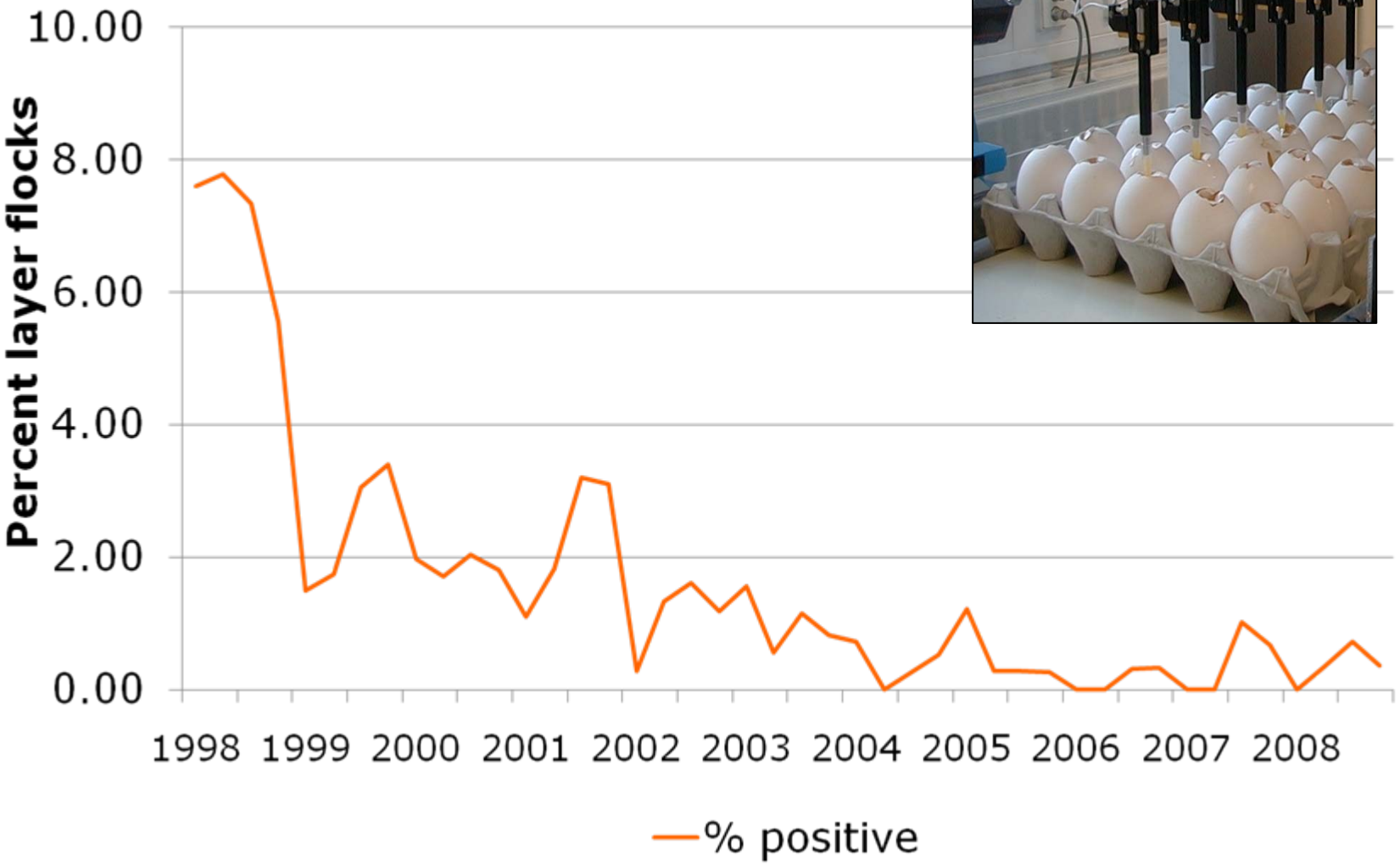
Salmonella control in breeders and laying hen flocks

- Serological positive samples
  - Under suspicion
  - Re-testing
- Infected central-rearing, parent flocks and rearing flocks
  - Slaughtered
- Infected/suspected table-egg layers
  - Intensive sampling for bacteriological testing
  - Eggs are heat-treated (pasteurisation)
  - Flocks and eggs from flocks are destroyed if:
    - Symptoms of salmonellosis
    - Infected with DT104

Effect of Salmonella control program in table-egge production

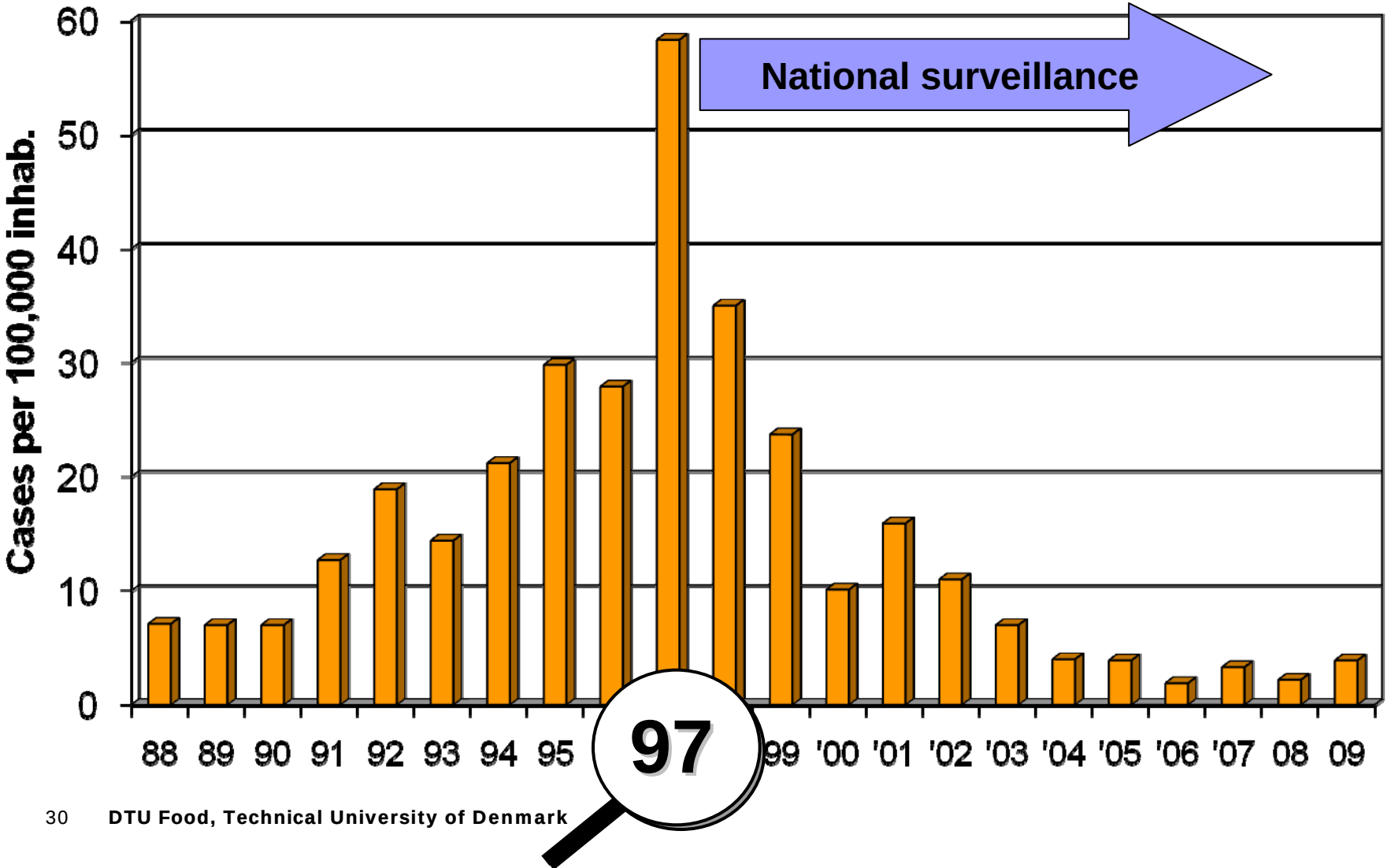
Occurrence of *Salmonella* in Danish table egg production



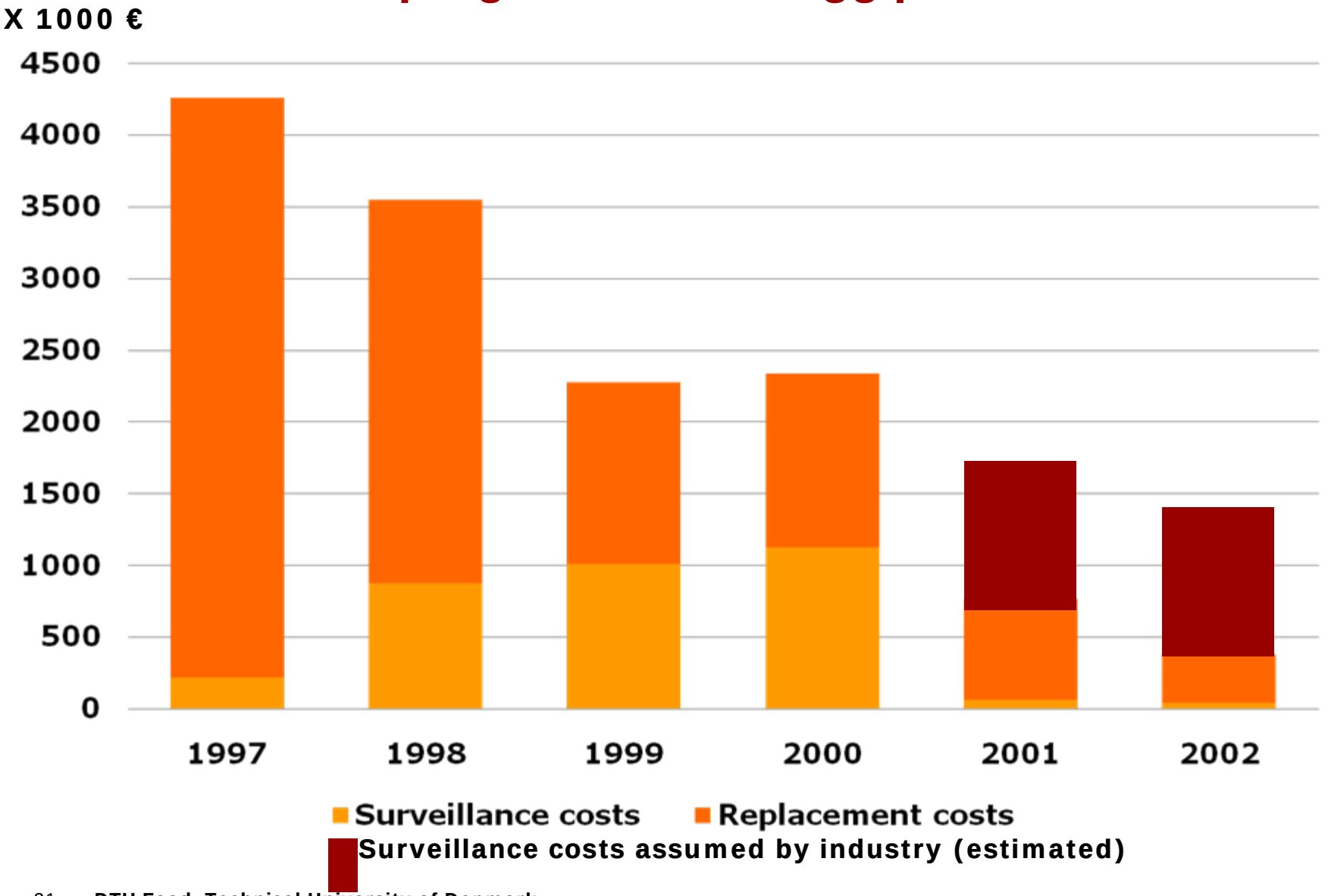


Human health benefits

Egg associated human salmonellosis in Denmark, 1988-2009



Public costs of the Danish salmonella control program in table-egg production



Ten-year cost-benefit assessment SE control in eggs in DK (1997-2006)

- 1997: ~ 3.000 registered egg associated cases
- 2006: ~ 100 registered egg associated cases

- Avoided societal costs: 23.3 mio. € (31,5 mio. $)
  - Lost labour and health care
- Public control costs: ~12-13 mio. €

- Continuingly decreasing cost-benefit ratio

Antibiotic use in the danish poultry production

- 0.04 ADD_{kg} (DK layers)

ADD: Defined Animal Daily Doses

- 0.15 ADD_{kg} (DK broilers)
- 5.0 ADD_{kg} (NL broilers)

No use of vaccines in DK or in imported breeders

Friday, 22 May 2009 14:34

Breaking News

the COPENHAGEN post Online

All eggs to be salmonella-free

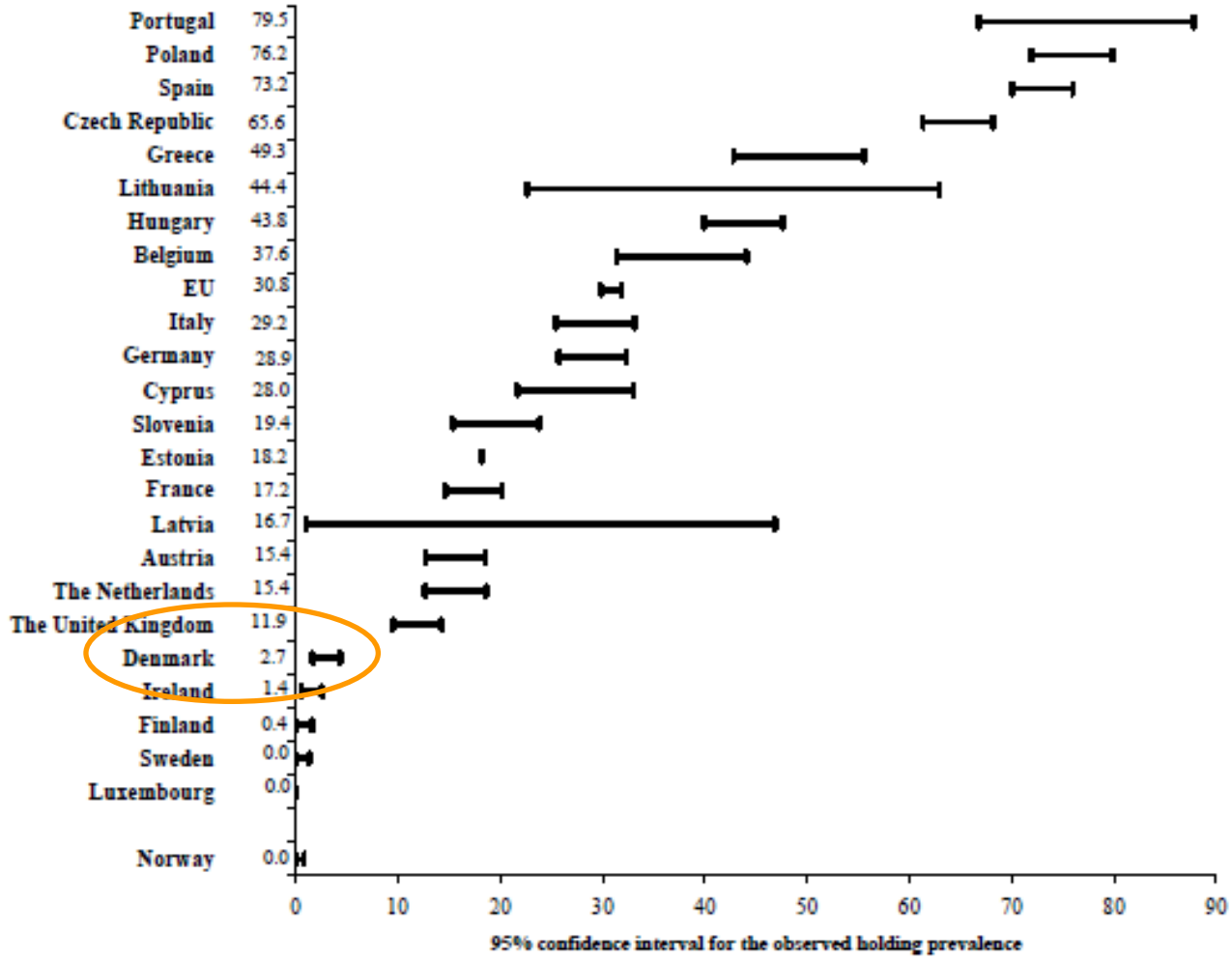
Denmark receives a special allowance from the EU to require all egg imports to be free of salmonella bacteria

European Union health authorities okayed a Danish application for 'special status' that will ensure all eggs imported to the country are guaranteed by their distributors as being 100 percent salmonella-free.

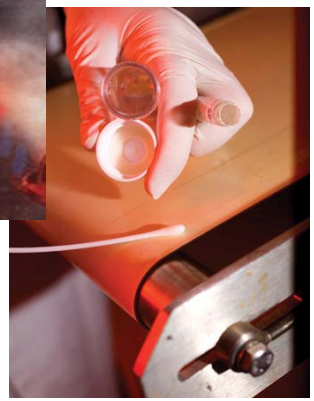
Eva Kjer Hansen, the food and veterinary minister, called the approval from Brussels a 'breakthrough' and said Denmark would also be seeking special status for chicken imports as well.

EU baseline study of SE in holdings of laying hens 2004-2005

Figure 1. Observed prevalence of *Salmonella*-positive holdings of laying hens, with 95% confidence intervals, in the EU, 2004-2005



Recipee for succesful control of SE in eggs in Denmark



Conclusions

- Control of Salmonella in table egg and broiler production highly succesful
- Top-down eradication strategy feasible
- No need for antimicrobials, vaccines and other anti-infectives
- No need for post-harvest control if on-farm control is effective
- Major public health benefits
- Cost-beneficial

Publications

- Feld NC, et al. 2000. Evaluation of a serological salmonella mix-ELISA for poultry used in a national surveillance programme. Epidemiol. Infect. *125*:263-68

- Wegener HC, et al. 2003. Salmonella control programs in Denmark. Emerg. Infect. Dis. *9*:774-780.

- Hald TM, et al. 2004. A Bayesiean approach to quantify the contribution of animal-food sources to human salmonellosis. Risk Analysis. *24*:255-69

- Korsgaard H. et al. 2009. The effects, costs and benefits of Salmonella control in the Danish table-egg sector. Epidemiol. Infect. *137*:828-36

Thank you for your attention!