

Accessory publication

Temporal and spatial variability of breeding in Australian birds and the potential implications of climate change

Heather M. Gibbs^{A,C,D}, Lynda E. Chambers^B and Andrew F. Bennett^A

^ASchool of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, VIC 3125, Australia.

^BCentre for Australian Weather and Climate Research, Bureau of Meteorology, GPO Box 1289, Melbourne, VIC 3001, Australia.

^CPresent address: PO Box 2110, Lygon Street North, East Brunswick, VIC 3057, Australia.

^DCorresponding author. Email: hgi@deakin.edu.au

Table A1. Relationships between breeding activity and altitude, latitude, year and winter value of the Southern Oscillation Index (SOI-W) based on NSW Atlas data

Values are coefficients (\pm s.e.) for altitude, latitude, year and the SOI-W for each species. Values in bold are significant at the $P < 0.05$ level. Effect sizes (coefficients) represent changes in the log odds of breeding being recorded in an atlas survey given that the species was recorded ($\times 10\,000$ for altitude (m) and $\times 100$ for other variables for display purposes). Data are from NSW only, thus results for latitude may not necessarily be representative of more widespread patterns. All records from 1967 onwards are included

Species	<i>N</i>	<i>P</i>	Altitude	Latitude	Year	SOI-W
Crested Pigeon	21 437	<0.001	7.2 \pm 1.3	1.5 \pm 1.6	-0.4 \pm 0.7	0.8 \pm 0.3
Galah	21 516	<0.001	8.8 \pm 1.1	5.5 \pm 1.6	-1.9 \pm 0.6	2.0 \pm 0.3
Welcome Swallow	25 080	<0.001	8.5 \pm 0.8	5.8 \pm 1.3	-2.4 \pm 0.5	0.8 \pm 0.3
Willie Wagtail	27 473	<0.001	8.2 \pm 0.8	4.3 \pm 1.2	-2.3 \pm 0.5	1.1 \pm 0.3
Magpie-lark	28 762	<0.001	2.7 \pm 1.0	8.4 \pm 1.3	-2.5 \pm 0.5	1.8 \pm 0.3
Superb Fairy-wren	30 105	<0.001	7.4 \pm 1.0	11.7 \pm 1.6	-0.9 \pm 0.6	1.6 \pm 0.4
Noisy Miner	31 890	<0.001	-5.0 \pm 1.4	4.2 \pm 1.7	-1.6 \pm 0.6	1.3 \pm 0.4
Australian Magpie	37 260	<0.001	3.2 \pm 0.7	-0.9 \pm 1.0	-0.6 \pm 0.4	1.5 \pm 0.2
All 8 species	223 523	<0.001	5.4 \pm 0.3	4.5 \pm 0.5	-1.6 \pm 0.2	1.4 \pm 0.1

Table A2. Relationships between breeding activity and altitude, latitude, year and winter value of the Southern Oscillation Index (SOI-W) based on Atlas 1 data

Values are coefficients (\pm s.e.) for altitude, latitude, year and the SOI-W for each species. Values in bold are significant at the $P < 0.01$ level. Effect sizes (coefficients) represent changes in the log odds of breeding being recorded in an atlas survey given that the species was recorded ($\times 10\,000$ for altitude (m) and $\times 100$ for other variables for display purposes). Most data are from five seasons (May 1977–April 1982), thus Year and SOI results may be not be representative of long-term patterns

Species	<i>N</i>	<i>P</i>	Altitude	Latitude	Year	SOI-W
Crested Pigeon	16425	<0.001	-0.1 \pm 1.8	-6.1 \pm 0.7	3.9 \pm 2.9	0.7 \pm 0.5
Galah	24277	<0.001	0.0 \pm 1.3	-0.2 \pm 0.6	5.9 \pm 2.4	2.6 \pm 0.5
Welcome Swallow	27317	<0.001	2.2 \pm 0.8	-2.8 \pm 0.4	4.9 \pm 1.8	1.4 \pm 0.3
Grey Fantail	21943	<0.001	3.4 \pm 1.1	-7.0 \pm 0.7	2.0 \pm 2.9	0.6 \pm 0.5
Willie Wagtail	31053	<0.001	3.4 \pm 0.8	-3.8 \pm 0.4	7.8 \pm 1.7	1.3 \pm 0.3
Magpie-lark	30726	<0.001	1.6 \pm 0.9	-1.2 \pm 0.3	4.5 \pm 1.7	1.8 \pm 0.3
Yellow-rumped Thornbill	17525	<0.001	-1.2 \pm 1.2	2.3 \pm 0.7	5.0 \pm 2.4	1.8 \pm 0.5
Superb Fairy-wren	18634	<0.001	-0.4 \pm 1.0	5.1 \pm 0.7	14.1 \pm 2.5	-0.3 \pm 0.5
Noisy Miner	13717	<0.001	-7.6 \pm 1.6	5.1 \pm 0.7	6.6 \pm 3.0	0.8 \pm 0.6
Red Wattlebird	14018	<0.001	-5.5 \pm 1.4	-0.7 \pm 1.4	9.3 \pm 2.9	-0.2 \pm 0.5
Noisy Friarbird	6711	<0.001	8.5 \pm 1.7	-3.3 \pm 1.1	-4.3 \pm 4.7	3.1 \pm 0.9
Pied Currawong	11416	0.001	5.6 \pm 1.4	-1.3 \pm 0.9	2.0 \pm 4.3	0.4 \pm 0.8
Australian Magpie	33799	<0.001	-0.5 \pm 0.7	-3.0 \pm 0.4	8.6 \pm 1.6	1.6 \pm 0.3
Common Blackbird	10369	<0.001	-2.9 \pm 1.5	7.6 \pm 1.4	9.2 \pm 2.9	-0.6 \pm 0.5
House Sparrow	19876	<0.001	-0.3 \pm 1.1	-0.3 \pm 0.5	6.6 \pm 2.1	1.1 \pm 0.4
Common Starling	21681	<0.001	0.6 \pm 0.9	-1.6 \pm 0.6	11.2 \pm 2.0	1.6 \pm 0.4
All 16 species	319487	<0.001	0.8 \pm 1.2	-1.6 \pm 0.6	6.9 \pm 1.8	1.2 \pm 0.6

Table A3. Summary of data in the Nest Record Scheme (NRS) used in Table 3 of the main paper, and concurrent climate statistics, by region

Single-observer bias describes the proportion of records in the NRS made by a single observer and the time-span of those records (the mean is taken across all species recorded in that region). Climatic trends and averages are calculated over the time period given, and for winter because this season immediately precedes breeding. Temperature trends are in bold if significant at the $P < 0.05$ level.

Regions are defined in Fig. 1. Temperature and rainfall statistics were provided by the Bureau of Meteorology

	C	CE	N	NE	SE	SW	T
Most data from	1970	1967	1964	1964	1964	1970	1964
Most data to	1990	1995	1998	1998	1992	1992	1988
Number of records	915	2675	85	713	8542	1425	533
Single-observer bias							
Mean proportion	51%	27%	46%	43%	20%	54%	53%
Mean span (years)	4	11	2	5	14	13	4
Year-round	1984	1986	1982	1983	1979	1984	1977
Mean winter							
Minimum temperature (°C)	7.2	6.0	16.7	10.2	6.2	8.1	5.8
Maximum temperature (°C)	20.9	16.9	29.0	21.2	14.4	16.9	12.5
Monthly rainfall (mm)	9.2	19.7	4.7	22.1	16.0	14.9	21.0
Trend in winter							
Minimum temperature (°C decade ⁻¹)	0.11	0.30	0.22	0.36	0.24	0.21	0.20
Maximum temperature (°C decade ⁻¹)	-0.43	0.09	0.18	0.15	0.03	-0.08	0.28
monthly rainfall (mm decade ⁻¹)	0.96	-2.94	0.05	-3.13	4.77	4.57	-5.21

Table A4. Regional data and climate statistics pertaining to Table 5 of the main paper

Sample sizes and index of breeding activity (Br-index) are given for the combined Atlas 1 and 2 datasets for each region. These are followed by relationships between seasonal climate statistics and winter values for the Southern Oscillation Index (SOI-W), and relevant climate averages, for the relevant periods (1977–82 and 1998–2007, combined). Winter climate values are given because this season immediately precedes breeding, and spring rainfall is given because SOI can have a 3-month lagged effect on rainfall. Significant relationships are shown in bold. Regions are defined in Fig. 1. Temperature and rainfall statistics were provided by the Bureau of Meteorology

	C	CE	N	NE	SE	SW	Tas.
Atlas 1 + 2 statistics by region							
Number of breeding records	4264	9874	671	6984	33245	4008	2233
Number of species records	115459	193337	46610	143510	530760	79298	35546
Mean Br-index (%) across 16 species	3.7%	5.1%	1.4%	4.9%	6.3%	5.1%	6.3%
Winter climate v. SOI-W							
Minimum temperature (°C per unit SOI)	0.21	0.08	0.11	0.09	0.03	0.00	0.01
Maximum temperature (°C per unit SOI)	-0.05	-0.05	0.06	-0.01	-0.03	-0.05	-0.01
Rainfall (mm month ⁻¹ per unit SOI)	0.84	2.22	0.27	1.53	1.65	0.90	1.46
Spring rainfall v. SOI-W							
Rainfall (mm month ⁻¹ per unit SOI)	0.57	1.27	1.44	1.74	0.96	0.23	0.77
Average winter values							
Daily minimum temperature (°C)	10.6	6.1	16.7	10.4	6.4	8.0	5.9
Daily maximum temperature (°C)	19.4	15.6	28.2	20.0	13.7	15.6	11.7
Rainfall (mm month ⁻¹)	5.6	24.9	3.6	8.9	36.1	67.4	62.5