FEDERAL INSTITUTE FOR RISK ASSESSMENT

Lessons learned from recent food-borne outbreaks in Germany

B. Appel
for the BfR outbreak team and
the food chain research team,
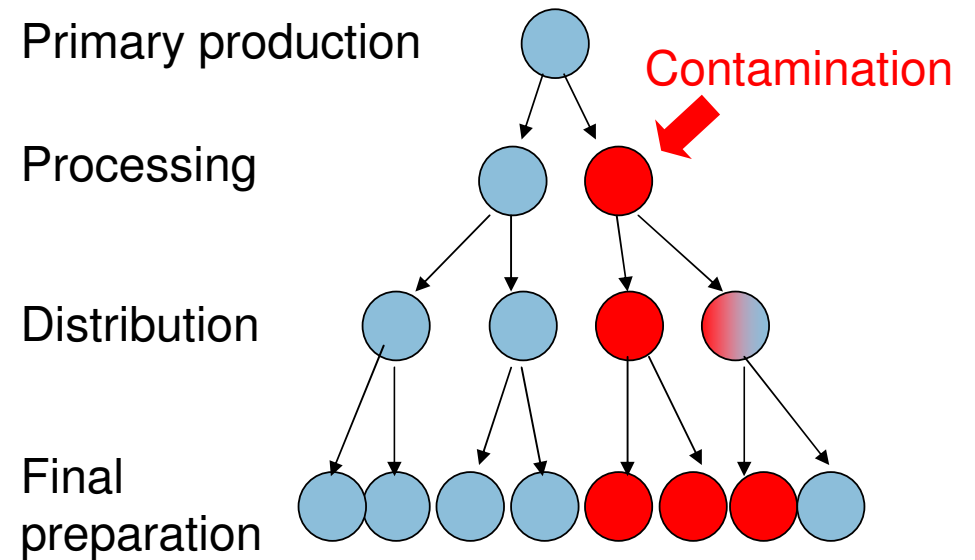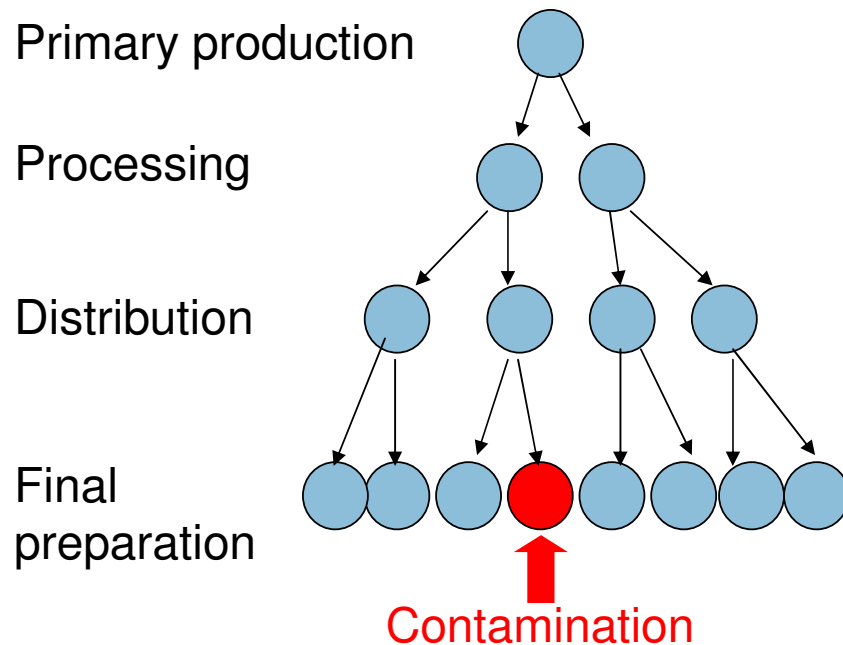**Dept. of Biological Safety**

Outline

- **food-borne outbreaks in the EU**

- **experiences with outbreaks**

- **research activities on food chains and outbreaks**

- **do we need new tools for investigations?**

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Outbreaks resulting from contaminations along the food chain

Local foodborne outbreak

vs.

Diffuse foodborne outbreak

Primary production

Processing

Distribution

Final preparation

Contamination

Primary production

Processing

Distribution

Final preparation

Contamination

Focal

Multifocal or diffuse

	Focal	Multifocal or diffuse
Source of contamination	local food handling	at production or processing
Contamination dose	high	low
Detection	self-reporting, lab follow-up	lab-based subtype surveillance
Investigation	local, tracing back	Complex multistate investigation

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Investigation of foodborne outbreaks along the food chain:
What are the tasks [to do]?

- Assembling an outbreak investigation team

- Exchange of information

- Interviews with patients and unaffected persons (cases & controls)

- Inspection of food establishments

- Tracing foodstuffs

- Collection and analysis of samples

- Interviews with food handlers

- Documentation, assessment and publication of results
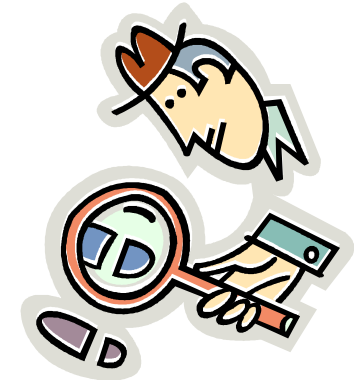
Experiences (1)

The majority of German food-borne outbreaks were caused by foods of animal origin.

Nevertheless, significant food-borne outbreaks in Germany were caused by foods of plant origin which have been eaten raw or slightly heated.
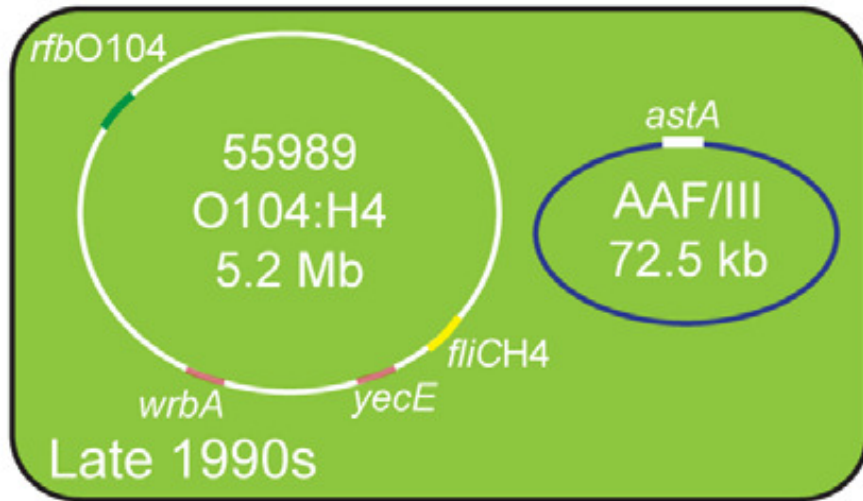
Example: *E. coli* O104:H4 outbreak, 2011

Largest outbreak by EHEC infection in Germany so far

Cases: 3793 (2353 hospitalized, 53 death)

Setting: Disseminated cases (restaurants, hotels, canteens, household)

Causative food: Sprouted fenugreek seeds

Epidemiol. evidence: Cohort study, trace-back and network analyses (delivery chains of sprouts and seeds)
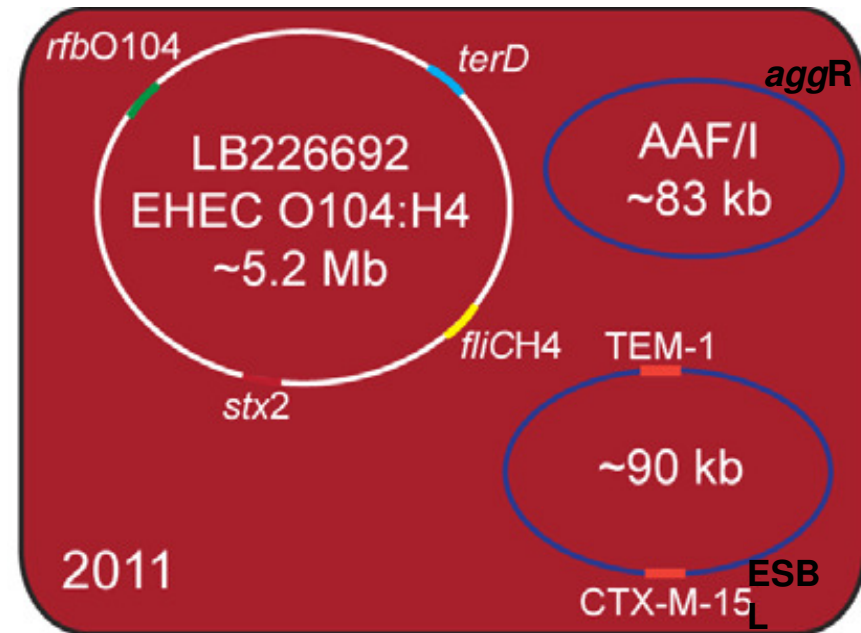
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Comparison of EAEC and German outbreak strain

outbreak isolate

AAF/III aggregative adherence fimbriae type III
intact *stx* integration site at *wrbA*

EAEC 1995/96

Entero-Aggregative *E. coli*

AAF/I aggregative adherence fimbriae type I

EAHEC 2011

Entero-Aggregative-
Haemorrhagic *E. coli*

Brzuszkiewicz et al. Arch Microbiol 2011 June 29

Mellmann et al. PLoS One. 2011;6(7):e22751

Example: Norovirus outbreak, 2012

Largest food-borne outbreak in Germany so far

Cases: 10 950 (38 hospitalized)

Setting: Disseminated cases (at least 390 affected facilities, almost exclusively schools and kindergartens)

Causative food: Imported frozen strawberries

Epidemiol. evidence: Case-control studies, trace-back investigations

Microbiol. evidence: Detection of outbreak strains in the suspected lot of frozen strawberries

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Norovirus in frozen strawberries

- **Detection of norovirus in 7/11 samples derived from the implicated lot**

- **Detection of 3 different genotypes (GI.9, GII.6, GII.16/II.13) in samples of frozen strawberries and in stool samples of outbreak-cases**

- **This genotype combination (GII.16/II.13) was previously detected in Asia and had not been reported in Germany so far**

Mäde, D. et al., 2013: „Detection and Typing of Norovirus from Frozen Strawberries Involved in a Large-Scale Gastroenteritis Outbreak in Germany. *Food Environ Virol* **5**:162-168

Examples: *Salmonella* Newport outbreaks in 2011

caused by mung bean sprouts from the Netherlands

- largest outbreak by *S.* Newport in Germany with 106 ill persons, further cases in the Netherlands
- clarified through epidemiological, microbiological, and trace-back investigations

caused by watermelons from South America

- outbreak in Germany and UK with 63 cases
- clarified through epidemiological, microbiological, and trace-back investigations

Food-borne outbreaks in the EU

Year	Outbreaks **without** identified foodstuff	Outbreaks **with** identified foodstuff	Source: vegetables and fruits
2007	3949	1784	18
2008	4442	890	19
2009	4537	977	43
2010	4564	698	70
2011	4947	701	54

Source: EFSA

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Causative agents in strong evidence outbreaks in the EU, 2011

n = 701

- 40% Salmonella
- 17% Bacterial toxins
- 6% Campylobacter
- 13% Viruses
- 13% other causative agents
- 2% E. coli, pathogenic
- 1% other bacterial agents
- 1% Parasites
- 7% unknown

Legend:
- Salmonella
- Bacterial toxins
- Campylobacter
- Viruses
- other causative agents
- E. coli, pathogenic
- other bacterial agents
- Parasites
- unknown

Source: EFSA

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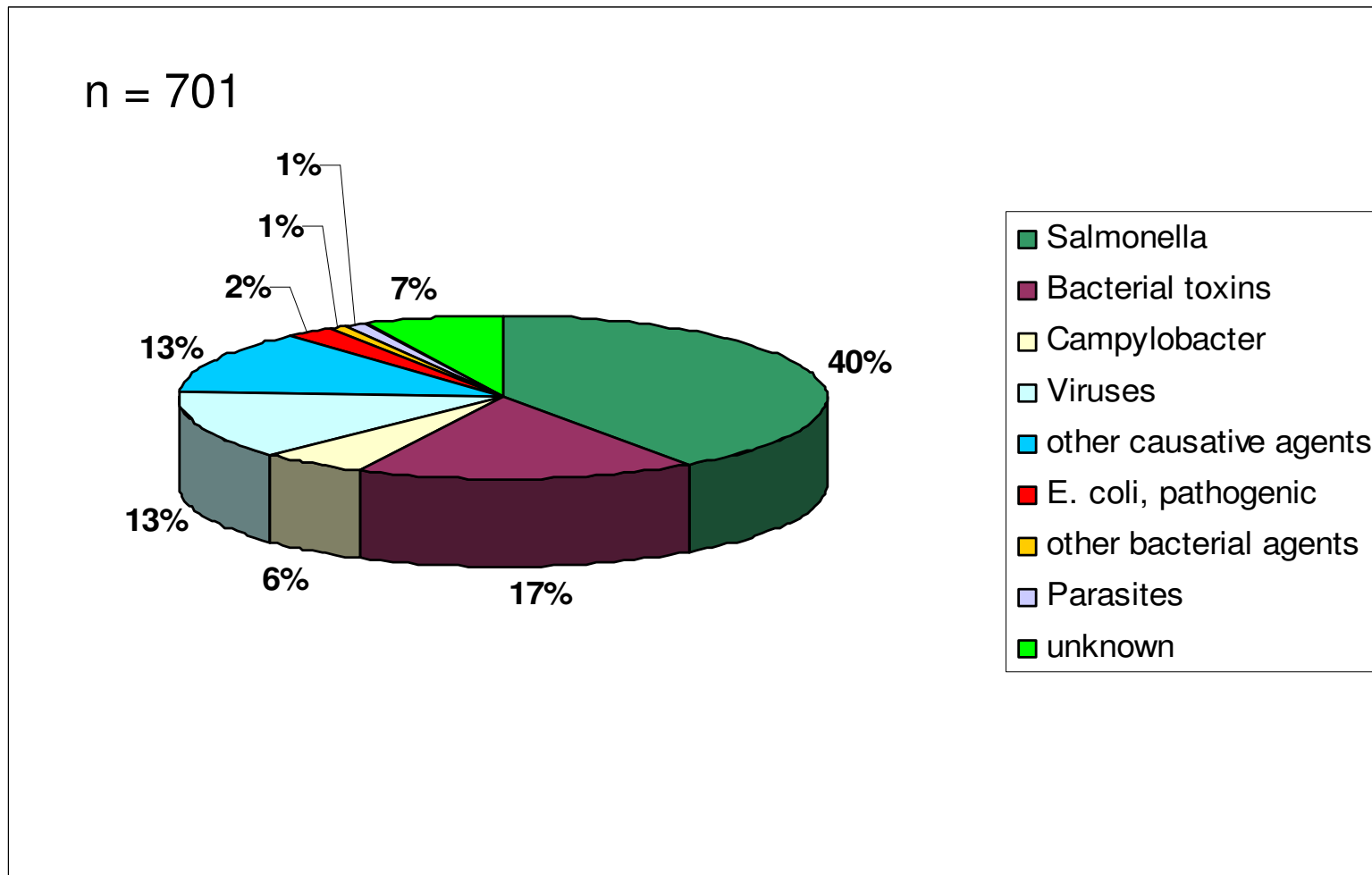
Causative agents in strong evidence outbreaks caused by food of non-animal origin in the EU, 2011

n = 80

Pie chart data:
- Viruses: 28.8%
- Bacillus: 22.5%
- Salmonella: 15.0%
- E.coli, pathogenic: 7.5%
- Mycotoxins: 7.5%
- Clostridium: 6.3%
- unknown: 6.3%
- Staphylococcal toxins: 5.0%
- Mushroom toxins: 1.3%

Legend:
- Viruses
- Bacillus
- Salmonella
- E.coli, pathogenic
- Mycotoxins
- Clostridium
- unknown
- Staphylococcal toxins
- Mushroom toxins
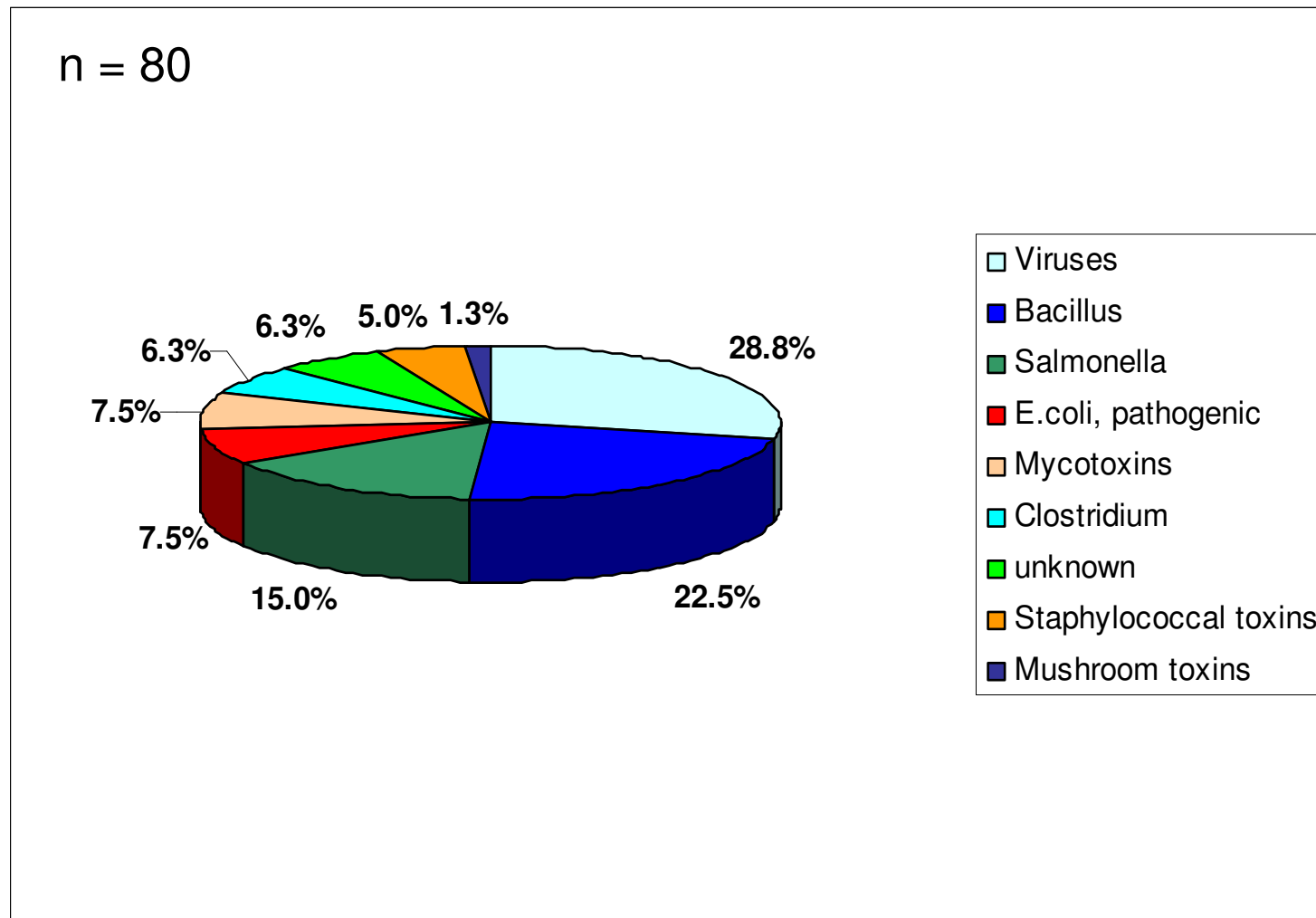
Source: EFSA

Experiences (2)
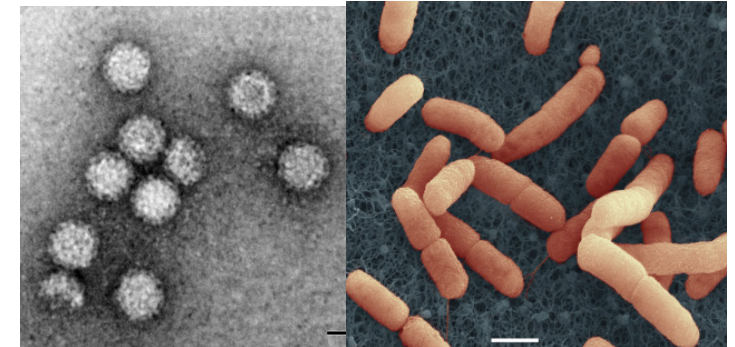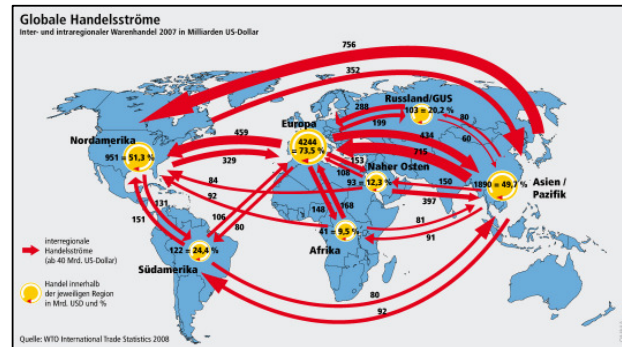
Source: World Trade Organisation

- The foods of plant origin (Fenugreek seeds, frozen strawberries, watermelons) had been imported from Third Countries in great amounts and were widely distributed.

- The contaminations did most likely happen in the countries of origin

- Unusual or unknown pathogens can be introduced into importing countries via those food vehicles.

Possible sources for pathogen migration in the field
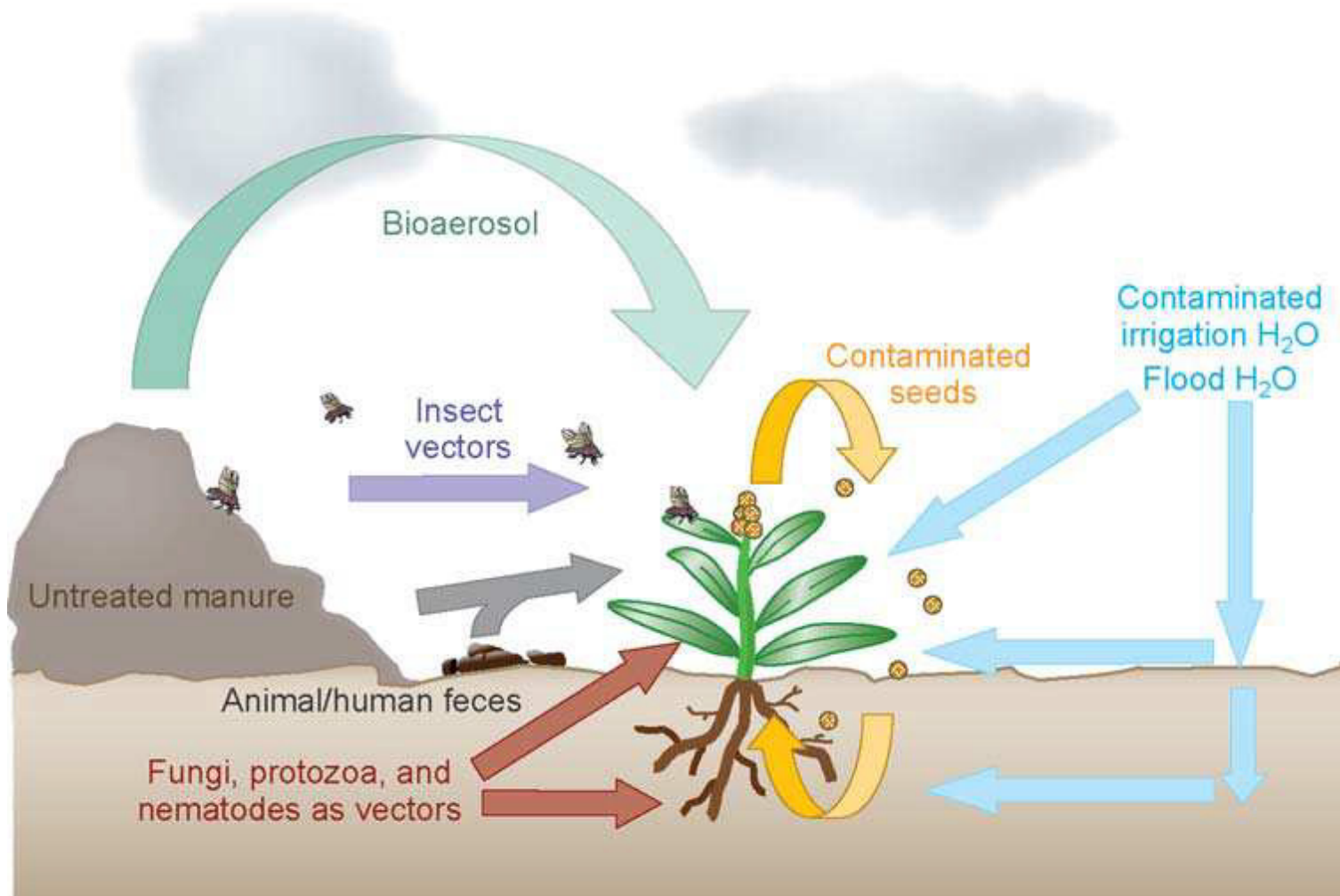
Brandl 2006, Annu. Rev. Phytopathol.

How do we cope with food-borne outbreaks in the context of global food chains?

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Are we prepared for risk assessment in global food chains?

ln(B_i) 4.9 — 9.3
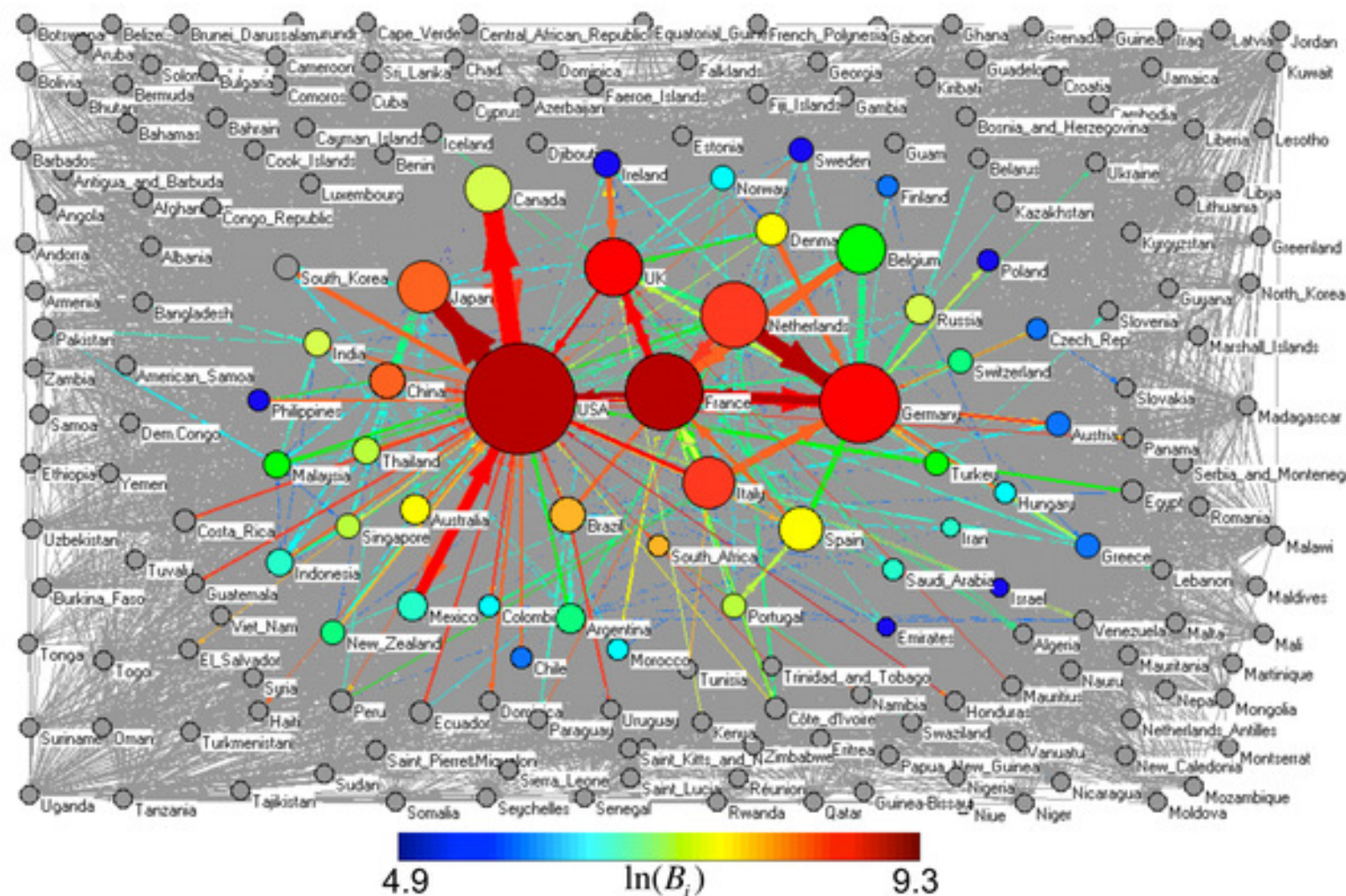
The complete International Agro-Food Trade Network in 1998.

Ercsey-Ravasz M, Toroczkai Z, Lakner Z, Baranyi J (2012) Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. PLoS ONE 7(5): e37810. doi:10.1371/journal.pone.0037810

Global food chains -

a challenge for risk assessors

- **Costumers purchase behaviour** is changing massively due to free market economy

- **Dissolution from local production** and supply

- Highly competitive environment => **cheap priced foodstuff**

- Differences with respect to regulations: **import regulations, border** controls, statutory requirements, internet trade

=> Do we have the **right information, methods and tools** for effective quality management and **risk assessment**?

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Risk Assessment in global trade: easy to do?

Problem formulation

Hazard Identification

- identification of adverse health effects (potential and nature)
    - human studies
    - animal-based toxicology studies
    - in vitro toxicology studies
    - structure-activity considerations

Exposure Assessment

- levels of substance in food and diet
- amounts of food consumed
- intake in individuals (max/min, regularly/occasionally)
- intake in special population groups

Hazard Characterisation

- kinetic and dynamic variability
- mode/mechanism of action
- dose-response for critical effect
- identification of starting point
- selection of critical data set, qualitative /quantitative

Risk Characterisation

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Implications of global food supply chains –
Increased complexity of risk / exposure assessments
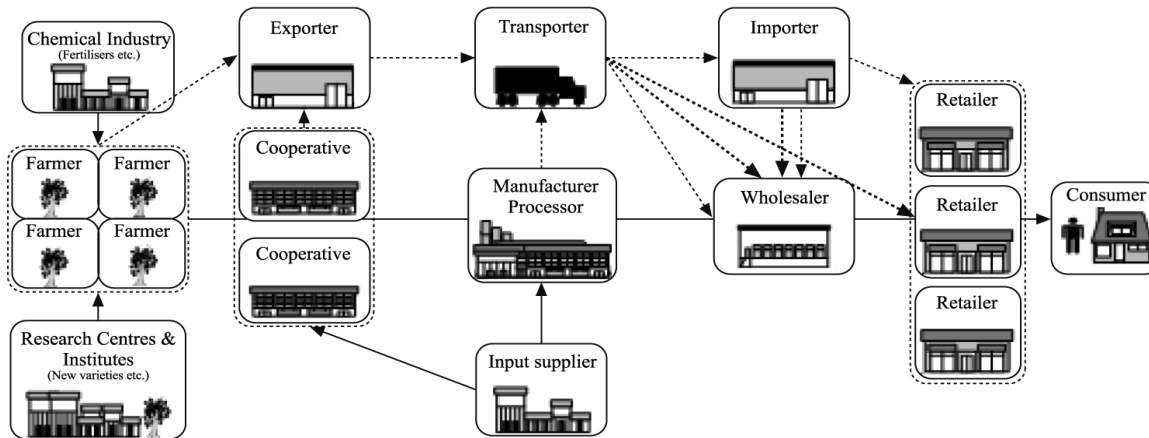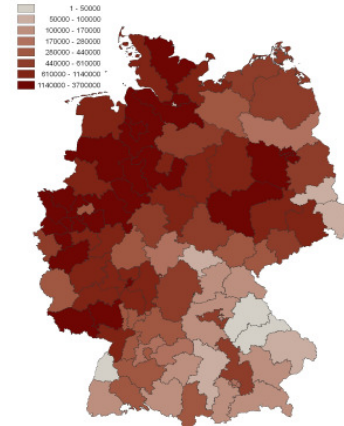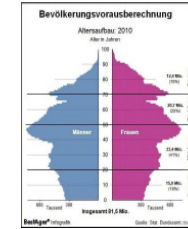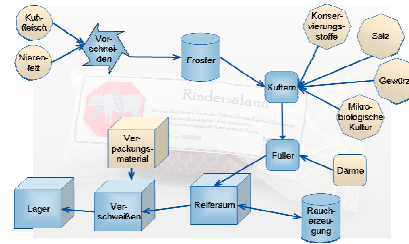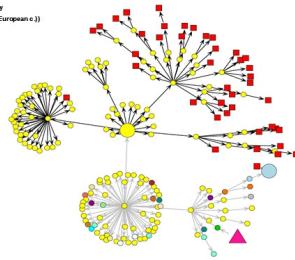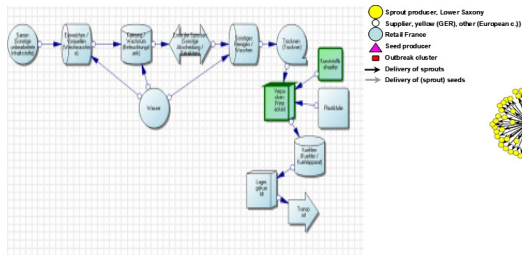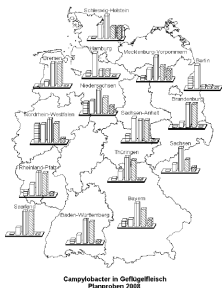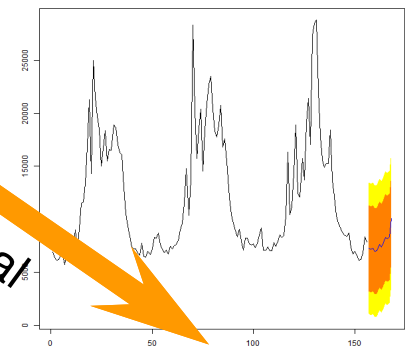
Matopoulos et a. (2007) Supply
Chain Management: Vol. 12
Iss: 3, pp.177 - 186
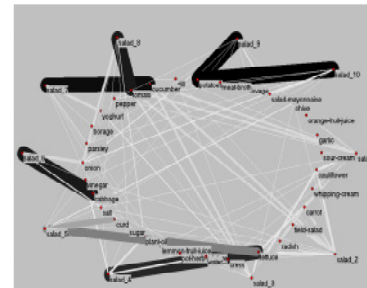
Our Vision and Invitation:
Join the development of food safety community tools + community databases
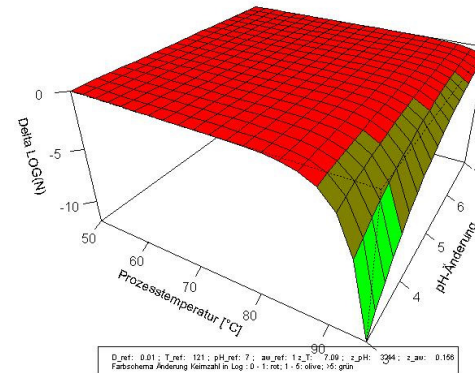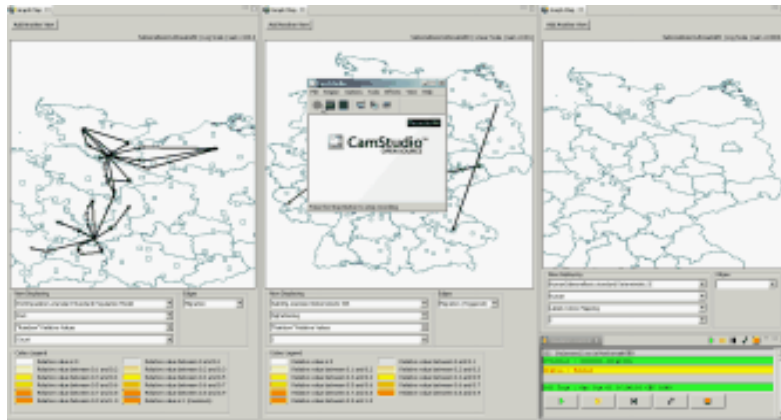
animal disease models	Food processing and distribution	human disease models
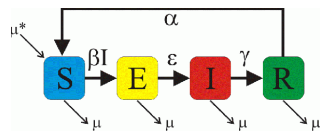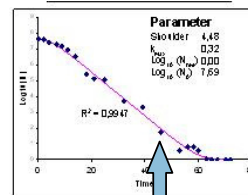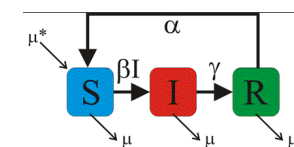
Environmental factors
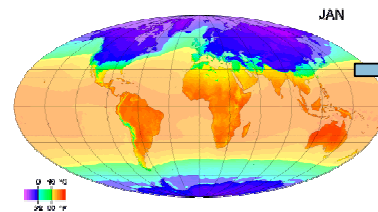
Processing parameters
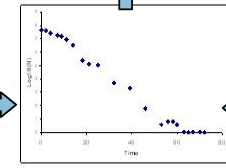
BfR solutions -
Integrated tools for risk / exposure assessment

PMM-Lab

KNIME
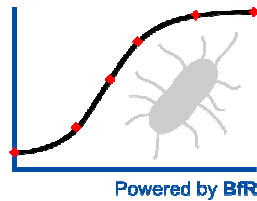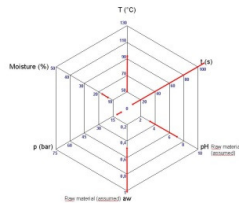
Food Chain Lab
Powered by BfR
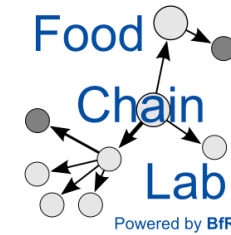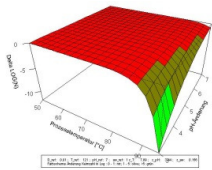
Predictive Microbiology

Data Analysis and Visualization

DB

Spatio-Temporal Modeling

Food Process Simulation

STEM
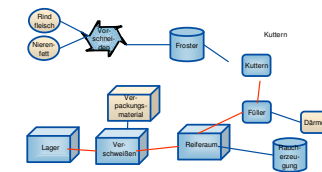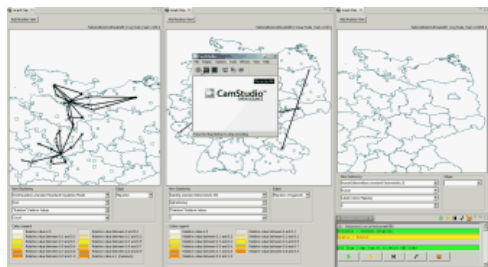
Food Process Lab
Powered by BfR

# Example: *E. coli* O104:H4 outbreak, 2011

Distribution of fenugreek seeds from Egypt (Batch 48088, 15 t)
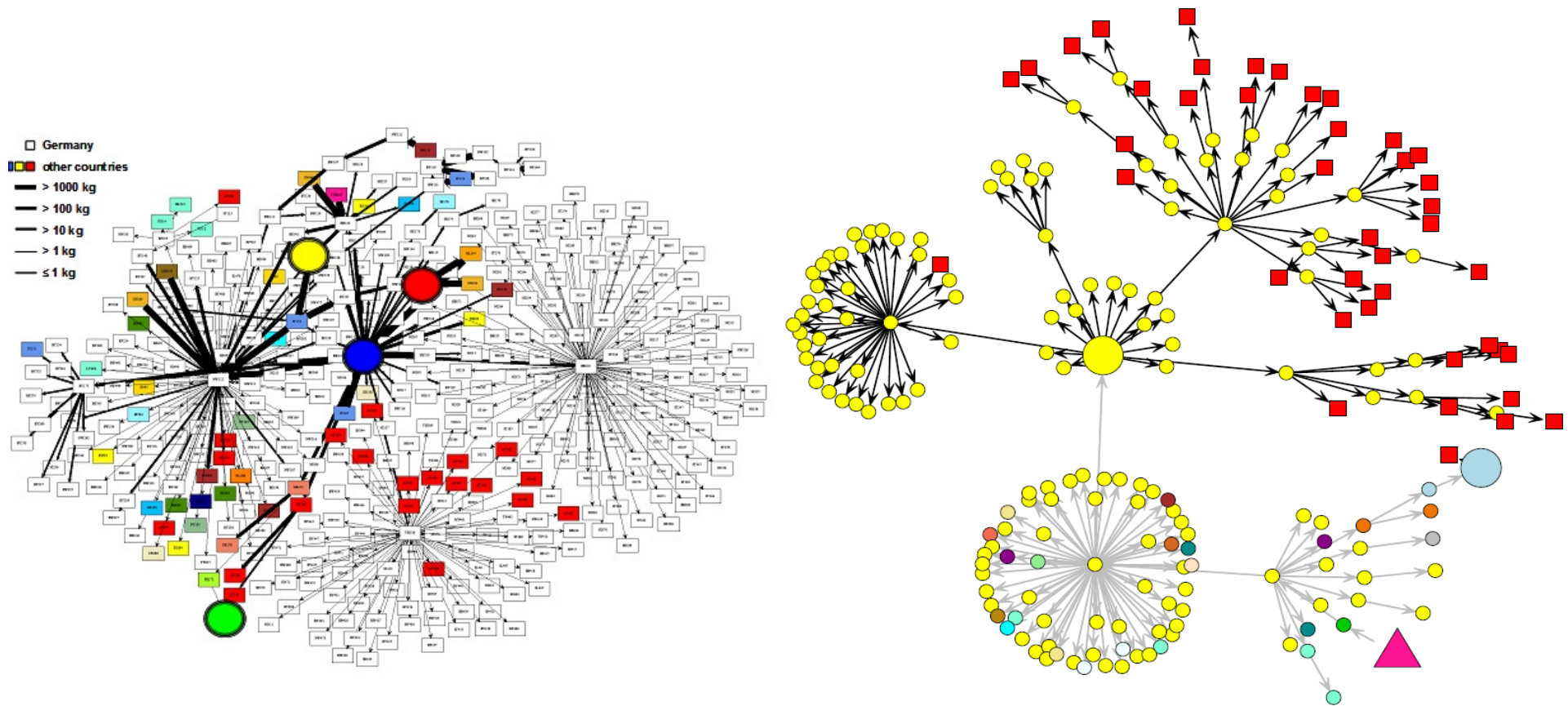
Weiser et al., 2013: "Trace-Back and Trace-Forward Tools Developed Ad Hoc and Used During the STEC O104:H4 Outbreak 2011 in Germany and Generic Concepts for Future Outbreak Situations", **Foodborne Pathog Dis. 2013**.
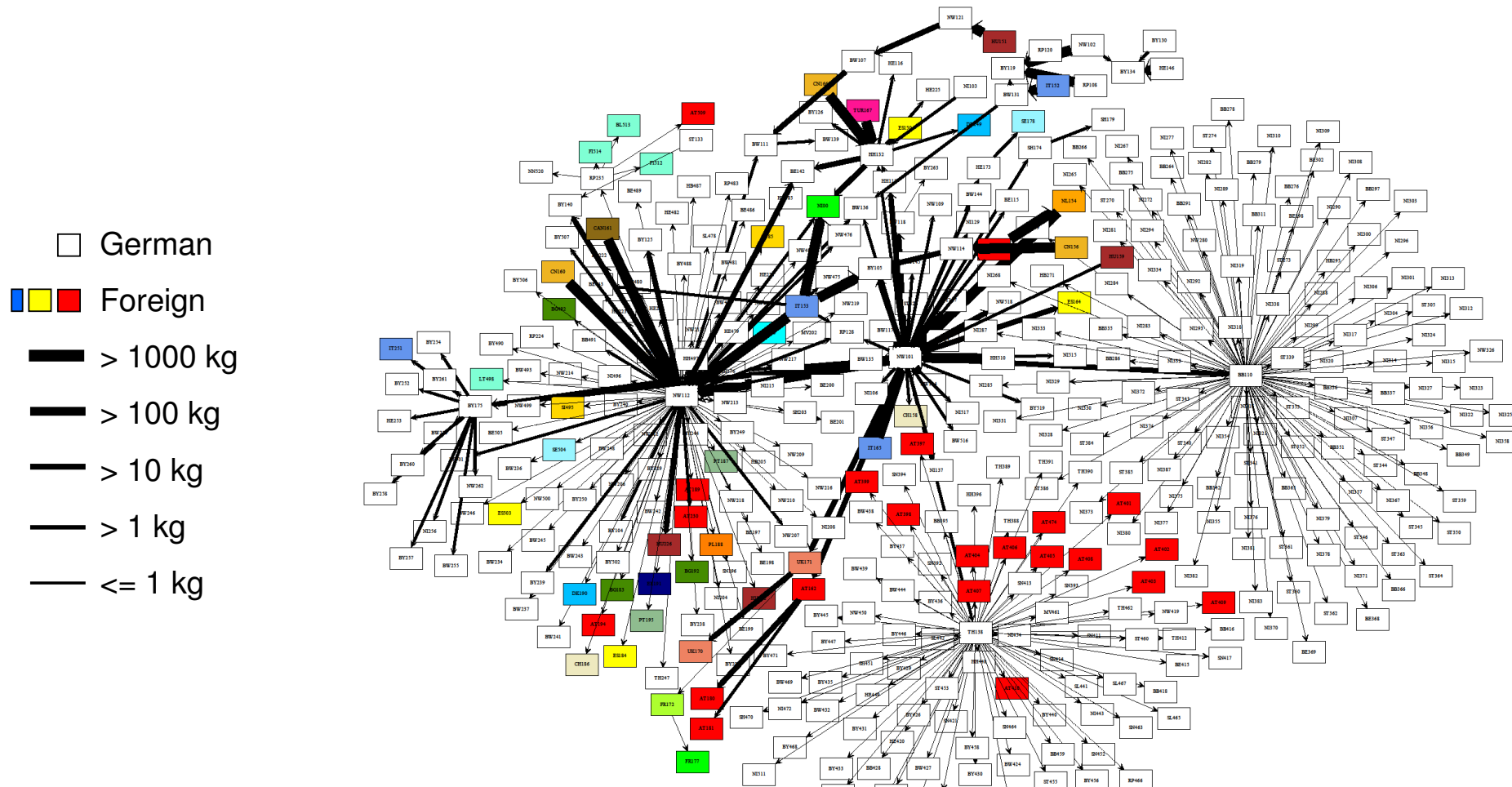
Epidemiological survey

Distribution of sprouts from the horticultural farm in lower saxony
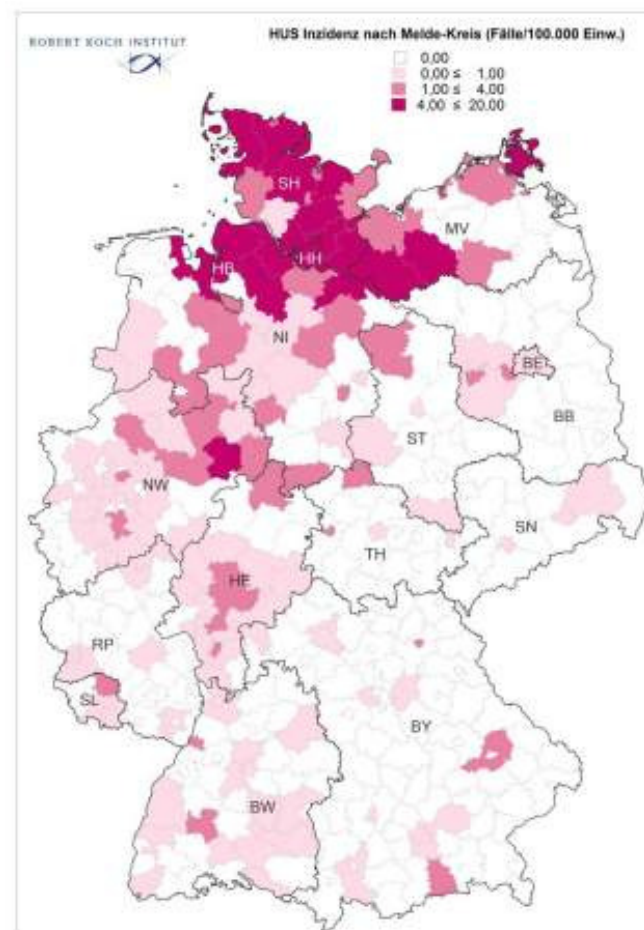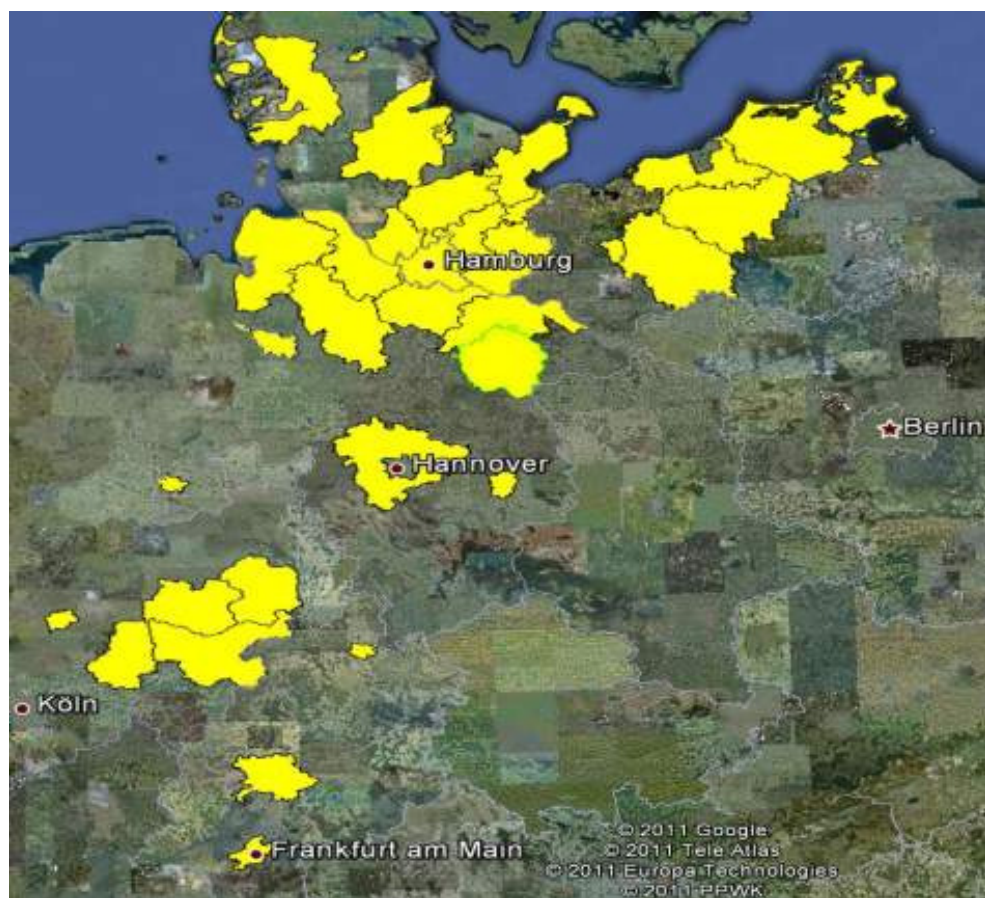
HUS incidences by residence
(per 100.000 inhabitants)
Robert Koch-Institute (*data 13 July 11*)

Epidemiological survey

Example: network graph for all collected data on seed supply chains

Legend:
- ☐ German
- 🟦🟨🟥 Foreign
- ▬▬ > 1000 kg
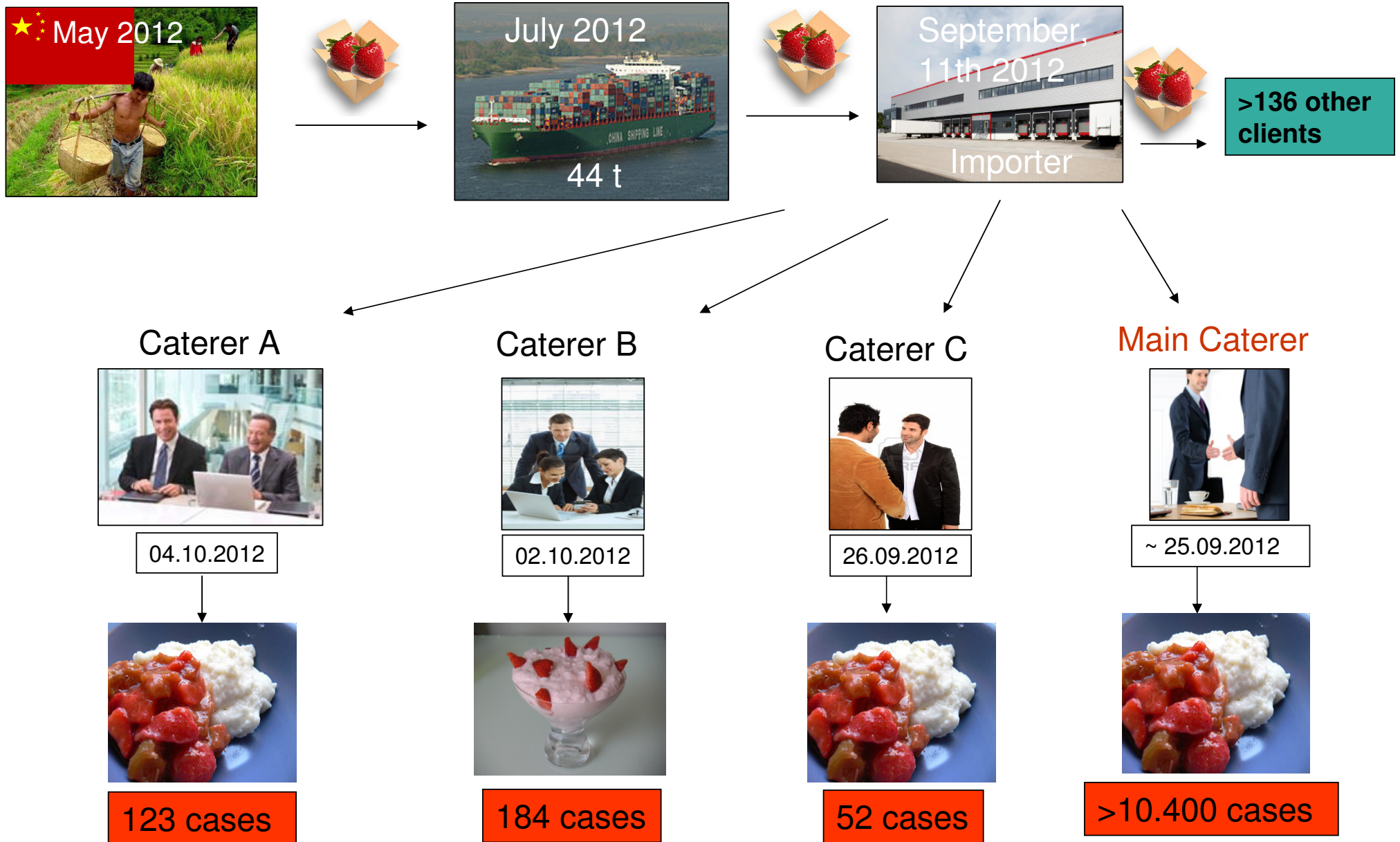- ▬ > 100 kg
- ── > 10 kg
- ── > 1 kg
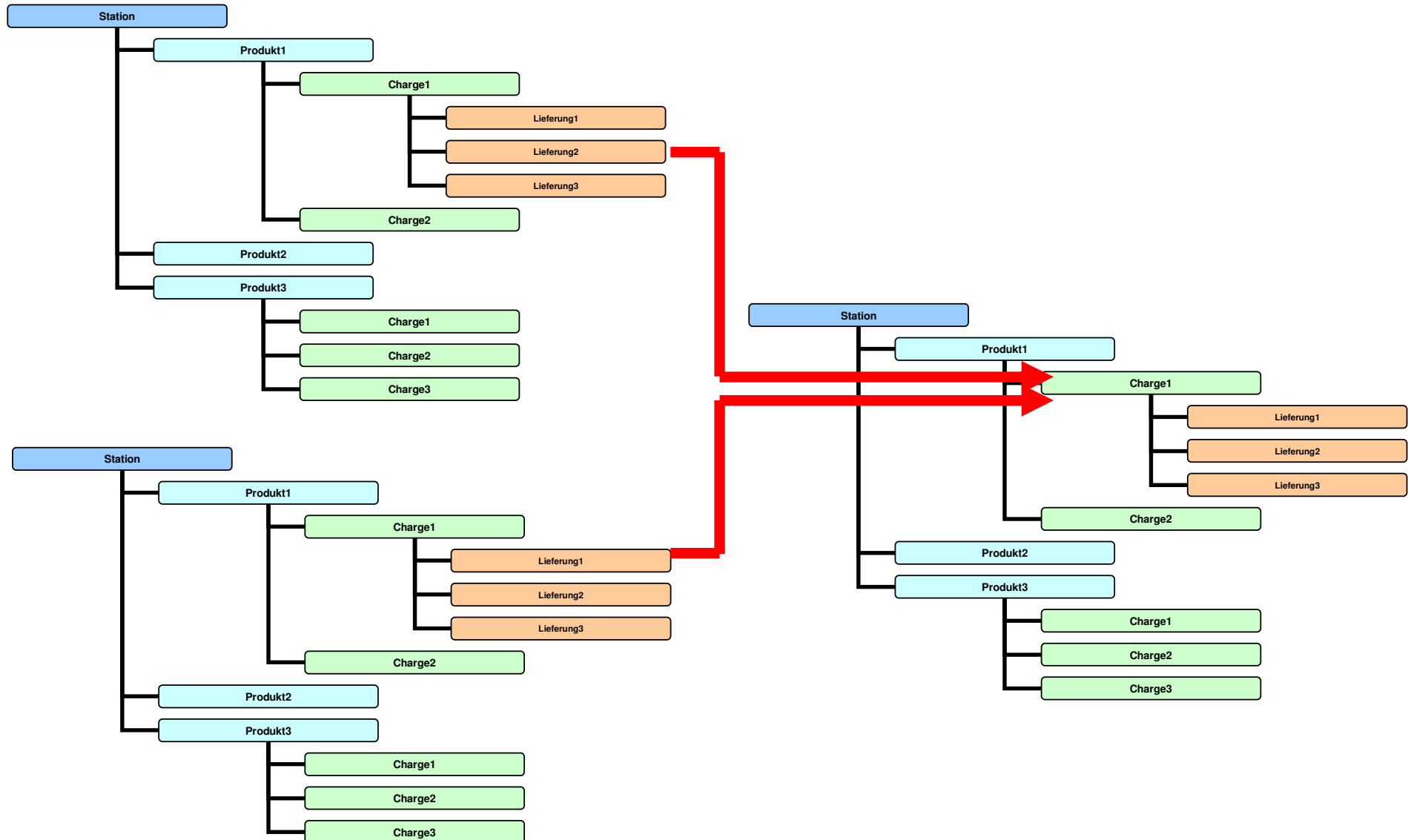- ── <= 1 kg

Another style of visualization:
- the boxes include anonymized names of the companies and represent a distributor/producer/consumer (colored: foreign)
- the delivery quantity varies between 50g packets und 15 tons

Example: Norovirus outbreak, 2012
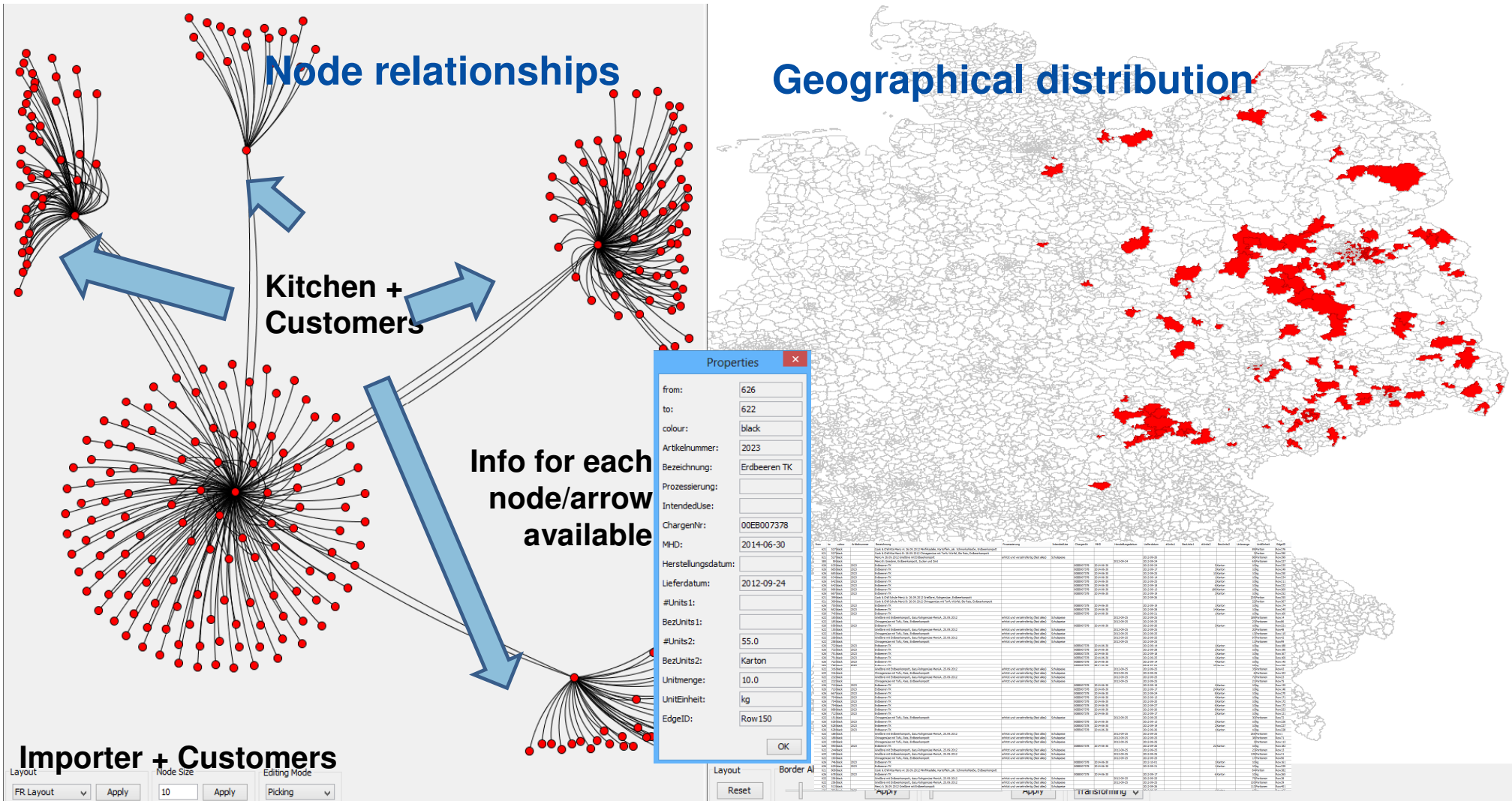## Distribution of frozen strawberries from China (Batch 00EB007378, 44 t)

May 2012 → July 2012 — 44 t → September, 11th 2012 — Importer → >136 other clients

Caterer A	Caterer B	Caterer C	Main Caterer
04.10.2012	02.10.2012	26.09.2012	~ 25.09.2012
123 cases	184 cases	52 cases	>10.400 cases

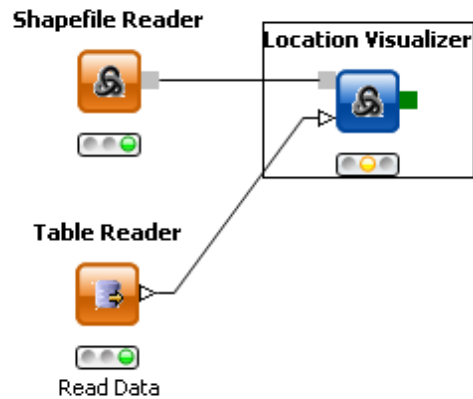# Example -
Data structure for successful back- and forward tracing

Example: Norovirus outbreak, 2012

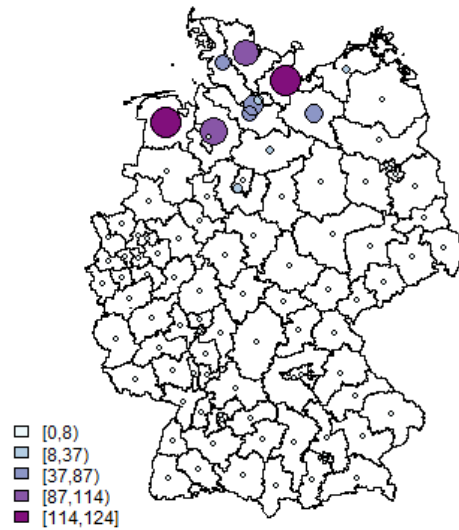## Distribution of frozen strawberries from China (Batch 00EB007378, 44 t)

Node relationships

Geographical distribution

Kitchen + Customers

Info for each node/arrow available

Importer + Customers

Properties

from:	626
to:	622
colour:	black
Artikelnummer:	2023
Bezeichnung:	Erdbeeren TK
Prozessierung:	
IntendedUse:	
ChargenNr:	00EB007378
MHD:	2014-06-30
Herstellungsdatum:	
Lieferdatum:	2012-09-24
#Units1:	
BezUnits1:	
#Units2:	55.0
BezUnits2:	Karton
Unitmenge:	10.0
UnitEinheit:	kg
EdgeID:	Row150

OK

Example - Location Visualizer

Get Coordinates with
Google Geocoding:

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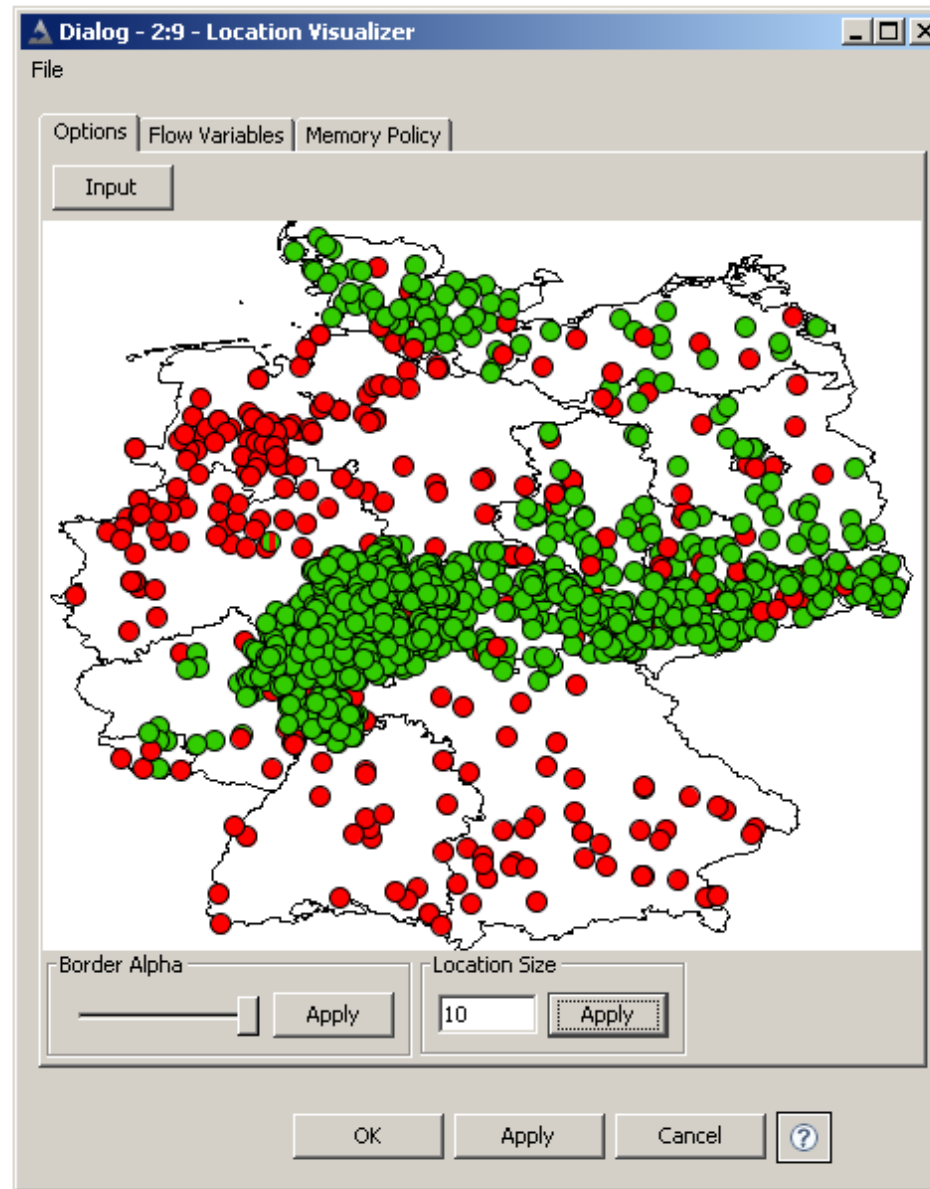
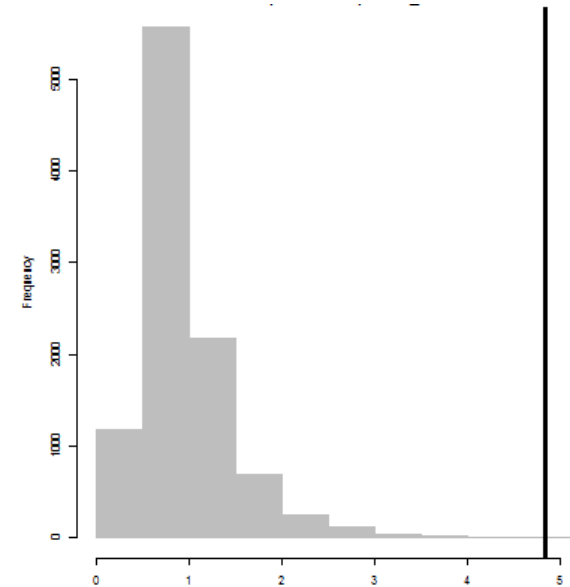# Example - Region To Region"/"Location To Location" Visualizer

Example –
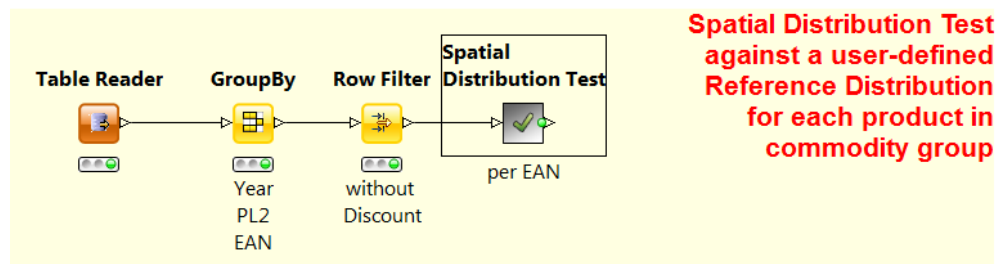# Tools to support outbreak investigations II

Product /
Product Group /
Retail Store
Distribution
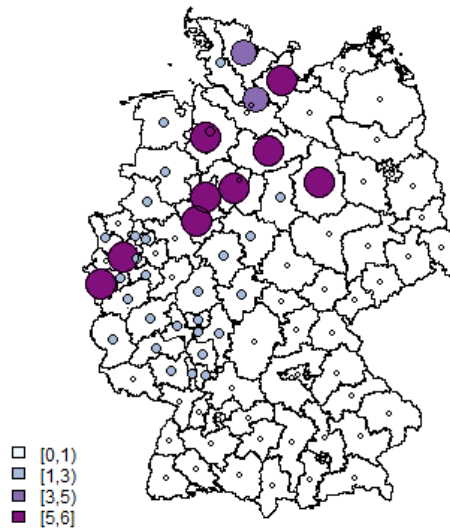
Human Cases
Distribution

Statistical Test
on
Similarity of Distributions

Thank you for your attention

Bernd Appel

Federal Institute for Risk Assessment

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