

Farm-to-slaughter phase:
microbial contamination in cattle
and beef

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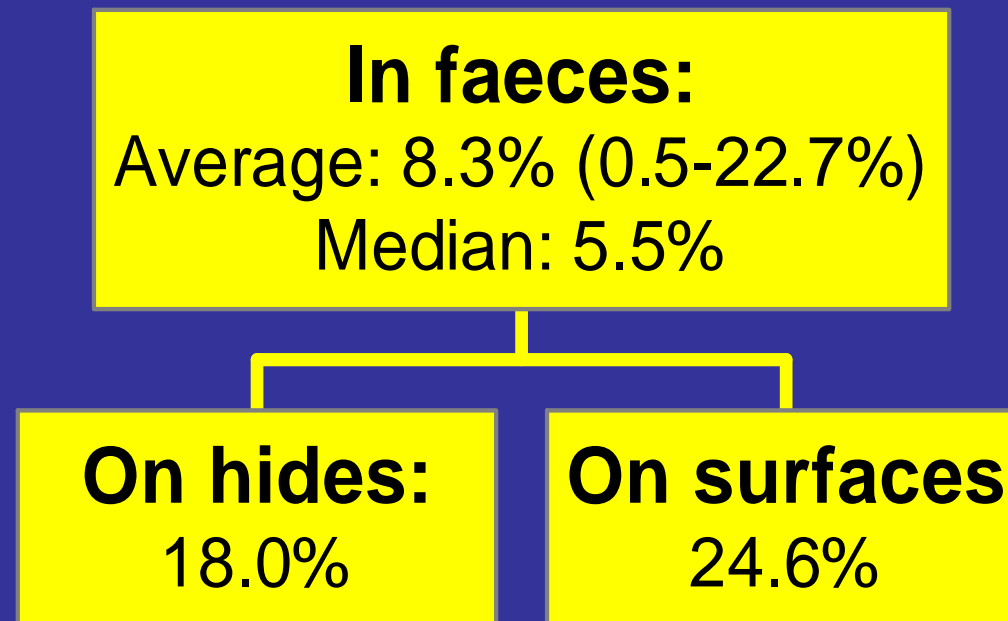
Summary

Contamination (using example of *E. coli* O157) in cattle:

- On-farm
- Transport
- Lairaging
- Slaughter
- Control strategies

E. coli O157 in cattle during
on-farm phase

Summary of published prevalences of *E. coli* O157 in cattle on-farm (Avery & Buncic, 2005)



On-farm controls of *E. coli* O157

Prevention of the pathogen's recycling

- Land management (animal wastes)
- Vectors (rodents, wildlife...)
- Animal husbandry (GHP)

Prevention of the ingestion of the pathogen:

- Feed treatments
- Water treatments
- Animal interactions (suckling, licking)

Suppression of the ingested pathogen:

- Dietary manipulation
- Probiotics
- Phage therapy

Modifications of the host responses

- Vaccination

Other controls?

E. coli O157 in cattle during
transport-lairaging phase

Risk factors during transport-lairaging: stress

- In cattle faeces: *Salmonella* increased but *E. coli* O157 decreased (Barham et al., 2002; Minihan et al., 2003)
- On cattle hides: both *Salmonella* and *E. coli* O157 increased during transport (Barham et al., 2002)
- A transportation controversy: *E. coli* O157 in faeces *versus* hide?
- Possible: stress-mediated increased defecation leading to:
 - increased *E. coli* O157 hide contamination;
 - elimination of *E. coli* O157 cells from colon content (those not attached to the epithelium).

Risk factors during transport-lairaging: other

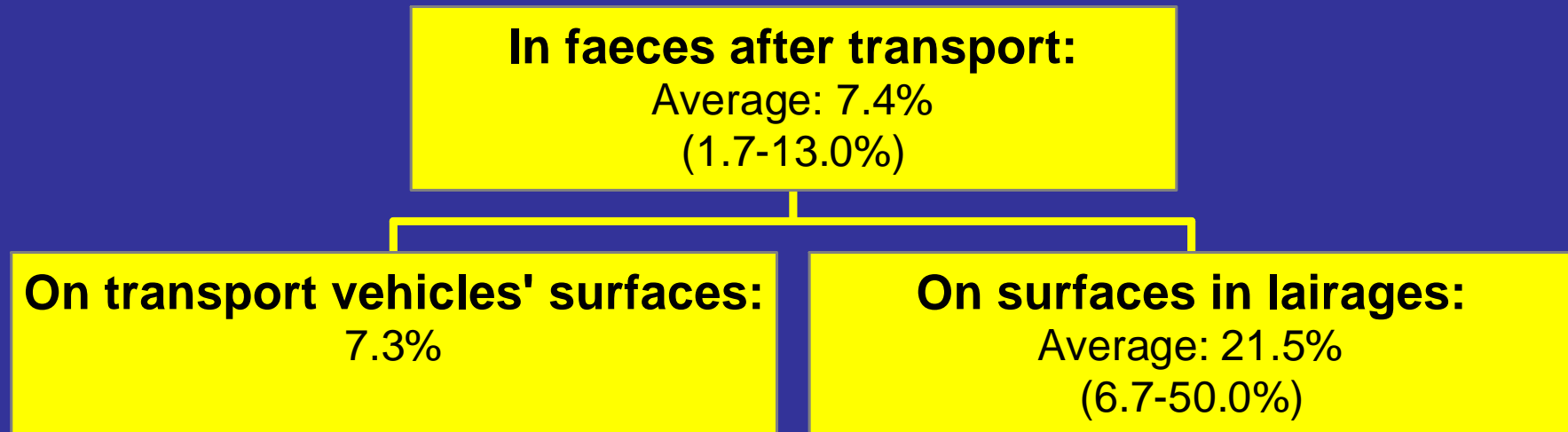
- Animal *versus* animal groups
 - Groups with *E. coli* O157 >20% have higher hide contamination (Woerner et al., 2006)
- Duration
 - The longer transport-lairaging the higher *E. coli* O157 hide contamination (Dewell et al, 2008)
- Inefficient cleaning of vehicle/lairage surfaces
 - *E. coli* O157:H7 on 64%, and *Salmonella* spp. on 71% of "cleaned" surfaces (Arthur et al., 2008)

Risk factors during transport-lairaging: other

- Survival of pathogens on surfaces
 - Can lead to pathogens' accumulation and/or carryover of contamination between days (Small et al., 2002, 2003)
- Animal activities and interactions
 - Contribute to cross-contamination (Small & Buncic, 2009)

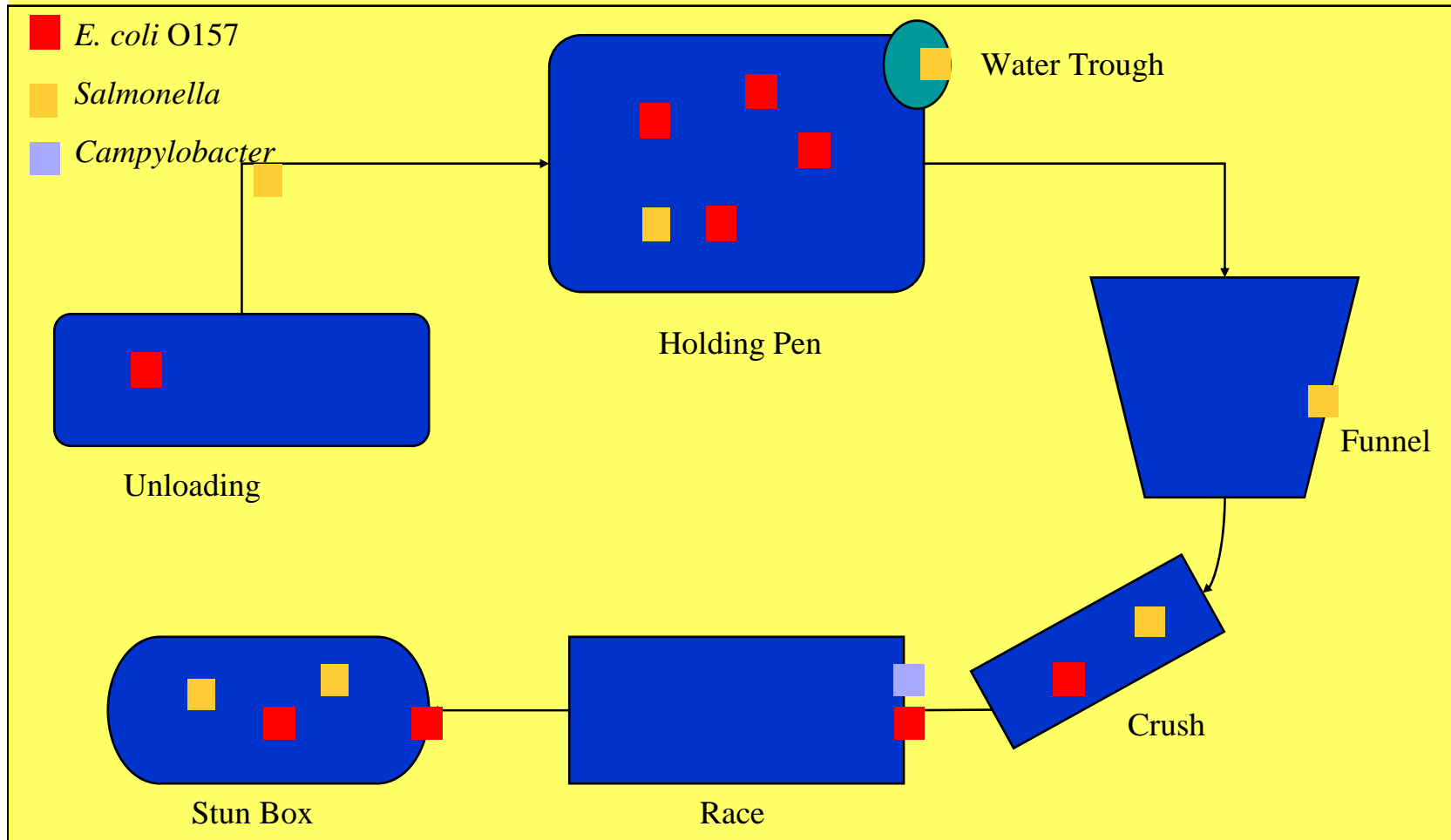
Summary of published prevalences of *E. coli* O157 in cattle during transport-lairage phase

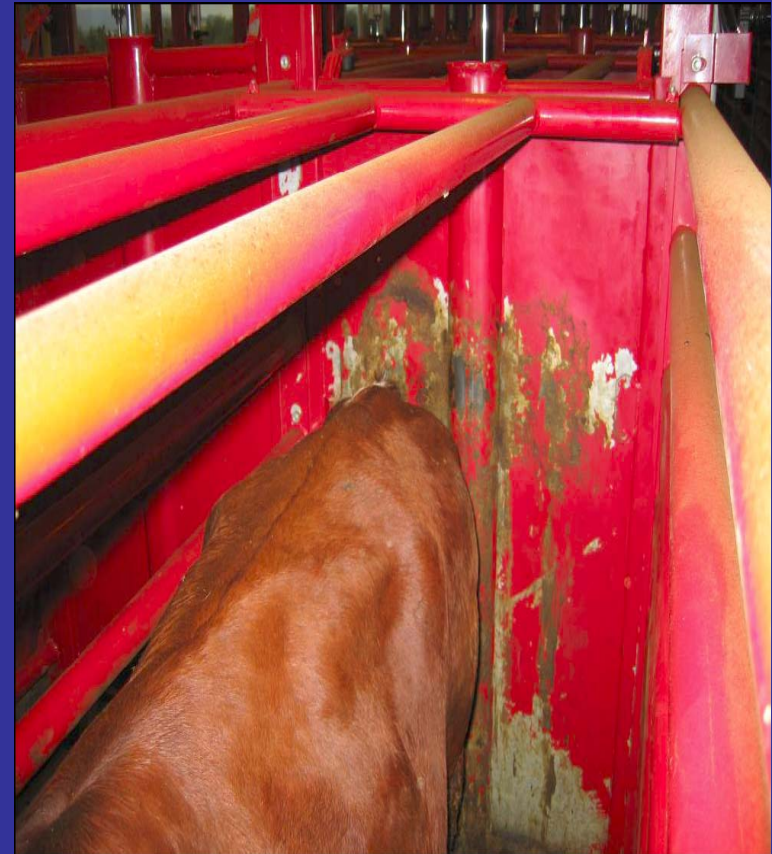
(Avery & Buncic, 2005)



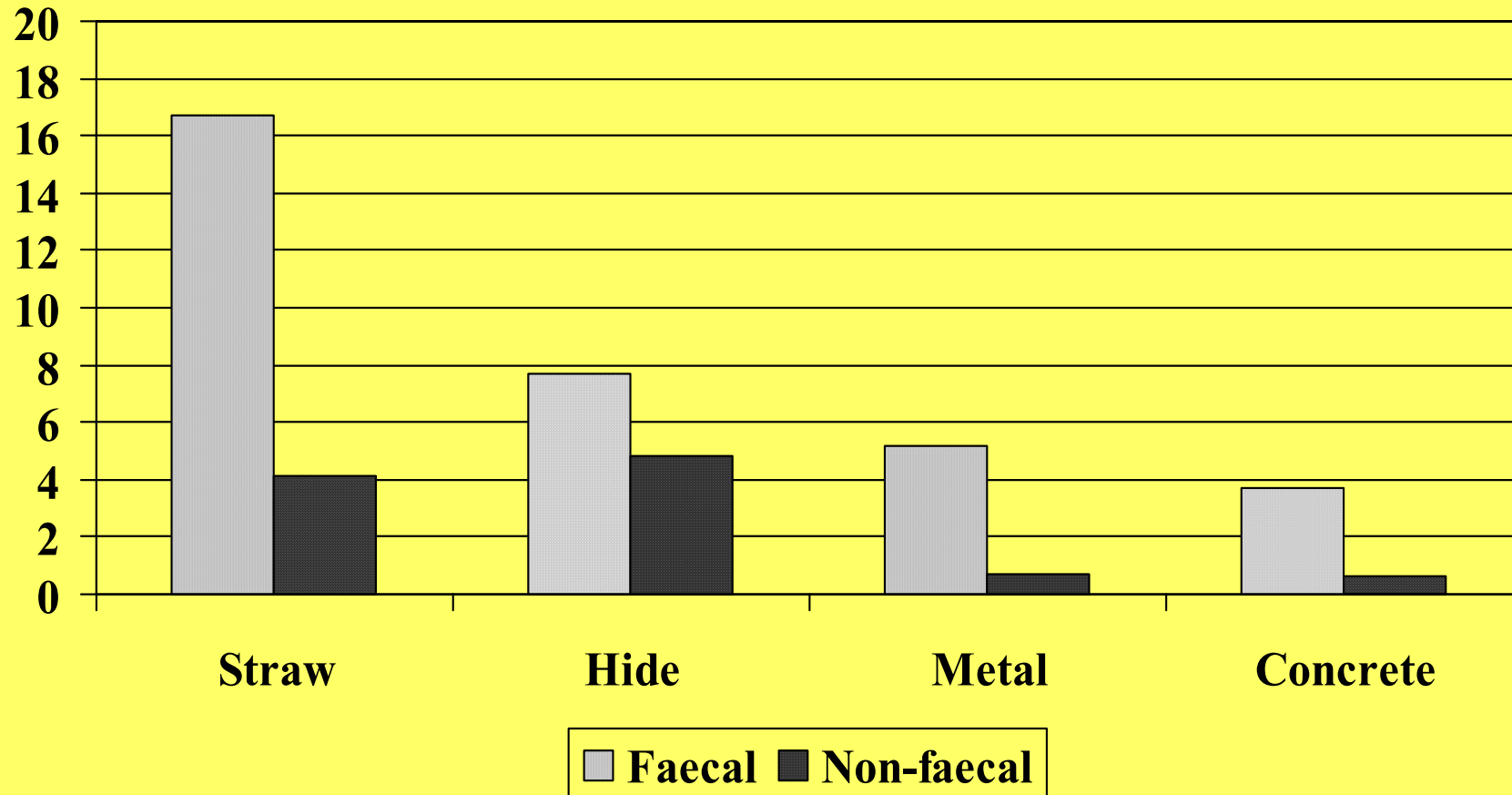
Contamination of surfaces in cattle lairages

(Small et al., 2002)





Survival (D_{250C} -values, days) of *Escherichia coli* O157 on contaminated transport- or lairage-related substrates (Small et al., 2002)



**Average survival rates of *E. coli* O157 isolates
(n=123) on concrete during 24 h (Avery & Buncic, 2003)**

Human ($n = 31$) 15.3%

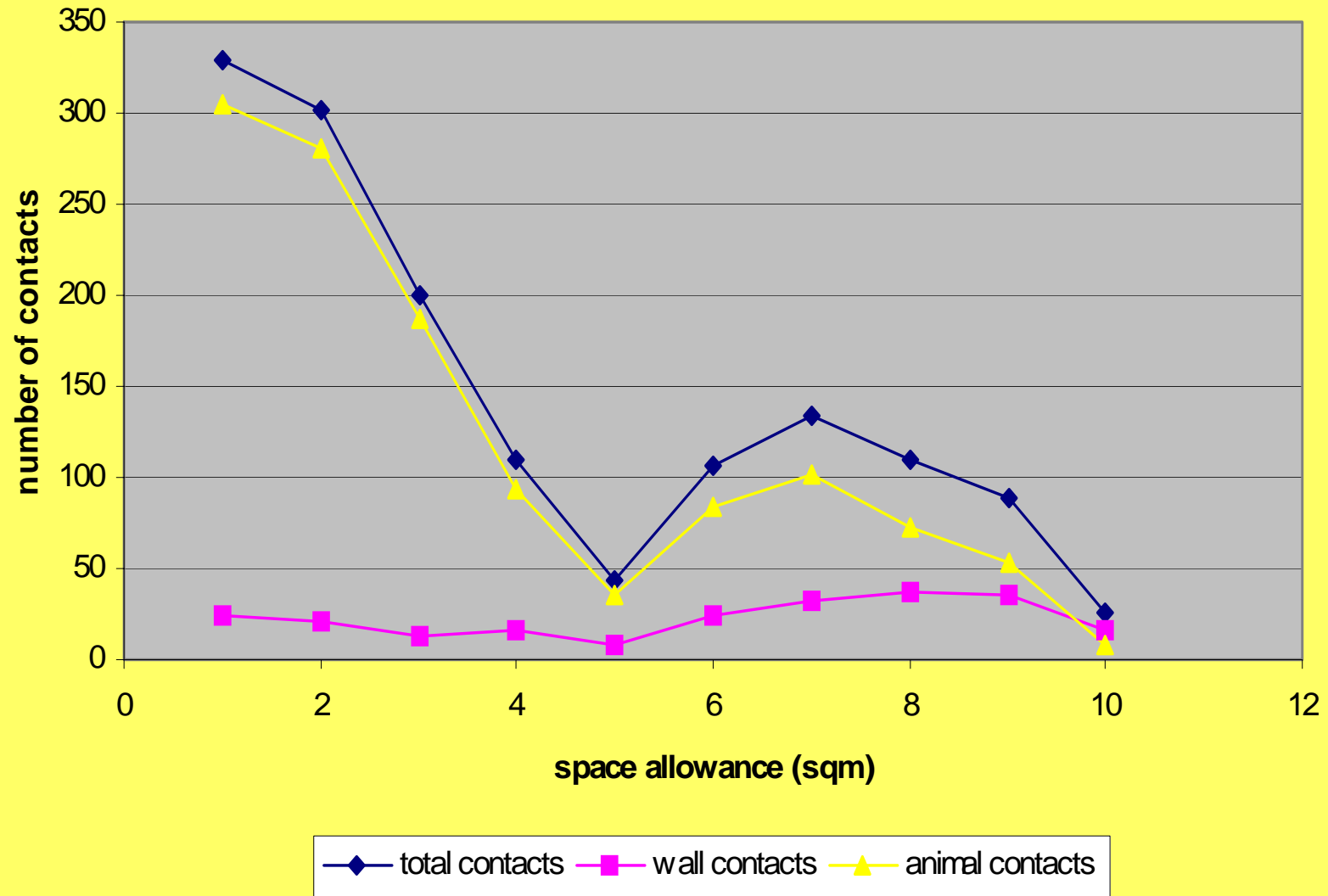
Meat ($n = 29$) 27.7%

Animal faeces ($n = 32$) 26.0%

Hides ($n = 31$) 22.9%

Average contacts per bovine in lairage over 30 minutes by space allowance

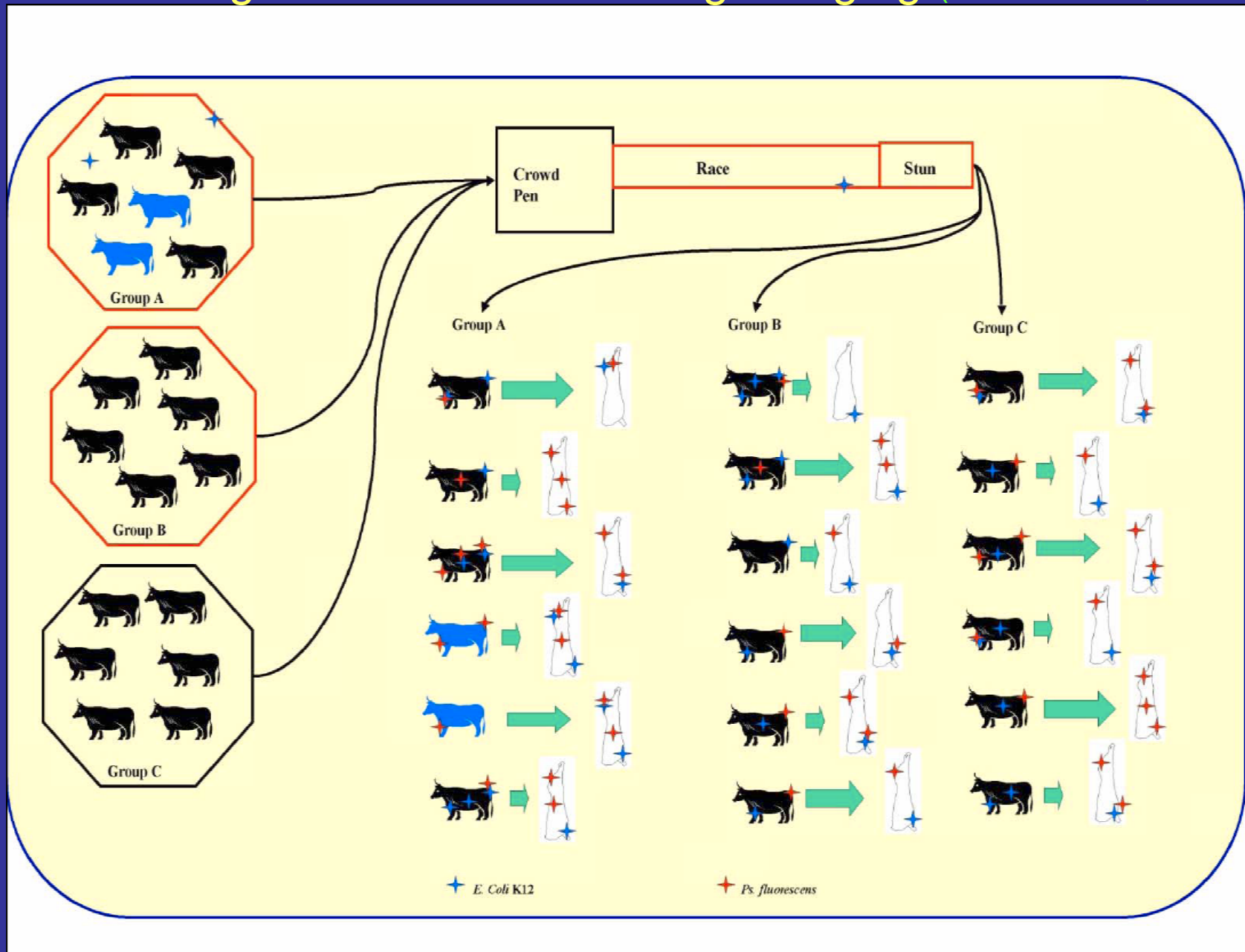
(Small & Buncic, 2009)



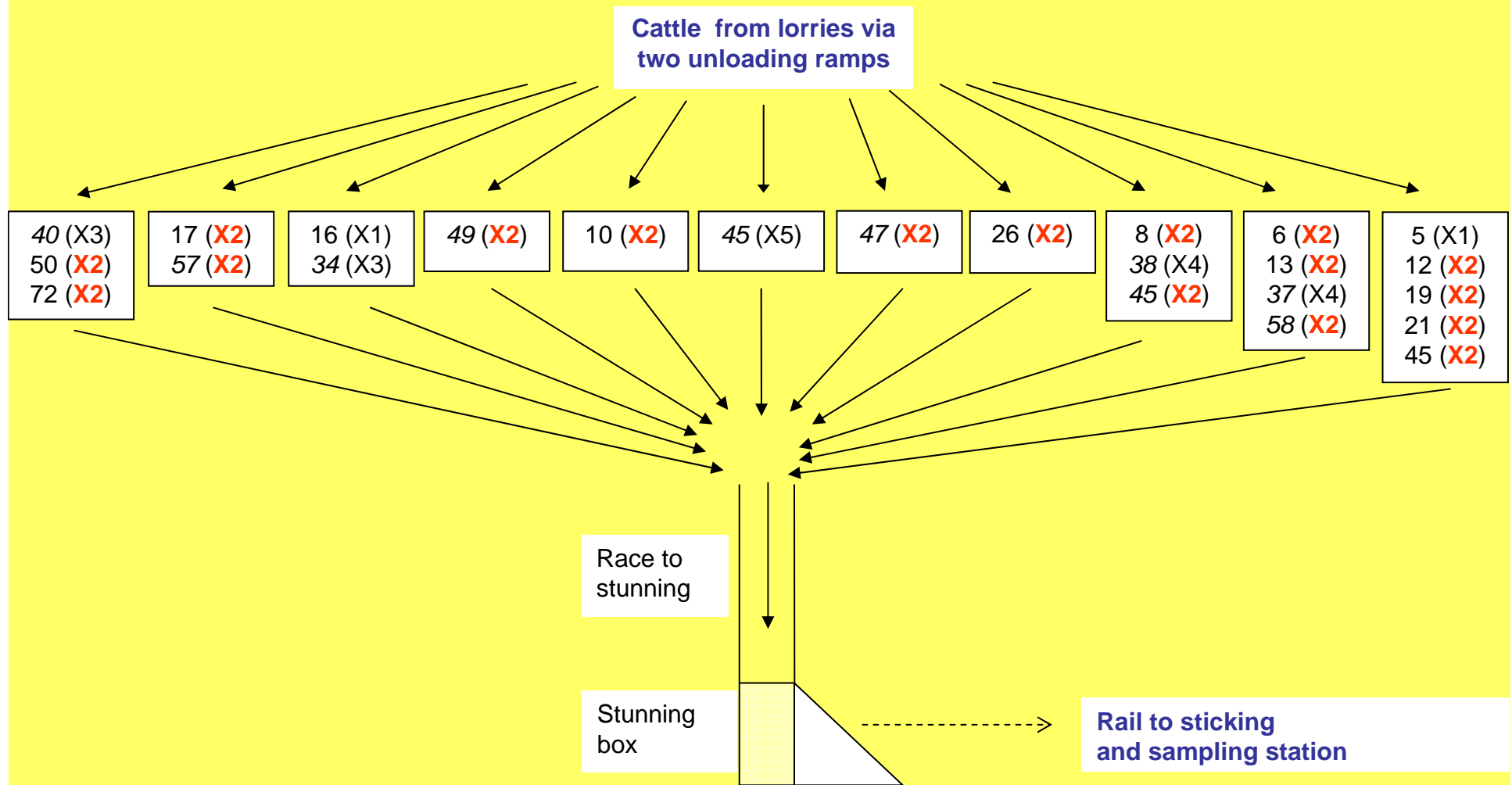
Possible cross-contamination between 8 cattle in a pen, if 50% transfer rate (Small & Buncic, 2005)



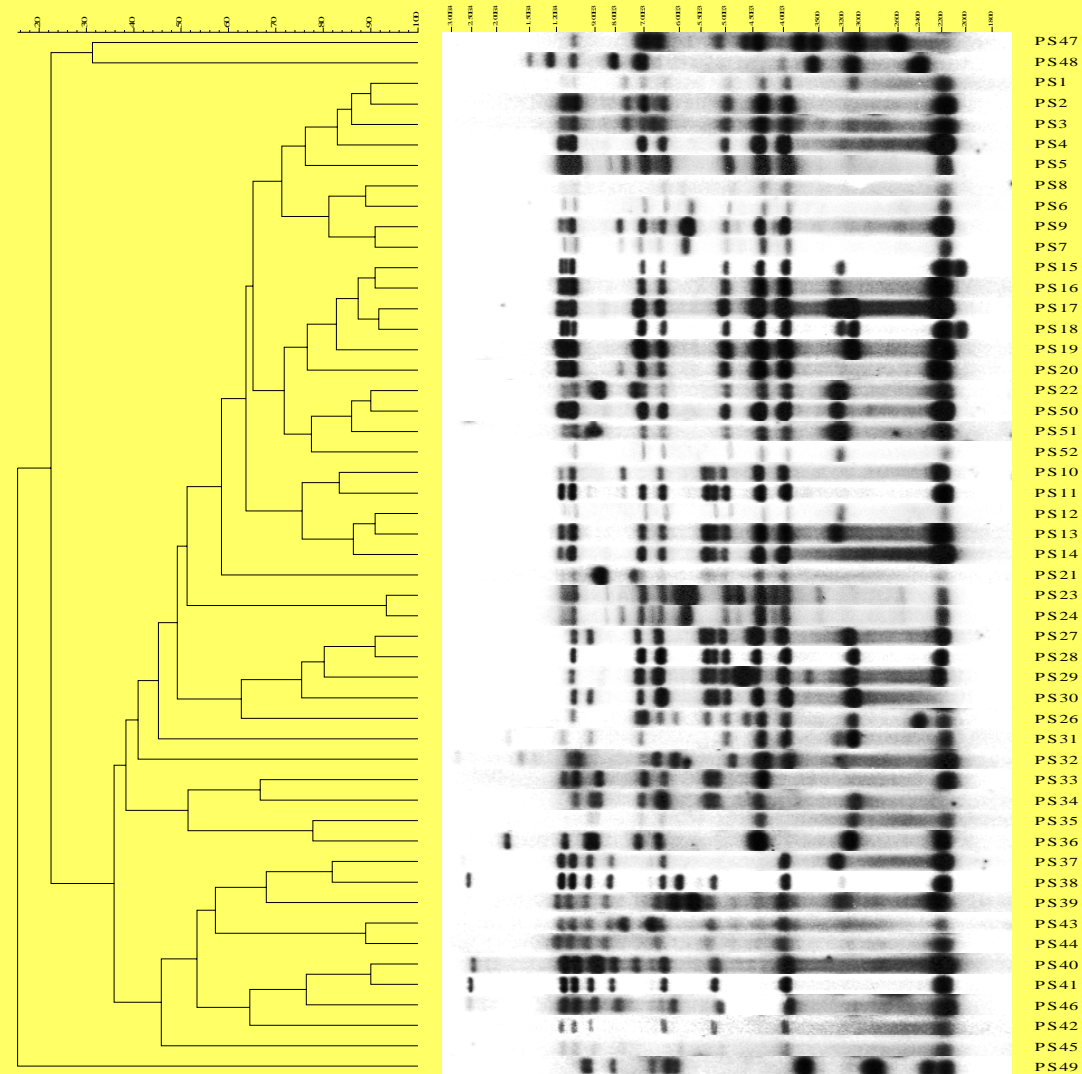
Marker-organisms in cattle during lairage (Collis et al., 2004)



PFGE fingerprint found on hide of slaughtered cattle from different farms and lairage pens (Avery et al., 2002)



Other molecular studies of hide/carcass *E. coli* O157 and *Salmonella* also demonstrated their transport-lairage origin (e.g. Tutenel et al., 2003; Childs et al., 2006; Arthur et al., 2007, 2008; Dewell et al., 2008).

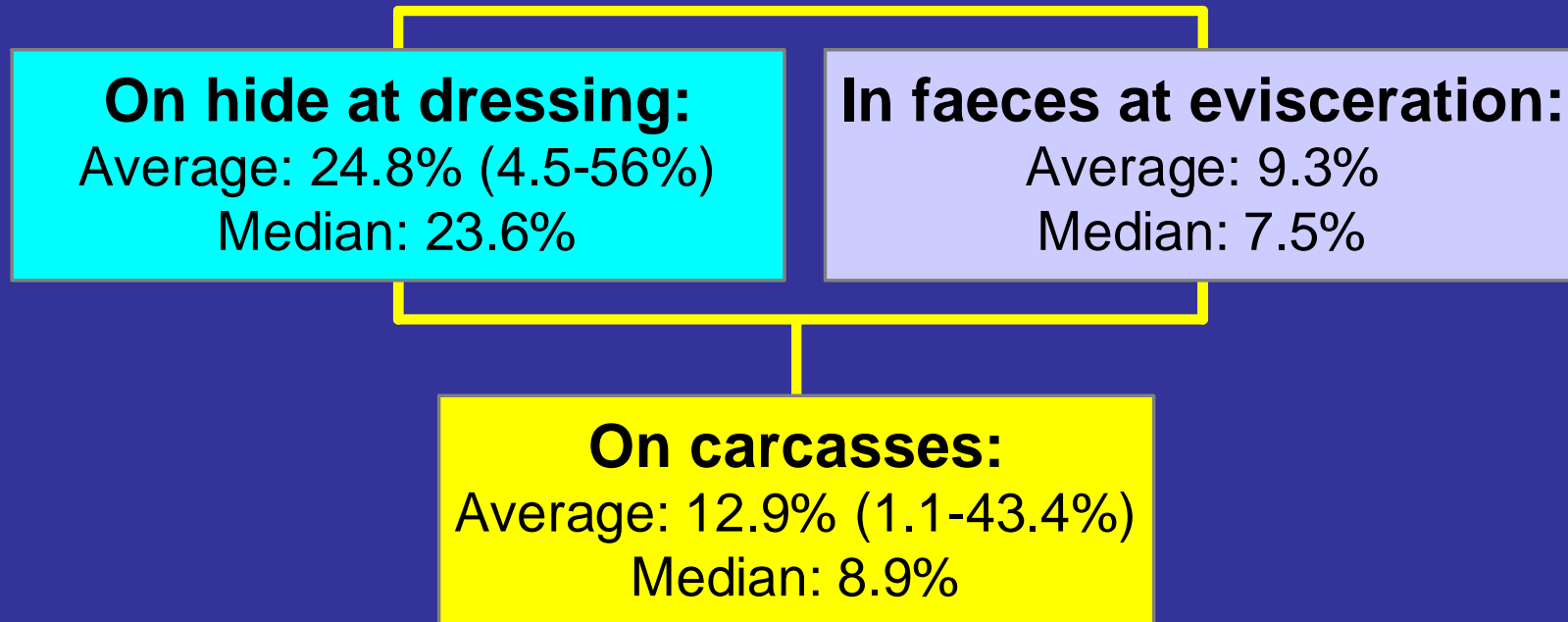


E. coli O157 in cattle during slaughter phase



Faeces-hide-meat relationship of *E. coli* O157 during dressing phase

(Avery & Buncic, 2005)



General microflora on hides of slaughtered cattle (overall literature data)

Counts of organisms	Average log cfu/cm ²	From	To
Total viable count - TVC	6.3	4.5	10.5
<i>Enterobacteriaceae</i>	4.1	2.9	6.0
Coliforms	4.5	4.0	5.9
Generic <i>E. coli</i>	4.2	1.7	5.5

Pathogens on hides of slaughtered cattle (overall literature data)

Prevalence of organisms	Average %	From	To
<i>E. coli</i> O157	45.8 (much data)	0	100
<i>Salmonella</i>	50.3 (fewer data)	0	100
<i>Campylobacter</i>	(scarce data)	0	13
<i>Listeria monocytogenes</i>	(scarce data)	0	47.9

Microbial distribution on hides

- Overall microbial loads (TVC):
 - visually “dirty” hides: 6-10 log cfu/cm²
 - visually “clean” hides: 4.5-8 log cfu/cm²
- Pathogen load: *E. coli* O157 between 2-3 cells/cm² (Arthur et al., 2004; 2007) and 2-3 log cfu/cm² (O’Brien et al, 2005; Arthur et al., 2004)
- Location of microflora on hide:
 - “horizontally”: feet (metacarpus)>brisket>rump>flank (Nastasijevic et al., 2008; Antic et al., 2008, unpublished)
 - “vertically”: no major differences between upper and lower layers of the hair (Antic et al., 2008, unpublished).

Microbial attachment on hides

- Attachment of microorganisms to hair:
 - dirt: contains much bacteria, but if hardened - physically “encapsulates” them;
 - water increases “removable” portion of microflora;
 - some products of skin glands (e.g. free monosacharids) diminish bacterial attachment to epidermal cells (*Meyer i sar. 2001*);
 - bacterial attaching “affinity” to hide stronger than to meat (?).

Microbial transfer from hide onto carcass

- Small proportions of hide microflora transferred onto meat:
 - via direct contact, experimentally, between 0.1% and 0.0004% (Antic et al., 2008, unpublished);
 - via all routes together, commercially, between 1.6% and 0.003% (Bacon et al., 2000; Vivas Alegre & Buncic, 2004; Arthur et al., 2004); **but**
- High occurrence on hide + regular transfer = high risk of pathogens contaminating meat

Microbial transfer from hide onto carcass

- Therefore, hide-to-meat transfer of pathogens must be:

- totally prevented during skinning by hygiene
(but is unachievable);

OR

- eliminated from hide before skinning by treatments
(seems possible).

Transport-lairage (pre-dressing) controls of *E. coli* O157:H7

Avoid livestock markets:

- Mixing of animals from different farms
- Environment-mediated cross-contamination

Minimise lairaging time:

- Accumulation of the excreted pathogen
- Environment-mediated cross-contamination
- Lying on contaminated floor

Minimise between-batches transfer:

- Efficient sanitation of pens
- Sanitation of stun-box after each animal?

Hide decontamination:

- After death but before skinning

Hide decontamination treatments

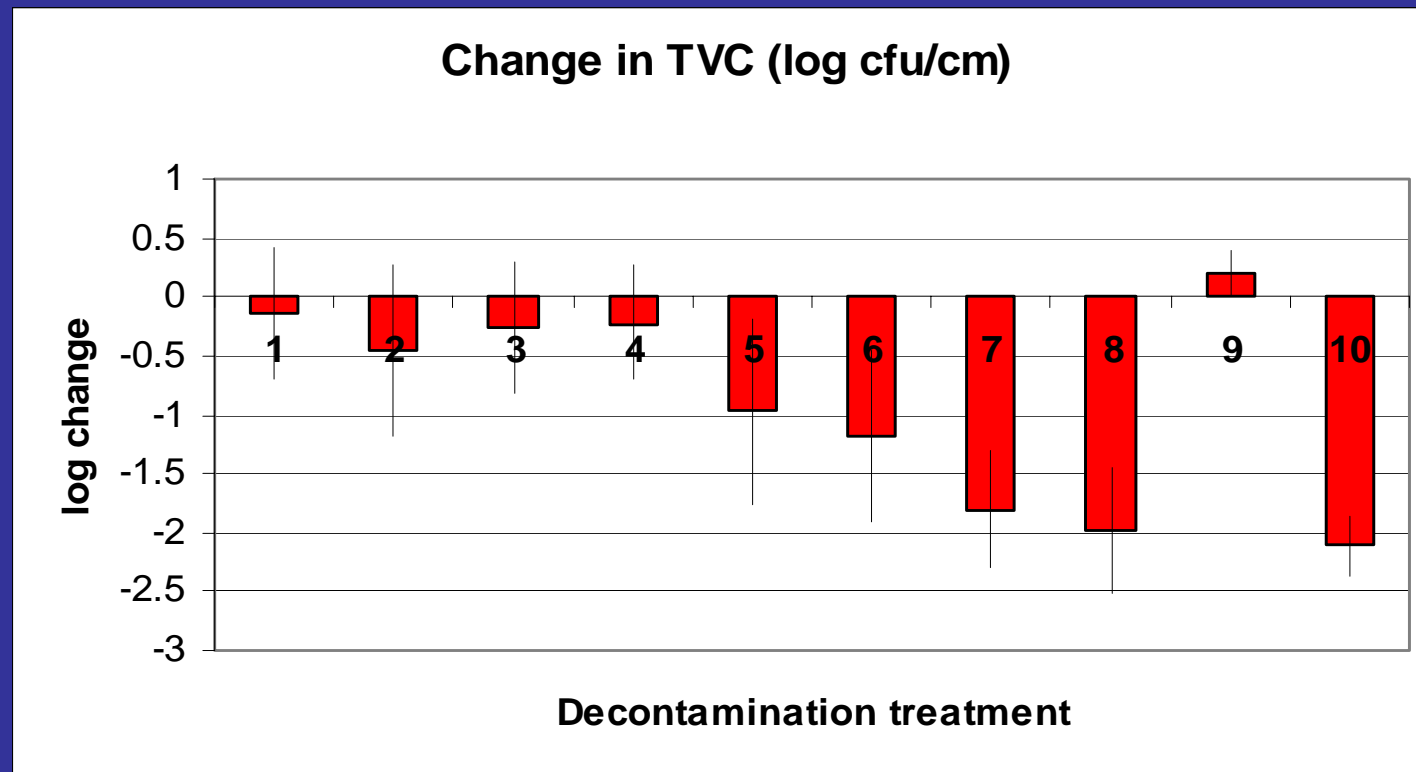


Global meat safety context of decontamination approaches

- Carcass (meat) decontamination:
 - reactive, deals with “consequences”;
 - limitations of treatments (edible; meat quality & safety concerns) limit the efficacies
- Hide decontamination:
 - proactive, deals with “causes”;
 - much harsher treatments possible (inedible)
- Either-or *versus* both

Decontamination of hides (Small et al., 2004):

1. Water at 50°C; 2. Water at 50°C plus dry,
3. Water at 50°C plus food-safe detergent; 4. Water at 50°C plus food-safe detergent plus dry.
5. Water at 50°C plus food industry approved disinfectant; 6. water at 50°C plus food industry approved disinfectant plus dry.
7. Water at 50°C plus food industry approved quaternary ammonium sanitizer; 8. Water at 50°C plus food industry approved quaternary ammonium sanitizer plus dry
9. Clipping the hair; 10. Clipping and singeing.



Microbial-immobilisation treatments of hide: general microflora (Antic et al., 2008, unpublished)

Treatments	TVC reductions (log CFU/cm ²)
Shellac, 23% in ethanol (an insect-produced natural resin)	6.56
Hair spray (commercial)	3.40
Antisept G rinse-vacuum (comparative “control”)	4.90

Microbial-immobilisation treatments of hide: pathogens (Antic et al., 2008 , unpublished)

Hides	<i>E. coli</i> O157 reductions
Uninoculated (natural) hide: <i>E. coli</i> O157 prevalence	3.7 -fold
Inoculated hide: with <i>E. coli</i> O157	2.1 log CFU/cm ²

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