Supplemental Figures for: Can existing data on WNV infection in birds and mosquitos explain strain replacement?

Morgan P. Kain[1†], Benjamin M. Bolker[1,2]

[1]Department of Biology, McMaster University, 1280 Main St. West, Hamilton, ON, Canada, L8S 4K1

[2]Department of Mathematics and Statistics, McMaster University, 1280 Main St. West, Hamilton, ON, Canada, L8S 4L8

[†]Correspondence author.
LSB-215
1280 Main St. West
Hamilton, ON
L8S 4K1
E-mail: kainm@mcmaster.ca

Table of Contents

(1) Model for mosquito titer to mosquito transmission

Due to a lack of publications that explicitly measured transmission from mosquitos after X days following infection with WNV, we fit a model to transmission with titer as a predictor used data from (Moudy et al., 2007) to obtain data from papers that only measured titer temporally and not transmission. To do so we fit a parameterization of a logistic cdf to transmission using non-linear least squares with the nlmrt package (Nash, 2012).

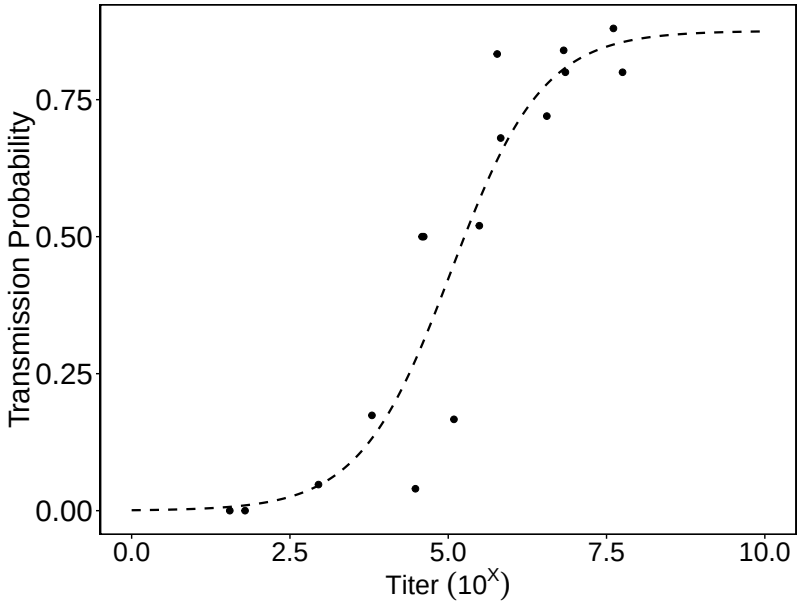

Figure S1: Relationship between Titer and Transmission from Moudy et al. 2007.

(2) Model for mosquito survival

We used data from (Andreadis et al., 2014) to fit a logistic model to mosqutio longevity. In our data analysis we used median survival at each temperature to calculate R_0. We appreciate that this study took place in Greece, far from the transmission events we are interested in, but it includes the most complete data on temperature dependent *Culex* survival that we could find.

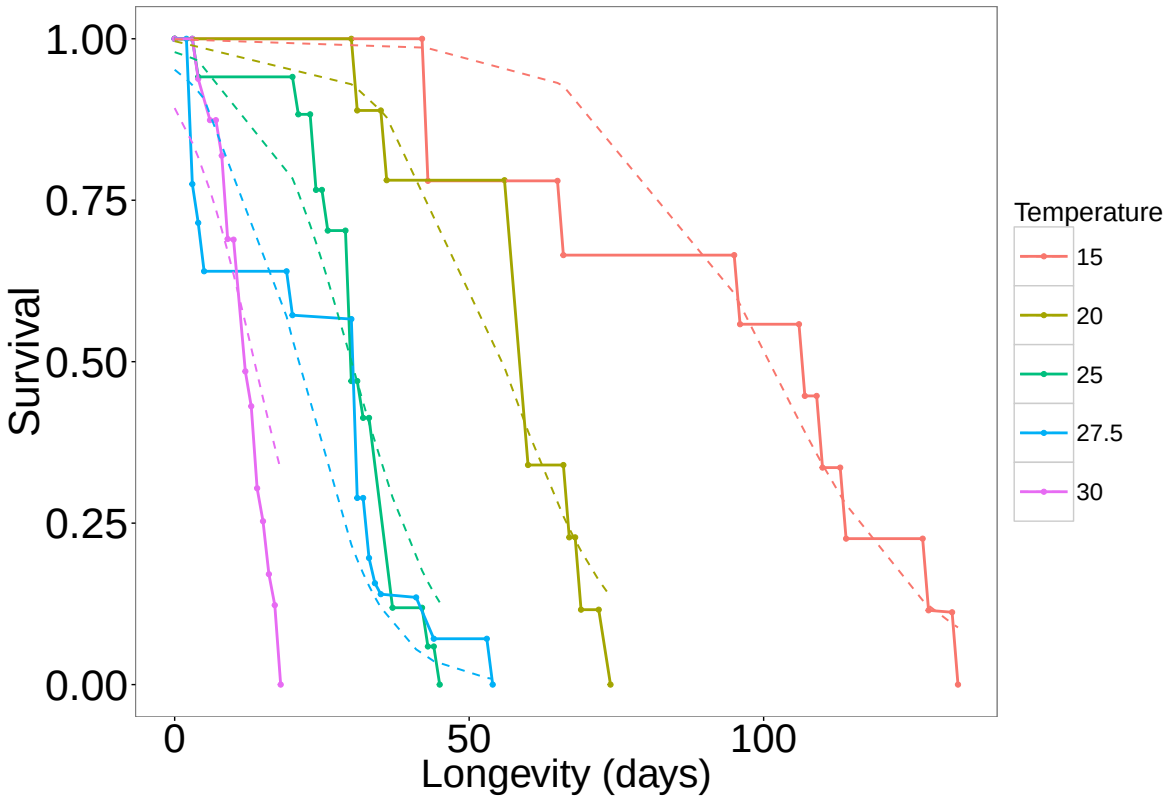

Figure S2: Relationship between Mosqutio Survival Probability and Days. Colored solid lines are extracted data from Andreadis et al. 2014 Figure 1C. Colored dashed lines are model estimates.

(3) Titer and Survival for "Other" Birds

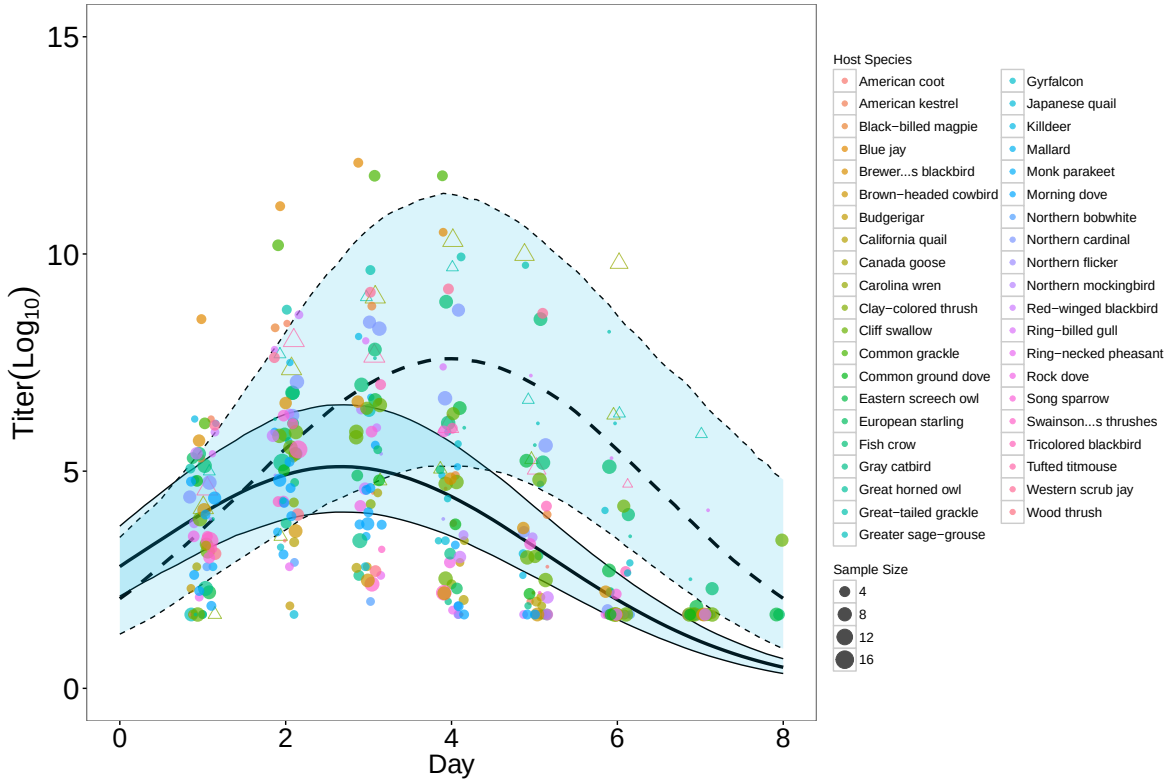

Figure S3.1: Titer Profiles for all other birds.

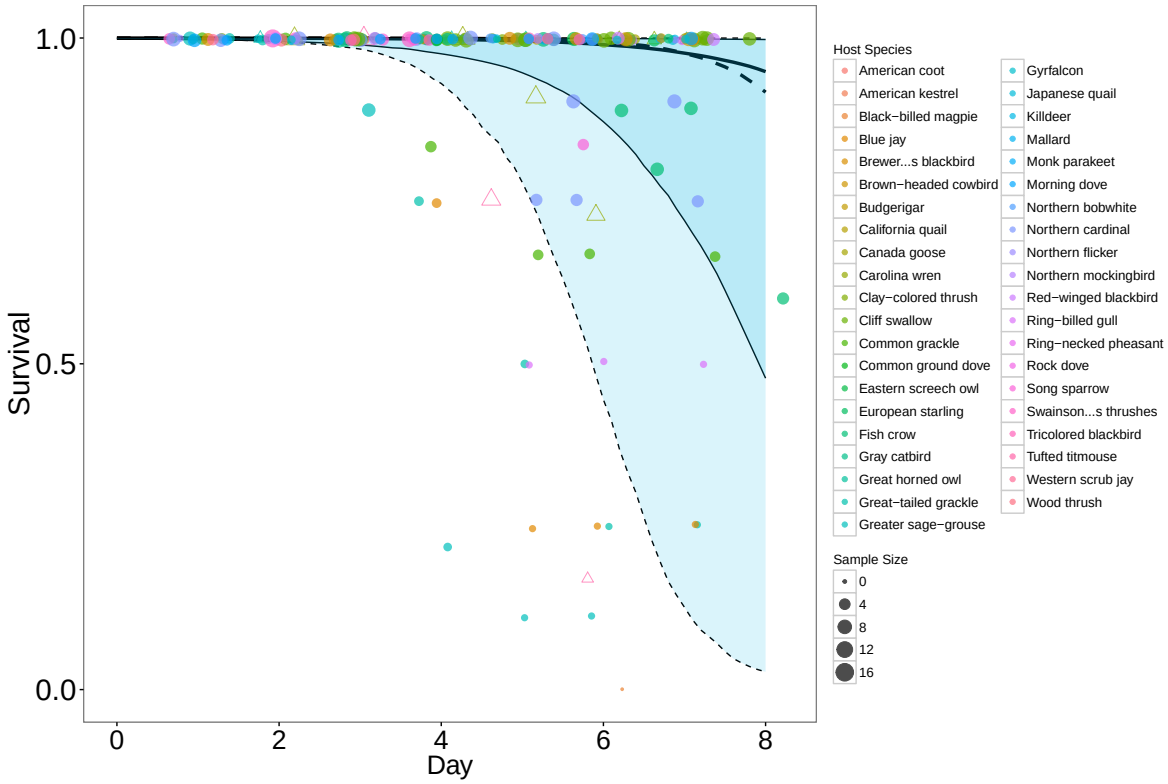

Figure S3.2: Survival for all other birds.

(4) Mosquito to bird transmission adjustments

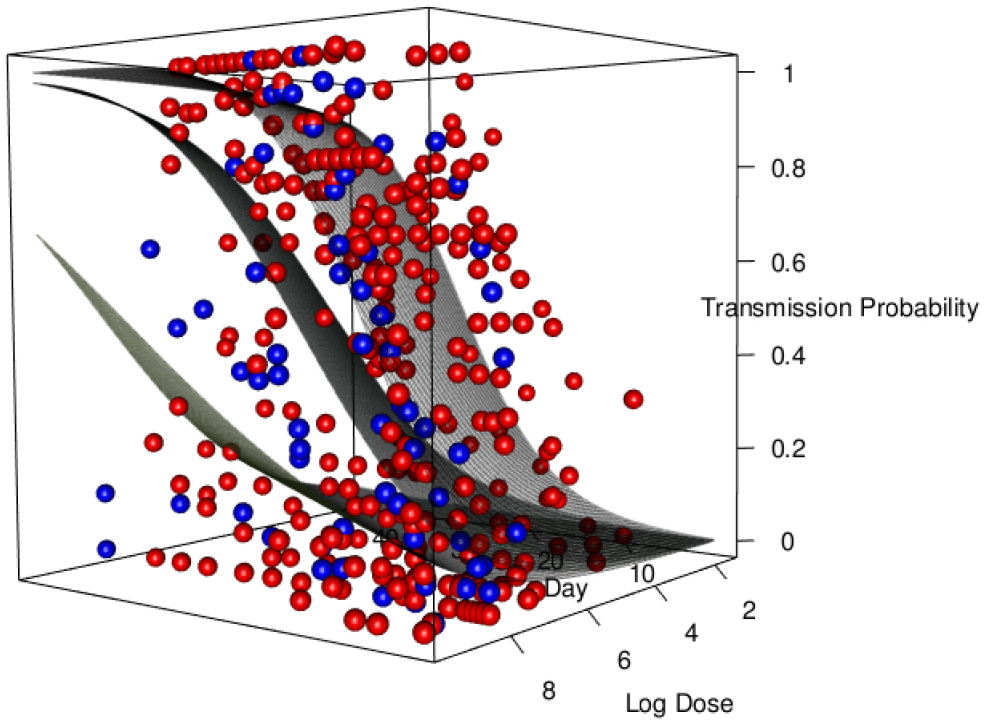

Figure S4.1: 3d figure of Mosquito to Bird model fit to raw data for *NY99 with JEV data*. Red points are NY99 data, blue points are WN02 data. Surfaces are predicted probabilities of transmission from an infected mosquito to a naive bird (Z-axis) *for NY99 with JEV data*. X-axis is days from 1-40, y-axis is Log Dose from 2 to 8. Light green surface is fitted surface at 16 degrees Celcius, darker green surface is 20 degrees Celcius, and black surface is 24 degrees Celcius.

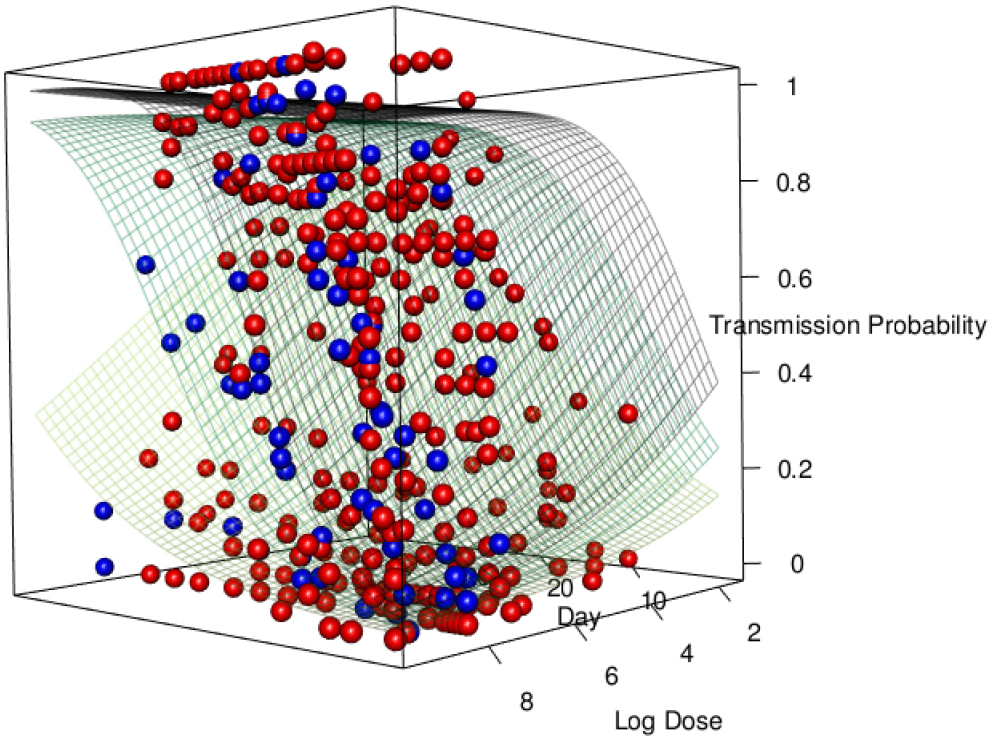

Figure S4.2: 3d figure of Mosquito to Bird model fit to raw data for *WN02 with JEV data*. Red points are NY99 data, blue points are WN02 data. Surfaces are predicted probabilities of transmission from an infected mosquito to a naive bird (Z-axis) *for WN02 with JEV data*. X-axis is days from 1-40, y-axis is Log Dose from 2 to 8. Light green surface is fitted surface at 16 degrees Celcius, darker green surface is 20 degrees Celcius, and black surface is 24 degrees Celcius.

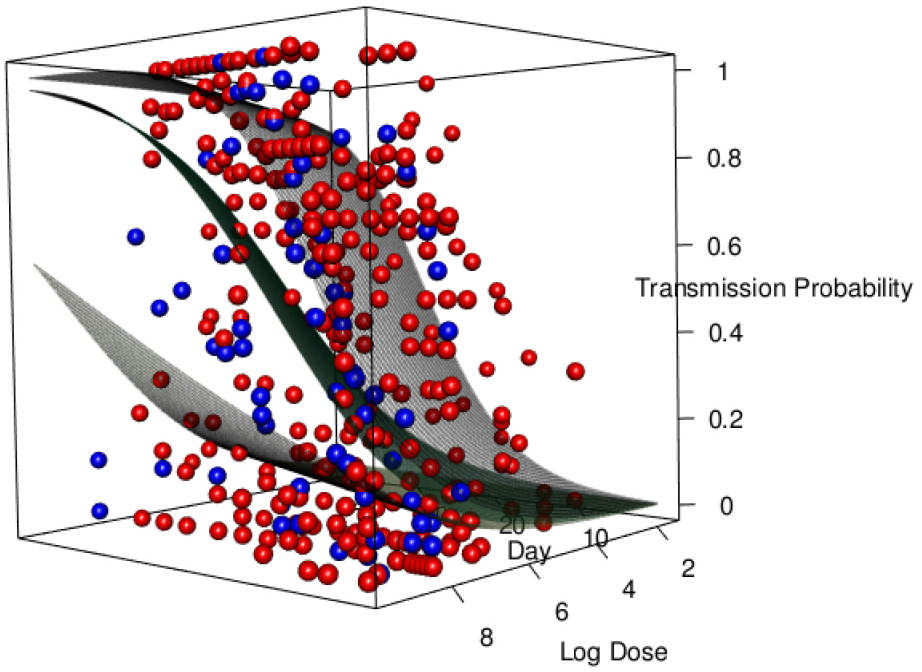

Figure S4.3: 3d figure of Mosquito to Bird model fit to raw data for *NY99 without JEV data*. Red points are NY99 data, blue points are WN02 data. Surfaces are predicted probabilities of transmission from an infected mosquito to a naive bird (Z-axis) *for NY99 without JEV data*. X-axis is days from 1-40, y-axis is Log Dose from 2 to 8. Light green surface is fitted surface at 16 degrees Celcius, darker green surface is 20 degrees Celcius, and black surface is 24 degrees Celcius.

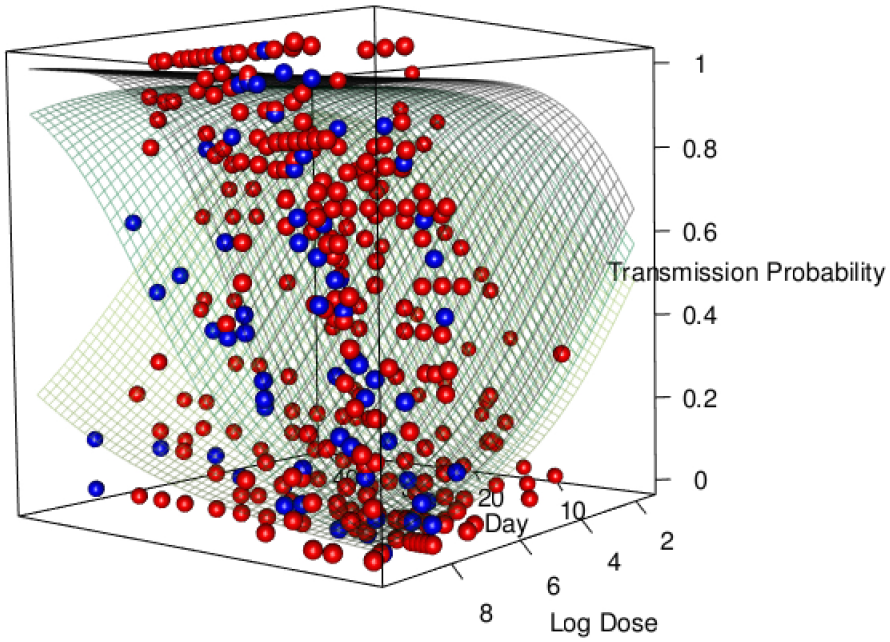

Figure S4.4: 3d figure of Mosquito to Bird model fit to raw data for *WN02 without JEV data*. Red points are NY99 data, blue points are WN02 data. Surfaces are predicted probabilities of transmission from an infected mosquito to a naive bird (Z-axis) *for WN02 without JEV data*. X-axis is days from 1-40, y-axis is Log Dose from 2 to 8. Light green surface is fitted surface at 16 degrees Celcius, darker green surface is 20 degrees Celcius, and black surface is 24 degrees Celcius.

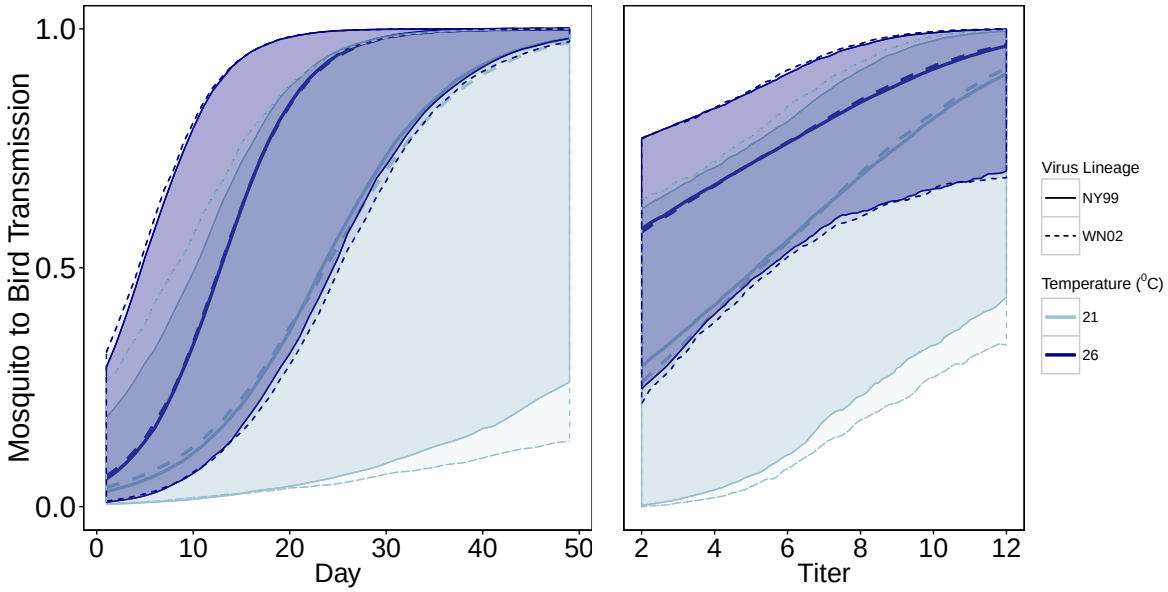

Figure S4.5: Figure 4a from the main text without encorporating mosquito survival

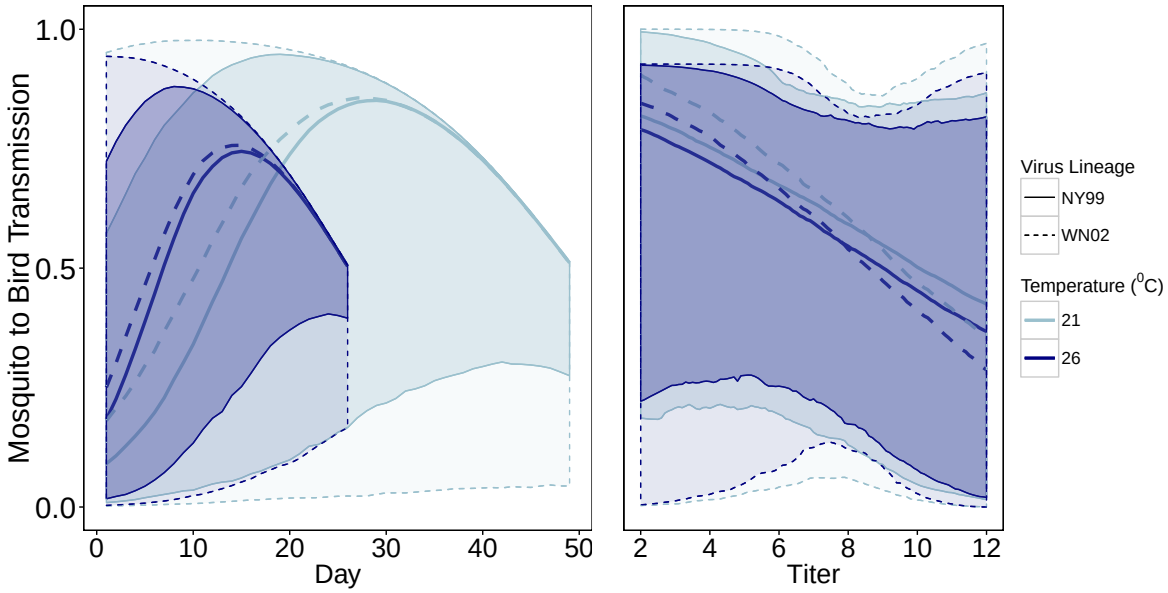

Figure S4.6: Figure 4a, b from the main text without JEV data. See Section 5 for coefficient plots for mosquito to bird transmission without JEV data.

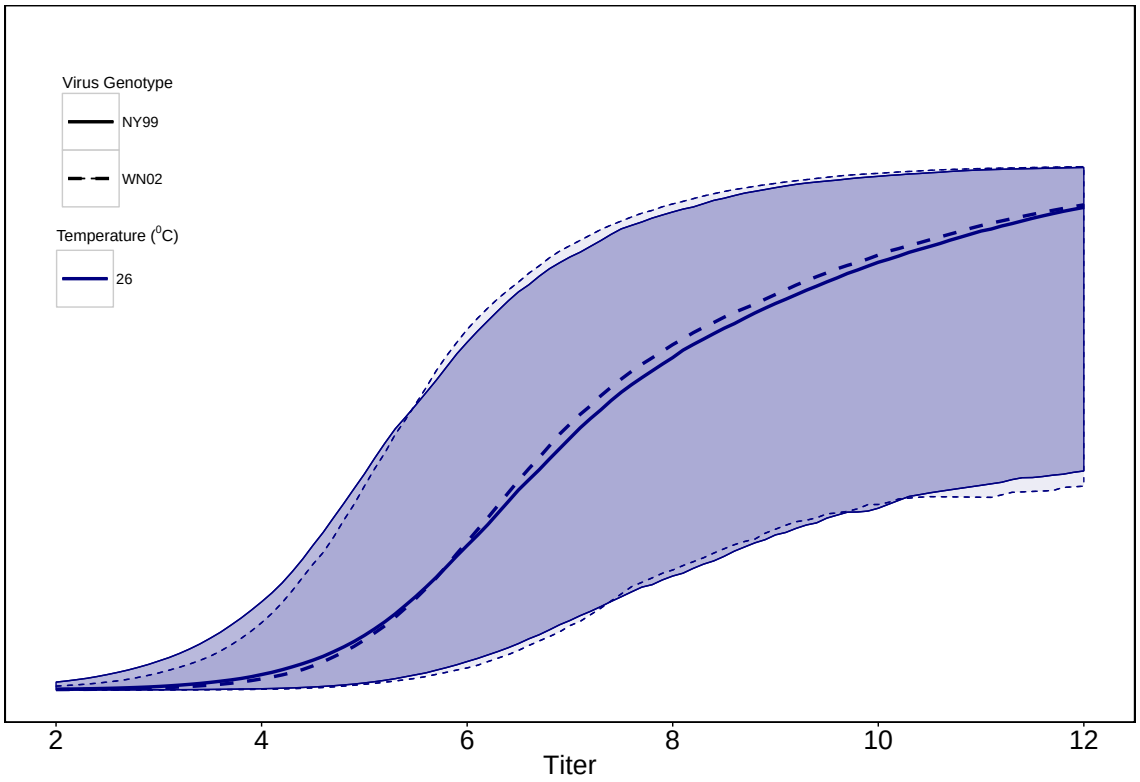

Figure S4.7: Vector-Competence for NY99 and WN02. Vector Competence at 26 Degrees Celcius, generated by combining Bird-to-Mosquito and Mosquito-to-Bird transmission (conditioning Mosquito-to-Bird transmission on all mosquitos that fed on an infected blood sample).

(5) R_0 Caculations without Japanese Encephalitis Virus (JEV) data

Here we present the analysis presented in the primary manuscript removing all "prior information" on mosquito transmission at lower titers using transmission of the closely realted JEV virus. Here we present parameter estimates for the Mosquito to Bird transmission model and R_0 estimates with and without the JEV transmission data.

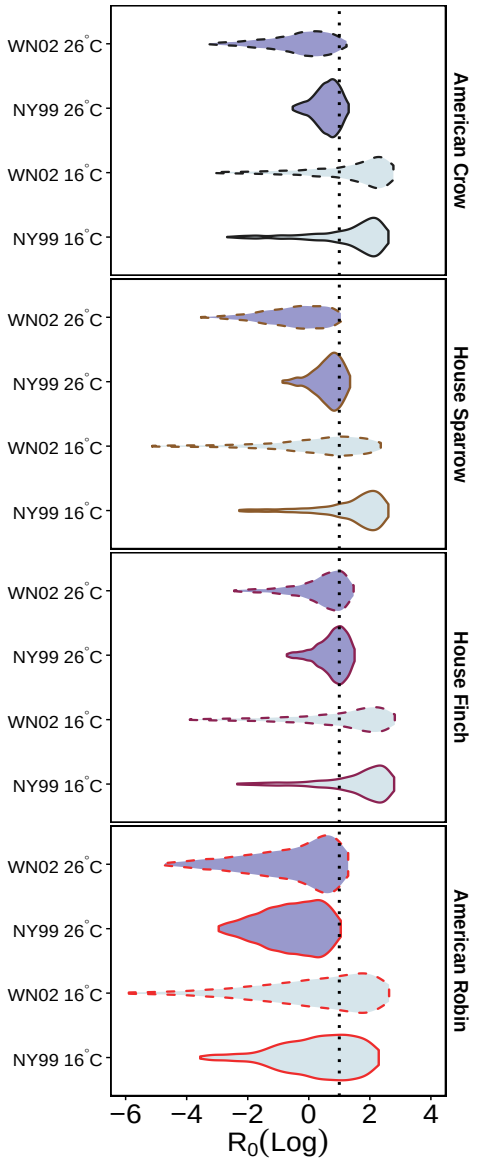

Figure S5: R_0*without* JEV data. Panels correspond to Figure 5 in the main text.

Community R_0s without JEV

In the Chicago, IL community *with* "other" birds median R_0 for NY99 was greater than WN02, but credible intervals overlap:

NY99 at 16^0C, Median: 0.83, CI: 0.02-3.06;

WN02 at 16^0C, Median: 1.54, CI: 0.01-4.93;

NY99 at 26^0C, Median: 0.30, CI: 0.07-0.88;

WN02 at 26^0C, Median: 0.55, CI: 0.06-1.33.

In the Chicago, IL community *without* "other" birds median R_0 WN02 was greater than NY99, but credible intervals also overlap:

NY99 at 16^0C, Median: 1.18, CI: 0.03-5.70;

WN02 at 16^0C, Median: 1.06, CI: 0.002-7.38;

NY99 at 26^0C, Median: 0.42, CI: 0.08-1.63;

WN02 at 26^0C, Median: 0.49, CI: 0.02-1.96.

(6) Coefficient plots for all models

In this section we include all coefficient plots for the fixed effects, random effects, and for the linear predictors from one of the random effects of our choice for each model.

Titer

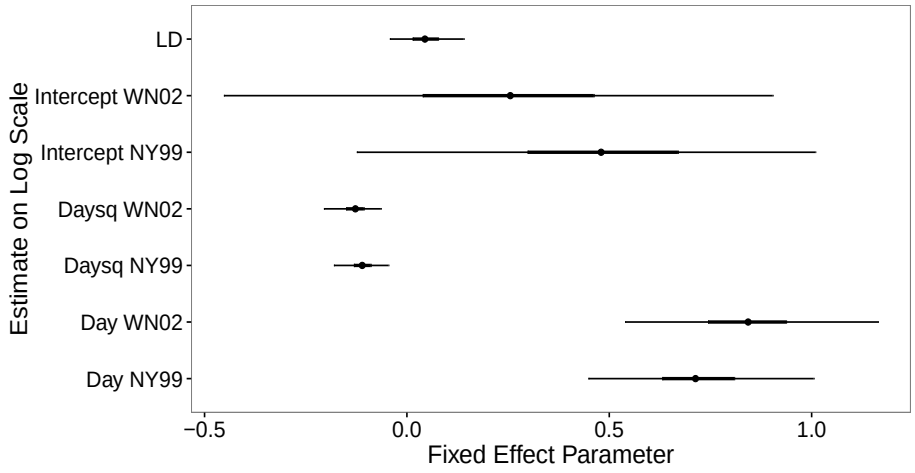

Figure S6.1: Fixed Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
LD	0.046	0.047	-0.042	0.014	0.044	0.077	0.140
Intercept WN02	0.249	0.336	-0.452	0.039	0.255	0.462	0.904
Intercept NY99	0.472	0.295	-0.124	0.298	0.480	0.670	1.009
Day WN02	0.843	0.156	0.539	0.744	0.843	0.937	1.164
Day NY99	0.719	0.139	0.448	0.631	0.713	0.809	1.005
Daysq WN02	-0.129	0.036	-0.205	-0.150	-0.127	-0.107	-0.064
Daysq NY99	-0.111	0.034	-0.180	-0.131	-0.110	-0.089	-0.046

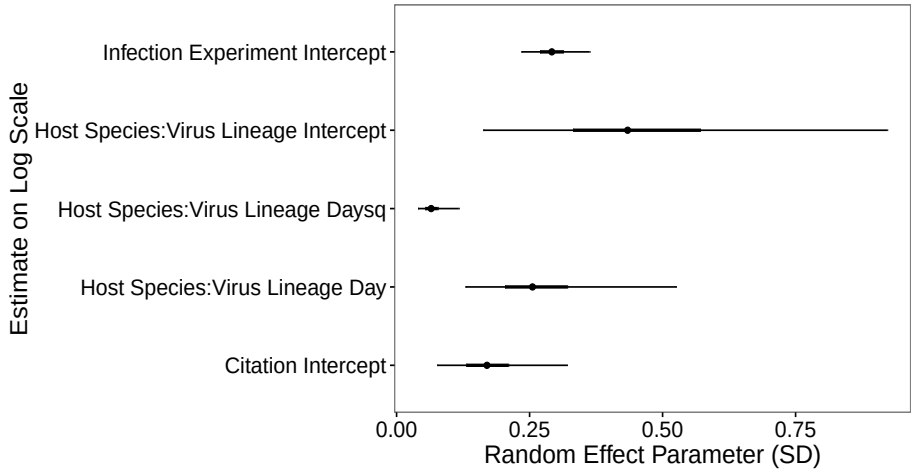

Figure S6.2: Random Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Infection Experiment Intercept	0.293	0.032	0.235	0.270	0.292	0.313	0.363
Host Species:Virus Lineage Daysq	0.068	0.021	0.040	0.054	0.065	0.077	0.117
Host Species:Virus Lineage Intercept	0.462	0.194	0.163	0.332	0.434	0.570	0.922
Host Species:Virus Lineage Day	0.272	0.101	0.130	0.204	0.255	0.321	0.525
Citation Intercept	0.176	0.062	0.076	0.131	0.170	0.210	0.320

Survival

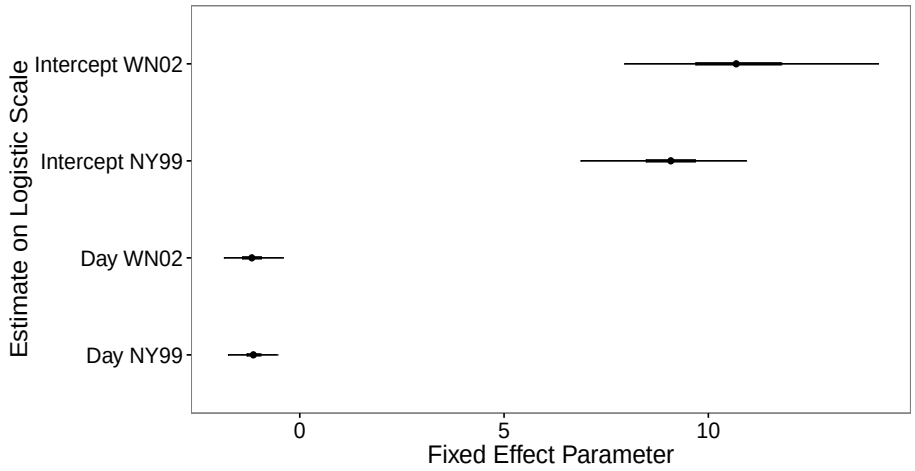

Figure S6.3: Fixed Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Intercept WN02	10.767	1.575	7.944	9.685	10.682	11.783	14.152
Intercept NY99	9.044	1.038	6.874	8.470	9.081	9.673	10.923
Day WN02	-1.163	0.365	-1.857	-1.406	-1.174	-0.949	-0.412
Day NY99	-1.135	0.286	-1.758	-1.299	-1.136	-0.960	-0.547

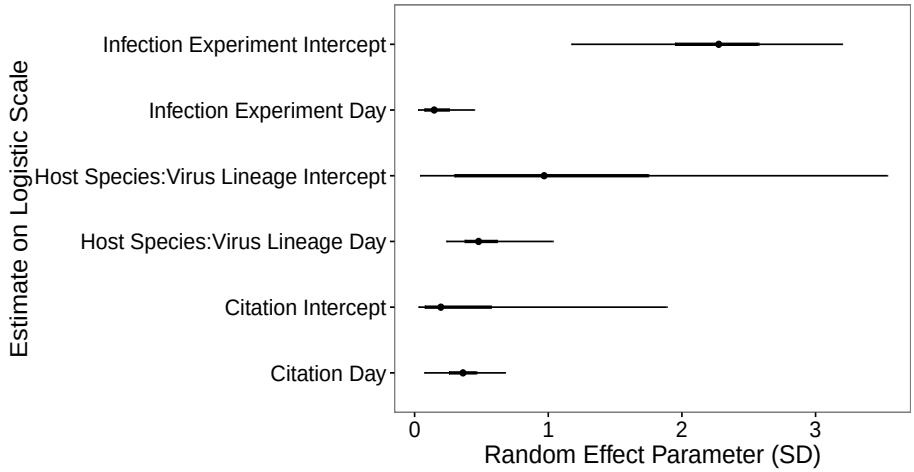

Figure S6.4: Random Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Infection Experiment Intercept	2.254	0.503	1.174	1.949	2.275	2.573	3.199
Infection Experiment Day	0.176	0.122	0.026	0.074	0.146	0.257	0.446
Host Species:Virus Lineage Intercept	1.181	1.068	0.042	0.299	0.969	1.748	3.536
Host Species:Virus Lineage Day	0.519	0.211	0.238	0.375	0.479	0.617	1.034
Citation Intercept	0.419	0.508	0.030	0.076	0.196	0.571	1.886
Citation Day	0.363	0.156	0.074	0.257	0.362	0.463	0.677

Bird to Mosquito Transmission

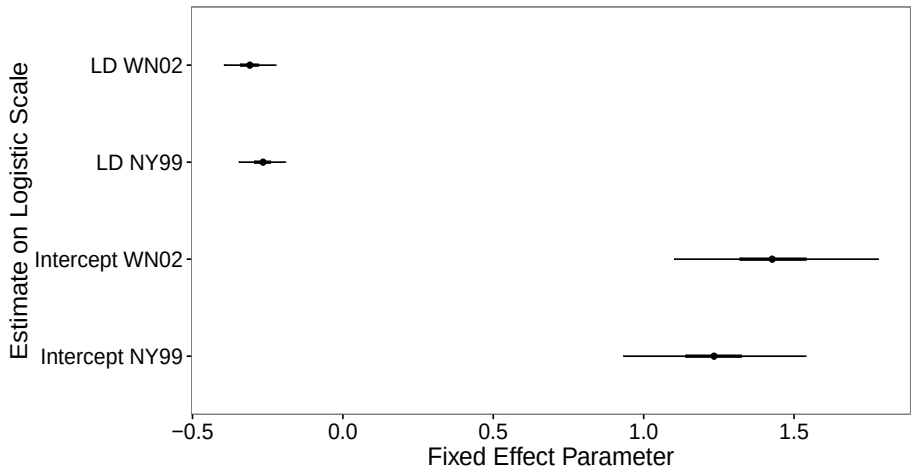

Figure S6.5: Fixed Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Intercept WN02	1.431	0.174	1.101	1.319	1.427	1.539	1.779
Intercept NY99	1.233	0.152	0.932	1.139	1.234	1.324	1.539
LD WN02	-0.310	0.044	-0.396	-0.341	-0.309	-0.282	-0.224
LD NY99	-0.267	0.039	-0.346	-0.295	-0.265	-0.242	-0.191

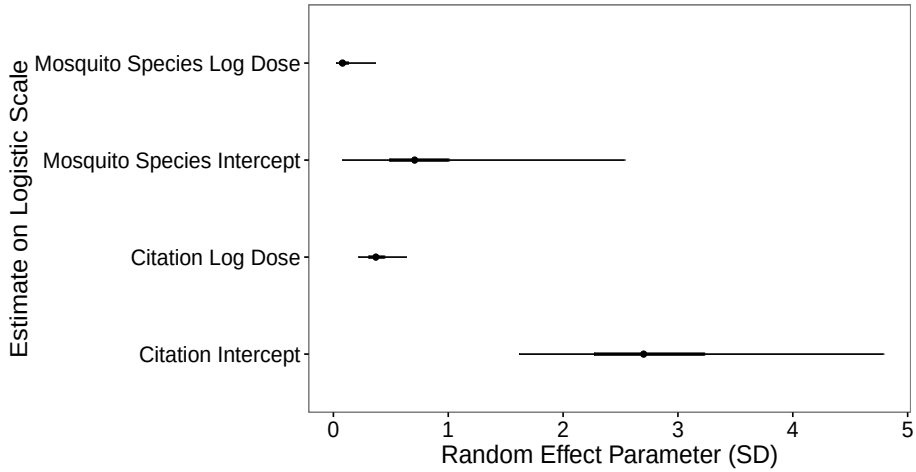

Figure S6.6: Random Effects (no intercept displayed)

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Mosquito Species Log Dose	0.106	0.097	0.024	0.049	0.080	0.126	0.362
Mosquito Species Intercept	0.839	0.620	0.078	0.488	0.707	1.003	2.535
Citation Log Dose	0.384	0.107	0.217	0.306	0.370	0.443	0.632
Citation Intercept	2.817	0.787	1.617	2.271	2.701	3.229	4.788

Mosquito to Bird Transmission: *With* JEV

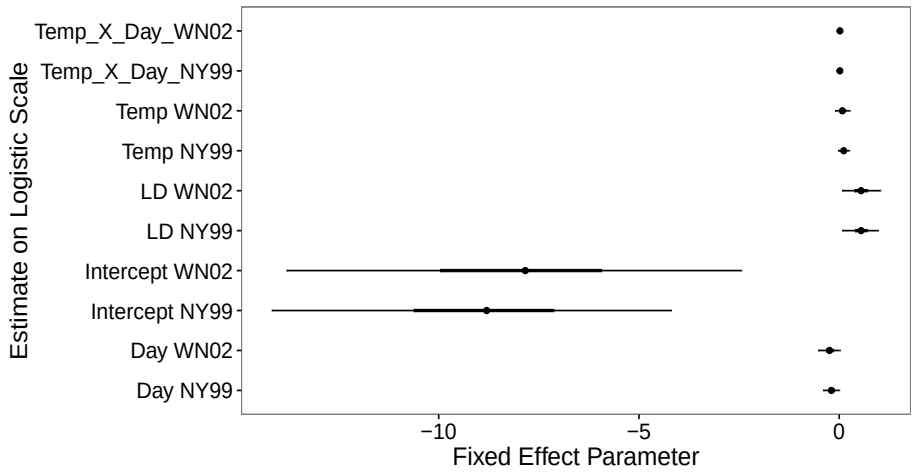

Figure S6.7: Fixed Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Temp_X_Day_WN02	0.018	0.005	0.009	0.015	0.018	0.021	0.028
Temp_X_Day_NY99	0.017	0.004	0.010	0.014	0.017	0.019	0.024
Temp WN02	0.078	0.092	-0.106	0.018	0.078	0.138	0.261
Temp NY99	0.112	0.072	-0.028	0.066	0.112	0.158	0.251
LD WN02	0.546	0.240	0.074	0.386	0.546	0.699	1.025
LD NY99	0.539	0.222	0.077	0.398	0.546	0.689	0.965
Intercept WN02	-7.957	2.954	-13.795	-9.961	-7.838	-5.947	-2.444
Intercept NY99	-8.919	2.518	-14.166	-10.620	-8.802	-7.134	-4.198
Day WN02	-0.242	0.135	-0.522	-0.328	-0.242	-0.149	0.014
Day NY99	-0.197	0.100	-0.399	-0.261	-0.196	-0.131	0.000

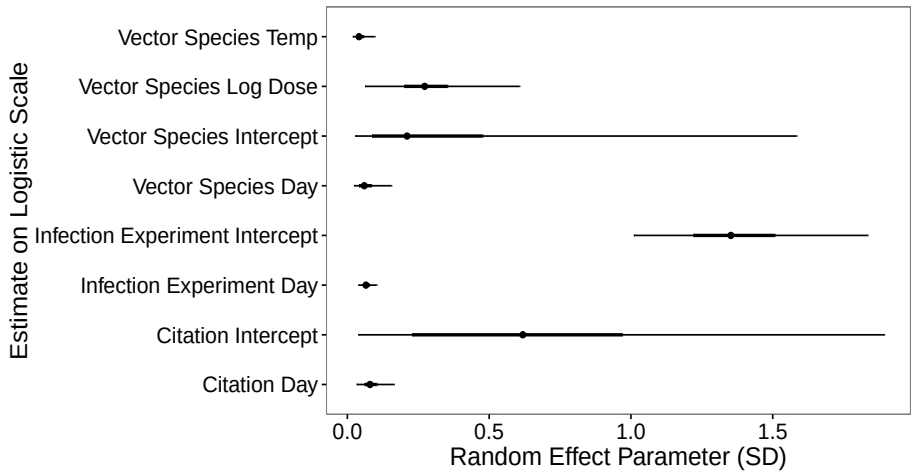

Figure S6.8: Random Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Vector Species Temp	0.046	0.020	0.019	0.031	0.041	0.056	0.096
Vector Species Log Dose	0.286	0.132	0.062	0.201	0.273	0.352	0.607
Vector Species Intercept	0.370	0.432	0.028	0.087	0.210	0.476	1.584
Vector Species Day	0.068	0.036	0.023	0.041	0.060	0.084	0.155
Infection Experiment Intercept	1.372	0.211	1.010	1.220	1.352	1.507	1.835
Infection Experiment Day	0.067	0.016	0.039	0.056	0.065	0.076	0.103
Citation Intercept	0.671	0.508	0.039	0.229	0.619	0.969	1.893
Citation Day	0.084	0.034	0.033	0.061	0.080	0.103	0.164

Mosquito to Bird Transmission: *Without* JEV

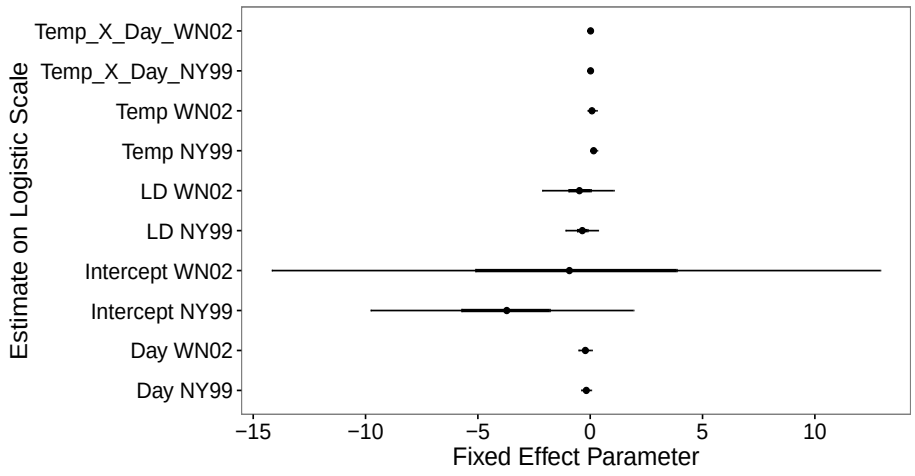

Figure S6.9: Fixed Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Temp_X_Day_WN02	0.018	0.006	0.007	0.015	0.018	0.022	0.029
Temp_X_Day_NY99	0.017	0.004	0.010	0.015	0.017	0.019	0.025
Temp WN02	0.079	0.104	-0.111	0.011	0.078	0.146	0.293
Temp NY99	0.153	0.078	0.004	0.103	0.152	0.204	0.313
LD WN02	-0.484	0.782	-2.134	-0.964	-0.480	0.027	1.050
LD NY99	-0.350	0.364	-1.097	-0.584	-0.352	-0.115	0.349
Intercept WN02	-0.644	6.983	-14.172	-5.112	-0.926	3.849	12.911
Intercept NY99	-3.752	2.972	-9.772	-5.732	-3.715	-1.800	1.925
Day WN02	-0.220	0.149	-0.520	-0.312	-0.216	-0.126	0.074
Day NY99	-0.174	0.111	-0.396	-0.246	-0.173	-0.106	0.041

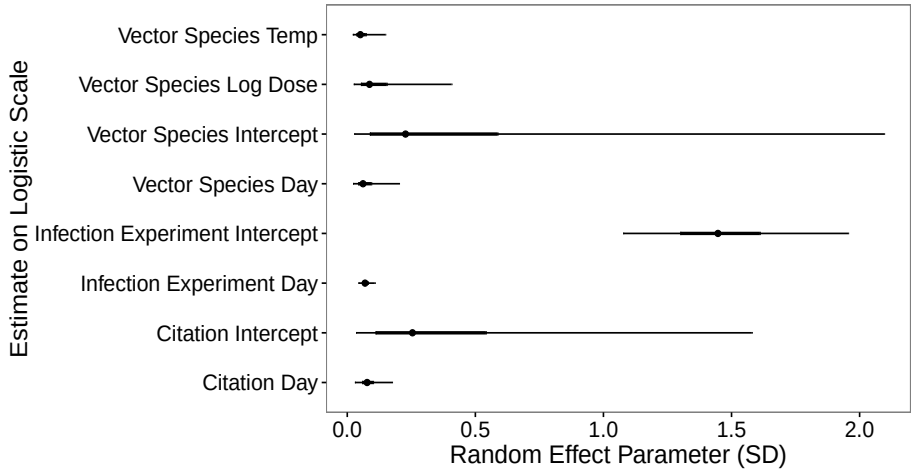

Figure S6.10: Random Effects

Parameter	Mean	SD	ci2.5	ci25	ci50	ci75	ci97.5
Vector Species Temp	0.060	0.036	0.022	0.036	0.051	0.072	0.148
Vector Species Log Dose	0.123	0.105	0.025	0.053	0.087	0.154	0.407
Vector Species Intercept	0.457	0.580	0.027	0.088	0.227	0.586	2.096
Vector Species Day	0.076	0.053	0.022	0.043	0.061	0.094	0.202
Infection Experiment Intercept	1.463	0.225	1.077	1.300	1.447	1.611	1.955
Infection Experiment Day	0.071	0.016	0.044	0.060	0.069	0.081	0.108
Citation Intercept	0.392	0.405	0.034	0.111	0.255	0.541	1.579
Citation Day	0.083	0.037	0.030	0.058	0.077	0.101	0.175

(7) Amplification Fraction Table

Species	Lower	Median	Upper
American Crow	0.000	0.000	0.003
House Sparrow	0.089	0.551	0.939
House Finch	0.004	0.031	0.222
American Robin	0.017	0.391	0.892

(8) Stan model notes

All stan models are available as .stan files in the online supplement and in the Github repository `https://github.com/morgankain/WNV_Synthesis.git`

For the titer profiles model, fixed effect parameters were given uninformative cauchy priors: intercepts were given cauchy(0, 10) priors and slopes were given cauchy(0, 2.5) priors. Variance parameters with positive constraints were given uninformative inverse gamma priors.

For the bird survival model, bird to mosquito transmission, and mosquito to bird transmission models parameters without constraints such as intercept or slope coefficients, were given normal(0.0, 1.0E3) priors. Variance parameters with positive constraints were given gamma(1.0E-3, 1.0E-3) priors.

References

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