Table S1 Long-term studies on the relationships between breeding dates of amphibians and climate factors

Species	Location	Elevation (m)	Phenology	Period	Predictors (p)	Thermal changes (°C)	References
Rana temporaria	48º06'6"N, 1º47'47"E[1]	—	26.6 d earlier in SS ($r = 62$, $P < 0.01$)	1984–2007	T* over the preceding 40 days of spawning	1.02 spring	Neveu 2009
Hynobius tokyoensis	35º44'N, 139º14'E[2]	200	19 d earlier in SS ($r = -0.47$, $P < 0.05$)	1976–2007	MMAT* in Feb, P before B	0.08/yr Feb, 0.05/yr Apr	Kusano and Inoue 2008
Hynobius tokyoensis	35º37'N, 139º23'E[2]	120	50.2 d earlier in SS ($r = -0.792$, $P = 0.001$)	1992–2007			Kusano and Inoue 2008
Rana ornativentris	35º37'N, 139º23'E[2]	120	19.5 d earlier in SS ($r = -0.51$, $P < 0.05$)	1992–2007			Kusano and Inoue 2008
Rhacophorus arboreus	35º37'N, 139º23'E[2]	120	58.7 d earlier in SS ($r = -0.774$, $P = 0.001$)	1992–2007	MMAT in Apr, P* and its interaction* with MMATpre-B	0.08/yr Feb, 0.05/yr Apr	Kusano and Inoue 2008
Bufo bufo	50º39'N, 2º7'E[3]	—	NS in FAD	1980–1998	Daily T* over the 40 days preceding main arrival	—	Reading 1998
Eurycea quadridigitata	33º15.6'N, 81º37.9'W[4]	85	76.4 d later in MAD ($r = 0.762$, $P = 0.001$)	1979–2008	MOT and R in pre-B and B season	1.2 Sep–Feb	Todd *et al.* 2011
Ambystoma opacum	33º15.6'N, 81º37.9'W[4]	85	15.3 d later in MAD ($r = 0.48$, $P = 0.01$)	1979–2008	MOT* and R in pre-B season, MOT and R in B season	1.2 Sep–Feb	Todd *et al.* 2011
Ambystoma tigrinum	33º15.6'N, 81º37.9'W[4]	85	56.4 d earlier in MAD ($r = -0.608$, $P < 0.05$)	1979–2008	MOT and R* in pre-B season, MOT* and R* in B season	1.2 Sep–Feb	Todd *et al.* 2011
Pseudacris ornata	33º15.6'N, 81º37.9'W[4]	85	59.5 d earlier in MAD ($r = -0.640$, $P = 0.005$)	1979–2008	MOT and R* in pre-B season, MOT* and R in B season	1.2 Sep–Feb	Todd *et al.* 2011
Ambystoma talpoideum	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R* in pre-B season, MOT and R in B season	1.2 Sep–Feb	Todd *et al.* 2011
Bufo terrestris	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R in pre-B season, MOT* and R in B season	1.2 Sep–Feb	Todd *et al.* 2011

Gastrophryne carolinensis	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R in pre-B season, MOT and R* in B season	1.2 Sep–Feb	Todd *et al.* 2011
Pseudacris crucifer	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R in pre-B season, MOT and R in B season	1.2 Sep-Feb	Todd *et al.* 2011
Rana sphenocephala	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R in pre-B season, MOT and R in B season	1.2 Sep–Feb	Todd *et al.* 2011
Scaphiopus holbrookii	33º15.6'N, 81º37.9'W[4]	85	NS in MAD	1979–2008	MOT and R in pre-B season, MOT and R in B season	1.2 Sep–Feb	Todd *et al.* 2011
Bufo boreas	44º25.8'N, 121º54.7'W[LL,4]	1215	NS in ADB	1982–1999	MDAT before B	—	Blaustein *et al.* 2001
	44º6.1'N, 121º38.6'W[TC,4]	2040	NS in ADB	1982–1999	MDAT* before B	—	Blaustein *et al.* 2001
	44º1.8'N, 121º44.1'W[TL,4]	1870	NS in ADB	1982–1999	MDAT* before B	—	Blaustein *et al.* 2001
Rana cascadae	—[SO,4]	—	NS in ADB	1982–1999	MDAT before B	—	Blaustein *et al.* 2001
	44º1.8'N, 121º44.1W'[TL,4]	1870	NS in ADB	1982–1999	MDAT* before B	—	Blaustein *et al.* 2001
Bufo fowleri	—[LP,5]	—	NS in ADB	1980–1981 *vs* 1988–1998	MDAT before B	—	Blaustein *et al.* 2001
Pseudacris crucifer	—[GF,4]	—	NS in ADB	1967–1994 (miss 1988)	MDAT* before B	—	Blaustein *et al.* 2001
Pseudacris crucifer	—[4]	—	13.6 d earlier in AFCD	1900–1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Rana sylvatica	—[4]	—	13 d earlier in AFCD	1900–1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Rana catesbeiana	—[4]	—	11.4 d earlier in AFCD	1900-1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Rana clamitans	—[4]	—	NS in AFCD	1900–1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Hyla versicolor	—[4]	—	10.5 d earlier in AFCD	1900–1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Bufo americanus	—[4]	—	NS in AFCD	1900–1912 *vs* 1990–1999	—	0.94 annual	Gibbs and Breisch 2001
Bufo boreas	44º25.8'N, 121º54.7'W[LL,4]	1215	16 d later in FBD	1982–1999	MEMAT in Mar and Apr before B, SWE on 1 Apr or 1 May	—	Corn 2003
	44º6.1'N, 121º38.6W'[TC,4]	2040	earlier in FBD	1982–1999	MEMAT in Mar and Apr before B, SWE on 1 Apr or 1 May	—	Corn 2003
	44º1.8'N, 121º44.1W'[TL,4]	1870	earlier in FBD	1982–1999	MEMAT in Mar and Apr before B, SWE on 1 Apr or 1 May	—	Corn 2003
Bufo calamita	—[HS,3]	—	2 weeks earlier in SS	1978–1994	AMIT* in Mar and Apr, AMAT* in Mar, R	1.76	Beebee 1995

			($r = -0.706$, $P < 0.001$)			Mar–Apr	
Rana kl. seculenta	—[SU,3]	—	3 weeks earlier in SS ($r = -0.608$, $P < 0.05$)	1978–1994	AMIT* in Mar and Apr, AMAT* in Mar, R	3.84 Mar–Apr	Beebee 1995
Rana temporaria	—[SU,3]	—	NS in SS	1978–1994	AMIT* in Mar and Apr, AMAT* in Mar, R	3.84 Mar–Apr	Beebee 1995
Triturus vulgaris	—[SU,3]	—	6–8 weeks earlier in FAD ($r = -0.623$, $P < 0.001$)	1978–1994	AMAT* in the month before arrival	3.84 Mar–Apr	Beebee 1995
Triturus cristatus	—[SU,3]	—	6–8 weeks earlier in FAD ($r = -0.592$, $P = 0.02$)	1978–1994	No checking	3.84 Mar–Apr	Beebee 1995
Triturus helveticus	—[SU,3]	—	6–8 weeks earlier in FAD ($r = -0.604$, $P = 0.02$)	1978–1994	No checking	3.84 Mar–Apr	Beebee 1995
Triturus helveticus	53º12'59"N, 3º27'3"W'[,3]	200	17.7 d earlier in MAD	1981–1987 *vs* 1997–2005	—	2.9 Feb	Chadwick *et al.* 2006
Triturus vulgaris	53º12'59"N, 3º27'3"W'[,3]	200	13.2 d earlier in MAD	1981–1987 *vs* 1997–2005	—	2.9 Feb	Chadwick *et al.* 2006
Rana temporaria	—[6]	—	2–13 d earlier among 5 areas in MDS	1846–1986	Mean temperatures*	—	Terhivuo 1988
Rana temporaria	52º04'N, 16º48'E'[7]	—	9 d earlier in SS ($r = -0.430$, $P = 0.07$)	1978–2002	MMAT* and P in Dec, Jan, Feb and Mar	—	Tryjanowski *et al.* 2003
Bufo bufo	52º04'N, 16º48'E'[,7]	—	8 d earlier in SS ($r = -0.550$, $P = 0.02$)	1978–2002	MMAT* and P in Mar	—	Tryjanowski *et al.* 2003
Rana temporaria	—[3]	—	5.1 d earlier in SS	1998–2007	T*	1.0 annual	Carroll *et al.* 2009
Rana temporaria	—[3]	—	0.8 d earlier per year in SS ($r = -0.933$, $P < 0.0001$)	1994–2005	T, soil tempertature, surface moisture	—	Scott *et al.* 2008

Triturus alpestris		Beebee 1995b

Warming was observed in all sites over the time span of the studies. Time period does not necessarily reflect number of years of observations, although the majority of years contained observations in all studies. Note: Corn (2003) is a re-analysis of Blaustein *et al.* (2001) data. 1 = France; 2 = Japan; 3 = UK; 4 = USA; 5 = Canada; 6 = Finland; 7 = Poland. LL = Lost Lake, Oregon; TC = Three Creeks, Oregon; TL = Todd Lake, Oregon; SO = Site One, Oregon; LP = Long Point, Ontario; GF = Germfask, Michigan; HS = Hampshire; SU = Sussex. SS = start of spawning; FAD = first arrival dates; MAD = median arrival date; ADB = average dates of breeding; AFCD = average first-calling date; FBD = first breeding dates; MDS = mean date of spawning; T = temperature; B = breeding; MMAT = monthly mean air temperature; P = precipitation; MOT = minimum overnight temperature; R = rainfall; MDAT = maximum daily air temperature; MEMAT = mean maximum air temperatures; SWE = snow water equivalent; AMIT = average minimum temperature; AMAT = average maximum temperature. * = significant predictor; NS = no significant difference.

REFERENCES

Beebee TJ (1995a). Amphibian breeding and climate. *Nature* **374**, 219–20.

Beebee TJ (1995b). Ever-earlier breeding migrations by alpine newts (*Triturus alpestris*) living wild in Britain. *British Herpetology Society Bulletin* **51**, 5–7.

Blaustein AR, Belden LK, Olson DH, Green DM, Root TL, Kiesecker JM (2001). Amphibian breeding and climate change. *Conservation Biology* **15**, 1804–9.

Carroll EA, Sparks TH, Collison N, Beebee TJC (2009). Influence of temperature on the spatial distribution of first spawning dates of the common frog (*Rana temporaria*) in the UK. *Global Change Biology* **15**, 467–73.

Chadwick EA, Slater FM, Ormerod SJ (2006). Inter- and intraspecific differences in climatically mediated phenological change in coexisting *Triturus* species. *Global Change Biology* **12**, 1069–78.

Corn PS (2003). Amphibian breeding and climate change: importance of snow in the mountains. *Conservation Biology* **17**, 622–5.

Gibbs JP, Breisch AR (2001). Climate warming and calling phenology of frogs near Ithaca, New York, 1900–1999. *Conservation Biology* **15**, 1175–8.

Kusano T, Inoue M (2008). Long-term trends toward earlier breeding of Japanese amphibians. *Journal of Herpetology* **42**, 608–14.

Neveu A (2009). Incidence of climate on common frog breeding: long-term and short-term changes. *Acta Oecologica* **35**, 671–8.

Reading C (1998). The effect of winter temperatures on the timing of breeding activity in the common toad *Bufo bufo*. *Oecologia* **117**, 469–75.

Scott WA, Pithart D, Adamson JK (2008). Long-term United Kingdom trends in the breeding phenology of the common frog, *Rana temporaria*. *Journal of Herpetology* **42**, 89–96.

Terhivuo J (1988). Phenology of spawning for the common frog (*Rana temporaria* L.) in Finland from 1846 to 1986. *Annual Zoology Fennici* **25**, 165–75.

Tryjanowski P, Rybacki M, Sparks T (2003). Inter- and intraspecific differences in climatically mediated phenological change in coexisting *Triturus* species. *Annual Zoology Fennici* **40**, 459–64.

Todd BD, Scott DE, Pechmann JHK, Gibbons JW (2011). Climate change correlates with rapid delays and advancements in reproductive timing in an amphibian community. *Proceedings of the Royal Society B* **278**, 2191–7.