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Supplementary material

Appendix 1.

Table A1. Timing of breeding, brood size and numbers of recruits for nests of common goldeneyes, Maaninka, Finland, 1985-2008. Shown are number of broods and ice-out date for each year. Mean (and standard deviation) are also shown for timing of breeding and breeding phenology variables; median (5-95% values) brood size; annual totals for recruitment measures. Relative recruitment is: (number of female recruits recaptured in year t≥1)/(number of ducklings produced in year t*2 [assumes a 50:50 sex ratio]). Adjusted recruitment is relative recruitment, adjusted for the number of juvenile females (i.e., <1 years old) reported shot by hunters.

Year	Broods	Ice-out date	Hatch date	Relative hatch date	Breeding phenology index	Brood size	Females recruited	Relative recruitment	Adjusted recruitment
1985	21	146	173 (6)	20 (6)	27 (6)	8 (5, 10)	1	0.012	0.015
1986	32	129	167 (8)	23 (8)	38 (8)	8 (4, 12)	4	0.032	0.044
1987	30	136	168 (7)	23 (7)	32 (7)	8 (5, 13)	5	0.037	0.044
1988	27	135	168 (7)	25 (7)	33 (7)	7 (2, 12)	2	0.020	0.022
1989	41	119	155 (8)	24 (8)	36 (8)	8 (5, 12)	6	0.034	0.036
1990	35	121	155 (8)	27 (8)	34 (8)	8 (4, 12)	2	0.014	0.016
1991	33	134	162 (10)	28 (10)	28 (10)	8 (3, 12)	3	0.022	0.024
1992	50	133	167 (8)	26 (8)	34 (8)	9 (5, 13)	3	0.014	0.015
1993	39	126	160 (7)	22 (7)	34 (7)	7 (5, 13)	7	0.045	0.048
1994	45	129	160 (6)	22 (6)	30 (6)	8 (5, 11)	3	0.016	0.017

Table A1 (continued)

Year	Broods	Ice-out date	Hatch date	Relative hatch date	Breeding phenology index	Brood size	Females recruited	Relative recruitment	Adjusted recruitment
1995	56	134	162 (8)	25 (8)	28 (8)	8 (5, 12)	3	0.013	0.013
1996	55	135	167 (7)	23 (7)	32 (7)	8 (4, 12)	5	0.022	0.023
1997	56	139	167 (8)	24 (8)	28 (8)	7 (5, 14)	6	0.027	0.029
1998	62	129	165 (7)	22 (7)	36 (7)	8 (4, 12)	11	0.045	0.047
1999	77	122	158 (8)	26 (8)	36 (8)	8 (5, 13)	13	0.040	0.040
2000	79	120	158 (7)	21 (7)	38 (7)	8 (5, 13)	2	0.006	0.006
2001	82	121	160 (9)	26 (9)	39 (9)	8 (5, 12)	6	0.018	0.018
2002	73	123	159 (7)	25 (7)	36 (7)	8 (4, 12)	2	0.007	0.007
2003	71	130	163 (7)	23 (7)	33 (7)	7 (3, 12)	7	0.026	0.027
2004	83	125	160 (8)	24 (8)	35 (8)	8 (4, 12)	18	0.054	0.055
2005	89	125	158 (8)	24 (8)	33 (8)	8 (4, 12)	3	0.008	0.008
2006	81	128	162 (7)	22 (7)	34 (7)	7 (4, 12)	2	0.006	0.006
2007	78	114	155 (8)	25 (8)	41 (8)	8 (5, 12)	13	0.041	0.041
2008	79	125	158 (8)	24 (8)	33 (8)	8 (5, 12)	1	0.003	0.003

Appendix 2

We conducted two additional series of tests to evaluate relationships between likelihood of a female being recruited to the breeding population and five explanatory variables retained in path analyses: female age (range, 2 to 7 years), relative hatch date, female wing length, female body mass and brood size. The first series explored the influence of model structure associated with the response variable (counts of recruited females), whereas the second series looked at random effects of year, given the best-supported model structure identified in the first step.

Model structure

We tested three models using PROC GENMOD in SAS version 9.3, all based on counts of recruited females (i.e., 0, 1 and ≥2), and using a common Poisson error structure with log link function. There was no support for using zero-inflation models. The standard Poisson model (AIC = 798.562; Table A2.1) performed slightly better than either the zero-inflated Poisson (AIC = 799.403) or zero-inflated negative exponential (Akaike's Information Criterion [AIC] = 801.403) models (the same conclusion was reached using the Bayesian Information Criterion [BIC]). There was also no evidence of overdispersion in any model (Poisson model, Pearson's χ^2/df = 1.013). Furthermore, the significance of explanatory variables was qualitatively similar across all three models, with no difference in conclusions about their relative importance. These results were also robust to relaxing the constraint (i.e., at 2) on the number of female recruits per brood. Models in which relative hatch date (RHD) was replaced with the spring phenology index (i.e., hatch date relative to iceout date) were less informative (ΔAIC [or ΔBIC] > 14 units larger).

Table A2.1. Analysis of maximum likelihood parameter estimates from Poisson regression. Brsize is brood size and RHD refers to relative hatch date; other effects include female age, body mass and wing length (measured near hatch).

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	3.0416	3.4311	-3.6831	9.7664	0.79	0.375
Brsize	1	0.1665	0.0411	0.086	0.247	16.44	<0.001
Wing	1	-0.028	0.0207	-0.0685	0.0126	1.83	0.176
Mass	1	-0.2095	0.1455	-0.4947	0.0756	2.07	0.150
RHD	1	-0.088	0.0154	-0.1183	-0.0578	32.5	<0.001
Age	1	0.1063	0.0555	-0.0025	0.2151	3.67	0.055

Furthermore, conclusions based on results of this analysis were very similar to those obtained via path analysis, with relative hatch date and brood size being most important, female age having a moderate effect on recruitment, and wing length and body mass being relatively unimportant (Table 1; Supplementary material Appendix 3, Table A3.1.).

Random effects of year

Next, we evaluated performance of the standard Poisson regression model above with a model that incorporated random effects of year. Both models were run in Proc GLIMMIX in SAS 9.3 to facilitate direct comparisons between models and inclusion of random effects. As intended, parameter estimates from the Poisson model were identical to those in Table A2.1. The covariance parameter estimate for random effects of year was marginally important (0.289 ± 0.145 SE). After accounting for year effects, the effect of female age was strengthened as was that of body mass (which nonetheless remained non-significant).

Table A2.2. Solutions for fixed effects in a mixed effects model incorporating a random effect of year. Brsize is brood size and RHD refers to relative hatch date; other effects include female age, body mass and wing length (measured near hatch).

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	3.9167	3.5022	23	1.12	0.275
Brsize	0.1643	0.04161	1343	3.95	<0.001
Mass	-0.2596	0.1485	1343	-1.75	0.0806
Wing	-0.02007	0.02082	1343	-0.96	0.3352
RHD	-0.08641	0.01558	1343	-5.55	<.0001
Age	0.1310	0.05854	1343	2.24	0.0254

To conclude, path analysis was robust to the distribution of the response variable and to the putative influence of year effects. Furthermore, because all explanatory variables are inter-correlated (and reasons for this are explained fully in the paper), path analysis was ideal for analysing these data.

Appendix 3.

Table A3.1. Combined effects of explanatory variables on offspring recruitment for female common goldeneyes, Finland, 1985-2010, as estimated by alternate path analysis models. The combined effect is the sum of direct and indirect median path coefficients obtained via 1,000 random samples (see Methods for details). The -- symbol signifies that the explanatory variable was not considered in the path analysis.

	Date effects included in model		
Explanatory variable	Hatch date, breeding phenology index[a]	Hatch date, relative hatch date, breeding phenology index[a]	Hatch date, ice-out date[b]
Female age	+0.013**	+0.013**	+0.082**
Hatch date	-0.167*	-0.0004**	-0.18*
Breeding phenology index	-0.013**	0	--
Relative hatch date	--	-0.191*	--
Iceout date	--	--	-0.064**
Wing length	+0.003**	+0.003**	+0.003**
Body mass	+0.013**	+0.012**	+0.012**
Brood size	+0.104*	+0.104*	+0.109*

[a] All date effects and female age were linked using covariances in these models.

[b] Hatch and ice-out dates were included as separate effects in this model.

* Direct and(or) indirect effects combined; ** Indirect effects only.

Table A3.2. Model fit indices obtained from path analyses of female offspring recruitment by adult female common goldeneyes, Finland, 1985-2010. Shown are median (95% confidence interval) obtained from 1,000 iterations of path analysis, with one record for adult females entering only once in each iteration.

	Path analysis with covariances		Path analysis with direct paths	
Indices of model fit[a]	Hatch date, BP index[b]	Hatch date, relative hatch date, BP index[b]	Hatch date, iceout date[c]	Relative hatch date[c,d]
GFI	0.991 (0.984, 0.996)	0.993 (0.987, 0.997)	0.991 (0.984, 0.995)	0.995 (0.987, 0.999)
χ^2	12.52 (5.72, 23.16)	11.32 (4.59, 22.28)	12.68 (5.76, 23.68)	6.30 (1.50, 15.41)
p	0.130 (0.003, 0.675)	0.414 (0.021, 0.945)	0.123 (0.003, 0.671)	0.278 (0.008, 0.909)

[a] Goodness of fit index (GFI); Chi-squared statistic (χ^2); Probability associated with the χ^2-squared statistic (p)

[b] BP signifies breeding phenology; these two models had a similar covariance structure and are directly comparable in terms of model fit indices

[c] Model fit indices can be compared directly for these two models

[d] This model is shown in Fig. 3, with direct and indirect effects summarized in Table 2