

Supplementary Materials for **Landscape variation influences trophic cascades in dengue vector food webs**

Robbie Weterings, Chanin Umponstira, Hannah L. Buckley

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This PDF file includes:

- table S1. Theoretical framework used to develop the hypothetical a priori models.
- table S2. Parameter estimates (Est.) for all direct and indirect effects in the terrestrial structural equation model.
- table S3. Parameter estimates (Est.) for all direct and indirect effects in the aquatic structural equation model.
- References (43–75)

table S1. Theoretical framework used to develop the hypothetical a priori models. This theory is based on our experimental work and data from the literature.

Species group	Species	Species interactions	Environment
Terrestrial food web			
Aedes adults	<i>Aedes aegypti</i> , <i>Aedes albopictus</i> and others.		Some <i>Aedes</i> species are associated with forest habitats (<i>Ae. albopictus</i>) while others are more associated with urban habitats (<i>Ae. aegypti</i>)(25). <i>Aedes</i> mosquito populations are generally higher in areas with more container habitats including water-filled treeholes (43). <i>Aedes</i> populations are generally higher during the rainy season due to increased numbers of breeding habitats (2, 44). However, temperature is a stronger predictor for <i>Aedes</i> abundance in Thailand (45).
Arachnids	Pholcidae, Salticidae, Arachnidae amongst others	<i>Crossopriza lyoni</i> , the most common Pholcidae in Kamphaeng Phet, has a predation rate of approximately 1.1 adult mosquito per day (16). We found that the most common Salticidae in Kamphaeng Phet have predation rates of approximately 4.3 to 10.8 adult mosquitoes per day (12).	Spiders densities are often higher in structurally complex habitats such as forest (46). Spider communities can be strongly affected by climatic events, such as rain or drought (47).
House geckos	<i>Hemidactylus frenatus</i> , <i>H. platyurus</i> and <i>Gehyra</i> spp.	<i>Hemidactylus frenatus</i> has a predation rate of approximately 63 adult mosquitoes per day (15). In an observational study we found that <i>H. frenatus</i> and <i>H. platyurus</i> from Kamphaeng Phet show a slight feeding preference for mosquitoes over most other prey (13).	<i>Hemidactylus frenatus</i> and <i>H. platyurus</i> are habitat generalists that can be found in almost any landscape within Southeast Asia (48). <i>H. frenatus</i> has been reported to reach very high densities in urban habitats (49).
Tokay	<i>Gekko gecko</i>	<i>Gekko gecko</i> from Thailand has been reported to feed on large insects and other large prey such as lizards and rats (50–52). Small prey, such as mosquitoes and non-active prey such as spiders, have not been reported to form an important part of its diet.	<i>Gekko gecko</i> is an arboreal species (53) that is sometimes found in urban areas as well (50). Its reproductive cycle is seasonal and may relate to certain climatic events (54).
Cats	<i>Felis catus</i>	Domesticated cats are known to reduce lizard populations including <i>Hemidactylus</i> species (55–57).	Domesticated cats are likely to be more common in agricultural and urban landscapes where household density is high in comparison to forest landscapes.

Aquatic food web			
<i>Aedes</i> larvae	<i>Aedes aegypti</i> , <i>Ae. albopictus</i> and others.	-	<i>Aedes</i> larvae are mainly found in container-like habitats (25). They need detritus as nutrition (58) and often occur in rain-water filled habitats (25). Rain-water is typical nutrient poor, slightly acid and has a low turbidity (59).
Backswimmers	<i>Notonecta</i> spp. and <i>Anisops</i> spp.	Many backswimmer species feed on mosquito larvae (19, 60, 61). Predation rates range between 1- 34 mosquito larvae per day. In an experimental study we have shown that the predation rates for a common species from Kamphaeng Phet ranges between 1.2 – 5.9 larvae per day (19).	Backswimmers are found in many different kinds of habitats (60). In Kamphaeng Phet they are more often found in container habitats in forest landscapes (11). Habitat isolation has a profound effect on its presence (11). Hence, container density may increase its occurrence. Habitat complexity (e.g. aquatic plants) may affect its feeding behaviour but also provides refuge (62). Backswimmers hunt by vision and water quality can therefore severely affect their feeding rate (63).
Anura	<i>Kaloula pulchra</i> , <i>Polypedates leucomystax</i> , <i>Bufo melanostictus</i> and <i>Hylarana raniceps</i> amongst others	We have shown that most local tadpoles do not feed on mosquito larvae (17). However, they are important egg predators (64) and strong competitors of mosquito larvae (65).	Several Anura species from Southeast Asia are often found in urban areas while others are more arboreal (66). The reproductive cycle of Anura is climate dependent (66). Anura are very sensitive to pollution, hence water quality is important (67).
Micro-heteroptera	Corixidae, Pleidae and Veliidae	Previously we have shown that allometry is an important factor in context of predation rates for local Heteroptera (18). Hence, small heteroptera are expected to have lower predation rates in comparison to Notonecta, for example. Although small in size, Corixidae, Pleidae and Veliidae can have a strong effect on mosquito larval abundance (68–70).	Corixidae, Pleidae and Veliidae occur often in small container-like habitats (68). They are common in many different aquatic habitats in various landscapes types including forest, urban and agricultural landscapes (71, 72).
<i>Toxorhynchites</i> spp.	<i>Toxorhynchites splendens</i>	<i>Toxorhynchites splendens</i> is a common local species that has a predation rate of 19.2 or higher (11). It is specialised in feeding on mosquito larvae (73). In addition, we found that <i>Toxorhynchites splendens</i> reduces <i>Aedes</i> larvae in greater numbers than <i>Culex</i> larvae when occurring in the same aquatic habitat (11).	<i>Toxorhynchites</i> spp. are arboreal and are often found in water-filled treeholes (74). Habitat isolation has a strong effect on its occurrence (11). Hence, container density may increase its occurrence. It is highly dependent on climatic conditions for its food and reproductive cycle (75).

table S2. Parameter estimates (Est.) for all direct and indirect effects in the terrestrial structural equation model. SE is the standard error and Std. Est. is the standardized parameter estimate.

Effects	Alternative model			
	Est.	SE	P-value	Std. Est.
Latent variables				
<i>Seasonality</i>				
Precipitation	-0.580	0.178	0.001	-0.584
Temperature	0.904	0.279	0.001	0.911
<i>Landscape</i>				
Forest	-0.998	0.102	< 0.001	-0.997
Agriculture	0.735	0.103	< 0.001	0.741
Water	0.081	0.091	0.373	0.082
Regressions				
<i>Aedes mosquitoes</i>				
House geckos → <i>Aedes</i>	-2.123	1.086	0.050	-0.261
House geckos → Spiders → <i>Aedes</i>	0.707	0.519	0.173	-0.087
Total	-1.415	1.136	0.213	0.174
Spiders → <i>Aedes</i>	-1.042	0.508	0.040	-0.262
Seasonality → <i>Aedes</i>	-0.214	0.136	0.115	-0.287
Seasonality → Spiders → <i>Aedes</i>	0.063	0.044	0.153	0.085
Seasonality → House geckos → <i>Aedes</i>	-0.003	0.027	0.900	-0.004
Seasonality → House geckos → Spiders → <i>Aedes</i>	0.000	0.001	0.896	0.001
Seasonality → Tokays → House geckos → <i>Aedes</i>	0.007	0.010	0.485	0.009
Seasonality → Tokays → House geckos → Spiders → <i>Aedes</i>	-0.002	0.004	0.581	-0.003
Seasonality → Containers → <i>Aedes</i>	-0.059	0.041	0.152	-0.079
Total indirect effects	0.005	0.053	0.923	0.008
Total	-0.209	0.116	0.072	-0.279
Landscape → <i>Aedes</i>	0.042	0.078	0.586	0.057
Landscape → Spiders → <i>Aedes</i>	0.017	0.023	0.452	0.023
Landscape → House geckos → <i>Aedes</i>	-0.046	0.045	0.304	-0.062
Landscape → House geckos → Spiders → <i>Aedes</i>	0.015	0.011	0.174	0.021
Landscape → Tokays → House geckos → <i>Aedes</i>	-0.047	0.023	0.044	-0.063
Landscape → Tokays → House geckos → Spiders → <i>Aedes</i>	0.016	0.015	0.291	0.021
Landscape → Cats → House geckos → <i>Aedes</i>	-0.211	0.159	0.183	-0.026

Landscape → Cats → House geckos → Spiders → <i>Aedes</i>	0.070	0.058	0.230	0.009
Total indirect effects	-0.186	0.187	0.321	-0.078
Total	-0.143	0.165	0.384	-0.021
Containers → <i>Aedes</i>	0.222	0.116	0.056	0.294
<i>Indirect effects</i>				
Cats → House geckos → <i>Aedes</i>	0.041	0.027	0.132	0.055
Cats → House geckos → Spiders → <i>Aedes</i>	-0.014	0.011	0.202	-0.018
Cats total indirect effects	0.027	0.026	0.285	0.036
Tokays → House geckos → <i>Aedes</i>	0.898	0.451	0.046	0.111
Tokays → House geckos → Spiders → <i>Aedes</i>	-0.299	0.296	0.312	-0.037
Tokays total indirect effects	0.599	0.383	0.118	0.074
<i>Spiders</i>				
House geckos → Spiders	-0.679	0.270	0.012	-0.332
Landscape → Spiders	-0.017	0.020	0.403	-0.088
Landscape → House geckos → Spiders	-0.015	0.009	0.105	-0.079
Landscape → Cats → House geckos → Spiders	0.001	0.001	0.128	0.007
Landscape → Tokays → House geckos → Spiders	-0.015	0.010	0.116	-0.080
Total indirect effects	-0.029	0.011	0.012	-0.152
Total	-0.045	0.019	0.017	-0.240
Seasonality → Spiders	-0.061	0.026	0.018	-0.323
Seasonality → House geckos → Spiders	-0.001	0.008	0.899	-0.006
Seasonality → Tokays → House geckos → Spiders	0.002	0.004	0.541	0.011
Total indirect effects	0.001	0.009	0.901	0.006
Total	-0.060	0.024	0.014	-0.317
<i>Indirect effects</i>				
Cats → House geckos → Spiders	0.013	0.006	0.027	0.069
Tokays → House geckos → Spiders	0.287	0.199	0.149	0.141
<i>House geckos</i>				
Tokays → House geckos	-0.423	0.171	0.014	-0.425
Landscape → House geckos	0.022	0.015	0.153	0.057
Landscape → Tokays → House geckos	0.022	0.008	0.006	0.241
Total	0.044	0.012	< 0.001	0.479
Seasonality → House geckos	0.002	0.013	0.901	0.017

Seasonality → Tokays → House geckos	-0.003	0.005	0.504	-0.035
Total	-0.002	0.013	0.899	-0.017
Cats → House geckos	-0.019	0.005	< 0.001	-0.209
<i>Container habitats</i>				
Seasonality → Containers	-0.268	0.223	0.229	-0.270
<i>Tokay</i>				
Landscape → Tokay	-0.052	0.010	< 0.001	-0.568
Seasonality → Tokay	0.008	0.010	0.471	0.081
<i>Cats</i>				
Landscape → Cats	0.099	0.049	0.044	0.100
Co-variance				
Landscape ~ Seasonality	0.072	0.158	0.651	0.072

table S3. Parameter estimates (Est.) for all direct and indirect effects in the aquatic structural equation model. SE is the standard error and Std. Est. is the standardized parameter estimate.

Effects	Alternative model			
	Est.	SE	P-value	Std. Est.
Latent Variables				
<i>Seasonality</i>				
Precipitation	-0.601	0.156	< 0.001	0.603
Temperature	-0.977	0.195	< 0.001	-0.980
<i>Landscape</i>				
Forest	0.912	0.147	< 0.001	0.915
Agriculture	-0.783	0.120	< 0.001	-0.786
Water	-0.089	0.111	0.420	-0.090
<i>Abiotic factors</i>				
EC	0.398	0.110	< 0.001	0.460
pH	0.394	0.134	0.003	0.456
Turbidity (ordinal)	0.470	0.106	< 0.001	0.540
Regressions				
<i>Aedes larvae</i> (presence/absence)				
Abiotic factors	-0.398	0.218	0.068	-0.424
Abiotic factors → Large predators → <i>Aedes larvae</i>	-0.054	0.081	0.505	-0.058
Abiotic factors → Large predators → Micro-Heteroptera → <i>Aedes larvae</i>	-0.001	0.005	0.859	-0.001
Abiotic factors → Micro-Heteroptera → <i>Aedes larvae</i>	-0.016	0.042	0.707	-0.017
Total indirect	-0.071	0.093	0.447	-0.076
Total	-0.469	0.260	0.071	-0.499
Landscape	-0.258	0.188	0.170	-0.239
Landscape → Large predators → <i>Aedes larvae</i>	-0.146	0.058	0.012	-0.135
Landscape → Micro-Heteroptera → <i>Aedes larvae</i>	-0.019	0.034	0.583	-0.017
Landscape → Large predators → Micro-Heteroptera → <i>Aedes larvae</i>	-0.002	0.013	0.858	-0.002
Landscape → Plants → <i>Aedes larvae</i>	0.003	0.042	0.950	0.002
Landscape → Plants → Large predators → <i>Aedes larvae</i>	0.002	0.032	0.949	0.002
Landscape → Plants → Large predators → Micro-Heteroptera → <i>Aedes larvae</i>	0.000	0.001	0.948	0.000
Landscape → Plants → Micro-Heteroptera → <i>Aedes larvae</i>	0.000	0.002	0.958	0.000

Landscape → Containers → <i>Aedes</i> larvae	0.011	0.013	0.390	0.010
Landscape → Containers → Large predators → <i>Aedes</i> larvae	0.004	0.005	0.474	0.004
Landscape → Containers → Micro-Heteroptera → <i>Aedes</i> larvae	-0.002	0.003	0.444	-0.002
Landscape → Containers → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	0.000	0.000	0.866	0.000
Landscape → Abiotic → <i>Aedes</i> larvae	0.167	0.117	0.152	0.167
Total indirect	-0.150	0.098	0.128	-0.138
Total	-0.408	0.173	0.018	-0.377
Seasonality	0.083	0.125	0.508	0.077
Seasonality → Large predators → <i>Aedes</i> larvae	-0.026	0.055	0.636	-0.024
Seasonality → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	-0.000	0.003	0.872	-0.000
Seasonality → Micro-Heteroptera → <i>Aedes</i> larvae	-0.016	0.031	0.612	-0.016
Seasonality → Abiotic → <i>Aedes</i> larvae	-0.127	0.100	0.204	-0.118
Seasonality → Abiotic → Large predators → <i>Aedes</i> larvae	-0.017	0.028	0.538	-0.016
Seasonality → Abiotic → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	-0.000	0.002	0.859	-0.000
Seasonality → Abiotic → Micro-Heteroptera → <i>Aedes</i> larvae	-0.005	0.014	0.710	-0.005
Seasonality → Containers → <i>Aedes</i> larvae	-0.036	0.026	0.158	-0.033
Seasonality → Containers → Large predators → <i>Aedes</i> larvae	-0.013	0.013	0.332	-0.012
Seasonality → Containers → Micro-Heteroptera → <i>Aedes</i> larvae	0.007	0.007	0.316	0.006
Seasonality → Containers → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	-0.000	0.001	0.865	-0.000
Total indirect	-0.234	0.107	0.029	-0.218
Total	-0.151	0.127	0.232	-0.141
Containers	0.620	0.372	0.096	0.153
Containers → Large predators → <i>Aedes</i> larvae	0.218	0.210	0.299	0.054
Containers → Micro-Heteroptera → <i>Aedes</i> larvae	-0.114	0.104	0.270	-0.028
Containers → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	0.003	0.020	0.864	0.001
Total indirect	0.107	0.228	0.638	0.026
Total	0.727	0.393	0.064	0.179
Plants	-0.262	0.304	0.389	-0.243
Plants → Large predators → <i>Aedes</i> larvae	-0.203	0.075	0.007	-0.188
Plants → Micro-Heteroptera → <i>Aedes</i> larvae	-0.011	0.064	0.863	-0.010
Plants → Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	-0.003	0.018	0.859	-0.003
Total indirect	-0.218	0.082	0.008	-0.201
Total	-0.480	0.291	0.099	-0.444
Large predators	-0.444	0.197	0.024	-0.405
Large predators → Micro-Heteroptera → <i>Aedes</i> larvae	-0.007	0.040	0.860	-0.006
Total	-0.452	0.210	0.032	-0.411
Micro-Heteroptera	-0.272	0.100	0.007	-0.269

<i>Large predators</i>					
Abiotic		0.122	0.213	0.566	0.143
Containers		-0.491	0.399	0.218	-0.133
Landscape		0.329	0.120	0.006	0.334
	Landscape → Plants → Large predators	-0.005	0.073	0.949	-0.005
	Landscape → Abiotic → Large predators	-0.053	0.099	0.594	-0.054
	Landscape → Containers → Large predators	-0.009	0.011	0.448	-0.009
	Total indirect	-0.066	0.112	0.556	-0.067
	Total	0.263	0.090	0.003	0.267
Plants		0.458	0.167	0.006	0.465
	Plants → Abiotic → Large predators	-0.018	0.071	0.800	-0.018
	Total	0.440	0.127	0.001	0.446
Seasonality		0.058	0.112	0.658	0.045
	Seasonality → Abiotic → Large predators	0.039	0.073	0.591	0.040
	Seasonality → Containers → Large predators	0.029	0.026	0.276	0.029
	Total indirect	0.068	0.075	0.367	0.069
	Total	0.126	0.088	0.154	0.128

<i>Micro-Heteroptera</i>					
Large predators		0.026	0.144	0.857	0.024
Containers		0.420	0.330	0.203	0.105
	Containers → Large predators → Micro-Heteroptera	-0.013	0.073	0.861	-0.003
	Total	0.407	0.326	0.211	0.102
Abiotic		0.058	0.167	0.726	0.063
	Abiotic → Large predators → Micro-Heteroptera	0.003	0.017	0.856	0.003
	Total	0.062	0.162	0.704	0.067
Landscape		0.068	0.135	0.614	0.064
	Landscape → Plants → Micro-Heteroptera	-0.000	0.008	0.959	-0.000
	Landscape → Abiotic → Micro-Heteroptera	-0.025	0.073	0.730	-0.024
	Landscape → Large predators → Micro-Heteroptera	0.009	0.047	0.855	0.008
	Landscape → Plants → Large predators → Micro-Heteroptera	-0.000	0.002	0.948	-0.000
	Landscape → Abiotic → Large predators → Micro-Heteroptera	-0.001	0.008	0.856	-0.001
	Landscape → Containers → Micro-Heteroptera	0.007	0.009	0.425	0.007
	Landscape → Containers → Large predators → Micro-Heteroptera	-0.000	0.001	0.863	-0.000
	Total indirect	-0.012	0.099	0.907	-0.011
	Total	0.057	0.092	0.540	0.053
Plants		0.040	0.242	0.867	0.038
	Plants → Abiotic → Micro-Heteroptera	-0.009	0.034	0.799	-0.008

Plants → Large predators → Micro-Heteroptera	0.012	0.064	0.856	0.011
Plants → Abiotic → Large predators → Micro-Heteroptera	-0.000	0.003	0.872	-0.000
Total indirect	-0.001	0.068	0.994	0.000
Total	0.035	0.179	0.845	0.033
Seasonality	0.048	0.108	0.658	0.045
Seasonality → Abiotic → Micro-Heteroptera	0.019	0.054	0.728	0.018
Seasonality → Large predators → Micro-Heteroptera	0.002	0.009	0.869	0.001
Seasonality → Abiotic → Large predators → Micro-Heteroptera	0.001	0.006	0.856	0.001
Seasonality → Containers → Micro-Heteroptera	-0.024	0.022	0.271	-0.023
Seasonality → Containers → Large predators → Micro-Heteroptera	0.001	0.004	0.862	0.001
Total indirect	-0.003	0.058	0.965	-0.002
Total	0.045	0.090	0.615	0.043
<i>Abiotic factors</i>				
Landscape	-0.432	0.159	0.007	-0.375
Landscape → Plants → Abiotic factors	0.001	0.023	0.949	0.001
Total	-0.431	0.159	0.007	-0.374
Seasonality	-0.320	0.172	0.063	0.278
Plants	-0.147	0.371	0.692	-0.128
<i>Containers</i>				
Landscape	0.017	0.016	0.288	0.065
Seasonality	-0.058	0.023	0.010	-0.219
<i>Plants</i>				
Landscape	-0.010	0.160	0.949	-0.010
Covariance				
EC ~ pH	0.183	0.089	0.041	0.233
Landscape ~ Seasonality	-0.067	0.083	0.445	-0.068