PERSPECTIVES ON MATH. MODELLING OF ANTIMICROBIAL AND INSECTICIDE EFFICIENCY

Ramsès Djidjou-Demasse

MIVEGEC, CNRS, IRD, Université de Montpellier ÉCOLE POLYTECHNIQUE DE THIÈS

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CONTEXT

Within-host dynamics of parasites (interactions dynamics of four parasite "strains").

- $N_s \rightarrow$ fully sensitive to the drug.
- $N_m \rightarrow$ with mutational (or 'genomic') resistance only.
- $N_p \rightarrow$ with plasmidic resistance only.
- $N_{m,p} \rightarrow$ with both form of resistances.

Svara & Rankin, BMC Evol Biol, 2011. Tazzyman & Bonhoeffer, Evolution, 2014. Djidjou-Demasse *et al.*, J Math Biol, 2021.

NON TRIVIAL DYNAMICS

Threshold parameters (effective reproduction numbers):

R_j's describe both the ecological and micro-evolutionary (or, 'eco-evolutionary') conditions of strain persistence, that is, their effective genetic contribution to each next generation.

NON TRIVIAL DYNAMICS



Djidjou-Demasse et al., J Math Biol, 2021.

NON TRIVIAL DYNAMICS

• Costs of mutation and plasmid compensate each other: $N_{m,p}$ performs at least as well than N_s . $1 < \min \{\mathcal{R}_p; \mathcal{R}_m\} \le \max \{\mathcal{R}_p; \mathcal{R}_m\} < \mathcal{R}_s \le \mathcal{R}_{m,p}$.



Djidjou-Demasse et al., J Math Biol, 2021.

AMR IS A CONTINUOUS TRAIT





log10 Minimum Inhibitory Concentration erythromycin (mg/L)

- "Resistant" (R) if MIC > C_1 .
- "Normal exposure" (S) if MIC $< C_0$.
- "Increased exposure" (I) if $C_0 < MIC < C_1$.

Denamur *et al.*, Hoboken, NJ: Wiley-Blackwell, 2010. EUCAST 2019 nomenclature.

AMR IS A CONTINUOUS TRAIT



Djidjou-Demasse et al., PCI Math Comp Biol, 2021.

AMR IS A CONTINUOUS TRAIT

Between-host

Treated infectious $\alpha_i^T(b_i^T(\tau, x)) + \mu_h$ $I_{i}^{T}(t, \tau = 0, x)$ Λ_i $= p_i^T(x)S_i(t)\lambda(t,x)$ $J(x,y)p(y)b_i^{\vartheta}(\tau,y)dy$ $\frac{1}{\left(1+\int_{-\infty}^{+\infty} b_i^{\vartheta}(\tau, x)dx\right)}$ $\omega_T^U(\tau, x)$ $\omega_U^T(\tau, x)$ $S_i(t)$ $\lambda(t, x)$ Treatment Treatment start stop $\begin{array}{c} I_i^U(t,\tau=0,x) \\ = p_i^U(x)S_i(t)\lambda(t,x) \end{array} \alpha_i^U(b_i^U(\tau,x)) + \mu_h \end{array}$ μ_h Untreated infectious $\lambda(t,x) = \sum \int_0^\infty [\beta_i^T(b_i^T(\tau,x))I_i^T(t,\tau,x) + \beta_i^U(b_i^U(\tau,x))I_i^U(t,\tau,x)]d\tau$ Immune response $\mu(x)$ and antimicrobial activity k(x) $\tau = time since infection$ *i*=host immune response levels x = resistance level $\beta_i^{\vartheta}, \alpha_i^{\vartheta}$ are function of the microbial load b_i^{ϑ} $\vartheta \in \{T, U\}, T =$ treated and U =untreated

Luther Mann et al., in progress.

Within-host

ABOUT INSECTICIDE EFFICIENCY ...

African Consortium in Modelling for Effective Vector Control (ACoMVeC)

- Support capacity-building efforts for mathematical modelling across sub-Saharan Africa.
- PhD-students Modellers across Africa (2023-2026).



https://crid-cam.net/vacancies/

https://mivegec.ird.fr https://ept.sn/

