METHODS

Evaporative water loss model

Typically, evaporative water loss (EWL) is relatively constant at low and moderate air temperature (T_a), but increases rapidly and approximately linearly at T_as approaching or exceeding body temperature (ESM Figure 2). For each species, we obtained the slope of a least-squares linear regression model fitted to the data over the range of high T_a over which EWL increased rapidly (ESM Figure 2). We also estimated the inflection T_a above which EWL began to increase rapidly as the intersection of the latter regression and one fitted to EWL data measured at lower T_a. Both the rate of increase in EWL at high T_a and the inflection T_a were significantly related to body mass (M_b) (ESM Figure 3). The relationship between inflection T_a and M_b was relatively weak ($r^2 = 0.487$), reflecting interspecific variation in thermoregulatory physiology. Whereas the unexplained variation in inflection T_a adds uncertainty to the precise quantification of increases in EWL, the qualitative predictions of the model and the probability of future catastrophic mortality events are not affected.

Current and future maximum air temperatures

We obtained daily maximum temperature data for the Yuma Mesa weather station for 1990-1999 from the Arizona Meteorological Network (http://ag.arizona.edu/AZMET/) and used the 95th percentile for June, July and August (T_a = 44.6°C) as representative of current T_a maxima. For Birdsville, we obtained daily maximum temperature data for the Birdsville Police Station weather station for the same period from the Australian Bureau of Meteorology (http://www.bom.gov.au/), and used the 95th percentile for December, January and February (T_a = 44.0°C). We obtained predicted increases in mid-summer maximum T_a for the 2080s from SRES general circulation models (GCMs) available on the Intergovernmental Panel for Climate Change Data Distribution Centre website (http://ipcc-ddc.cru.uea.ac.uk/). For the 18 GCMs that include predicted increases in maximum T_a, the modal values for Yuma and Birdsville are > 5°C and 3-4 °C, respectively. Accordingly, for estimating EWL increases we used values of 5.5°C for Yuma and 3.5°C for Birdsville.

Predicting evaporative water loss during the hottest part of the day

We plotted hourly air temperature data for the hottest day in each year from 1990-1999 in Yuma, AZ (ESM Figure 4), and fitted a polynomial regression to the data between 08:00 and 20:00. To model the effects of increases in maximum air temperatures, we adjusted the y-intercept of the regression model obtained in this way so that the maximum air temperature value matched current or predicted values.

Dehydration tolerance

Most published dehydration tolerance values for birds (Bartholomew & MacMillen 1960, 1961, Cade & Dybas 1962) are not appropriate for modelling the effects of acute water loss since they involved long-term (days) water deprivation at room temperature in caged inactive birds, and thus reflected mass losses of both water and tissue (Wolf 2000). These studies suggest that birds can lose 30 - 50% of M_b over a period of 7 to 40 days and survive. Body mass data collected 24 hrs after rehydration following eight days without water in monk parakeets (*Myiopsitta monachus*) indicates that of the total mass loss of 29% of M_b, approximately 18% was associated with tissue loss (Weathers & Caccamise

1975). There are few data that examine the effects of high heat stress and rapid dehydration in birds or mammals. In verdins exposed to $T_a \geq 45$°C, dehydration equivalent to 11% of M_b led to the loss of the capacity for coordinated movement (Wolf & Walsberg 1996). Human data suggests that high heat stress coupled with acute dehydration results in a significant deficit in physical performance during exercise at moderate levels (6-10%) and death occurs when 15 - 25% of M_b is lost through dehydration (McArdle *et al.* 2001).

Table 1. Species for which we obtained data on evaporative water loss (EWL) rates at air temperatures (T_a) above 41°C. The inflection T_a at which EWL rates begin to increase rapidly, and the slope of a least-squares linear regression relating EWL to T_a above the inflection T_a, is provided for each species.

Species	**Body mass (g)**	**Inflection T_a (°C)**	**Slope [mg H_2O (g h °C)$^{-1}$]**	**Reference**
Dromaius novaehollandiae	40,700	29.4	0.139	Maloney & Dawson (1994)
Alectorus chukar	250	32.5	0.578	Marder & Bernstein (1983)
Zenaida macroura	120		1.304	Hoffman & Walsberg (1999)
Zenaida asiatica	142		1.468	McKechnie & Wolf (2004)
Geophaps plumifera	89	37.7	1.490	Withers & Williams (1990)
Geopelia cuneata	38	39.4	2.442	Schleucher (1999)
Speotyto cunicularia	100	35.6	1.391	Coulombe (1970)
Chordeiles minor	72	35.8	1.502	Lasiewski & Dawson (1964)
Podargus ocellatus	145	37.8	1.614	Lasiewski *et al.* (1970)

Eurostopodus argus	88	41.1	1.860	Dawson & Fisher (1969)
Myopsitta monachus	80	34.3	1.833	Weathers & Caccamise (1975)
Melopsittacus undulates	34	37.9	3.460	Weathers & Schoenbaechler (1976)
Pterocles orientalis	386	31.3	0.285	Hinsley *et al.* (1993)
Pterocles alchata	243	33.0	0.499	Hinsley *et al.* (1993)
Pterocles bicinctus	197	34.5	0.703	Hinsley (1992)
Chlamydotis macqueenii	1,248	34.7	0.387	Tieleman *et al.* (2002)
Lonchura fuscans	10	34.7	2.792	Weathers (1977)
Baeolophus ridgwayi	17	36.3	2.910	Weathers & Greene (1998)
Baeolophus wollweberi	11	37.9	5.074	Weathers & Greene (1998)
Eremiornis carteri	12	37.3	4.097	Ambrose *et al.* (1996)
Alaemon alaudipes	38	38.6	4.318	Tieleman & Williams (2002)
Eremalauda dunni	21	39.8	4.545	Tieleman & Williams (2002)
Certhilauda erythrocephalus	27	36.5	5.336	Tieleman & Williams (2002)
Sporophila aurita	11	37.9	4.476	Weathers (1997)

Auriparus flaviceps	7	37.8	5.328	Wolf & Walsberg (1996)
Estrilda troglodytes	6	38.7	6.276	Cade *et al.* (1964)
Erythrura gouldiae	17	36.4	3.181	Burton & Weathers (2003)

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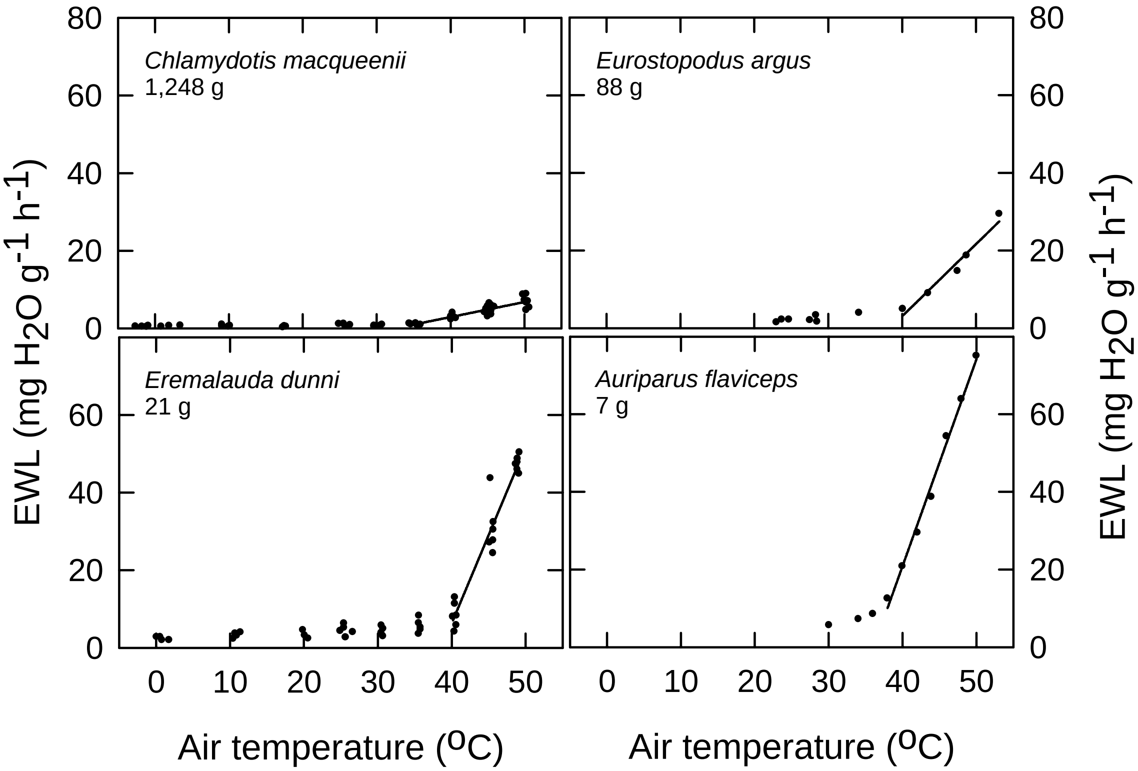
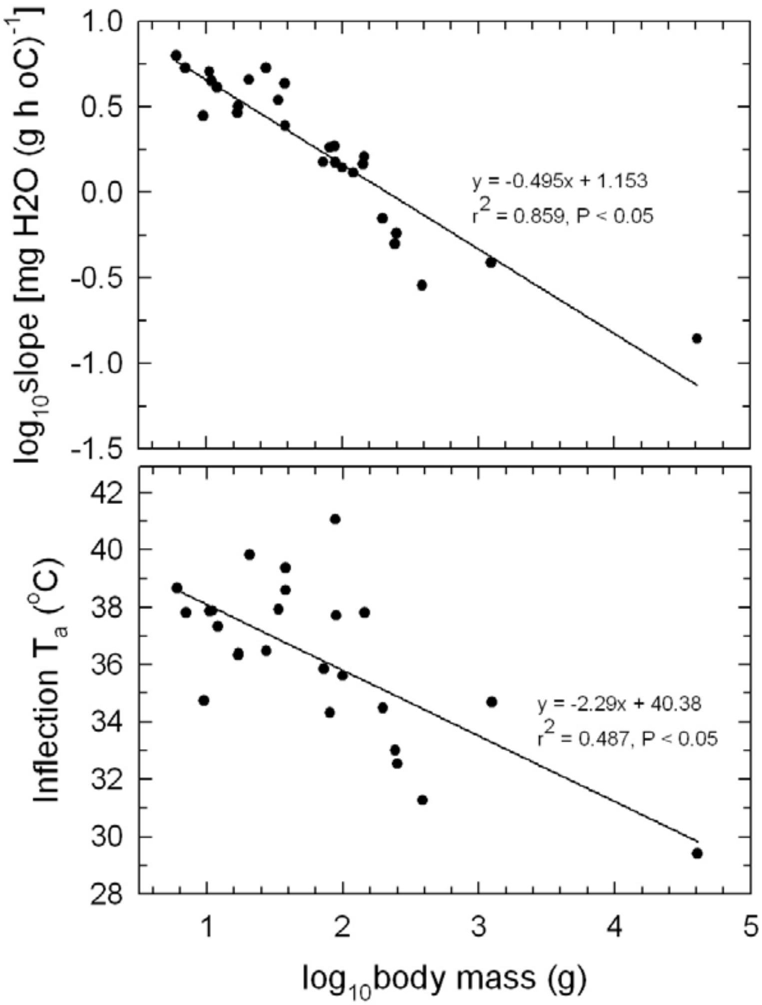
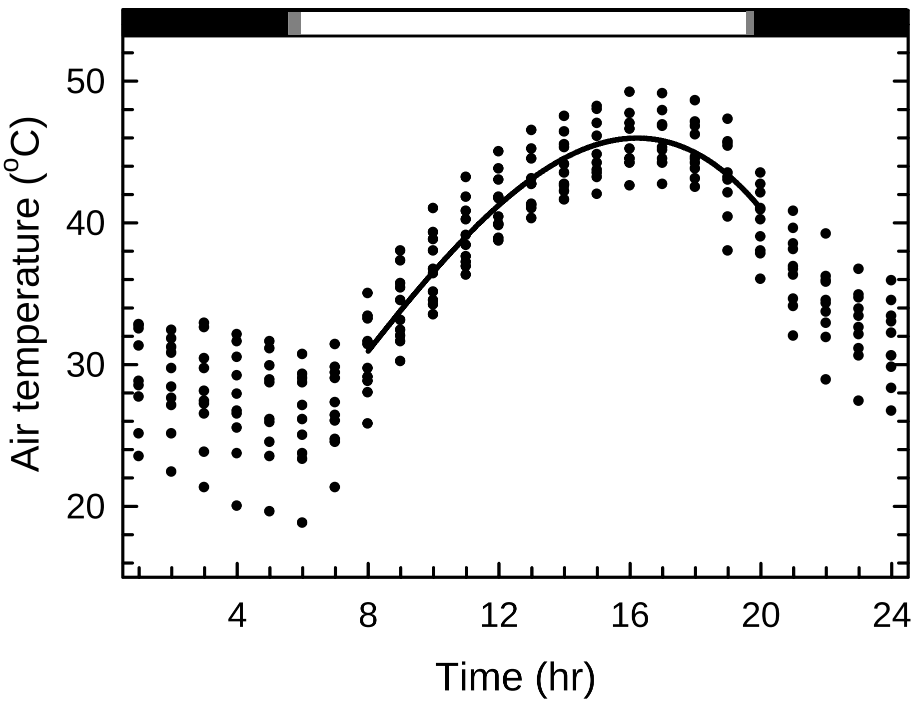
ESM Figure 1. Dead Budgerigars (*Melopsittacus undulatus*) during a severe heat wave in western Australia during January 2009 (photograph supplied by Northern Guardian Newspaper).



ESM Figure 2. Relationship between mass-specific evaporative water loss (EWL) and air temperature (T_a) in four avian species ranging in body mass from 7 g to ~ 1,250 g. EWL is low and approximately constant at T_a < 30-35°C, but increases linearly at higher T_a. Data are shown for houbara bustard (*Chlamydotis macqueenii*; Tieleman *et al.* 2002), spotted nightjar (*Eurostopodus argus*; Dawson & Fisher 1969), Dunn's lark (*Eremalauda dunni*; Tieleman & Williams 2002) and verdin (*Auriparus flaviceps*; Wolf & Walsberg 1996).



ESM Figure 3. Scaling relationships for the slope of a linear regression model relating evaporative water loss (EWL) to high air temperature (T_a) (upper graph), and the inflection T_a at which EWL begins to rapidly increase (lower graph).



ESM Figure 4. Hourly air temperature data for the hottest day of each year from (1990 to 1999) for Yuma, AZ, U.S.A. The solid line represents a polynomial regression model fitted to the data from 08:00 to 20:00 ($y = -0.011x^3 + 0.206x^2 + 1.672x + 9.792$; $r^2 = 0.814$). We adjusted the y-intercept of this regression equation to predict temperature profiles for the period 12:00 to 18:00 for current and predicted air temperature maxima. The bar at the top of the figure indicates night-time (black), with the grey regions indicating variation in sunrise and sunset times.