Molecular epidemiology of clinical, animal, and environmental isolates of *Acinetobacter baumannii*

Paul G. Higgins

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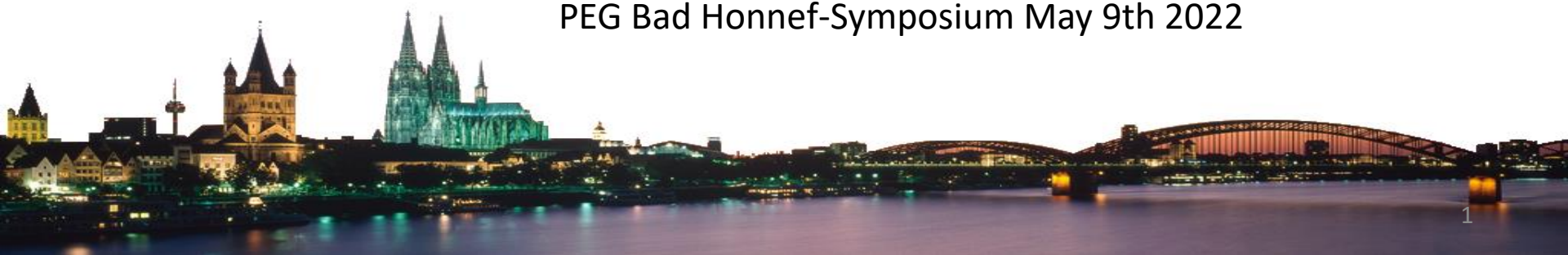
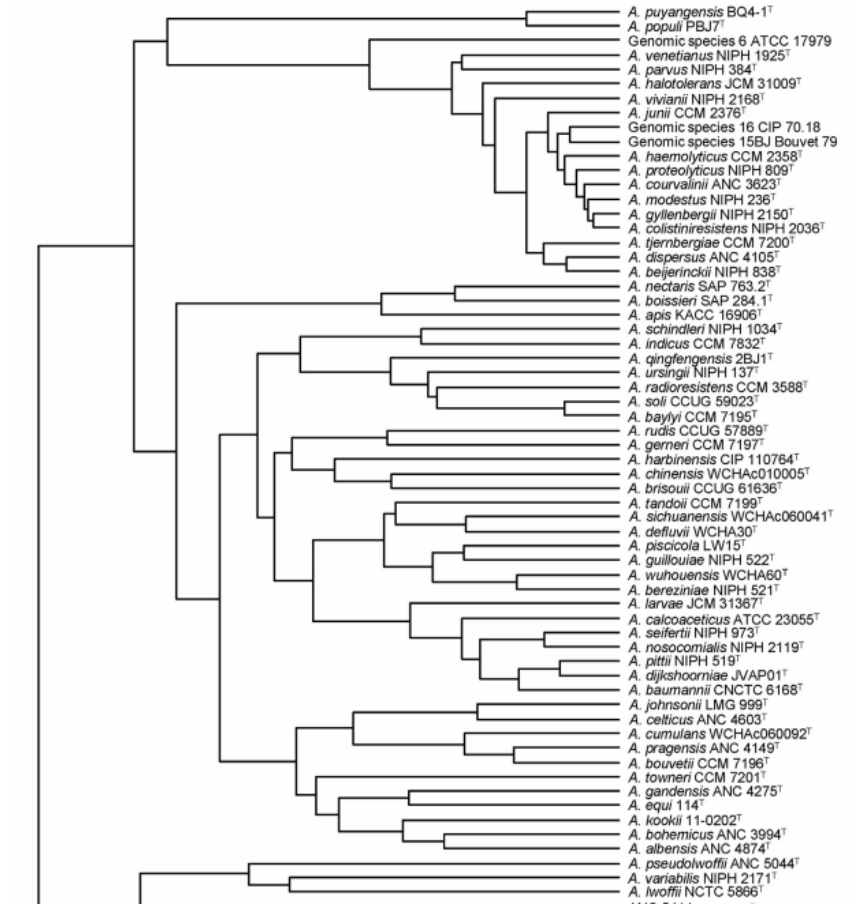
PEG Bad Honnef-Symposium May 9th 2022



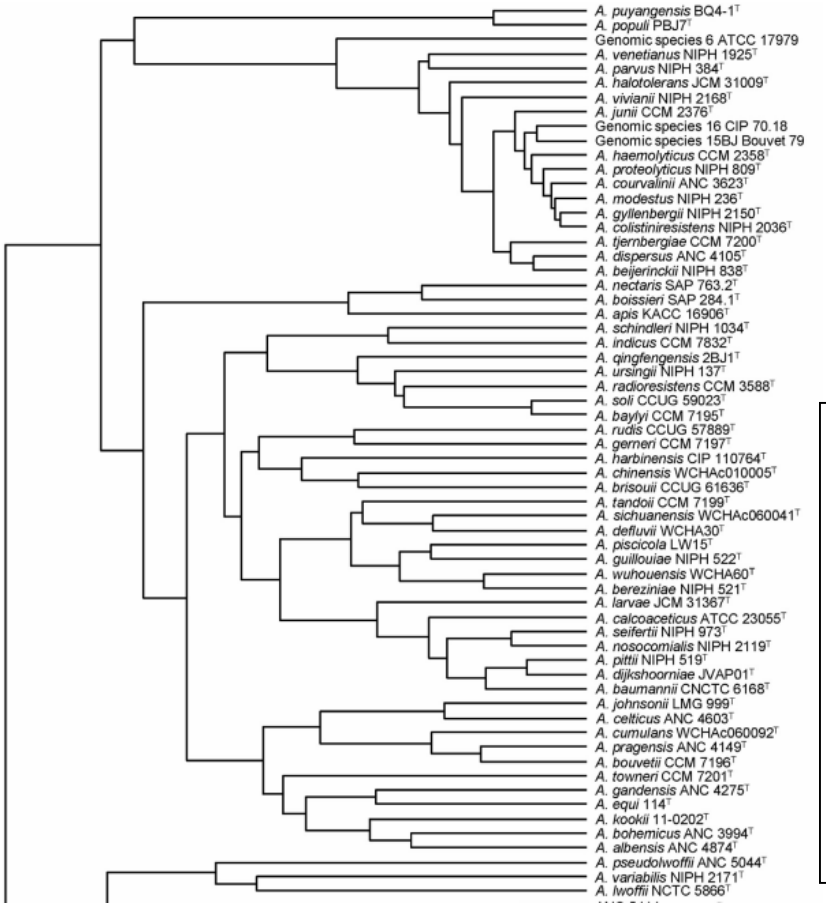
The genus Acinetobacter



Alexandr Nemec (apps.szu.cz/anemec/anemec.htm) last updated 05/05/2022

- Non-fermenting, oxidase negative, Gram-negative cocobacilli
- 74 named species
- Found in diverse environments; soil, water, sludge, nuclear reactors, animals....
- Most clinically relevant
  - *A. baumannii*
  - VAP, UTI, sepsis, wound infections
  - Causes outbreaks
  - MDR, XDR, PDR

The genus Acinetobacter



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- Found in diverse environments; soil, water, sludge, nuclear reactors, animals....
- Most clinically relevant

J Antimicrob Chemother 2014
doi:10.1093/jac/dku170
Advance Access publication 15 May 2014

Detection of pan drug-resistant *Acinetobacter baumannii* in Germany

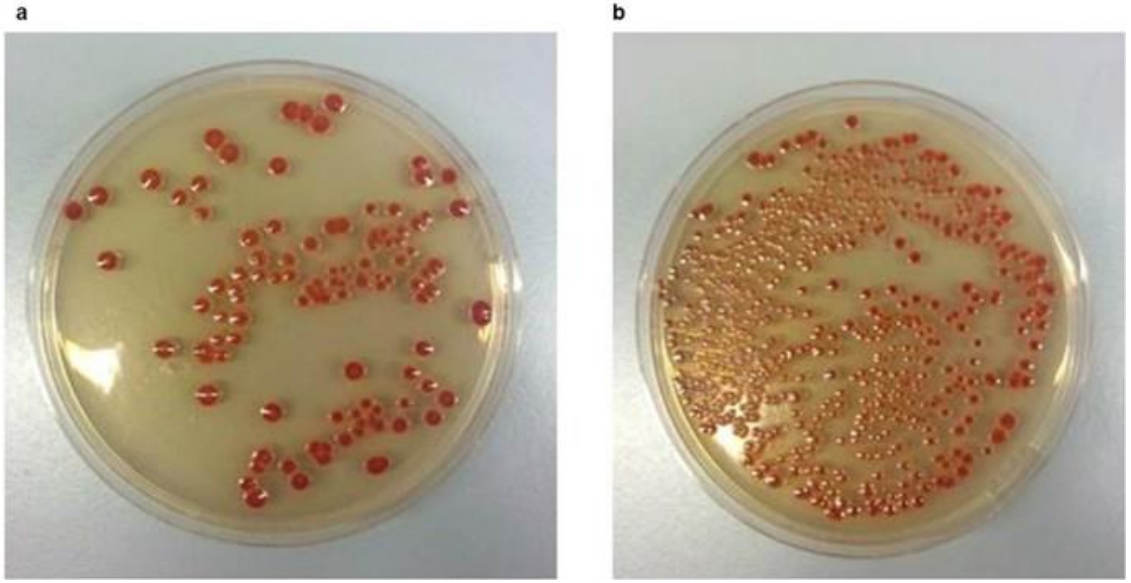
Stephan Göttig[1]*, Teresa M. Gruber[1], Paul G. Higgins[2], Maik Wachsmuth[1], Harald Seifert[2] and Volkhard A. J. Kempf[1]

Alexandr Nemec (apps.szu.cz/anemec/anemec.htm) last updated 05/05/2022

Acinetobacter baumannii isolated from multiple sources

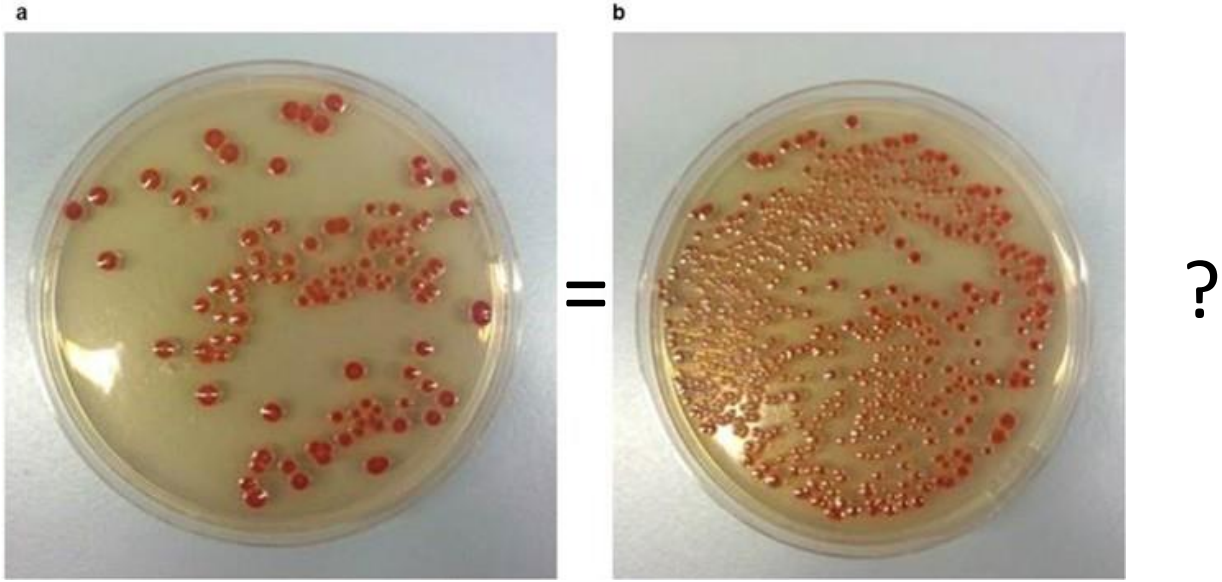
Diverse habitats, but are the isolates the same?

Bacterial typing



Bacterial typing

Is A the same as B?



A. baumannii typing nomenclature

Sporadic and Outbreak

European clone

Sequence type/Clonal complex
Oxford and Pasteur

Sequence group

OXA-51 type

Worldwide clonal lineage

International clone

Global clone

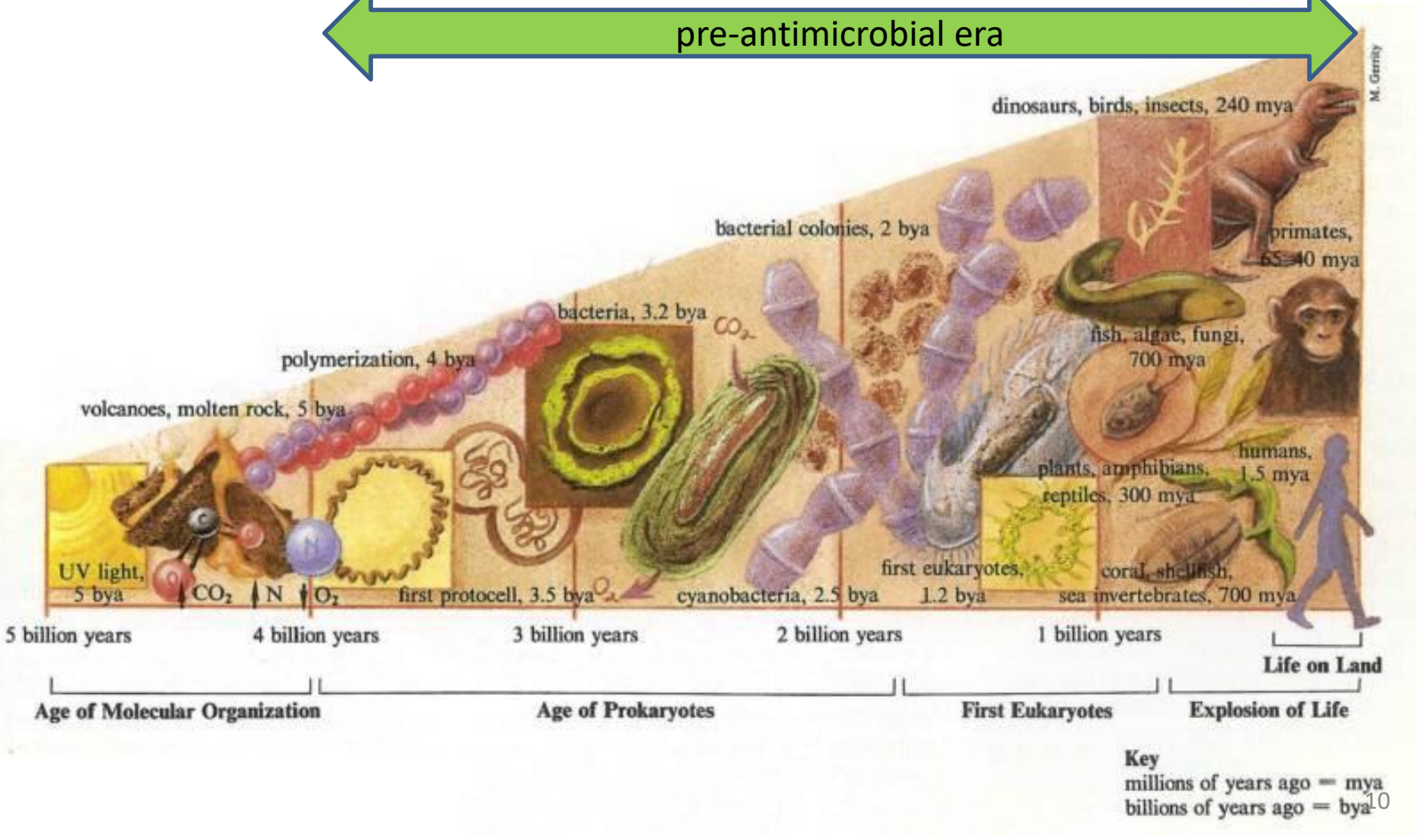
International clone

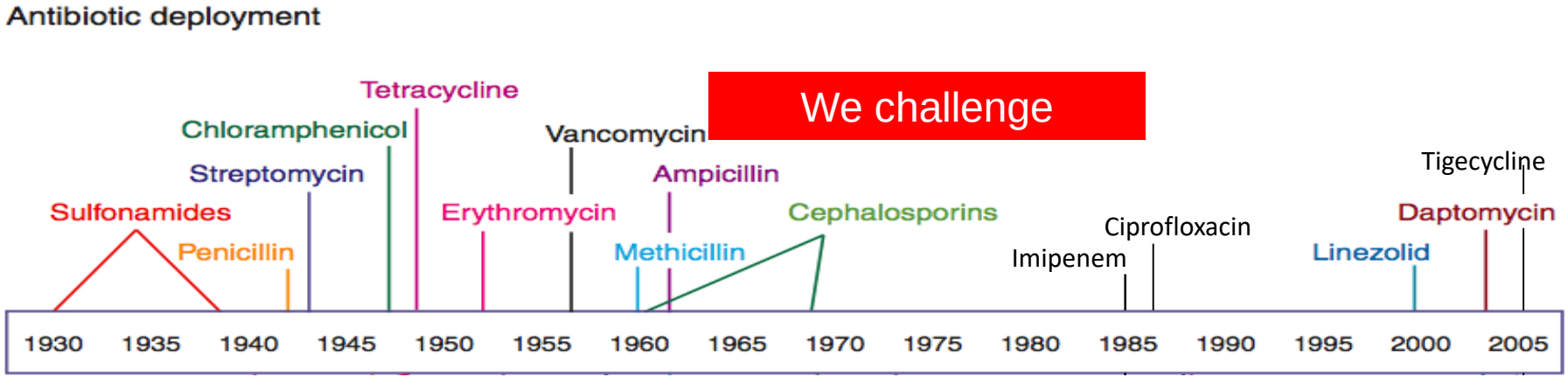
Defined as;

At least two isolates that have been collected from at least two countries showing a high degree of clonality

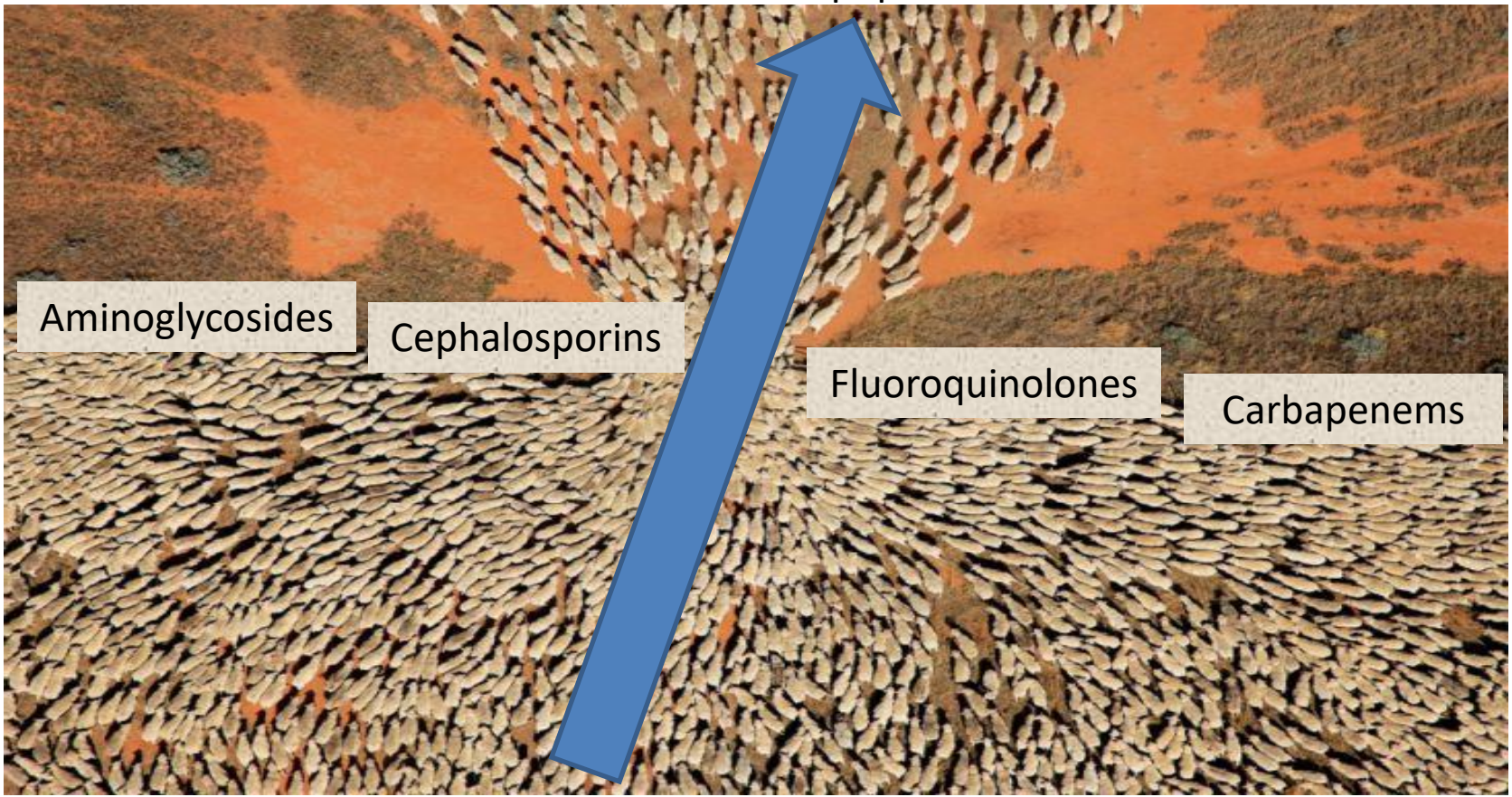
Why do we have different clonal lineages?

pre-antimicrobial era



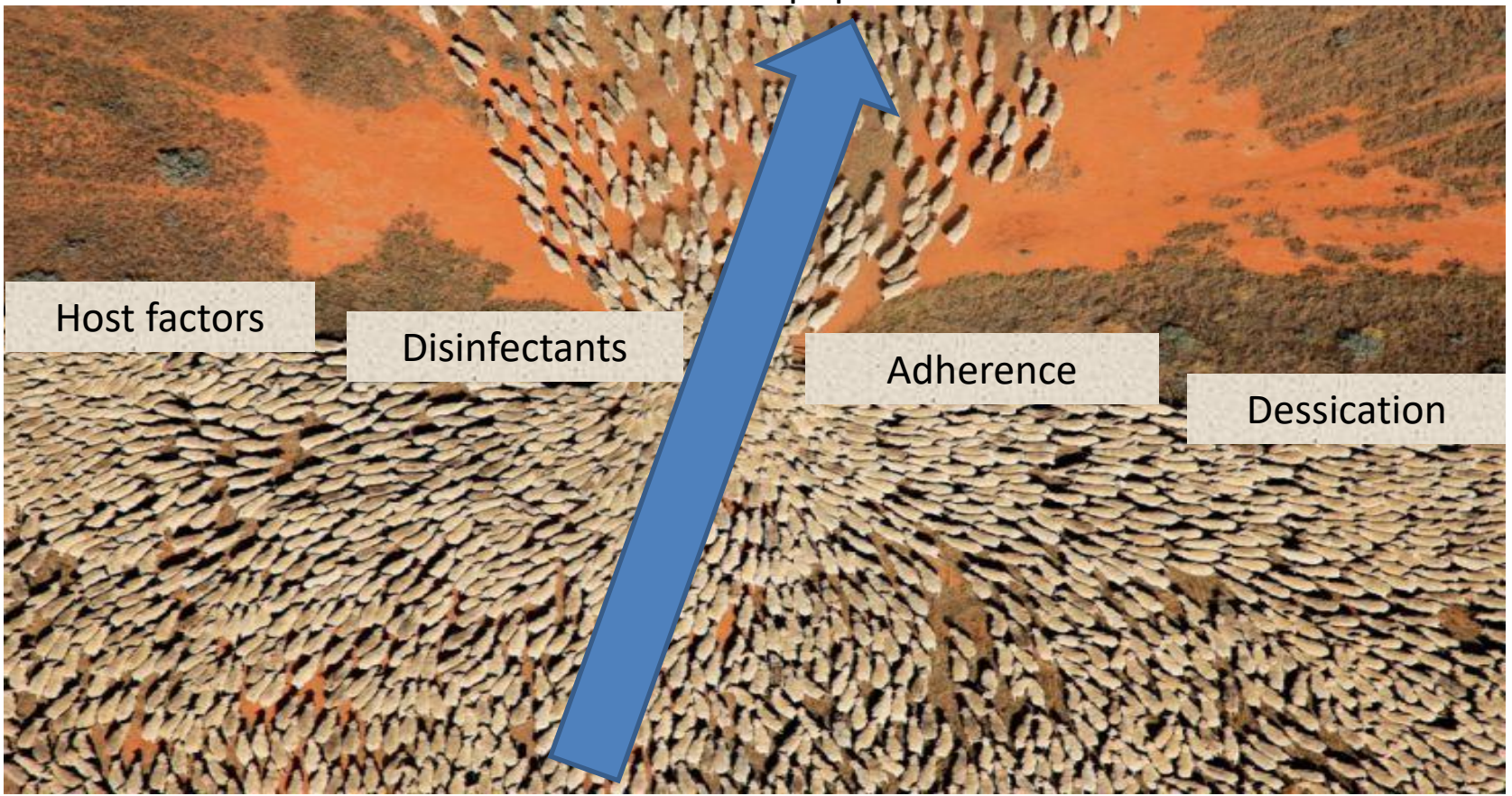

Antibiotic deployment
Tetracycline
Chloramphenicol
Streptomycin
Sulfonamides
Penicillin
Vancomycin
Erythromycin
Ampicillin
Methicillin
Cephalosporins
We challenge
Tigecycline
Daptomycin
Ciprofloxacin
Imipenem
Linezolid
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Antibiotic resistant population



Pre-antibiotic exposure population

Post-selection population



Pre-selection population

genetic armoury

A. baumannii genomes (n = 5257) encode:

1982 genes
(strain Ab25)

Median 3691 genes
(strain pet_ACB87)

9800 genes
(strain 4300STDY7045842)

There is a lot of genetic material available for selection

genetic armoury

A. baumannii genomes (n = 5257) encode:

Accessory

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genetic armoury

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Accessory

1982 gene
(strain Ab25)

(strain pet_ACB87)

(strain 4300STDY7045842)

There is a lot of genetic material available for selection

A few caveats;

- Species misidentification
    - *Acinetobacter spp. ≠ A. baumannii* "diluting" the species
- Publication bias
    - the majority of studies favour MDR/XDR/PDR isolates
- Incomplete metadata
    - species, source, country, often missing
    - people don‘t submit data to PubMLST: frequency of ST‘s hard to determine

European clones

JOURNAL OF CLINICAL MICROBIOLOGY, June 1996, p. 1519–1525 Vol. 34, No. 6
0095-1137/96/$04.00+0

Comparison of Outbreak and Nonoutbreak *Acinetobacter baumannii* Strains by Genotypic and Phenotypic Methods

L. DIJKSHOORN,[1]* H. AUCKEN,[2] P. GERNER-SMIDT,[3] P. JANSSEN,[4] M. E. KAUFMANN,[2] J. GARAIZAR,[5] J. URSING,[6] AND T. L. PITT[2]

- Using biotyping, antibiogram, cell envelope profiling, ribotyping, AFLP
- Isolates from Belgium, Rep. Ireland, Netherlands, Sweden, Denmark (1978-1990)
- Outbreak strains were more MDR than non-outbreak strains
- Nearly all outbreak strains were resistant to gentamicin (bottleneck 1?)
- Outbreaks strains clustered in two groups that were termed

European clone I and clone II

Identification of European clone III

Table 1
Overview of the 50 strains under study with typing data, antimicrobial susceptibility and geographic origin

Strain code	Other code	Ribo-type	AFLP	PFGE	Com-bined	SIT	CIP	P/T	CTR	CAZ	IMI	GEN	AMIK	COT	City, country
18A418	LUH 6040	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	64	> 8	Barcelona, SP
18A410	LUH 6039	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	> 64	> 8	Barcelona, SP
18A518	LUH 6041	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	> 64	> 8	Barcelona, SP
18C075	LUH 6043	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	4	4	Barcelona, SP
18C103	LUH 6044	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	> 64	> 8	Barcelona, SP
18C144	LUH 6045	2	1	1	1	4	> 16	> 128	> 64	> 64	> 16	> 32	4	8	Barcelona, SP
18C132	LUH 5865	2	1	1	1	2	> 16	> 128	> 64	> 64	> 16	> 32	2	8	Barcelona, SP
09A242	LUH 6011	2	2	6	2	0.5	> 16	32	> 64	> 64	1	16	16	4	Athens, GR
18A350	LUH 6038	2	3	1	3	2	> 16	> 128	> 64	> 64	> 16	> 32	> 64	8	Barcelona, SP
17C003	LUH 6034	2	3	1	3	2	> 16	> 128	> 64	> 64	> 16	> 32	> 64	> 8	Madrid, SP
36D042	LUH 6051	2	4	5	6	0.12	2	16	> 64	16	0.5	> 32	64	2	Pretoria, SA
15A250	LUH 6023	2	4	5	6	1	> 16	128	> 64	64	1	8	4	> 8	Coimbra, PT
16E057	LUH 6033	2	4	2	4	2	> 16	64	> 64	32	2	> 32	> 64	> 8	Sevilla, SP
16E027	LUH 6032	2	4	2	4	4	> 16	> 128	> 64	64	8	> 32	> 64	> 8	Sevilla, SP
16C085	LUH 6027	2	4	2	4	2	> 16	128	> 64	32	2	> 32	> 64	> 8	Sevilla, SP
16A502	LUH 6024	2	4	3	5	2	> 16	64	> 64	32	2	> 32	> 64	> 8	Sevilla, SP
16C024	LUH 6026	2	4	2	4	2	> 16	64	> 64	32	1	> 32	> 64	> 8	Sevilla, SP
16A528	LUH 6025	2	4	3	5	4	> 16	64	> 64	32	2	> 32	> 64	> 8	Sevilla, SP
16D086	LUH 6031	2	4	2	4	2	> 16	> 128	> 64	64	2	> 32	> 64	> 8	Sevilla, SP
06A102	LUH 5868	2	4	9	7	2	> 16	16	> 64	> 64	8	> 32	64	> 8	Lille, FR
16D042	LUH 6029	2	4	3	5	2	> 16	> 128	> 64	32	2	> 32	> 64	0.25	Sevilla, SP
22D035	LUH 6049	2	5	4	8	0.06	0.5	> 128	> 64	> 64	1	> 32	4	> 8	Ankara, TK
RUH 134	RUH 134	2	5	8	10	–	–	–	–	–	–	–	–	–	Clone II ref.
14C003	LUH 6021	2	5	7	9	2	> 16	32	64	16	1	> 32	> 64	> 8	Krakow, PO
10C070	LUH 6012	3	6	10	11	2	> 16	16	64	16	0.5	> 32	> 64	> 8	Genoa, IT
18D047	LUH 6048	3	7	12	12	2	> 16	> 128	> 64	16	8	> 32	> 64	> 8	Barcelona, SP
06A201	LUH 5874	3	8	10	13	2	> 16	4	32	32	0.5	> 32	32	> 8	Lille, FR
12A133	LUH 5875	3	8	10	13	4	> 16	> 128	> 64	32	1	> 32	> 64	> 8	Utrecht, NL
04C048	LUH 6009	3	8	10	13	2	> 16	4	> 64	16	0.5	> 32	> 64	2	Paris, FR
06A225	LUH 6010	3	8	10	13	8	> 16	0.12	32	16	1	> 32	> 64	> 8	Lille, FR
16D025	LUH 6028	3	8	10	13	2	> 16	64	> 64	32	1	> 32	> 64	> 8	Sevilla, SP
12A126	LUH 6020	3	8	10	13	2	> 16	> 128	> 64	32	1	> 32	64	> 8	Utrecht, NL
18A155	LUH 6037	3	8	10	13	4	> 16	64	> 64	32	2	> 32	64	> 8	Barcelona, SP
18D001	LUH 6046	3	8	10	13	4	> 16	32	64	32	0.5	> 32	64	> 8	Barcelona, SP
18C005	LUH 6042	3	8	10	13	2	> 16	32	> 64	16	1	> 32	64	> 8	Barcelona, SP
18A025	LUH 6036	3	8	10	13	2	> 16	64	> 64	32	1	> 32	64	> 8	Barcelona, SP
17C085	LUH 6035	3	8	10	13	4	> 16	> 128	> 64	> 64	> 16	> 32	> 64	> 8	Madrid, SP
18D017	LUH 6047	3	8	10	13	2	> 16	64	> 64	16	1	> 32	64	> 8	Barcelona, SP
16D083	LUH 6030	3	8	11	14	2	> 16	> 128	32	8	8	> 32	64	4	Sevilla, SP
17C078	LUH 5881	1	9	13	22	2	> 16	16	32	32	0.25	> 32	32	> 8	Madrid, SP
36C058	LUH 6050	1	9	14	23	2	> 16	0.06	64	32	0.5	> 32	2	> 8	Pretoria, SA
11C096	LUH 6017	1	10	17	17	2	> 16	128	> 64	> 64	1	> 32	> 64	> 8	Rome, IT
11E057	LUH 6019	1	10	15	15	2	> 16	16	> 64	> 64	0.5	> 32	2	> 8	Rome, IT
11A221	LUH 6014	1	10	16	16	2	> 16	> 128	> 64	> 64	2	> 32	> 64	> 8	Rome, IT
11A352	LUH 6015	1	10	16	16	2	> 16	16	> 64	> 64	0.25	> 32	2	> 8	Rome, IT
11D078	LUH 6018	1	10	17	17	2	> 16	> 128	> 64	> 64	1	> 32	> 64	> 8	Rome, IT
RUH 875	RUH 875	1	11	18	18	–	–	–	–	–	–	–	–	–	Clone I ref.
11 COOS	LUH 6016	1	12	19	19	2	> 16	> 128	> 64	> 64	8	> 32	> 64	> 8	Rome, IT
11A018	LUH 6013	1	13	16	20	4	> 16	64	> 64	> 64	2	> 32	> 64	8	Rome, IT
14C052	LUH 6022	1	14	20	21	2	> 16	32	64	16	0.12	> 32	> 64	> 8	Krakow, PO

SIT, sitafloxacin; CIP, ciprofloxacin; P/T, piperacillin-tazobactam; CTR, ceftriaxone; CAZ, ceftazidime; IMI, imipenem; GEN, gentamicin; AMIK, amikacin; COT, trimethoprim-sulfamethoxazole. The susceptibility data of reference strains RUH 134 and RUH 875 were not determined using the same methods and they are therefore not presented here.

II

III

I

EU clones I-III:

gentamicin resistance

ciprofloxacin resistance (bottleneck 2?)

Beginning to see emergence of carbapenem resistance (bottleneck 3?)

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Research in Microbiology 155 (2004) 105–112

Research in Microbiology

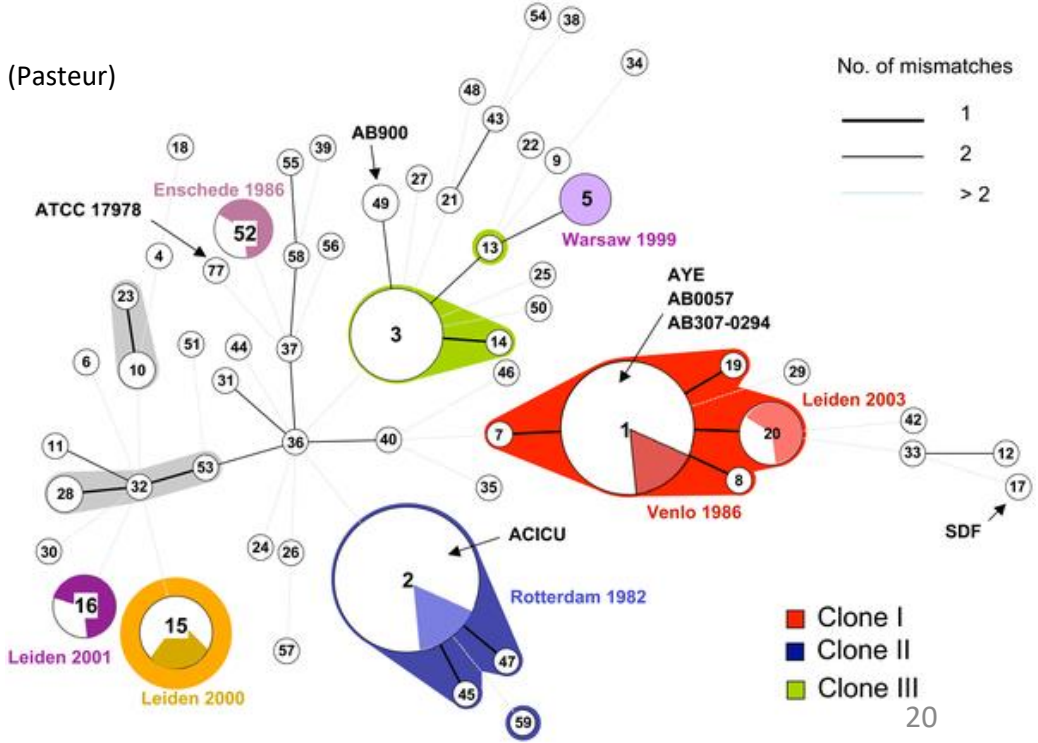
www.elsevier.com/locate/resmic

Identification of a new geographically widespread multiresistant *Acinetobacter baumannii* clone from European hospitals

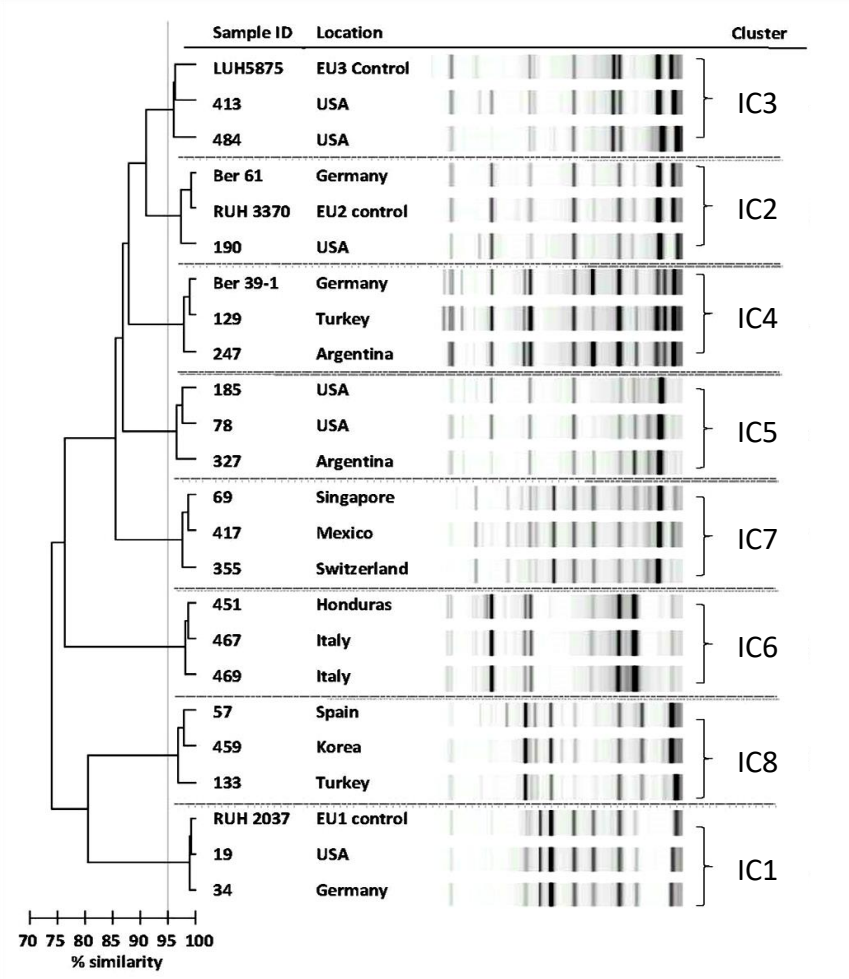
Helke van Dessel [a], Lenie Dijkshoorn [b], Tanny van der Reijden [b], Nancy Bakker [b], Armand Paauw [a], Peterhans van den Broek [b], Jan Verhoef [a], Sylvain Brisse [a]

- In 2005 typing became portable
  - Bartual SG et al. 2005. J. Clin. Microbiol. 43: 4382-4390 (Oxford)
- Second MLST scheme
  - Nemec A et al. 2008. J. Antimicrob. Chemother. 62: 484-489 (Pasteur)
  - Diancourt L et al. 2010. PLoS One Apr 7;5(4):e10034
    - First use of the term "international clone"
    - IC1-3 and ST15 were more resistant than other STs

"…..A. baumannii is a genetically compact species that suffered a severe bottleneck in the recent past, possibly linked to a restricted ecological niche."



DiversiLab fingerprints



CRAb isolates 2004-2006 (n = 492)

IC1, IC2, IC3 correspond to EUI, EUII, EUIII

Evidence for a further 5 ICs

Higgins et al. 2010. J. Antimicrob. Chemother.

Intercontinental clones

Epidemiological group	No. of centres	No. of isolates	Country of origin
IC1	17	44	AR, BG, CH, DE, ES, GR, IN, IT, PK, PL, PR, SG, US
IC2	75	241	AU, AT, CN, DE, ES, GR, IE, IL, IT, KR, PK, PT, SG, TW, UK, US, ZA
IC3	14	23	ES, US, ZA
IC4	11	27	AR, CL, DE, HU, IN, PL, TR
IC5	26	80	AR, CO, DE, ES, MX, US, VE
IC6	2	12	HN, IT
IC7	8	13	AR, BG, CH, CO, MX, SG, VE
IC8	4	9	BG, ES, FR, TR
Unrelated	28	43	AR, AU, BG, BR, CL, CO, ES, IN, IT, MX, PL, SG, TW, US, VE
Total	185	492	

AR, Argentina; AT, Austria; AU, Australia; BG, Bulgaria; BR, Brazil; CH, Switzerland; CL, Chile; CN, China; CO, Columbia; DE, Germany; ES, Spain; FR, France; GR, Greece; HN, Honduras; HU, Hungary; IE, Ireland; IL, Israel; IN, India; IT, Italy; KR, South Korea; MX, Mexico; PK, Pakistan; PL, Poland; PR, Puerto Rico; PT, Portugal; SG, Singapore; TR, Turkey; TW, Taiwan; UK, United Kingdom; US, United States; VE, Venezuela; ZA, South Africa

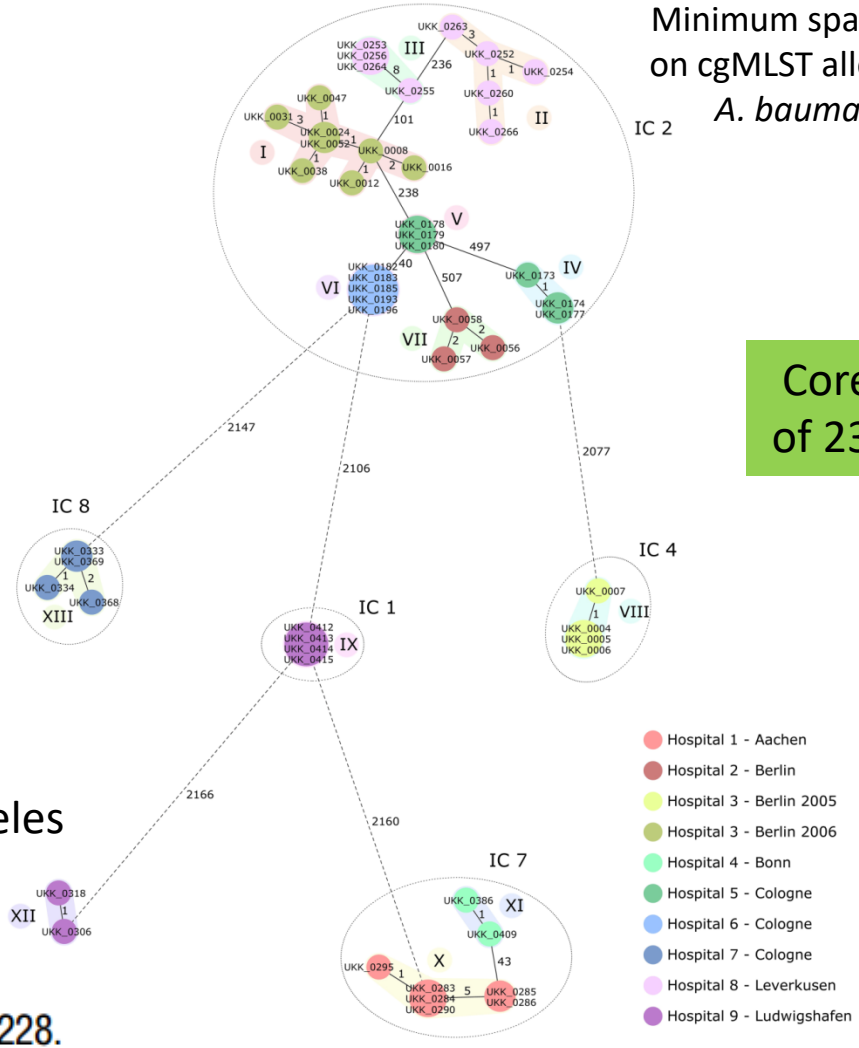
Europe
Australia
S. Africa
Middle East
Far East
Asia
USA

American

Typing in the genomic era

- repPCR no longer used
- MLST uses 7 partial alleles
- cgMLST using thousands of full alleles
- Higher resolution

Minimum spanning tree based on cgMLST allelic profiles of 53 *A. baumannii* isolates.



Core genome of 2390 alleles

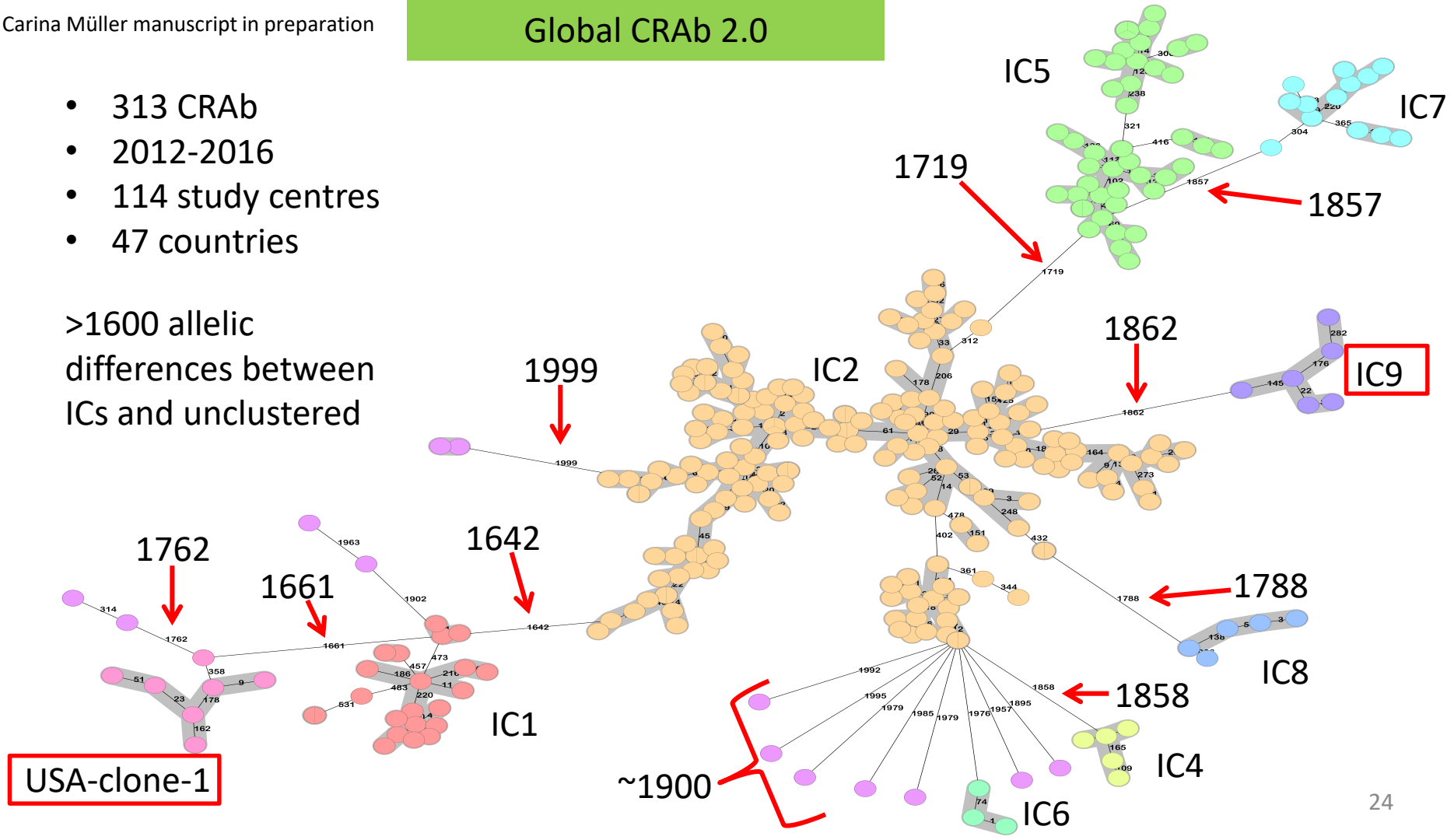
PLoS ONE 12(6): e0179228.

Carina Müller manuscript in preparation

Global CRAb 2.0

- 313 CRAb
- 2012-2016
- 114 study centres
- 47 countries

>1600 allelic differences between ICs and unclustered



cgMLST CRAb 2012-2016 (n = 313)

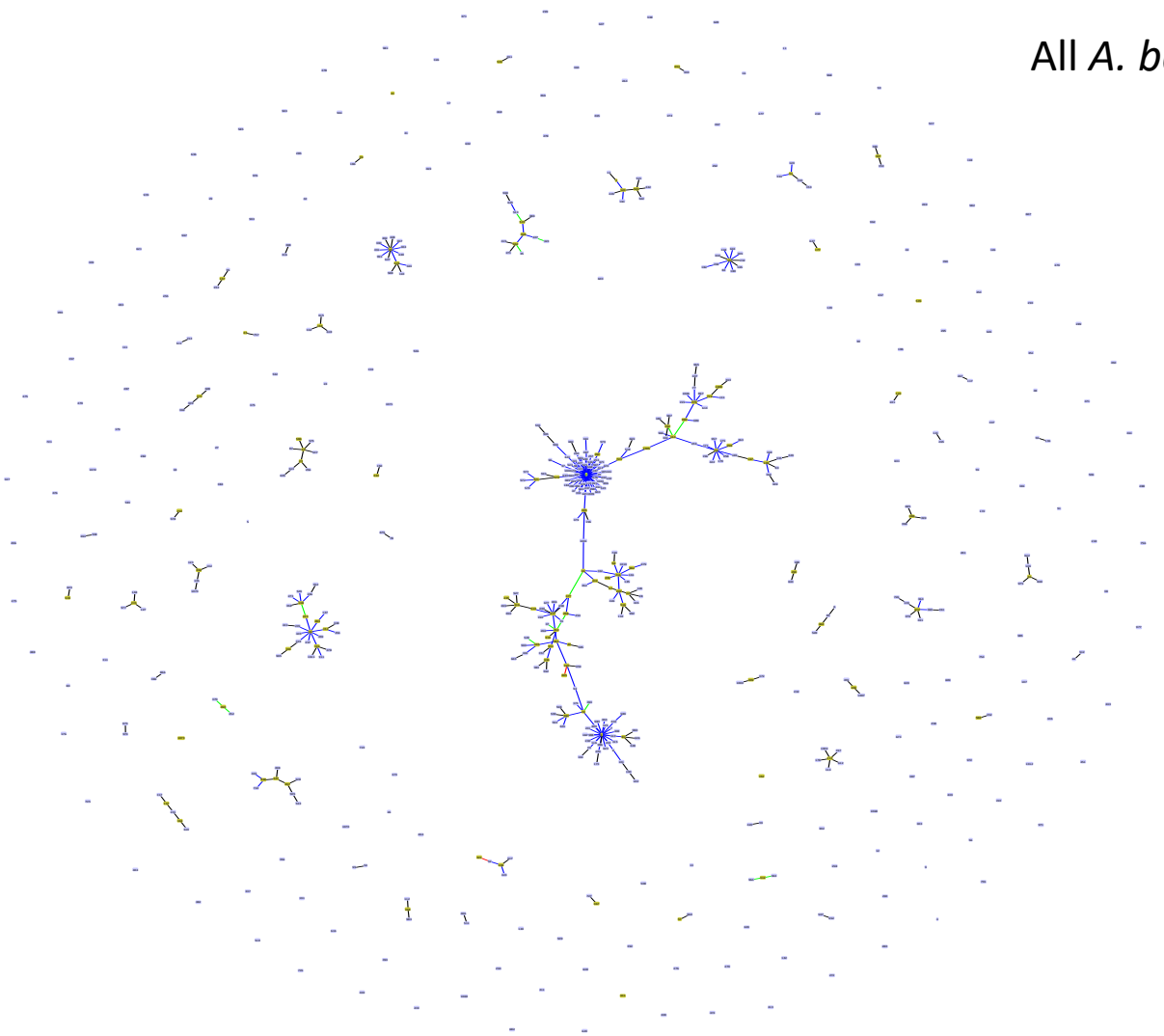
IC2 most prevalent except in Latin America

Region (no. of study centres)	IC1	IC2	IC3	IC4	IC5	IC6	IC7	IC8	IC9	no IC
Africa (6)	1	23					1	2	1	1
Asia and Middle East (15)	2	74					2	2	3	5
Europe (56)	5	54	1		1			1	2	3
Latin America (15)	9	8		4	41	3	8			3
North America (22)	9	37	1	1	2		1			2
ALL (113)	**26**	**196**	**2**	**5**	**44**	**3**	**12**	**5**	**6**	**14**

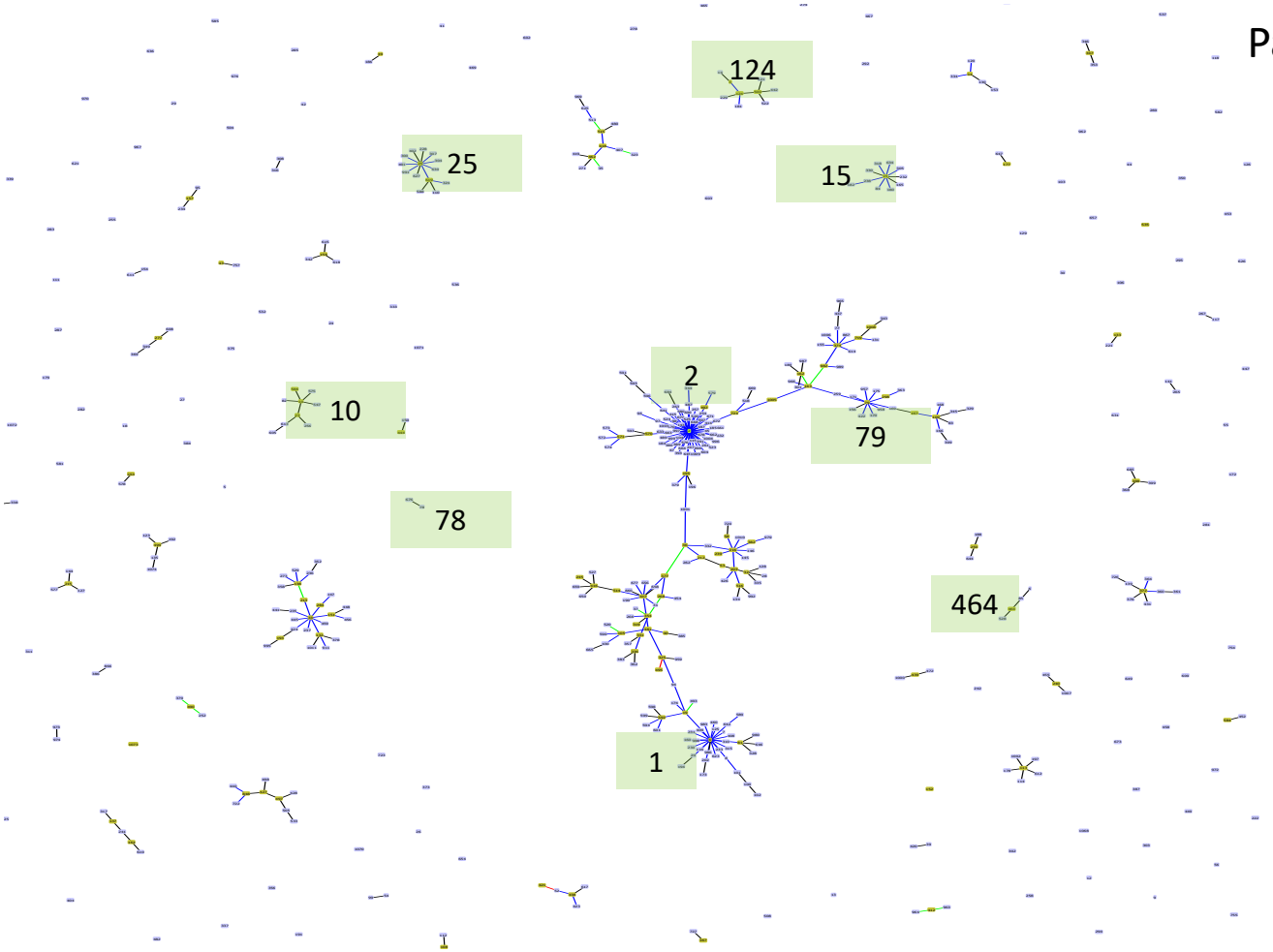
Open questions

- So far it is all clinical isolates, what about from other sources?
- Are there more than 9 IC‘s?
- Is antibiotic resistance only found in the the hospital?

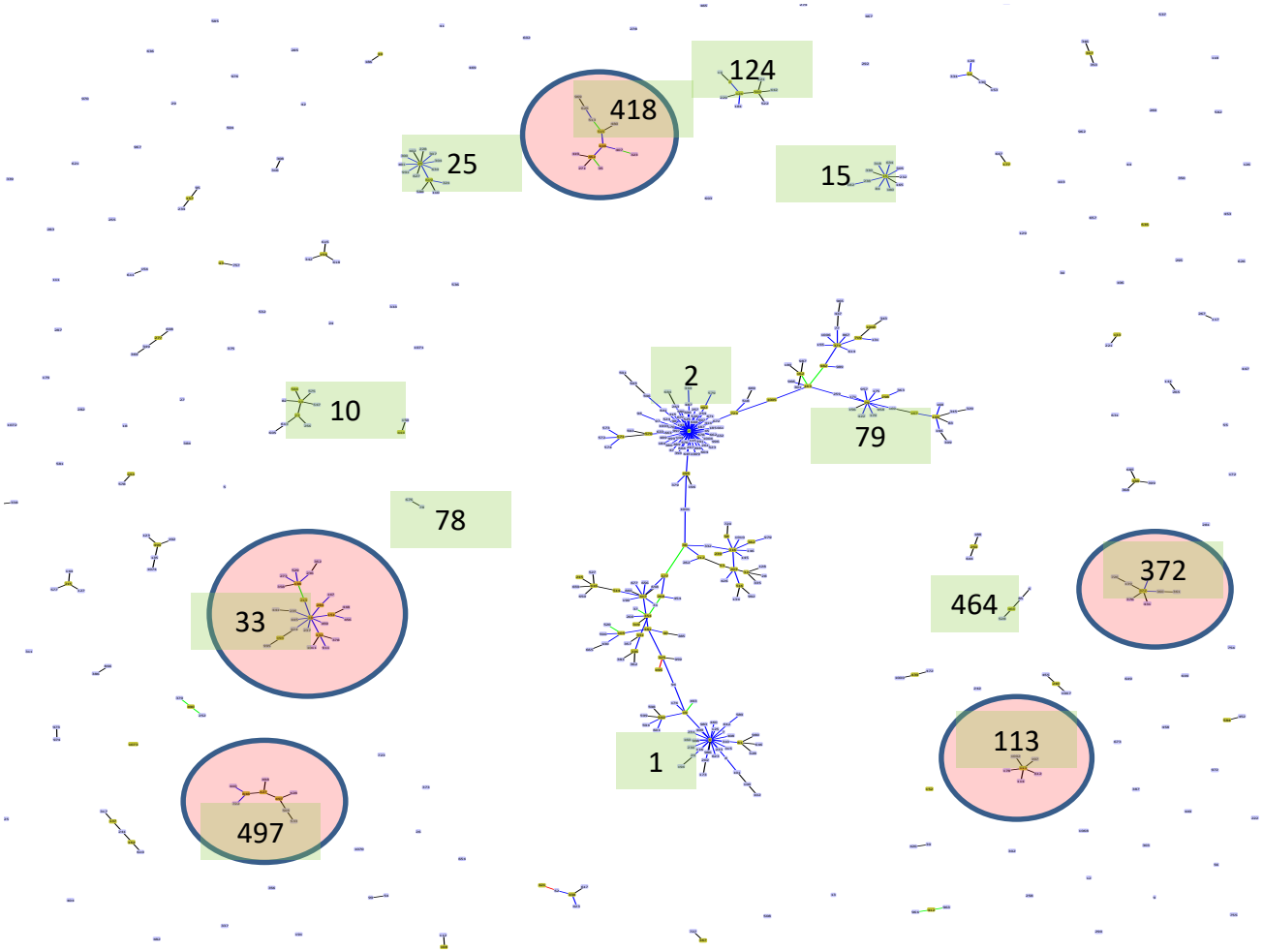
All *A. baumannii* Pasteur STs



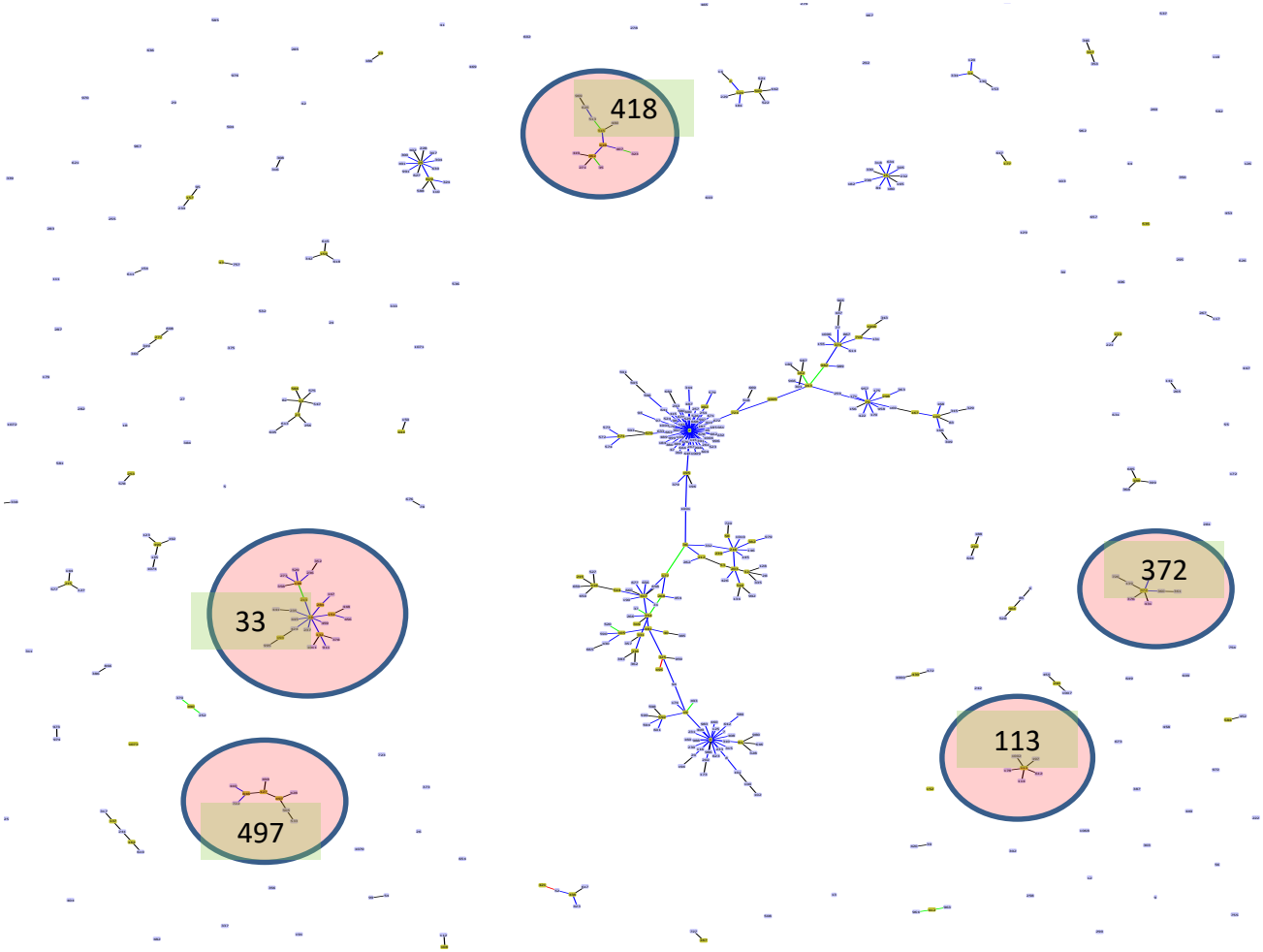
Pasteur MLST and IC1-9



IC1	CC1
IC2	CC2
IC3	CC124
IC4	CC15
IC5	CC79
IC6	CC78
IC7	CC25
IC8	CC10
IC9	CC464



Pasteur MLST and 5 other putative ICs



Pasteur MLST and 5 other putative ICs

CC33: USA, Japan, Germany (**Goose**), Poland, Switzerland (**calf, chicken**), Australia, Bolivia

CC418: Czechia, Spain, Iran, Iraq, Germany, USA, Lebanon, France (**animal**), Nepal, Tanzania

CC497: USA, Japan, Taiwan

CC113: China, USA, Brazil, Kuwait, Saudi Arabia, Colombia

CC372: Taiwan, Spain, Croatia, Switzerland (**chicken**)

A. baumannii from animals

- Companion
- Livestock
- Wild

Companion animals

International Journal of Antimicrobial Agents 49 (2017) 37–44

Contents lists available at ScienceDirect

International Journal of Antimicrobial Agents

journal homepage: www.elsevier.com/locate/ijantimicag

OXA-23 and IS*Aba1*–OXA-66 class D β-lactamases in *Acinetobacter baumannii* isolates from companion animals

Christa Ewers [a,*], Peter Klotz [a], Ursula Leidner [a], Ivonne Stamm [b], Ellen Prenger-Berninghoff [a], Stephan Göttig [c], Torsten Semmler [d], Sandra Scheufen [a]

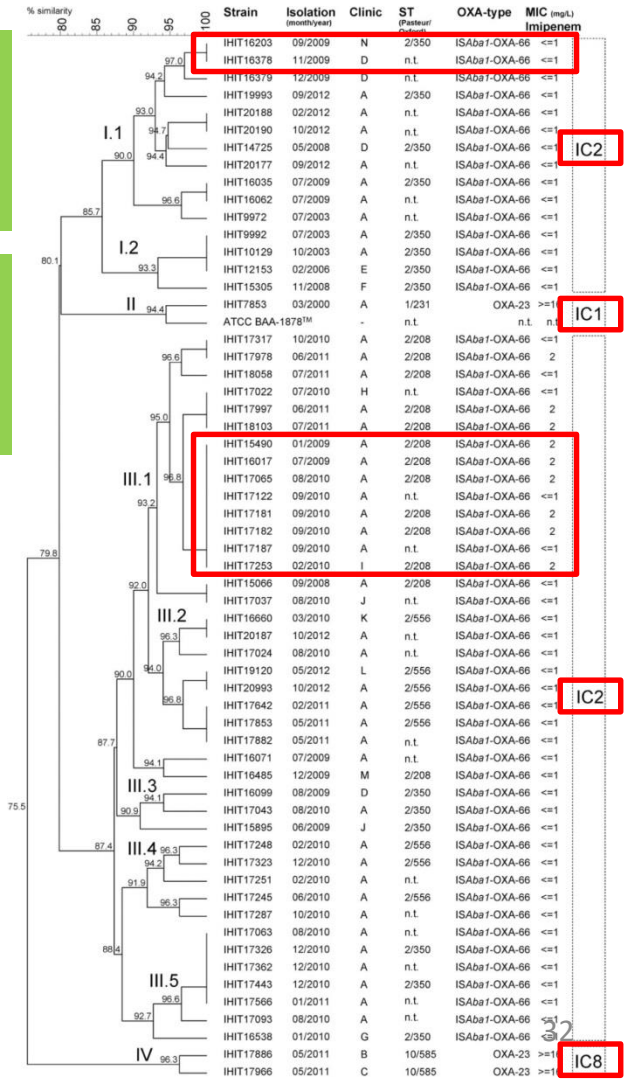
Source	Number	Antibiotic resistance
Dogs	168	43 IS*Aba1*-OXA-51-like* 2 x OXA-23
Cats	42	15 IS*Aba1*-OXA-51-like* 1 x OXA-23
Rabbit, ferret, snake, rat, duck	13	

*Growth on MEM ≥ 2-4mg/l

PFGE suggests spread of clones within and between veterinary clinics

MLST data identifies IC1, IC2, IC8 human (hospital) associated isolates

Elevated MEM MIC's associated with resistance to:
SXT
CTX
PIP
TZP
LEV
CIP
GEN
TET
TGC



Wild animals

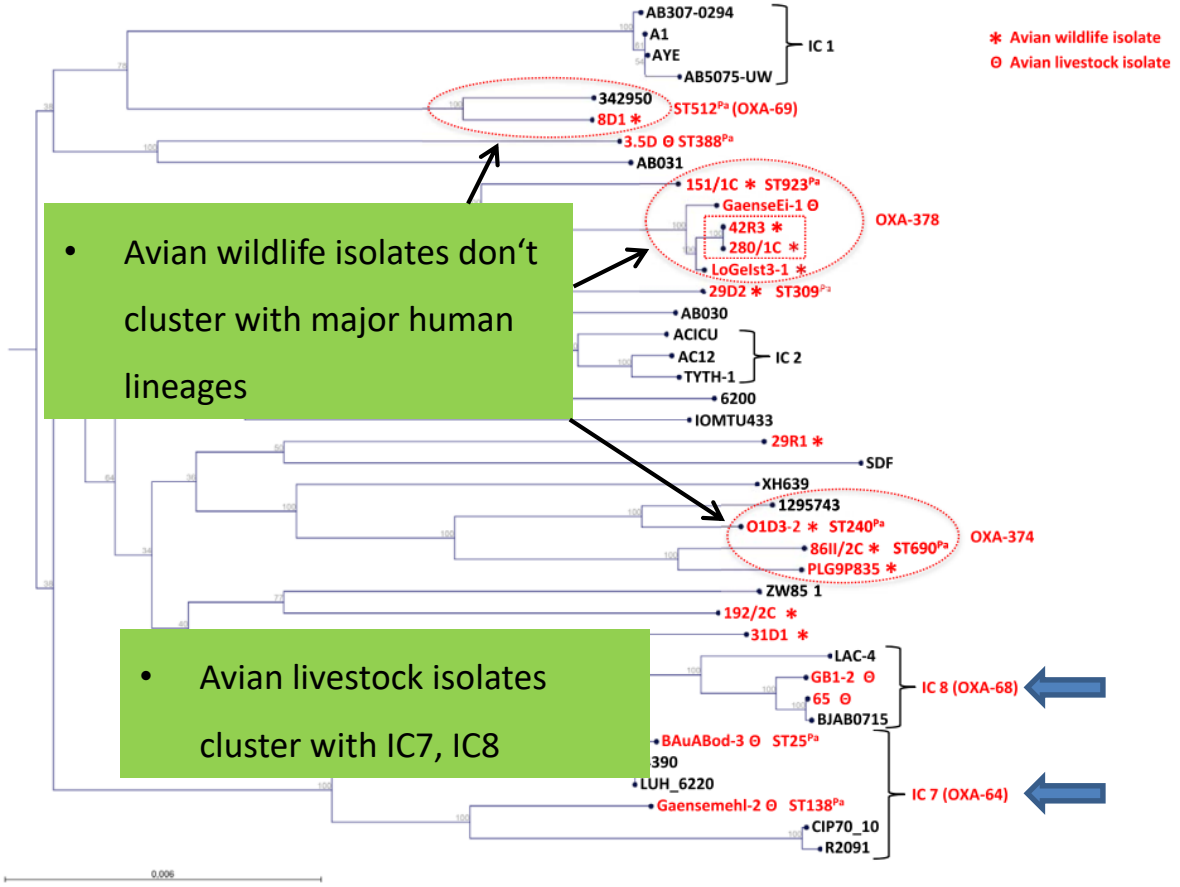
Environmental Microbiology (2017) 19(10), 4349–4364 doi:10.1111/1462-2920.1

Relatedness of wildlife and livestock avian isolates of the nosocomial pathogen *Acinetobacter baumanni* to lineages spread in hospitals worldwide

Wilharm G, et al

Source	Number	Antibiotic resistance
Chicken	6	Kan/Gen (2)
Geese	3	Kan-intermediate /sulfamerazine-R (1)
Stork nestlings	212	0

Colonisation of storks is transient
A. baumannii probably comes their food



- Avian wildlife isolates don‘t cluster with major human lineages
- Avian livestock isolates cluster with IC7, IC8

Fig. 4. Core genome-based phylogeny reveals the high diversity of avian isolates. Maximum likelihood tree based on 2181 orthologous genes present in all 40 *A. baumannii* strains included. Wildlife avian isolates are flagged with an asterisk (★), livestock-associated avian isolates are labelled with a theta (Θ); designation of all avian isolates in red. Strains representing international clones IC1, IC2, IC7 and IC8 are marked with brackets. The *scale* indicates substitutions per site. The red dashed ovals indicate clades outside of the IC nomenclature which include avian isolates. The red dashed box indicates two isolates from white stork nestlings recovered from neighbouring villages in consecutive years. Multilocus sequence types and OXA-types are indicated for isolates discussed in the main text.

frontiers in Microbiology
ORIGINAL RESEARCH
published: 22 February 2019
doi: 10.3389/fmicb.2019.00272

Cattle

Seasonal Occurrence and Carbapenem Susceptibility of Bovine *Acinetobacter baumannii* in Germany

Klotz P, et al

Linked to use of sewage sludge as fertiliser

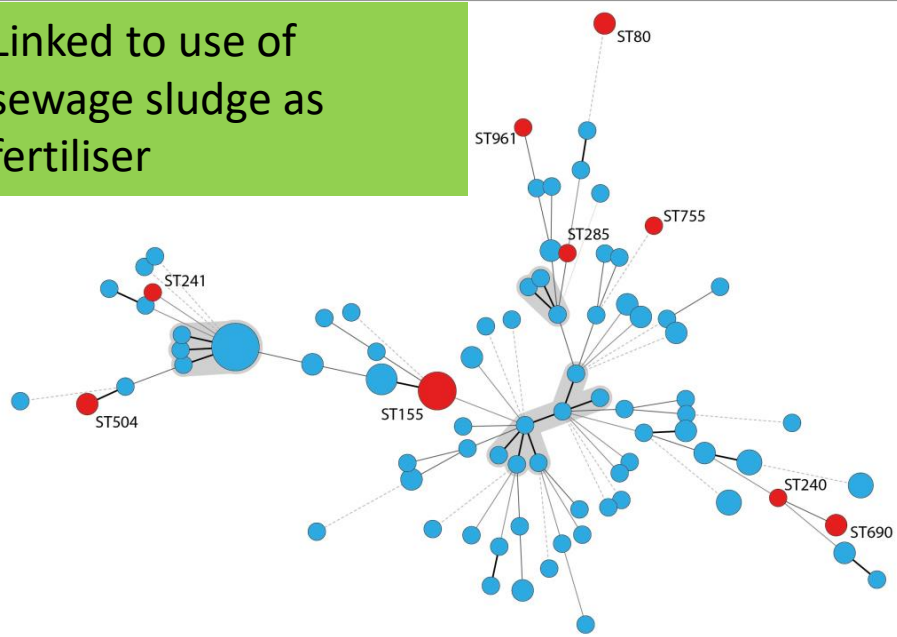


FIGURE 2 | Minimum spanning tree of 126 *A. baumannii* cattle field isolates. STs that have been previously found in human samples are labeled with the ST number and circles indicating the STs are marked in red; clonal complexes are shaded gray; thick lines: single locus variant, thin lines: double locus variant, dashed line: multiple locus variants.

- 422 cattle screened
- 126 (15.6%) harboured *A. baumannii*
  - 60.3% nose
- 19 x IC2, 16 x IC3
- Peak occurance between May and August
- All 126 *A. baumannii* isolates showed resistance against ampicillin, amoxicillin-clavulanic acid, cefalexin, ceftiofur, nitrofurantoin and chloramphenicol, intermediate resistance was determined for piperacillin (6%) and rifampicin (25%)
- All isolates were susceptible to aminoglycosides, fluoroquinolones, polymyxin B and carbapenems

Wild type

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Comparative Immunology, Microbiology and Infectious Diseases

Volume 70, June 2020, 101451

Drug resistance and virulence traits of *Acinetobacter baumannii* from Turkey and chicken raw meat

Manal Hadi Ghaffoori Kanaan [a], Shahrazad M.J. Al-Shadeedi [b], Aseel Jameel Al-Massody [c], Abdolmajid Ghasemian [d]

High proportion of isolates carried *tetA*, *tetB*, *dfrA*, $bla_{\text{oxa-51-like}}$, $bla_{\text{oxa-23-like}}$, $bla_{\text{oxa-24-like}}$, $bla_{\text{oxa-58-like}}$, *sul1*, *fosA3,* and *mcr*-1 genes

Not all isolates had OXA-51, probably not *A. baumannii*

Virulent Epidemic Pneumonia in Sheep Caused by the Human Pathogen *Acinetobacter baumannii*

Bodo Linz[1,2†], Nadia Mukhtar[3†], Muhammad Zubair Shabbir[3], Israel Rivera[1,2], Yury V. Ivanov[1‡], Zarfishan Tahir[3], Tahir Yaqub[3] and Eric T. Harvill[1,2*]*

frontiers in Microbiology

- 4-month outbreak of respiratory disease among Kajli sheep, Khizarabad, Pakistan
- 473/1200 animals died within 3 days of symptoms
- BAL samples identified *A. baumannii*
- Typing revealed the isolate was IC2
- Carried multiple antibiotic resistance genes
- Human-sheep transfer?

ELSEVIER

Science of The Total Environment

Volume 726, 15 July 2020, 138232

Healthcare-associated carbapenem-resistant OXA-72-producing *Acinetobacter baumannii* of the clonal complex CC79 (IC5) colonizing migratory and captive aquatic birds in a Brazilian Zoo

Ana Clara Narciso [a], Willames M.B.S. Martins [a], Luiz G.P. Almeida [b], Rodrigo Cayô [a, c], Stéfanie Vanessa Santos [a], Patrícia Locosque Ramos [d], Nilton Lincopan [e], Ana Tereza R. Vasconcelos [b], Ana Cristina Gales [a]

https://www.frontiersin.org/articles/10.3389/fmicb.2018.02616/full

Other studies

- Germany: cats, dogs, horse: carbapenem-susceptible
- IC2 often isolated
- Gentamicin resistance not universal but IC clones were FQ^R

Zordan et al. 2011. EID

- Switzerland: cats, dogs, horses: carbapenem-susceptible
- IC1 and IC2
- Mostly gentamicin and/or ciprofloxacin resistant

Endimiani et al. 2011; JAC

- Switzerland: commercial raw meat: poultry most contaminated, carbapenem-susceptible
- Genetically diverse, a few CC79 (IC5)
- MDR rare

Lupo et al. 2014. J. Food. Protect

- Lebanon: water, food, animals: cows were a good source, carbapenem-susceptible
- Genetically diverse; only 4/42 IC1, IC3 or IC8
- Susceptible to most antibiotics. One CIP^R
- *Rafei et al*. 2015. App. Environ. Microbiol

- Japan: cats and dogs. Low-level gentamicin and ciprofloxacin resistance. A few ST25 (IC7)

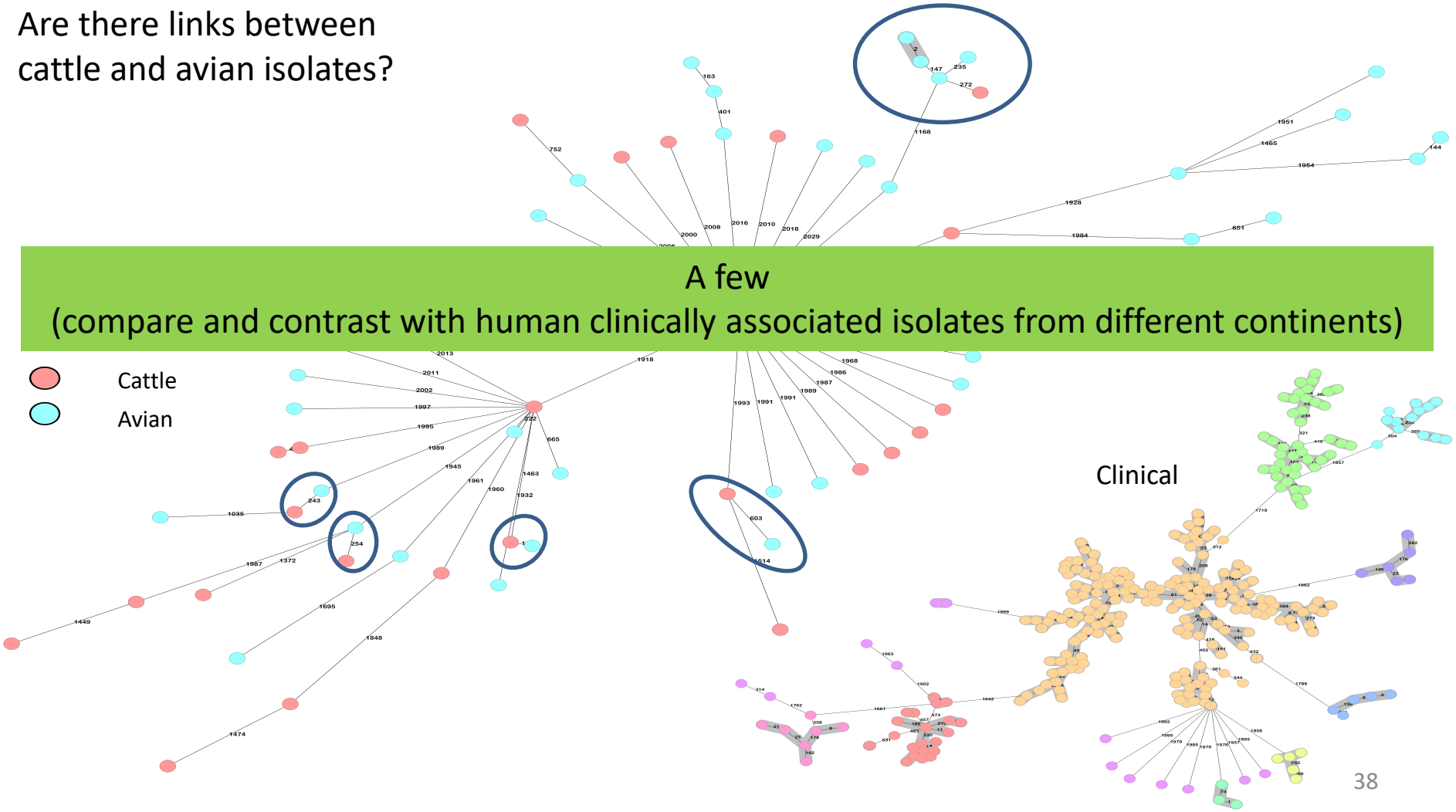
Kimura et al. 2018. Microbiol Immunol

Acinetobacter baumannii: Its Clinical Significance in Human and Veterinary Medicine

Paola Nocera et al. 2021. Pathogens

Are there links between cattle and avian isolates?

A few
(compare and contrast with human clinically associated isolates from different continents)

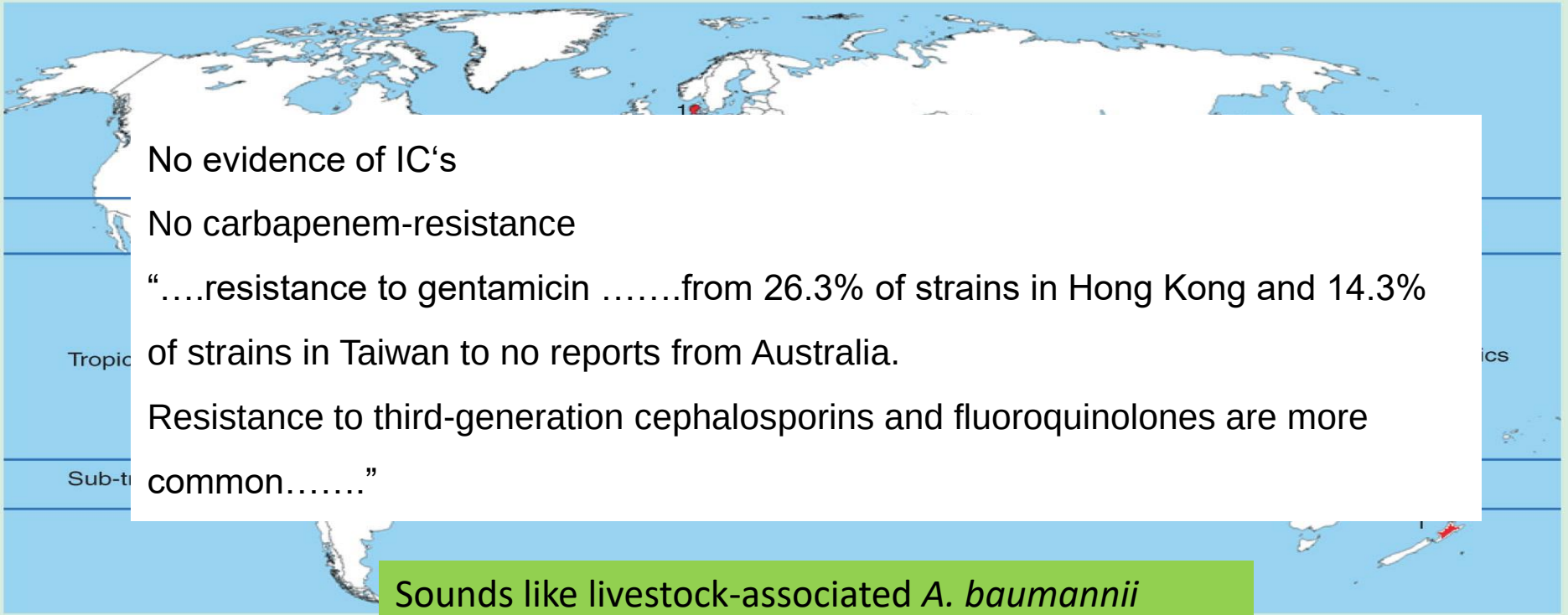


Community-acquired *A. baumannii*

Community-acquired *A. baumannii*

- Community acquired *A. baumannii* is mainly found in tropical areas
- Mortality can be as high as 64%
- Host prediposing factors or bacterial characteristics
- Characterised by fever (often rapid onset), severe respiritory symptoms and multi-organ disfunction

Regions that have reported cases of CA-Ab infections, numbers denote the number of cases reported per region



No evidence of IC‘s

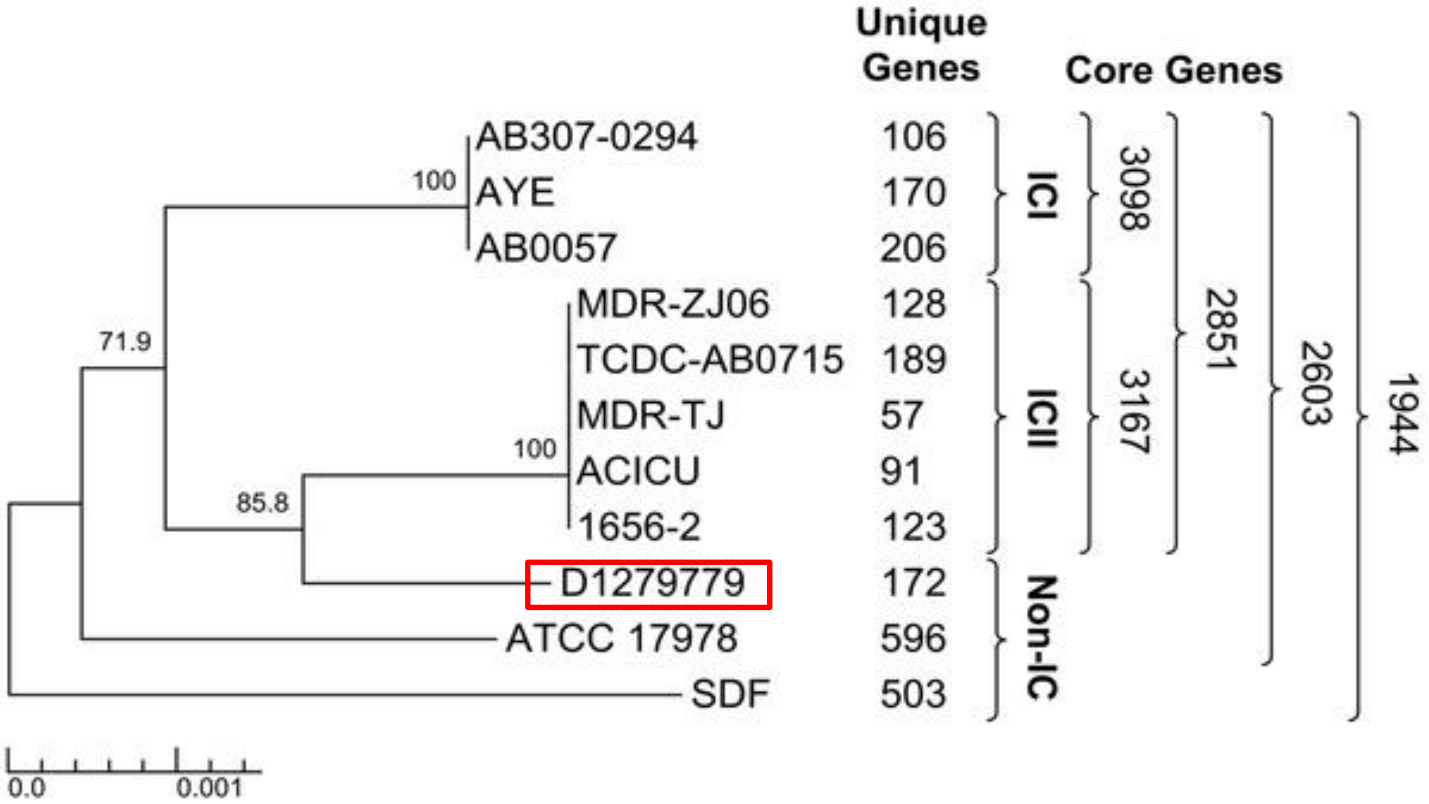
No carbapenem-resistance

“….resistance to gentamicin …….from 26.3% of strains in Hong Kong and 14.3% of strains in Taiwan to no reports from Australia.

Resistance to third-generation cephalosporins and fluoroquinolones are more common…….”

Sounds like livestock-associated *A. baumannii*

Community-acquired *Acinetobacter baumannii*: clinical characteristics, epidemiology and pathogenesis
Carina Dexter et al. Expert Review of Anti-infective Therapy. Volume 13, 2015 - Issue 5



"The phylogenetic relationship of D1279779 to other *A. baumannii* strains was also consistent with the notion that **community-acquired isolates are epidemiologically distinct** from nosocomial isolates"

- No resistance island

Farrugia DN, Elbourne LDH, Hassan KA, Eijkelkamp BA, Tetu SG, et al. (2013) The Complete Genome and Phenome of a Community-Acquired Acinetobacter baumannii. PLOS ONE 8(3): e58628. https://doi.org/10.1371/journal.pone.0058628
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0058628

TABLE 1. ***In vitro*** **susceptibility of the 32 isolates to 11 antimicrobial agents tested.**

Antimicrobial agent	MIC (mg/L) Range	50%	90%	Susceptible rate (%)
Sulbactam	0.03–16	0.25	16	–*
Meropenem	0.03–32	0.03	8	87.5
Imipenem	0.03–16	0.0625	16	65.625
Cefepime	0.03–128	1	16	59.375
Ceftazidime	0.03–128	2	64	50
Aztreonam	0.03–512	8	64	21.875
Piperacillin-tazobactam	0.03–128	8	8	50
Minocycline	0.03–1	0.03	0.25	100
Polymyxins	0.03–0.03	0.03	0.03	100
Ofloxacin	0.03–128	0.03	64	46.875
Amikacin	0.03–512	0.0625	512	53.125

*The breakpoints were not defined by the Clinical and Laboratory Standards Institute.

"….. results suggest that the epidemiology of *A. baumannii* from the **community** is of multiclonal origins**, different** from those in **hospital** settings."

Peng et al. Clin Microbiol Infect 2012;18:E491–E493

Taiwan

Chen et al **Journal of Microbiology, Immunology and Infection** Volume 51, Issue 5, 2018, Pages 629-635

Multidrug resistance rates were **higher in nosocomial** *A. baumannii* isolates than in those acquired in the community (81.5% vs 38.9%,p ≤ 0.002)

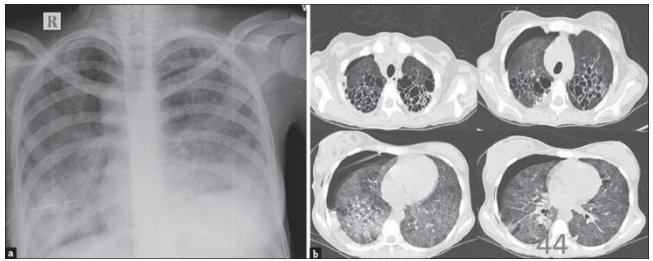
India

Case Report

Pneumothorax in a Case of Community-acquired Pneumonia Due to *Acinetobacter*

Ghewade B, et al. J Assoc Chest Physicians 2017;5:83-6.

- The isolate was sensitive to imipenem and resistant to amikacin



MICROBIAL GENOMICS

RESEARCH ARTICLE

Meumann *et al.*, *Microbial Genomics* 2019;5

DOI 10.1099/mgen.0.000258

MICROBIOLOGY SOCIETY

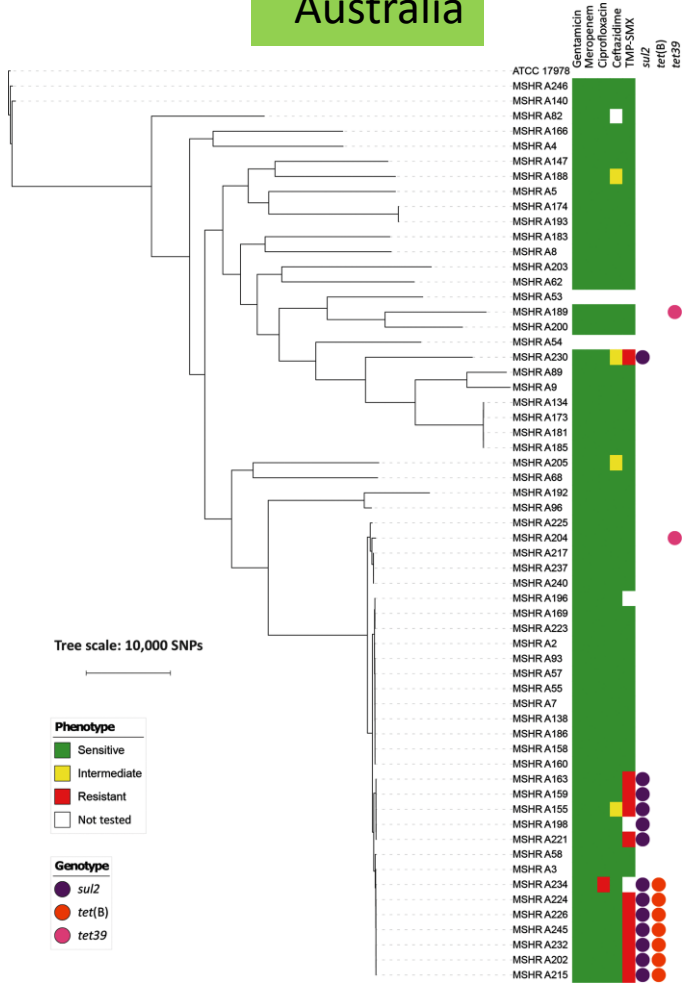
OPEN DATA OPEN MICROBIOLOGY

Genomic epidemiology of severe community-onset *Acinetobacter baumannii* infection

Ella M. Meumann,[1,2,*] Nicholas M. Anstey,[1,2] Bart J. Currie,[1,2] Kim A. Piera,[1] Johanna J. Kenyon,[3] Ruth M. Hall,[4] Joshua S. Davis[1,5†] and Derek S. Sarovich[1,6†]

- 41 CAP were investigated
- Pasteur ST-10 (IC8) was the dominant ST (59% of isolates)
- Community-onset isolates are not MDR, but are closely related to MDR clinical isolates

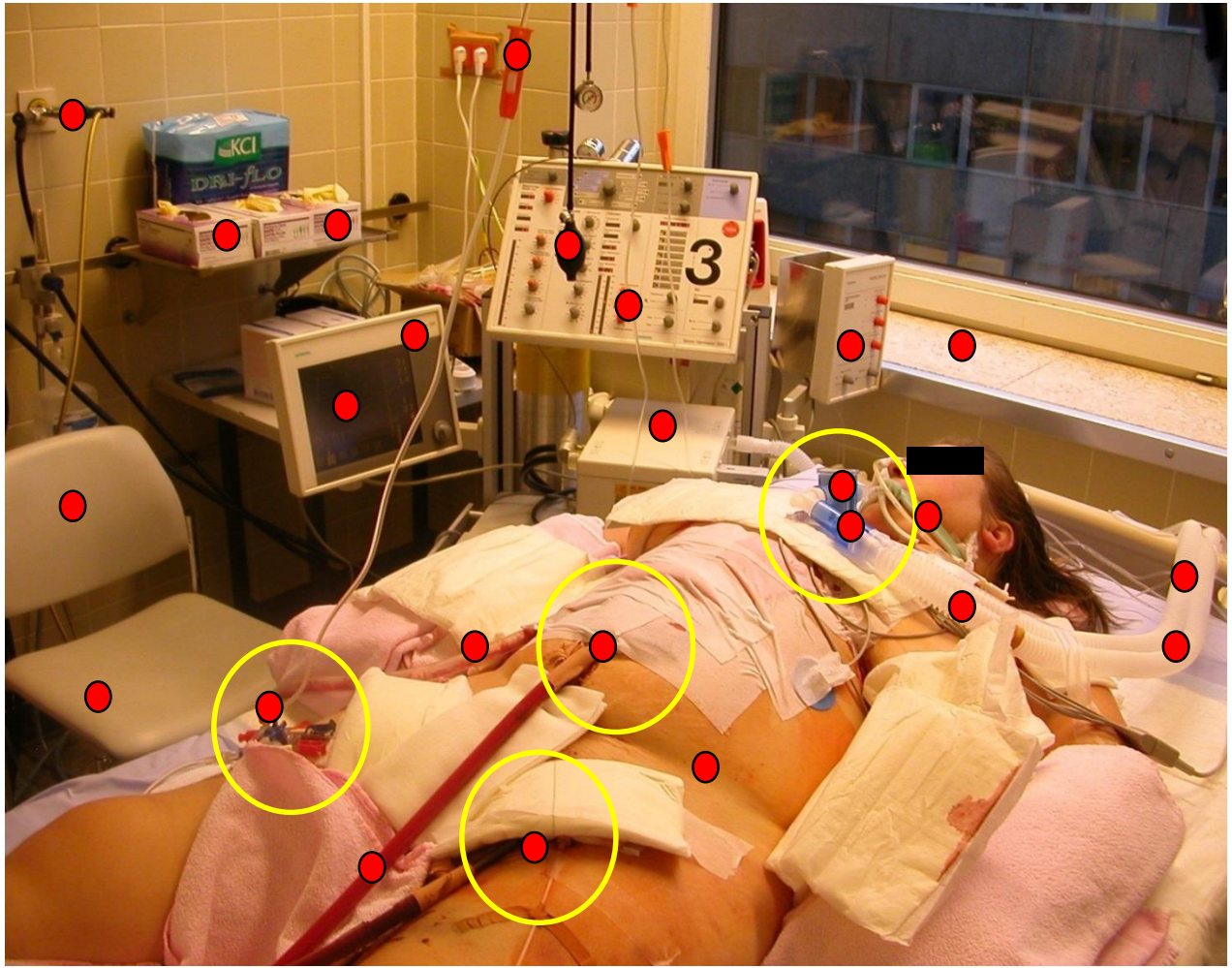
Australia



Phenotypic antimicrobial susceptibilities and antimicrobial resistance genes

Community-acquired *A. baumannii*

- Generally, community-acquired *A. baumannii* isolates do not exhibit antimicrobial resistance, and are mostly unrelated to clinically relevant lineages
- What other differences are there between hospital- and community-acquired *A. baumannii*?



Risk factors in the hospital

- Indwelling catheters
- Contaminated surfaces

Risk factors in the community

- Excess alcohol consumption
- Diabetes
- Smoking
- Chronic lung disease

Different patient groups

A. baumannii from the environment

Most studies look for resistant isolates

ANTIMICROBIAL AGENTS AND CHEMOTHERAPY, Jan. 2010, p. 578–579 Vol. 54, No. 1
0066-4804/10/$12.00 doi:10.1128/AAC.00861-09

Letters to the Editor

First Isolation of the *bla*$_{OXA-23}$ Carbapenemase Gene from an Environmental *Acinetobacter baumannii* Isolate$^{\nabla}$

Girlich D, Poirel L, Nordmann P

A. baumannii B9 was recovered from water of the Seine river in downtown Paris

Where do the isolates come from?

PLOS ONE | www.plosone.org June 2013 | Volume 8 | Issue 6 | e64857

Higher Isolation of NDM-1 Producing *Acinetobacter baumannii* from the Sewage of the Hospitals in Beijing

Chuanfu Zhang[1☯], Shaofu Qiu[1*☯], Yong Wang[1☯], Lihua Qi[1☯], Rongzhang Hao[1☯], Xuelin Liu[1☯], Yun Shi[1☯], Xiaofeng Hu[1☯], Daizhi An[1☯], Zhenjun Li[2☯], Peng Li[1☯], Ligui Wang[1☯], Jiajun Cui[1], Pan Wang[1], Liuyu Huang[1], John D. Klena[3], Hongbin Song[1*]

Recovered from sewage but not after disinfection

Hospital sewage

MICROBIAL DRUG RESISTANCE
Volume 22, Number 7, 2016
© Mary Ann Liebert, Inc.
DOI: 10.1089/mdr.2015.0275

Emergence of Oxacillinases in Environmental Carbapenem-Resistant *Acinetobacter baumannii* Associated with Clinical Isolates

Ivana Goic-Barisic,[1,2] Jasna Hrenovic,[3] Ana Kovacic,[4] and Martina Šeruga Musić[3]

MIC values of antibiotics (mg/L)

Isolate	*MEM*	*IPM*	*LVX*	*CIP*	*TOB*	*GEN*	*AMK*	*SXT*	*CST*	bla$_{OXA}$
IN4	>16^{R}	>16^{R}	>8^{R}	4^{R}	>16^{R}	8^{R}	4	20	0.50	OXA-51, OXA-23
IN10	>16^{R}	>16^{R}	>8^{R}	8^{R}	>16^{R}	>16^{R}	2	16	0.25	OXA-51
IN12	>16^{R}	>16^{R}	>8^{R}	4^{R}	8^{R}	>16^{R}	4	16	0.50	OXA-51, OXA-40
IN18	>16^{R}	>16^{R}	>8^{R}	8^{R}	8^{R}	>16^{R}	4	20	0.50	OXA-51, OXA-23
EF2	>16^{R}	>16^{R}	4^{R}	8^{R}	8^{R}	8^{R}	4	20	0.25	OXA-51, OXA-23
EF6	>16^{R}	>16^{R}	>8^{R}	4^{R}	>16^{R}	>16^{R}	64^{R}	32	0.50	OXA-51

MICROBIAL DRUG RESISTANCE
Volume 17, Number 2, 2011
© Mary Ann Liebert, Inc.
DOI: 10.1089/mdr.2010.0013

Presence of OXA-23-Producing Isolates of *Acinetobacter baumannii* in Wastewater from Hospitals in Southern Brazil

Alessandra E. Ferreira, Desirée P. Marchetti, Lyvia M. De Oliveira, Carolina S. Gusatti, Daiane B. Fuentefria, and Gertrudes Corção

Journal of Hospital Infection 96 (2017) 323–327
Available online at www.sciencedirect.com
Journal of Hospital Infection
journal homepage: www.elsevierhealth.com/journals/jhin
ELSEVIER

Emission of extensively-drug-resistant *Acinetobacter baumannii* from hospital settings to the natural environment

M. Seruga Music[a], J. Hrenovic[a,*], I. Goic-Barisic[b], B. Hunjak[c], D. Skoric[a], T. Ivankovic[a]

MICROBIAL DRUG RESISTANCE
Volume 25, Number 5, 2019

DOI: 10.1089/mdr.2018.0087

Carbapenem-Resistant *Acinetobacter baumannii* Recovered from Swine Manure

Jasna Hrenovic,[1] Martina Seruga Music,[1] Goran Durn,[2] Svjetlana Dekic,[1] Blazenka Hunjak,[3] and Ivica Kisic[4]

Two isolates
IC2 (ST-195)
XDR

Isolate	*Sequence type*	*Clonal lineage*	*Intrinsic* bla_{OXA}	*Acquired* bla_{OXA}	*MIC values of antibiotics (mg/L)*									
					MEM	*IPM*	*CIP*	*LVX*	*TOB*	*GEN*	*AMK*	*SAM*	*SXT*	*CST*
3/1	ST-195	IC2	OXA-66	OXA-23	$\geq 16^R$	$\geq 16^R$	$\geq 4^R$	4^R	$\geq 16^R$	$\geq 16^R$	$\geq 256^R$	16^I	$\geq 32^R$	1
3/9	ST-195	IC2	OXA-66	OXA-23	$\geq 16^R$	$\geq 16^R$	$\geq 4^R$	4^R	$\geq 16^R$	$\geq 16^R$	$\geq 256^R$	16^I	1.5	0.75

Extensively and multi drug-resistant *Acinetobacter baumannii* recovered from technosol at a dump site in Croatia

Jasna Hrenovic [a], Goran Durn [b,*], Martina Seruga Music [a], Svjetlana Dekic [a], Tamara Troskot-Corbic [c], Dijana Skoric [a]

Science of the Total Environment 607–608 (2017) 1049–1055

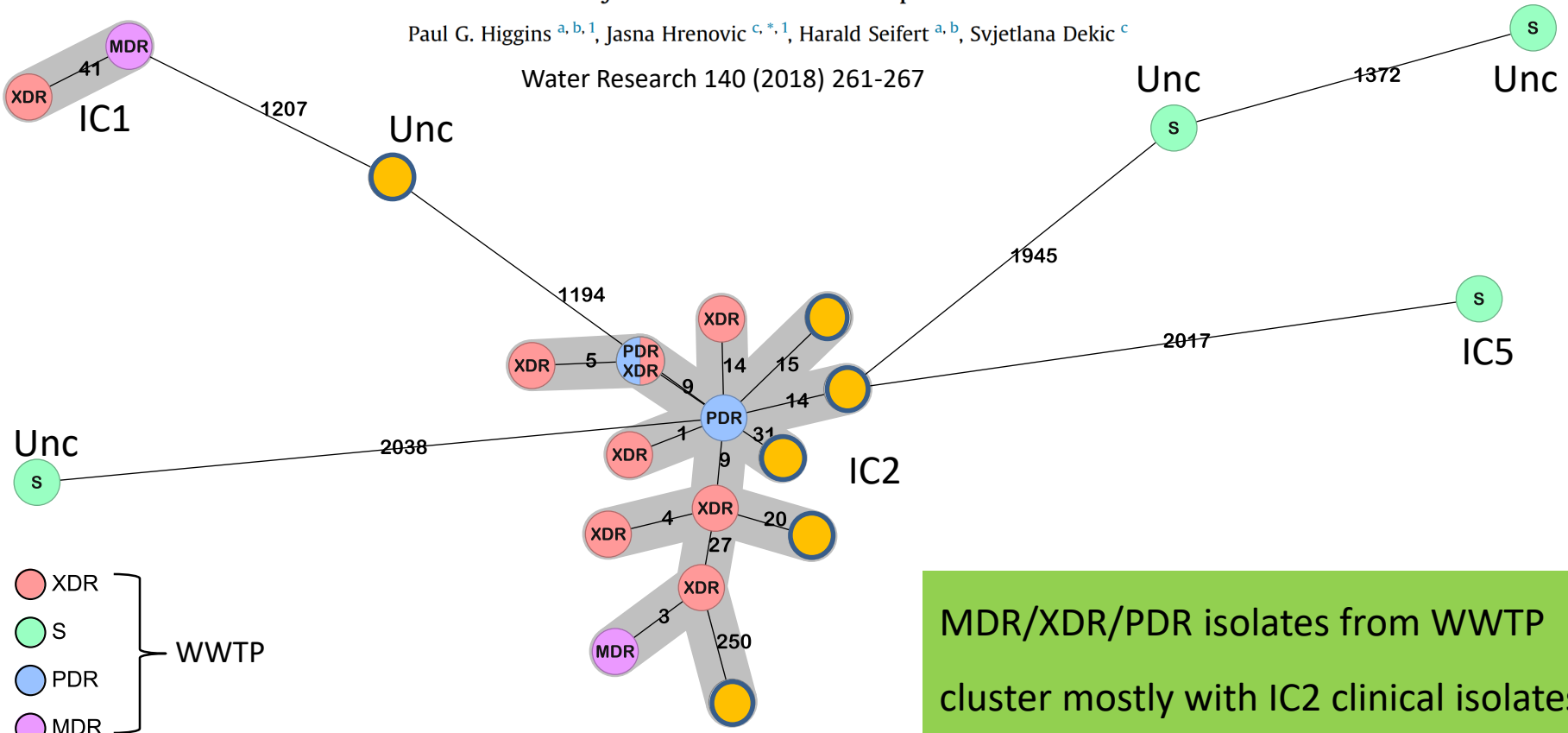
Three isolates
IC2 and IC1
MDR

Isolate	Sequence type	Clonal complex	IC type	MIC values of antibiotics (mg/L)												bla_{OXA}
				MEM	IPM	CIP	LVX	TOB	GEN	AMK	MIN	SAM	TIM	TZP	SXT	CST	
Sovjak 1	231	109	1	$\geq 16^R$	$\geq 16^R$	$\geq 4^R$	4^R	≤ 1	≤ 1	32^R	≤ 1	16^I	$\geq 128^R$	$\geq 128^R$	≤ 20	≤ 0.5	OXA-72
Sovjak 2	231	109	1	$\geq 16^R$	$\geq 16^R$	$\geq 4^R$	4^R	≤ 1	≤ 1	16^I	≤ 1	16^I	$\geq 128^R$	$\geq 128^R$	≤ 20	≤ 0.5	OXA-72
Sovjak 3	195	92	2	$\geq 16^R$	$\geq 16^R$	$\geq 4^R$	4^R	≤ 1	≤ 1	$>64^R$	8^I	16^I	$\geq 128^R$	$\geq 128^R$	$\geq 320^R$	≤ 0.5	OXA-23

Characterization of *Acinetobacter baumannii* from water and sludge line of secondary wastewater treatment plant

Paul G. Higgins [a, b, 1], Jasna Hrenovic [c, *, 1], Harald Seifert [a, b], Svjetlana Dekic [c]

Water Research 140 (2018) 261-267



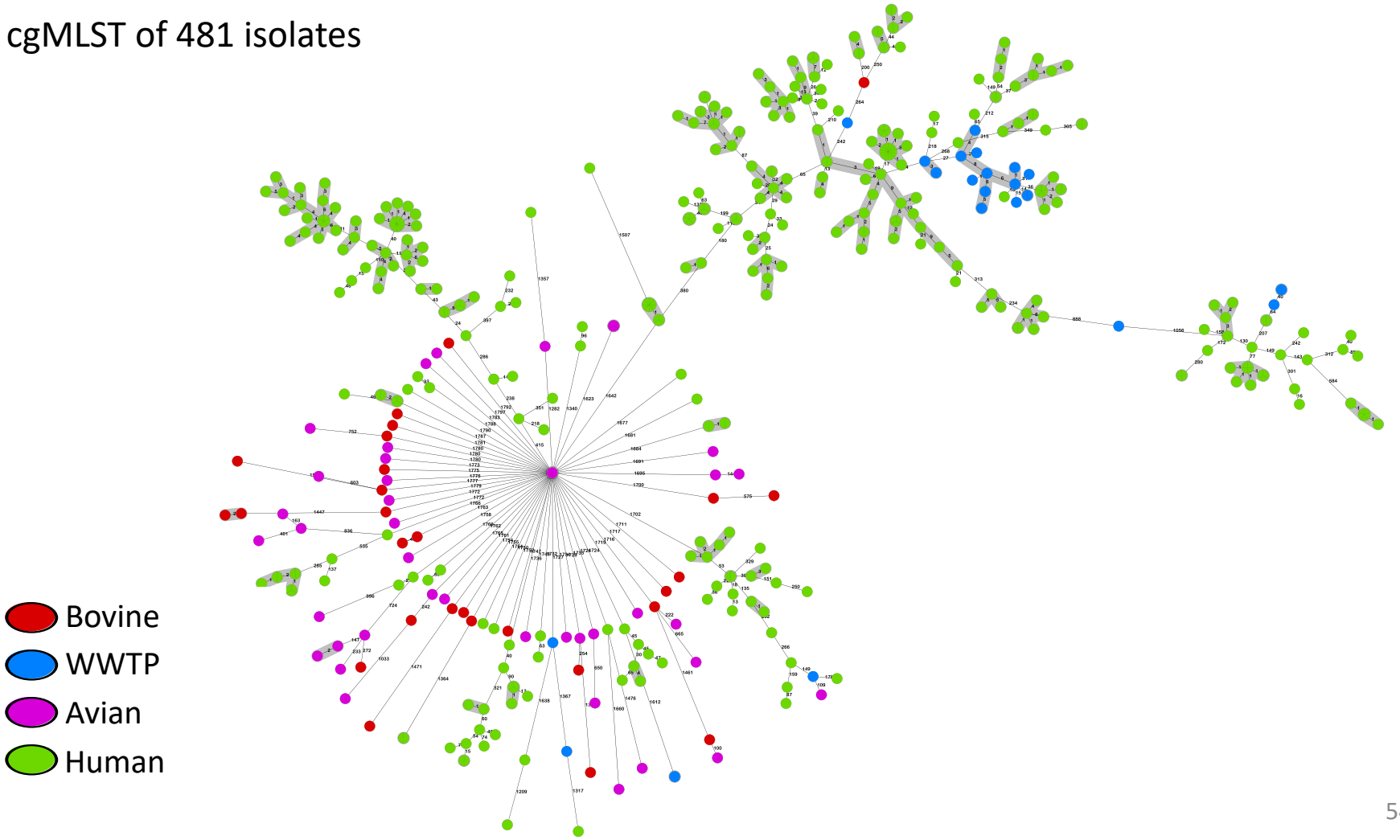
MDR/XDR/PDR isolates from WWTP cluster mostly with IC2 clinical isolates

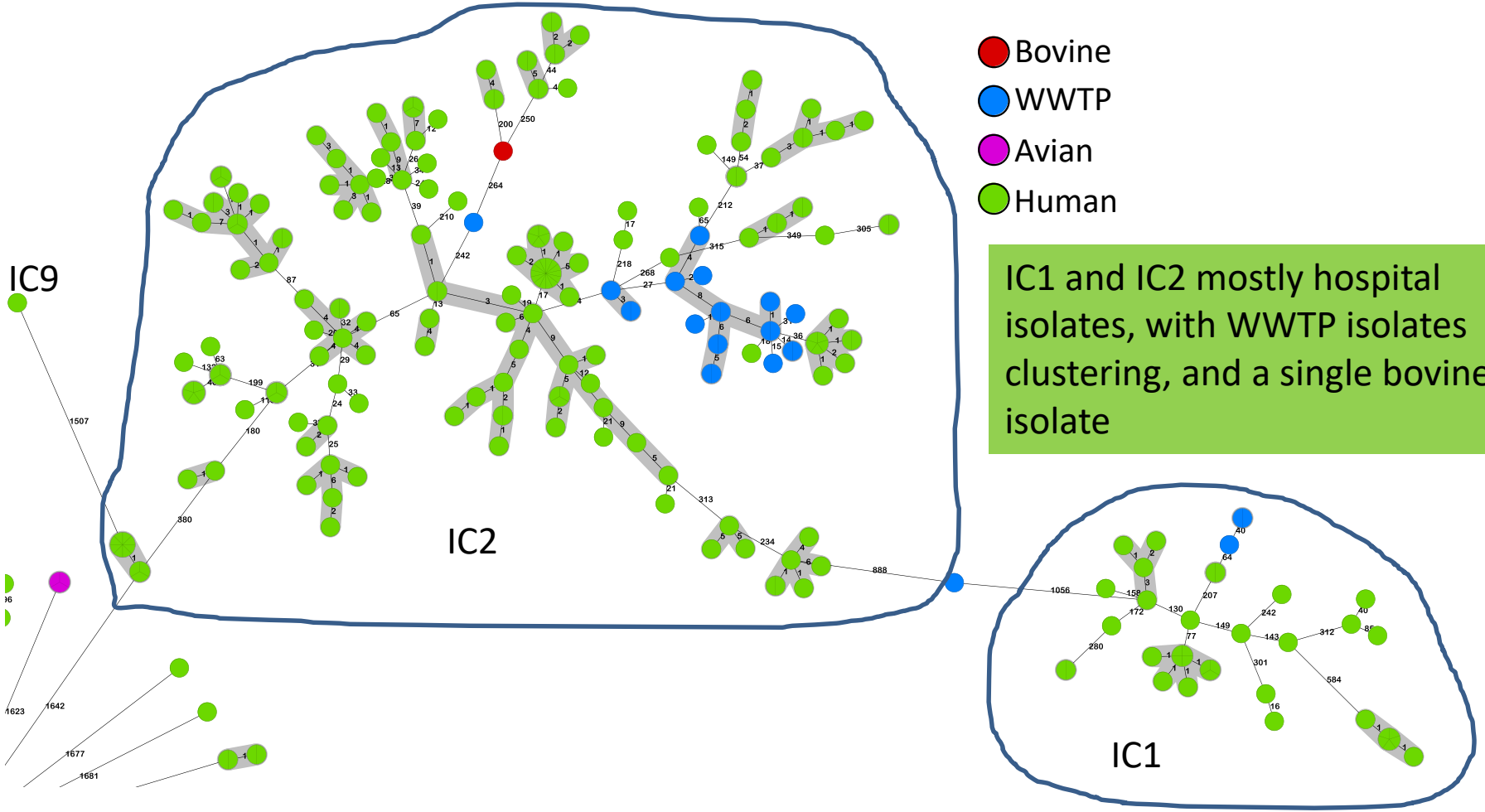
- Human-associated

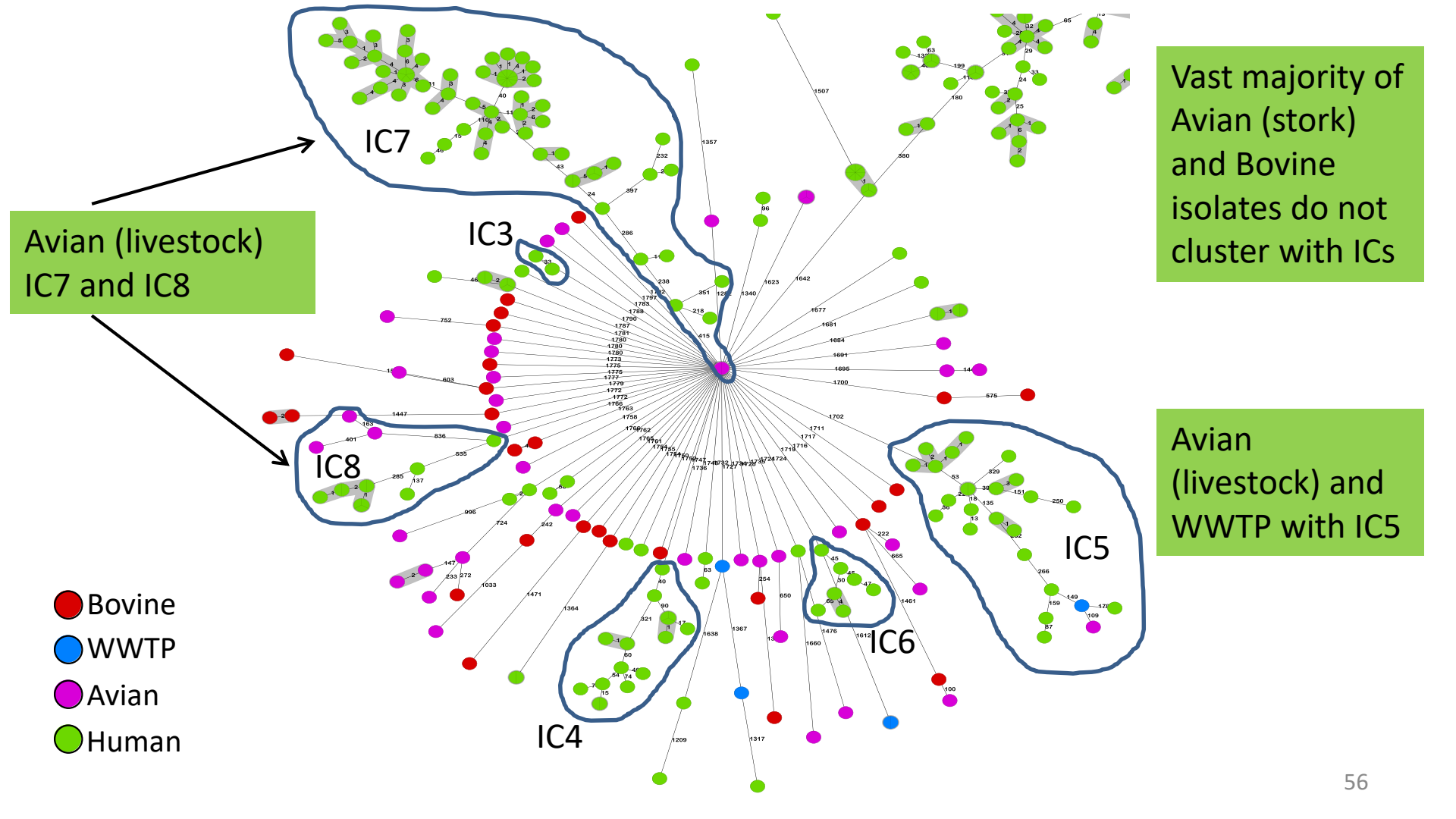
Summary

Molecular epidemiology of clinical, animal, and environmental isolates of *A. baumannii*

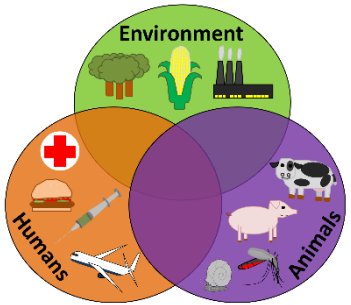
cgMLST of 481 isolates




Bovine
WWTP
Avian
Human
IC9
IC2
IC1
IC1 and IC2 mostly hospital isolates, with WWTP isolates clustering, and a single bovine isolate


Avian (livestock) IC7 and IC8
Vast majority of Avian (stork) and Bovine isolates do not cluster with ICs
Avian (livestock) and WWTP with IC5
IC7
IC3
IC8
IC5
IC6
IC4
Bovine
WWTP
Avian
Human

Why IC2/IC5 prevalence?
Resistance?
Host factor?



Wastewater
MDR/XDR/PDR
IC2

Community
Susceptible
Unique
IC8

Livestock
Low levels of resistance
IC1,2,3,5,7,8
Unique

Hospital
MDR/XDR/PDR
IC1-9
IC2 worldwide
IC5 Latin America

Wild animals
Susceptible
Mostly unique

Companion animals
MDR
IC1,2,8

Low-level resistance provide a toehold from livestock to the clinic?

What makes IC's adapted to human and animal hospitals?

#LaboratoryOfEskapology
@docpolski

Thanks to

Julia Wille -WGS

Tessa Burgwinkel-WGS

- Alex Nemec
- Branka Bedenić
- Gottfried Wilharm
- Ignasi Roca
- Jasna Hrenovic
- Leena Al Hassan
- Lucia Gallego
- Monica Cerezales
- Peter Klotz
- Stephan Göttig

DFG

FOR 2251 Acinetobacter

DZIF