Ecotoxicology is not normal.

How the use of proper statistical models can increase statistical power in ecotoxicological experiments.

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1 Supplement 1 - Additional Figures / Tables

1.1 Count data simulations

Table 1: Count data simulations - Proportion of models converged. N = sample sizes, μ_C = mean abundance in control, LM = Linear model after transformation, GLM_{nb} = negative binomial model, GLM_{qp} = quasi-Poisson model.

N	μ_C	LM	GLM_{nb}	GLM_{qp}
3.00	2.00	1.00	0.30	1.00
3.00	4.00	1.00	0.51	1.00
3.00	8.00	1.00	0.72	1.00
3.00	16.00	1.00	0.93	1.00
3.00	32.00	1.00	0.98	1.00
3.00	64.00	1.00	1.00	1.00
3.00	128.00	1.00	1.00	1.00
6.00	2.00	1.00	0.57	1.00
6.00	4.00	1.00	0.87	1.00
6.00	8.00	1.00	0.97	1.00
6.00	16.00	1.00	1.00	1.00
6.00	32.00	1.00	1.00	1.00
6.00	64.00	1.00	1.00	1.00
6.00	128.00	1.00	1.00	1.00
9.00	2.00	1.00	0.82	1.00
9.00	4.00	1.00	0.98	1.00
9.00	8.00	1.00	0.99	1.00
9.00	16.00	1.00	1.00	1.00
9.00	32.00	1.00	1.00	1.00
9.00	64.00	1.00	1.00	1.00
9.00	128.00	1.00	1.00	1.00

Table 2: Count data simulations - Power to detect a global treatment effect. N = sample sizes, μ_C = mean abundance in control, LM = Linear model after transformation, GLM_{nb} = negative binomial model, GLM_{qp} = quasi-Poisson model, GLM_{pb} = negative binomial model with parametric boostrap, np = pairwise Wilcoxon.

N	μ_C	LM	GLM_{nb}	GLM_{qp}	GLM_{pb}	np
3.00	2.00	0.14	0.17	0.19	0.07	0.09
3.00	4.00	0.13	0.18	0.20	0.08	0.05
3.00	8.00	0.21	0.38	0.24	0.19	0.12
3.00	16.00	0.28	0.45	0.32	0.26	0.18
3.00	32.00	0.33	0.54	0.45	0.36	0.18
3.00	64.00	0.30	0.57	0.35	0.37	0.14
3.00	128.00	0.25	0.57	0.35	0.32	0.13
6.00	2.00	0.30	0.33	0.33	0.21	0.27
6.00	4.00	0.36	0.45	0.43	0.33	0.26
6.00	8.00	0.44	0.65	0.59	0.53	0.44
6.00	16.00	0.58	0.78	0.72	0.65	0.49
6.00	32.00	0.59	0.82	0.71	0.67	0.51
6.00	64.00	0.65	0.74	0.73	0.68	0.63
6.00	128.00	0.80	0.91	0.85	0.84	0.70
9.00	2.00	0.34	0.30	0.35	0.27	0.30
9.00	4.00	0.54	0.65	0.65	0.61	0.47
9.00	8.00	0.56	0.74	0.73	0.67	0.58
9.00	16.00	0.80	0.89	0.90	0.88	0.79
9.00	32.00	0.88	0.93	0.92	0.91	0.89
9.00	64.00	0.90	0.94	0.95	0.93	0.91
9.00	128.00	0.91	0.95	0.93	0.94	0.91

Table 3: Count data simulations - Power to detect LOEC. N = sample sizes, μ_C = mean abundance in control, LM = Linear model after transformation, GLM_{nb} = negative binomial model, GLM_{qp} = quasi-Poisson model, np = Kruskal-Wallis test.

N	μ_C	LM	GLM_{nb}	GLM_{qp}	np
3.00	2.00	0.08	0.00	0.00	0.00
3.00	4.00	0.11	0.14	0.11	0.00
3.00	8.00	0.14	0.29	0.18	0.00
3.00	16.00	0.15	0.34	0.18	0.00
3.00	32.00	0.18	0.33	0.21	0.00
3.00	64.00	0.15	0.32	0.21	0.00
3.00	128.00	0.18	0.35	0.26	0.00
6.00	2.00	0.19	0.16	0.11	0.02
6.00	4.00	0.25	0.26	0.20	0.07
6.00	8.00	0.25	0.34	0.26	0.11
6.00	16.00	0.33	0.48	0.42	0.16
6.00	32.00	0.31	0.47	0.37	0.16
6.00	64.00	0.40	0.47	0.42	0.16
6.00	128.00	0.54	0.66	0.59	0.25
9.00	2.00	0.19	0.13	0.14	0.03
9.00	4.00	0.30	0.38	0.28	0.10
9.00	8.00	0.35	0.52	0.43	0.23
9.00	16.00	0.53	0.64	0.60	0.36
9.00	32.00	0.65	0.75	0.70	0.50
9.00	64.00	0.55	0.64	0.66	0.40
9.00	128.00	0.61	0.73	0.68	0.40

Table 4: Count data simulations - Type 1 error to detect a global treatment effect. N = sample sizes, μ_C = mean abundance in control, LM = Linear model after transformation, GLM_{nb} = negative binomial model, GLM_{qp} = quasi-Poisson model, GLM_{pb} = negative binomial model with parametric boostrap, np = Kruskal-Wallis test.

N	μ_C	LM	GLM_{nb}	GLM_{qp}	GLM_{pb}	np
3.00	2.00	0.09	0.03	0.00	0.10	0.04
3.00	4.00	0.07	0.11	0.04	0.06	0.03
3.00	8.00	0.05	0.11	0.09	0.07	0.01
3.00	16.00	0.03	0.12	0.05	0.03	0.01
3.00	32.00	0.05	0.14	0.05	0.04	0.00
3.00	64.00	0.02	0.11	0.04	0.04	0.00
3.00	128.00	0.07	0.19	0.05	0.09	0.02
6.00	2.00	0.04	0.03	0.03	0.05	0.02
6.00	4.00	0.04	0.12	0.05	0.09	0.04
6.00	8.00	0.05	0.04	0.04	0.04	0.03
6.00	16.00	0.04	0.09	0.04	0.06	0.04
6.00	32.00	0.06	0.08	0.06	0.07	0.05
6.00	64.00	0.05	0.06	0.05	0.05	0.03
6.00	128.00	0.04	0.09	0.02	0.04	0.01
9.00	2.00	0.04	0.03	0.03	0.05	0.05
9.00	4.00	0.05	0.07	0.03	0.07	0.04
9.00	8.00	0.08	0.12	0.07	0.09	0.08
9.00	16.00	0.07	0.09	0.06	0.08	0.06
9.00	32.00	0.06	0.07	0.05	0.06	0.05
9.00	64.00	0.03	0.06	0.04	0.04	0.03
9.00	128.00	0.05	0.07	0.04	0.07	0.02

Table 5: Count data simulations - Type 1 error to detect LOEC. N = sample sizes, μ_C = mean abundance in control, LM = Linear model after transformation, GLM_{nb} = negative binomial model, GLM_{qp} = quasi-Poisson model, np = pairwise Wilcoxon.

N	μ_C	LM	GLM_{nb}	GLM_{qp}	np
3.00	2.00	0.06	0.03	0.02	0.00
3.00	4.00	0.10	0.14	0.10	0.00
3.00	8.00	0.04	0.08	0.05	0.00
3.00	16.00	0.01	0.12	0.02	0.00
3.00	32.00	0.04	0.16	0.03	0.00
3.00	64.00	0.01	0.14	0.03	0.00
3.00	128.00	0.08	0.14	0.11	0.00
6.00	2.00	0.05	0.05	0.05	0.00
6.00	4.00	0.10	0.15	0.09	0.02
6.00	8.00	0.04	0.07	0.03	0.02
6.00	16.00	0.04	0.08	0.04	0.02
6.00	32.00	0.06	0.10	0.06	0.05
6.00	64.00	0.06	0.07	0.05	0.07
6.00	128.00	0.04	0.12	0.06	0.05
9.00	2.00	0.04	0.06	0.04	0.03
9.00	4.00	0.05	0.05	0.05	0.04
9.00	8.00	0.09	0.11	0.09	0.09
9.00	16.00	0.04	0.04	0.01	0.02
9.00	32.00	0.08	0.09	0.07	0.03
9.00	64.00	0.05	0.10	0.04	0.05
9.00	128.00	0.05	0.11	0.05	0.03

1.2 Binomial data simulations

Table 6: Binomial data simulations - Power to detect a global treatment effect. N = sample sizes, p_E = probability in effect treatments, LM = Linear model after transformation, GLM = binomial model, np = Kruskal-Wallis test.

N	p_E	LM	GLM	np
3.00	0.60	0.96	1.00	0.86
3.00	0.65	0.88	0.99	0.73
3.00	0.70	0.79	0.97	0.64
3.00	0.75	0.63	0.85	0.44
3.00	0.80	0.44	0.63	0.28
3.00	0.85	0.22	0.42	0.10
3.00	0.90	0.08	0.13	0.04
3.00	0.95	0.06	0.07	0.03
6.00	0.60	1.00	1.00	1.00
6.00	0.65	1.00	1.00	1.00
6.00	0.70	1.00	1.00	1.00
6.00	0.75	0.98	1.00	0.96
6.00	0.80	0.82	0.88	0.80
6.00	0.85	0.55	0.64	0.50
6.00	0.90	0.16	0.24	0.14
6.00	0.95	0.04	0.06	0.02
9.00	0.60	1.00	1.00	1.00
9.00	0.65	1.00	1.00	1.00
9.00	0.70	1.00	1.00	1.00
9.00	0.75	1.00	1.00	1.00
9.00	0.80	0.98	0.99	0.97
9.00	0.85	0.74	0.83	0.73
9.00	0.90	0.28	0.32	0.25
9.00	0.95	0.07	0.06	0.05

Table 7: Count data simulations - Power to detect LOEC. N = sample sizes, p_E = probability in effect treatments, LM = Linear model after transformation, GLM = binomial model, np = pairwise Wilcoxon.

N	p_E	LM	GLM	np
3.00	0.60	0.82	0.71	0.00
3.00	0.65	0.75	0.58	0.00
3.00	0.70	0.61	0.43	0.00
3.00	0.75	0.45	0.23	0.00
3.00	0.80	0.28	0.11	0.00
3.00	0.85	0.12	0.03	0.00
3.00	0.90	0.04	0.01	0.00
3.00	0.95	0.01	0.00	0.00
6.00	0.60	1.00	0.95	0.98
6.00	0.65	0.99	0.95	0.95
6.00	0.70	0.94	0.92	0.83
6.00	0.75	0.78	0.76	0.59
6.00	0.80	0.52	0.51	0.32
6.00	0.85	0.30	0.22	0.13
6.00	0.90	0.10	0.04	0.03
6.00	0.95	0.00	0.00	0.00
9.00	0.60	1.00	0.98	0.98
9.00	0.65	1.00	0.99	0.97
9.00	0.70	0.99	0.96	0.95
9.00	0.75	0.95	0.97	0.92
9.00	0.80	0.80	0.81	0.72
9.00	0.85	0.42	0.50	0.34
9.00	0.90	0.16	0.14	0.08
9.00	0.95	0.02	0.01	0.00

Table 8: Binomial data simulations - Type 1 error to detect a global treatment effect. N = sample sizes, p = probability, LM = Linear model after transformation, GLM = binomial model, np = Kruskal-Wallis test.

N	p	LM	GLM	np
3.00	0.60	0.03	0.03	0.02
3.00	0.65	0.04	0.06	0.01
3.00	0.70	0.05	0.04	0.00
3.00	0.75	0.05	0.06	0.01
3.00	0.80	0.06	0.06	0.01
3.00	0.85	0.06	0.06	0.02
3.00	0.90	0.06	0.09	0.02
3.00	0.95	0.04	0.04	0.02
6.00	0.60	0.07	0.08	0.06
6.00	0.65	0.04	0.05	0.04
6.00	0.70	0.04	0.06	0.04
6.00	0.75	0.04	0.06	0.04
6.00	0.80	0.05	0.06	0.03
6.00	0.85	0.04	0.05	0.03
6.00	0.90	0.06	0.08	0.04
6.00	0.95	0.04	0.08	0.03
9.00	0.60	0.05	0.04	0.04
9.00	0.65	0.06	0.04	0.04
9.00	0.70	0.08	0.06	0.07
9.00	0.75	0.04	0.04	0.03
9.00	0.80	0.03	0.02	0.02
9.00	0.85	0.03	0.02	0.02
9.00	0.90	0.04	0.05	0.02
9.00	0.95	0.05	0.07	0.04

Table 9: Binomial data simulations - Type 1 error to detect LOEC. N = sample sizes, p = probability, LM = Linear model after transformation, GLM = binomial model, np = pairwise Wilcoxon.

N	p_E	LM	GLM	np
3.00	0.60	0.03	0.04	0.00
3.00	0.65	0.04	0.04	0.00
3.00	0.70	0.05	0.04	0.00
3.00	0.75	0.05	0.02	0.00
3.00	0.80	0.08	0.06	0.00
3.00	0.85	0.06	0.04	0.00
3.00	0.90	0.07	0.00	0.00
3.00	0.95	0.06	0.00	0.00
6.00	0.60	0.06	0.04	0.01
6.00	0.65	0.02	0.04	0.02
6.00	0.70	0.05	0.05	0.02
6.00	0.75	0.05	0.06	0.04
6.00	0.80	0.03	0.04	0.02
6.00	0.85	0.06	0.04	0.02
6.00	0.90	0.05	0.03	0.02
6.00	0.95	0.04	0.00	0.01
9.00	0.60	0.07	0.06	0.04
9.00	0.65	0.04	0.03	0.02
9.00	0.70	0.06	0.06	0.05
9.00	0.75	0.06	0.07	0.04
9.00	0.80	0.03	0.03	0.01
9.00	0.85	0.05	0.04	0.02
9.00	0.90	0.02	0.03	0.02
9.00	0.95	0.04	0.01	0.01