Online Supplementary Material

Alien species in a warmer world: risks and opportunities

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Table S1. A (non-exhaustive) compilation of studies* reporting recent warming-mediated invasions of non-native species, gr according to the sequential transitions of a successful invasion process (*cf.* Figure 1).

Climatic parameter	Response	Species	Taxonomic group	Origin	Introduced range	Vector	Reference
INTRODUCTION / IMMIGRATION ('new' species)							
Arctic's diminishing ice cover	new migration corridor with modified Arctic hydrography and circulation	*Neodenticula seminae*	phytoplankton	Pacific	Atlantic	migration	Reid, C. *et al.* (2007) *Global Change Biol.* 13, 1910–1921

Milder winter temperatures	all-season survival outdoors	*Trachycarpus fortunei,* a.o. evergreen broad-leaved spp.	plants	warm-temperate regions (mainly South-East Asia)	USA Central Europe	horticulture	Francko, D.A. (2003) *Palms won't grow here and other myths*, Timber Press Walther, G.-R. *et al.* (2007) *Global Ecol. Biogeogr.* 16, 801–809 Stähler, M. and Spanner, T.W. (2007) *Winterharte Palmen*, Medemia
Warming of mean winter and night-time temperatures	enhanced survival rate through the winter	*Orbivirus* spec. *Culicoides* spp.	virus insects	Africa / southern Asia	Europe	movement of infected ruminants or wind-dispersal of infected midges	Purse, B. V. *et al*. (2005) *Nature Rev. Microbiol.* 3, 171–181
Higher average summer temperatures	first occurrence	*Halyomorpha halys*	insect (bug)	East Asia	Switzerland	unintentional introduction with woody or floral ornamentals or fruit	Wermelinger, B. *et al.* (2008) *Mitt. Schweiz. Entomol. Ges*. 81, 1–8
Warmer urban environments	first occurrence	*Monomorium destructor*	insect (ant)	North Africa and Central-East Asia	Temperate latitudes (> 35°) Melbourne (Australia), Auckland (New Zealand), Tennessee (USA)	unintentional introductions	Wetterer, J. K. (2009) Myrmecol. News 12, 97-108
Temperature > 5°C	enhanced flight activity	*Agrotis ipsilon aneituma,* a.o.	insects (moth)	New Zealand	subantarctic Macquarie Island	migration	Greenslade, P. *et al.* (1999) *J. Biogeogr.* 26, 1161–1167
Warmer temperatures	first occurrence	*Chrysobasis lucifer* *Nehalennia minuta* a.o.	insects (dragonflies)	Caribbean	Florida (USA)	migration	Paulson, D.R. (2001) *Int. J. Odonatology* 4, 57-69.
Positive temperature anomalies (e.g. March-July)	northward range expansion	75 migratory Lepidoptera	insects	Southern Europe	United Kingdom	migration	Sparks, T.H. *et al*. (2007) *Eur. J. Entomol.* 104, 139–143
Increased water temperature in summer	enhanced survival	*Cercopagis pengoi, Cornigerius maeoticus, Evadne anonyx*	aquatic invertebrates	Ponto-Caspian	Baltic Sea	ballast water	Panov, V.E. *et al*. (2007) *Hydrobiol.* 590, 3–14
Warmer temperatures	enhanced survival	*Ferrissia fragilis*	aquatic invertebrate (mollusc)	North America	Pripyat river basin, Belarus	escaped from cooling reservoir of nuclear power station	Semenchenko, V. and Laenko, T. (2008) *Aquat. Invasions* 3, 80–82
Milder winter temperatures	enhanced survival	*Crepidula fornicata*	marine invertebrate (mollusc)	North America	Atlantic coast of Europe	introduced in association with imported American oysters	Thieltges, D. W. *et al*. (2004) *J. Exp. Mar. Biol. Ecol.* 311, 375–391

COLONISATION (increased survival and growth)

Higher sea surface water temperatures in the cold season	more regular and frequent appearance	*Stephanopyxis palmeriana*, *Rhizosolenia indica,* a.o.	phytoplankton	Mediterranean Sea Atlantic	North Sea	currents	Nehring, S. (1998) *ICES J. Mar. Sci.* 55, 818–823
Longer and warmer growing season	increasing abundance of individuals reaching maturity	*Lycopersicon esculentum*	plant	South America	Rhine river banks, Germany	cultivation	Schmitz, U. (2004) *Flora* 199, 476–480
Warming and urban heat island	increasing juvenile survival with individu-	*Celtis australis*	plant	southern Europe	Castle Hill, Budapest	horticulture	Czúcz, B. (2005) *Kitaibelia* 10, 85–99

	als reaching maturity						
Climate warming of the last 10-15 years	occur more frequently and persist	*Fumaria montana,* a.o.	plants	Macaronesia	North Rhine-Westphalia (Germany)	unintentional introductions	Schmitz, J. (2001) *Flor. Rundbr.* 35, 37–43
Lengthening of the growing season	better survival and growth	*Poa pratensis,* a.o.	plants	South America	Antarctica	unintentional introductions	Smith, R. I. L. (1996) *Biol. Conserv.* 76, 135–146
Increased climate suitability	higher probability of completing its life cycle	*Lymantria dispar*	insects (moth)	Europe	Canada	accidental introduction	Régnière J., *et al.* (2009) *Biol. Invasions* 11, 135–148
Elevated sea temperatures	appeared for the first time in the 1996-1998 high temperature episode and persisted	*Gnatholepis thompsoni*	fish	tropical Atlantic	Canary Islands	migration	Rocha, L. A. *et al*. (2005) *Molecular Ecol.* 14, 3921–3928
Warmer sea surface temperatures	first occurrence	*Hemiramphus far*; *Paraexocoetus mento,* a.o.	fishes	Red Sea	Adriatic Sea	migration[(?)], currents	Dulcic, J. and Grbec, B. (2000) *Fish. Oceanogr.* 9, 187–191
ESTABLISHMENT / **NATURALISATION** (fully reproducing populations)							
Warmer urban environments	establishment of cold sensitive species due to the urban heat island	*Ailanthus altissima*	plant	Asia	Leipzig (Germany) and other cities in Central Europe	horticulture	Gutte, P. *et al.* (1997) *Folia Geobot. Phytotax.* 22, 241–262 Kowarik, I. and Säumel, I. (2007) *Persp. Plant Ecol. Evol. Syst*. 8, 207–237
Mean temperature of coldest month > 2.2°C (when GDD_5 >= 2300)	reproducing populations in the wild	*Trachycarpus fortunei,* a.o. evergreen broad-leaved spp.	plants	China	Ticino (southern Switzerland)	horticulture	Walther, G.-R. *et al.* (2007) *Global Ecol. Biogeogr.* 16, 801–809
Increased minimum temperatures	reduced winter mortality	*Araujia sericifera,* a.o.	plants	eastern South America	Iberian Peninsula	horticulture	Sobrino Vesperinas, E. *et al.* (2001) In *„Fingerprints“ of Climate Change – Adapted behaviour and shifting species ranges* (Walther, G.-R. *et al*., eds), pp. 163–184, Kluwer Academic/Plenum Publishers
Increases in winter water temperatures	higher growth rates through earlier initiation of recruitment	*Botrylloides violaceus,* a.o.	marine invertebrates	Japan	New England (USA)	boat traffic	Stachowicz, J.J. *et al.* (2002) *Proc. Natl Acad. Sci. USA* 99, 15497–15500
Recent climate change	growing populations	*Percnon gibbesi*	marine invertebrate (crustacean)	subtropical Atlantic	Sicily (Italy), Mediterranean Sea	currents	Pippitone, C. *et al.* (2001) *Crustaceana* 74, 1009–1017
Increased summer temperature in confined bays	spawning and settlement capability	*Crassostrea gigas*	aquatic invertebrate	North Pacific	Europe	aquaculture	Diederich, S. *et al*. (2005) *Helgol. Mar. Res.* 59, 97–106 Schmidt, A. *et al.* (2008) *Helgol. Mar. Res.* 62, 367–376
Increased water temperature in summer	spawning capability	*Dreissena polymorpha*	aquatic invertebrate	Ponto-Caspian	Gulf of Finland, Baltic Sea	human introductions (ballast water)	Orlova, M. I. and Panov, V. E. (2004) *Hydrobiol.* 514, 207–217
High water temperatures in summer	former sterile pseudo-populations reproduce	*Thalassoma pavo*	fish	southern parts of the Mediterranean Sea	Ligurian Sea (Italy)	migration	Vacchi, M. *et al.* (2001) *Archo Oceanogr. Limnol.* 22, 149–154
Warmer winters and early summer temperatures	successful breeding	*Merops apiaster*	bird	Mediterranean	areas north of the Alps	migration	Schelbert, B. (1992) *Orn. Beob.* 89, 63–65 Kinzelbach, R. *et al.* (1997) *J. Ornithol.* 138, 297–308

Warmer urban environments	better survival through e.g. reduced cryogenic feet deformations (D.Franz, written com.)	*Aratinga acuticaudata,* a.o.	birds	South America	London area (United Kingdom), Brussels (Belgium), Wiesbaden (Germany)	intentional or unintentional releases of captive individuals	Pithon, J. A. and Dytham, C. (2002) *Bird Study* 49, 110–117 Butler, C. *et al.* (2002) *Brit. Birds* 95, 17–20 Strubbe, D. and Matthysen, E. (2007) *Ecography* 30, 578–588

SPREAD (climate-induced range expansion)

Higher summer sea temperatures	former isolated populations expand rapidly	*Codium fragile* ssp. *Tomentosoides*	algae	Pacific Ocean around Japan	Gulf of Maine (North America)	introduced from Europe	Harris, L. G. and Tyrrell, M. C. (2001) *Biol. Inv.* 3, 9–21
General warming	increasing in frequency, becoming common throughout the area	warm temperate and subtropical lichens, e.g. *Flavoparmelia soredians,* a.o.	lichens	tropical and subtropical regions	north-western European lowlands	air currents	van Herk, C.M. *et al.* (2002) *The Lichenologist*, 34, 141–154 Aptroot, A. and van Herk, C. M. (2007) *Environ. Pollut.* 146, 293–298
Warmer water temperatures	increased possibility for overwintering and spread in several cold water channels since 1995 (formerly exclusively confined to thermal waters)	*Cabomba caroliniana*	plant	subtropical and warm-temperate Americas	Kiskunság (Hungary)	aquaristic	Sipos, V. *et al.* (2003) *Arch. Hydrobiol. Suppl.bd., Large rivers* 14, 143–166
Winter warming	reduced winter mortality	*Thaumetopoea pityocampa*	insect (moth)	Mediterranean region	North Central France and Alps	expansion	Battisti, A. *et al.* (2005) *Ecol. Appl.* 15, 2084–2096 Robinet, C. *et al.* (2007) *Global Ecol. Biogeogr.* 16, 460–471
					Sierra Nevada		Hódar, J. A. and Zamora, R. (2004) *Biodiv. Conserv.* 13, 493–500
Summer warming	increased adult dispersal				Italian Alps		Battisti, A. *et al.* (2006) *Global Change Biol.* 12, 662–671
Winter warming	reduced winter mortality	*Nezara viridula*	insect (bug)	tropical and subtropical Asia	Central Japan	expansion	Tougou *et al.* (2009) *Entomol. Exp. Appl.* 130, 249- 258
Higher temperature	increased flight activity and radius of adults	*Crocothemis erythraea,* a.o.	insects (dragonflies)	Mediterranean	Germany	migration	Ott, J. (2001) In *„Fingerprints" of Climate Change – Adapted behaviour and shifting species ranges* (Walther, G.-R. *et al.*, eds), pp. 89–111, Kluwer Academic/Plenum Publishers Ott, J. (2007) In *Odonata – Biology of Dragonflies,* (Tyagi, B. K., ed), pp. 201–222, Scientific Publishers
		Trithemis annulata, Trithemis kirbyi, *Selysiothemis nigra*, a.o.		Africa	southern Europe		Ott, J. (2009) In *Monitoring climate change with dragonflies*. (Ott, J., ed), in press, Pensoft Publishers
Higher temperatures	rate of establishment correlated with increase in mean annual temperature in the 20th century	10 butterfly species	insects	South (e.g. Taiwan)	Nansei Islands (Japan)	migrations	Kiritani, K. (2006) *Popul. Ecol.* 48, 5–12
Rising sea temperatures	increases in abundance	*Engraulis encrasicholus Sardinia pilchardus*	fishes	southern Europe	north-western North Sea	migration	Beare, D. *et al.* (2004) *Global Change Biol.* 10, 1209–1213
Milder winter temperatures	extension of the species' breeding	*Egretta garzetta,* a.o.	birds	southern Europe	United Kingdom & Ireland	migration	Robinson, R. A. *et al.* (2005) *Climate Change and Migratory Species*. BTO Research Report

distribution	414

*The criteria for selecting these studies included empirical rather than simulation studies, field rather than laboratory or mesocosm results, and where population or performance measures could unambiguously be related to recent warming. The selectivity of these criteria may explain the number and to some extent geographic biases of the studies. For example, there are few long-term time series of plant and animal populations in the Southern Hemisphere, so that for Australia and New Zealand, examples that seem to be available are (numerous) projections of future change but much less evidence of recent change (yet?).