

Appendix S1. Examples of rapid evolutionary change in ten traits associated with invasiveness. Coding in the ‘Evidence’ column refers to the methodology used to verify that observed changes between introduced and native populations had a genetic basis: FO, field observations; CG, common gardens (i.e. common environments, including greenhouses); RT, reciprocal transplantation; NI, native and introduced populations examined; I, only introduced populations examined; GM, genetic analyses based on genetic markers or molecular traits; TM, tests to address potential maternal effects; AM, steps to avoid potential maternal effects (such as rearing a pilot generation).

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
		Reference	Introduced Species	Trait(s)	Location	Timeframe	Evidence
High growth rate	Newsome & Noble 1986 Ashton & Mitchell 1989 Lodge 1993ab Rejmánek 1996 ¹ Rejmánek & Richardson 1996 ¹ Grotkopp <i>et al.</i> 2002 Kolar & Lodge 2002 ² McMahon 2002 Rejmánek <i>et al.</i> 2005 ¹ Pyšek & Richardson 2007	Thompson <i>et al.</i> 1991ab	<i>Spartina anglica</i> (common cordgrass)	biomass, various morphology	England	100 yrs	CG, RT, I
		Blossey & Nötzold 1995	<i>Lythrum salicarium</i> (purple loosestrife)	height, biomass	North America	<200 yrs	CG, NI
		Kinnison <i>et al.</i> 1998a	<i>Oncorhynchus tshawytscha</i> (chinook salmon)	length, mass	New Zealand	100 yrs, 30 gens	FO, NI
		Weber & Schmid 1998	<i>Solidago altissima</i> (late goldenrod)	relative growth rate	Europe	250 yrs	FO, CG, I
		Weber & Schmid 1998	<i>Solidago gigantea</i> (giant goldenrod)	relative growth rate	Europe	250 yrs	FO, CG, I
		Siemann & Rogers 2001, 2003b	<i>Sapium sebiferum</i> (Chinese tallow tree)	basal area, stem growth, root mass, shoot mass	Southeastern US	100 yrs	CG, NI, TM
		Koskinen <i>et al.</i> 2002	<i>Thymallus thymallus</i> (grayling)	growth rate	Norway	80-120 yrs	CG, NI, GM, AM
		Leger & Rice 2003	<i>Eschscholzia californica</i> (California poppy)	biomass	Chile	110-150 yrs	CG, NI
		Blair & Wolfe 2004	<i>Silene latifolia</i> (white campion)	size (1 mo), size at flower	North America	150 yrs	FO, CG, NI, TM
		Maron <i>et al.</i> 2004	<i>Hypericum perforatum</i> (St. John's wort)	plant volume	North America	150 yrs, 12-15 gens	CG, NI, GM, TM
Buschmann <i>et al.</i> 2005	<i>Rorippa austriaca</i> (Austrian yellowcress)	# leaves, # stems	Southern Great Lakes, N Amer	200+ yrs	CG, NI, AM		
Buschmann <i>et al.</i> 2005	<i>Cardaria draba</i> (whitetop)	# leaves	Southern Great Lakes, N Amer	200+ yrs	CG, NI, AM		

¹ Rejmánek and others did not explicitly find that high rates of growth were associated with invasive behavior, but they point out that high relative growth rates (especially in seedlings), larger numbers of seeds, better dispersal, higher initial germinability, and simplified germination requirements are all likely byproducts of having a small seed (or genome) size, which is positively associated with invasiveness.

² Kolar and Lodge found that a high growth rate was positively associated with establishment, but negatively associated with spread; this result supports their hypothesis that biotic invasions transpire in distinct stages and that the importance of particular characteristics depends upon the stage of invasion.

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
		Reference	Introduced Species	Trait(s)	Location	Timeframe	Evidence
Wide climatic or environmental tolerance	Baker 1974 Moyle 1986 Ashton & Mitchell 1989 Ehrlich 1989 Lodge 1993ab Kolar & Lodge 2002 Rejmánek <i>et al.</i> 2005	Clegg & Allard 1972	<i>Avena barbata</i> (slender wild oat)	various morphology	California	150-400 yrs	FO, NI, GM
		Johnston & Selander 1973	<i>Passer domesticus</i> (house sparrow)	size, morphology	North America	<125 yrs	FO, NI
		Kendeigh & Blem 1974	<i>Passer domesticus</i> (house sparrow)	metabolic rates	North America	<125 yrs	FO, NI
		Lacey 1988	<i>Daucus carota</i> (wild carrot)	flowering time	North America	300 yrs, 150 gens	RT, I, TM
		Thompson <i>et al.</i> 1991ab	<i>Spartina anglica</i> (common cordgrass)	plasticity breadth	England	100 yrs	CG, RT, I
		Weber & Schmid 1998	<i>Solidago altissima</i> (late goldenrod)	morphology, phenology, growth rate	Europe	250 yrs	FO, CG, I
		Weber & Schmid 1998	<i>Solidago gigantea</i> (giant goldenrod)	morphology, phenology, growth rate	Europe	250 yrs	FO, CG, I
		Lee 1999, Lee <i>et al.</i> 2003, Lee <i>et al.</i> 2007	<i>Eurytemora affinis</i> (calanoid copepod)	freshwater tolerance	Worldwide	<200 yrs, 6+ gens	FO, CG, NI, GM, AM
		Milne & Abbott 2000	<i>Rhododendron ponticum</i> (common rhododendron)	cold tolerance	England	240 yrs	FO, GM, NI
		Del Pozo <i>et al.</i> 2002	<i>Medicago polymorpha</i> (burr medic)	winter growth rate	Chile	400 yrs	CG, I
		Koskinen <i>et al.</i> 2002	<i>Thymallus thymallus</i> (grayling)	size, growth rate, survival	Norway	80-120 yrs	CG, NI, GM, AM
		Maron <i>et al.</i> 2004	<i>Hypericum perforatum</i> (St. John's wort)	plant volume, # seed capsules, leaf area	North America	150 yrs, 12-15 gens	CG, NI, GM, TM
		Butin <i>et al.</i> 2005	<i>Adelges tsugae</i> (hemlock woolly adelgid)	resistance to cold shock	North America	50 yrs, 100 gens	FO, CG, I, AM
		Franks <i>et al.</i> 2007	<i>Brassica rapa</i> (field mustard)	flowering time (drought avoidance)	California	7 yrs	CG, I, TM, AM
Leger & Rice 2007	<i>Eschscholzia californica</i> (California poppy)	morphology, fecundity, phenology	Chile	110-150 yrs	CG, NI, TM		
Short generation time	Baker 1974 Ehrlich 1989 Lodge 1993ab Rejmánek 1996	Jain & Martins 1979	<i>Trifolium hirtum</i> (rose clover)	flowering time	California	20 yrs	FO, CG, I, GM
		Stearns 1983ab	<i>Gambusia affinis</i> (mosquitofish)	age at maturity	Hawaii	80 yrs, 70 gens	CG, I, AM

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
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	Rejmánek & Richardson 1996 Daehler 1998 Kolar & Lodge 2001 Grotkopp <i>et al.</i> 2002 McMahon 2002 Rejmánek <i>et al.</i> 2005	Lacey 1988	<i>Daucus carota</i> (wild carrot)	flowering time	North America	300 yrs, 150 gens	RT, I, TM
		Rice & Mack 1991	<i>Bromus tectorum</i> (cheatgrass)	flowering time	North America	uncertain	CG, I, AM
		Weber & Schmid 1998	<i>Solidago altissima</i> (late goldenrod)	phenological rate	Europe	250 yrs	FO, CG, I
		Weber & Schmid 1998	<i>Solidago gigantea</i> (giant goldenrod)	phenological rate	Europe	250 yrs	FO, CG, I
		Siemann & Rogers 2001	<i>Sapium sebiferum</i> (Chinese tallow tree)	% fruiting at 14 yrs	Southeastern US	100 yrs	CG, NI, TM
		Lee <i>et al.</i> 2003, Lee <i>et al.</i> 2007	<i>Eurytemora affinis</i> (calanoid copepod)	juvenile period	Lake Michigan, US	6 gens	CG, NI, AM
		Blair & Wolfe 2004	<i>Silene latifolia</i> (white campion)	flowering time	North America	150 yrs	FO, CG, NI, TM
		Leger & Rice 2007	<i>Eschscholzia californica</i> (California poppy)	flowering time	Chile	110-150 yrs	CG, NI, TM
Prolific or consistent reproduction	Baker 1974 O'Connor 1986 Ashton & Mitchell 1989 Noble 1989 Lodge 1993ab Rejmánek 1996 Rejmánek & Richardson 1996 Kolar & Lodge 2001 McMahon 2002 Rejmánek <i>et al.</i> 2005 Pyšek & Richardson 2007	Jain & Martins 1979	<i>Trifolium hirtum</i> (rose clover)	# flowers/plant	California	20 yrs	FO, CG, I, GM
		Kinnison <i>et al.</i> 1998b, Kinnison <i>et al.</i> 2001	<i>Oncorhynchus tshawytscha</i> (chinook salmon)	fecundity, ovary mass, gonadosomatic index	New Zealand	100 yrs, 30 gens	FO, CG, NI
		Weber & Schmid 1998	<i>Solidago altissima</i> (late goldenrod)	inflorescence size	Europe	250 yrs	FO, CG, I
		Weber & Schmid 1998	<i>Solidago gigantea</i> (giant goldenrod)	inflorescence size	Europe	250 yrs	FO, CG, I
		Hill <i>et al.</i> 1999	<i>Pararge aegeria</i> (speckled wood butterfly)	thorax & abdomen size	UK and Madeira	20 yrs	FO, NI
		Leiss & Mueller-Scharer 2001	<i>Senecio vulgaris</i> (common groundsel)	# flowering heads	European cropland	<100 yrs	CG, NI, AM
		Leger & Rice 2003	<i>Eschscholzia californica</i> (California poppy)	# flowers	Chile	100-150 yrs	CG, NI
		Blair & Wolfe 2004	<i>Silene latifolia</i> (white campion)	flower production	North America	150 yrs	FO, CG, NI, TM
		Maron <i>et al.</i> 2004	<i>Hypericum perforatum</i> (St. John's wort)	# seed capsules	North America	150 yrs, 12-15 gens	CG, NI, GM, TM
		Buschmann <i>et al.</i> 2005	<i>Barbarea vulgaris</i> (garden yellowrocket)	# fruits, # seeds/fruit	Southern Great Lakes, N Amer	200+ yrs	CG, NI, AM

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
		Reference	Introduced Species	Trait(s)	Location	Timeframe	Evidence
		Meyer <i>et al.</i> 2005	<i>Solidago gigantea</i> (giant goldenrod)	infructescence mass	Europe	250 yrs	CG, NI, AM
		Leger & Rice 2007	<i>Eschscholzia californica</i> (California poppy)	seeds per flower	Chile	110-150 yrs	CG, NI, TM
Small seed or egg size	Rejmánek 1996 Rejmánek & Richardson 1996 Kolar & Lodge 2001, 2002 Grotkopp <i>et al.</i> 2002 Rejmánek <i>et al.</i> 2005	Wu & Jain 1978	<i>Bromus rubens</i> (red brome)	seed mass	North America	150 yrs	CG, I, AM
		Rice & Mack 1991	<i>Bromus tectorum</i> (cheatgrass)	seed mass	North America	70-100 yrs	CG, I, AM
		Kinnison <i>et al.</i> 1998b, Kinnison <i>et al.</i> 2001	<i>Oncorhynchus tshawytscha</i> (chinook salmon)	egg mass	New Zealand	100 yrs, 30 gens	FO, CG, NI
		Buschmann <i>et al.</i> 2005	<i>Cardaria draba</i> (whiteweed)	seed mass	Southern Great Lakes, N Amer	200+ yrs	CG, NI, AM
		Leger & Rice 2007	<i>Eschscholzia californica</i> (California poppy)	seed mass	Chile	110-150 yrs	CG, NI, TM
Good (efficient and/or effective) dispersal	Baker 1974 Moyle 1986 O'Connor 1986 Ashton & Mitchell 1989 Noble 1989 Lodge 1993ab Rejmánek 1996 ³ Daehler 1998 ³ McMahon 2002 Rejmánek <i>et al.</i> 2005 Pyšek & Richardson 2007	Cody & Overton 1996	<i>Hypochaeris radicata</i> (hairy catsear)	pappus:achene ratio	British Columbia	10 yrs	FO, NI
		Cody & Overton 1996	<i>Mycelis (Lactuca) muralis</i> (wall lettuce)	pappus:achene ratio	British Columbia	10 yrs	FO, NI
		Able & Belthoff 1998	<i>Carpodacus mexicanus</i> (house finch)	migratory frequency & distance	New York	<60 yrs	FO, NI
		Kinnison <i>et al.</i> 1998a, Kinnison <i>et al.</i> 2001	<i>Oncorhynchus tshawytscha</i> (chinook salmon)	body size, ovary mass, egg size:number ⁴	New Zealand	100 yrs, 30 gens	FO, CG, NI, RT
		Hill <i>et al.</i> 1999	<i>Pararge aegeria</i> (speckled wood butterfly)	thorax size, wing morphology	UK and Madeira	20 yrs	FO, NI
		Badyaev & Hill 2000	<i>Carpodacus mexicanus</i> (house finch)	migratory morphology	North America	150 yrs	FO, GM, NI
		Thomas <i>et al.</i> 2001	<i>Conocephalus discolor</i> (conehead grasshopper)	wing morph frequency	England	20 years	FO, NI
		Phillips <i>et al.</i> 2006	<i>Bufo marinus</i> (cane toad)	leg length, rate of spread	Australia	70 yrs	FO, NI
High rate of or capacity for uniparental reproduction	Baker 1974 Brown & Marshall 1981 Ashton &	Thompson <i>et al.</i> 1991ab	<i>Spartina anglica</i> (common cordgrass)	# tillers/plant	England	100 yrs	CG, RT, I
		Novak & Welfley 1997	<i>Poa bulbosa</i> (bulbous bluegrass)	vegetative reproduction	Western US	uncertain	FO, GM, I

³ Rejmánek and Daehler found that vertebrate and abiotic dispersal, respectively, were highly effective and associated with invasiveness in the taxa examined.

⁴ Kinnison *et al.* observed changes in these traits that they considered to be part of a tradeoff between dispersal and reproduction that led to enhanced dispersal.

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
		Reference	Introduced Species	Trait(s)	Location	Timeframe	Evidence
	Mitchell 1989 Ehrlich 1989 Lodge 1993ab Reichard & Hamilton 1997 Kolar & Lodge 2001	Daehler 1999 Buschmann <i>et al.</i> 2005	<i>Spartina alterniflora</i> (smooth cordgrass) <i>Rorippa austriaca</i> (Austrian yellowcress)	selfing rate # fruits ⁵	San Francisco Bay Southern Great Lakes, N Amer	30 yrs 200+ yrs	CG, I CG, NI, AM
Absence of specialized germination or hatching requirements	Baker 1974 Reichard & Hamilton 1997	Moore 1975 Meyer & Allen 1999 Moritz & Kadereit 2001 Allen & Meyer 2002 Lounibos <i>et al.</i> 2003	<i>Cirsium arvense</i> (Canada thistle) <i>Bromus tectorum</i> (cheatgrass) <i>Senecio vulgaris</i> ssp. <i>vulgaris</i> (common groundsel) <i>Bromus tectorum</i> (cheatgrass) <i>Aedes albopictus</i> (Asian tiger mosquito)	germination requirements germination requirements germination requirements germination requirements photoperiod tolerance	North America Western US cosmopolitan Western US Florida	100 yrs 70-100 yrs 200 yrs 70-100 yrs 10 yrs	FO, I CG, I, AM GM, NI CG, I CG, NI, AM
High competitive ability	Baker 1974 Moyle 1986 Newsome & Noble 1986 O'Connor 1986 Ashton & Mitchell 1989 Blossey & Nötzold 1995 Pyšek <i>et al.</i> 1995 Rejmánek <i>et al.</i> 2005	Blossey & Nötzold 1995 Perry <i>et al.</i> 2001ab Siemann & Rogers 2003b; Rogers & Siemann 2004; Siemann <i>et al.</i> 2006 Meyer <i>et al.</i> 2005	<i>Lythrum salicarium</i> (purple loosestrife) <i>Orconectes rusticus</i> (rusty crayfish) X <i>O. propinquus</i> (northern clearwater crayfish) <i>Sapium sebiferum</i> (Chinese tallow tree) <i>Solidago gigantea</i> (giant goldenrod)	height, biomass, herbivore resistance foraging ability various growth, fecundity, defense infructescence mass, pathogen resistance, herbivore tolerance	North America Wisconsin Southeastern US Europe	<200 yrs 20 yrs 100 yrs 250 yrs	CG, NI FO, NI, foraging trials FO, CG, NI, TM CG, NI, AM
Ability to escape or survive natural enemies or disease	Elton 1958 Newsome & Noble 1986 Ashton &	Donald 1994 Blossey & Nötzold 1995	<i>Cirsium arvense</i> (Canada thistle) <i>Lythrum salicarium</i> (purple loosestrife)	pathogen resistance herbivore resistance	North America North America	100 yrs <200 yrs	FO, I CG, NI

⁵ Buschmann *et al.* used fruiting characteristics as a proxy for vegetative (asexual) reproduction; the significant reduction in fruit number here suggests a reallocation of resources consistent with a shift from sexual to asexual reproduction.

Trait	Reference for association with invasiveness	Example of rapid evolutionary change					
		Reference	Introduced Species	Trait(s)	Location	Timeframe	Evidence
	Mitchell 1989 Mack <i>et al.</i> 2000	Daehler & Strong 1997	<i>Spartina alterniflora</i> (smooth cordgrass)	herbivore resistance	Willapa Bay, Washington	100 yrs	CG, NI, AM
	Keane & Crawley 2002 Rejmánek <i>et al.</i> 2005 Pyšek & Richardson 2007	Siemann & Rogers 2001, 2003ab; Rogers & Siemann 2004, 2005; Siemann <i>et al.</i> 2006	<i>Sapium sebiferum</i> (Chinese tallow tree)	herbivore resistance and tolerance	Southeastern US	100 yrs	FO, CG, NI, TM
		Blair & Wolfe 2004	<i>Silene latifolia</i> (white campion)	trichome density, capsule mass	North America	150 yrs	FO, CG, NI
		Meyer <i>et al.</i> 2005	<i>Solidago gigantea</i> (giant goldenrod)	pathogen resistance, herbivore tolerance	Europe	250 yrs	CG, NI, AM
		Zangerl & Berenbaum 2005	<i>Pastinaca sativa</i> (wild parsnip)	furanocoumarin levels	North America	115 yrs	FO, NI

References for Appendix S1

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