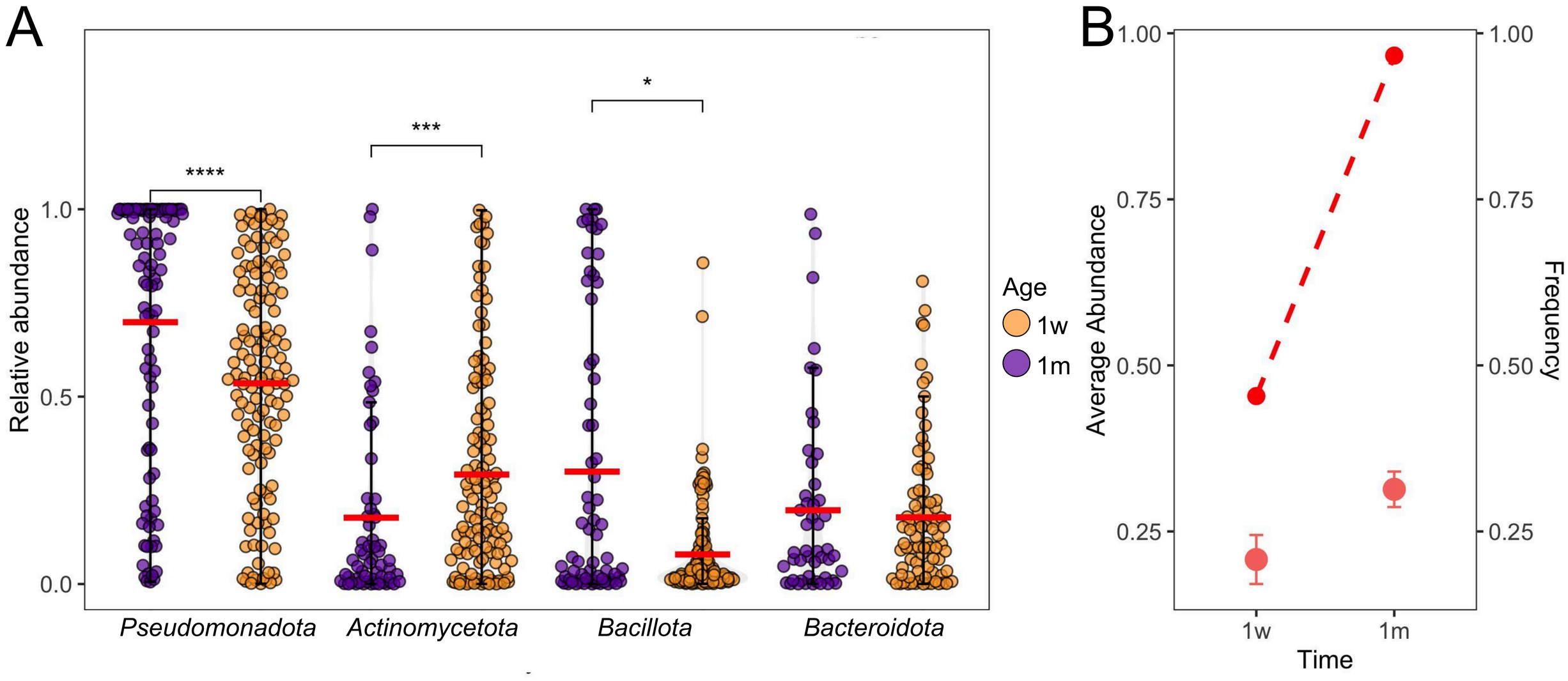
CORA Cork Open Research Archive
Cartlann Taighde Oscailte Chorcaí

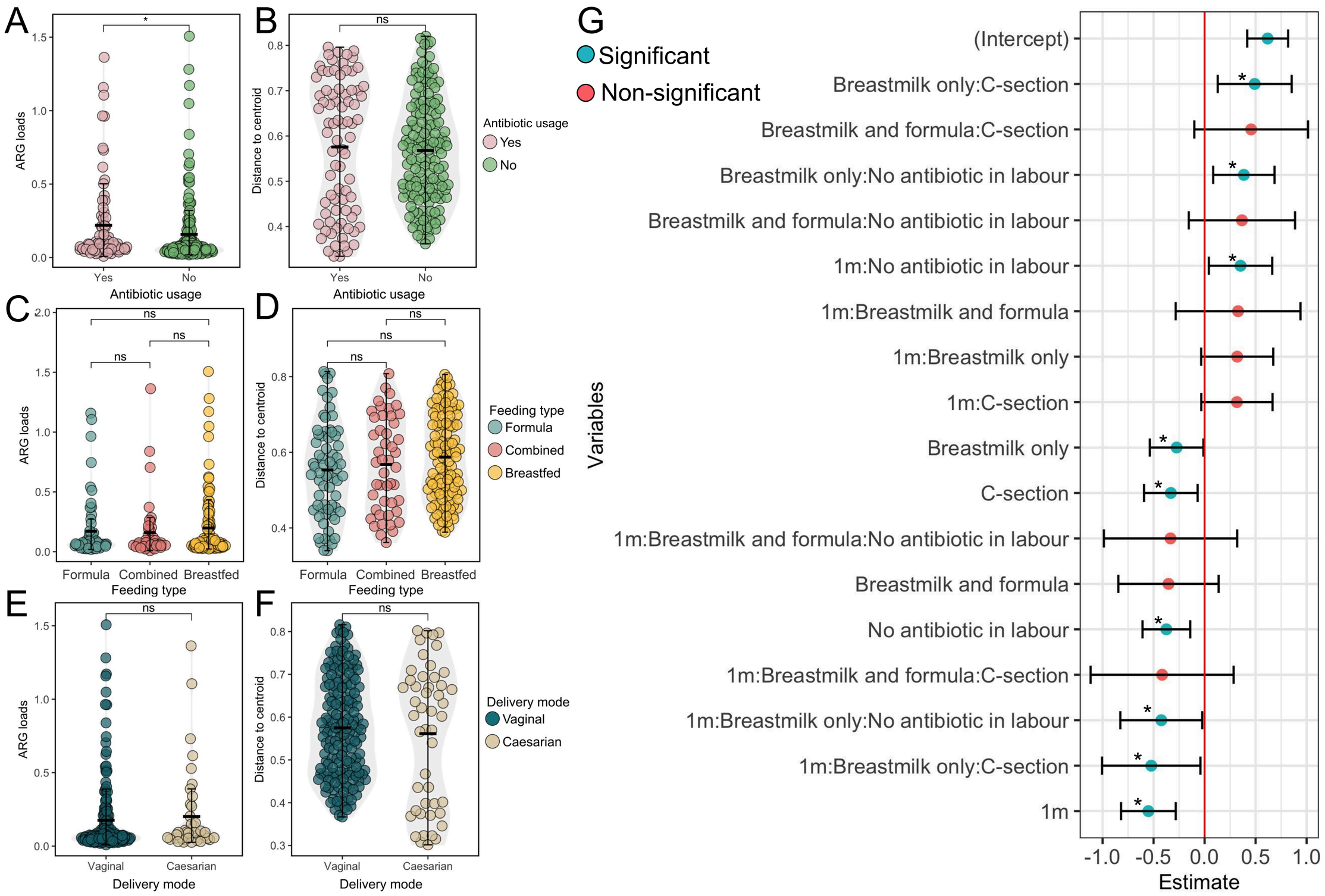
Title	Breastfeeding and the milk resistome shape the establishment and transmission of antibiotic resistance genes in the infant gut microbiome
Authors	Pan, Zhe;Walsh, Calum J.;Feehily, Conor;Nori, Sai Ravi Chandra;McAuliffe, Fionnuala M.;Cotter, Paul D.;MacSharry, John;van Sinderen, Douwe
Publication date	2025-08-04
Original Citation	Pan, Z., Walsh, C.J., Feehily, C., Nori, S.R.C., McAuliffe, F.M., Cotter, P.D., MacSharry, J. and Van Sinderen, D. (2025) 'Breastfeeding and the milk resistome shape the establishment and transmission of antibiotic resistance genes in the infant gut microbiome', Gut Microbes, 17(1), 2541033. https://doi.org/10.1080/19490976.2025.2541033
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.1080/19490976.2025.2541033
Rights	© 2025, University College Cork. Published with license by Taylor & Francis Group, LLC. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permitsunrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allowthe posting of the Accepted Manuscript in a repository by the author(s) or with their consent. - https://creativecommons.org/licenses/by/4.0/
Download date	2026-08-25 07:00:35
Item downloaded from	https://hdl.handle.net/10468/17799

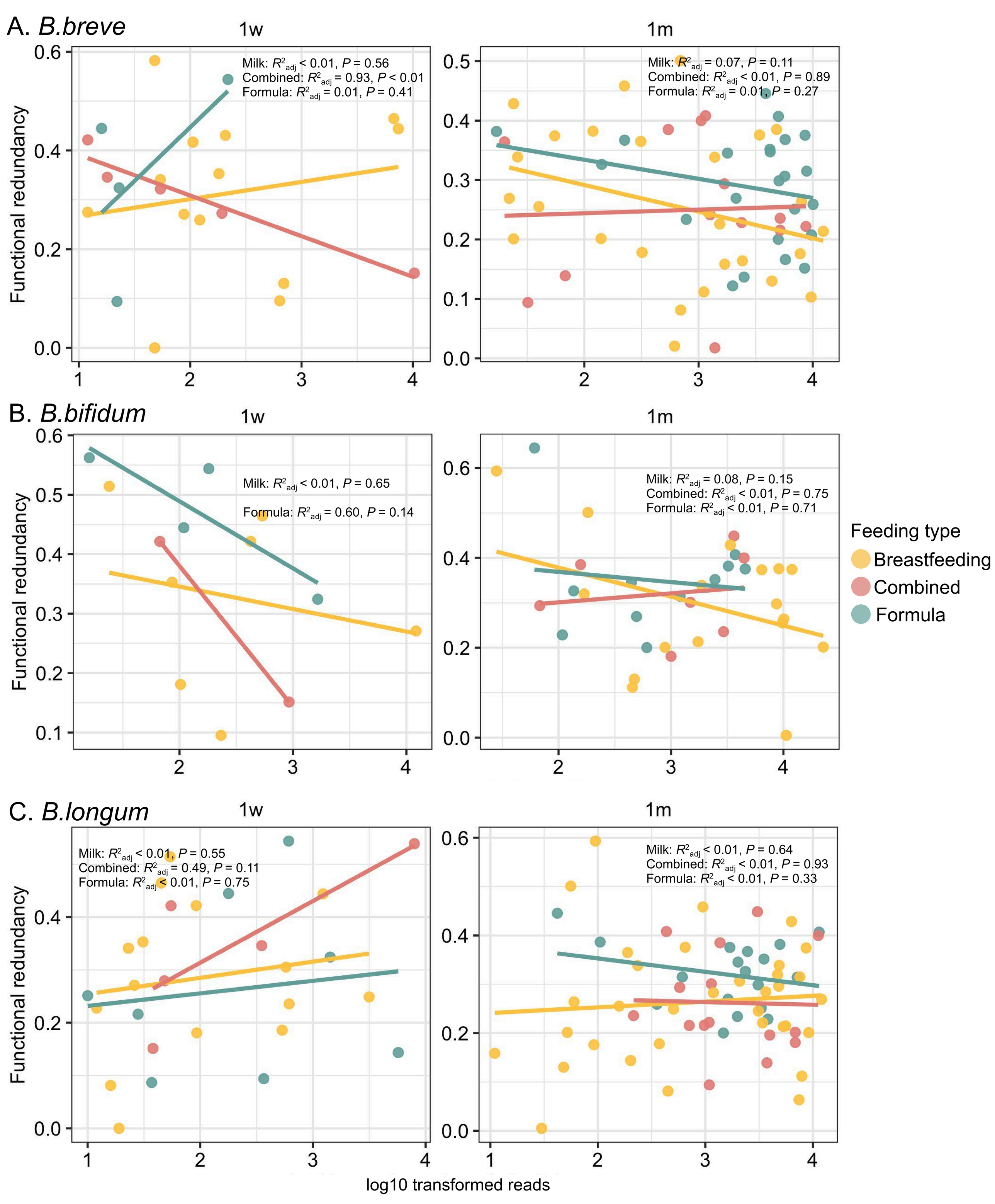
UCC

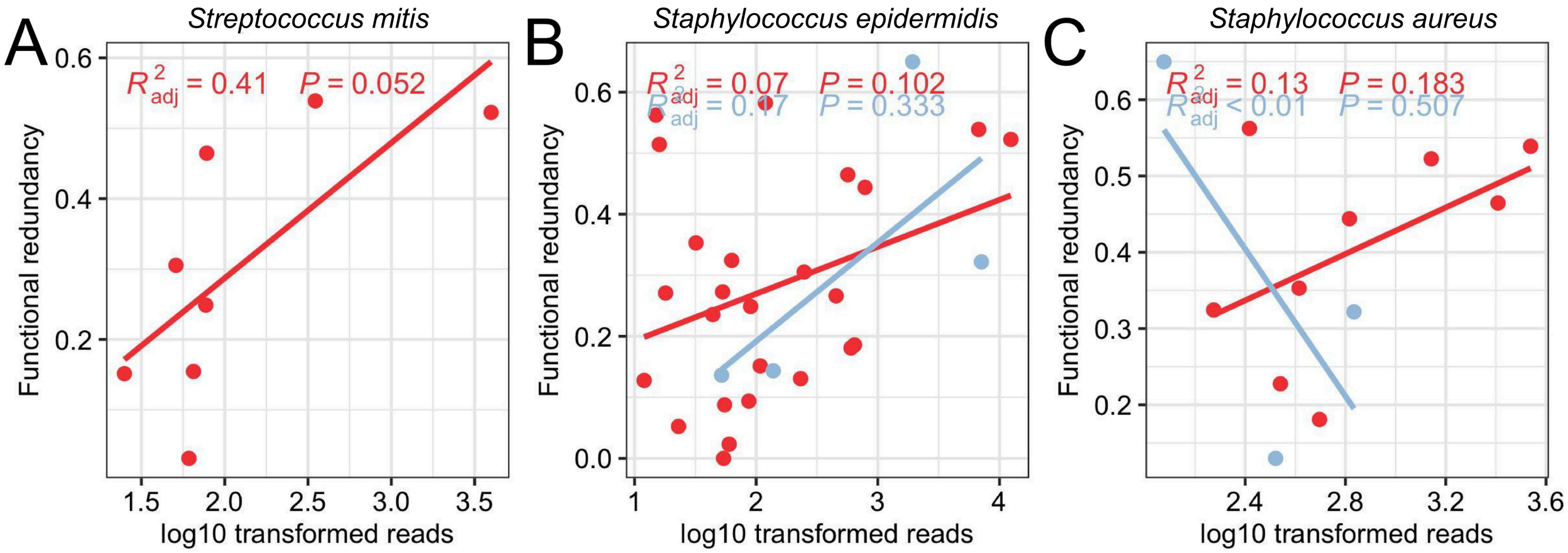
University College Cork, Ireland

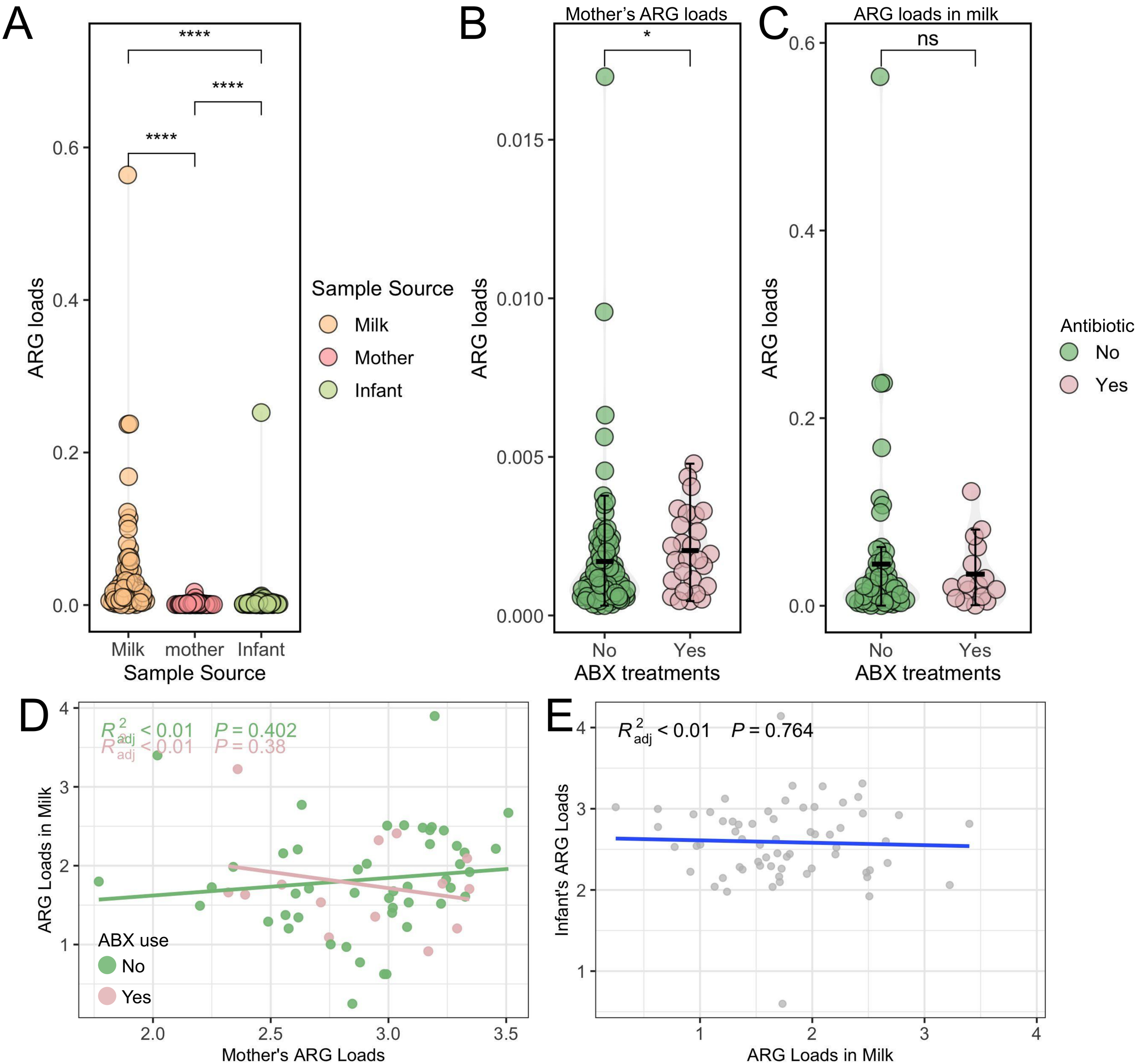
Coláiste na hOllscoile Corcaigh

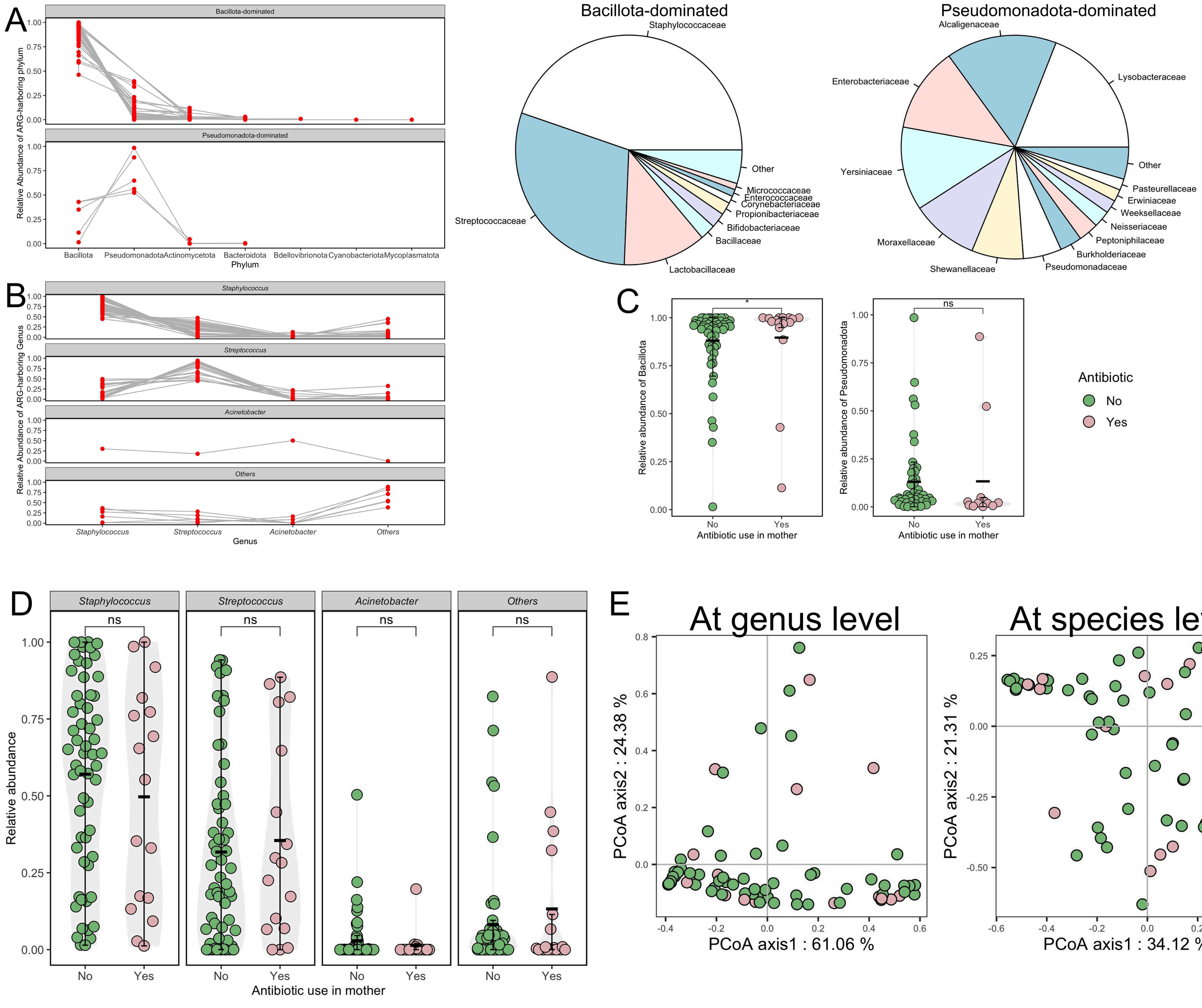

A
Relative abundance
1.0
0.5
0.0
****
***
*
Pseudomonadota
Actinomycetota
Bacillota
Bacteroidota
Age
1w
1m
B
Average Abundance
Frequency
1.00
0.75
0.50
0.25
1w
1m
Time

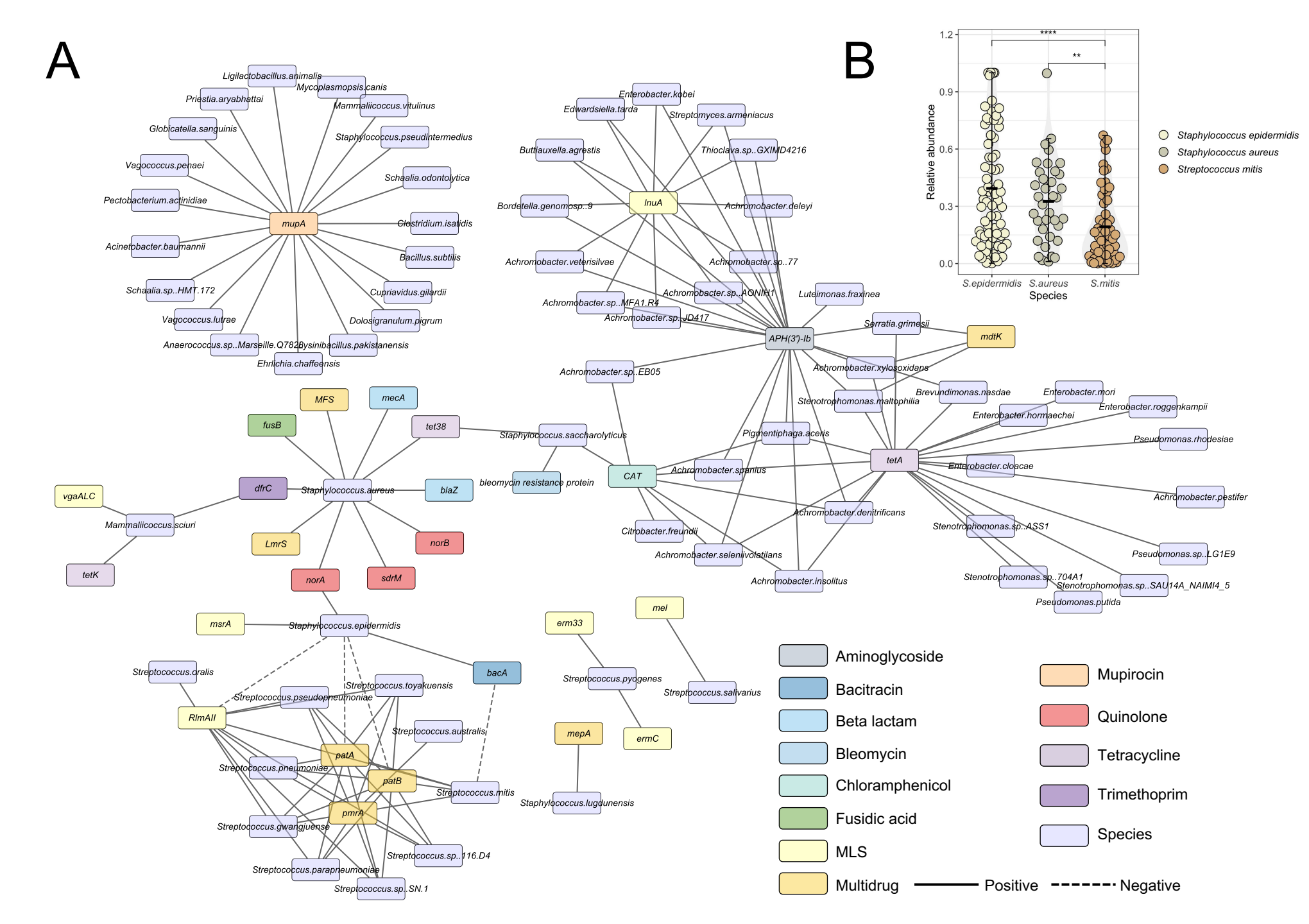

A
B
C
D
E
F
G
ARG loads
Distance to centroid
Antibiotic usage
Yes
No
Feeding type
Formula
Combined
Breastfed
Delivery mode
Vaginal
Caesarian
ns
*
Significant
Non-significant
Variables
(Intercept)
Breastmilk only:C-section
Breastmilk and formula:C-section
Breastmilk only:No antibiotic in labour
Breastmilk and formula:No antibiotic in labour
1m:No antibiotic in labour
1m:Breastmilk and formula
1m:Breastmilk only
1m:C-section
Breastmilk only
C-section
1m:Breastmilk and formula:No antibiotic in labour
Breastmilk and formula
No antibiotic in labour
1m:Breastmilk and formula:C-section
1m:Breastmilk only:No antibiotic in labour
1m:Breastmilk only:C-section
1m
Estimate

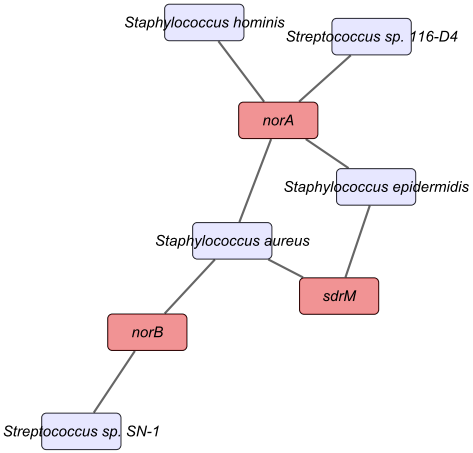

A. B.breve
1w
1m
Milk: R^2_{adj} < 0.01, P = 0.56
Combined: R^2_{adj} = 0.93, P < 0.01
Formula: R^2_{adj} = 0.01, P = 0.41
Milk: R^2_{adj} = 0.07, P = 0.11
Combined: R^2_{adj} < 0.01, P = 0.89
Formula: R^2_{adj} = 0.01, P = 0.27
B. B.bifidum
Milk: R^2_{adj} < 0.01, P = 0.65
Formula: R^2_{adj} = 0.60, P = 0.14
Milk: R^2_{adj} = 0.08, P = 0.15
Combined: R^2_{adj} < 0.01, P = 0.75
Formula: R^2_{adj} < 0.01, P = 0.71
C. B.longum
Milk: R^2_{adj} < 0.01, P = 0.55
Combined: R^2_{adj} = 0.49, P = 0.11
Formula: R^2_{adj} < 0.01, P = 0.75
Milk: R^2_{adj} < 0.01, P = 0.64
Combined: R^2_{adj} < 0.01, P = 0.93
Formula: R^2_{adj} < 0.01, P = 0.33
Functional redundancy
log10 transformed reads
Feeding type
Breastfeeding
Combined
Formula


A
Streptococcus mitis
R^2_{adj} = 0.41
P = 0.052
Functional redundancy
0.6
0.4
0.2
1.5
2.0
2.5
3.0
3.5
log10 transformed reads
B
Staphylococcus epidermidis
R^2_{adj} = 0.07
P = 0.102
R^2_{adj} = 0.17
P = 0.333
Functional redundancy
0.6
0.4
0.2
0.0
1
2
3
4
log10 transformed reads
C
Staphylococcus aureus
R^2_{adj} = 0.13
P = 0.183
R^2_{adj} < 0.01
P = 0.507
Functional redundancy
0.6
0.5
0.4
0.3
0.2
2.4
2.8
3.2
3.6
log10 transformed reads


A
****
****
****
ARG loads
0.6
0.4
0.2
0.0
Milk
mother
Infant
Sample Source
Sample Source
Milk
Mother
Infant
B
Mother's ARG loads
*
ARG loads
0.015
0.010
0.005
0.000
No
Yes
ABX treatments
C
ARG loads in milk
ns
ARG loads
0.6
0.4
0.2
0.0
No
Yes
ABX treatments
Antibiotic
No
Yes
D
$R^2_{adj} < 0.01$ $P = 0.402$
$R^2_{adj} < 0.01$ $P = 0.38$
ARG Loads in Milk
4
3
2
1
2.0
2.5
3.0
3.5
Mother's ARG Loads
ABX use
No
Yes
E
$R^2_{adj} < 0.01$ $P = 0.764$
Infant's ARG Loads
4
3
2
1
1
2
3
4
ARG Loads in Milk


A
Bacillota-dominated
Pseudomonadota-dominated
Relative Abundance of ARG-harboring phylum
Bacillota
Pseudomonadota
Actinomycetota
Bacteroidota
Bdellovibrionota
Cyanobacteriota
Mycoplasmatota
Phylum
Bacillota-dominated
Staphylococcaceae
Streptococcaceae
Lactobacillaceae
Other
Micrococcaceae
Enterococcaceae
Corynebacteriaceae
Propionibacteriaceae
Bifidobacteriaceae
Bacillaceae
Pseudomonadota-dominated
Alcaligenaceae
Lysobacteraceae
Enterobacteriaceae
Yersiniaceae
Moraxellaceae
Shewanellaceae
Pseudomonadaceae
Burkholderiaceae
Peptoniphilaceae
Neisseriaceae
Weeksellaceae
Erwiniaceae
Pasteurellaceae
Other
B
Staphylococcus
Streptococcus
Acinetobacter
Others
Relative Abundance of ARG-harboring Genus
Genus
C
Relative abundance of Bacillota
Relative abundance of Pseudomonadota
Antibiotic use in mother
No
Yes
ns
Antibiotic
D
Relative abundance
Antibiotic use in mother
E
At genus level
At species level
PCoA axis1 : 61.06 %
PCoA axis2 : 24.38 %
PCoA axis1 : 34.12 %
PCoA axis2 : 21.31 %


A
B
mupA
Ligilactobacillus.animalis
Mycoplasmopsis.canis
Priestia.aryabhattai
Mammaliicoccus.vitulinus
Globicatella.sanguinis
Staphylococcus.pseudintermedius
Vagococcus.penaei
Schaalia.odontolytica
Pectobacterium.actinidiae
Clostridium.isatidis
Acinetobacter.baumannii
Bacillus.subtilis
Schaalia.sp..HMT.172
Cupriavidus.gilardii
Vagococcus.lutrae
Dolosigranulum.pigrum
Anaerococcus.sp..Marseille.Q782
Bysinibacillus.pakistanensis
Ehrlichia.chaffeensis
lnuA
Enterobacter.kobei
Edwardsiella.tarda
Streptomyces.armeniacus
Buttiauxella.agrestis
Thioclava.sp..GXIMD4216
Bordetella.genomosp..9
Achromobacter.deleyi
Achromobacter.veterisilvae
Achromobacter.sp..77
Achromobacter.sp..AONIH1
Achromobacter.sp..MFA1.R4
Luteimonas.fraxinea
Achromobacter.sp..JD417
APH(3')-Ib
Serratia.grimesii
mdtK
Achromobacter.sp.EB05
Achromobacter.xylosoxidans
Stenotrophomonas.maltophilia
Brevundimonas.nasdae
Enterobacter.mori
Enterobacter.hormaechei
Enterobacter.roggenkampii
Pigmentiphaga.aceris
Pseudomonas.rhodesiae
Staphylococcus.saccharolyticus
tetA
Enterobacter.cloacae
CAT
Achromobacter.spanius
bleomycin resistance protein
Achromobacter.pestifer
Achromobacter.denitrificans
Stenotrophomonas.sp..ASS1
Citrobacter.freundii
Pseudomonas.sp..LG1E9
Achromobacter.seleniivolatilans
Stenotrophomonas.sp..704A1
Stenotrophomonas.sp..SAU14A_NAIMI4_5
Achromobacter.insolitus
Pseudomonas.putida
MFS
mecA
fusB
tet38
dfrC
Staphylococcus.aureus
blaZ
vgaALC
Mammaliicoccus.sciuri
LmrS
norB
tetK
norA
sdrM
msrA
Staphylococcus.epidermidis
bacA
Streptococcus.oralis
Streptococcus.toyakuensis
Streptococcus.pseudopneumoniae
RlmAII
Streptococcus.australis
patA
Streptococcus.pneumoniae
patB
Streptococcus.mitis
pmrA
Streptococcus.gwangjuense
Streptococcus.sp..116.D4
Streptococcus.parapneumoniae
Streptococcus.sp..SN.1
erm33
mel
Streptococcus.pyogenes
Streptococcus.salivarius
mepA
ermC
Staphylococcus.lugdunensis
Relative abundance
Species
S.epidermidis
S.aureus
S.mitis
Staphylococcus epidermidis
Staphylococcus aureus
Streptococcus mitis
Aminoglycoside
Bacitracin
Beta lactam
Bleomycin
Chloramphenicol
Fusidic acid
MLS
Multidrug
Mupirocin
Quinolone
Tetracycline
Trimethoprim
Species
Positive
Negative


Staphylococcus hominis
Streptococcus sp. 116-D4
norA
Staphylococcus epidermidis
Staphylococcus aureus
sdrM
norB
Streptococcus sp. SN-1