Interspecific behavioural interference and range dynamics: current insights and future directions

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Abstract

Novel biotic interactions in shifting communities play a key role in determining the ability of species' ranges to track suitable habitat. To date, the impact of biotic interactions on range dynamics have predominantly been studied in the context of interactions between different trophic levels or, to a lesser extent, exploitative competition between species of the same trophic level. Yet, both theory and a growing number of empirical studies show that interspecific behavioural interference, such as interspecific territorial and mating interactions, can slow down range expansions, preclude coexistence, or drive local extinction, even in the absence of resource competition. We conducted a systematic review of the current empirical research into the consequences of interspecific behavioural interference on range dynamics. Our findings demonstrate there is abundant evidence that behavioural interference by one species can impact the spatial distribution of another. Furthermore, we identify several gaps where more empirical work is needed to robustly test predictions from theory. Finally, we outline several avenues for future research, providing suggestions for how interspecific behavioural interference could be incorporated into existing biotic-interactions frameworks of range expansion, such as species distribution models, to build a stronger understanding of the potential consequences of behavioural interference on the outcome of future range dynamics.

Keywords (5-10)

interspecific behavioural interference, reproductive interference, interspecific aggression, range dynamics, systematic review, elevational gradients, invasion biology, range shift

Contents

I. Introduction

As anthropogenic changes continue to alter the availability and distribution of habitats, the spatial distribution of species’ niches will shift, in turn driving shifts in species' ranges (Parmesan and Yohe 2003). Given that species vary in their niches and in their responses to environmental change, communities will not shift in concert, resulting in a global reshuffling of diversity and the formation of novel species assemblages. Similarly, invasions due to anthropogenic factors can have disruptive effects on species assemblages. Interactions between species--whether between previously coexisting species or between newly co-occurring species in shifting communities--play key roles in determining the ability of species’ ranges to track suitable habitats (Alexander, Diez, and Levine 2015; Blois et al. 2013; Early and Keith 2019; Ockendon et al. 2014). For instance, the arrival of novel predators can drive prey species to extinction (e.g., brown tree snakes [*Boiga irregularis*] drove the local extinction of several bird species after they were introduced to Guam, (Savidge 1987); conversely, the local extinction of one species can destabilize interaction networks, driving secondary extinctions (e.g., experimental removal of a keystone predator [*Pisaster ochraceus*] led to a decline in diversity in the marine intertidal zone, (Paine 1966)). By and large, studies on the impacts of biotic interactions on population and range dynamics have predominantly focused on interactions across trophic levels or, to a lesser extent, exploitative competition between species of the same trophic level (Sirén and Morelli 2020; Early and Keith 2019; Louthan, Doak, and Angert 2015; Svenning et al. 2014; Legault et al. 2020; Ortego and Knowles 2020).

Yet, an important type of competition between closely related animal species is often overlooked: interspecific behavioural interference (Grether et al. 2017). Behavioural interference encompasses any aggressive, territorial, or mating behaviour by one species that has a negative impact on the fitness of another species (Grether et al. 2017; Gröning and

Hochkirch 2008; Burdfield-Steel and Shuker 2011) and has been documented across a wide range of taxa (Gröning and Hochkirch 2008; Peiman and Robinson 2010). In general, aggressive and sexual interactions arise between species that are phenotypically and ecologically similar owing to recent shared ancestry (e.g., species with similar sexual signals and/or perceptual systems). Such interactions are costly and lead to decreased fitness as individuals waste energy, are driven to use suboptimal habitat, or miss out on mating opportunities with conspecifics. Consequently, behavioural interference can decrease population growth rates, cause exclusion from adequate habitat, and reduce or prevent dispersal into novel areas (Grether et al. 2017). Thus, interspecific behavioural interference is likely to have important impacts on range dynamics.

Several theoretical investigations of behavioural interference have modelled the factors that promote or preclude coexistence (T. J. Case and Gilpin 1974; Kuno 1992; Liou and Price 1994; Amarasekare 2002; Mikami and Kawata 2004; Kishi and Nakazawa 2013; Kyogoku and Sota 2017; Iritani and Noriyuki 2021; Irwin and Schluter 2022; Grether and Okamoto 2022) and a handful have even explicitly analysed how processes affecting coexistence locally scale up to influence the outcome of movement across landscapes (Ribeiro and Spielman 1986; Crowder et al. 2011; Nishida, Takakura, and Iwao 2015; Ruokolainen and Hanski 2016; Legault et al. 2020). One key insight from these models is that the impact of interspecific behavioural interference is likely to be highest when one of the interacting species occurs at a much lower frequency than the other, as interspecific interference will be more common than intraspecific interactions for the rarer species (e.g., (Amarasekare 2002; Kuno 1992). Consequently, Allee effects resulting from behavioural interference may make it very difficult for viable populations to become established in novel geographic areas (Grether et al. 2017) or may drive precipitous local extinction once population densities fall below a certain threshold. A common result in models incorporating behavioural interference is the formation and maintenance of abutting (parapatric) range limits, which may move according to the magnitude of and degree of asymmetry in interference (Ribeiro and Spielman 1986; Nishida, Takakura, and Iwao 2015). Another insight from these models relates to the interactive effect of resource competition and behavioural interference--several models also show dynamics of systems with both resource competition and behavioural interference are markedly different than systems with resource competition alone (Ribeiro and Spielman 1986; Amarasekare 2002; Crowder et al. 2011), which underscores the importance of further research into behavioural interference in attempts at predicting species responses to shifting assemblages.

Insights derived from theory about the impact of behavioural interference on range dynamics are now backed up by a growing body of empirical research. Interspecific behavioural interference has been shown to impact a range of spatial dynamics, ranging from local-scale habitat use (Vallin et al. 2012) to large-scale range limit shifts (Duckworth and Badyaev 2007). Here we present the results of the first synthesis of this body of work through a systematic literature review, and, in light of the widespread evidence that behavioural interference impacts range dynamics, we discuss patterns emerging from existing studies, highlight key gaps in the literature, and suggest several avenues for future research.

II. Systematic literature review

To identify examples of interspecific behavioural interference influencing the spatial distribution of a species, we conducted a search of peer-review literature using the "all databases" option in Web of Science (https://www.webofscience.com/). We used the search term *"TS=(((behaviour* OR behavior*) NEAR/6 interference) OR (reproduct* NEAR/6 interference) OR (interspecific NEAR/6 (behaviour* OR behavior*) NEAR/6 competition) OR ((interspecific OR heterospecific) NEAR/6 aggress*) OR ((interspecific OR* *heterospecific) NEAR/6 dominan*) OR ((interspecific OR heterospecific) NEAR/6 territor*) OR ((interspecific OR heterospecific) NEAR/6 interference) OR (sister AND (taxa OR species) AND (competition OR aggress* OR territor*OR dominan* OR interference))) AND TS= ((range* NEAR/6 shift*) OR (species NEAR/6 distribution*) OR (range* NEAR/6 expansion*) OR (range* NEAR/6 dynamic*) OR (species NEAR/6 displace*) OR (species NEAR/6 replace*) OR (Altitud* NEAR/6 (zonat* OR zone)))".* As of the search date (2022-10-13), this produced a database of 338 unique peer-reviewed articles, which both authors contributed to reading and extracting data from. To reduce bias in data extraction between readers, the first 37 papers (10%) were independently read by both of us and data extraction compared. For the 10% of papers initially read by both readers, the interpretation of the paper and data extracted was concordant. We only included cases for which there are direct observations of interspecific behavioural interference and an explicit link between that interference to spatial dynamics, which added 72 papers in our final set. For instance, in cases where species have abutting boundaries (e.g., parapatric range limits), we only included cases where behavioural interference has been documented and this boundary does not also coincide with clear shifts in habitat types. Similarly, for instances of microhabitat segregation or mosaic distribution patterns, we required the study to demonstrate that shifts in habitat use directly result from behavioural interference. While reading these papers, we also noted papers that the authors cited as further evidence for behavioural interference and/or range dynamics within their own or other study systems which added 26 additional papers to our final set. Of the 98 studies in our final set, 62 studies provided clear evidence that interspecific behavioural interference impacts the spatial distribution of a species, with 19 additional studies providing corroborating evidence in combination with other papers. The remaining papers either found no effect (n=15) or were inconclusive (n=2). The 81 papers that, either provide evidence directly or in collaboration with other studies, found clear evidence in favour of interspecific behavioural interference impacting the spatial distribution of a species and were sorted into 54 unique study systems (Figure 1, Table 1).

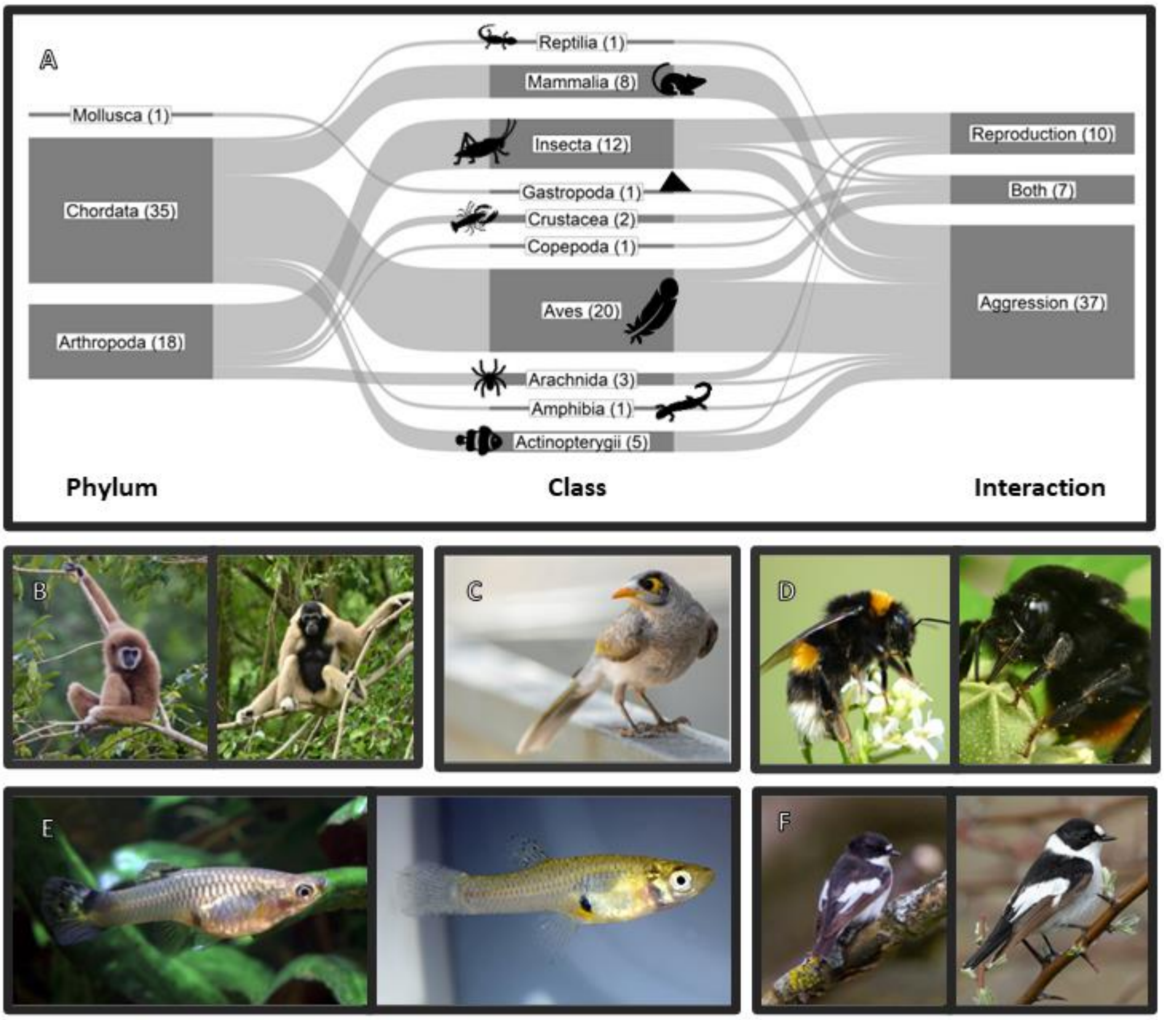


Figure 1. There is widespread evidence that behavioural interference influences spatial dynamics in animals. **A**. The breakdown of study systems that directly measured the impact of interspecific behavioural interference on the spatial distribution of one of more species by phylum, class, and whether the study covered aggressive, reproductive behavioural interference, or both. All studies investigated the impact of intraclass behavioural interference, except for one case of interphylum behavioural interference between a Crustacean and Actinopterygii (Bubb et al. 2009). The interphyla study is counted here as Crustacea study as the Crustacea was the more aggressive species. Sankey diagram was

created using the R package ggsankey **B.** In Thailand, two species of gibbon, the white-handed gibbon (*Hylobates lar*) and the pileated gibbon *(Hylobates pileatus*), have a parapatric distribution with only a small (<1km wide) boundary where the species are found in sympatry. Both *H. lar and H. pileatus* hold territories that are controlled exclusively by monogamous pairs. Detailed mapping of territories and observation of conflict events show that where the two species are found in sympatry, pairs defend territories from conspecifics and heterospecifics (Asensio et al. 2017). The relatively low abundance of hybrids at the boundary suggests that there is strong reproductive isolation between the two species. However, interspecific aggression persists which prevents the two species from dispersing into each other’s ranges. **C.** Indiscriminate hyperaggression of Noisy miners (*Manorina melanocephala*) has led to shift in the whole structure of avian communities (Mac Nally et al. 2012). **D.** In Japan, the invasive bumblebee *Bombus terrestris* engages in reproductive interference with two species of native bumblebee species. Copulation between male *B. terrestris* and female *Bombus hypocrita sapporoensis* or *Bombus ignites* results in unviable eggs being laid the following spring when there are no further intraspecific mating opportunities. Consequently, *B. ignities* and *B. h. sapporeenis* have declined rapidly in areas with *B. terrestris* and could lead to the extinction of the native bumblebee species (Tsuchida et al. 2019). (https://github.com/davidsjoberg/ggsankey). **E.** The accidental introduction of guppies *Poecilia reticulata*) led to the eradication of invasive mosquito fish (*Gambusia affinis*) in Okinawa owing to reproductive interference, and consequently guppies have been proposed as a potential control agent for mosquito fish elsewhere (Tsurui-Sato et al. 2019). **F.** Pied flycatchers (*Ficedula hypoleuca*) are driven to use sub-optimal habitat by the high aggression of collared flycatchers (*Ficedula albicollis*) (Vallin et al. 2012; Rybinski et al. 2016). All photos under creative commons by Wikimedia-user:Kongkham6211, JJ

Harrison, flickr-user:coniferconifer, Vera Buhl, Rex Boggs, Andrej Chudý, Ron Knight, Holger Krisp, and Wikimedia-user:Fredlyfish4.

Table 1: All 54 study systems identified during the literature review that found clear evidence that interspecific behavioural interference (IBI) impacts the spatial distribution of a species. An expanded table which includes a description of each study system can be found in Supplementary Table 1.

Interacting Species	IBI.Type	Elevational (Y/N)	Invasion (Y/N)	Comparative (Y/N)	References
Aves					
Great reed warblers (*Acrocephalus arundinaceus*) & marsh warblers (*Acrocephalus palustris*)	Aggression	N	N	N	(Rolando and Palestrini 1989)
Bicknell's thrushes (*Catharus bicknelli*) & Swainson's thrushes (*Catharus ustulatus*)	Aggression	Y	N	N	(Freeman and Montgomery 2015)
Black-headed nightingale thrushes (*Catharus mexicanus*) & ruddy-capped nightingale-thrushes (*Catharus frantzii*)	Aggression	Y	N	N	(Jones et al. 2020)
Collared (*Ficedula albicollis*) & pied (*Ficedula hypoleuca*) flycatchers	Aggression	N	N	N	(Vallin et al. 2012; Rybinski et al. 2016)
Several species of wood wrens (*Henicorhina leucophrys* & Henicorhina *leucosticta*) and thrushes (*Catharus mexicanus & Catharus aurantiirostris*) along an elevational gradient in Costa Rica.	Aggression	Y	N	N	(Jankowski, Robinson, and Levey 2010)
Narrow-billed woodcreepers (*Lepidocolaptes angustirostris*) & scaled woodcreepers (*Lepidocolaptes squamatus*)	Aggression	N	N	N	(Maldonado-Coelho et al. 2017)
Common nightingales (*Luscinia megarhynchos*) & thrush nightingales (*Luscinia luscinia*)	Aggression	N	N	N	(Sorjonen 1986; Reif et al. 2015; 2018)
Noisy miners (*Manorina melanocephala*) & local bird assemblages	Aggression	N	N	N	(Mac Nally et al. 2012; Lill and Muscat 2015)
Flame robins (Petroica phoenicea) & Norfolk robins (Petroica multicolor)	Aggression	N	N	N	(Robinson 1992)
Carolina chickadees (*Poecile carolinensis*) and black-capped chickadees (*Poecile atricapillus*)	Aggression and Reproductive Interference	N	N	N	(Bronson et al. 2003; McQuillan and Rice 2015)
Invasive ring-necked *parakeets (Psittacula krameri*) and native communities	Aggression	N	Y	N	(Hernández-Brito et al. 2014)
Townsend's warblers (*Setophaga townsendi*) and hermit warblers (*Setophaga occidentalis*)	Aggression and Reproductive Interference	N	N	N	(Pearson 2000; Pearson and Rohwer 2000)
Western bluebirds (*Sialia mexicana*) & mountain bluebirds (*Sialia currucoides*)	Aggression	N	N	N	(Duckworth and Badyaev 2007; Duckworth 2013; Duckworth, Belloni, and Anderson 2015)
Spotted owls (*Strix occidentalis*) & barred owls (*Strix varia*)	Aggression	N	Y	N	(Gutiérrez et al. 2007; Van Lanen et al. 2011; Wiens, Anthony, and Forsman 2014)
Dominant and subordinate congeneric birds in urban environmetns	Aggression	N	N	Y	(Martin and Bonier 2018; Martin, Burke, and Bonier 2021)
Dominant and subordinate birds from North America	Aggression	N	N	Y	(Freshwater, Ghalambor, and Martin 2014)
Birds along an elevational gradient in Borneo	Aggression	Y	N	Y	(Boyce and Martin 2019)
North american perching birds (passerines)	Aggression and	N	N	Y	(Cowen, Drury, and Grether 2020)

	Reproductive Interference				
Birds along an elevational gradient in Papua New Guinea	Aggression	Y	N	Y	(Freeman, Class Freeman, and Hochachka 2016)
Amphibia					
Southern Appalachian salamander (*Plethodon teyahalee*) & red-cheeked salamanders (*Plethodon jordani*)	Aggression	Y	N	N	(Hairston, Nishikawa, and Stenhouse 1987; Gifford and Kozak 2012)
Actinopterygii					
Damselfish (Dischistodus spp.) in the Great Barrier Reef	Aggression	N	N	N	(Bay, Jones, and McCormick 2001)
Guppies (*Poecilia reticulata*) & mosquitofish (*Gambusia affinis*)	Reproductive Interference	N	Y	N	(Tsurui-Sato et al. 2019)
Obscure damselfish (*Pomacentrus adelus*) & speckled damselfish (*Pomacentrus bankanensis)*	Aggression	N	N	N	(Eurich, McCormick, and Jones 2018)
Invasive brown trout (*Salmo trutta*) & white-spotted charr (*Salvelinus leucomaenis*) in Japan	Aggression	N	Y	N	(Takami et al. 2002; Hasegawa et al. 2004; Hasegawa and Maekawa 2009)
Gopher rockfish (*Sebastes carnatus*) & Black-and-yellow rockfish (*Sebastes chrysomelas*)	Aggression	N	N	N	(Larson 1980)
Arachnida					
Invasive sheet-web spiders (*Linyphia triangularis*) & bowl-and-doily spiders (*Frontinella communis*)	Aggression	N	Y	N	(Houser, Ginsberg, and Jakob 2014)
Copepoda					
Skistodiaptomus copepods	Reproductive Interference	N	N	N	(Thum 2007)
Crustacea					
Invasive rusty crayfish (*Orconectes rusticus*) and native Sanborn crayfish (*Orconectes sanborni*)	Aggression and Reproductive Interference	N	Y	N	(Butler and Stein 1985)
Invasive signal crayfish (*Pacifastacus leniusculus)* in Europe & native communities	Aggression and Reproductive Interference	N	Y	N	Svärdson et al. 1991 (Björn Söderbäck 1994; B. Söderbäck 1995; Westman and Savolainen 2001; Westman, Savolainen, and Julkunen 2002; Bubb et al. 2009)
Gastropoda					
Keyhole limpets (*Siphonaria lessonii*) & pulmonate limpets (*Fissurella crassa*)	Aggression	N	N	N	(Aguilera and Navarrete 2012)
Insecta					
Aedes mosquitos (*Ae. albopictus* & *Ae. aegypti*)	Reproductive Interference	N	Y	N	(Nasci, Hare, and Willis 1989; Irka E. Bargielowski, Lounibos, and Carrasquilla 2013; Irka Ewa Bargielowski and Lounibos 2016; Lounibos and Juliano 2018; Zhou et al. 2022)
Two tick species (*Amblyomma variegatum* & *Amblyomma hebraeum*)	Reproductive Interference	N	N	N	(Bournez et al. 2015)
Whiteflies (*Bemisia tabaci* spp.)	Reproductive Interference	N	Y	N	(Liu et al. 2007; Crowder et al. 2011; Wang, Crowder, and Liu 2012)
Invasive buff-tailed bumblebees (*Bombus terrestris*) & native bumblebees *(Bombus h. sapporoensis* 7 *Bombus ignitus*) in Japan	Reproductive Interference	N	Y	N	(Tsuchida et al. 2019)
Rubyspot damselflies (*Hetaerina* spp.)	Aggression	N	N	Y	(McEachin et al. 2022)

Two ant species (*Iridomyrmex* spp.)	Aggression	N	N	N	(Haering and Fox 1987)
Arboreal termite species in Papua New Guinea (*Microcerotermes biroi*, *Nasutitermes novarumhebridiarum*, & *Nasutitermes princeps*)	Aggression	N	N	Y	(Leponce, Roisin, and Pasteels 1997)
White-crossed seed bugs (*Neacoryphus bicrurus*) and co-occurring insect communities	Aggression and Reproductive Interference	N	N	N	(McLain and Shure 1987)
Invasive southern green stink bugs (*Nezara viridula*) & native green stink bugs (*Nezara antennata*)	Reproductive Interference	N	Y	N	(Kiritani 2011)
Alpine dark bush-crickets (*Pholidoptera aptera*) & Transylvanian dark bush-crickets (*Pholidoptera transsylvanica*)	Reproductive Interference	N	N	N	(Dorková et al. 2020)
Eastern subterranean termites (*Reticulitermes flavipes*) & Western subterranean termits (*Reticulitermes grassei*)	Aggression	N	Y	N	(Perdereau et al. 2011)
Invasive Asian blue ticks (*Rhipicephalus [Boophilus] microplus) &* African blue ticks (*Rhipicephalus [Boophilus] decoloratus*) in South Africa	Reproductive Interference	N	Y	N	(Sutherst 1987; Tønnesen et al. 2004)
Cepero's groundhoppers (*Tetrix ceperoi*) & slender groundhoppers (*Tetrix subulata*)	Reproductive Interference	N	N	N	(Gröning et al. 2007; Hochkirch, Gröning, and Bücker 2007; Hochkirch and Gröning 2012)
Arboreal ant species in Papua New Guinea	Aggression	N	N	Y	(Mottl et al. 2021)
Mammalia					
Fallow deer (*Dama dama*) & roe deer (*Capreolus capreolus*)	Aggression	N	Y	N	(Ferretti and Mori 2020)
White-handed gibbons (*Hylobates lar*) & Pileated gibbons (*Hylobates pileatus*)	Aggression	N	N	N	(Suwanvecho and Brockelman 2012; Asensio et al. 2017)
Least chipmunks (*Neotamias minimus*) & yellow-pine chipmunks (*Neotamias amoenus*)	Aggression	Y	N	N	(Chappell 1978; Heller 1971)
Townsend's chipmunks (*Neotamias townsendii*) & yellow-pine chipmunks (*Neotamias amoenus*)	Aggression	N	N	N	(Trombulak 1985)
Uinta chipmunks (*Neotamias umbrinus*) & Colorado chipmunks (*Neotamias quadrivittatus*)	Aggression	Y	N	N	(Bergstrom 1992)
Stoats (*Mustela erminea*) & least weasels (*Mustela nivalis*)	Aggression	N	N	N	(Erlinge and Sandell 1988)
Pied tamarins (*Saguinus bicolor*) & Golden-handed tamarins (*Saguinus midas*)	Aggression	N	N	N	(Sobroza et al. 2021)
Chiriquí singing mice (*Scotinomys xerampelinus*) & Alston's singing mice (*Scotinomys teguina*)	Aggression	Y	N	N	(Pasch, Bolker, and Phelps 2013)
Reptilia					
Invasive house geckos (*Hemidactylus frenatus*) & native communities	Aggression and Reproductive Interference	N	Y	N	(Bolger and Case 1992; Petren, Bolger, and Case 1993; Ted J. Case, Bolger, and Petren 1994; Dame and Petren 2006)

(1) Reproductive interference versus interspecific aggression

We identified more study systems where aggressive interference (N = 37) influenced range dynamics than reproductive interference (N = 10). Seven study systems found both reproductive and aggression influencing range dynamics (Figure 1, Table 1). This suggest that competitive exclusion via interference competition is likely to be more widespread than sexual exclusion. Nevertheless, it is also possible that the role of reproductive interference in such cases has been overlooked. Indeed, interspecific territoriality often occurs between species that engage in reproductive interference (Drury et al. 2015; Drury, Cowen, and Grether 2020; Grether et al. 2020; Payne 1980), including in several case studies uncovered by the systematic literature review (Vallin et al. 2012; Wiens, Anthony, and Forsman 2014; Reif et al. 2018), so the abundance of examples of aggressive interference influencing spatial dynamics in vertebrates may also be indicative of undetected reproductive interference. Further empirical and theoretical work would help clarify the relative importance as well as the interactive, potentially non-additive, impacts of different types of behavioural interference on spatial dynamics.

The taxonomic distribution of case studies was the most apparent difference among the factors associated with different types of behavioural interference (Figure 1). Most examples of reproductive interference influencing range dynamics were conducted on arthropods (9 out of 10). This contrasts with studies of aggressive interference that were dominated by vertebrates (30 out of 37), especially birds (n = 17). Empirical examples of reproductive interference are taxonomically widespread (Gröning and Hochkirch 2008), so it is surprising to see that evidence of reproductive interference influencing the spatial dynamics of a species come predominantly from insects and arachnids. One potential explanation for this apparent bias is that it reflects a biological reality about the costs of reproductive interference in arthropods; the fitness cost of reproductive interference may be especially high in arthropods because of females' short reproductive lifespans, and, because in some species, females produce no viable offspring after interspecific mating (Ribeiro and Spielman 1986), which makes a species particularly vulnerable to local extinction (Irwin and Schluter 2022). Alternatively, the bias may reflect a methodological convenience of working with invertebrates—reproductive interference may be hard to measure in the field without experimental mating trails, making larger scale field research of the sort necessary to build a link between reproductive interference and range dynamics more feasible on arthropods.

(2) Elevational gradients

Range dynamics along elevational gradients have long been of interest to ecologists and evolutionary biologists. For instance, a classic hypothesis posits that abiotic factors are likely to play a more important role than biotic factors at high-elevation range limits (Louthan, Doak, and Angert 2015). As a result, there may be an increased risk of extinction in montane ecosystems caused by the 'escalator to extinction' (Sekercioglu et al. 2008; Freeman et al. 2018) in which warming conditions cause high-elevation species' climate niches to disappear. Given the interest in biotic interactions along elevational gradients, it is not surprising that we identified multiple examples of interspecific behavioural interference of one species influencing the elevational distribution of another species (17% of cases documenting an impact of behavioural interference on range dynamics). Due to rapid habitat turnover with altitude, range boundaries across elevational gradient are often sharply defined, making studies of range limits inherently simpler along an elevational gradient (Žagar et al. 2015; Pasch, Bolker, and Phelps 2013; Jones et al. 2020), so it would be premature to conclude how likely that behavioural interference is to influence elevational range limits in comparison to range boundaries across landscape scales.

Several key patterns emerge from studies along elevational gradients. First, interspecific territoriality plays a key role in creating and maintaining elevational range limits. Comparative analyses, for instance, have shown that bird species have wider elevational ranges in mountains without competitors (Burner et al. 2020). Moreover, the response of several species of montane birds to heterospecific songs decreases with distance from their parapatric boundary, indicating a learned response to the presence of an aggressive congener (Jankowski, Robinson, and Levey 2010; Freeman and Montgomery 2015; Freeman, Class Freeman, and Hochachka 2016; Jones et al. 2020; Boyce and Martin 2019). Additionally, asymmetries in dominance are not consistently biased in favour of low elevation species, as there are examples of species pairs with subordinate high elevation species (e.g., *Catharus* thrushes, (Freeman and Montgomery 2015) and of pairs in which the lower elevation species is subordinate (e.g., *Scotinomys* singing mice (Pasch, Bolker, and Phelps 2013), *Neotamias* chipmunks (Bergstrom 1992) and, if aquatic depth gradients are comparable to elevational gradients, *Pomacentrus* damselfish (Eurich, McCormick, and Jones 2018)) (see also Freeman 2020). These examples demonstrate the varied and often unpredictable role that behavioural interference can play in influencing elevational range limits, thereby challenging the hypothesis that abiotic factors are likely to play a more important role than biotic factors at high-elevation range limits (Louthan, Doak, and Angert 2015). We also note a bias in the geographic locations of studies investigating behavioural interference across elevational gradients, with two exceptions in Borneo and Papa New Guinea, all study systems were located Northern and Central America (Figure 2). Studies across landscapes were found across a wider area, but still with noted gaps in Africa and Asia, likely due to an underlying geographic bias in scientific research (Culumber et al. 2019).

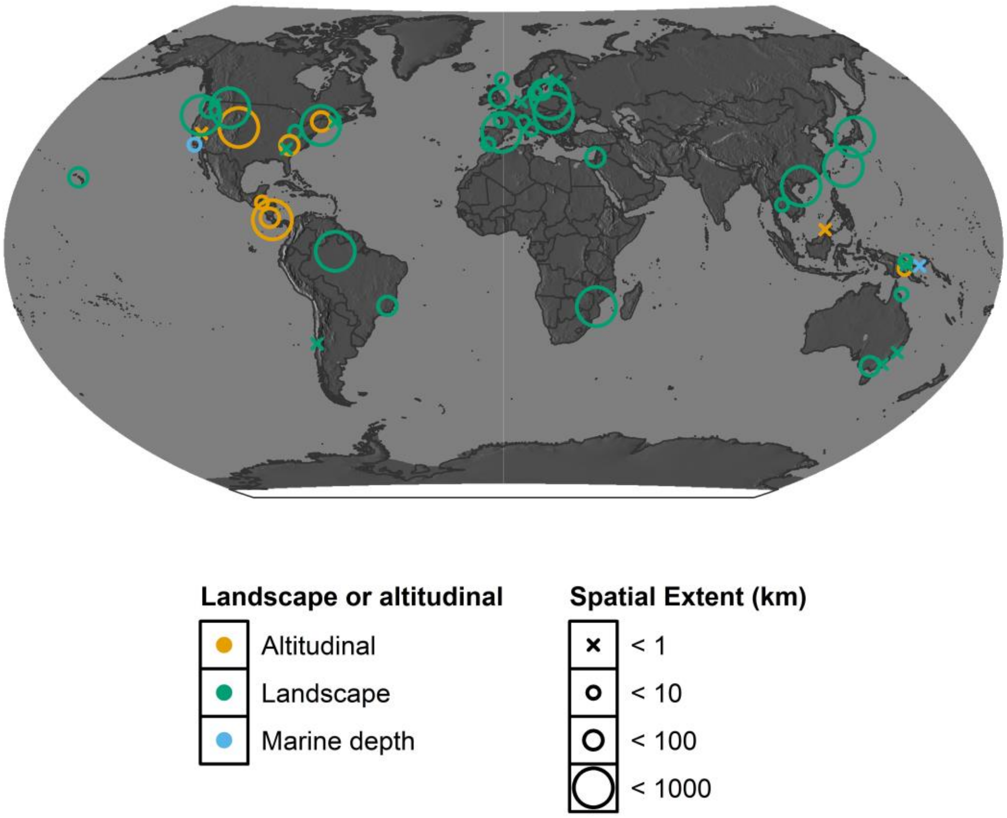


Figure 2. The global distribution of field studies that found an effect of Interspecific behavioural interference on the spatial distribution of a one of more species. Colour denotes whether the study investigated the spatial distributions across a landscape (i.e., latitude and longitude), across an elevational gradient (altitudinal), or across a sea-depth gradient (marine depth). Size indicates the maximum spatial extent for where data was collected for study but is not to scale, excluding comparative studies which had a greater than 1000km global distribution (N = 7).

(3) Invasion biology

Anthropogenic influences have led to a dramatic rise in the number of non-native species that become invasive after being translocated to novel regions (Blackburn et al. 2011). As the ranges of invasive species expand they may engage in interspecific behavioural interference, driving displacement of native species (Rowles and O’Dowd 2007; Lounibos and Juliano 2018; Pereira, Lourenço, and Mota 2020; Kyogoku and Sota 2017). The systematic review identified multiple examples of invasive species engaging in reproductive interference (Tsurui-Sato et al. 2019; Lounibos and Juliano 2018; Tsuchida et al. 2019; Tønnesen et al. 2004; Westman, Savolainen, and Julkunen 2002) and aggressive interference (Bubb et al. 2009; Houser, Ginsberg, and Jakob 2014; Westman, Savolainen, and Julkunen 2002; Rowles and O’Dowd 2007) with native species (15/54 =28% of cases). For instance, invading Argentine ants in Australia outcompete native ant species through direct aggressive interactions (Rowles & O’Dowd 2007). Similarly, in Japan, invasive buff-tailed bumblebees (*Bombus terrestris*) engage in reproductive interference with two species of native bumblebee species. Copulation between male *B. terrestris* and female *Bombus hypocrite sapporoensis* or *Bombus ignites* results in unviable eggs being laid the following spring when there are no further intraspecific mating opportunities. Consequently, *B. ignities* and *B. h. sapporeenis* have declined rapidly in areas with *B. terrestris*, and further declines could lead to the extinction of the native bumblebee species (Tsuchida et al. 2019). Other well-established cases where invading lineages quickly replace previously established lineages include the replacement of asexual gecko lineages throughout the Pacific that have been displaced by interference from invasive common house geckos (Dame & Petren 2016, Bolger & Case 1992, Petren et al. 1993), and the replacement of *Aedes aegypti* by *Ae. albopictus* both throughout the southern U.S. (Nasci, Hare, and Willis 1989) and in China (Zhou et al. 2022).

Yet, behavioural interference is not always beneficial to invasive species and detrimental to native species. Invasive species may be unable to establish in areas which contain a more aggressive congener, and higher levels of aggressive or reproductive interference could allow native species to tolerate the presence of the invading species (Crowder et al. 2011), or even prevent its spread (Cisterne, Schwarzkopf, and Pike 2019; Bizwell and Mattingly 2010). Whether asymmetries in behavioural interference generally influence the outcome of translocations of animal species is, therefore, an important open question.

In addition to being a potentially accelerating factor in biological invasions, behavioural interference has also been suggested as a management tool for invasive species. On Okinawa, for instance, the accidental introduction of guppies (*Poecilia reticulata*) led to the eradication of invasive mosquito fish (*Gambusia affinis*) (Tsurui-Sato et al. 2019). Laboratory experiments indicate that male guppies attempt to mate with female mosquito fish, thereby reducing their reproductive output. Introduced guppies also have negative impacts on native taxa, but by introducing only males, or mixed populations into environments with lethal winter temperatures, guppies could be used to eradicate mosquito fish from other river systems (Tsurui-Sato et al. 2019). Similarly, a study on aggression between invasive brown trout and native white-spotted charr demonstrated that habitat modifications in the form of visual barriers could reduce observed levels of interspecific aggression (Hasegawa & Maekawa 2009).

(4) Empirical validation of theoretical predictions

The formation of parapatric ranges, where two species have adjacent ranges with little or no overlap, is a key prediction of the theorical models of how interspecific behavioural interference impacts range dynamics when the impacts of behavioural interference are symmetrical (Ribeiro and Spielman 1986). In line with this prediction, we found that, where the impact of behavioural interference is equal, the ranges of interacting species pairs are stable (Asensio et al. 2017; Bull and Burzacott 1994; Thum 2007). If the impact of behavioural interference is asymmetrical, however, replacement of one species by the other commonly results (Tønnesen et al. 2004; Tsuchida et al. 2019; Tsurui-Sato et al. 2019; Duckworth and Badyaev 2007; Vallin et al. 2012; Sobroza et al. 2021). Some studies found that the ranges of the two species were stable even in the presence of asymmetrical behavioural interference because the more dominant species was limited by an abiotic or a different biotic factor (Pasch, Bolker, and Phelps 2013; Bergstrom 1992).

Although Allee effects are common in theoretical models of behavioural interference, relatively few case studies identified by our literature review explicitly tested for Allee effects, though several investigators of these studies suggest that Allee effects generate range turnovers (Soderback 1994, Tønnesen et al. 2004, Thum 2007, Kiritani 2011). The paucity of direct evidence for Allee effects was surprising, given documented Allee effects in laboratory studies (e.g., Kyogoku & Nishida 2012) and frequency- and/or density-dependent impacts of interspecific interference in the field (Svensson et al. 2018, Gomez-Llano et al. 2018). Future research, therefore, should aim to understand the importance of Allee effects in determining the outcome of spatial dynamics. For instance, a key test of the impact of behavioural interference on range dynamics would be to artificially induce an Allee effect in field systems known to engage in behavioural interference, by heightening or inversing the densities and/or frequencies of two species that engage in behavioural interference.

Similarly, though several models incorporate both behavioural interference and resource competition (Ribeiro and Spielman 1986; Amarasekare 2002; Crowder et al. 2011), our literature search found few explicit analyses disentangling the relative impacts of behavioural interference and resource competition, or the predicted interactive dynamics of both, on range dynamics (but see Duckworth 2014, Cowen 2020).

III. Future Directions

Our systematic literature review demonstrated that there are now many studies that show varied impacts of behavioural interference on range expansion, but it also highlighted several gaps in our understanding. Here, we argue that further research is needed in several key areas, including the role that behavioural interference has played in shaping historical patterns of range dynamics, the impacts of behavioural interference on future range dynamics under climate change, and the extent to which evolution influences outcomes.

(1) Identifying the impact of behavioural interference on historical spatial processes

There are several existing approaches for studying historical range dynamics that would be useful to develop further to understand outcomes of behavioural interference across a range of timescales. For instance, at a deep evolutionary timescale, models of ancestral biogeography have proven to be useful tools for making inferences about the pace and trajectory of range evolution within independently evolving lineages (Ronquist 2011). Recently, there have been calls for extending these methods to incorporate ecological factors such as species interactions (Sukumaran and Knowles 2018), and the development of tools for identifying the signature of competitive exclusion in range data (Quintero and Landis 2020). Incorporating the possibility for the presence and/or magnitude of behavioural interference to modulate the impacts of competition on range dynamics into these models, similar to advances already developed for trait-mediated dispersal (Klaus and Matzke 2020), could provide a novel tool that would make it possible to test a range of hypotheses that cannot be tested with current methods (Fig 3A).

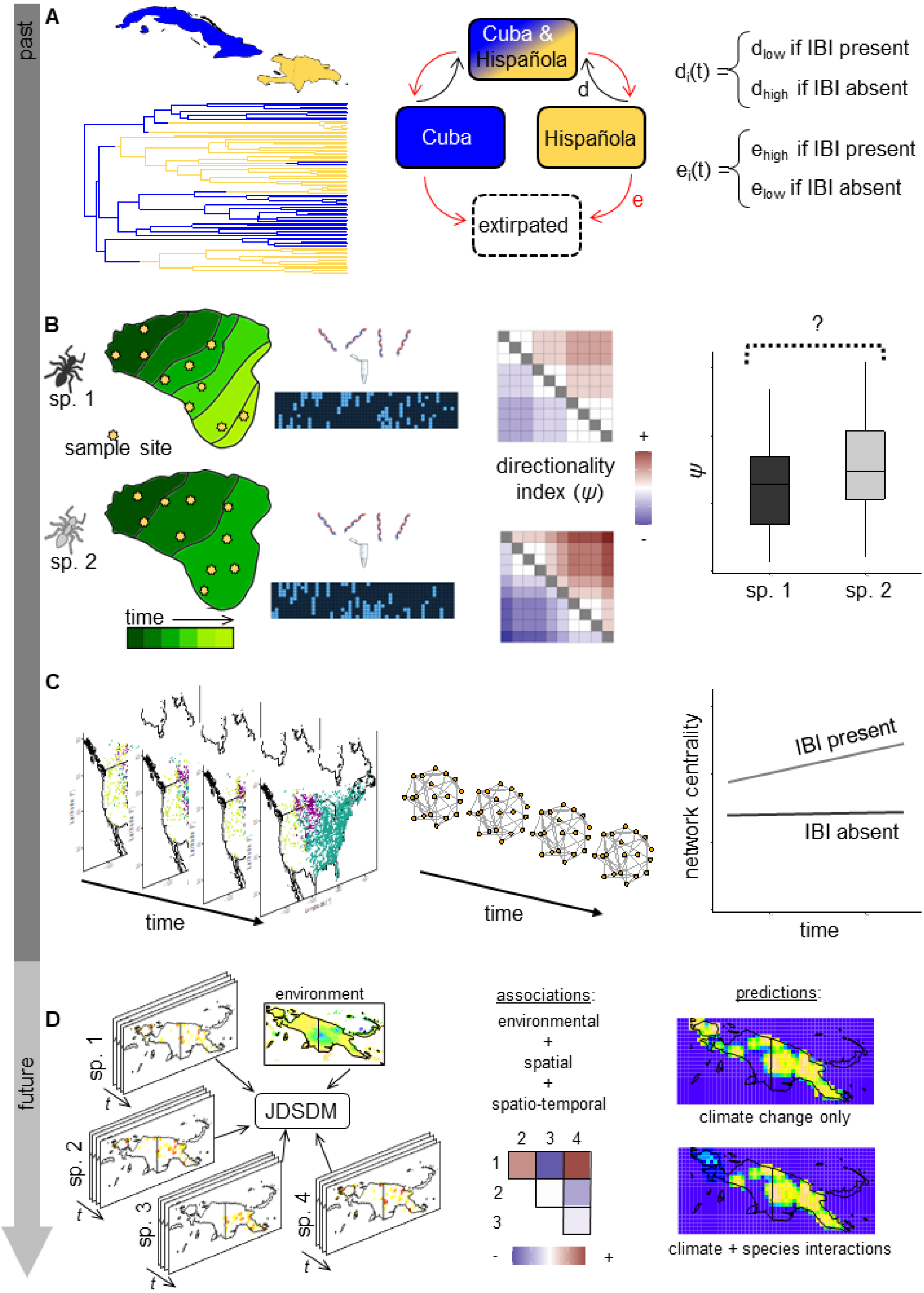
At shallower evolutionary scales, existing population genomic techniques leverage the signatures of historical processes preserved in genomes to test hypotheses about spatial (Peter and Slatkin 2013; Petkova, Novembre, and Stephens 2015; Al-Asadi et al. 2019; He, Prado, and Knowles 2017) and demographic (Gutenkunst et al. 2009; Gronau et al. 2011; Excoffier et al. 2021) dynamics that have unfolded over scales of thousands to millions of years. Largely, these developments have been designed to examine dynamics within independently evolving lineages. Within this constraint, one way forward would be to conduct comparative analyses to test the hypothesis that lineages (e.g., populations, species) experiencing higher levels of behavioural interference expand their ranges at different rates than lineages experiencing little or no behavioural interference (Fig 3B). Recently, Ortego & Knowles (2020) developed an analytical pipeline that explicitly tests for the impact of facilitation and/or competition between species on generating contemporary geographic patterns of genomic diversity. Extending these models to explicitly test for impacts of behavioural interference is an exciting possibility that would generate new insights.

On a more contemporary scale, long-term census data have proven to be a useful tool for monitoring dynamics of species assemblages over the past century (Rosenberg et al. 2019, Saunders et al. 2022). Such datasets contain interacting species, and understanding how those interactions impact temporal dynamics is one way forward (Fig 3C). One recent attempt has shown that species-pairs that are interspecifically territorial have increased their fine scale habitat overlap more than non-interspecifically territorial pairs (Nesbit et al. 2022).

(2) Predicting the impact of behavioural interference in novel assemblages

Insights generated from investigations of the impacts of behavioural interference on historical range dynamics will be essential for generating predictions about the future impacts of behavioural interference on climate-change driven range dynamics. At the heart of attempts to predict how species' ranges will shift in response to global changes are species distribution models (SDMs). SDMs use measures of abiotic factors and presence-absence data to project the species' current released range onto future climate models (Elith and Leathwick 2009; Titley et al. 2021).

Attempts to incorporate biotic factors into species distribution models have given rise to joint species distribution models (JSDMs) (Wilkinson et al. 2019; Tikhonov et al. 2017). Yet, implementing and validating JSDMs is fraught with difficulties because positive and negative occurrence patterns often correlate with abiotic factors (Poggiato et al. 2021). Consequently, many examples of interspecific behavioural interference limiting the spatial distribution of species would not be detected using JSDMs, although some attempts to implement behavioural interference into SDMs/JSDMs have been conducted (Bastianelli et al. 2017; Engler et al. 2013). Despite challenges, joint species distribution modelling remains an active area of research with many promising recent developments (Pichler and Hartig 2021; Escamilla Molgora et al. 2022). For instance, joint *dynamic* species distribution models (JDSDMs) use time-series data on abundance to examine the impact of concurrent changes in abundance across assemblages more directly (Thorson, Pinsky, and Ward 2016; Elo et al. 2023). Consequently, we imagine that these tools will be useful for generating predictive models of future range dynamics in the presence of behavioural interference (Fig. 3d), for instance by comparing the marginal predictions of such models (i.e., the effects of environmental variables only), to conditional predictions which also incorporate impacts of changing species interactions (Wilkinson et al. 2021) (Wilkinson et al. 2020). Recently, for instance, (Novella-Fernandez et al. 2021) devised an index of 'geographic avoidance' by comparing species suitable ranges (calculated from SDMs) to their observed ranges. Using this index, they found that two pairs of cryptic species of bats in Europe exhibited spatial partitioning consistent with interspecific competition driving exclusion. They then examined range overlap under future climate projections, demonstrating that some predicted range shifts may not be possible due to predicted range overlap with competitors (Novella-Fernandez et al. 2021), see also Engler et al. 2013 and McQuillan and Rice 2015 for a similar approach). Future attempts to generate predictions of range dynamics in the presence of behavioural interference could also be used to disentangle and quantify the differing impacts of behavioural interference versus resource competition.


past
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$e_i(t) = \begin{cases} e_{high} \text{ if IBI present} \\ e_{low} \text{ if IBI absent} \end{cases}$
B
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predictions:
climate change only
climate + species interactions

Fig 3. Possible directions for future research into the historical (A-C) and forecasted (D) impacts of behavioural interference (BI) on range dynamics. Approaches to test for historical impacts of BI include (A) extending models of ancestral biogeography to include separate parameters for species that engage in BI and those that do not, (B) deploying genomic tools to test whether the historical dynamics of range expansion differ between species that engage in BI (sp. 2, in this example) and species that do not by calculating pairwise indices of directional movement such as the ψ index (Peter and Slatkin 2013), and (C) using long-term census data to analyse how BI has impacted dynamics of species cooccurrence through time using tools from network analyses (e.g., indices of network centrality). Developments for forecasting and mitigating the impacts of BI on global-change induced range shifts might include (D) fitting joint dynamic species distribution models (JDSDMs) and using model inferences to compare future ranges under pure climate-tracking scenarios to scenarios that incorporate species interactions inferred from JDSDMs.

The preceding approaches largely rely on metrics of cooccurrence to make inferences about the impacts of behavioural interference, under the assumption that cooccurring lineages are likely to interact. Yet, range overlap per se is not robust evidence that interactions occur. One way forward is to use measurements of fine-scale range overlap (i.e., 'syntopy'), which may be more indicative of the opportunity for species interactions (Drury, Cowen, and Grether 2020). Still, there is no substitute to direct observations of behaviour across large spatiotemporal scales. For instance, a large-scale study of spatiotemporal variation in agonistic behaviour in damselfish shows that interactions between individuals of different species increase after coral bleaching events (Keith et al. 2023). Future studies should directly observe behaviours to demonstrate concrete links between behavioural interference and range dynamics.

(3) The role of evolution in mediating responses to behavioural interference

Historically, empirical research into behavioural interference has largely focused on understanding factors that lead to behavioural interference (e.g., Drury, Cowen, and Grether 2020; Leighton et al. 2023) and its evolutionary consequences, such as its impact on trait evolution (Grether et al. 2009; Pfennig and Pfennig 2009) or other aspects of the speciation cycle (Tobias, Ottenburghs, and Pigot 2020). This work has shown that the likelihood of behavioural interference decreases with increasing divergence time (e.g., Drury, Cowen, and Grether 2020; Barley et al. 2022) likely owing to the relative similarity in perceptual systems and agonistic and/or mating signals used in closely related species (Grether et al. 2009; Orians and Willson 1964). Consequently, behavioural interference is thought to have a strong impact on the rate of speciation by limiting the rate at which two recently diverged allopatric lineages can coexist in secondary sympatry (Tobias, Ottenburghs, and Pigot 2020). One possible evolutionary outcome of behavioural interference is divergent reproductive or agonistic character displacement, in which selection acts on mating or agonistic signals or perceptual systems to prevent or reduce the occurrence of behavioural interference (Grether et al. 2009; Pfennig and Pfennig 2009). Yet, the benefits of diverging in signals and/or perceptual systems do not always outweigh the costs--for instance, because of the continued pressure of stabilising selection for intraspecific mate recognition (Drury et al. 2019) or because interspecific competitor recognition may be an adaptive pathway to interspecific resource partitioning (Grether and Okamoto 2022) -- and consequently, selection may preclude divergence or even drive convergence between interacting lineages.

The evolutionary responses to behavioural interference in shifting ranges should, therefore, play an important role in determining the outcome of range dynamics. For instance, in the case of *Aedes* mosquitoes, reproductive character displacement appears to have slowed down the invasion of *Ae. albopictus* in Florida (Irka E. Bargielowski, Lounibos, and Carrasquilla 2013; I. Bargielowski, Blosser, and Lounibos 2015). Similarly, native bumblebees in Japan have evolved polyandrous mating systems in response to reproductive interference from invasive buff-tailed bumblebees (Tsuchida et al. 2019). The extent to which and circumstances under which evolutionary changes mediate the impact of behavioural interference on range dynamics are thus open questions. Future long-term studies of zones where behavioural interference occurs, in addition to comparisons between sympatric and allopatric populations, could shed further light on these questions.

IV. Concluding remarks

(1) Multiple lines of evidence now demonstrate that interspecific behavioural interference can limit the spatial distribution of species. Case studies demonstrate that this is true across a wide range of animal taxa, and that both reproductive interference and interspecific aggression can influence spatial dynamics.

(2) In line with predictions derived from theoretical models of behavioural interference, the case studies we compiled demonstrate that symmetry (or lack thereof) in behavioural interference determines the spatial outcome of interactions. Further work is necessary to test other key predictions of theoretical models, such as the presence of Allee effects and interactive impacts of behavioural interference and exploitative competition for resources.

(3) We identified several other gaps that remain in our broad-scale understanding of the impacts of behavioural interference on spatial dynamics. For instance, which factors (e.g., phylogenetic distance, life history, climate niche, etc.) explain variation in the presence or magnitude of the effect of behavioural interference on range dynamics?

(4) Several recent developments have paved the way for modelling the impacts of species interactions on both historical and future spatial dynamics, and future work adapting these methods to further explore the links between behavioural interference and range dynamics is an important way forward.

(5) In addition to modelling approaches, further work aimed at quantifying the interactive effects of evolutionary change and spatial movement is crucial for predicting the outcome of range dynamics in the presence of behavioural interference.

(6) The spatial distribution of species has implication for conservation, human health, and agriculture. Alongside other abiotic and biotic factors, our study highlights the need to include interspecific behavioural interference in predicting and managing the current and future distribution of species.

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VI. References

Aguilera, Moisés A., and Sergio A. Navarrete. 2012. ‘Interspecific Competition for Shelters in Territorial and Gregarious Intertidal Grazers: Consequences for Individual Behaviour’. *PLOS ONE* 7 (9): e46205. https://doi.org/10.1371/journal.pone.0046205.

Al-Asadi, Hussein, Desislava Petkova, Matthew Stephens, and John Novembre. 2019. ‘Estimating Recent Migration and Population-Size Surfaces’. *PLoS Genetics* 15 (1): e1007908. https://doi.org/10.1371/journal.pgen.1007908.

Alexander, Jake M., Jeffrey M. Diez, and Jonathan M. Levine. 2015. ‘Novel Competitors Shape Species’ Responses to Climate Change’. *Nature* 525 (7570): 515–18. https://doi.org/10.1038/nature14952.

Amarasekare, P. 2002. ‘Interference Competition and Species Coexistence’. *Proc. R. Soc. B* 269: 2541–50. https://doi.org/10.1098/rspb.2002.2181.

Asensio, Norberto, Juan Manuel José-Domínguez, Chalita Kongrit, and Warren Y. Brockelman. 2017. ‘The Ecology of White-Handed and Pileated Gibbons in a Zone of Overlap and Hybridization in Thailand’. *American Journal of Physical Anthropology* 163 (4): 716–28. https://doi.org/10.1002/ajpa.23241.

Bargielowski, Irka, Erik Blosser, and L. P. Lounibos. 2015. ‘The Effects of Interspecific Courtship on the Mating Success of Aedes Aegypti and Aedes Albopictus (Diptera: Culicidae) Males’. *Annals of the Entomological Society of America* 108 (4): 513–18. https://doi.org/10.1093/aesa/sav037.

Bargielowski, Irka E., L. Philip Lounibos, and María Cristina Carrasquilla. 2013. ‘Evolution of Resistance to Satyrization through Reproductive Character Displacement in Populations of Invasive Dengue Vectors’. *Proceedings of the National Academy of Sciences* 110 (8): 2888–92. https://doi.org/10.1073/pnas.1219599110.

Bargielowski, Irka Ewa, and Leon Philip Lounibos. 2016. *Satyrization and Satyrization-Resistance in Competitive Displacements of Invasive Mosquito Species*. *Insect Science*. Vol. 23. Blackwell Publishing Ltd. https://doi.org/10.1111/1744-7917.12291.

Barley, Anthony J, Adrián Nieto-Montes de Oca, Norma L Manríquez-Morán, and Robert C Thomson. 2022. ‘The Evolutionary Network of Whiptail Lizards Reveals Predictable Outcomes of Hybridization’. *Science* 377 (6607): 773–77.

Bastianelli, Giulia, Brendan A. Wintle, Elizabeth H. Martin, Javier Seoane, and Paola Laiolo. 2017. ‘Species Partitioning in a Temperate Mountain Chain: Segregation by Habitat vs. Interspecific Competition’. *Ecology and Evolution* 7 (8): 2685–96. https://doi.org/10.1002/ECE3.2883.

Bay, L. K., G. P. Jones, and M. I. McCormick. 2001. ‘Habitat Selection and Aggression as Determinants of Spatial Segregation among Damselfish on a Coral Reef’. *Coral Reefs* 20 (3): 289–98. https://doi.org/10.1007/S003380100173.

Bergstrom, Bradley J. 1992. ‘Parapatry and Encounter Competition between Chipmunk (Tamias) Species and the Hypothesized Role of Parasitism’. *American Midland Naturalist* 128 (1): 168. https://doi.org/10.2307/2426422.

Bizwell, Emily A., and Hayden T Mattingly. 2010. ‘Aggressive Interactions of the Endangered Nashville Crayfish, Orconectes Shoupi’. *Southeastern Naturalist* 9 (2): 359–72. https://doi.org/10.1656/058.009.0211.

Blackburn, Tim M, Petr Pyšek, Sven Bacher, James T Carlton, Richard P Duncan, Vojtěch Jarošík, John RU Wilson, and David M Richardson. 2011. ‘A Proposed Unified Framework for Biological Invasions’. *Trends in Ecology & Evolution* 26 (7): 333–39.

Blois, Jessica L., Phoebe L. Zarnetske, Matthew C. Fitzpatrick, and Seth Finnegan. 2013. ‘Climate Change and the Past, Present, and Future of Biotic Interactions’. *Science*. Vol. 341. https://doi.org/10.1126/science.1237184.

Bolger, Douglas T., and Ted J. Case. 1992. ‘Intra- and Interspecific Interference Behaviour among Sexual and Asexual Geckos’. *Animal Behaviour* 44 (1): 21–30. https://doi.org/10.1016/S0003-3472(05)80750-X.

Bournez, L., N. Cangi, R. Lancelot, D. R.J. Pleydell, F. Stachurski, J. Bouyer, D. Martinez, T. Lefrançois, L. Neves, and J. Pradel. 2015. ‘Parapatric Distribution and Sexual Competition between Two Tick Species, Amblyomma Variegatum and A. Hebraeum (Acari, Ixodidae), in Mozambique’. *Parasites and Vectors* 8 (1): 1–14. https://doi.org/10.1186/S13071-015-1116-7/FIGURES/4.

Boyce, Andy J., and Thomas E. Martin. 2019. ‘Interspecific Aggression among Parapatric and Sympatric Songbirds on a Tropical Elevational Gradient’. *Behavioral Ecology* 30 (2): 541–47. https://doi.org/10.1093/BEHECO/ARY194.

Bronson, C. L., Thomas C. Grubb, Gene D. Sattler, and Michael J. Braun. 2003. ‘Mate Preference: A Possible Causal Mechanism for a Moving Hybrid Zone’. *Animal Behaviour* 65 (3): 489–500. https://doi.org/10.1006/anbe.2003.2103.

Bubb, Damian H., Oliver J. O’Malley, Angela C. Gooderham, and Martyn C. Lucas. 2009. ‘Relative Impacts of Native and Non-Native Crayfish on Shelter Use by an Indigenous Benthic Fish’. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19 (4): 448–55. https://doi.org/10.1002/AQC.1001.

Bull, C. M., and D. Burzacott. 1994. ‘Reproductive Interactions between Two Australian Reptile Tick Species’. *Experimental and Applied Acarology* 18 (9): 555–65. https://doi.org/10.1007/BF00058938.

Burdfield-Steel, Emily R, and David M Shuker. 2011. ‘Reproductive Interference’. *CURBIO* 21: R450–51. https://doi.org/10.1016/j.cub.2011.03.063.

Burner, Ryan C., Andy J. Boyce, David Bernasconi, Alison R. Styring, Subir B. Shakya, Chandradewana Boer, Mustafa Abdul Rahman, Thomas E. Martin, and Frederick H. Sheldon. 2020. ‘Biotic Interactions Help Explain Variation in Elevational Range Limits of Birds among Bornean Mountains’. *Journal of Biogeography* 47 (3): 760–71. https://doi.org/10.1111/JBI.13784.

Butler, Mark J., and Roy A. Stein. 1985. ‘An Analysis of the Mechanisms Governing Species Replacements in Crayfish’. *Oecologia* 66 (2): 168–77. https://doi.org/10.1007/BF00379851.

Case, T. J., and M. E. Gilpin. 1974. ‘Interference Competition and Niche Theory’. *Proceedings of the National Academy of Sciences of the United States of America* 71 (8): 3073–77. https://doi.org/10.1073/pnas.71.8.3073.

Case, Ted J., Douglas T. Bolger, and Ken Petren. 1994. ‘Invasions and Competitive Displacement among House Geckos in the Tropical Pacific’. *Ecology* 75 (2): 464–77. https://doi.org/10.2307/1939550.

Chappell, Mark A. 1978. ‘Behavioral Factors in the Altitudinal Zonation of Chipmunks (Eutamias)’. *Ecology* 59 (3): 565–79. https://doi.org/10.2307/1936586.

Cisterne, Adam, Lin Schwarzkopf, and David A. Pike. 2019. ‘Australian House Geckos Are More Aggressive than a Globally Successful Invasive Asian House Gecko’. *Behavioral Ecology* 30 (1): 107–13. https://doi.org/10.1093/BEHECO/ARY156.

Cowen, Madeline C., Jonathan P. Drury, and Gregory F. Grether. 2020. ‘Multiple Routes to Interspecific Territoriality in Sister Species of North American Perching Birds’. *Evolution* 74 (9): 2134–48. https://doi.org/10.1111/evo.14068.

Crowder, David W., A. Rami Horowitz, Haggai Breslauer, Mario Rippa, Svetlana Kontsedalov, Murad Ghanim, and Yves Carrière. 2011. ‘Niche Partitioning and Stochastic Processes Shape Community Structure Following Whitefly Invasions’. *Basic and Applied Ecology* 12 (8): 685–94. https://doi.org/10.1016/j.baae.2011.09.007.

Culumber, Zachary W, Jaime M Anaya-Rojas, William W Booker, Alexandra P Hooks, Elizabeth C Lange, Benjamin Pluer, Natali Ramírez-Bullón, and Joseph Travis. 2019. ‘Widespread Biases in Ecological and Evolutionary Studies’. *BioScience* 69 (8): 631–40. https://doi.org/10.1093/biosci/biz063.

Dame, Elizabeth A., and Kenneth Petren. 2006. ‘Behavioural Mechanisms of Invasion and Displacement in Pacific Island Geckos (Hemidactylus)’. *Animal Behaviour* 71 (5): 1165–73. https://doi.org/10.1016/j.anbehav.2005.10.009.

Dorková, Martina, Anton Krištín, Benjamín Jarčuška, and Peter Kaňuch. 2020. ‘The Mosaic Distribution Pattern of Two Sister Bush-Cricket Species and the Possible Role of

Reproductive Interference’. *Ecology and Evolution* 10 (5): 2570–78. https://doi.org/10.1002/ECE3.6086.

Drury, Jonathan P., Christopher N. Anderson, Maria B.Cabezas Castillo, Jewel Fisher, Shawn McEachin, and Gregory F. Grether. 2019. ‘A General Explanation for the Persistence of Reproductive Interference’. *American Naturalist* 194 (2): 268–75. https://doi.org/10.1086/704102.

Drury, Jonathan P., M. Cowen, and Gregory F. Grether. 2020. ‘Competition and Hybridization Drive Interspecific Territoriality in Birds.’ *Proceedings of the National Academy of Sciences.* https://doi.org/10.1073/pnas.1921380117.

Drury, Jonathan P., Kenichi W. Okamoto, Christopher N. Anderson, and Gregory F. Grether. 2015. ‘Reproductive Interference Explains Persistence of Aggression between Species’. *Proceedings of the Royal Society B: Biological Sciences* 282 (1804). https://doi.org/10.1098/rspb.2014.2256.

Duckworth, Renée A. 2013. ‘Human-Induced Changes in the Dynamics of Species Coexistence: An Example with Two Sister Species’. *Avian Urban Ecology*, November. https://doi.org/10.1093/ACPROF:OSOBL/9780199661572.003.0014.

Duckworth, Renée A., and Alexander V. Badyaev. 2007. ‘Coupling of Dispersal and Aggression Facilitates the Rapid Range Expansion of a Passerine Bird’. *Proceedings of the National Academy of Sciences of the United States of America* 104 (38): 15017–22. https://doi.org/10.1073/pnas.0706174104.

Duckworth, Renée A., Virginia Belloni, and Samantha R. Anderson. 2015. ‘Cycles of Species Replacement Emerge from Locally Induced Maternal Effects on Offspring Behavior in a Passerine Bird’. *Science* 347 (6224): 875–77. https://doi.org/10.1126/SCIENCE.1260154/SUPPL_FILE/DUCKWORTH.SM.PDF.

Early, R., and S. A. Keith. 2019. ‘Geographically Variable Biotic Interactions and Implications for Species Ranges’. Edited by Maria Dornelas. *Global Ecology and Biogeography* 28 (1): 42–53. https://doi.org/10.1111/geb.12861.

Elith, Jane, and John R. Leathwick. 2009. ‘Species Distribution Models: Ecological Explanation and Prediction Across Space and Time’. *Http://Dx.Doi.Org/10.1146/Annurev.Ecolsys.110308.120159* 40 (February): 677–97. https://doi.org/10.1146/ANNUREV.ECOLSYS.110308.120159.

Elo, Merja, Mira H. Kajanus, Jere Tolvanen, Vincent Devictor, Jukka T. Forsman, Aleksi Lehikoinen, Mikko Mönkkönen, James T. Thorson, Maximilian G. R. Vollstädt, and Sami M. Kivelä. 2023. ‘Do Large-Scale Associations in Birds Imply Biotic Interactions or Environmental Filtering?’ *Journal of Biogeography* 50 (1): 169–82. https://doi.org/10.1111/jbi.14520.

Engler, J. O., D. Rödder, O Elle, A Hochkirch, and J Secondi. 2013. ‘Species Distribution Models Contribute to Determine the Effect of Climate and Interspecific Interactions in Moving Hybrid Zones’. *Journal of Evolutionary Biology* 26 (11): 2487–96. https://doi.org/10.1111/jeb.12244.

Erlinge, Sam, and Mikael Sandell. 1988. ‘Coexistence of Stoat, Mustela Erminea, and Weasel, M. Nivalis: Social Dominance, Scent Communication, and Reciprocal Distribution’. *Oikos* 53 (2): 242–46. https://doi.org/10.2307/3566069.

Escamilla Molgora, Juan M., Luigi Sedda, Peter Diggle, and Peter M. Atkinson. 2022. ‘A Joint Distribution Framework to Improve Presence-Only Species Distribution Models by Exploiting Opportunistic Surveys’. *Journal of Biogeography* 49 (6): 1176–92. https://doi.org/10.1111/jbi.14365.

Eurich, Jacob G., Mark I. McCormick, and Geoffrey P. Jones. 2018. ‘Direct and Indirect Effects of Interspecific Competition in a Highly Partitioned Guild of Reef Fishes’. *Ecosphere* 9 (8): e02389. https://doi.org/10.1002/ECS2.2389.

Excoffier, Laurent, Nina Marchi, David Alexander Marques, Remi Matthey-Doret, Alexandre Gouy, and Vitor C. Sousa. 2021. ‘Fastsimcoal2: Demographic Inference under Complex Evolutionary Scenarios’. *Bioinformatics* 37 (24): 4882–85. https://doi.org/10.1093/bioinformatics/btab468.

Ferretti, Francesco, and Emiliano Mori. 2020. ‘Displacement Interference between Wild Ungulate Species: Does It Occur?’ *Ethology Ecology & Evolution* 32 (1): 2–15. https://doi.org/10.1080/03949370.2019.1680447.

Freeman, Benjamin G. 2020. ‘Lower Elevation Animal Species Do Not Tend to Be Better Competitors than Their Higher Elevation Relatives’. *Global Ecology and Biogeography* 29 (1): 171–81.

Freeman, Benjamin G., Alexandra M. Class Freeman, and Wesley M. Hochachka. 2016. ‘Asymmetric Interspecific Aggression in New Guinean Songbirds That Replace One Another along an Elevational Gradient’. *Ibis* 158 (4): 726–37. https://doi.org/10.1111/ibi.12384.

Freeman, Benjamin G., and Graham Montgomery. 2015. ‘Interspecific Aggression by the Swainson’s Thrush (Catharus Ustulatus) May Limit the Distribution of the Threatened Bicknell’s Thrush (Catharus Bicknelli) in the Adirondack Mountains’. *Condor* 118 (1): 169–78. https://doi.org/10.1650/CONDOR-15-145.1.

Freeman, Benjamin G., Micah N. Scholer, Viviana Ruiz-Gutierrez, and John W. Fitzpatrick. 2018. ‘Climate Change Causes Upslope Shifts and Mountaintop Extirpations in a Tropical Bird Community’. *Proceedings of the National Academy of Sciences of the United States of America* 115 (47): 11982–87. https://doi.org/10.1073/PNAS.1804224115.

Freshwater, Cameron, Cameron K. Ghalambor, and Paul R. Martin. 2014. ‘Repeated Patterns of Trait Divergence between Closely Related Dominant and Subordinate Bird Species’. *Ecology* 95 (8): 2334–45. https://doi.org/10.1890/13-2016.1.

Gifford, Matthew E., and Kenneth H. Kozak. 2012. ‘Islands in the Sky or Squeezed at the Top? Ecological Causes of Elevational Range Limits in Montane Salamanders’. *Ecography* 35 (3): 193–203. https://doi.org/10.1111/j.1600-0587.2011.06866.x.

Grether, Gregory F., Jonathan P. Drury, Kenichi W. Okamoto, Shawn McEachin, and Christopher N. Anderson. 2020. ‘Predicting Evolutionary Responses to Interspecific Interference in the Wild’. *Ecology Letters* 23 (2): 221–30. https://doi.org/10.1111/ele.13395.

Grether, Gregory F., Neil Losin, Christopher N Anderson, and Kenichi Okamoto. 2009. ‘The Role of Interspecific Interference Competition in Character Displacement and the Evolution of

Competitor Recognition'. *Biological Reviews* 84: 617–35. https://doi.org/10.1111/j.1469-185X.2009.00089.x.

Grether, Gregory F., and Kenichi W. Okamoto. 2022. 'Eco-Evolutionary Dynamics of Interference Competition'. *Ecology Letters* 25 (10): 2167–76. https://doi.org/10.1111/ele.14091.

Grether, Gregory F., Kathryn S. Peiman, Joseph A. Tobias, and B.W. Beren W. Robinson. 2017. *Causes and Consequences of Behavioral Interference between Species*. *Trends in Ecology and Evolution*. Vol. 32. Elsevier Ltd. https://doi.org/10.1016/j.tree.2017.07.004.

Gronau, Ilan, Melissa J. Hubisz, Brad Gulko, Charles G. Danko, and Adam Siepel. 2011. 'Bayesian Inference of Ancient Human Demography from Individual Genome Sequences'. *Nature Genetics* 43 (10): 1031–35. https://doi.org/10.1038/ng.937.

Gröning, Julia, and Axel Hochkirch. 2008. 'Reproductive Interference between Animal Species'. *Quarterly Review of Biology* 83 (3): 257–82. https://doi.org/10.1086/590510.

Gröning, Julia, Niklas Lücke, Alexander Finger, and Axel Hochkirch. 2007. 'Reproductive Interference in Two Ground-Hopper Species: Testing Hypotheses of Coexistence in the Field'. *Oikos* 116 (9): 1449–60. https://doi.org/10.1111/j.0030-1299.2007.15850.x.

Gutenkunst, Ryan N., Ryan D. Hernandez, Scott H. Williamson, and Carlos D. Bustamante. 2009. 'Inferring the Joint Demographic History of Multiple Populations from Multidimensional SNP Frequency Data'. *PLoS Genetics* 5 (10): e1000695. https://doi.org/10.1371/journal.pgen.1000695.

Gutiérrez, R. J., M. Cody, S. Courtney, and Alan B. Franklin. 2007. 'The Invasion of Barred Owls and Its Potential Effect on the Spotted Owl: A Conservation Conundrum'. *Biological Invasions* 9 (2): 181–96. https://doi.org/10.1007/s10530-006-9025-5.

Haering, Ron, and Barry J. Fox. 1987. 'Short-Term Coexistence and Long-Term Competitive Displacement of Two Dominant Species of Iridomyrmex: The Successional Response of Ants to Regenerating Habitats'. *Journal of Animal Ecology* 56 (2): 495–507. https://doi.org/10.2307/5063.

Hairston, Nelson G., Kiisa C. Nishikawa, and Sarah L. Stenhouse. 1987. ‘The Evolution of Competing Species of Terrestrial Salamanders: Niche Partitioning or Interference?’ *Evolutionary Ecology* 1 (3): 247–62. https://doi.org/10.1007/BF02067555.

Hasegawa, Koh, and Koji Maekawa. 2009. ‘Role of Visual Barriers on Mitigation of Interspecific Interference Competition between Native and Non-Native Salmonid Species’. *Canadian Journal of Zoology* 87 (9): 781–86. https://doi.org/10.1139/Z09-071.

Hasegawa, Koh, Toshiaki Yamamoto, Masashi Murakami, and Koji Maekawa. 2004. ‘Comparison of Competitive Ability between Native and Introduced Salmonids: Evidence from Pairwise Contests’. *Ichthyological Research* 51 (3): 191–94. https://doi.org/10.1007/s10228-004-0214-x.

He, Qixin, Joyce R. Prado, and Laura Lacey Knowles. 2017. ‘Inferring the Geographic Origin of a Range Expansion: Latitudinal and Longitudinal Coordinates Inferred from Genomic Data in an ABC Framework with the Program x-Origin’. *Molecular Ecology* 26 (24): 6908–20. https://doi.org/10.1111/mec.14380.

Heller, Horace Craig. 1971. ‘Altitudinal Zonation of Chipmunks (Eutamias): Interspecific Aggression, Water Balance, and Energy Budgets’. Ph.D., United States -- Connecticut: Yale University. https://www.proquest.com/docview/288230936/citation/2C2072B0CE784FA1PQ/1.

Hernández-Brito, Dailos, Martina Carrete, Ana G. Popa-Lisseanu, Carlos Ibáñez, and José L. Tella. 2014. ‘Crowding in the City: Losing and Winning Competitors of an Invasive Bird’. *PLOS ONE* 9 (6): e100593. https://doi.org/10.1371/journal.pone.0100593.

Hochkirch, Axel, and Julia Gröning. 2012. ‘Niche Overlap in Allotopic and Syntopic Populations of Sexually Interacting Ground-Hopper Species’. *Insect Science* 19 (3): 391–402. https://doi.org/10.1111/j.1744-7917.2011.01462.x.

Hochkirch, Axel, Julia Gröning, and Amelie Bücker. 2007. ‘Sympatry with the Devil: Reproductive Interference Could Hamper Species Coexistence’. *Journal of Animal Ecology* 76 (4): 633–42. https://doi.org/10.1111/J.1365-2656.2007.01241.X.

Houser, Jeremy D., Howard Ginsberg, and Elizabeth M. Jakob. 2014. ‘Competition between Introduced and Native Spiders (Araneae: Linyphiidae)’. *Biological Invasions* 16 (11): 2479–88. https://doi.org/10.1007/S10530-014-0679-0/FULLTEXT.HTML.

Iritani, Ryosuke, and Suzuki Noriyuki. 2021. ‘Reproductive Interference Hampers Species Coexistence despite Conspecific Sperm Precedence’. *Ecology and Evolution* 11 (5): 1957–69. https://doi.org/10.1002/ece3.7166.

Irwin, Darren, and Dolph Schluter. 2022. ‘Hybridization and the Coexistence of Species’. *The American Naturalist*. https://doi.org/10.1086/720365.

Jankowski, Jill E., Scott K. Robinson, and Douglas J. Levey. 2010. ‘Squeezed at the Top: Interspecific Aggression May Constrain Elevational Ranges in Tropical Birds’. *Ecology* 91 (7): 1877–84. https://doi.org/10.1890/09-2063.1.

Jones, Samuel E.I., Joseph A. Tobias, Robin Freeman, and Steven J. Portugal. 2020. ‘Weak Asymmetric Interspecific Aggression and Divergent Habitat Preferences at an Elevational Contact Zone between Tropical Songbirds’. *Ibis* 162 (3): 814–26. https://doi.org/10.1111/IBI.12793.

Keith, SA, JP A Hobbs, L Boström-Einarsson, IR Hartley, and NJ Sanders. 2023. ‘Rapid Resource Depletion on Coral Reefs Disrupts Competitor Recognition Processes among Butterflyfish Species’. *Proceedings of the Royal Society B* 290 (1990): 20222158.

Kiritani, Keizi. 2011. ‘Impacts of Global Warming on Nezara Viridula and Its Native Congeneric Species’. *Journal of Asia-Pacific Entomology* 14 (2): 221–26. https://doi.org/10.1016/j.aspen.2010.09.002.

Kishi, Shigeki, and Takefumi Nakazawa. 2013. ‘Analysis of Species Coexistence Co-Mediated by Resource Competition and Reproductive Interference’. *Population Ecology* 55 (2): 305–13. https://doi.org/10.1007/s10144-013-0369-2.

Klaus, Kristina V, and Nicholas J Matzke. 2020. ‘Statistical Comparison of Trait-Dependent Biogeographical Models Indicates That Podocarpaceae Dispersal Is Influenced by Both Seed Cone Traits and Geographical Distance’. *Systematic Biology* 69 (1): 61–75. https://doi.org/10.1093/sysbio/syz034.

Kuno, Eizi. 1992. ‘Competitive Exclusion through Reproductive Interference’. *Researches on Population Ecology* 34 (2): 275–84. https://doi.org/10.1007/BF02514797.

Kyogoku, Daisuke, and Teiji Sota. 2017. ‘A Generalized Population Dynamics Model for Reproductive Interference with Absolute Density Dependence’. *Scientific Reports* 7 (1): 1–8. https://doi.org/10.1038/s41598-017-02238-6.

Larson, Ralph J. 1980. ‘Competition, Habitat Selection, and the Bathymetric Segregation of Two Rockfish (Sebastes) Species’. *Ecological Monographs* 50 (2): 221–39. https://doi.org/10.2307/1942480.

Legault, Geoffrey, Matthew E. Bitters, Alan Hastings, and Brett A. Melbourne. 2020. ‘Interspecific Competition Slows Range Expansion and Shapes Range Boundaries’. *Proceedings of the National Academy of Sciences of the United States of America* 117 (43): 26854–60. https://doi.org/10.1073/pnas.2009701117.

Leighton, Gavin M., Dominique Lamour, Khalil Malcolm, and Eliot T. Miller. 2023. ‘Both Morphological and Behavioral Traits Predict Interspecific Social Dominance in Birds’. *Journal of Ornithology* 164 (1): 163–69. https://doi.org/10.1007/s10336-022-02022-y.

Leponce, Maurice, Yves Roisin, and Jacques Pasteels. 1997. ‘Structure and Dynamics of the Arboreal Termite Community in New Guinean Coconut Plantations’. *Tropical Biology* 29 (2): 193–203.

Lill, Alan, and Ingrid Muscat. 2015. ‘Importance of Inherent Suitability, Behavioural Flexibility and Competitiveness in Occupancy of Urban Parks by an Endemic Honeyeater’. *Avian Biology Research* 8 (4): 227–36. https://doi.org/10.3184/175815515X14428542803227.

Liou, L. W., and T. D. Price. 1994. ‘Speciation By Reinforcement of Premating Isolation’. *Evolution* 48 (5): 1451–59. https://doi.org/10.1111/j.1558-5646.1994.tb02187.x.

Liu, Shu-Sheng, P. J. De Barro, Jing Xu, Jun-Bo Luan, Lian-Sheng Zang, Yong-Ming Ruan, and Fang-Hao Wan. 2007. ‘Asymmetric Mating Interactions Drive Widespread Invasion and Displacement in a Whitefly’. *Science* 318 (5857): 1769–72. https://doi.org/10.1126/science.1149887.

Lounibos, L. Philip, and Steven A. Juliano. 2018. ‘Where Vectors Collide: The Importance of Mechanisms Shaping the Realized Niche for Modeling Ranges of Invasive Aedes Mosquitoes’. *Biological Invasions* 20 (8): 1913–29. https://doi.org/10.1007/s10530-018-1674-7.

Louthan, Allison M., Daniel F. Doak, and Amy L. Angert. 2015. ‘Where and When Do Species Interactions Set Range Limits?’ *Trends in Ecology and Evolution* 30 (12): 780–92. https://doi.org/10.1016/j.tree.2015.09.011.

Mac Nally, Ralph, Michiala Bowen, Alison Howes, Clive A. McAlpine, and Martine Maron. 2012. ‘Despotic, High-Impact Species and the Subcontinental Scale Control of Avian Assemblage Structure’. *Ecology* 93 (3): 668–78. https://doi.org/10.1890/10-2340.1.

Maldonado-Coelho, Marcos, Miguel Ângelo Marini, Fábio Raposo Do Amaral, and Rômulo Ribon. 2017. ‘The Invasive Species Rules: Competitive Exclusion in Forest Avian Mixed-Species Flocks in a Fragmented Landscape’. *Revista Brasileira de Ornitologia 2017 25:1* 25 (1): 54–59. https://doi.org/10.1007/BF03544377.

Martin, Paul R., and Frances Bonier. 2018. ‘Species Interactions Limit the Occurrence of Urban-Adapted Birds in Cities’. *Proceedings of the National Academy of Sciences of the United States of America* 115 (49): E11495–504. https://doi.org/10.1073/pnas.1809317115.

Martin, Paul R., Kevin W. Burke, and Frances Bonier. 2021. ‘Plasticity versus Evolutionary Divergence: What Causes Habitat Partitioning in Urban-Adapted Birds?’ *The American Naturalist* 197 (1): 60–74. https://doi.org/10.1086/711753.

McEachin, Shawn, Jonathan P Drury, Christopher N Anderson, and Gregory F Grether. 2022. ‘Mechanisms of Reduced Interspecific Interference between Territorial Species’. *Behavioral Ecology* 33 (1): 126–36. https://doi.org/10.1093/beheco/arab115.

McLain, Denson Kelly, and Donald J. Shure. 1987. ‘Pseudocompetition: Interspecific Displacement of Insect Species through Misdirected Courtship’. *Oikos* 49 (3): 291–96. https://doi.org/10.2307/3565763.

McQuillan, Michael A, and Amber M Rice. 2015. ‘Differential Effects of Climate and Species Interactions on Range Limits at a Hybrid Zone: Potential Direct and Indirect Impacts of Climate Change’. *Ecology and Evolution* 5 (21): 5120–37.

Mikami, Osamu K., and Masakado Kawata. 2004. ‘Does Interspecific Territoriality Reflect the Intensity of Ecological Interactions? A Theoretical Model for Interspecific Territoriality’. *Evolutionary Ecology Research* 6 (5): 765–75.

Mottl, Ondřej, Jacob Yombai, Vojtěch Novotný, Maurice Leponce, George D Weiblen, and Petr Klimeš. 2021. ‘Inter-Specific Aggression Generates Ant Mosaics in Canopies of Primary Tropical Rainforest’. *Oikos* 130 (7): 1087–99. https://doi.org/10.1111/oik.08069.

Nasci, R. S., S. G. Hare, and F. S. Willis. 1989. ‘Interspecific Mating between Louisiana Strains of Aedes Albopictus and Aedes Aegypti in the Field and Laboratory’. *Journal of the American Mosquito Control Association* 5 (3): 416–21.

Nesbit, D. A., M. C. Cowen, G. F. Grether, and J. P. Drury. 2022. ‘Interspecific Territoriality Has Facilitated Recent Increases in the Breeding Habitat Overlap of North American Passerines’. bioRxiv. https://doi.org/10.1101/2022.08.23.504954.

Nishida, Takayoshi, Kohichi Takakura, and Keisuke Iwao. 2015. ‘Host Specialization by Reproductive Interference between Closely Related Herbivorous Insects’. *Population Ecology* 57 (2): 273–81. https://doi.org/10.1007/s10144-015-0490-5.

Novella-Fernandez, Roberto, Javier Juste, Carlos Ibáñez, Hugo Rebelo, Danilo Russo, Antton Alberdi, Andreas Kiefer, et al. 2021. ‘Broad-Scale Patterns of Geographic Avoidance between Species Emerge in the Absence of Fine-Scale Mechanisms of Coexistence’. *Diversity and Distributions* 27 (9): 1606–18. https://doi.org/10.1111/DDI.13375.

Ockendon, Nancy, David J. Baker, Jamie A. Carr, Elizabeth C. White, Rosamunde E.A. Almond, Tatsuya Amano, Esther Bertram, et al. 2014. ‘Mechanisms Underpinning Climatic Impacts on Natural Populations: Altered Species Interactions Are More Important than Direct Effects’. *Global Change Biology* 20 (7): 2221–29. https://doi.org/10.1111/gcb.12559.

Orians, Gordon, and Mary Willson. 1964. ‘Interspecific Territories of Birds’. *Ecology* 45 (4): 736–45.

Ortego, Joaquín, and L. Lacey Knowles. 2020. ‘Incorporating Interspecific Interactions into Phylogeographic Models: A Case Study with Californian Oaks’. *Molecular Ecology* 29 (23): 4510–24. https://doi.org/10.1111/mec.15548.

Paine, Robert T. 1966. ‘Food Web Complexity and Species Diversity’. *The American Naturalist* 100 (910): 65–75.

Parmesan, Camille, and Gary Yohe. 2003. ‘A Globally Coherent Fingerprint of Climate Change Impacts across Natural Systems’. *Nature* 421 (6918): 37–42. https://doi.org/10.1038/nature01286.

Pasch, Bret, Benjamin M. Bolker, and Steven M. Phelps. 2013. ‘Interspecific Dominance via Vocal Interactions Mediates Altitudinal Zonation in Neotropical Singing Mice’. *American Naturalist* 182 (5). https://doi.org/10.1086/673263.

Payne, Robert B. 1980. ‘Behavior and Songs of Hybrid Parasitic Finches’. *The Auk* 97 (1): 118–34. https://doi.org/10.1093/auk/97.1.118.

Pearson, Scott F. 2000. ‘Behavioral Asymmetries in a Moving Hybrid Zone’. *Behavioral Ecology* 11 (1): 84–92. https://doi.org/10.1093/beheco/11.1.84.

Pearson, Scott F., and Sievert Rohwer. 2000. ‘Asymmetries in Male Aggression across an Avian Hybrid Zone’. *Behavioral Ecology* 11 (1): 93–101. https://doi.org/10.1093/beheco/11.1.93.

Peiman, Kathryn S., and Beren W. Robinson. 2010. ‘Ecology and Evolution of Resource-Related Heterospecific Aggression’. *Quarterly Review of Biology* 85 (2): 133–58. https://doi.org/10.1086/652374.

Perdereau, E., F. Dedeine, J.-P. Christidès, S. Dupont, and A.-G. Bagnères. 2011. ‘Competition between Invasive and Indigenous Species: An Insular Case Study of Subterranean Termites’. *Biological Invasions* 13 (6): 1457–70. https://doi.org/10.1007/s10530-010-9906-5.

Pereira, Pedro Filipe, Rui Lourenço, and Paulo Gama Mota. 2020. ‘Two Songbird Species Show Subordinate Responses to Simulated Territorial Intrusions of an Exotic Competitor’. *Acta Ethologica* 23 (3): 143–54. https://doi.org/10.1007/s10211-020-00347-6.

Peter, Benjamin M., and Montgomery Slatkin. 2013. ‘Detecting Range Expansions from Genetic Data’. *Evolution* 67 (11): 3274–89. https://doi.org/10.1111/evo.12202.

Petkova, Desislava, John Novembre, and Matthew Stephens. 2015. ‘Visualizing Spatial Population Structure with Estimated Effective Migration Surfaces’. *Nature Genetics* 48 (1): 94–100. https://doi.org/10.1038/ng.3464.

Petren, Kenneth, Douglas T. Bolger, and Ted J. Case. 1993. ‘Mechanisms in the Competitive Success of an Invading Sexual Gecko over an Asexual Native’. *Science* 259 (5093): 354–58. https://doi.org/10.1126/science.259.5093.354.

Pfennig, Karin S, and David W Pfennig. 2009. ‘Character Displacement: Ecological and Reproductive Responses to a Common Evolutionary Problem’. *Quarterly Review of Biology* 84 (3): 253–76.

Pichler, Maximillian, and Florian Hartig. 2021. ‘A New Joint Species Distribution Model for Faster and More Accurate Inference of Species Associations from Big Community Data’. *Methods in Ecology and Evolution* 12 (11): 2159–73.

Poggiato, Giovanni, Tamara Münkemüller, Daria Bystrova, Julyan Arbel, James S. Clark, and Wilfried Thuiller. 2021. ‘On the Interpretations of Joint Modeling in Community Ecology’. *Trends in Ecology & Evolution* 36 (5): 391–401. https://doi.org/10.1016/J.TREE.2021.01.002.

Quintero, Ignacio, and Michael J Landis. 2020. ‘Interdependent Phenotypic and Biogeographic Evolution Driven by Biotic Interactions’. *Systematic Biology* 69 (4): 739–55. https://doi.org/10.1093/sysbio/syz082.

Reif, Jiří, Martin Jiran, Radka Reifová, Jana Vokurková, Paweł T. Dolata, Adam Petrusek, and Tereza Petrusková. 2015. ‘Interspecific Territoriality in Two Songbird Species: Potential Role of Song Convergence in Male Aggressive Interactions’. *Animal Behaviour* 104 (June): 131–36. https://doi.org/10.1016/j.anbehav.2015.03.016.

Reif, Jiří, Radka Reifová, Anna Skoracka, and Lechosław Kuczyński. 2018. ‘Competition-Driven Niche Segregation on a Landscape Scale: Evidence for Escaping from Syntopy towards Allotopy in Two Coexisting Sibling Passerine Species’. *Journal of Animal Ecology* 87 (3): 774–89. https://doi.org/10.1111/1365-2656.12808.

Ribeiro, J. M.C., and A. Spielman. 1986. ‘The Satyr Effect: A Model Predicting Parapatry and Species Extinction’. *American Naturalist* 128 (4): 513–28. https://doi.org/10.1086/284584.

Robinson, Doug. 1992. ‘Habitat Use and Foraging Behaviour of the Scarlet Robin and the Flame Robin at a Site of Breeding-Season Sympatry’. *Wildlife Research* 19 (4): 377–95. https://doi.org/10.1071/WR9920377.

Rolando, A., and C. Palestrini. 1989. ‘Habitat Selection and Interspecific Territoriality in Sympatric Warblers at Two Italian Marshland Areas’. *Ethology Ecology & Evolution* 1 (2): 169–83. https://doi.org/10.1080/08927014.1989.9525521.

Ronquist, Fredrik. 2011. ‘Phylogenetic Methods in Historical Biogeography’. *Annual Review of Ecology, Evolution, and Systematics* 42: 441–64. https://doi.org/10.1146/annurev-ecolsys-102209-144710.

Rowles, Alexei D., and Dennis J. O’Dowd. 2007. ‘Interference Competition by Argentine Ants Displaces Native Ants: Implications for Biotic Resistance to Invasion’. *Biological Invasions* 9 (1): 73–85. https://doi.org/10.1007/s10530-006-9009-5.

Ruokolainen, Lasse, and Ilkka Hanski. 2016. ‘Stable Coexistence of Ecologically Identical Species: Caonspecific Aggregation via Reproductive Interference’. *Journal of Animal Ecology* 85 (3): 638–47. https://doi.org/10.1111/1365-2656.12490.

Rybinski, Jakub, Päivi M. Sirkiä, S. Eryn McFarlane, Niclas Vallin, David Wheatcroft, Murielle Ålund, and Anna Qvarnström. 2016. ‘Competition-Driven Build-up of Habitat Isolation and Selection Favoring Modified Dispersal Patterns in a Young Avian Hybrid Zone’. *Evolution* 70 (10): 2226–38. https://doi.org/10.1111/evo.13019.

Savidge, Julie A. 1987. ‘Extinction of an Island Forest Avifauna by an Introduced Snake’. *Ecology* 68 (3): 660–68.

Sekercioglu, Cagan H., Stephen H. Schneider, John P. Fay, and Scott R. Loarie. 2008. ‘Climate Change, Elevational Range Shifts, and Bird Extinctions’. *Conservation Biology* 22 (1): 140–50. https://doi.org/10.1111/j.1523-1739.2007.00852.x.

Sirén, Alexej P.K., and Toni Lyn Morelli. 2020. 'Interactive Range-Limit Theory (IRLT): An Extension for Predicting Range Shifts'. *Journal of Animal Ecology* 89 (4): 940–54. https://doi.org/10.1111/1365-2656.13150.

Sobroza, Tainara V., Marcelo Gordo, Adrian P.A. Barnett, Jean P. Boubli, and Wilson R. Spironello. 2021. 'Parapatric Pied and Red-Handed Tamarin Responses to Congeneric and Conspecific Calls'. *Acta Oecologica* 110 (May): 103688. https://doi.org/10.1016/J.ACTAO.2020.103688.

Söderbäck, B. 1995. 'Replacement of the Native Crayfish Astacus-Astacus by the Introduced Species Pacifastacus Leniusculus in a Swedish Lake - Possible Causes and Mechanisms'. *FRESHWATER BIOLOGY* 33 (2): 291–304.

Söderbäck, Björn. 1994. 'Interactions among Juveniles of Two Freshwater Crayfish Species and a Predatory Fish'. *Oecologia* 100 (3): 229–35.

Sorjonen, Jorma. 1986. 'Mixed Singing and Interspecific Territoriality - Consequences of Secondary Contact of Two Ecologically and Morphologically Similar Nightingale Species in Europe'. *Ornis Scandinavica (Scandinavian Journal of Ornithology)* 17 (1): 53–67. https://doi.org/10.2307/3676753.

Sukumaran, Jeet, and L. Lacey Knowles. 2018. 'Trait-Dependent Biogeography: (Re)Integrating Biology into Probabilistic Historical Biogeographical Models'. *Trends in Ecology and Evolution* 33 (6): 390–98. https://doi.org/10.1016/j.tree.2018.03.010.

Sutherst, R. W. 1987. 'The Dynamics of Hybrid Zones between Tick (Acari) Species'. *International Journal for Parasitology* 17 (4): 921–26. https://doi.org/10.1016/0020-7519(87)90009-9.

Suwanvecho, Udomlux, and Warren Y. Brockelman. 2012. 'Interspecific Territoriality in Gibbons (Hylobates Lar and H. Pileatus) and Its Effects on the Dynamics of Interspecies Contact Zones'. *Primates; Journal of Primatology* 53 (1): 97–108. https://doi.org/10.1007/s10329-011-0284-0.

Svenning, Jens Christian, Dominique Gravel, Robert D. Holt, Frank M. Schurr, Wilfried Thuiller, Tamara Münkemüller, Katja H. Schiffers, et al. 2014. 'The Influence of Interspecific Interactions on Species Range Expansion Rates'. *Ecography* 37 (12): 1198–1209. https://doi.org/10.1111/j.1600-0587.2013.00574.x.

Takami, T., T. Yoshihara, Y. Miyakoshi, and R. Kuwabara. 2002. ‘Replacement of white-spotted charr Salvelinus leucomaenis by brown trout Salmo trutta in a branch of the Chitose River, Hokkaido [Japan]’. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)*. https://scholar.google.com/scholar_lookup?title=Replacement+of+white-spotted+charr+Salvelinus+leucomaenis+by+brown+trout+Salmo+trutta+in+a+branch+of+the+Chitose+River%2C+Hokkaido+%5BJapan%5D&author=Takami%2C+T.+%28Hokkaido.+Fish+Hatchery%2C+Eniwa+%28Japan%29%29&publication_year=2002.

Thorson, James T., Malin L. Pinsky, and Eric J. Ward. 2016. ‘Model-Based Inference for Estimating Shifts in Species Distribution, Area Occupied and Centre of Gravity’. *Methods in Ecology and Evolution* 7 (8): 990–1002. https://doi.org/10.1111/2041-210X.12567.

Thum, Ruan A. 2007. ‘Reproductive Interference, Priority Effects and the Maintenance of Parapatry in Skistodiaptomus Copepods’. *Oikos* 116 (5): 759–68. https://doi.org/10.1111/j.0030-1299.2007.15782.x.

Tikhonov, Gleb, Nerea Abrego, David Dunson, and Otso Ovaskainen. 2017. ‘Using Joint Species Distribution Models for Evaluating How Species-to-Species Associations Depend on the Environmental Context’. *Methods in Ecology and Evolution* 8 (4): 443–52. https://doi.org/10.1111/2041-210X.12723.

Titley, Mark A, Stuart HM Butchart, Victoria R Jones, Mark J Whittingham, and Stephen G Willis. 2021. ‘Global Inequities and Political Borders Challenge Nature Conservation under Climate Change’. *Proceedings of the National Academy of Sciences* 118 (7): e2011204118.

Tobias, Joseph A., Jente Ottenburghs, and Alex L. Pigot. 2020. ‘Avian Diversity: Speciation, Macroevolution, and Ecological Function’. *Annual Review of Ecology, Evolution, and Systematics* 51 (1): 533–60. https://doi.org/10.1146/annurev-ecolsys-110218-025023.

Tønnesen, M. H., B. L. Penzhorn, N. R. Bryson, W. H. Stoltsz, and T. Masibigiri. 2004. ‘Displacement of Boophilus Decoloratus by Boophilus Microplus in the Soutpansberg Region, Limpopo Province, South Africa’. *Experimental and Applied Acarology* 32 (3): 199–208. https://doi.org/10.1023/B:APPA.0000021789.44411.b5.

Trombulak, Stephen C. 1985. ‘The Influence of Interspecific Competition on Home Range Size in Chipmunks (Eutamias)’. *Journal of Mammalogy* 66 (2): 329–37. https://doi.org/10.2307/1381245.

Tsuchida, Koji, Ayumi Yamaguchi, Yuya Kanbe, and Koichi Goka. 2019. ‘Reproductive Interference in an Introduced Bumblebee: Polyandry May Mitigate Negative Reproductive Impact’. *Insects* 10 (2): 59. https://doi.org/10.3390/insects10020059.

Tsurui-Sato, K., S. Fujimoto, O. Deki, T. Suzuki, H. Tatsuta, and K. Tsuji. 2019. ‘Reproductive Interference in Live-Bearing Fish: The Male Guppy Is a Potential Biological Agent for Eradicating Invasive Mosquitofish’. *Scientific Reports 2019 9:1* 9 (1): 1–9. https://doi.org/10.1038/s41598-019-41858-y.

Vallin, Niclas, Amber M. Rice, Hanna Arntsen, Katarzyna Kulma, and Anna Qvarnström. 2012. ‘Combined Effects of Interspecific Competition and Hybridization Impede Local Coexistence of Ficedula Flycatchers’. *Evolutionary Ecology* 26 (4): 927–42. https://doi.org/10.1007/s10682-011-9536-0.

Van Lanen, Nicholas J., Alan B. Franklin, Kathryn P. Huyvaert, Raoul F. Reiser, and Peter C. Carlson. 2011. ‘Who Hits and Hoots at Whom? Potential for Interference Competition between Barred and Northern Spotted Owls’. *Biological Conservation* 144 (9): 2194–2201. https://doi.org/10.1016/j.biocon.2011.05.011.

Wang, P., D. W. Crowder, and S. S. Liu. 2012. ‘Roles of Mating Behavioural Interactions and Life History Traits in the Competition between Alien and Indigenous Whiteflies’. *Bulletin of Entomological Research* 102 (4): 395–405. https://doi.org/10.1017/S000748531100071X.

Westman, Kai, and R. Savolainen. 2001. ‘Long Term Study of Competition between Two Co-Occurring Crayfish Species, the Native Astacus Astacus l. And the Introduced Pacifastacus Leniusculus Dana, in a Finnish Lake.’ *Bulletin Français de La Pêche et de La Pisciculture*, no. 361: 613–27. https://doi.org/10.1051/kmae:2001008.

Westman, Kai, Riitta Savolainen, and Markku Julkunen. 2002. ‘Replacement of the Native Crayfish Astacus Astacus by the Introduced Species Pacifastacus Leniusculus in a Small, Enclosed

Finnish Lake: A 30-Year Study'. *Ecography* 25 (1): 53–73. https://doi.org/10.1034/J.1600-0587.2002.250107.X.

Wiens, J. David, Robert G. Anthony, and Eric D. Forsman. 2014. 'Competitive Interactions and Resource Partitioning between Northern Spotted Owls and Barred Owls in Western Oregon'. *Wildlife Monographs* 185 (1): 1–50. https://doi.org/10.1002/WMON.1009.

Wilkinson, David P., Nick Golding, Gurutzeta Guillera-Arroita, Reid Tingley, and Michael A. McCarthy. 2019. 'A Comparison of Joint Species Distribution Models for Presence–Absence Data'. *Methods in Ecology and Evolution* 10 (2): 198–211. https://doi.org/10.1111/2041-210X.13106.

Wilkinson, David P, Nick Golding, Gurutzeta Guillera-Arroita, Reid Tingley, and Michael A McCarthy. 2021. 'Defining and Evaluating Predictions of Joint Species Distribution Models'. *Methods in Ecology and Evolution* 12 (3): 394–404.

Žagar, Anamarija, Miguel A. Carretero, Nadja Osojnik, Neftalí Sillero, and Al Vrezec. 2015. 'A Place in the Sun: Interspecific Interference Affects Thermoregulation in Coexisting Lizards'. *Behavioral Ecology and Sociobiology* 69 (7): 1127–37. https://doi.org/10.1007/s00265-015-1927-8.

Zhou, Jiayong, Shuang Liu, Hongkai Liu, Zhensheng Xie, Liping Liu, Lifeng Lin, Jinyong Jiang, et al. 2022. 'Interspecific Mating Bias May Drive Aedes Albopictus Displacement of Aedes Aegypti during Its Range Expansion'. *PNAS Nexus* 1 (2): pgac041. https://doi.org/10.1093/pnasnexus/pgac041.

SUPPLEMENTARY INFORMATION

Supplementary Table 1: All 54 study systems identified during the literature review that found clear evidence that interspecific behavioural interference (IBI) impacts the spatial distribution of a species.

Interacting Species	**IBI.Type**	**Elevational (Y/N)**	**Invasion (Y/N)**	**Comparative (Y/N)**	**Impacts of IBI on Spatial Dynamics**	**References**	**Additional Explanations?**
Aves							
Great reed warblers (*Acrocephalus arundinaceus*) & marsh warblers (*Acrocephalus palustris*)	Aggression	N	N	N	Territorial mapping and behavioural observations demonstrate that great reed warblers and marsh warblers are interspecifically territorial, with great reed warblers dominating interactions. In areas where both species occur, marsh warblers use habitat further from reed habitats than sites where great reed warblers are absent.	(Rolando and Palestrini, 1989)	
Bicknell's thrushes (*Catharus bicknelli*) & Swainson's thrushes (*Catharus ustulatus*)	Aggression	Y	N	N	Playback experiments between two parapatric thrush species. Lower elevation Swaison's thruses respond aggresively to the calls of higher elevation Bikcnells thrushes, but not vice versa. The aggresive responses of Swaison's thrush toward heterospecifics increases with altitude (i.e., closer to range boundary).	(Freeman and Montgomery, 2015)	
Black-headed nightingale thrushes (*Catharus mexicanus*) & ruddy-capped nightingale-thrushes (*Catharus frantzii*)	Aggression	Y	N	N	Playback experiments showed that lower elevation black-capped nightingale-thrushes respond aggressively to the ruddy-capped nightingale-thrush, but not vice-versa.	(Jones *et al.*, 2020)	Habitat segregation
Collared (*Ficedula albicollis*) & pied (*Ficedula hypoleuca*) flycatchers	Aggression	N	N	N	Collared and pied flycatchers have recently (150 years ago) come into sympatry. Collared flycatchers are more aggressive, which shifts the nest occupancy of pied flycatchers into suboptial habitat. However, pied flycatchers that nest in suboptimal habitat are less likely to hybridise with Collared flycatchers, this reenforces the habitat use of the two species.	(Vallin *et al.*, 2012; Rybinski *et al.*, 2016)	Exploitative competition for nestboxes (but nestbox access mediated by aggression)
Several species of wood wrens (*Henicorhina leucophrys &* Henicorhina *leucosticta*) and thrushes (*Catharus mexicanus & Catharus aurantiirostris*) along an elevational gradient in Costa Rica.	Aggression	Y	N	N	Playback experiments show aggressive responses to heterospecific congeners, with the magnitude of such responses increase toward contact zones.	(Jankowski, Robinson and Levey, 2010)	Habitat turnover
Narrow-billed woodcreepers (*Lepidocolaptes angustirostris*) & scaled woodcreepers (*Lepidocolaptes squamatus*)	Aggression	N	N	N	Fragmentation of the Atlantic Forest in Brazil has facilitated range expansion of narrow-billed woodcreepers. Scaled woodcreepers have been forced to recede into the remaining fragments of forest. However, narrow-billed woodcreepers regularly join mixed-species flocks within the forest and aggressively exclude scaled woodcreepers from joining flocks	(Maldonado-Coelho *et al.*, 2017)	
Common nightingales (*Luscinia megarhynchos*) & thrush nightingales (*Luscinia luscinia*)	Aggression	N	N	N	Common and thrush nightingales are interspecifically territorial and exhibit evidence of song convergence in sympatry. This aggression drives shifts in habitat preferences in sympatry compared to allopatric populations.	(Sorjonen, 1986; Reif *et al.*, 2015, 2018)	

Noisy miners (*Manorina melanocephala*) & local bird assemblages	Aggression	N	N	N	Noisy miners are extremely aggressive towards nearly all heterospecific birds, even those with little overlap in diet and foraging behaviour, and their presence shapes the structure of entire avian assemblages.	(Mac Nally *et al.*, 2012; Lill and Muscat, 2015)	
Flame robins (Petroica phoenicea) & Norfolk robins (Petroica multicolor)	Aggression	N	N	N	Both species are interspecifically territorial. Migratory flame robins displace the less aggressive Norfolk robin upon returning to breeding habitat, likely displacing Norfolk robins into suboptimal habitat.	(Robinson, 1992)	
Carolina chickadees (*Poecile carolinensis*) and black-capped chickadees (*Poecile atricapillus*)	Aggression and Reproductive Interference	N	N	N	Carolina chickadees are more aggressive (dominant) than black-capped chickadees, and that dominant chickadees are prefered by females of both species in mate choice trails. SDMs show that Carolina chickadees' distribution limit largely matches climatic predictors, whereas black-capped chickadee distribution does nor, suggesting that it is limited instead by interactions with Carolina chickadees.	(Bronson *et al.*, 2003; McQuillan and Rice, 2015)	
Invasive ring-necked *parakeets (Psittacula krameri*) and native communities	Aggression	N	Y	N	Invasive ring-necked parakeets tend to be dominant in aggressive interactions, and consequnetly the parakeets exclude other species that use tree cavities, including greater noctules (*Nyctalus lasiopterus*), a threatened bat species. Although many birds currently appear to benefit from parakeet aggression towards predators, greater noctules decline where parakeets occur.	(Hernández-Brito *et al.*, 2014)	
Townsend's warblers (*Setophaga townsendi*) and hermit warblers (*Setophaga occidentalis*)	Aggression and Reproductive Interference	N	N	N	Moving hybrid zone attributed to asymmetries in behavioural interference. Both species defend mutually exclusive territories, though Townsend warbler's are likely to be more aggressive toward hermit warblers than vice versa. Similarly, though mating is largely assortative, exceptions are more likely with Townsend males mating with hermit females (not vice versa).	(Pearson, 2000; Pearson and Rohwer, 2000)	
Western bluebirds (*Sialia mexicana*) & mountain bluebirds (*Sialia currucoides*)	Aggression	N	N	N	As western bluebirds range shifts into mountain bluebirds range, mountain bluebird populations are going locally extinct due to aggression from western bluebirds limiting nesting opportunities.	(Duckworth and Badyaev, 2007; Duckworth, 2013; Duckworth, Belloni and Anderson, 2015)	Exploitative competition for nestboxes (but nestbox access mediated by aggression)
Spotted owls (*Strix occidentalis*) & barred owls (*Strix varia*)	Aggression	N	Y	N	Barred owls are invading spotted owls' range and driving declines in spotted owls. Playback experiments with mounts demonstrate asymmetric aggression from barred owls toward spotted owls, and tracking data suggest they exclude spotted owls from breeding territories.	(Gutiérrez *et al.*, 2007; Van Lanen *et al.*, 2011; Wiens, Anthony and Forsman, 2014)	Habitat loss, exploitative competition
Dominant and subordinate congeneric birds in urban environmetns	Aggression	N	N	Y	Subordinate species are less likely to occur and less abundant in cities where dominant species are widespread breeders (compared to in cities where the sub-dominant species is found in allopatry).	(Martin and Bonier, 2018; Martin, Burke and Bonier, 2021)	Exploitative competition for resources not ruled out
Dominant and subordinate birds from North America	Aggression	N	N	Y	Subordinate species migrate further distances than dominant species	(Freshwater, Ghalambor and Martin, 2014)	
Birds along an elevational gradient in Borneo	Aggression	Y	N	Y	Simulated instrusion paper testing whether interspecific aggression drives parapatric ranges along an elevational gradient for different pairs of birds. They found support for this hypothesis in bulbuls: ochraceus bulbuls (Alophoixus ochraceus) respond aggressivly to pale-faced bulbuls (Pycnonotus leucops). However, they did not find evidence that parapatric white-eyes (Zosterops sp.) are aggressive to congeners.	(Boyce and Martin, 2019)	

North american perching birds (passerines)	Aggression and Reproductive Interference	N	N	Y	Analyses of sister taxa show that transitions from allopatry to secondary sympatry are best predicted by the interactive effect of interspecific territoriality and hybridization.	(Cowen, Drury and Grether, 2020)	
Birds along an elevational gradient in Papua New Guinea	Aggression	Y	N	Y	Playback experiments on five species pairs demonstrate that the lower elevation species are more aggressive toward heterospecifics than upper elevation confamilial counterparts, and that species only engaged in aggression towards HS at the range boundary, for three of the five species pairs.	(Freeman, Class Freeman and Hochachka, 2016)	
Amphibia							
Southern Appalachian salamander (*Plethodon teyahalee*) & red-cheeked salamanders (*Plethodon jordani*)	Aggression	Y	N	N	Extensive observational and experimental data (from removal experiments and behavioural experiments) demonstrate that aggressive interference is the cause of the species parapatric elevational ranges in the Great Smokey Mountains. Later modelling suggesting interspecific interactions prevent the low elevation southern Appalachian salamander from expanding into higher elevations.	(Hairston, Nishikawa and Stenhouse, 1987; Gifford and Kozak, 2012)	
Actinopterygii							
Damselfish (Dischistodus spp.) in the Great Barrier Reef	Aggression	N	N	N	Four species of damselfish have non overlapping habitat use within reef. Aquarium studies show the damselfish have wider habitat use than seen in the field and simulated intruder experiments in the field reveal high levels of interspecific aggression between species that use adjacent habitat.	(Bay, Jones and McCormick, 2001)	Habitat segregation
Guppies (*Poecilia reticulata*) & mosquitofish (*Gambusia affinis*)	Reproductive Interference	N	Y	N	Mosquitofish decline upon introduction of guppies, and experimental evidence shows that reproductive interference occurrs asymetrically, with negative fitness impacts on mosquitofish, but not guppies.	(Tsurui-Sato *et al.*, 2019)	
Obscure damselfish (*Pomacentrus adelus*) & speckled damselfish (*Pomacentrus bankanensis)*	Aggression	N	N	N	Species are interspecifically territorial, and upon removal of obscure damsels, speckled damsels expand territories to occupy vacant space, with knock-on effects for other habitat use of other reef fish.	(Eurich, McCormick and Jones, 2018)	
Invasive brown trout (*Salmo trutta*) & white-spotted charr (*Salvelinus leucomaenis*) in Japan	Aggression	N	Y	N	Introduced brown trout has expanded throughout drainage, except upstream of weirs where white-spotted charr are more abundant. Experimental data shows that brown trout are dominant in behavioural trials.	(Takami *et al.*, 2002; Hasegawa *et al.*, 2004; Hasegawa and Maekawa, 2009)	
Gopher rockfish (*Sebastes carnatus*) & Black-and-yellow rockfish (*Sebastes chrysomelas*)	Aggression	N	N	N	Lab experiments show interspecific aggression for territories and removal experiments in the field show that the removal of both species allows the other to expand is depth range.	(Larson, 1980)	
Arachnida							
Invasive sheet-web spiders (*Linyphia triangularis*) & bowl-and-doily spiders (*Frontinella communis*)	Aggression	N	Y	N	An invasive species of spider displaces a native species from their contructed web. Furthermore, field experiments demonstrate that bowl-and-doily spiders are less likely to settle in plots where the invasive species is present and that introducing the invasive species leads to declines in bowl-and-doily spiders.	(Houser, Ginsberg and Jakob, 2014)	Exploitative competition for resources ruled out
Copepoda							
***Skistodiaptomus* copepods**	Reproductive Interference	N	N	N	*S. oregonensis* and *S. pygmaeus* exhibit a parapatric boundary. Laboratory studies demonstrate high levels of reproductive interference	(Thum, 2007)	Ecological gradients ruled out as possible explanation

					(though no evidence of introgression), suggesting that Allee effects generated by reproductive interference maintain this parapatric boundary.		
Crustacea							
Invasive rusty crayfish (*Orconectes rusticus*) and native Sanborn crayfish (*Orconectes sanborni*)	Aggression and Reproductive Interference	N	Y	N	An invasive crayfish (*O. rusticus*) that replaces native crafish (*O. sanborni*) tends to be dominant, and because females of the invasive species are larger, males of the native species prefer to mate with invasive females, reducing native female fitness.	(Butler and Stein, 1985)	Juvenile susceptibility to predation of native species
Invasive signal crayfish (*Pacifastacus leniusculus)* in Europe & native communities	Aggression and Reproductive Interference	N	Y	N	Signal crayfish have been introduced in many locations throughout Europe, and In several instances, have coincided with decline of native species. In Finland & Sweden, longitudinal data show replacement of native *Astacus astacus*, with experimental evidence that both reproductive interference and aggression implicated in the decline. Agonistic interactions with bullhead (*Cottus gobio)* drive bullhead out of shelters, which may explain pattern where density of signal crayfish is negatively correlated with that of bullhead.	Svärdson et al. 1991 (Söderbäck, 1994, 1995; Westman and Savolainen, 2001; Westman, Savolainen and Julkunen, 2002; Bubb *et al.*, 2009)	Signal crayfish are resistent to crayfish plague that contributes to decline of native crayfish species; Life history traits (e.g., developmental time)
Gastropoda							
Keyhole limpets (*Siphonaria lessonii*) & pulmonate limpets (*Fissurella crassa*)	Aggression	N	N	N	Mesocosm experiments demonstrate that large keyhole limpets aggressively displace smaller pulmonate limpets from crevices, and that displacement has fitness consequences not related to exploitative competition.	(Aguilera and Navarrete, 2012)	
Insecta							
***Aedes* mosquitos (*Ae. albopictus* & *Ae. aegypti*)**	Reproductive Interference	N	Y	N	In places where *Ae. aegypti* is established, males in invading populations of *Ae. albopictus* mate with *Ae. aegypti* females, greatly reducing their fitness and leading to replacement of *Ae. aegypti* by *Ae. albopictus*.	(Nasci, Hare and Willis, 1989; Bargielowski, Lounibos and Carrasquilla, 2013; Bargielowski and Lounibos, 2016; Lounibos and Juliano, 2018; Zhou *et al.*, 2022)	Larval resource competition
Two tick species (*Amblyomma variegatum* & *Amblyomma hebraeum*)	Reproductive Interference	N	N	N	Two species of tick are larglely parapatric . In sympatry, interspecific copulations are commonly observed, with little geographic overlap, suggesting symmetric reproductive interference may maintain parapatric boundary.	(Bournez *et al.*, 2015)	
Whiteflies (*Bemisia tabaci* spp.)	Reproductive Interference	N	Y	N	Invading whitefly species have replaced native strains in several locations owing to asymmetric reproductive interference, in which matings from invading males reduce fitness of native females.	(Liu *et al.*, 2007; Crowder *et al.*, 2011; Wang, Crowder and Liu, 2012)	Life history traits (e.g., developmental time, relative fecundity; though not sufficient without asymmetric reproductive interference to explain rapid replacement)
Invasive buff-tailed bumblebees (*Bombus terrestris*) & native bumblebees *(Bombus h. sapporoensis* 7 *Bombus ignitus*) in Japan	Reproductive Interference	N	Y	N	The invasive bumblebee species bombus terrestris engages in reproductive interference with two species of native bumblebee. Copulation between B. terrestris and B. h. sapporoensis or B. ignitus results in unviable eggs being laid the following spring, driving declines native bumblebee species.	(Tsuchida *et al.*, 2019)	Exploitative competition for nectar and nest sites

Rubyspot damselflies (*Hetaerina* spp.)	Aggression	N	N	Y	Rubyspot damselflies, which engage in high levels of reproductive interference and interspecific territoriality, have diverged in microhabitat use in a way that reduces the effects of behavioural interference.	(McEachin *et al.*, 2022)	
Two ant species (*Iridomyrmex* spp.)	Aggression	N	N	N	Removal experiments that two species hold mutually exclusive territories and compete for space to build colonies. Over a short period of time (11 months), one species ("C") replaced by another ("A"), in part due to asymmetric competition.	(Haering and Fox, 1987)	Habitational succession
Arboreal termite species in Papua New Guinea (*Microcerotermes biroi*, *Nasutitermes novarumhebridiarum*, & *Nasutitermes princeps*)	Aggression	N	N	Y	Long term mapping of arboreal termite nests and their territories in combination with behavioural observations shows that species defend mutually exclusive territories. Removal experiments of *N. princeps* drives concomitant increase in *M. biroi* home range.	(Leponce, Roisin and Pasteels, 1997)	
White-crossed seed bugs (*Neacoryphus bicrurus*) and co-occurring insect communities	Aggression and Reproductive Interference	N	N	N	White-crossed seed bugs engage in asymmetrical reproductive interference (misdirected courtship) and aggression towards many species, and removal experiments demonstrate that several other species increase in density when white-crossed seed bugs are removed.	(McLain and Shure, 1987)	
Invasive southern green stink bugs (*Nezara viridula*) & native green stink bugs (*Nezara antennata*)	Reproductive Interference	N	Y	N	Invasive southern green stink bugs are expanding in Japan into the range of and replacing native green stink bugs. In regions of coexistence, heterospecific copulations are commonly observed, and reproductive interference is suspected to drive declines of native species.	(Kiritani, 2011)	Shifting climatic suitability
Alpine dark bush-crickets (*Pholidoptera aptera*) & Transylvanian dark bush-crickets (*Pholidoptera transsylvanica*)	Reproductive Interference	N	N	N	Bush-crickets exhibit a 'mosaic' pattern of distribution, where the two species are rarely found in syntopy. Experiments demonstrate that heterospecific matings resulting in transfer of spermatophores are common.	(Dorková *et al.*, 2020)	Habitat segregation ruled out
Eastern subterranean termites (*Reticulitermes flavipes*) & Western subterranean termits (*Reticulitermes grassei*)	Aggression	N	Y	N	Invasive eastern subterranean termites are dominant in aggressive interactions over native western subterranean termites; success of invasion is attributed to this asymmetry.	(Perdereau *et al.*, 2011)	Lack of intraspecific aggression in invasive species; demographic factors (large colony size)
Invasive Asian blue ticks (*Rhipicephalus [Boophilus] microplus) &* African blue ticks (*Rhipicephalus [Boophilus] decoloratus*) in South Africa	Reproductive Interference	N	Y	N	Invasive Asian blue ticks have replaced African blue ticks in South Africa. Interspecific matings lead to sterile hybrids, so rapid demographic increases in invader populations lead to Allee effects driving local extinction of native species.	(Sutherst, 1987; Tønnesen *et al.*, 2004, 2004)	Life history traits (e.g., developmental time); host resistance
Cepero's groundhoppers (*Tetrix ceperoi*) & slender groundhoppers (*Tetrix subulata*)	Reproductive Interference	N	N	N	Groundhoppers exhibit a 'mosaic' pattern of distribution, where the two species are rarely found in syntopy. Laboratory and field experiments demonstrate that extensive reproductive interference is likely responsible for this spatial distribution.	(Gröning *et al.*, 2007; Hochkirch, Gröning and Bücker, 2007; Hochkirch and Gröning, 2012)	Habitat segregation ruled out
Arboreal ant species in Papua New Guinea	Aggression	N	N	Y	Colony mapping and behavioural experiments demonstrate that interspecific aggression is the key factor shaping the spatial distribution of ant species in a 9 hectare plot	(Mottl *et al.*, 2021)	Habitat segregation ruled out
Mammalia							

Fallow deer (*Dama dama*) & roe deer (*Capreolus capreolus*)	Aggression	N	Y	N	Fallow deer displace roe deer but not vice versa, and that habitat use by roe deer is affected by presence of fallow dear. Together, these suggest behavioural interference has led to decline in roe deer populations as fallow deer populations have increased.	(Ferretti and Mori, 2020)	Exploitative competition for resources not ruled out
White-handed gibbons (*Hylobates lar*) & Pileated gibbons (*Hylobates pileatus*)	Aggression	N	N	N	Two species of gibbon are largely parapatric, with a small contact zone that is maintained by interspecific territorial aggression.	(Suwanvecho and Brockelman, 2012; Asensio *et al.*, 2017)	Niche partitioning (via habitat segregation or diet divergence) ruled out.
Least chipmunks (*Neotamias minimus*) & yellow-pine chipmunks (*Neotamias amoenus*)	Aggression	Y	N	N	Removal experiments of two species of chipmunk that engage in aggressive interference. When yellow-pine chipmunks were removed, least chipmunks captures increased; the converse did not occur.	(Chappell, 1978; Heller, no date)	
Townsend's chipmunks (*Neotamias townsendii*) & yellow-pine chipmunks (*Neotamias amoenus*)	Aggression	N	N	N	Removal experiments of two species of chipmunk that engage in aggressive intractions with one another show that when heterospecifics are removed, the range size of the retained species and juvenile recruitment increases.	(Trombulak, 1985)	Habitat segregation ruled out
Uinta chipmunks (*Neotamias umbrinus*) & Colorado chipmunks (*Neotamias quadrivittatus*)	Aggression	Y	N	N	Colorado chipmunks cannot move into higher elevational because of aggressive interactions with Uinta chipmunks. Uinta chipmunks hypothesised to be restricted to higher elevations because of the high parasitic load of a bot file found at lower elevations.	(Bergstrom, 1992)	
Stoats (*Mustela erminea*) & least weasels (*Mustela nivalis*)	Aggression	N	N	N	Experimental data demonstrates that stoats are dominant over weasels, and observational data shows that weasels are very rarely found in prefered habitat when a stoats held a territory in the area. Distributional data collected over several years shows that when stoats declined, weasels increased locally.	(Erlinge and Sandell, 1988)	
Pied tamarins (*Saguinus bicolor*) & Golden-handed tamarins (*Saguinus midas*)	Aggression	N	N	N	Playback experiment of two species on Tarmarin, in allopatry and sympatry. Pied tamarins are critically edangered and experiencing range fragmentation, while red-handed tamarins have expanded their range into the range of pied tamarins. Playback experiments show that red-handed tarmarin respond more agressively than the pied tamarins.	(Sobroza *et al*., 2021)	
Chiriquí singing mice (*Scotinomys xerampelinus*) & Alston's singing mice (*Scotinomys teguina*)	Aggression	Y	N	N	Playback experiments, laboratory experiments, and removal experiments all demonstrate that the higher elevation species (*Scotinomys xerampelinus*) is dominant and preempts range intrusions from lower elevation species. In removal experiments, *Scotinomys xerampelinus* didn't descend to occupy areas where *Scotinomys teguina* was removed, but *Scotinomys teguina* did invade higher elevation areas when *Scotinomys xerampelinus* was removed.	(Pasch, Bolker and Phelps, 2013)	
Reptilia							
Invasive house geckos (*Hemidactylus frenatus*) & native communities	Aggression and Reproductive Interference	N	Y	N	Comprehensive longitudinal data, in combination with laboratory and field experiments, show that introduced house geckos are aggressive to and avoided by native species, leading to the decline of native species accross many different locations. Reproductive interference has also been demonstrated in some locations.	(Bolger and Case, 1992; Petren, Bolger and Case, 1993; Case, Bolger and Petren, 1994; Dame and Petren, 2006)	Competitive exclusion due to differential resource acquisition (though this results from interference competition)

References

Aguilera, M.A. and Navarrete, S.A. (2012) ‘Interspecific Competition for Shelters in Territorial and Gregarious Intertidal Grazers: Consequences for Individual Behaviour’, *PLOS ONE*, 7(9), p. e46205. Available at: https://doi.org/10.1371/journal.pone.0046205.

Asensio, N. *et al.* (2017) ‘The ecology of white-handed and pileated gibbons in a zone of overlap and hybridization in Thailand’, *American Journal of Physical Anthropology*, 163(4), pp. 716–728. Available at: https://doi.org/10.1002/ajpa.23241.

Bargielowski, I.E. and Lounibos, L.P. (2016) *Satyrization and satyrization-resistance in competitive displacements of invasive mosquito species*, *Insect Science*. Blackwell Publishing Ltd. Available at: https://doi.org/10.1111/1744-7917.12291.

Bargielowski, I.E., Lounibos, L.P. and Carrasquilla, M.C. (2013) ‘Evolution of resistance to satyrization through reproductive character displacement in populations of invasive dengue vectors’, *Proceedings of the National Academy of Sciences*, 110(8), pp. 2888–2892. Available at: https://doi.org/10.1073/pnas.1219599110.

Bay, L.K., Jones, G.P. and McCormick, M.I. (2001) ‘Habitat selection and aggression as determinants of spatial segregation among damselfish on a coral reef’, *Coral Reefs*, 20(3), pp. 289–298. Available at: https://doi.org/10.1007/S003380100173.

Bergstrom, B.J. (1992) ‘Parapatry and Encounter Competition between Chipmunk (Tamias) Species and the Hypothesized Role of Parasitism’, *American Midland Naturalist*, 128(1), p. 168. Available at: https://doi.org/10.2307/2426422.

Bolger, D.T. and Case, T.J. (1992) ‘Intra- and interspecific interference behaviour among sexual and asexual geckos’, *Animal Behaviour*, 44(1), pp. 21–30. Available at: https://doi.org/10.1016/S0003-3472(05)80750-X.

Bournez, L. *et al.* (2015) ‘Parapatric distribution and sexual competition between two tick species, Amblyomma variegatum and A. hebraeum (Acari, Ixodidae), in Mozambique’, *Parasites and Vectors*, 8(1), pp. 1–14. Available at: https://doi.org/10.1186/S13071-015-1116-7/FIGURES/4.

Boyce, A.J. and Martin, T.E. (2019) ‘Interspecific aggression among parapatric and sympatric songbirds on a tropical elevational gradient’, *Behavioral Ecology*, 30(2), pp. 541–547. Available at: https://doi.org/10.1093/BEHECO/ARY194.

Bronson, C.L. *et al.* (2003) ‘Mate preference: a possible causal mechanism for a moving hybrid zone’, *Animal Behaviour*, 65(3), pp. 489–500. Available at: https://doi.org/10.1006/anbe.2003.2103.

Bubb, D.H. *et al.* (2009) ‘Relative impacts of native and non-native crayfish on shelter use by an indigenous benthic fish’, *Aquatic Conservation: Marine and Freshwater Ecosystems*, 19(4), pp. 448–455. Available at: https://doi.org/10.1002/AQC.1001.

Butler, M.J. and Stein, R.A. (1985) ‘An analysis of the mechanisms governing species replacements in crayfish’, *Oecologia*, 66(2), pp. 168–177. Available at: https://doi.org/10.1007/BF00379851.

Case, T.J., Bolger, D.T. and Petren, K. (1994) ‘Invasions and Competitive Displacement among House Geckos in the Tropical Pacific’, *Ecology*, 75(2), pp. 464–477. Available at: https://doi.org/10.2307/1939550.

Chappell, M.A. (1978) ‘Behavioral Factors in the Altitudinal Zonation of Chipmunks (Eutamias)’, *Ecology*, 59(3), pp. 565–579. Available at: https://doi.org/10.2307/1936586.

Cowen, M.C., Drury, J.P. and Grether, G.F. (2020) ‘Multiple routes to interspecific territoriality in sister species of North American perching birds’, *Evolution*, 74(9), pp. 2134–2148. Available at: https://doi.org/10.1111/evo.14068.

Crowder, D.W. *et al.* (2011) ‘Niche partitioning and stochastic processes shape community structure following whitefly invasions’, *Basic and Applied Ecology*, 12(8), pp. 685–694. Available at: https://doi.org/10.1016/j.baae.2011.09.007.

Dame, E.A. and Petren, K. (2006) ‘Behavioural mechanisms of invasion and displacement in Pacific island geckos (Hemidactylus)’, *Animal Behaviour*, 71(5), pp. 1165–1173. Available at: https://doi.org/10.1016/j.anbehav.2005.10.009.

Dawson, N.M. *et al.* (2011) ‘Interactions with Great Skuas Stercorarius skua as a factor in the long-term decline of an Arctic Skua Stercorarius parasiticus population’, *Ibis*, 153(1), pp. 143–153. Available at: https://doi.org/10.1111/j.1474-919X.2010.01065.x.

Dorková, M. *et al.* (2020) ‘The mosaic distribution pattern of two sister bush-cricket species and the possible role of reproductive interference’, *Ecology and Evolution*, 10(5), pp. 2570–2578. Available at: https://doi.org/10.1002/ECE3.6086.

Duckworth, R.A. (2013) ‘Human-induced changes in the dynamics of species coexistence: An example with two sister species’, *Avian Urban Ecology* [Preprint]. Available at: https://doi.org/10.1093/ACPROF:OSOBL/9780199661572.003.0014.

Duckworth, R.A. and Badyaev, A.V. (2007) ‘Coupling of dispersal and aggression facilitates the rapid range expansion of a passerine bird’, *Proceedings of the National Academy of Sciences of the United States of America*, 104(38), pp. 15017–15022. Available at: https://doi.org/10.1073/pnas.0706174104.

Duckworth, R.A., Belloni, V. and Anderson, S.R. (2015) ‘Cycles of species replacement emerge from locally induced maternal effects on offspring behavior in a passerine bird’, *Science*, 347(6224), pp. 875–877. Available at: https://doi.org/10.1126/SCIENCE.1260154/SUPPL_FILE/DUCKWORTH.SM.PDF.

Erlinge, S. and Sandell, M. (1988) ‘Coexistence of Stoat, Mustela Erminea, and Weasel, M. Nivalis: Social Dominance, Scent Communication, and Reciprocal Distribution’, *Oikos*, 53(2), pp. 242–246. Available at: https://doi.org/10.2307/3566069.

Eurich, J.G., McCormick, M.I. and Jones, G.P. (2018) ‘Direct and indirect effects of interspecific competition in a highly partitioned guild of reef fishes’, *Ecosphere*, 9(8), p. e02389. Available at: https://doi.org/10.1002/ECS2.2389.

Ferretti, F. and Mori, E. (2020) ‘Displacement interference between wild ungulate species: does it occur?’, *Ethology Ecology & Evolution*, 32(1), pp. 2–15. Available at: https://doi.org/10.1080/03949370.2019.1680447.

Freeman, B.G., Class Freeman, A.M. and Hochachka, W.M. (2016) ‘Asymmetric interspecific aggression in New Guinean songbirds that replace one another along an elevational gradient’, *Ibis*, 158(4), pp. 726–737. Available at: https://doi.org/10.1111/ibi.12384.

Freeman, B.G. and Montgomery, G. (2015) ‘Interspecific aggression by the Swainson’s Thrush (Catharus ustulatus) may limit the distribution of the threatened Bicknell’s Thrush (Catharus bicknelli) in the Adirondack Mountains’, *The Condor*, 118(1), pp. 169–178. Available at: https://doi.org/10.1650/CONDOR-15-145.1.

Freshwater, C., Ghalambor, C.K. and Martin, P.R. (2014) ‘Repeated patterns of trait divergence between closely related dominant and subordinate bird species’, *Ecology*, 95(8), pp. 2334–2345. Available at: https://doi.org/10.1890/13-2016.1.

Gifford, M.E. and Kozak, K.H. (2012) ‘Islands in the sky or squeezed at the top? Ecological causes of elevational range limits in montane salamanders’, *Ecography*, 35(3), pp. 193–203. Available at: https://doi.org/10.1111/j.1600-0587.2011.06866.x.

Gröning, J. *et al.* (2007) ‘Reproductive interference in two ground-hopper species: Testing hypotheses of coexistence in the field’, *Oikos*, 116(9), pp. 1449–1460. Available at: https://doi.org/10.1111/j.0030-1299.2007.15850.x.

Gutiérrez, R.J. *et al.* (2007) ‘The Invasion of Barred Owls and its Potential Effect on the Spotted Owl: a Conservation Conundrum’, *Biological Invasions*, 9(2), pp. 181–196. Available at: https://doi.org/10.1007/s10530-006-9025-5.

Haering, R. and Fox, B.J. (1987) ‘Short-Term Coexistence and Long-Term Competitive Displacement of Two Dominant Species of Iridomyrmex: The Successional Response of Ants to Regenerating Habitats’, *Journal of Animal Ecology*, 56(2), pp. 495–507. Available at: https://doi.org/10.2307/5063.

Hairston, N.G., Nishikawa, K.C. and Stenhouse, S.L. (1987) ‘The evolution of competing species of terrestrial salamanders: niche partitioning or interference?’, *Evolutionary Ecology*, 1(3), pp. 247–262. Available at: https://doi.org/10.1007/BF02067555.

Hasegawa, K. *et al.* (2004) ‘Comparison of competitive ability between native and introduced salmonids: evidence from pairwise contests’, *Ichthyological Research*, 51(3), pp. 191–194. Available at: https://doi.org/10.1007/s10228-004-0214-x.

Hasegawa, K. and Maekawa, K. (2009) ‘Role of visual barriers on mitigation of interspecific interference competition between native and non-native salmonid species’, *Canadian Journal of Zoology*, 87(9), pp. 781–786. Available at: https://doi.org/10.1139/Z09-071.

Heller, H.C. (no date) *Altitudinal Zonation of Chipmunks (eutamias): Interspecific Aggression, Water Balance, and Energy Budgets*. Ph.D. Yale University. Available at: https://www.proquest.com/docview/288230936/citation/2C2072B0CE784FA1PQ/1 (Accessed: 22 February 2023).

Hernández-Brito, D. *et al.* (2014) ‘Crowding in the City: Losing and Winning Competitors of an Invasive Bird’, *PLOS ONE*, 9(6), p. e100593. Available at: https://doi.org/10.1371/journal.pone.0100593.

Hochkirch, A. and Gröning, J. (2012) ‘Niche overlap in allotopic and syntopic populations of sexually interacting ground-hopper species’, *Insect Science*, 19(3), pp. 391–402. Available at: https://doi.org/10.1111/j.1744-7917.2011.01462.x.

Hochkirch, A., Gröning, J. and Bücker, A. (2007) ‘Sympatry with the devil: reproductive interference could hamper species coexistence’, *Journal of Animal Ecology*, 76(4), pp. 633–642. Available at: https://doi.org/10.1111/J.1365-2656.2007.01241.X.

Houser, J.D., Ginsberg, H. and Jakob, E.M. (2014) ‘Competition between introduced and native spiders (Araneae: Linyphiidae)’, *Biological Invasions*, 16(11), pp. 2479–2488. Available at: https://doi.org/10.1007/S10530-014-0679-0/FULLTEXT.HTML.

Jankowski, J.E., Robinson, S.K. and Levey, D.J. (2010) ‘Squeezed at the top: Interspecific aggression may constrain elevational ranges in tropical birds’, *Ecology*, 91(7), pp. 1877–1884. Available at: https://doi.org/10.1890/09-2063.1.

Jones, S.E.I. *et al.* (2020) ‘Weak asymmetric interspecific aggression and divergent habitat preferences at an elevational contact zone between tropical songbirds’, *Ibis*, 162(3), pp. 814–826. Available at: https://doi.org/10.1111/IBI.12793.

Kiritani, K. (2011) ‘Impacts of global warming on Nezara viridula and its native congeneric species’, *Journal of Asia-Pacific Entomology*, 14(2), pp. 221–226. Available at: https://doi.org/10.1016/j.aspen.2010.09.002.

Larson, R.J. (1980) ‘Competition, Habitat Selection, and the Bathymetric Segregation of Two Rockfish (Sebastes) Species’, *Ecological Monographs*, 50(2), pp. 221–239. Available at: https://doi.org/10.2307/1942480.

Leponce, M., Roisin, Y. and Pasteels, J. (1997) ‘Structure and Dynamics of the Arboreal Termite Community in New Guinean Coconut Plantations’, *Tropical Biology*, 29(2), pp. 193–203.

Lill, A. and Muscat, I. (2015) ‘Importance of Inherent Suitability, Behavioural Flexibility and Competitiveness in Occupancy of Urban Parks by an Endemic Honeyeater’, *Avian Biology Research*, 8(4), pp. 227–236. Available at: https://doi.org/10.3184/175815515X14428542803227.

Liu, S.-S. *et al.* (2007) ‘Asymmetric Mating Interactions Drive Widespread Invasion and Displacement in a Whitefly’, *Science*, 318(5857), pp. 1769–1772. Available at: https://doi.org/10.1126/science.1149887.

Lounibos, L.P. and Juliano, S.A. (2018) ‘Where vectors collide: the importance of mechanisms shaping the realized niche for modeling ranges of invasive Aedes mosquitoes’, *Biological Invasions*, 20(8), pp. 1913–1929. Available at: https://doi.org/10.1007/s10530-018-1674-7.

Mac Nally, R. *et al.* (2012) ‘Despotic, high-impact species and the subcontinental scale control of avian assemblage structure’, *Ecology*, 93(3), pp. 668–678. Available at: https://doi.org/10.1890/10-2340.1.

Maldonado-Coelho, M. *et al.* (2017) ‘The invasive species rules: competitive exclusion in forest avian mixed-species flocks in a fragmented landscape’, *Revista Brasileira de Ornitologia 2017 25:1*, 25(1), pp. 54–59. Available at: https://doi.org/10.1007/BF03544377.

Martin, P.R. and Bonier, F. (2018) ‘Species interactions limit the occurrence of urban-adapted birds in cities’, *Proceedings of the National Academy of Sciences of the United States of America*, 115(49), pp. E11495–E11504. Available at: https://doi.org/10.1073/pnas.1809317115.

Martin, P.R., Burke, K.W. and Bonier, F. (2021) ‘Plasticity versus Evolutionary Divergence: What Causes Habitat Partitioning in Urban-Adapted Birds?’, *The American Naturalist*, 197(1), pp. 60–74. Available at: https://doi.org/10.1086/711753.

McEachin, S. *et al.* (2022) ‘Mechanisms of reduced interspecific interference between territorial species’, *Behavioral Ecology*, 33(1), pp. 126–136. Available at: https://doi.org/10.1093/beheco/arab115.

McLain, D.K. and Shure, D.J. (1987) ‘Pseudocompetition: Interspecific Displacement of Insect Species through Misdirected Courtship’, *Oikos*, 49(3), pp. 291–296. Available at: https://doi.org/10.2307/3565763.

McQuillan, M.A. and Rice, A.M. (2015) ‘Differential effects of climate and species interactions on range limits at a hybrid zone: potential direct and indirect impacts of climate change’, *Ecology and Evolution*, 5(21), pp. 5120–5137.

Mottl, O. *et al.* (2021) ‘Inter-specific aggression generates ant mosaics in canopies of primary tropical rainforest’, *Oikos*, 130(7), pp. 1087–1099. Available at: https://doi.org/10.1111/oik.08069.

Nasci, R.S., Hare, S.G. and Willis, F.S. (1989) ‘Interspecific mating between Louisiana strains of Aedes albopictus and Aedes aegypti in the field and laboratory’, *Journal of the American Mosquito Control Association*, 5(3), pp. 416–421.

Pasch, B., Bolker, B.M. and Phelps, S.M. (2013) ‘Interspecific dominance via vocal interactions mediates altitudinal zonation in neotropical singing mice’, *American Naturalist*, 182(5). Available at: https://doi.org/10.1086/673263.

Pearson, S.F. (2000) ‘Behavioral asymmetries in a moving hybrid zone’, *Behavioral Ecology*, 11(1), pp. 84–92. Available at: https://doi.org/10.1093/beheco/11.1.84.

Pearson, S.F. and Rohwer, S. (2000) ‘Asymmetries in male aggression across an avian hybrid zone’, *Behavioral Ecology*, 11(1), pp. 93–101. Available at: https://doi.org/10.1093/beheco/11.1.93.

Perdereau, E. *et al.* (2011) ‘Competition between invasive and indigenous species: an insular case study of subterranean termites’, *Biological Invasions*, 13(6), pp. 1457–1470. Available at: https://doi.org/10.1007/s10530-010-9906-5.

Petren, K., Bolger, D.T. and Case, T.J. (1993) ‘Mechanisms in the Competitive Success of an Invading Sexual Gecko over an Asexual Native’, *Science*, 259(5093), pp. 354–358. Available at: https://doi.org/10.1126/science.259.5093.354.

Reif, J. *et al.* (2015) ‘Interspecific territoriality in two songbird species: potential role of song convergence in male aggressive interactions’, *Animal Behaviour*, 104, pp. 131–136. Available at: https://doi.org/10.1016/j.anbehav.2015.03.016.

Reif, J. *et al.* (2018) ‘Competition-driven niche segregation on a landscape scale: Evidence for escaping from syntopy towards allotopy in two coexisting sibling passerine species’, *Journal of Animal Ecology*, 87(3), pp. 774–789. Available at: https://doi.org/10.1111/1365-2656.12808.

Robinson, D. (1992) ‘Habitat use and foraging behaviour of the scarlet robin and the flame robin at a site of breeding-season sympatry’, *Wildlife Research*, 19(4), pp. 377–395. Available at: https://doi.org/10.1071/WR9920377.

Rolando, A. and Palestrini, C. (1989) ‘Habitat selection and interspecific territoriality in sympatric warblers at two Italian marshland areas’, *Ethology Ecology & Evolution*, 1(2), pp. 169–183. Available at: https://doi.org/10.1080/08927014.1989.9525521.

Rybinski, J. *et al.* (2016) ‘Competition-driven build-up of habitat isolation and selection favoring modified dispersal patterns in a young avian hybrid zone’, *Evolution*, 70(10), pp. 2226–2238. Available at: https://doi.org/10.1111/evo.13019.

Sobroza, T.V. *et al.* (2021) ‘Parapatric pied and red-handed tamarin responses to congeneric and conspecific calls’, *Acta Oecologica*, 110, p. 103688. Available at: https://doi.org/10.1016/J.ACTAO.2020.103688.

Söderbäck, B. (1994) ‘Interactions among Juveniles of Two Freshwater Crayfish Species and a Predatory Fish’, *Oecologia*, 100(3), pp. 229–235.

Söderbäck, B. (1995) ‘Replacement of the native crayfish Astacus-astacus by the introduced species Pacifastacus leniusculus in a Swedish lake - possible causes and mechanisms’, *FRESHWATER BIOLOGY*, 33(2), pp. 291–304.

Sorjonen, J. (1986) ‘Mixed Singing and Interspecific Territoriality - Consequences of Secondary Contact of Two Ecologically and Morphologically Similar Nightingale Species in Europe’, *Ornis Scandinavica (Scandinavian Journal of Ornithology)*, 17(1), pp. 53–67. Available at: https://doi.org/10.2307/3676753.

Sutherst, R.W. (1987) ‘The dynamics of hybrid zones between tick (Acari) species’, *International Journal for Parasitology*, 17(4), pp. 921–926. Available at: https://doi.org/10.1016/0020-7519(87)90009-9.

Suwanvecho, U. and Brockelman, W.Y. (2012) ‘Interspecific territoriality in gibbons (Hylobates lar and H. pileatus) and its effects on the dynamics of interspecies contact zones’, *Primates; Journal of Primatology*, 53(1), pp. 97–108. Available at: https://doi.org/10.1007/s10329-011-0284-0.

Takami, T. *et al.* (2002) ‘Replacement of white-spotted charr Salvelinus leucomaenis by brown trout Salmo trutta in a branch of the Chitose River, Hokkaido [Japan]’, *Bulletin of the Japanese Society of Scientific Fisheries (Japan)* [Preprint]. Available at: https://scholar.google.com/scholar_lookup?title=Replacement+of+white-spotted+charr+Salvelinus+leucomaenis+by+brown+trout+Salmo+trutta+in+a+branch+of+the+Chitose+River%2C+Hokkaido+%5BJapan%5D&author=Takami%2C+T.+%28Hokkaido.+Fish+Hatchery%2C+Eniwa+%28Japan%29%29&publication_year=2002 (Accessed: 22 February 2023).

Thum, R.A. (2007) ‘Reproductive interference, priority effects and the maintenance of parapatry in Skistodiaptomus copepods’, *Oikos*, 116(5), pp. 759–768. Available at: https://doi.org/10.1111/j.0030-1299.2007.15782.x.

Tønnesen, M.H. *et al.* (2004) ‘Displacement of Boophilus decoloratus by Boophilus microplus in the Soutpansberg region, Limpopo Province, South Africa’, *Experimental and Applied Acarology*, 32(3), pp. 199–208. Available at: https://doi.org/10.1023/B:APPA.0000021789.44411.b5.

Trombulak, S.C. (1985) ‘The Influence of Interspecific Competition on Home Range Size in Chipmunks (Eutamias)’, *Journal of Mammalogy*, 66(2), pp. 329–337. Available at: https://doi.org/10.2307/1381245.

Tsuchida, K. *et al.* (2019) ‘Reproductive interference in an introduced bumblebee: Polyandry may mitigate negative reproductive impact’, *Insects*, 10(2), p. 59. Available at: https://doi.org/10.3390/insects10020059.

Tsurui-Sato, K. *et al.* (2019) 'Reproductive interference in live-bearing fish: the male guppy is a potential biological agent for eradicating invasive mosquitofish', *Scientific Reports 2019 9:1*, 9(1), pp. 1–9. Available at: https://doi.org/10.1038/s41598-019-41858-y.

Vallin, N. *et al.* (2012) 'Combined effects of interspecific competition and hybridization impede local coexistence of Ficedula flycatchers', *Evolutionary Ecology*, 26(4), pp. 927–942. Available at: https://doi.org/10.1007/s10682-011-9536-0.

Van Lanen, N.J. *et al.* (2011) 'Who hits and hoots at whom? Potential for interference competition between barred and northern spotted owls', *Biological Conservation*, 144(9), pp. 2194–2201. Available at: https://doi.org/10.1016/j.biocon.2011.05.011.

Wang, P., Crowder, D.W. and Liu, S.S. (2012) 'Roles of mating behavioural interactions and life history traits in the competition between alien and indigenous whiteflies', *Bulletin of Entomological Research*, 102(4), pp. 395–405. Available at: https://doi.org/10.1017/S000748531100071X.

Westman, K. and Savolainen, R. (2001) 'Long term study of competition between two co-occurring crayfish species, the native Astacus astacus l. And the introduced Pacifastacus leniusculus dana, in a Finnish lake.', *Bulletin Français de la Pêche et de la Pisciculture*, (361), pp. 613–627. Available at: https://doi.org/10.1051/kmae:2001008.

Westman, K., Savolainen, R. and Julkunen, M. (2002) 'Replacement of the native crayfish Astacus astacus by the introduced species Pacifastacus leniusculus in a small, enclosed Finnish lake: a 30-year study', *Ecography*, 25(1), pp. 53–73. Available at: https://doi.org/10.1034/J.1600-0587.2002.250107.X.

Wiens, J.D., Anthony, R.G. and Forsman, E.D. (2014) 'Competitive interactions and resource partitioning between northern spotted owls and barred owls in western Oregon', *Wildlife Monographs*, 185(1), pp. 1–50. Available at: https://doi.org/10.1002/WMON.1009.

Zhou, J. *et al.* (2022) 'Interspecific mating bias may drive Aedes albopictus displacement of Aedes aegypti during its range expansion', *PNAS Nexus*, 1(2), p. pgac041. Available at: https://doi.org/10.1093/pnasnexus/pgac041.