Quantifying and categorising the environmental impacts of alien birds

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Declaration

I, Thomas George Evans, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Thomas Evans, 1 September 2018

Abstract

We are faced with a rising tide of alien species introductions across the globe. Some of these species can have significant impacts on native biodiversity. Being able to identify those species that are likely to cause the most damage when introduced to new environments is crucial if we are to minimise the broad range of impacts that they may have. A protocol has recently been developed to quantify and categorise the environmental impacts of alien species: the Environmental Impact Classification for Alien Taxa (EICAT). In **Chapter 2**, I use EICAT to quantify and categorise the impacts of alien species for an entire taxonomic class (birds). In so doing, I generate the first, directly comparable global dataset on their environmental impacts. The assessment reveals that most alien birds have relatively minor impacts, but that some have population-level impacts that result in native species extirpations and extinctions. The EICAT assessment provides useful information on the ways in which alien birds can adversely affect the environment, and the types of species that have the most severe impacts. It also reveals that we do not have any data on the environmental impacts of over 70% of alien bird species globally: these species are classified as Data Deficient (**DD**) under EICAT.

I use the data generated by the EICAT assessment to answer a number of outstanding questions regarding the environmental impacts of alien birds. In **Chapter 3**, I examine the factors that influence whether we have impact data for alien birds. I show that many species may be **DD** because they have minor impacts that do not attract scientific research, but that some species may be **DD** for reasons unrelated to the severity of their impacts. In **Chapter 4**, I identify the traits of alien birds that influence the severity of their environmental impacts, finding that widely distributed, generalist birds tend to have the most severe impacts. In **Chapter 5**, I identify the drivers of spatial variation in the severity of alien bird impacts, finding that factors relating to the duration and frequency of alien bird invasions are key in determining whether the impacts sustained by a region will be damaging. I also produce the first global maps displaying the impacts generated by alien species from an entire taxonomic class. These maps, and the data underpinning them, can be used to identify regions of the world

susceptible to the impacts of alien birds. They may therefore assist in directing management interventions to regions where they are most needed.

Impact statement

International conservation policy

The results of the alien bird EICAT assessment undertaken as part of this thesis were recently presented at a workshop convened to discuss the potential adoption of EICAT by the IUCN as its formal method for quantifying and categorising the impacts of alien species. The workshop was attended by senior invasion scientists from eight countries, along with the Chair of the IUCN SSC Invasive Species Specialist Group (ISSG), Dr Piero Genovesi. EICAT will shortly be adopted by the IUCN, following extensive stakeholder consultation. By demonstrating how EICAT can be successfully used to quantify and categorise the impacts of alien species, this study has had a positive influence on the development of international conservation policy.

Meeting global conservation targets

The IUCN aims to publish EICAT assessments for all alien species worldwide by 2020, in-line with the requirements stipulated under Aichi Target 9 of the Convention on Biological Diversity and Target 5 of the EU 2020 Biodiversity Strategy. It is expected that these assessments will be published online via the IUCN Global Invasive Species Database (http://www.iucngisd.org/gisd). In so doing, EICAT and the IUCN will provide the most comprehensive source of information on the environmental impacts of alien species globally. The global alien bird EICAT assessment presented in this thesis will be used to this end, providing the data underpinning individual EICAT assessments for all alien birds worldwide. The alien bird EICAT assessments will be among the first to be formally published by the IUCN. The research undertaken in this thesis will therefore assist the IUCN in meeting global conservation targets.

Predicting and managing the impacts of alien birds

The results of this research can be used to inform risk assessments for alien birds: widespread, generalist species tend to have more severe impacts as aliens, and should be prioritised for monitoring wherever they pose a risk of invasion. The results can also be used to direct management interventions to regions where they are most needed to mitigate the impacts of alien birds. Indeed, the maps presented in this thesis may be used to identify regions characterised by the variables found to be associated with impact severity (the regions most likely to be sustaining damaging alien bird impacts). In particular, regions subject to alien invasions for longer periods of time, and those supporting relatively high numbers of alien birds are likely to be at particular risk. Early interventions, and the prevention of new invasions, may therefore be strategies that effectively minimise the impacts of alien birds.

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Table of contents

Declaration **3**

Abstract **5**

Impact statement **7**

Acknowledgments **9**

List of figures **15**

List of tables **19**

Attribution **27**

Chapter 1: Introduction **29**

1.1 Quantifying and categorising the environmental impacts of alien species ... 31

1.1.1 EICAT 33

1.2 The environmental impacts of alien birds 36

1.3 Alien species impact prediction 38

1.4 Thesis overview 40

Chapter 2: Application of the Environmental Impact Classification for Alien Taxa (EICAT) to a global assessment of alien bird impacts **43**

2.1 Abstract 45

2.2 Introduction 46

2.3 Methods 49

2.3.1 Data 49

2.3.2 Analysis 53

2.4 Results 53

2.5 Discussion 62

2.6 Conclusions 66

Chapter 3: Determinants of data deficiency in the impacts of alien bird species **69**

3.1 Abstract 71

3.2 Introduction 72

3.3 Methods 76

3.3.1 Data 76

3.3.2 Analysis 79

3.4 Results 81
3.5 Discussion 85
3.6 Conclusions 90

Chapter 4: **Identifying the factors that determine the severity and type of alien bird impacts 93**
4.1 Abstract 95
4.2 Introduction 96
4.3 Methods 99
4.3.1 Data 99
4.3.2 Analysis 103
4.4 Results 104
4.5 Discussion 111
4.6 Conclusions 116

Chapter 5: Determinants of spatial variation in the severity of alien bird impacts 117
5.1 Abstract 119
5.2 Introduction 120
5.3 Methods 125
5.3.1 Data 125
5.3.2 Analysis 128
5.3.3 Mapping 130
5.4 Results 131
5.4.1 Actual impacts 136
5.4.2 Potential impacts 141
5.5 Discussion 144
5.6 Conclusions 150

Chapter 6: **Discussion 153**
6.1 In summary 155
6.2 The applicability of this research and future directions 155
6.2.1 Alien species impact data 155
6.2.2 Quantifying and categorising the socio-economic impacts of alien birds 156

6.2.3 Using EICAT to identify the factors that increase the vulnerability of native species to the impacts of alien birds 157
6.3 In conclusion 159

References **161**

Appendix A: Literature review protocol **183**
Appendix B: EICAT assessment results summary (by alien bird order) ... **209**
Appendix C: EICAT assessment results summary (by alien bird species) **211**
Appendix D: Data for all predictor variables used to undertake the analysis in Chapter 3 ………………………………………………………………….... **233**
Appendix E: Data for all predictor variables used to undertake the analysis in Chapter 4 ………………………………………………………………….... **283**
Appendix F: A list of regions with actual and potential alien bird impacts, and the data for all predictor variables used to undertake the analysis in Chapter 5 ………………………………………………………………………... **301**

List of figures

Figure 1.1: The EICAT categories, and the relationship between them (from Blackburn *et al*. 2014). Under EICAT, an alien species can be categorised into one of five impact categories depending on the severity of its impacts. At the start of the EICAT process, all species are categorised as Not Evaluated (**NE**). On evaluation, if a species is not present anywhere as an alien, it is categorised as having No Alien Populations (**NA**). If a species has alien populations, but there are no data available to make an assessment of its impacts, it is categorised as Data Deficient (**DD**). Where impact data are available for a species, it is then categorised according to the severity of its impacts, to one of the five EICAT impact categories: Minimal Concern (**MC**), Minor (**MN**), Moderate (**MO**), Major (**MR**) or Massive (**MV**). 34

Figure 2.1: The orders of alien birds with recorded data on their environmental impacts. This bar chart shows that almost 90% of the species with recorded impacts come from five orders: Passeriformes (perching birds), Psittaciformes (parrots), Anseriformes (ducks, geese and swans), Galliformes (gamebirds), and Columbiformes (pigeons and doves). 54

Figure 2.2: Under EICAT, each alien species is categorised to one of five EICAT impact categories, depending on the severity of its impacts. This bar chart shows the number of impacts assigned to each EICAT impact category (categories as described for Figure 1.1). 56

Figure 2.3: Under EICAT, each alien species is categorised by the mechanism of its most severe impact into one of 12 EICAT impact mechanisms: (1) Competition, (2) Predation, (3) Hybridisation, (4) Transmission of diseases to native species, (5) Parasitism, (6) Poisoning / toxicity, (7) Biofouling, (8) Grazing / herbivory / browsing, (9, 10, 11) Chemical, physical, or structural impact on ecosystem, (12) Interaction with other alien species. This bar chart shows the number of impacts assigned to each EICAT impact mechanism. 57

Figure 3.1: The availability of impact data on the impacts of alien bird species is not randomly distributed. These boxplots show the distribution of alien bird species that are Data Deficient (**DD**) or have impact data for the six variables found to be associated with impact data availability in univariate analysis. Data deficiency in the impacts of alien species is influenced by: alien range size, relative brain size, habitat breadth, human development, the number of realms occupied by an alien bird species, and alien bird residence time. 83

Figure 4.1: The severity of impacts generated by alien bird species is not randomly distributed. These boxplots show the distribution of alien bird species generating 'less severe' and 'more severe' impacts for the six variables found to be associated with impact severity in univariate analysis: alien and native range size, diet and habitat breadth, alien bird residence time, and dietary preference. 106

Figure 5.1: This map shows the most severe impact score sustained by the 58 regions of the world supporting alien bird species with actual, recorded impacts. Impact scores were created by converting EICAT impact category data to numeric values (**MC** = 1, **MN** = 2, **MO** = 3, **MR** = 4, **MV** = 5). 132

Figure 5.2: This map shows the most severe impact score sustained by the 241 regions of the world supporting alien bird species with potential impacts. These are regions that support alien birds that have been found to have actual, recorded impacts elsewhere, but where no impacts of these species have yet been recorded. Impact scores were created as described for Figure 5.1. …………..... 133

Figure 5.3: This map shows the average impact score sustained by the 58 regions of the world supporting alien bird species with actual, recorded impacts. Impact scores were created as described for Figure 5.1. 134

Figure 5.4: This map shows the average impact score sustained by the 241 regions of the world supporting alien bird species with potential impacts. These are regions that support alien birds that have been found to have actual, recorded impacts elsewhere, but where no impacts of these species have yet been recorded. Impact scores were created as described for Figure 5.1. 135

Figure 5.5: The severity of impacts generated by alien birds is not randomly distributed across regions of the world. These boxplots show the relationships between the most severe actual impact score sustained by a region, and the seven variables found to influence spatial variation in impact severity: location of impact (either continent or island <100km^2), average alien bird residence time for a region, average native range size for a region, the proportion of the total impact score sustained by a region comprising hybridisation, predation or competition impacts, and the native bird species richness of a region. 137

Figure 5.6: The severity of impacts generated by alien birds is not randomly distributed across regions of the world. These boxplots show the relationships between the average actual impact score sustained by a region, and the seven variables found to influence spatial variation in impact severity: location of impact (either continent or island <100km^2), average alien bird residence time for a region, the proportion of the total impact score sustained by a region comprising predation, competition or disease transmission impacts, and the native and alien bird species richness of a region. 138

List of tables

Table 1.1: Examples of the semi-quantitative scenarios for two EICAT impact mechanisms: (1) Competition and (2) Predation. Documented evidence of impacts by an alien species is compared to these scenarios in order to categorise its impacts to one of five impact categories (**MC**, **MN**, **MO**, **MR** or **MV**) depending on the severity of its impacts. The semi-quantitative scenarios have been designed such that each step change in impact category (**MC** – **MV**) reflects an increase in the order of magnitude of the particular impact, so that a new level of organisation is involved. Thus: (**MC**) discernible impacts, but no effects on the individual fitness of native species; (**MN**) effects on individual fitness, but not on populations of native species; (**MO**) changes to populations, but not to native species community composition; (**MR**) community changes, which are reversible; and (**MV**) irreversible community changes and native species extinctions. 35

Table 2.1: A list of the 12 EICAT impact mechanisms used to categorise the impacts of an alien species, along with alien bird impact examples for each impact mechanism. 51

Table 2.2: A contingency table showing the actual and expected numbers of alien bird species with and without recorded impacts for each order of alien birds: Passeriformes (perching birds), Psittaciformes (parrots), Galliformes, (gamebirds), Anseriformes (ducks, geese and swans), Columbiformes (pigeons and doves), and the remaining species from other orders of alien birds which were combined to produce one group titled 'Other'. 55

Table 2.3: A contingency table showing the actual and expected numbers of alien bird impacts categorised to less severe (**MC** and **MN**) and more severe (**MO**, **MR** and **MV**) EICAT impact categories for each order of alien birds (orders as described for Table 2.2). 56

Table 2.4: A contingency table showing the actual and expected numbers of alien bird impacts categorised to less severe (**MC** and **MN**) and more severe (**MO**, **MR** and **MV**) EICAT impact categories for each EICAT impact mechanism. 58

Table 2.5: A contingency table showing the actual and expected numbers of alien bird impacts categorised to each EICAT impact mechanism for each order of alien birds (orders as described for Table 2.2). ……….. 59

Table 2.6: A contingency table showing the actual and expected numbers of alien bird impacts categorised to less severe (**MC** and **MN**) and more severe (**MO**, **MR** and **MV**) EICAT impact categories for each region (Asia, Australasia, Europe, North and Central America, Islands of the Atlantic, Indian and Pacific oceans). 60

Table 2.7: A contingency table showing the actual and expected numbers of 'low', 'medium' and 'high' confidence assessments allocated to: (a) each EICAT impact mechanism, and (b) less severe (**MC** and **MN**) and more severe (**MO**, **MR** and **MV**) EICAT impact categories. 61

Table 2.8: A contingency table showing the actual and expected numbers of 'low', 'medium' and 'high' confidence assessments allocated to each order of alien birds (orders as described for Table 2.2). 62

Table 3.1: A worked example for the Mandarin duck (*Aix galericulata*), to demonstrate how Simpson's Diversity Index (SDI) scores were calculated for each alien bird species. ……………………….. 79

Table 3.2: The results of the univariate analysis undertaken using the MCMCglmm model (Hadfield, 2010), showing relationships between the availability of data on the impacts of alien birds and eight predictor variables: alien range size, body mass, relative brain size, diet and habitat breadth, Human Development Index (HDI), the number of realms occupied by an alien bird species, and alien bird residence time. 82

Table 3.3: Variance Inflation Factors for the eight predictor variables (as described for Table 3.2), calculated using the car package (Fox and Weisberg, 2011). 82

Table 3.4: The results of the multivariate analysis undertaken using the MCMCglmm package in R (Hadfield, 2010), showing significant relationships ($P < 0.05$) between the availability of data on the impacts of alien birds and five predictor variables (following model simplification): alien range size, relative brain size, habitat breadth, the number of realms occupied by an alien bird species, and alien bird residence time. 84

Table 3.5: Hierarchical Partitioning for the five predictor variables found to influence the availability of impact data for alien birds in multivariate analysis (as described for Table 3.4), calculated using the hier.part package (Walsh and Mac Nally, 2013). 85

Table 3.6: A contingency table showing the actual and expected numbers of alien bird species with and without impact data amongst species from conspicuous and inconspicuous alien bird families. For this test, conspicuous families = Psittacidae and Psittaculidae (true parrots) and Phasianidae (pheasants and allies); inconspicuous families = Estrildidae (waxbills, munias and allies), Fringillidae (true finches) and Thraupidae (tanagers). 85

Table 4.1: Details on the approach to the assessment undertaken to establish diet and habitat breadth scores for each alien bird species, including the diet and habitat categories, and the data sources used to collate information on the diet and habitat preferences of each species. 100

Table 4.2: Variance Inflation Factors, calculated using the car package in R (Fox and Weisberg, 2011), for the nine predictor variables considered to potentially influence the severity of impacts generated by alien bird species: alien range size, body mass, relative brain size, diet and habitat breadth, dietary preference (the proportion of an alien bird species' diet comprising animal matter, and the proportion comprising vertebrate prey), native range size, and alien bird residence time. 104

Table 4.3: The results of the univariate analysis undertaken using the phylolm package in R (Ho & Ane, 2014), showing significant relationships (*P* < 0.05) between the severity of impacts generated by alien birds and six predictor variables: native and alien range size, diet and habitat breadth, alien bird residence time, and dietary preference (the proportion a species' diet comprising vertebrate prey). 105

Table 4.4: The results of the multivariate analysis undertaken using the phylolm package in R (Ho & Ane, 2014), showing significant relationships (*P* < 0.05) between the severity of impacts generated by alien birds and two predictor variables (following model simplification): alien range size and habitat breadth. 107

Table 4.5: The results of the univariate analysis undertaken using the phylolm package in R (Ho & Ane, 2014), showing significant relationships (*P* < 0.05) between the types of impacts generated by alien birds and predictor variables. Significant relationships were found for predation impacts with: alien range size, relative brain size, dietary preference (the proportion of an alien bird species' diet comprising animal matter, and the proportion comprising vertebrate prey), and alien bird residence time. 109

Table 4.6: The results of the multivariate analysis undertaken using the phylolm package in R (Ho & Ane, 2014), showing significant relationships (*P* < 0.05) between predation and interaction (alien seed dispersal) impacts and predictor variables (following model simplification). Significant relationships were found for predation impacts with: alien range size, relative brain size, dietary preference (the proportion of an alien bird species' diet comprising animal matter), native range size, and alien bird residence time. Significant relationships were found for interaction impacts with: alien range size and diet breadth. 110

Table 5.1: Variance Inflation Factors, calculated using the car package in R (Fox and Weisberg, 2011), for the 13 predictor variables considered to potentially influence spatial variation in the severity of impacts generated by alien bird species: alien bird residence time, native and alien bird species richness, islands (<100km^2), average monthly temperature and rainfall, diet and habitat breadth, native and alien range size, impact mechanism (competition, predation, hybridisation, interaction with other alien species, disease transmission, grazing / herbivory / browsing, chemical impact on ecosystem), Human Development Index (HDI), and population density. 130

Table 5.2: The results of the univariate analysis undertaken using the lme4 package in R (Bates *et al*. 2015), showing significant relationships (*P* < 0.05) between the severity of actual impacts across regions and predictor variables for A_{max} (the most severe actual impact score sustained by a region) and A_{ave} (the average actual impact score sustained by a region). Significant relationships for A_{max}: alien bird residence time, islands (<100km^2), native bird species richness, native range size, competition, predation, and hybridisation. Significant relationships for A_{ave}: alien bird residence time, alien and native bird species richness, islands (<100km^2), habitat breadth, competition, predation, and disease transmission. 136

Table 5.3: The best multivariate models, as ranked by AICc using the MuMIn package (Bartoń, 2018), displaying the relationships between predictor variables and A_{max} (the most severe actual impact score sustained by a region) and A_{ave} (the average actual impact score sustained by a region). 140

Table 5.4: Relative importance values (the sum of the Akaike weights over all models for each predictor variable) obtained using the Importance function in the MuMIn package (Bartoń, 2018). Values highlighted in bold are for predictor variables within the best model for regions with actual impacts (A_{max} and A_{ave}). 140

Table 5.5: The results of the univariate analysis undertaken using the lme4 package in R (Bates *et al*. 2015), showing significant relationships ($P < 0.05$) between the severity of potential impacts across regions and predictor variables for P_{max} (the most severe potential impact score sustained by a region) and P_{ave} (the average potential impact score sustained by a region). Significant relationships for P_{max}: alien bird residence time, alien bird species richness, native and alien range size, Human Development Index (HDI), and predation, hybridisation, and interaction with other alien species. Significant relationships for P_{ave}: alien bird species richness, diet and habitat breadth, native and alien range size, HDI, and competition, predation, interaction with other alien species, and disease transmission. 141

Table 5.6: The best multivariate models, as ranked by AICc using the MuMIn package (Bartoń, 2018), displaying the relationships between predictor variables and P_{max} (the most severe potential impact score sustained by a region) and P_{ave} (the average potential impact score sustained by a region). 143

Table 5.7: Relative importance values (the sum of the Akaike weights over all models for each predictor variable) obtained using the Importance function in the MuMIn package (Bartoń, 2018). Values highlighted in bold are for predictor variables within the best model for regions with potential impacts (P_{max} and P_{ave}). 143

Table B1 (**Appendix B**): A summary of the alien bird EICAT assessment, showing the number of impacts allocated to each EICAT impact category and EICAT impact mechanism, for each order of alien birds. 209

Table C1 (**Appendix C**): A summary of the alien bird EICAT assessment for each alien bird species, showing the EICAT impact category and EICAT impact mechanism assigned to each species, and the level of confidence associated with each species assessment. 211

Table D1 (**Appendix D**): The data for all predictor variables used to undertake the analysis in Chapter 3. 233

Table E1 (**Appendix E**): The data for all predictor variables used to undertake the analysis in Chapter 4. 283

Table F1 (**Appendix F**): The regions sustaining actual (**Table F1a**) and potential (**Table F1b**) alien bird impacts. Regions with actual impacts are those for which we have impact data on the impacts of alien birds; regions with potential impacts are those that support alien birds that have been found to have actual, recorded impacts elsewhere, but where no impacts of these species have yet been recorded. This table includes the most severe and average alien bird impact score sustained by each region, along with the data for all predictor variables used to undertake the analysis in Chapter 5. 301

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Chapter 1

Introduction

1.1 Quantifying and categorising the environmental impacts of alien species

An alien species is a species introduced by human action, either intentionally or unintentionally, to an area outside of its natural distribution (IUCN, 2018). Alien species are well known for having damaging impacts on the environment. A recent analysis of the prevalence of alien species as a driver of recent extinctions in five major taxa (plants, amphibians, reptiles, birds and mammals) identified 215 extinct species for which causes could be determined. For 58% of these, causes of extinctions included impacts attributable to alien species (Bellard *et al*. 2016a). Moreover, alien species currently pose a threat to the continued existence of 27% of mammal, bird, reptile and amphibian species worldwide (Bellard *et al*. 2016b).

For example, alien feral cats (*Felis catus*) now inhabit 99.8% of Australia (Legge *et al*. 2017), a continent with no native cat species. Here, they kill approximately one million birds every day, 650 million reptiles every year (Woinarski *et al*. 2017; Woinarski *et al*. 2018), and have caused the extinction of 22 endemic mammal species (Doherty, 2017). Indeed, feral cats are considered to be the most significant threat to the survival of mammals across the continent (Woinarski *et al*. 2014). Mammals in general have been found to have some of the most severe impacts as aliens (Kumschick & Nentwig, 2010; Kumschick *et al*. 2013): other damaging species include the brown rat (*Rattus norvegicus*) and American mink (*Neovison vison*) (Nentwig *et al*. 2010). However, examples of alien species with severe impacts exist for a wide variety of taxa (Kumschick *et al*. 2015a). Predation by the brown tree snake (*Boiga irreguaris*) has severely affected populations of all but one native bird species on Guam, with 11 being extirpated from the island (Wiles *et al*. 2003). Lethal toxic ingestion of the alien cane toad (*Bufo marinus*) has adversely affected populations of large predators in Australia, including the death adder (*Acanthophis praelongus*) and the northern quoll (*Dasyurus hallucatus*) (Shine, 2010). The introduction of the Nile perch (*Lates niloticus*) to Lake Victoria in East Africa resulted in the extinction of numerous endemic haplochromine cichlid species (Witte *et al*. 1992). The arrival of the alien hemlock woolly adelgid (*Adelges tsugae*) in the Northeast USA caused widespread hemlock (*Tsuga canadensis*) mortality, radically altering the composition of forest communities (Small *et al*. 2005). The appearance of cheatgrass brome (*Bromus* *tectorum*) in the Intermountain West of the USA drastically altered sagebrush (*Artemisia spp.*), steppe and bunchgrass communities (Zouhar, 2003).

The numerous examples of the damage caused by alien species suggests that there is a strong incentive to stop these incursions. Yet, as a result of globalisation and increasing economic development, the rate at which alien species are being introduced to new environments has increased rapidly over the last 50 years (Hulme, 2009). Approximately 37% of all first records of alien species were reported for the period 1970 – 2014; for the period 2000 – 2005, one in four new records of alien species occurrences related to species that had never before been recorded as an alien (Seebens *et al*. 2017; Seebens *et al*. 2018). In recognition of this growing problem, the Strategic Plan for Biodiversity 2011-2020 (https://www.cbd.int/sp), developed under the Convention on Biological Diversity (CBD), includes a specific target to address the impacts of alien species. Aichi Target 9 states that by 2020, invasive alien species and their pathways should be identified and prioritised, and priority species should be controlled or eradicated (CBD, 2013). Similarly, in 2015, the European Union (EU) published new legislation in response to the potential threat associated with biological invasions across the region. Target 5 of the EU 2020 Biodiversity Strategy (http://ec.europa.eu/environment/nature/biodiversity/strategy) requires the development of a list of invasive alien species of Union concern, to be drawn up and managed by Member States using risk assessments and scientific evidence (European Commission, 2015a).

Unfortunately, a significant impediment to achieving these strategic goals is a lack of comparable data on the damage caused by alien species. As a result, we are often unable to determine the causes and consequences of different invasions, and hence to identify the species we should prioritise for management (Kumschick *et al*. 2015a; Hoffmann & Courchamp, 2016; Wilson *et al*. 2016a; Kumschick *et al*. 2017). Thus, an urgent challenge for the advancement of invasion science is to develop standardised measures to quantify and categorise the impacts of alien species in a manner that allows their impacts to be compared across taxa and regions (Nentwig *et al*. 2010). In this regard, the Environmental Classification for Alien Taxa (EICAT: Blackburn *et al*. 2014) has recently been developed to quantify and categorise the environmental impacts of alien species.

1.1.1 EICAT

The principal aim of EICAT is to enable invasion biologists to quantify variation in the magnitude and types of impacts associated with alien taxa, allowing clear comparisons to be made regarding their impacts across different regions and taxonomic groups. Following an explicit framework and guidelines for implementation (Hawkins *et al*. 2015), semi-quantitative scenarios are used to categorise alien species into one of five impact categories depending on the severity of their impacts – Minimal Concern (**MC**), Minor (**MN**), Moderate (**MO**), Major (**MR**), Massive (**MV**) – via one of 12 EICAT impact mechanisms: (1) Competition, (2) Predation, (3) Hybridisation, (4) Transmission of diseases to native species, (5) Parasitism, (6) Poisoning / toxicity, (7) Biofouling, (8) Grazing / herbivory / browsing, (9, 10, 11) Chemical, physical, or structural impact on ecosystem, (12) Interaction with other alien species.

Table 1.1 provides an example of the semi-quantitative scenarios used to guide an EICAT assessment for two of the twelve impact mechanisms: (1) Competition and (2) Predation. The semi-quantitative scenarios have been designed such that each step change in impact category (**MC** – **MV**) reflects an increase in the order of magnitude of the particular impact, so that a new level of organisation is involved. Thus: (**MC**) discernible impacts, but no effects on the individual fitness of native species; (**MN**) effects on individual fitness, but not on populations of native species; (**MO**) changes to populations, but not to native species community composition; (**MR**) community changes, which are reversible; and (**MV**) irreversible community changes and native species extinctions (**Figure 1.1**). Where no impact data are available for a species it is categorised as Data Deficient (**DD**). EICAT considers only the environmental impacts of alien species (not socio-economic impacts as with other classification schemes such as the Generic Impact Scoring System (GISS: Nentwig *et al*. 2010)). The impact category to which a species is assigned, corresponds to its most severe impact associated with any impact mechanism. By highlighting the worst observed impact of a species, EICAT can be used to identify species with particularly damaging impacts (Blackburn *et al*. 2014).

EICAT will shortly be adopted by the IUCN as its formal method for quantifying and categorising the impacts of alien species. The IUCN aims to publish EICAT assessments for all alien species world-wide by 2020, in-line with the requirements stipulated under Aichi Target 9 and Target 5 of the EU 2020 Biodiversity Strategy.

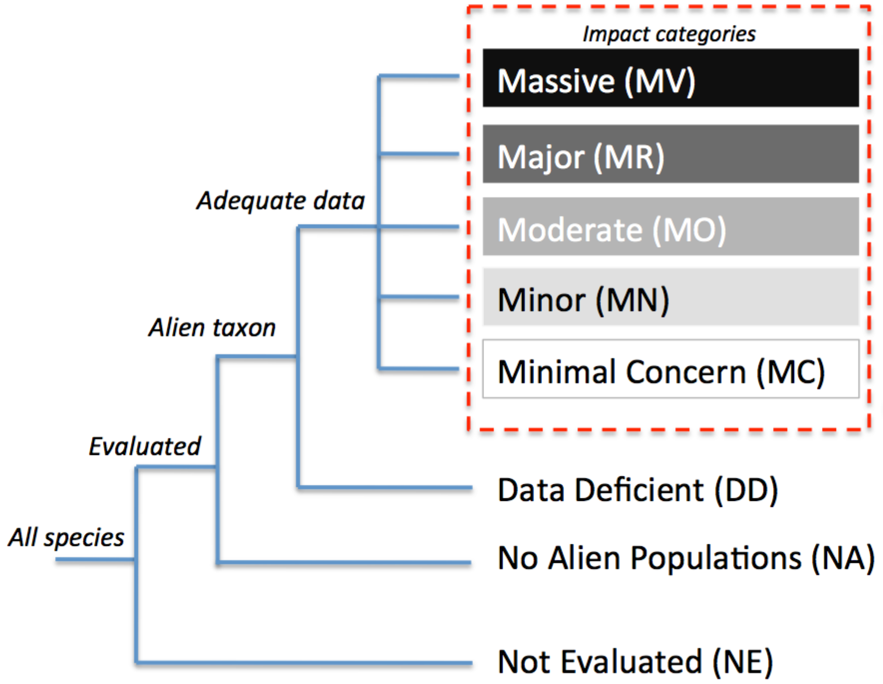

Figure 1.1: The EICAT categories, and the relationship between them (Blackburn *et al*. 2014). At the start of the EICAT process, all species are categorised as **NE**. On evaluation, if a species has no alien populations it is categorised as **NA**. If a species has alien populations, but there are no data available to make an assessment of its impacts, it is categorised as **DD**. Where impact data are available for a species, it is then categorised according to the severity of its impacts, to one of the five impact categories: **MC**, **MN**, **MO**, **MR** or **MV**.

Table 1.1: The semi-quantitative scenarios for (1) Competition and (2) Predation (Blackburn *et al*. 2014). Documented evidence of impacts by an alien species is compared to these scenarios in order to categorise it to one of the five impact categories (**MC**, **MN**, **MO**, **MR** or **MV)** depending on the severity of its impacts.

	Minimal Concern (MC)	**Minor (MN)**	**Moderate (MO)**	**Major (MR)**	**Massive (MV)**
Categories should adhere to the following general meaning	No effect on fitness of individuals of native species	Causes reductions in individual fitness, but no declines in native population densities	Causes declines in population densities, but no changes in community composition	Causes changes in community composition, which are reversible if the alien species is removed	Causes at least local extinction of species, and irreversible changes in community composition; even if the alien species is removed the system does not recover its original state
(1) Competition	Negligible level of competition with native species; reduction of fitness of native individuals is not detectable	Competition affects fitness (e.g. growth, reproduction, defence, immunocompetence) of native individuals without decline of their populations	Competition resulting in a decline of population size of at least one native species, but no changes in community composition	Competition resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien species is removed	Competition resulting in replacement or local extinction of one or several native species; changes in community composition are irreversible
(2) Predation	Negligible level of predation on native species	Predators directly or indirectly (e.g. via mesopredator release) affecting fitness (e.g. growth, reproduction) of native individuals without decline of their populations	Predators directly or indirectly (e.g. via mesopredator release) resulting in a decline of population size of at least one native species but no changes in community composition	Predators directly or indirectly (e.g. via mesopredator release) resulting in local or population extinction of at least one native species, leading to changes in community composition, but changes are reversible when the alien species is removed	Predators directly or indirectly (e.g. via mesopredator release) resulting in replacement or local extinction of one or several native species (i.e. species vanish from communities at sites where they occurred before the alien arrived); changes in community composition are irreversible

1.2 The environmental impacts of alien birds

Whilst there is a broad array of alien species with damaging impacts, this thesis focuses on the impacts of alien birds. As noted by Duncan *et al*. (2003), birds make a good model taxon for the study of biological invasions for several reasons. First, we have a comprehensive record of global bird invasions as documented by Long (1981) and Lever (2005), and more recently through the development of the Global Avian Invasions Atlas (GAVIA) database (Dyer *et al*. 2017a). GAVIA is a global database (incorporating data up to March 2014) that brings together information on alien bird introductions to provide the most comprehensive resource on the global distributions of alien bird species. Second, birds in general have been comprehensively studied, and we therefore have a rich source of data on the ecology, distribution, phylogeny and biological traits of a broad range of bird species from which to test hypotheses regarding the impacts of biological invasions (e.g. Şekercioğlu, 2012). Third, because many attempts have been made to introduce birds to new countries and regions across the globe, we have a large collection of alien birds to study, and are therefore able to test a variety of hypotheses regarding the characteristics of alien birds and how these may influence invasion success (Duncan, 2003).

Alien bird species have been shown to cause significant and wide-ranging impacts (Long, 1981; Lever, 2005; Baker *et al*. 2014). The Global Invasive Species Database (GISD: http://www.iucngisd.org/gisd), developed and managed by the Invasive Species Specialist Group (ISSG) of the IUCN, presents a list of 100 of the world's worst alien species, which includes three birds: the European starling (*Sturnus vulgaris*), the common myna (*Acridotheres tristis*) and the red-vented bulbul (*Pycnonotus cafer*). Furthermore, the Delivering Alien Invasive Species Inventories for Europe project (DAISIE: http://www.europe-aliens.org), funded by the European Commission, has developed a list of 100 of the worst alien invasive species in Europe, which includes four bird species: the Canada goose (*Branta canadensis*), the ruddy duck (*Oxyura jamaicensis*), the rose-ringed parakeet (*Psittacula krameri*) and the sacred ibis (*Threskiornis aethiopicus*).

Alien birds impact upon the environment in a number of ways. They compete with native species for food and habitat (e.g. competition between the alien rose-ringed parakeet and Eurasian nuthatch (*Sitta europaea*) for nest sites in Belgium: Strubbe & Matthysen, 2009); they predate upon native species (e.g. predation by the alien great horned owl *(Bubo virginianus)* on the Marquesan kingfisher *(Todiramphus godeffroyi)* on Hiva-Oa, French Polynesia: Shine *et al*. 2003); they transmit diseases to native species (e.g. the spread of mycoplasmal conjunctivitis from the alien house finch (*Carpodacus mexicanus*) to the American goldfinch (*Carduelis tristis*) in the Eastern USA: Fischer *et al*. 1997); they hybridise with native species (e.g. hybridisation between the alien ruddy duck *(Oxyura jamaicensis*) and white-headed duck *(Oxyura leucocephala*) in Spain: Muñoz-Fuentes *et al*. 2007); they adversely affect native habitat quality by spreading the seeds of alien plants (e.g. dispersal of alien barberry (*Berberis glaucocarpa*) seeds by the alien common blackbird (*Turdus merula*) in New Zealand: Wotton & McAlpine, 2015); they graze on, and defoliate vegetation (e.g. grazing on reedbed communities by the alien Canada goose in Sweden (Josefsson & Andersson, 2001) and defoliation of native tree and epiphyte species by the alien sulphur-crested cockatoo (*Cacatua galerita*) in New Zealand (Styche, 2000)); and they pollute waterbodies with droppings (e.g. water pollution by the alien Muscovy duck (*Cairina moschata*) in Florida: Johnson & Hawk, 2012). Less frequently documented impacts of alien birds include brood parasitism (e.g. parasitism by the alien shiny cowbird (*Molothrus bonariens*) on the yellow-shouldered blackbird (*Agelaius xanthoma*) in Puerto Rico: Cruz *et al*. 2005), and structural impacts to ecosystems (e.g. disturbance of forest floor invertebrate communities in Tasmania by the superb lyrebird (*Menura novaehollandiae*: Tassell, 2014).

Two recent studies have undertaken global assessments of the environmental impacts of alien birds (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015). They identified impact data for a relatively small number of alien bird species (33 and 39, respectively), and concluded that there is a lack of data on the impacts of alien birds, particularly for less developed regions of the world (see also Pyšek *et al*. 2008). Baker *et al*. (2014) undertook an extensive literature review of alien bird impacts, finding only ten cases where an alien bird species has been implicated in a process that threatens populations of a native species. They conclude that there is little evidence to suggest that alien birds are a major threat to avian diversity globally, and that further research on the impacts of alien birds is needed. Martin-Albarracin *et al*. (2015) found that the majority of studies on the impacts of alien birds were being undertaken in the developed world, particularly Europe, and suggested more studies were required for the developing world, particularly Africa and South America. Species found to have the most severe impacts were the mallard, red-whiskered bulbul (*Pycnonotus jocosus*), Chinese hwamei (*Garrulax canorus*), red-billed leiothrix (*Leiothrix lutea*), Japanese white-eye (*Zosterops japonicus*), silver-eye (*Zosterops lateralis*) and Eurasian blackbird (*Turdus merula*). The study concluded that these species should be prioritised for eradication wherever they are introduced.

1.3 Alien species impact prediction

Once established, the damage caused by alien species, and the measures required to control and eradicate them, can prove to be extremely costly. For example, on the island of Guam, mitigation required to address impacts associated with the brown tree snake have been estimated to amount to over US$400 million every year (Colvin *et al*. 2005). In Europe, the annual bill resulting from the implementation of measures to contain and eradicate alien species, and to mitigate for their impacts, exceeds €12 billion (McGeoch *et al*. 2010). As such, it is clearly preferable to prevent invasions from happening in the first place. It follows, that being able to predict which species are likely to be successful invaders, or to have the most severe impacts, would be extremely useful for risk assessment purposes, allowing measures to be put in place to prioritise actions against high risk species, preventing potential invasions.

One approach to this problem is to use the biological traits of species to predict their likely impacts. This requires determining whether there are certain characteristics or traits associated with a group of alien species that are correlated with successful invasions and / or more severe impacts, which can therefore be used as an indicator of potentially successful and damaging invaders. To date, five studies that have tested for relationships between the characteristics of alien birds and their impacts, all at relatively restricted spatial scales. Taken together, the results of these studies suggest that impact severity is influenced by traits that are intrinsic to bird species. However, as these studies were undertaken at a limited (regional) scale, we do not yet know whether the results apply to alien birds generally.

Shirley and Kark (2009) reviewed published data on the impacts of alien birds, allocating scores for three different types of impacts (environmental, economic and human health). They then undertook analyses for a series of biological traits such as body size and fecundity, to determine whether any such traits were associated with impact severity. Habitat generalist birds were found to have more severe economic impacts; small, flock-forming species had more severe environmental impacts. Combined economic, environmental and human health impacts were also associated with habitat generalists, as well as species with higher brood production.

Kumschick and Nentwig (2010) used the GISS (Nentwig *et al*. 2010), a protocol developed to rank the severity of impacts generated by alien species, to quantify and categorise the impacts of alien birds. Impacts were broadly identified as being either environmental or economic, and then assigned using a series of sub-categories (environmental impacts – competition, predation, hybridisation, transmission of diseases, herbivory, impact on ecosystem; economic impacts – impact on agriculture, livestock, forestry, human health, infrastructure and human social life). The study concluded that some alien bird species have as severe an impact as those associated with the most damaging alien mammal species, and suggested that management interventions should be prioritised for the three species with the most damaging impacts: the ruddy duck, Canada goose and rose-ringed parakeet.

Using directly comparable data on a series of biological traits, Kumschick *et al*. (2013) identified drivers of impact severity for alien birds and mammals in Europe. Species were ranked by the severity of their environmental and economic impacts, with analyses undertaken to identify associations with biological traits. Large, habitat generalist, widespread bird and mammal species were found to have the greatest impacts as aliens. The study also confirmed that mammals tend to be more damaging than birds.

Evans *et al*. (2014) undertook a study which aimed to determine whether there are biological traits correlated with the impacts of alien birds in Europe and Australia. The GISS was applied to 27 alien bird species in Australia. Impacts were assigned through a literature review, following the same procedure undertaken by Kumschick *et al*. (2013) for alien birds in Europe. The results were then compared to those obtained from Kumschick *et al*. (2013). Of the range of biological traits tested, only habitat generalism was found to be consistently correlated with impacts on both continents.

Kumschick *et al*. (2015b) applied the GISS to 300 species from five major taxonomic groups: mammals, birds, fish, terrestrial arthropods and plants. One of the aims of the study was to determine whether the impacts of alien species, across a range of taxa, could be quantified and compared using a standardised approach (the GISS). The study concluded that comparing the impacts of alien species is vital to inform management interventions, and also demonstrated how a 'black-listing' process could be adopted to compare the impacts of alien species.

1.4 Thesis overview

The general aim of this thesis is to use EICAT to further our understanding of the environmental impacts of alien birds.

In **Chapter 2**, I present a global assessment of the environmental impacts of alien birds, using EICAT to quantify and categorise these impacts by their severity and type. The results of this assessment indicate that whilst the majority of alien bird species have relatively minor environmental impacts, some alien birds have more severe impacts, causing native species extirpations and extinctions. The results also demonstrate that we have no data on the impacts of approximately 70% of alien bird species globally. These species are categorised as Data Deficient (**DD**) under EICAT. Through completion of the EICAT assessment, I generate the most comprehensive, unified dataset on the impacts of alien birds, which I use in the following chapters of my thesis, to further our understanding of these impacts.

In **Chapter 3**, I examine the factors that influence whether we have impact data for alien birds. I show that many species are likely to be **DD** because they have minor impacts that do not attract scientific research. However, I also demonstrate that some species may be **DD** for reasons that are unrelated to the severity of their impacts. For example, the availability of impact data was found to be strongly associated with the length of time a species had been resident as an alien, and the size of its alien range. This is important, because it suggests that some alien bird species (e.g. those introduced to new environments relatively recently, or those with restricted alien ranges) may have environmental impacts that are going unnoticed. The study highlights the need to improve our impact prediction capabilities in order to identify the types of **DD** species that are likely to have damaging impacts.

In **Chapters 4 and 5**, with the aim of improving our impact prediction capabilities, I examine the factors that influence the severity of impacts generated by an alien bird species. In **Chapter 4**, I identify the traits of alien birds that are associated with more severe environmental impacts. This is the first study to do so on a global basis, and represents one of the first formal analyses of alien species impacts undertaken using EICAT data. The results indicate that widely distributed, generalist birds have the most severe impacts. This may be because they have greater opportunity to cause impacts through their sheer number and ubiquity, but could be because they are more frequently studied. Should the former be true, this study provides support for measures to minimise the global distribution of alien birds.

In **Chapter 5**, I produce the first global maps of the impacts generated by alien species from an entire taxonomic class. The maps display both the global distribution of actual, recorded impacts generated by alien birds, and the potential impacts of alien birds, for regions where they are present, but where we know nothing about their impacts. The maps illustrate that whilst the actual, recorded impacts of alien birds are generally restricted to temperate, developed regions of the world, their potential impacts are far more widespread. I also identify the factors that influence spatial variation in the severity of alien bird impacts. The results indicate that the severity of impacts generated by alien bird species is not randomly distributed across regions. For regions with actual, recorded impacts, factors relating to the duration and frequency of alien bird invasions are key in determining whether the impacts sustained by a region will be damaging. Characteristics of alien birds, and of the receiving environment, also influence the severity of impacts sustained by a region. Many of these factors also influence impact severity amongst regions with potential impacts. This study has important implications for alien species impact prediction, as the maps, and the data underpinning them, can be used to identify regions of the world that are characterised by the variables found to be associated with impact severity. This may assist in directing management interventions to regions where they are most needed.

In **Chapter 6**, I conclude the thesis with a summary of the key findings of my research, and discuss their implications for the management of biological invasions. Finally, I consider future avenues for research regarding the quantification and categorisation of impacts associated with alien species.

Chapter 2

Application of the Environmental Impact Classification for Alien Taxa (EICAT) to a global assessment of alien bird impacts

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2.1 Abstract

Aim: To apply the recently published EICAT protocol to an assessment of the magnitude and type of environmental impacts generated by alien bird species worldwide.

Location: Global.

Methods: A review of published literature and online resources was undertaken to collate information on the reported environmental impacts of 415 bird species with self-sustaining alien populations worldwide. The resulting data were then categorised following the EICAT guidelines, and analysed using R.

Results: Environmental impact data were found for approximately 30% of species with alien populations. Most alien birds had low impacts, categorised as either Minimal Concern (**MC**) or Minor (**MN**). However, 37 bird species had moderate (**MO**) impacts or above, including five with massive (**MV**) impacts. Almost half of all impacts identified related to competition between alien birds and native species. Impact magnitudes were non-randomly distributed: impacts due to predation tended to be more severe than for other impact mechanisms, and impacts on oceanic islands tended to be more severe than for other regions, but impacts associated with Psittaciform species tended to be less severe than for other alien bird orders. Approximately 35% of assessments were allocated a 'low' confidence rating.

Main conclusions: The EICAT protocol can be effectively applied to quantify and categorise the impacts of alien species for an entire taxonomic class. The results demonstrate significant variation in both the severity and type of impacts generated by alien birds. However, I found no data regarding the environmental impacts of the great majority of alien bird species, and where impact data were available, my assessments were frequently allocated a 'low' confidence rating. This study therefore identifies major data gaps that will help influence the direction of future alien species impact research.

2.2 Introduction

It is widely recognised that alien taxa can have significant adverse environmental impacts (Simberloff, 2013a; European Commission, 2015b; Pagad *et al*. 2015). In recognition of this, the Strategic Plan for Biodiversity 2011-2020 (https://www.cbd.int/sp), developed under the Convention on Biological Diversity (CBD), includes a specific target to address their impacts. Aichi Target 9 states that by 2020, invasive alien species and their pathways should be identified and prioritised, and priority species should be controlled or eradicated (CBD, 2013). Similarly, in 2015, the European Union (EU) published new legislation in response to the potential threat associated with biological invasions across the region. Target 5 of the EU 2020 Biodiversity Strategy (http://ec.europa.eu/environment/nature/biodiversity/strategy) requires the development of a list of invasive alien species of Union concern, to be drawn up and managed by Member States using risk assessments and scientific evidence (European Commission, 2015a).

However, the type and severity of the impacts associated with alien species varies greatly among taxa, and despite the regulatory requirements imposed by the CBD and the EU, there is much uncertainty regarding the mechanisms and processes that lead to successful invasions; the species which have (or are likely to have) the most damaging impacts; and the most appropriate courses of action to prioritise and manage alien invasions (Ricciardi *et al*. 2013; Simberloff *et al*. 2013b; Kumschick *et al*. 2015a). This may in part be due to the fact that the international community has yet to formally adopt a standardised method by which to compare and contrast the impacts of alien species. In recognition of this problem, Blackburn *et al*. (2014) proposed a protocol to classify alien species according to the magnitude of their environmental impacts. This protocol was recently formalised as the Environmental Impact Classification for Alien Taxa (EICAT) with the provision of a framework and guidelines for implementation (Hawkins *et al*. 2015). The principal aim of EICAT is to enable invasion biologists to identify variation in the magnitude and types of impacts associated with alien taxa, allowing clear comparisons to be made regarding their impacts across different regions and taxonomic groups (Hawkins *et al*. 2015).

The EICAT protocol has been developed in consultation with the IUCN, and will soon be formally adopted as their mechanism for classifying the environmental impacts of alien species. Following this, it is expected that EICAT assessments for all known alien species worldwide will be completed and peer reviewed by 2020, in-line with the requirements stipulated under Aichi Target 9 and Target 5 of the EU 2020 Biodiversity Strategy. It is envisaged that EICAT will be used to develop a biodiversity indicator for alien species impacts, and through on-going periodic assessments of impacts, will provide a mechanism to monitor changes in the impacts of alien species, for example to determine the effectiveness of a management intervention in alleviating adverse impacts. A significant outcome arising from the application of EICAT will be a global stocktake of the broad range of impacts associated with alien taxa. Thus, the EICAT protocol will help to direct attention not only to the most damaging alien species, but also to those species, taxa, locations or impact mechanisms for which we do not have sufficient information from which to make informed management decisions to mitigate the impacts of alien taxa.

A key next step in the development of the EICAT protocol is to apply it to a set of species with alien populations, in order to test how readily it can be applied, and to identify any aspects of the protocol that may need refinement. Here, I present one of the first applications of EICAT, with a global assessment of the environmental impacts of alien bird species. More than 400 bird species have established alien populations somewhere in the world (Dyer *et al*. 2017a), and some of these established populations have been shown to cause significant impacts to the environment (Long, 1981; Brochier *et al*. 2010; Kumschick *et al*. 2013). For example, on the Seychelles, the common myna (*Acridotheres tristis*) has been found to compete with, and subsequently affect the breeding success of the Seychelles magpie robin (*Copsychus sechellarum*) (Komdeur, 1995); in Sweden, the Canada goose (*Branta canadensis*) damages natural shoreline vegetation communities through intense grazing (Josefsson & Andersson, 2001); in France, the African sacred ibis (*Threskiornis aethiopicus*) predates upon eggs of the sandwich tern (*Thalasseus sandvicensis*) (Yesou & Clergeau, 2005); and in Spain, the ruddy duck (*Oxyura jamaicensis*) hybridises with the globally endangered white-headed duck (*Oxyura leucocephala*) (Muñoz-Fuentes *et al*. 2007). I use data obtained from a thorough search and review of the available literature to quantify alien bird impacts under the EICAT protocol.

This study follows two recent global assessments of the impacts of alien birds using different methodologies (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015). These assessments identified impact data for a relatively small number of alien bird species (33 and 39, respectively), and concluded that there is a lack of data on the impacts of alien birds, particularly for less developed regions of the world (see also Pyšek *et al*. 2008). Data availability has also been shown to vary with impact type and alien bird order. Martin-Albarracin *et al*. (2015) found nearly 40% of data were for competition impacts, whilst Evans *et al*. (2014) found that orders with a strong association with human activity, particularly Passeriformes (perching birds), Anseriformes (ducks, geese and swans) and Galliformes (gamebirds), had the most frequently reported impacts. I therefore expected to find little or no impact data for many alien bird species, and to find significant variation in the availability of data across regions, impact types and taxa.

Notwithstanding the examples above, I expected to find that impacts associated with alien birds are relatively weak, particularly in comparison to other taxa such as mammals. Baker *et al*. (2014) concluded that there is little evidence for detrimental impacts generated by alien birds, and the low number of alien birds implicated in the extinction of native species (Bellard *et al*. 2016a) also suggests that their impacts are not particularly severe. However, previous studies suggest that impact severity varies with impact mechanism (Kumschick *et al*. 2013; Evans *et al*. 2014; Baker *et al*. 2014; Martin-Albarracin *et al*. 2015) and across alien bird orders. Kumschick & Nentwig (2010) examined the impacts of alien birds in Europe, and found Anseriformes and Psittaciformes (parrots) to generally be associated with more severe impacts, whilst Martin-Albarracin *et al*. (2015) found Anatidae (Anseriformes) to have the highest impacts globally. Thus, I expected to find variation in impact severity across different types of impact, and across bird orders, with Anseriformes amongst the most damaging. Impacts generated by alien species may be particularly severe on oceanic islands (Pearson, 2009; CBD, 2017). Although to my knowledge no studies have been undertaken to determine whether this generalisation can be extended to alien birds, I expected to find variation in impact severity across geographic regions, with more severe impacts associated with islands.

Based on the evidence provided by past studies, I test whether the magnitude of alien bird impacts varies across impact mechanisms, and whether the magnitude, mechanisms and availability of data on alien bird impacts vary across alien bird orders. I further test whether the magnitude of alien bird impacts varies across biogeographic regions. I also test whether confidence in the EICAT assessment for each alien bird species (as measured through the allocation of a confidence rating of 'high', 'medium' or 'low' for each assessment) varies with impact mechanism, impact magnitude and across bird orders. By determining the form and extent of such variations, I aim to improve our understanding of the nature of environmental impacts generated by alien birds, and to identify knowledge gaps that will inform the prioritisation of future impact studies. I conclude with some observations on the application of the EICAT protocol to real-world data on impacts.

2.3 Methods

2.3.1 Data

A list of 415 alien bird species with self-sustaining populations across the globe was extracted from the Global Avian Invasions Atlas (Dyer *et al*. 2017a). GAVIA is a global database (incorporating data up to March 2014) that brings together information on global alien bird introductions (from sources including atlases, country species lists, peer-reviewed articles, websites and through correspondence with in-country experts) to provide the most comprehensive resource on the global distributions of alien bird species. Data extracted from the GAVIA database has recently been used to study the drivers of global alien bird species introductions (Dyer *et al*. 2017b), and also to undertake a global analysis of the determinants of alien bird geographic range size (Dyer *et al*. 2016).

A review of published literature was then undertaken to collate information on the reported impacts of each of these species (for details on the method adopted for the literature review, see **Appendix A**). The environmental impacts of each alien bird species identified from the literature search were categorised into one of 12 impact mechanisms defined in the EICAT guidelines (Hawkins *et al*. 2015) and summarised in **Table 2.1**. For each of the 12 mechanisms, a series of semi-quantitative scenarios were used to assign impacts to one of the following five impact categories. In order of increasing severity, these are: Minimal Concern (**MC**), Minor (**MN**), Moderate (**MO**), Major (**MR**) or Massive (**MV**). The scenarios reflect increases in the order of magnitude of the impacts associated with a species, as reflected in the level of biological organisation affected (a full description of the scenarios associated with each impact mechanism is presented in Hawkins *et al*. 2015). As an example, the most severe impacts associated with alien populations of the rose-ringed parakeet (*Psittacula krameri*) were for competition (impact mechanism (1) in **Table 2.1**): parakeets have been found to cause reductions in the size of populations of nuthatches (*Sitta europeae*) in Belgium, but with no evidence to show that these impacts have resulted in local population extinction or changes to the structure of communities (Strubbe & Matthysen, 2007; Strubbe & Matthysen, 2009). As such, recorded impacts match the semi-quantitative scenario relating to **MO** in the EICAT framework.

Table 2.1: The 12 EICAT impact mechanisms used to categorise the impacts of alien species (Hawkins *et al*. 2015), and alien bird impact examples.

Impact mechanism	Description	Alien bird example	Impacted species / location	Reference
(1) Competition	The alien taxon competes with native taxa for resources (e.g. food, water, space), leading to deleterious impact on native taxa.	Green junglefowl (*Gallus varius*)	Buff banded rail (*Gallirallus philippensis andrewsi*) – Cocos (Keeling) Islands (Australia)	Reid & Hill, 2005
(2) Predation	The alien taxon predates on native taxa, either directly or indirectly (e.g. via mesopredator release), leading to deleterious impact on native taxa.	American crow (*Corvus brachyrhynchos*)	White-eyed tropicbird (*Phaethon lepturus catsbyii*) – Bermuda (British Overseas Territory)	Madeiros, 2011
(3) Hybridisation	The alien taxon hybridises with native taxa, leading to deleterious impact on native taxa.	Chukar (*Alectoris chukar*)	Rock partridge (*Alectoris graeca*); red-legged partridge (*Alectoris rufa*) – France, Italy, Spain, Portugal	Barilani *et al*. 2007
(4) Transmission of disease to native species	The alien taxon transmits diseases to native taxa, leading to deleterious impact on native taxa.	House finch (*Carpodacus mexicanus*)	Various (song birds) – USA	Fischer *et al*. 1997
(5) Parasitism	The alien taxon parasitises native taxa, leading directly or indirectly (e.g. through apparent competition) to deleterious impact on native taxa.	Shiny cowbird (*Molothrus bonariensis*)	Yellow-shouldered blackbird (*Agelaius xanthomus*) – Puerto Rico	Cruz *et al*. 2005
(6) Poisoning / toxicity	The alien taxon is toxic, or allergenic by ingestion, inhalation or contact to wildlife, or allelopathic to plants, leading to deleterious impact on native taxa.	No impacts identified		
(7) Bio-fouling	Bio-fouling by the alien taxon leads to deleterious impact on native taxa.	No impacts identified		
(8) Grazing / herbivory / browsing	Grazing, herbivory or browsing by the alien taxon leads to deleterious impact on native plant species.	Mute swan (*Cygnus olor*)	Various (submerged aquatic vegetation) – USA	Allin & Husband, 2003
(9) Chemical impact on ecosystem	The alien taxon causes changes to the chemical biotope characteristics of the native environment; nutrient and / or water cycling; disturbance regimes; or natural succession, leading to deleterious impact on native taxa.	Egyptian goose (*Alopochen aegyptiaca*)	Various (eutrophication of waterbodies) – UK	Rehfisch *et al*. 2010
(10) Physical impact on ecosystem	The alien taxon causes changes to the physical biotope characteristics of the native environment; nutrient and / or water cycling; disturbance regimes; or natural succession, leading to deleterious impact on native taxa.	No impacts identified		
(11) Structural impact on ecosystem	The alien taxon causes changes to the structural biotope characteristics of the native environment; nutrient and / or water cycling; disturbance regimes; or natural succession, leading to deleterious impact on native taxa.	Superb lyrebird (*Menura novaehollandiae*)	Various (forest floor communities including invertebrate assemblages) – Tasmania (Australia)	Tassell, 2014
(12) Interaction with other alien species	The alien taxon interacts with other alien taxa, (e.g. through pollination, seed dispersal, habitat modification), facilitating deleterious impact on native species. These interactions may be included in other impact classes (e.g. predation, apparent competition) but would not have resulted in the particular level of impact without an interaction with other alien species.	Japanese white-eye (*Zosterops japonicus*)	Various (native plant communities) – Hawaii (USA)	Chimera & Drake, 2010

Each species was assessed for its impact under all of the 12 mechanisms for which data were available. However, a species was assigned to an impact category in the EICAT scheme based on the evidence of its most severe impacts only. Thus, the rose-ringed parakeet would be assigned to **MO** on the basis of available evidence of its impacts in terms of competition, as this is the mechanism of its highest impact. Some species' most severe impacts related to more than one impact mechanism: for example, the most severe impacts associated with the mute swan (*Cygnus olor*) were **MO** for both competition and grazing / herbivory / browsing. In such cases, species were assigned to impact categories on the basis of all mechanisms ranked equally most severe (in this case of the mute swan, both impacts were assigned to **MO**).

To quantify uncertainty about the correct classification of the magnitude of the environmental impacts of any alien species, confidence ratings of 'high', 'medium' or 'low' were appended to each assessment, following the EICAT guidance (Hawkins *et al*. 2015). For example, the impact data for the rose-ringed parakeet were published, peer reviewed and empirical. There were also several studies suggesting the same level of impact (**MO**). Consequently, a confidence rating of 'high' was allocated to the EICAT assessment for this species. Where there was evidence to suggest that a species had an alien population, but insufficient data was available to determine and classify any impacts of that species, it was assigned to the Data Deficient (**DD**) category.

As this represents the first comprehensive assessment of birds using the EICAT protocol, both the maximum recorded impact and the current recorded impact were assessed for each bird species with a known alien population. The maximum recorded impact measures the greatest deleterious impacts associated with a species. The current recorded impact reflects the existing impacts associated with a species. The current and maximum recorded impacts of a species with alien populations may differ, for example if management actions have been applied to mitigate species impacts. For example, rinderpest, a viral disease of ungulates, was introduced from Asia to southern Africa in cattle in the late 19th Century. It caused dramatic declines in the populations of native species including wildebeest (*Connochaetes spp.*) and buffalo (*Syncerus caffer*) (Simberloff, 2013a). Under the EICAT protocol, the maximum recorded impact for rinderpest would therefore be Moderate (**MO**), as the virus caused declines in populations of native species. However, rinderpest has since been successfully eradicated globally. Under EICAT, the eradication of rinderpest would have initially resulted in its classification being reduced to Minimal Concern (**MC**), and upon official confirmation of its global eradication in 2011, its classification would have been updated to No Alien Population (**NA**).

2.3.2 Analysis

The actual and expected distributions of impact magnitudes and impact mechanisms across orders, and impact magnitudes across impact mechanisms, were all analysed using contingency tables tests (Chi-Square Test of Independence, or where expected numbers were small (less than 5), Fisher's Exact Test for Count Data (following McDonald (2014)). Low samples sizes in some of the categories of interest meant that I amalgamated categories for some analyses. Thus, impact categories were combined to produce two groups: 'lower tier' impacts, consisting of impacts classified as **MC** and **MN**, and 'upper tier' impacts, consisting of impacts classified as **MO**, **MR** and **MV**. I used the Wilcoxon Rank Sum test to compare the number of empirical data sources underlying 'lower tier' and 'upper tier' impact classifications, and underlying different confidence ratings. For analyses involving bird orders, five orders (Passeriformes, Psittaciformes, Galliformes, Anseriformes and Columbiformes (pigeons and doves)) were tested as separate groups, with the remaining orders combined to produce one group titled 'Other'. For analyses regarding regions, areas were defined by continent (Africa, Asia, Australasia, Europe, North (including Central) America, South America) with the islands of the Atlantic, Indian and Pacific oceans combined to form one category. All analyses were carried out using RStudio version 0.99.893 (R Core Team, 2017).

2.4 Results

The 415 bird species with alien populations derive from 26 orders. The majority of these species (363, or 87.5%) come from just five orders: Passeriformes (43.9% of the dataset), Psittaciformes (14.9%), Galliformes (13%), Anseriformes (8.9%) and Columbiformes (6.7%). The remaining 52 species are distributed across the other 21 orders. A summary of the EICAT assessment by alien bird order is given in **Appendix B**, **Table B1**. The full list of EICAT assessment results for individual species is provided in **Appendix C**, **Table C1**.

Impact data were obtained for 119 species from 14 orders (28.7% of alien bird species) (**Figure 2.1**). The same five orders that contain most alien bird species also include most of the species with recorded impacts (88.2%), with the remainder spread across a further nine orders. Data describing the most severe impacts of the 119 alien species (data used to allocate species' impacts) were obtained from 311 sources, 72.5% of which were anecdotal, with the remainder being empirical. An average of 0.4 empirical data sources per alien bird species was found for those with 'lower tier' (**MC** and **MN**) impacts, versus 1.3 per alien bird species with 'upper tier' (**MO**, **MR** and **MV**) impacts (Wilcoxon Rank Sum Test; W = 1376.5, N = 102, $P < 0.001$).

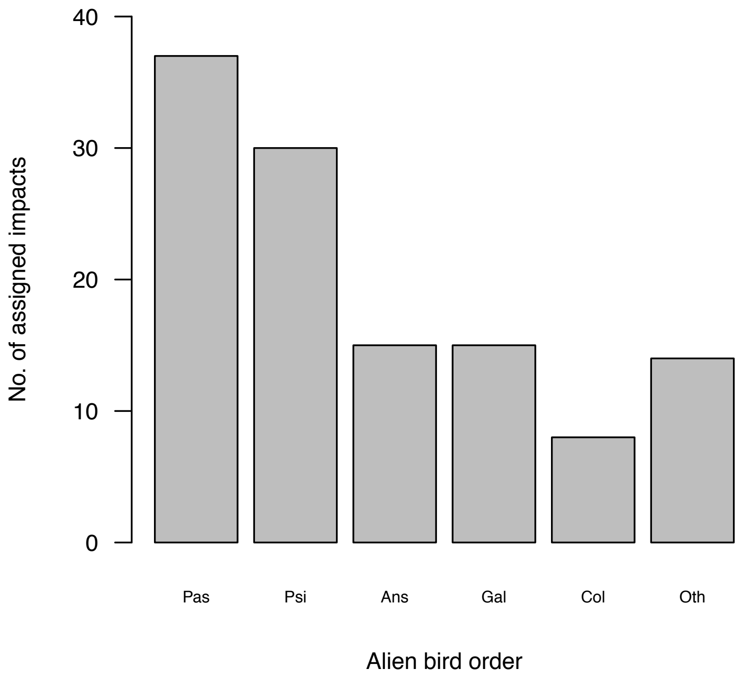

Figure 2.1: The distribution across orders of alien bird species with impact data. Pas = Passeriformes; Psi = Psittaciformes; Ans = Anseriformes; Gal = Galliformes; Col = Columbiformes; Oth = Other orders.

No impact data were found for 296 species (71.3%), which were therefore categorised at Data Deficient (**DD**). No impact data were obtained for any of the species in 12 orders with alien populations, such that almost half of the 26 orders with aliens were entirely **DD**. Recorded impacts are non-randomly distributed across orders (χ^2 = 20.6, df = 5, P = 0.001). This result arises primarily from fewer Passeriform species, and more Psittaciform species, with recorded impacts than expected by chance (**Table 2.2**).

Table 2.2: Contingency table (Chi-square Test of Independence) showing actual and expected numbers of alien bird species for each order, with and without recorded impacts. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses).

	No. of species with recorded impacts	No. of species without recorded impacts (**DD**)	Total no. of species
Passeriformes	37 *52.19* (4.42)	145 *129.81* (1.78)	182
Psittaciformes	30 *17.78* (8.40)	32 *44.22* (3.38)	62
Anseriformes	15 *10.61* (1.82)	22 *26.39* (0.73)	37
Galliformes	15 *15.48* (0.02)	39 *38.52* (0.01)	54
Columbiformes	8 *8.03* (0.00)	20 *19.97* (0.00)	28
Other	14 *14.91* (0.06)	38 *37.09* (0.02)	52
Total	119	296	415

For all 119 species with recorded impacts, the maximum recorded impact was found to be the same as the current recorded impact. For 23 species, the highest recorded impact was equally high for two or more impact mechanisms, resulting in a total of 146 impact mechanism allocations (**Appendix B**, **Table B1**). The majority of these 146 impacts were categorised as 'lower tier' (**MC** or **MN**) (69.9%) (**Figure 2.2**). However, 37 species had 'upper tier' impacts, with five having massive (**MV**) impacts, resulting in native species' population extinctions. Impact magnitudes are non-randomly distributed across orders (χ^2 = 16.0, df = 5, P = 0.003), primarily because of fewer Psittaciform species with 'upper tier' (**MO**, **MR** and **MV**) impacts than expected (**Table 2.3**).

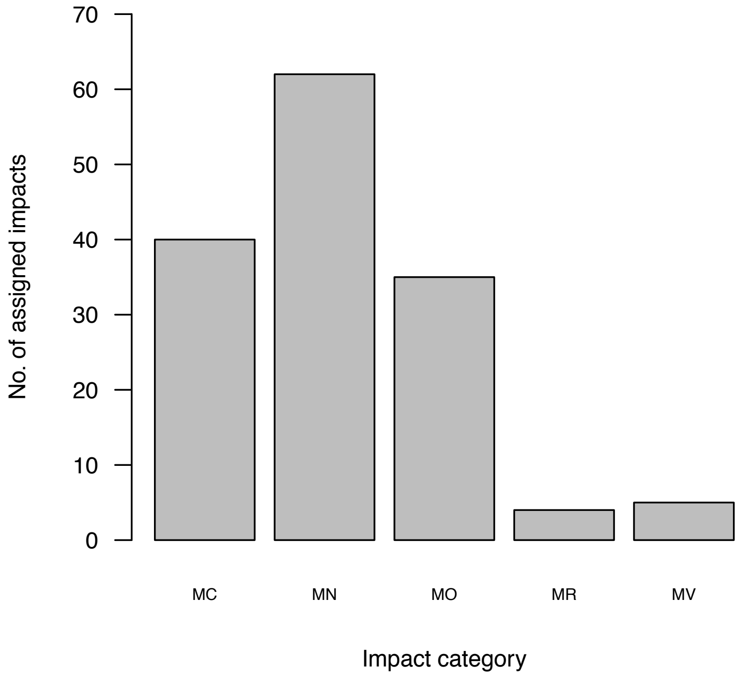

Figure 2.2: The number of impacts assigned to each impact category. A further 296 species were Data Deficient (**DD**). **MC** = Minimal Concern; **MN** = Minor; **MO** = Moderate; **MR** = Major; **MV** = Massive.

Table 2.3: Contingency table (Fisher's Exact Test for Count Data) showing actual and expected numbers of impact allocations to 'lower tier' (**MC** and **MN**) and 'upper tier' (**MO**, **MR** and **MV**) impact categories for each order. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses).

	No. of allocations to **MC** and **MN** impact categories ('lower tier')	No. of allocations to **MO**, **MR** and **MV** impact categories ('upper tier')	Total impact allocations
Passeriformes	27 *33.53* (1.27)	21 *14.47* (2.95)	48
Psittaciformes	30 *22.36* (2.61)	2 *9.64* (6.06)	32
Anseriformes	15 *14.67* (0.01)	6 *6.33* (0.02)	21
Galliformes	12 *11.88* (0.00)	5 *5.12* (0.00)	17
Columbiformes	9 *7.68* (0.23)	2 *3.32* (0.52)	11
Other	9 *11.88* (0.70)	8 *5.12* (1.62)	17
Total	102	44	146

Nearly half of all impact allocations were for competition (43.2%) (**Figure 2.3**), whilst no impacts were allocated for physical impacts on ecosystems, poisoning / toxicity or bio-fouling. Impact magnitudes are non-randomly distributed across impact mechanisms (χ^2 = 13.6, df = 5, P = 0.018). In particular, more predation impacts are allocated to 'upper tier' (**MO**, **MR** and **MV**) categories than expected (**Table 2.4**).

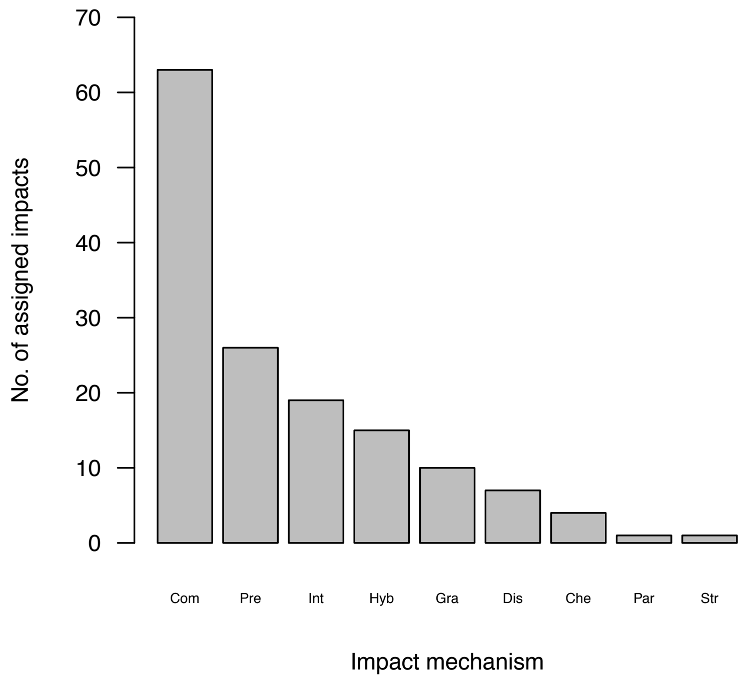

Figure 2.3: The number of impacts assigned to each impact mechanism. Com = Competition; Pre = Predation; Int = Interaction with other alien species; Hyb = Hybridisation; Gra = Grazing / herbivory / browsing; Dis = Transmission of disease to native species; Che = Chemical impact on ecosystem; Par = Parasitism; Str = Structural impact on ecosystem.

Table 2.4: Contingency table (Fisher's Exact Test for Count Data) showing actual and expected numbers of impact allocations to 'lower tier' (**MC** and **MN**) and 'upper tier' (**MO**, **MR** and **MV**) impact categories for each impact mechanism. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses). Data for impact mechanisms (5) Parasitism, (9) Chemical impact on ecosystem and (11) Structural impact on ecosystem were removed from the dataset for the test, due to low sample size.

	No. of allocations to **MC** and **MN** impact category ('lower tier')	No. of allocations to **MO**, **MR** and **MV** impact category ('upper tier')	Total impact allocations
Competition	49 *43.65* (0.66)	14 *19.35* (1.48)	63
Predation	11 *18.01* (2.73)	15 *7.99* (6.16)	26
Interaction with other alien species	16 *13.16* (0.61)	3 *5.84* (1.38)	19
Hybridisation	9 *10.39* (0.19)	6 *4.61* (0.42)	15
Grazing / herbivory / browsing	7 *6.93* (0.00)	3 *3.07* (0.00)	10
Transmission of disease to native species	5 *4.85* (0.00)	2 *2.15* (0.01)	7
Total	97	43	140

Impact mechanisms are also non-randomly distributed across orders (χ^2 = 116.2, df = 25, P < 0.001). There were more Psittaciform species than expected with competition impacts, more Anseriform species with hybridisation impacts, more Columbiform species with disease impacts, and more Galliform species with interaction impacts. There were also more species in 'Other' orders with predation impacts than expected; these were Accipitriformes (hawks, eagles and allies), Coraciiformes (kingfishers, rollers, hornbills and allies), Cuculiformes (cuckoos), Falconiformes (falcons), Gruiformes (cranes and allies), Pelecaniformes (pelicans and allies) and Strigiformes (owls and allies), which together accounted for 42.3% of all predation impacts (**Table 2.5**).

Table 2.5: Contingency table (Fisher's Exact Test for Count Data) showing actual and expected numbers of impact allocations to each impact mechanism for each order. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses). Data for impact mechanisms (5) Parasitism, (9) Chemical impact on ecosystem and (11) Structural impact on ecosystem were removed from the dataset for the test, due to low sample size.

	Competition	Predation	Interaction with other alien species	Hybridisation	Grazing / herbivory / browsing	Transmission of disease to native species
Passeriformes	20 *20.70* (0.02)	13 *8.54* (2.33)	8 *6.24* (0.49)	1 *4.93* (3.13)	1 *3.29* (1.59)	3 *2.30* (0.21)
Psittaciformes	27 *14.40* (11.02)	1 *5.94* (4.11)	0 *4.34* (4.34)	1 *3.43* (1.72)	2 *2.29* (0.04)	1 *1.60* (0.23)
Galliformes	5 *7.65* (0.92)	1 *3.16* (1.47)	7 *2.31* (9.55)	3 *1.82* (0.76)	1 *1.21* (0.04)	0 *0.85* (0.85)
Anseriformes	5 *7.65* (0.92)	0 *3.16* (3.16)	0 *2.31* (2.31)	7 *1.82* (14.72)	5 *1.21* (11.80)	0 *0.85* (0.85)
Columbiformes	4 *4.95* (0.18)	0 *2.04* (2.04)	2 *1.49* (0.17)	2 *1.18* (0.57)	0 *0.79* (0.79)	3 *0.55* (10.91)
Other	2 *7.65* (4.17)	11 *3.16* (19.48)	2 *2.31* (0.04)	1 *1.82* (0.37)	1 *1.21* (0.04)	0 *0.85* (0.85)
	63	26	19	15	10	7

The greatest number of impacts were recorded on oceanic islands (57 impact assignments, or 34%), primarily those of the Pacific (24.4%), particularly Hawaii (13.7% of all impact allocations). Continents with the most recorded impacts were North America (21.4%) and Australasia (17.3%). The fewest impacts were recorded in South America and Africa (3.6% each). Impact magnitudes were non-randomly distributed across regions (χ^2 = 15.5, df = 4, P = 0.004). This result arises primarily from more 'upper tier' (**MO**, **MR** and **MV**) impacts on oceanic islands than expected, and fewer in North (and Central) America (**Table 2.6**).

Table 2.6: Contingency table (Fisher's Exact Test for Count Data) showing actual and expected numbers of impact allocations by region, to 'lower tier' (**MC** and **MN**) and 'upper tier' (**MO**, **MR** and **MV**) impact categories. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses). Data for Africa and South America were removed from the dataset for the test, due to low sample size.

	No. of allocations to **MC** and **MN** impact categories ('lower tier')	No. of allocations to **MO**, **MR** and **MV** impact categories ('upper tier')	Total impact allocations
Asia	11 *10.09* (0.08)	4 *4.91* (0.17)	15
Australasia	20 *19.51* (0.01)	9 *9.49* (0.03)	29
Europe	19 *16.82* (0.28)	6 *8.18* (0.58)	25
North and Central America	31 *24.22* (1.90)	5 *11.78* (3.90)	36
Islands (Atlantic, Pacific and Indian oceans)	28 *38.35* (2.79)	29 *18.65* (5.75)	57
Total	109	53	162

Impact assessments were allocated a 'high' confidence rating on 53 occasions (36.3%). A similar proportion were allocated a 'low' rating (51), whilst 42 were allocated a 'medium' rating. Confidence ratings were randomly distributed across impact mechanisms (χ^2 = 19.3, df = 10, P = 0.065), although a relatively high proportion of assessments relating to disease transmission were allocated a 'low' confidence rating (**Table 2.7a**). Confidence ratings were non-randomly distributed across impact magnitudes (χ^2 = 11.9, df = 2, P < 0.003), with more 'upper tier' (**MO**, **MR** and **MV**) impact assessments allocated a 'high' confidence rating than expected (**Table 2.7b**). Confidence ratings were also non-randomly distributed across orders (χ^2 = 47.9, df = 10, P < 0.001), with more Galliform and Columbiform assessments allocated a 'low' confidence rating, than expected. 'Medium' confidence ratings tended to be over-represented amongst Psittaciformes (**Table 2.8**).

Table 2.7: Contingency table showing actual and expected numbers of 'low', 'medium' and 'high' confidence assessments allocated to (a): each impact mechanism (Fisher's Exact Test for Count Data); and (b): 'lower tier' (**MC** and **MN**) and 'upper tier' (**MO**, **MR** and **MV**) impact categories (Chi-Square Test of Independence). Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses). Data for impact mechanisms (5) Parasitism, (9) Chemical impact on ecosystem and (11) Structural impact on ecosystem were removed from the dataset for the test, due to low sample size (**Table 2.7(a)** only).

Table 2.7(a)

	No. of 'low' confidence assessments	No. of 'medium' confidence assessments	No. of 'high' confidence assessments	Total confidence assessment allocations
Competition	21 *22.50* (0.10)	23 *17.55* (1.69)	19 *22.95* (0.68)	63
Predation	8 *9.29* (0.18)	8 *7.24* (0.08)	10 *9.47* (0.03)	26
Interaction with other alien species	10 *6.79* (1.52)	3 *5.29* (0.99)	6 *6.92* (0.12)	19
Hybridisation	3 *5.36* (1.04)	3 *4.18* (0.33)	9 *5.46* (2.29)	15
Grazing / herbivory / browsing	2 *3.57* (0.69)	2 *2.79* (0.22)	6 *3.64* (1.53)	10
Transmission of disease to native species	6 *2.50* (4.90)	0 *1.95* (1.95)	1 *2.55* (0.94)	7
Total	50	39	51	140

Table 2.7(b)

MC and **MN** impact categories ('lower tier')	42 *35.63* (1.14)	32 *29.34* (0.24)	28 *37.03* (2.20)	102
MO, **MR** and **MV** impact categories ('upper tier')	9 *15.37* (2.64)	10 *12.66* (0.56)	25 *15.97* (5.10)	44
Total	51	42	53	146

Table 2.8: Contingency table (Fisher's Exact Test for Count Data) showing actual and expected numbers of 'low', 'medium' and 'high' confidence assessments allocated to each order. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses).

	No. of 'low' confidence assessments	No. of 'medium' confidence assessments	No. of 'high' confidence assessments	Total confidence assessment allocations
Passeriformes	15 *16.77* (0.19)	8 *13.81* (2.44)	25 *17.42* (3.29)	48
Psittaciformes	8 *11.18* (0.90)	19 *9.21* (10.42)	5 *11.62* (3.77)	32
Galliformes	12 *5.94* (6.19)	1 *4.89* (3.09)	4 *6.17* (0.76)	17
Anseriformes	4 *7.34* (1.52)	9 *6.04* (1.45)	8 *7.62* (0.02)	21
Columbiformes	9 *3.84* (6.92)	0 *3.16* (3.16)	2 *3.99* (0.99)	11
Other	3 *5.94* (1.45)	5 *4.89* (0.00)	9 *6.17* (1.30)	17
	51	42	53	146

An average of 2.7 empirical data sources were found for assessments allocated a 'high' confidence rating, 0.5 for those allocated a 'medium' confidence rating, and 0.4 for those allocated a 'low' confidence rating. More empirical data sources were found for 'high' confidence assessments than for 'low' (Wilcoxon Rank Sum Test; W = 2413.5, N = 102, $P < 0.001$) or 'medium' (W = 1986, N = 102, $P < 0.001$), while medium and low categories did not differ in this regard (W = 1050, N = 102, $P = 0.77$).

2.5 Discussion

Birds are one of the best-known and best-studied groups, yet to date there are no recorded environmental impacts for more than 70% of bird species with alien populations. This includes all the alien species in half of the 26 bird orders with aliens. The obvious exception to this general paucity of data is the Psittaciformes – parrot species tend to be noisy and conspicuous, and are relatively well studied (**Table 2.2**). The absence of knowledge regarding alien bird impacts reflects the findings of other recent studies on the impacts of alien taxa (Baker *et al*. 2014; Martin-Alberracin *et al*. 2015; Kraus, 2015), and alien birds have even received proportionately lower levels of research effort in comparison to other taxonomic groups (Pyšek *et al*. 2008). Despite growth in the study of invasion biology (Richardson & Pyšek, 2008), impact is a topic that remains understudied.

There are at least two broad reasons why no environmental impact data exist for most alien bird species. First, some alien bird populations may be perceived to cause little or no environmental damage, and consequently their potential impacts are not studied. Lack of data here reflects a perceived (but perhaps real) lack of impact. This would fit with a recent synthesis of bias in invasion biology research (Pyšek *et al*. 2008), which found a tendency for research to focus on species that were considered to have the most severe impacts – as would be expected in a climate of scarce research funding (see Joseph *et al*. 2009). Whether such species actually have no environmental impacts, or their impacts have just not been noticed, is unknown.

Second, alien bird species may have clear (and perhaps high) impacts, but these impacts are unknown – in this case, a lack of data belies impact. This lack of knowledge may be because alien populations occur in remote locations where they go unnoticed or are not easily recorded or studied (e.g. tropical regions such as parts of Africa and South America). Consistent with this hypothesis, we found more data on alien bird impacts for invasions within more industrially developed regions of the world. At the continental scale, 53.6% of data on recorded impacts came from mainland North (and Central) America, Australia and Europe. For Asia, two-thirds of all impact records were for invasions to Singapore, Japan and Hong Kong, the three most highly ranked Asian economies in the Global Competitiveness Index (World Economic Forum, 2014). The fewest records were for Africa and South America. It is generally the case that comparatively less conservation research is being undertaken in these most biodiverse regions of the world (Wilson *et al*. 2016b).

Pyšek *et al*. (2008) also found a significant geographical bias regarding the locations of invasion biology studies, with oceanic islands (which play host to a large range of alien species) being largely ignored in comparison with North America and continental Europe. Yet, I found that approximately 34% of recorded impacts were for invasions on islands of the Atlantic, Indian and Pacific oceans. This may be because islands are more susceptible to impacts associated with alien species (Pearson, 2009; CBD, 2017; Harper & Bunbury, 2015), and the severity of their impacts has resulted in higher levels of research there. My results support this suggestion, as I found impacts to be more severe on islands (**Table**

2.6). It may also be because approximately 65% of the islands identified in this study are territories of developed countries (e.g. Bermuda; Hawaii; Mariana Islands; Marquesas Islands; Tahiti).

As I had expected, the environmental impacts of alien bird species were generally low, with approximately 70% found to be either negligible, or without population-level impacts (**Figure 2.2**). If invasion research is biased towards species with more severe impacts (Pyšek *et al*. 2008), this suggests that the majority of alien bird species have low environmental impacts, and lack of data simply reflects lack of impact. The same is true if alien bird species with impact data are a random sample of all alien bird species. Only if studies of alien birds were biased away from species with higher-level impacts would my analyses give a false impression of the levels of alien bird impacts. This is possible if alien birds have lower environmental impacts in areas that are better studied, such as Europe and North America, perhaps because the environments there are generally degraded by other processes (e.g. destruction of primary habitat). Ultimately, there is no way of knowing whether the few higher level impacts for alien bird species is absence of evidence or evidence of absence.

Nevertheless, 37 bird species did have 'upper tier' environmental impacts, with 28 negatively affecting populations of native species (**MO**), four affecting the composition of native communities (**MR**), and five resulting in species extinctions (**MV**). For example, on Lord Howe Island (Australia), the mallard (*Anas platyrhynchos*) hybridises with the Pacific black duck (*Anas superciliosa*), resulting in the local extirpation of this native species, and its replacement by mallard x Pacific black duck hybrids (Guay *et al.* 2014). Despite current concerns regarding the need for eradication campaigns to address the impacts of invasive birds (Strubbe *et al.* 2011), in the case of the mallard, management is considered warranted.

Four mechanisms accounted for almost 85% of alien bird environmental impacts: competition, predation, interaction with other alien species (which relates primarily to the spread of alien plants) and hybridisation (**Figure 2.3**). Almost 45% of all recorded impacts were associated with competition between alien birds and native species (**Figure 2.3**). The prevalence of competition may be because this mechanism is associated with frequent, daily interactions between alien birds and native species, when compared to other impact mechanisms (more alien bird species compete with other species for food or habitat, than predate, hybridise or interact with other aliens to have impacts). This result is supported by two recent global studies on the impacts of alien birds. Martin-Albarracin *et al*. (2015) found competition to be the most studied impact mechanism (39% of all studies), whilst Baker *et al*. (2014) found both competition for nesting sites (33 studies) and interference competition (24 studies) to be reported more frequently than any other impact mechanism (the next most frequently reported mechanism being hybridisation with 21 studies). However, the competitive impacts of alien bird species tended to be low when compared to other impact mechanisms (**Table 2.4**). In contrast, I found that predation by alien birds on native species tended to be associated with more severe impacts when compared to other impact mechanisms (**Table 2.4**).

Impact mechanisms were not distributed randomly across bird taxa with alien populations (**Table 2.5**). Thus, Psittaciformes were associated with competition impacts, Anseriformes with hybridisation impacts, Columbiformes with disease impacts, Galliformes with impacts generated by interactions with other alien species (primarily the spread of seeds of alien plants), and orders grouped together as ‘Other’ with predation impacts. These patterns generally reflect the behaviour and life history of species from these orders within their native ranges. For example, Psittaciformes are often cavity-nesting species, and cavities tend to be the subject of competition, particularly by species unable to excavate their own (secondary cavity-nesters) (Newton, 1994; Grarock *et al*. 2013). Anseriformes have long been associated with hybridisation, with more than 400 interspecies hybrid combinations recorded within the Anatidae – more than for any other bird family (Johnsgard, 1960). Orders associated with predation impacts include well-known avian predators, including Accipitriformes, Falconiformes and Strigiformes.

Impact magnitudes were also not distributed randomly across bird taxa with alien populations (**Table 2.3**). Psittaciformes were associated with less severe impacts when compared to other orders of alien birds, reflecting the fact that parrots generally interact with other native species through competition. Alien parrots have often been introduced to areas with no native parrot species, which may further reduce opportunities for direct competition with species that have similar habitat and food preferences (e.g. rose-ringed parakeet (*Psittacula krameri*) establishment in the UK; Peck *et al*. 2014). Almost 30% of impact assessments for alien parrots were for North America, which may explain why impacts on this continent were found to be less severe when compared to other continents (**Table 2.6**). Conversely, Passeriformes and orders in the 'Other' category tended to be associated with more severe environmental impacts (**Table 2.3**). This is because nearly 30% of Passeriform impact assessments (primarily for Corvids (crows and allies)), and over 65% of impact assessments for species within the 'Other' category, related to predation impacts (**Table 2.5**), which were found to be more severe when compared to other impact mechanisms (**Table 2.4**).

My results showed that in general, we have higher confidence in assessments associated with more severe impacts (**Table 2.7b**). This relationship may arise because severe impacts are more obvious, and therefore the data on impacts used to undertake the EICAT assessment are considered more robust. It may also be attributable to data availability, whereby alien bird species with severe impacts tend to be more frequently studied than those with minor impacts (Pyšek *et al*. 2008). This was true here, as a significantly greater number of empirical data sources were available for species with 'upper tier' (**MO**, **MR** and **MV**) than 'lower tier' (**MC** and **MN**) impacts, and also for impacts assigned a 'high' confidence rating, compared to those allocated a 'medium' or 'low' confidence rating. Less confidence was placed in disease impact assessments when compared to assessments for other impact mechanisms (**Table 2.7a**). Disease assessments can be complex, with recent studies suggesting it is often difficult to prove whether an alien species is solely responsible for the transmission of a disease to native species (Tompkins & Jakob-Hoff, 2011; Blackburn & Ewen, 2016). Less confidence was also placed in Columbiform assessments when compared to other bird orders (**Table 2.8**), probably because Columbiformes were generally associated with disease impacts (**Table 2.5**).

2.6 Conclusions

This study represents one of the first large-scale applications of the EICAT protocol, demonstrating that it is a practical means to quantify and categorise the impacts of alien species for a complete taxonomic class. Overall, the impact assessment phase of the work took about 3 months, suggesting an average of <1 day per species assessed. The actual time taken to assess a species obviously varied substantially, but was manageable even for data-rich species. On the whole, it was straightforward to assign impacts to mechanism, if harder to assign impacts to categories. The process did, however, highlight some gaps in the existing EICAT guidelines (Hawkins *et al*. 2015), most notably in terms of limited information on the approach to adopt when searching for, and recording, impact data. It would be beneficial to develop a search protocol and standardised record sheet to be used during EICAT assessments.

The biggest hindrance to the successful application of EICAT is the lack of impact data for most species. This problem is of course common to all evidence-based protocols. Unlike other recent studies (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015), I used all available data to conduct assessments, from peer-reviewed papers in international scientific journals to unreviewed information lodged on websites. The quality of these data is likely to vary substantially, and I used EICAT confidence ratings to reflect any uncertainty regarding their robustness. I also used confidence ratings to reflect uncertainty related to the presence of additional factors that could adversely impact upon native species (primarily habitat loss and other alien species). For example, local population extinctions of the Cocos buff-banded rail (*Gallirallus philippensis andrewsi*) on the Cocos (Keeling) Islands (Australia) have been attributed to competition between this species and introduced junglefowl (*Gallus gallus* and *G. varius*). However, habitat modification and predation by introduced mammals are also believed to have contributed to the decline of the native rail (Reid & Hill, 2005). In such cases, it was often difficult to determine the level of impact attributable solely to the subject of the EICAT assessment.

Having used EICAT to identify variation in the type and severity of impacts generated by alien birds, this study sets the scene for further research to test for causes of this variation. These studies will improve our understanding of the factors that influence the type and severity of impacts associated with alien species introductions. Obvious avenues for future investigation include whether or not certain life-history characteristics of alien birds (e.g. diet generalism, body mass, fecundity) are associated with more severe impacts, and a more detailed exploration of spatial variation in impacts, and characteristics of the receiving environment that moderate them. Such studies have the potential to assist in predicting the potential impacts of species that do not yet have alien populations, and to inform recommendations for alien species management.

Nevertheless, this study demonstrates that there is still a long way to go to understand the impacts of even a well-studied group such as birds. We have no information on the environmental impacts of the great majority of bird species with alien populations. Further, even where impact data were available, assessments were frequently allocated a ‘low’ confidence rating. One of the potential benefits of the EICAT protocol is that it can be used to identify knowledge gaps and hopefully influence the direction of future alien species research.

Chapter 3

Determinants of data deficiency in the impacts of alien bird species

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3.1 Abstract

Aim: To identify the factors that influence the availability of data on the negative impacts of alien bird species, in order to understand why more than 70% are currently classified as Data Deficient (**DD**) by the Environmental Impact Classification for Alien Taxa (EICAT) protocol.

Location: Global.

Methods: Information on factors hypothesised to influence the availability of impact data were collated for 344 alien bird species (107 with impact data and 237 **DD**). These data were analysed using mixed effects models accounting for phylogenetic non-independence of species (MCMCglmm).

Results: Data deficiency in the negative impacts of alien birds is not randomly distributed. Residence time, relative brain size and alien range size were found to be strongly related to the availability of data on impacts.

Main conclusions: The availability of data on the negative impacts of alien birds is mainly influenced by the spatial and temporal extents of their alien ranges. The results of this study suggest that the impacts of some **DD** alien birds are likely to be minor (e.g. species with comparatively long residence times as aliens, such as the common waxbill (*Estrilda astrild*) and the Java sparrow (*Padda oryzivora*)). However, the results also suggest that some **DD** alien birds may have damaging impacts (e.g. species from orders of alien birds known for their impacts to biodiversity but with comparatively small alien ranges, such as the New Caledonian crow (*Corvus moneduloides*)). This implies that at least some **DD** alien birds may have impacts that are being overlooked. Studies examining the traits that influence the severity of alien bird impacts are needed to help predict which **DD** species are more likely to impact upon biodiversity.

3.2 Introduction

In recent years, there has been much debate regarding the implications of biological invasions for native biodiversity (see Sax & Gaines, 2003; Briggs, 2013; Russell & Blackburn, 2017). However, there is no doubt that alien species can have severe negative impacts upon native biodiversity. For example, they have been shown to pose a threat to the existence of 27% of mammals, birds, reptiles and amphibians worldwide (Bellard *et al*. 2016a), and to represent the most common threat associated with vertebrate extinctions, having been implicated in approximately two-thirds of all such extinctions since AD1500 (Bellard *et al*. 2016b). Recent studies also demonstrate that alien species are contributing to the global homogenisation of biodiversity. For example, alien invasions have substantially altered the global distribution of terrestrial gastropods (snails and slugs), the distribution of which is now shaped primarily by global trade relationships and climate (Capinha *et al*. 2015).

Despite the well-known and substantial impacts of some alien species, there is a lack of systematic and quantitative data on alien species impacts in general (Kumschick *et al*. 2015a; Hoffmann & Courchamp, 2016; Wilson *et al*. 2016a; Kumschick *et al*. 2017). Birds are amongst the best-studied animal groups, but alien birds are no exception to this rule. A recent global review of alien bird impacts on native biodiversity, undertaken using a new protocol developed to quantify and categorise the impacts of alien species (the Environmental Impact Classification for Alien Taxa (EICAT): Hawkins *et al*. 2015), could not find any impact data for 296 of 415 species (>70%) with known alien populations (Evans *et al*. 2016). These species were therefore classified as Data Deficient (**DD**) by the EICAT method. (Note that the usage of **DD** here differs from that of the IUCN Red List (http://www.iucnredlist.org), which relates to species extinction risk: “A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and / or population status.” (IUCN, 2016)). Two other recent studies of the global impacts of alien birds (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015) also found data for a relatively small number of species (33 and 39 respectively), and concluded that we need more information on their impacts.

The limited data that are available reveal significant variation in the severity of the environmental impacts attributable to alien birds. For example, in New Zealand, the alien population of the mallard (*Anas platyrhynchos*) could be on the verge of causing the extinction of the Pacific black duck (*A. superciliosa*) through hybridisation (Guay *et al*. 2014), but the impacts of the alien Australian magpie have not resulted in declining populations of any native species (Morgan *et al*. 2006). While it is possible that a lack of data on the impacts of an alien bird species stems from the fact that it has no impacts, it would be unwise to assume so. Therefore it is likely that there is also variation in the severity of impacts associated with **DD** alien bird species. The reasons why we may be lacking data for some alien bird species but not others have yet to be examined, and as such, drivers of data deficiency regarding their impacts represent a gap in our understanding of biological invasions. An obvious question therefore, is are there factors that determine whether alien birds have been subject to research in order to assess their impacts as invaders? Identifying these factors would help us to understand why some species have not been studied, and what the implications of data deficiency might be for the prevalence of alien bird impacts more widely.

There are at least three broad reasons why we might lack data on the impacts of alien birds. First, species perceived by scientists or the general public to have severe impacts may attract research, whilst species perceived to have negligible impacts on biodiversity may remain unstudied. A recent examination of bias in invasion biology found that alien species with documented impacts are more frequently studied than alien species with no documented impacts (Pyšek *et al*. 2008). Similarly, Evans *et al*. (2016) found a greater number of studies on the impacts of alien bird species that had more severe documented impacts (but see Kumschick *et al*. 2017). Given the scarce resources allocated to conservation (Joseph *et al*. 2009), the prioritisation of research towards those species that are perceived to cause the most damage is to be expected. In this case, **DD** species would tend to be those with low perceived impacts; whether or not a bird species was **DD** would potentially be related to the severity of its impacts, depending on the accuracy of those perceptions.

Second, some species may be more amenable to study because of their availability. For example, there will have been greater opportunity to study species with longer residence times (*sensu* Wilson *et al*. 2007), by dint of their longer existence as aliens. Such species have also had more time to cause impacts, which may prompt research. Species with larger alien ranges and those introduced to a broader range of locations may be encountered and studied more frequently, simply because they are more widespread. Furthermore, widespread species are likely to have had more opportunities to impact biodiversity due to the breadth of habitats they may encounter. As species with more severe impacts are more frequently researched, we may therefore have more information about widespread species. Similarly, generalist species (as determined by their dietary and habitat preferences) may be more readily studied because they are likely to utilise or occupy and impact upon a broader variety of habitats (*sensu* Carrascal *et al*. 2008; Reif *et al*. 2016). Larger brain size relative to body mass (an indicator of enhanced behavioural flexibility) has been linked to increased abundance in UK farmland birds (Shultz *et al*. 2005), and has been found to enhance survival amongst birds and mammals introduced to novel environments (Sol *et al*. 2007; Sol *et al*. 2008); thus large-brained birds may also be encountered more regularly. Large-brained birds have also been found to have higher levels of urban tolerance, with more of these species (compared to birds with smaller brains) being able to breed successfully within city centres (Maklakov *et al*. 2011). This brings large-brained birds into direct contact with human population centres, which may also increase their exposure to research.

In contrast, species may be encountered less frequently when they occur in remote, inhospitable or politically unstable regions of the world, where their impacts are difficult to record, where there is a lack of capacity (funding / knowledge / political will) to undertake research, or from locations where existing studies may be harder to locate. Two recent studies examining geographic bias in invasive species research (Pyšek *et al*. 2008; Bellard & Jeschke, 2015) found that the majority of studies on a broad range of taxonomic groups are being undertaken in the more developed regions of the world. Similarly, over 50% of the impact data uncovered by Evans *et al*. (2016) related to invasions within mainland North America, Australia and Europe, with the fewest data for those within Africa and South America (7.2% combined). A related study by Martin-Albarracin *et al*. (2015) found that most alien bird impact data were available for invasions within Europe, with little for those within Africa and South America. Evans *et al*. (2016) also found that amongst orders of alien birds, comparatively more impact data were available for Psittaciformes (parrots), possibly because the majority of alien parrot species were within North America. These results are congruent with those from a recent study examining reasons for data deficiency amongst species listed on the IUCN Red List, which found that IUCN **DD** terrestrial mammal species tend to occupy highly specific, remote habitats (Bland *et al*. 2015). Here then, **DD** alien species are expected to be those with smaller alien ranges, specific dietary and habitat preferences and relatively small brains. They would also tend to have been introduced more recently and to fewer new locations, and be established in less developed, more remote and inaccessible regions of the world. In such cases, whether or not a bird species was **DD** would potentially be unrelated to the severity of its impacts where it occurs.

Third, some species may be easier or more preferable to study, due to their specific characteristics. For example, large-brained species may receive greater research attention because they possess interesting traits relating directly to their enhanced intelligence (e.g. Lefebvre *et al*. 2002; Emery & Clayton, 2004; Sol *et al*. 2005; Maklakov *et al*. 2011; Lefebvre *et al*. 2013). Certain orders of large-brained birds (primarily Corvids (crows and allies) and Strigiformes (owls and allies)) have been found to be associated with more severe impacts (Evans *et al*. 2016). This may be due to their enhanced intelligence and behavioural flexibility, which enables them to exploit the available resources in their new surroundings more effectively (in the case of crows and owls, through predation). As species with more severe impacts tend to be more frequently studied, we may therefore have more impact data for large-brained alien birds. In support of this, in their global reviews of the impacts of alien birds, Baker *et al*. (2014) and Martin-Albarracin *et al*. (2015) found large-brained birds to be associated with more severe impacts.

Conspicuous species may also be more amenable to study because they have a higher detection probability (*sensu* McCallum, 2005). For example, nearly 90%

of the impact data found by Evans *et al*. (2016) were for species from five orders (Passeriformes (perching birds), Psittaciformes, Galliformes (gamebirds), Anseriformes (ducks, geese and swans) and Columbiformes (pigeons and doves)). Similarly, the majority of the impact data compiled by Martin-Albarracin *et al*. (2015) came from four of the same five orders. Many of the species amongst these orders are large-bodied and conspicuous. Evans *et al*. (2016) also found that amongst all orders with impact data, comparatively more data were available on the impacts of Psittaciformes, but fewer for Passeriformes. Parrots tend to be relatively large, colourful and noisy whereas, by comparison, many perching birds are small and inconspicuous (although many have distinctive songs). Large-bodied bird species have also been found to have more severe impacts in Europe (Kumschick *et al*. 2013), and as high-impact species attract research, we may know more about larger-bodied birds. Taken together, these studies suggest that **DD** species would tend to have smaller brain and body sizes, and to be less conspicuous. Again, whether or not a bird species was **DD** would potentially be unrelated to the severity of its impacts.

Here, I test a range of hypotheses (H) better to understand why impact data is available for some alien bird species, whilst others remain **DD**. Based on the factors discussed above and the results of previous studies, I expect to find proportionally more **DD** species amongst those species which: (H1) have alien ranges within less developed regions of the world; (H2) are small-bodied and less conspicuous; (H3) have smaller relative brain sizes; (H4) are specialists; (H5) have small alien ranges; (H6) are present in fewer biogeographic realms; and (H7) have shorter residence times as aliens.

3.3 Methods

3.3.1 Data

A list of 415 alien bird species, comprising 119 species with impact data and 296 **DD** species, was taken from Evans *et al*. (2016); as far as I am aware, this represents the most comprehensive global dataset on the impacts of alien birds. For this study, impact data were identified through a literature review, with **DD** species being those for which no impact information was found (for more information on the literature review methodology, see Evans *et al*. (2016)). The analysis was restricted to those alien birds for which I had a complete dataset for all predictor variables described below – a total of 344 species (107 with impact data and 237 **DD**).

I assembled data on the following variables to test each of the seven hypotheses listed in the Introduction:

H1: I used the Human Development Index (HDI) to test whether **DD** species tend to have alien ranges within less developed regions of the world. The HDI (downloaded from http://hdr.undp.org/en/2015-report on 21 November 2016) is a country-level, composite measure of achievement in three key aspects of human development: being educated, having a long and healthy life and maintaining a decent standard of living. Here it is used as a proxy for the research potential of a country. A list of countries occupied by each alien bird species was extracted from the Global Avian Invasions Atlas (GAVIA) (Dyer *et al*. 2017a), and the highest country HDI score was taken for each species. This provided a measure of the potential exposure of a species to research. Data on the impacts of alien populations of the Christmas white-eye (*Zosterops natalis*) relate only to the Cocos (Keeling) Islands, which currently does not have a published HDI. The Cocos (Keeling) Islands is a territory of Australia, so the HDI score for Australia was applied for this species.

H2: I tested whether **DD** species tend to be smaller-bodied using data on adult body mass (g), extracted from the recently published amniote life-history database (Myhrvold *et al*. 2015). Missing data for ten species were taken from Şekercioğlu (2012).

To determine whether inconspicuous species are more likely to be **DD**, I tested whether **DD** species are less likely to belong to families of birds which I considered to be conspicuous based on their broad taxonomic characteristics. I selected three families of alien birds which I considered to be inconspicuous, primarily because they comprise small to medium sized birds (Estrildidae (waxbills, munias and allies), Fringillidae (true finches) and Thraupidae (tanagers)) (n = 55), and three families which I considered to be conspicuous, because they generally comprise species that are large, colourful and have loud and distinctive calls (Psittacidae and Psittaculidae (true parrots) and Phasianidae (pheasants and allies)) (n = 92).

H3: To test whether **DD** species have smaller relative brain sizes, data on this trait (measured as the residuals of a log–log least-squares linear regression of brain mass against body mass) were taken from Sol *et al*. (2012). Using data that have been adjusted for body mass takes into account allometric effects, as larger species tend to have larger brains due to their size alone (Sol *et al*. 2005). Data were not available for 86 species, so for those species I estimated relative brain size using data from species from the closest taxonomic level within the Sol *et al*. (2012) dataset. Thus, brain size data for 47 species were calculated by taking an average for species from the same genus, 22 by taking an average for species from the same family, and 17 by taking an average for species from the same order.

H4: To test whether data deficiency is related to measures of habitat specialism, I followed Kumschick *et al*. (2013) and calculated the number of the following broad habitat types occupied by each species in its native range: marine habitats, including littoral rock and sediment; coastal habitats; inland surface waters; mires, bogs, and fens; grasslands and lands dominated by forbs, mosses or lichens; heathland, scrub, and tundra; woodland, forest, and other wooded land; inland unvegetated or sparsely vegetated habitats; regularly or recently cultivated agricultural, horticultural, and domestic habitats; constructed, industrial, and other artificial habitats. Data on habitat preferences were extracted from BirdLife International (2017). To test whether **DD** is related to measures of diet specialism, I used proportionate data on the major food types consumed by a species taken from Şekercioğlu (2012). These data were used to calculate a Simpson's Diversity Index (SDI) for each species, where $D = \sum(n/N)^2$ (n = proportion of food types utilised by a species; N = maximum number of possible food types). SDI values range between 0 and 1, with lower scores indicating more diversity (generalism) in a species dietary preferences. A worked example for the Mandarin duck (*Aix galericulata*) is provided in **Table 3.1**.

Table 3.1: Simpson's Diversity Index (SDI): worked example for diet breadth for the Mandarin duck (*Aix galericulata*).

Food type	Invertebrates	Fish	Seeds	Plants	
Proportion of diet (%)	20	10	40	30	
Proportion of diet / total proportion for food type	20 / 100 = 0.2	10 / 100 = 0.1	40 / 100 = 0.4	30 / 100 = 0.3	
Squared total	$0.2^2 = 0.04$	$0.1^2 = 0.01$	$0.4^2 = 0.16$	$0.3^2 = 0.09$	
SDI (sum of squared totals)	0.04	0.01	0.16	0.09	**SDI = 0.3**

H5: I used data on alien range sizes (km^2) from GAVIA (Dyer *et al*. 2017a) to test whether **DD** species have smaller alien range sizes.

H6: I used data from GAVIA (Dyer *et al*. 2017a) on the number of eight biogeographic realms (Afrotropics, Australasia, Indomalaya, Nearctic, Neotropics, Oceanic, Palearctic and Antarctic) occupied by each species, to test whether **DD** species are present as aliens in fewer biogeographic realms.

H7: I used data on residence time (the length of time (in years) since the first record of introduction for an established alien bird species) from GAVIA (Dyer *et al*. 2017a) to test whether **DD** species have been introduced more recently. Details on the methods used to calculate alien range sizes, number of biogeographic realms occupied and residence time are given in Dyer *et al*. (2017a).

A list of all species included in the analysis, and the data for all predictor variables described above, is provided in **Appendix D**, **Table D1**.

3.3.2 Analysis

The presence or absence of impact data for each of the 344 alien bird species was analysed as a binary response variable (0 = absence of impact data; 1 = presence). To test whether there is phylogenetic signal in data deficiency, I first downloaded 100 randomly selected phylogenetic trees (Hackett backbone) incorporating all 344 species from Birdtree.org (http://birdtree.org/subsets). The caper package (Orme *et al*. 2013) in R was used to determine the strength of the phylogenetic signal using the D statistic developed by Fritz & Purvis (2010). I compared the distribution of the binary trait across the tips of the 100 phylogenetic trees for two null models – a Brownian motion model of trait evolution and a random trait distribution model (generated by shuffling species tip values). D = 0 is the expected result under Brownian motion, whilst D = 1 infers a random distribution of data deficiency with respect to the phylogeny. I found a phylogenetic signal in data deficiency (D = 0.78, with the probability of D resulting from either Brownian phylogenetic structure or no phylogenetic structure both being 0). This necessitates using an analytical method that incorporates phylogenetic structure in the data.

I used the MCMCglmm package (Hadfield, 2010) to create linear mixed models using Bayesian Markov Chain Monte Carlo methods to account for correlated random effects arising from phylogenetic relatedness. I used a probit link function and included phylogenetic covariance between species as a random effect, setting flat, largely uninformative priors. To ensure adequate model convergence and mixing, I ran the models for 1000000 iterations with a burn-in of 2500 iterations, which maintained effective sample sizes for all estimated parameters at >1000.

Data for all predictor variables were log transformed, with the exception of habitat breadth, number of realms occupied and HDI score. HDI score data were not normally distributed and could not be normalised by log transformation. Here, I divided the data into four categories of Low (HDI score of 0 – 0.549), Medium (0.550 – 0.699), High (0.700 – 0.799) and Very High (0.800 and above), following the four formal HDI categories adopted by the United Nations Development Programme (see http://hdr.undp.org/en/composite/HDI).

The car package (Fox and Weisberg, 2011) was used to calculate variance inflation factors for all variables, to check for the potential effects of multicollinearity. I also used hierarchical partitioning (Chevan & Sutherland, 1991; Mac Nally, 1996), implemented using the hier.part package (Walsh and Mac Nally, 2013), to determine the extent to which each predictor variable was independently related to the response variable, relative to the effects of other variables analysed.

For multivariate analysis, I included only variables that demonstrated significant relationships ($P < 0.05$) during univariate analysis. Following an initial run of the multivariate model, iterative model simplification was undertaken by removing the least significant variable and rerunning the model, and repeating the process until the multivariate model contained only variables with significant terms ($P < 0.05$).

To examine the effect of conspicuousness on the availability of impact data, the actual and expected distributions of impact data availability across alien bird families were analysed using a contingency tables test (Chi-Square Test of Independence).

All statistical analyses were undertaken using RStudio version 0.99.893 (R Core Team, 2017).

3.4 Results

Univariate analysis revealed positive relationships between impact data availability and all predictor variables except diet breadth (**Table 3.2**). There were strong positive relationships ($P < 0.01$) between data availability and alien range size, relative brain size, habitat breadth, HDI, number of biogeographic realms occupied and residence time. The distribution of species with and without impact data for these variables is shown in **Figure 3.1**. There was also a weak positive relationship between data availability and body mass (**Table 3.2**). Using the car package, I found no evidence of significant collinearity between variables (all variance inflation factors <3; **Table 3.3**).

Table 3.2: Univariate analysis undertaken using the MCMCglmm package in R (Hadfield, 2010), showing relationships between the availability of data on the impacts of alien birds and eight predictor variables. Total sample size = 344 species.

	DIC	Post. mean	l-95% CI	u-95% CI	Eff. samp	pMCMC
Alien range size	308.54	0.79	0.54	1.02	4519	< 0.001 ***
Body mass	375	0.54	0.09	0.10	9975	0.024 *
Brain size	366.3	0.57	0.19	0.95	7504	0.002 **
Diet breadth	370.22	-1.17	-2.39	0.13	9975	0.065
Habitat breadth	349.81	0.42	0.23	0.62	7040	< 0.001 ***
HDI	351.68	1.38	0.64	2.13	6388	< 0.001 ***
No. realms occupied	303.91	0.73	0.50	0.97	4732	< 0.001 ***
Residence time	314.04	2.36	1.64	3.14	5821	< 0.001 ***

Iterations = 2501: 999901; Thinning interval = 100; Sample size = 9975. DIC = deviance information criterion; Post. mean = mean of posterior samples; l-95% CI and u-95% CI = lower and upper credible intervals; Eff. samp = effective sample size; pMCMC = p-value. Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

Table 3.3: Variance Inflation Factors for eight predictor variables (calculated using the car package (Fox and Weisberg, 2011)).

	Variance Inflation Factor
Alien range size	1.59
Body mass	1.17
Brain size	1.40
Diet breadth	1.04
Habitat breadth	1.07
Human Development Index (HDI)	1.14
Number of realms occupied	1.43
Residence time	1.47

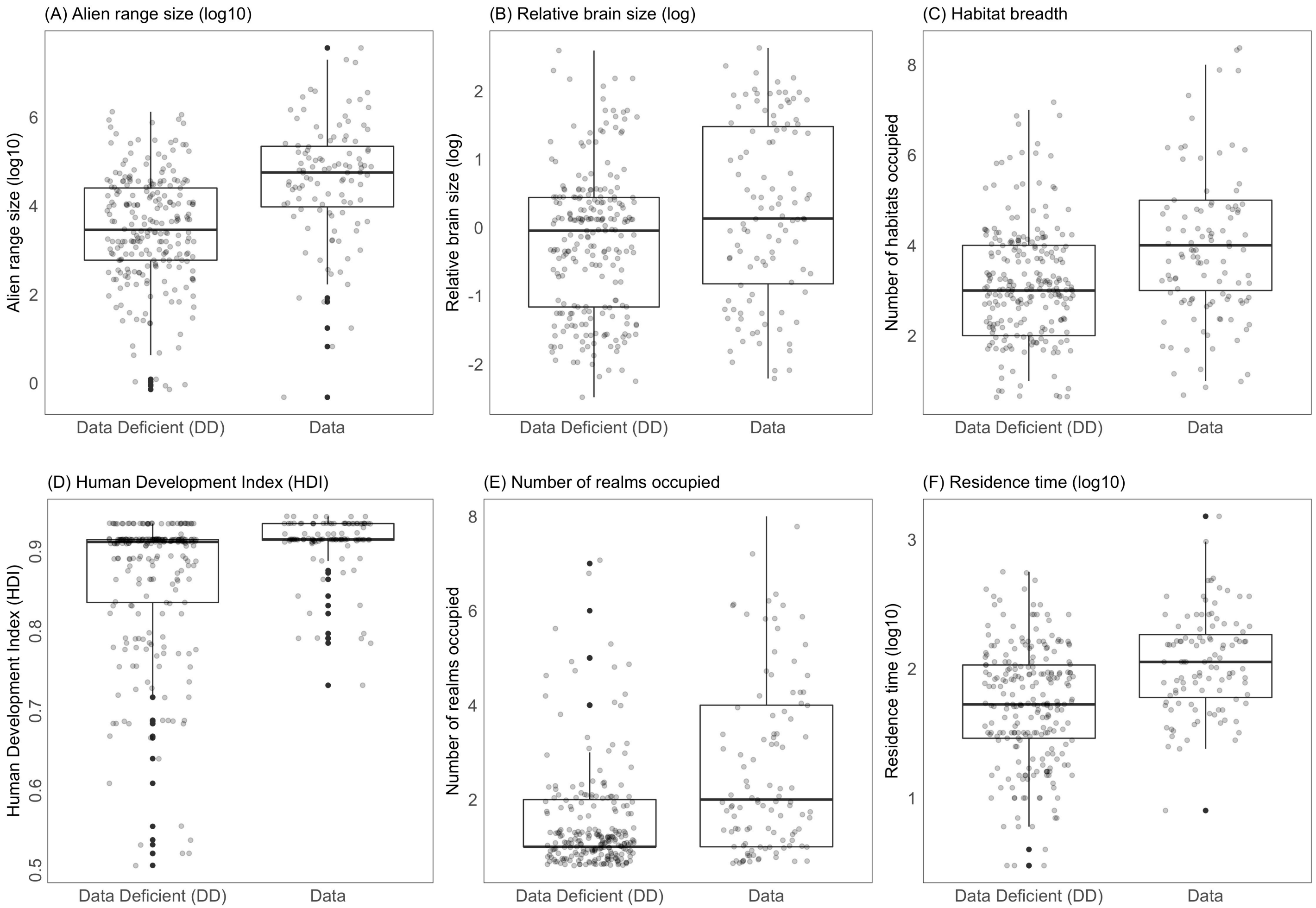

Figure 3.1: The distribution of alien bird species that are Data Deficient (**DD**) or have impact data for: (A) Alien range size; (B) Relative brain size; (C) Habitat breadth; (D) Human Development Index (HDI); (E) Number of realms occupied; (F) Residence time. **DD** species: n = 237, species with impact data: n = 107. Jitter used to add random noise to data to prevent overplotting. Boxplots show the median and first and third quartiles (the 25th and 75th percentiles), with outliers plotted individually in bold.

Following model simplification, multivariate analysis indicated that birds with impact data tend to have longer residence times than **DD** species (163.1 versus 85.4 years, on average), larger relative brain sizes (mean residual = 0.24 versus –0.21 for **DD** species) and larger alien ranges (1,017,337km^2 versus 51,393km^2 for **DD** species) (**Table 3.4**). The reduced model also indicated that we are more likely to have impact data for alien bird species that occupy more biogeographic realms as aliens (average number of realms occupied = 2.57 versus 1.48 for **DD** species), and that occupy a broader range of habitats in their native ranges (average number of habitats occupied = 3.83 versus 3.19 for **DD** species), although these relationships were weaker (**Table 3.4**). The positive univariate relationships between data availability and HDI and body mass were not recovered when controlling for other predictors. During model simplification the deviance information criterion (DIC) did not increase by >2.

Table 3.4: Multivariate analysis undertaken using the MCMCglmm package in R (Hadfield, 2010), showing significant relationships ($P < 0.05$) between the availability of data on the impacts of alien birds and predictor variables (following model simplification).

	Post. mean	**l-95% CI**	**u-95% CI**	**Eff. samp**	**pMCMC**
Intercept	-5.92	-8.17	-3.69	3843	< 0.001 ***
Alien range size	0.41	0.12	0.70	7776	0.003 **
Brain size	1.01	0.49	1.59	4150	< 0.001 ***
Habitat breadth	0.24	0.01	0.48	6355	0.035 *
Number of realms occupied	0.33	0.07	0.59	6865	0.011 *
Residence time	1.36	0.53	2.19	6652	< 0.001 ***

Iterations = 2501:999901; Thinning interval = 100; Sample size = 9975; DIC = 268.38. DIC = deviance information criterion; Post. mean = mean of posterior samples; l-95% CI and u-95% CI = lower and upper credible intervals; Eff. samp = effective sample size; pMCMC = p-value. Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

Hierarchical partitioning also identified relatively strong independent effects of alien range size, residence time and relative brain size on the availability of impact data (**Table 3.5**). Relatively large joint contributions of alien range size and number of realms occupied may arise because these two variables are correlated with each other (Pearson's product-moment correlation: r = 0.63, df = 342, P = < 0.001).

Table 3.5: Hierarchical Partitioning for the five predictor variables found to influence the availability of impact data for alien birds in multivariate analyses (calculated using the hier.part package (Walsh and Mac Nally, 2013)).

	I	I(%)	J	Total
Alien range size	14.38	28.81	13.27	27.65
Brain size	11.08	22.20	-5.50	5.58
Habitat breadth	3.87	7.75	4.23	8.10
Number of realms occupied	8.84	17.71	11.60	20.44
Residence time	11.75	23.53	8.64	20.38

I = Independent contribution of each variable; I(%) = Independent contribution of each variable as a percentage of total explained variance; J = Conjoint contribution of each variable; Total = I + J. I and J are average changes in log likelihood (direct and indirect) resulting from the addition of the variable to models not including that variable.

Data availability was also non-randomly distributed with respect to conspicuousness (χ^2 = 18.2, *df* = 1, *P* = 0.00002). More impact data were available for alien species from conspicuous bird families and less for species from inconspicuous families (**Table 3.6**).

Table 3.6: Contingency table (Chi-Square Test of Independence) showing actual and expected numbers of species with and without impact data amongst conspicuous and inconspicuous alien bird families. Expected values are displayed in italics. Individual X-squared values are displayed in (parentheses).

	Number of species without impact data (DD)	Number of species with impact data	Total number of species
Inconspicuous families (Estrildidae, Fringillidae & Thraupidae)	50 *38.54* (3.41)	5 *16.46* (7.98)	55
Conspicuous families (Psittacidae, Psittaculidae & Phasianidae)	53 *64.46* (2.04)	39 *27.54* (4.77)	92
Total	103	44	147

3.5 Discussion

Information on the environmental impacts of alien birds is not available for over 70% of species globally. However, data deficiency is not randomly distributed amongst alien birds. Three variables demonstrated consistent, strong positive relationships with impact data availability in both univariate and multivariate analysis: data deficient alien birds tend to have shorter residence times, smaller relative brain sizes and smaller alien range sizes. These results suggest that data deficiency amongst alien birds is influenced by all three of the factors proposed in the Introduction: the severity of their impacts (perceived or real), their availability for research, and their specific characteristics.

Residence time was found to be the strongest predictor of impact data availability (**Figure 3.1**, **Table 3.4**) (based on DIC values produced during univariate analysis: **Table 3.2**). This is likely to be because it influences a species' availability for research. Residence times vary substantially amongst alien birds. For example, the Seychelles fody (*Foudia sechellarum*) and Guanay cormorant (*Phalacrocorax bougainvillii*) have both had recorded alien populations for <10 years, and are **DD** (Evans *et al*. 2016) whilst alien populations of the common pheasant (*Phasianus colchicus*) and the red junglefowl (*Gallus gallus*) date back approximately 1000 and 1500 years, respectively (Dyer *et al*. 2017a), and their impacts are comprehensively recorded (Evans *et al*. 2016). The effect of residence time may reflect the time it takes for the impacts of an established alien species to be noticed and quantified – this could well be the case for species that invade remote environments away from human populations. It may also reflect the lag time between the arrival of an alien species and its establishment, spread and the eventual onset of impacts (*sensu* Crooks, 2005). That said, Aagaard & Lockwood (2014) studied invasion lags amongst 17 alien bird species, and found that lag times were relatively short (ranging from 10 to 38 years). Making generalisations based on this study, given an average residence time for **DD** alien birds of 85.4 years, it suggests that while recent alien bird arrivals may require monitoring for the onset of impacts, **DD** alien bird species with long residence periods may indeed have negligible impacts (unless they have restricted alien ranges and therefore have yet to be noticed). For example, the common waxbill (*Estrilda astrild*) and Java sparrow (*Padda oryzivora*) are both **DD**, and have residence times of over 300 years, larger than average alien ranges (422,399km^2 and 864,438km^2 respectively) and alien populations in developed regions of the world including North America and Europe (Dyer *et al*. 2017a). It is certainly conceivable that these species have low environmental impacts.

With regards to the intrinsic characteristics of alien bird species, the trait with the strongest effect on impact data availability was relative brain size (**Table 3.4**). Bird species with large brains, relative to their body mass, have been shown to be more successful at establishing in novel environments, which is argued to be due to their enhanced ecological flexibility (Sol *et al*. 2005). Large-brained birds have also been shown to possess higher levels of urban tolerance and to be more successful at establishing within urban environments due to their propensity for innovative behaviour (Maklakov *et al*. 2011). Parrots account for most of the 30 species with the largest brains in my dataset (*n* = 25), and are conspicuously successful at establishing in large urban centres (Butler, 2005; Menchetti & Mori, 2014; Pârâu *et al*. 2016). For example, the rose-ringed parakeet (*Psittacula krameri*) has established breeding populations in major urban areas across ten European countries, with a conservative European population estimate of more than 85,000 individuals (Pârâu *et al*. 2016). Other Psittaciform species with established alien populations in large cities include monk parakeets (*Myiopsitta monachus*) in New York, red-breasted parakeets (*Psittacula alexandri*) in Singapore, red-crowned parrots (*Amazona viridigenalis*) in San Diego, and rainbow lorikeets (*Trichoglossus haematodus*) and little corellas (*Cacatua sanguinea*) in Perth. This proximity to human populations may be driving research into the impacts of parrot species, and may also be one of the reasons why we have proportionately more impact data for parrots than any other order of alien birds (Evans *et al*. 2016). In this case, data deficiency would relate to availability for study and the possession of interesting traits, but would be unrelated to the severity of a species impacts. Indeed, while we have proportionately more information on the impacts of alien parrots, their impacts tend to be less severe than those caused by alien birds from other orders (Evans *et al*. 2016).

Nevertheless, there is also some evidence that relatively large-brained species may be more likely to have environmental impacts. Approximately two-thirds (*n* = 23) of the species with more severe impacts identified by Evans *et al*. (2016) (those causing declining populations, population extirpations or species extinctions) were large-brained. Indeed, of the five species allocated to the most damaging EICAT impact category (**MV**), four were large-brained: the great horned owl (*Bubo virginianus*), barn owl (*Tyto alba*), Australian masked-owl (*Tyto novaehollandiae*) and great kiskadee (*Pitangus sulphuratus*). Furthermore, of the ten alien bird species with population level impacts identified by Baker *et al*. (2014), six were large-brained (the common myna (*Acridotheres tristis*), crimson rosella (*Platycercus elegans*), Japanese white-eye (*Zosterops japonicus*), red-vented bulbul (*Pycnonotus cafer*), rose-ringed parakeet and shiny cowbird (*Molothrus bonariensis*)). Likewise, two of the three most damaging species identified by Martin-Albarracin *et al*. (2015) were large brained (the common myna and red-whiskered bulbul (*Pycnonotus jocosus*)). Although there has been no formal analysis of the effect of brain size on the magnitude of environmental impacts in birds, as we have more information on species with more severe impacts (Pyšek *et al*. 2008; Evans *et al*. 2016), we may know more about the impacts of large-brained species. Therefore, data deficiency may truly reflect low impacts amongst alien birds, and the strong effect of brain size in my analyses may be because it relates to all three factors which positively influence data availability: impact magnitude, availability for study and intrinsic interest.

The size of a species' alien range was also found to be a strong predictor of impact data availability: we have more data on the impacts of widespread alien species (**Figure 3.1**, **Table 3.4**). A species' impact has been argued to be the product of its abundance, range size and per capita impact (Parker *et al*. 1999), while range size and abundance are generally positively correlated for birds in both native (Gaston *et al*. 2000) and alien ranges (Blackburn *et al*. 2001). Therefore, the positive effect of alien range size on data availability may be because widespread species have more severe environmental impacts, and alien species with more severe impacts have been found to be more frequently studied (Pyšek *et al*. 2008; Evans *et al*. 2016). This may also explain some of the exceptions to the trend, relating to the presence of alien birds on islands, where impacts tend to be more severe (Evans *et al*. 2016). For example, despite their restricted alien ranges (all <200km^2) we have impact data for the green junglefowl (*Gallus varius*) on the Cocos (Keeling) Islands, the Australian masked-owl on Lord Howe Island, the chimango caracara (*Milvago chimango*) on Easter Island, and the American crow (*Corvus brachyrhynchos*) on Bermuda. The impacts of these species are classified as Moderate (**MO**), Major (**MR**) or Massive (**MV**) under EICAT, and these species are therefore amongst the most damaging alien birds with impact data (Evans *et al*. 2016). These effects suggest that species with recorded impacts may genuinely be those with greater impacts, and hence that data deficiency may be indicative of low impact. Lacking information on the impacts of **DD** species, it is impossible to be certain on this point, but I would predict on this basis that future research would find most **DD** alien bird species to be classified in low EICAT impact categories (Minimal Concern (**MC**) or Minor (**MN**)).

The size of a species' alien range is also likely to matter due to its influence on the availability of a species for study (**Figure 3.1**, **Table 3.4**). More than one-third (*n* = 81) of the **DD** species in my dataset have alien ranges <1000km^2 (over 1000 times smaller than the average range size for species with impacts). They include species from orders of birds known for their impacts to biodiversity, such as Sturnidae (starlings, an order including species such as the common myna which has severe documented impacts; Grarock *et al*. 2012) and Corvidae (crows and allies, an order including species such as the Indian house crow (*Corvus splendens*), the impacts of which are also well documented; Ryall, 1992). It is therefore possible that the impacts of some species have yet to be noticed due to their relatively small range sizes, and that data deficiency may not guarantee that a species has minor impacts upon biodiversity. The relative importance of range size in my models of data deficiency is likely to arise because it relates both to magnitude of impact and availability of a species for research.

The breadth of habitats occupied by a species in its native range is also positively related to impact data availability (**Figure 3.1**, **Table 3.4**). This suggests that we may know more about the impacts of generalist species that are able to occupy a broad range of habitats because they are more available for study. Similarly, the number of biogeographic realms occupied by alien birds also influences impact data availability. Some species, such as the house sparrow (*Passer domesticus*), are globally distributed, occupying all eight realms, but >60% (*n* = 211) occupy one realm alone, including the yellow-vented bulbul (*Pycnonotus goiavier*) and Palawan peacock-pheasant (*Polyplectron napoleonis*) (Dyer *et al*. 2017a). However, both of these relationships were weaker than for the other variables identified during multivariate analysis, most likely because their influence is better captured by alien range size (**Table 3.4**). The relatively large joint contributions of alien range size and number of realms occupied identified by hierarchical partitioning (**Table 3.5**) may reflect the correlation between these two variables. Nevertheless, I found proportionately more **DD** species amongst those occupying fewer habitats in their native range and fewer biogeographic realms as aliens (**Figure 3.1**), even when controlling for alien range size (**Table 3.4**). Specialist species are significantly more likely to be threatened with extinction, rare and localised (Şekercioğlu, 2011), whereas generalists that occupy more habitats or realms are likely to be more available for study, especially if those habitats or realms are associated with a hotspot of invasion research, such as Australasia.

I found proportionately more **DD** species amongst families considered to be inconspicuous (Estrildidae, Fringillidae and Thraupidae), and proportionately fewer amongst conspicuous families (Psittacidae, Psittaculidae and Phasianidae) (**Table 3.6**). This result may be influenced by the presence of parrot species in the dataset, which account for over 25% of species with impact data. Parrots tend to be conspicuous – they often have loud calls and bright plumage. However, as well as possessing large relative brain sizes and high levels of urban tolerance (Maklakov *et al*. 2011), both traits which I found to be positively associated with the availability of impact data, the alien ranges of all but one of the 28 parrot species for which we have impact data are located in North America, Australasia, Europe or Singapore. These are highly developed regions of the world with capacity for research. Given that human development was found to be a predictor of data availability in univariate analysis (**Table 3.2**), it is difficult to determine the influence of conspicuousness alone as a factor driving research into alien birds. Further, I was unable to examine the effect of conspicuousness using the MCMCglmm model because conspicuousness in birds is a combination of several traits (such as their size, shape, colour, and the loudness / distinctiveness of their calls). Therefore, the approach used (contingency tables) did not take into account the influence of phylogeny on these results, and neither could it account for covariation with other variables.

3.6 Conclusions

Our understanding of the impacts of alien birds remains compromised by the number of species that remain **DD**. This study represents one of the first attempts to identify those factors that influence the availability of impact data amongst alien birds. Whilst some of my results suggest that the impacts of many **DD** alien bird species may be minor (e.g. species with comparatively long residence times as aliens, such as the common waxbill and the Java sparrow), others suggest that data deficiency amongst alien birds may not be related to the severity of their impacts (e.g. species from orders of alien birds known to have damaging impacts but with comparatively small alien ranges, such as the New Caledonian crow (*Corvus moneduloides*)). It is therefore possible that we are overlooking the impacts of some **DD** alien birds. As the severity of impacts generated by alien birds have been found to vary from negligible, to causing declines in populations of native species and in some cases species extinctions, the next step is clearly to examine whether there are certain factors that influence the severity of impacts associated with alien birds for which impact data are available. Studies have looked at traits associated with the impacts of alien birds on a regional scale in Europe (Shirley & Kark, 2009; Kumschick & Nentwig, 2010; Kumschick *et al*. 2013) and Australia (Evans *et al*. 2014). However, such work has yet to be undertaken using a global dataset of alien bird impacts or using data from the recently published GAVIA database (Dyer *et al*. 2017a). As such, this remains an area requiring further investigation, as it may help us to identify the types of species that are likely to have more severe impacts when introduced to novel locations, including those that are currently **DD**. It may also provide further insights as to the factors that influence data availability amongst alien birds.

Chapter 4

Identifying the factors that determine the severity and type of alien bird impacts

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4.1 Abstract

Aim: To identify traits related to the severity and type of environmental impacts generated by alien bird species, in order to improve our ability to predict which species may have the most damaging impacts.

Location: Global.

Methods: Information on traits hypothesised to influence the severity and type of alien bird impacts were collated for 113 bird species. These data were analysed using mixed effects models accounting for phylogenetic non-independence of species.

Results: The severity and type of impacts generated by alien bird species are not randomly distributed with respect to their traits. Alien range size and habitat breadth were strongly associated with impact severity. Predation impacts were strongly associated with dietary preference, but also with alien range size, relative brain size and residence time. Impacts mediated by interactions with other alien species were related to alien range size and diet breadth.

Main conclusions: Widely distributed, generalist alien birds have the most severe environmental impacts. This may be because these species have greater opportunity to cause environmental impacts through their sheer number and ubiquity, but could also be because they are more likely to be identified and studied. My research found little evidence for an effect of per capita impact on impact severity.

4.2 Introduction

Recent years have seen some important advances in our understanding of the processes associated with biological invasions. In particular, the recognition that invasion is a multi-stage process has enabled the identification of traits that mediate the successful passage of species through different stages (Blackburn *et al*. 2011). For example, studies have shown that for birds, the likelihood of transport and introduction is higher for widespread and abundant species (Blackburn & Duncan, 2001) and that establishment is more likely for species with larger relative brain sizes (Sol *et al*. 2005). A recent study has also shown that bird species attain larger alien range sizes if they also have larger native range sizes, have been introduced more often and have longer residence times as aliens (Dyer *et al*. 2016).

However, less progress to date has been made regarding our understanding of the causes of variation in the impacts generated by alien birds. This may be because until recently, there has been no widely adopted standard method available to quantify and compare the impacts of alien species in general. However, this has changed with the advent of such methods as the Generic Impact Scoring System (GISS; Nentwig *et al*. 2016) and the Environmental Impact Classification for Alien Taxa (EICAT) protocol (Blackburn *et al*. 2014). These methods enable us to categorise the impacts of alien species under a standard semi-quantitative framework, which can form the basis for analyses of the factors that influence the severity and type of alien bird impacts. A recent global assessment undertaken using the EICAT protocol showed that the severity of environmental impacts generated by alien birds varies substantially, and that some species have severe impacts (Evans *et al*. 2016).

The number of bird species being introduced to new environments has increased rapidly over the last 50 years, driven by globalisation and increasing economic development (Dyer *et al*. 2017b; Seebens *et al*. 2017). Given that this trend is likely to continue (Levine & D'Antonio, 2003), and that the environmental impacts of some alien bird species can be severe, it would be useful to identify the factors that influence the severity and type of their impacts. This may help us to identify bird species that have the most damaging impacts as aliens, which in turn may enable timely management interventions to prevent or mitigate these impacts.

As far as I am aware, four studies have attempted to identify traits that may influence the severity of impacts generated by alien birds at the regional scale, three focussing on Europe (Shirley & Kark, 2009; Kumschick & Nentwig, 2010; Kumschick *et al*. 2013) and one on Australia (Evans *et al*. 2014). Two of these studies found larger-bodied birds to be associated with more severe impacts (Kumschick *et al*. 2013; Evans *et al*. 2014) suggesting that species with greater per capita resource requirements place greater demands on their new environment. Measures of generalism were also found to be linked with the impacts of alien birds, with habitat generalist species having more severe impacts in both Europe and Australia (Shirley & Kark, 2009; Kumschick *et al*. 2013; Evans *et al*. 2014), and diet generalist species having more severe impacts in Australia (Evans *et al*. 2014). Furthermore, species with large native geographic ranges (often used as a proxy for the breadth of environments that can be occupied by a species) were also found to have more severe impacts in Europe (Kumschick *et al*. 2013). This suggests that alien species able to exploit a wider range of environmental conditions have more opportunities to generate negative impacts.

A further three recent studies (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015; Evans *et al*. 2016) have categorised alien bird species in terms of their environmental impacts without explicitly testing for traits associated with impact severity or type. However, the results of these studies suggest further traits that might relate to variation in impact. For example, of the most damaging species identified in all three studies, approximately two-thirds were large-brained (relative to their body size). Further, relative brain size has been linked to higher rates of invasion success amongst alien birds (Sol and Lefebvre, 2000) and to lower rates of avian mortality (Sol *et al*. 2007). Birds with larger brains may therefore have more severe impacts because they are better able to persist in new environments. Relative brain size has also been correlated with increased abundance in UK farmland birds (Shultz *et al*. 2005) and greater levels of ecological flexibility (Sol *et al*. 2005). Therefore, birds with larger brains may have more severe impacts on the environment by placing greater demands on resources. Evans *et al*. (2016) also found that predation impacts were more severe than those caused through other impact mechanisms. Thus, dietary preference may influence the severity of impacts associated with alien birds, with carnivorous species having more severe impacts.

More generally, Parker *et al*. (1999) hypothesise that an alien species' impact should be the product of its abundance, range size and per capita impact. If so, widespread and / or abundant alien bird species may have greater impacts on the environment because they are distributed more widely and in greater numbers. Bird species with longer residence times tend to have larger alien range sizes in comparison to more recent alien arrivals (Dyer *et al*. 2016), and may have had more time to cause impacts or be studied (Evans *et al*. 2018a). It is therefore sensible to account for the effects of residence time in understanding how intrinsic traits influence alien species impacts.

Taken together, the results of these studies suggest that impact severity is influenced by traits that are intrinsic to bird species. However, as these studies were either undertaken at a limited (regional) scale (Shirley & Kark, 2009; Kumschick & Nentwig, 2010; Kumschick *et al*. 2013; Evans *et al*. 2014), or did not formally analyse relationships between impacts and traits (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015; Evans *et al*. 2016), we do not yet know whether the results apply to alien birds generally. Therefore, here I test a range of hypotheses (H) to identify the factors that influence the severity of impacts generated by alien birds. Based on the results of previous studies, I expect to find impacts to be more severe amongst species which: (H1) are large-bodied; (H2) are generalists; (H3) are carnivorous; (H4) have larger alien ranges; and (H5) have larger relative brain sizes. I include residence time as a covariate in my analyses to take into account the possibility that it increases the likelihood of alien bird impacts being observed (H6).

While some studies have addressed relationships between bird species' traits and impact severity, to my knowledge relationships between traits and the types of impacts generated by alien birds have yet to be formally examined. However, impact types have been found to vary across alien bird families (Martin-Albarracin *et al*. 2015) and orders (Evans *et al*. 2016). Furthermore, whilst related species tend to share a range of intrinsic characteristics, these traits often differ across orders and families (Bennett & Owens, 2002). As such, specific physical traits and behavioural characteristics of alien birds may be associated with specific types of impacts. Therefore, I additionally test the general hypothesis (H7) that different impact mechanisms are associated with different traits of alien bird species.

4.3 Methods

4.3.1 Data

My analysis is based on a global dataset of alien bird impacts (Evans *et al*. 2016). This dataset was generated by applying the EICAT protocol (Blackburn *et al*. 2014) to 415 bird species with alien populations identified in the recently published Global Avian Invasions Atlas (GAVIA; Dyer *et al*. 2017a). During the EICAT assessment (Evans *et al*. 2016), each bird species with an alien population was allocated to one of five EICAT impact categories based on the severity of its environmental impacts: Minimal Concern (**MC**); Minor (**MN**); Moderate (**MO**); Major (**MR**); Massive (**MV**). Each species was also allocated to one or more of the 12 EICAT impact mechanisms depending on the type of impacts it generated: (1) Competition; (2) Predation; (3) Hybridisation; (4) Transmission of disease to native species; (5) Parasitism; (6) Poisoning / toxicity; (7) Biofouling; (8) Grazing / herbivory / browsing; (9) Chemical, (10) Physical or (11) Structural impact on ecosystem; (12) Interaction with other alien species. Evans *et al*. (2016) identified alien bird impacts from nine of the 12 EICAT mechanisms (all except (6) Poisoning / toxicity; (7) Biofouling; and (9) Chemical impact on ecosystem). During the EICAT assessment, data on impacts were available for 119 of the 415 species, with the rest being categorised as Data Deficient (**DD**). A summary of the EICAT assessment results can be found in **Appendix C**, **Table C1**.

I collated data on the following nine variables (here numbered v1 to v9) to test the hypotheses listed in the Introduction:

H1: I tested whether larger species tend to have more severe impacts using data on adult body mass (g; v1) taken from Myhrvold *et al*. (2015).

H2: To test whether diet or habitat generalist species are more damaging, I calculated the number of major food types consumed by each species (diet breadth; v2), and the number of major habitat types occupied by each species in its native range (habitat breadth; v3). A list of food and habitat types is provided in **Table 4.1**. This approach follows that adopted for two previous studies on the impacts of alien birds in Europe (Kumschick *et al*. 2013) and Australia (Evans *et al*. 2014) enabling direct comparisons to be made with the results of these studies.

Table 4.1: Diet and habitat breadth assessment details

Major food types used for diet breadth analysis	Grasses / forbs Seeds / grains Fruits / berries Pollen / nectar / flowers Tree leaves / branches / bark Roots / tubers Invertebrate prey Vertebrate prey / carrion
Major habitat types used for habitat breadth analysis	Marine habitats, including littoral rock and sediment Coastal habitats Inland surface waters Mires, bogs, and fens Grasslands and lands dominated by forbs, mosses or lichens Heathland, scrub, and tundra Woodland, forest, and other wooded land Inland unvegetated or sparsely vegetated habitats Regularly or recently cultivated agricultural, horticultural, and domestic habitats Constructed, industrial, and other artificial habitats
Data sources used to collate information on diet and habitat preferences of alien birds	Audubon Guide to North American Birds (www.audubon.org/bird-guide) BirdLife Australia (www.birdlife.org.au) BirdLife International (www.birdlife.org) British Garden Birds (www.garden-birds.co.uk) British Trust for Ornithology (www.bto.org) Cornell Lab of Ornithology All About Birds Database (www.allaboutbirds.org) Handbook of the Birds of the World Alive (www.hbw.com) New Zealand Birds Online (www.nzbirdsonline.org.nz)

To further assess the effect of generalism on impact severity, I used data on the size of a species' native breeding range (km^2; v4) (as a proxy for the breadth or ubiquity of the environmental conditions that can be utilised by a species), taken from GAVIA (Dyer *et al*. 2017a).

H3: To examine the effect of carnivory on impact severity, I used proportionate data on the types of food consumed by each species (Şekercioğlu, 2012), to calculate: the proportion of a species diet comprising animal matter (both vertebrate and invertebrate prey; v5); and the proportion of a species diet comprising vertebrate prey (v6).

H4**:** To test whether widespread alien species have more severe impacts, I used alien range size data (km^2; v7) taken from GAVIA (Dyer *et al*. 2017a). I would also predict that impacts should be more severe for abundant alien species. However, data on alien range abundance (either population size or density) are available for relatively few bird species, and therefore I did not pursue abundance analyses.

H5: To investigate whether alien birds with larger brains have greater impacts, brain size data (relative to body mass; v8) were taken from Sol *et al*. (2012). Where these data were unavailable (11 species), I calculated brain size data using averages for species from the closest taxonomic level within the Sol *et al*. (2012) dataset. Thus, brain sizes for seven species were calculated using data from species of the same genus (dusky-headed parakeet (*Aratinga weddellii*), wandering whistling-duck (*Dendrocygna arcuate*), black-rumped waxbill (*Estrilda troglodytes*), Spanish sparrow (*Passer hispaniolensis*), Chilean flamingo (*Phoenicopterus chilensis*), light-vented bulbul (*Pycnonotus sinensis*) and vinous-breasted starling (*Sturnus burmannicus*)); one using species of the same family (Madagascar turtle-dove (*Nesoenas picturata*)); and three using species of the same order (Japanese bush-warbler (*Cettia diphone*), red-fronted parakeet (*Cyanoramphus novaezelandiae*) and velvet-fronted nuthatch (*Sitta frontalis*)).

H6: To determine whether impact severity is related to the length of time a species has been resident as an alien, I used data on the number of years since the first record of introduction for a species from GAVIA (Dyer *et al*. 2017a) as a measure of residence time (v9). The methods used to calculate residence times and native and alien range sizes are described in Dyer *et al*. (2017a).

H7: To test whether the types of impacts generated by alien birds are influenced by their traits, I used data on all nine variables described above. During the EICAT assessment undertaken for birds (Evans *et al*. 2016), no impacts were allocated to three of the 12 EICAT mechanisms, and a further six EICAT mechanisms only received a small number of impact allocations (13 or fewer allocations for each mechanism). Therefore these nine mechanisms were discounted from the analysis, which was restricted to the three remaining EICAT mechanisms: Competition (59 impact allocations), Predation (25) and Interaction with other alien species (18; for alien birds this mechanism was found to relate solely to impacts associated with the dispersal of seeds of alien plants).

For competition impacts, I tested relationships with all variables except dietary preference. Birds with larger brains have been shown to possess higher levels of ecological flexibility (Sol *et al*. 2005). Therefore, because they are better able to exploit the resources available to them, I expect large-brained birds to be effective competitors. Larger birds may have an advantage over smaller species when it comes to competition for resources (Morse, 1974; Peters, 1983; Donadio & Buskirk, 2006). Generalist birds, more widespread species, and those with longer residence times are more likely to have come into contact with, and compete with other species.

For predation impacts, I tested for relationships with all variables except diet breadth. Orders and families of alien birds with large brains, including Strigiformes, Falconiformes (falcons) and Corvidae (crows and allies) were found to be associated with predation impacts by Evans *et al*. (2016). Predators are often large-bodied species (e.g. Accipitriformes (hawks, eagles and allies), Falconiformes and Strigiformes) (Therrien *et al*. 2014; Evans *et al*. 2016). Predators are expected by definition to be carnivorous (e.g. Van der Vliet *et al*. 2008; Evans *et al*. 2016). Habitat generalists, more widespread species, and those with longer residence times are more likely to have come into contact with, and predated upon other species.

For interaction (alien seed dispersal) impacts, I tested relationships with habitat and diet generalism, range size and residence time, because these traits may influence the opportunity to generate impacts, and also because more diverse diets may include fruits and seeds. I also tested for an effect of relative brain size, as the ecological flexibility of large-brained species suggests that they may be better at exploiting the resources available to them by having diverse diets that may include fruit and seeds.

A list of all species included in the analysis, and the data for all predictor variables described above, is provided in **Appendix E**, **Table E1**.

4.3.2 Analysis

I included in my analysis only those species for which I had data on all nine variables described above (113 species: **Appendix E**, **Table E1**). Due to the relatively small size of my impact dataset, impact severity data were converted into a two-level response variable: less severe impacts (those categorised as either Minimal Concern (**MC**) or Minor (**MN**) under the EICAT protocol) = 76 species; more severe impacts (those categorised as Moderate (**MO**), Major (**MR)** or Massive (**MV**)) = 37 species. This divided impacts such that less severe impacts are those that are negligible or only affect the fitness of individuals of native species, and more severe impacts are those that, as a minimum, cause declines in populations of native species, or worse, cause local population extirpations or species extinctions. To test the effect of traits on the types of impacts generated by alien birds, for each species, data on each EICAT impact mechanism was divided into a two-level response variable (e.g. for competition impacts: 0 = no competition impact; 1 = competition impact).

My dataset considers traits that are well known to show strong phylogenetic signal (e.g. body mass). Furthermore, different bird taxa have been shown to be associated with specific types of impact (e.g. Evans *et al*. 2016). I therefore expected to find evidence for phylogenetic autocorrelation in my analysis (*sensu* Münkemüller *et al*. 2012). To address this, I used Birdtree.org (http://birdtree.org/subsets) to download 100 randomly selected phylogenetic trees incorporating the 113 species in my dataset. I then tested for phylogenetic signal in impact severity, using the caper package in R (Orme *et al*. 2013) to calculate the D statistic (Fritz & Purvis, 2010) for each phylogenetic tree. I identified phylogenetic signal in impact severity in my dataset (average D = 0.74; range 0.7 – 0.79) with a low probability of D resulting from either Brownian phylogenetic structure (average $P < 0.001$; range 0 – 0.005) or no phylogenetic structure (average $P = 0.026$; range 0.009 – 0.055). I therefore examined the relationships between each of the nine predictor variables and the severity and type of impacts generated by alien bird species using phylogenetic linear regression (the phylolm package in R: Ho & Ane, 2014) to account for potential phylogenetic relatedness amongst species.

I analysed each variable independently, and then undertook multivariate analysis for all variables. After each run of the multivariate model, I removed the least significant variable, repeating the process until the simplified model contained only variables with significant terms ($P < 0.05$). I checked for multicollinearity amongst the nine predictor variables using the car package in R (Fox and Weisberg, 2011), finding no evidence for this (**Table 4.2**).

Table 4.2: Variance Inflation Factors for predictor variables (calculated using the car package in R; Fox and Weisberg, 2011).

Predictor variable	Variance Inflation Factor
Alien range size	1.647
Body mass	1.360
Brain size	1.505
Diet breadth	1.244
Diet preference (proportion animal matter)	1.746
Diet preference (proportion vertebrate prey)	1.906
Habitat breadth	1.266
Native range size	1.289
Residence time	1.433

Data for body mass, relative brain size, native and alien range size and residence time were log transformed for analysis. All statistical analyses were undertaken using RStudio version 0.99.893 (R Core Team, 2017).

4.4 Results

Univariate analysis revealed positive relationships ($P < 0.01$) between impact severity and five predictor variables (native and alien range size, diet and habitat breadth and residence time): bird species had more severe impacts if they had larger native and alien ranges, broader habitat and dietary preferences and longer residence times (**Table 4.3**). These relationships were significant for all 100 phylogenies used. I also found a positive relationship ($P < 0.05$) between impact severity and dietary preference (the proportion a species diet comprising vertebrate prey); this effect was significant on average, but not over all the phylogenies analysed (**Table 4.3**). The distribution of species with less severe impacts (Minimal Concern (**MC**) or Minor (**MN**)) and more severe impacts (Moderate (**MO**), Major (**MR**) or Massive (**MV**)) for these variables is shown in **Figure 4.1** (these plots do not account for potential phylogenetic relatedness of the species in my dataset). I found no relationships between impact severity and body mass, relative brain size or the proportion of a species diet comprising animal matter (invertebrate and vertebrate prey) (**Table 4.3**), albeit that a positive relationship to body mass was observed over some of the phylogenies used.

Table 4.3: The relationships between the severity of impacts generated by alien birds and predictor variables. All parameters in this table derive from phylogenetic linear regression using the phylolm package in R (Ho & Ane, 2014) to account for potential autocorrelation among species due to their phylogenetic relatedness. Results are the mean values for 100 phylogenies (lower and upper confidence limits (2.5% & 97.5%) are also provided in parentheses). Significant relationships (*P* < 0.05) are highlighted in bold. Total sample size = 113 species.

Predictor variable	Estimate	Std. Error	P
Alien range size	**0.062** (0.041 – 0.077)	**0.017** (0.015 – 0.019)	**0.001** ** (< 0.001 *** – 0.006 **)
Body mass	0.236 (0.108 – 0.392)	0.162 (0.139 – 0.182)	0.180 (0.021 * – 0.503)
Brain size	0.017 (-0.061 – 0.090)	0.126 (0.117 – 0.139)	0.798 (0.483 – 0.988)
Diet breadth	**0.116** (0.084 – 0.157)	**0.033** (0.029 – 0.035)	**0.003** ** (< 0.001 *** – 0.009 **)
Diet preference (animal matter)	0.003 (0.001 – 0.004)	0.003 (0.002 – 0.003)	0.368 (0.155 – 0.669)
Diet preference (vertebrates)	**0.014** (0.010 – 0.018)	**0.007** (0.006 – 0.007)	**0.047** * (0.007 ** – 0.139)
Habitat breadth	**0.118** (0.091 – 0.150)	**0.027** (0.024 – 0.030)	**0.002** ** (< 0.001 *** – < 0.009 **)
Native range size	**0.170** (0.109 – 0.237)	**0.047** (0.041 – 0.054)	**0.007** ** (< 0.001 *** – 0.030 *)
Residence time	**0.204** (0.107 – 0.309)	**0.066** (0.051 – 0.078)	**0.008** ** (< 0.001 *** – 0.042 *)

Estimate = Estimated Coefficient; Std. Error = Standard Error; Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

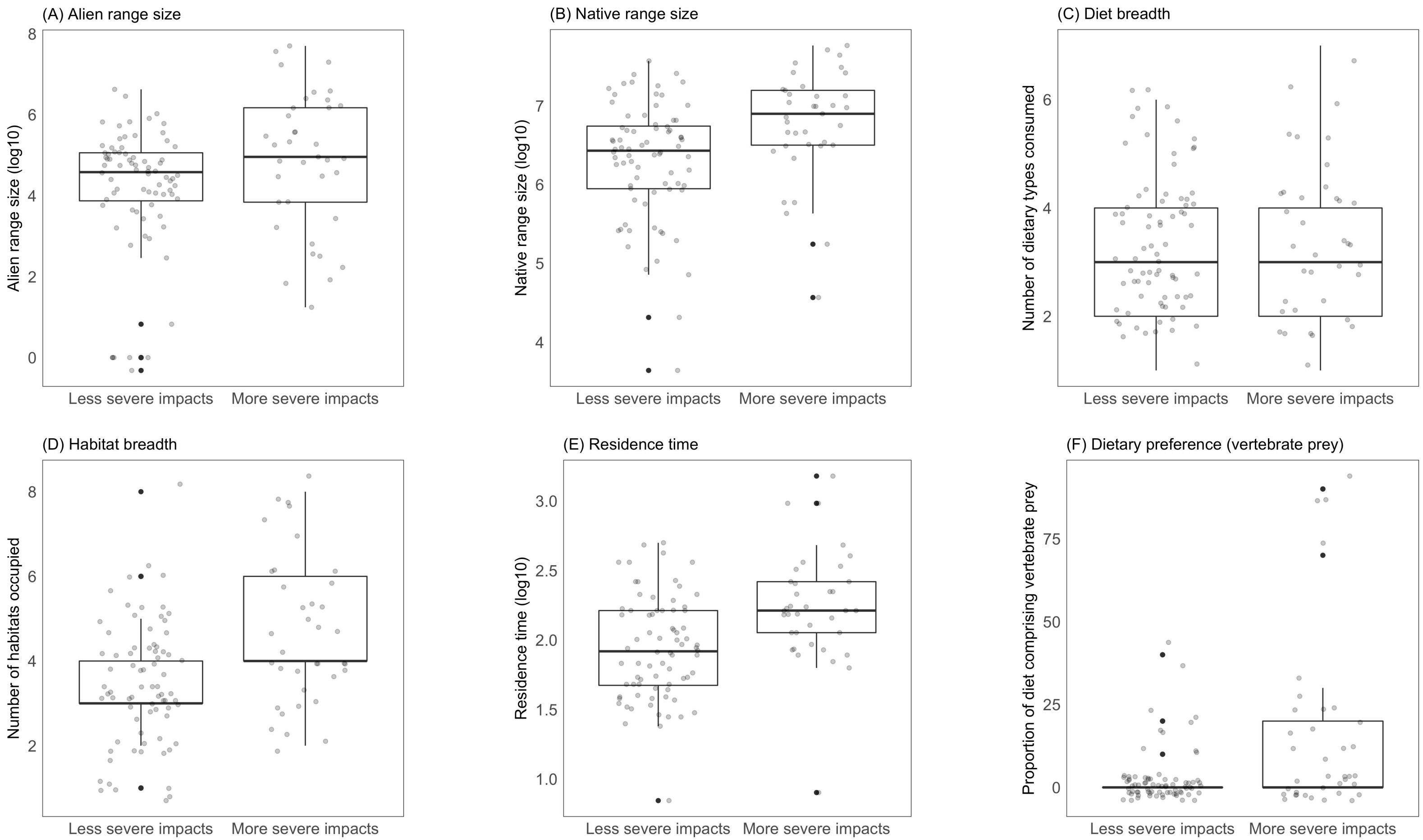

Figure 4.1: The distribution of alien bird species generating 'less severe' and 'more severe' impacts for: (A) Alien range size (km^2); (B) Native range size (km^2); (C) Diet breadth (number of dietary types consumed); (D) Habitat breadth (number of habitats occupied); (E) Residence time (number of years since first introduction); (F) Dietary preference (proportion of diet comprising vertebrate prey). Species with less severe impacts: n = 76, species with more severe impacts: n = 37. Jitter used to add random noise to data to prevent overplotting. Boxplots show the median and first and third quartiles (the 25th and 75th percentiles), with outliers plotted individually in bold.

Following model simplification, multivariate analysis indicated that birds generating more severe impacts have larger alien ranges (on average approximately 20 times the size of those for species with less severe impacts) and occupy a greater breadth of habitats in their native range (an average of 4.7 habitats for species with more severe impacts versus 3.4 for species with less severe impacts) (**Table 4.4**). The positive univariate relationships between impact severity and native range size, diet breadth, diet preference (the proportion of a species diet comprising vertebrate prey) and residence time were not recovered when controlling for other predictors.

Table 4.4: Multivariate analysis showing significant relationships (*P* < 0.05) following model simplification, between the severity of impacts generated by alien birds and predictor variables. All parameters in this table derive from phylogenetic linear regression using the phylolm package in R (Ho & Ane, 2014) to account for potential autocorrelation among species due to their phylogenetic relatedness. Results are the mean for 100 phylogenies (lower and upper confidence limits (2.5% & 97.5%) are also provided in parentheses). Total sample size = 113 species.

Predictor variable	Estimate	Std. Error	P
Alien range size	0.054 (0.039 – 0.064)	0.016 (0.014 – 0.018)	0.002 ** (< 0.001 *** – 0.007 **)
Habitat breadth	0.108 (0.080 – 0.138)	0.026 (0.023 – 0.029)	0.003 ** (< 0.001 *** – 0.003 **)

Estimate = Estimated Coefficient; Std. Error = Standard Error; Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

I did not find evidence in support of any consistent relationships between competition impacts and predictor variables in either univariate or multivariate analysis, albeit that negative effects of alien range size, body mass, relative brain size and diet breadth were recovered for some of the phylogenies used (**Table 4.5**).

Univariate analysis revealed positive relationships (*P* < 0.001) between predation impacts and alien range size and dietary preference (the proportion of a species diet comprising animal matter) (**Table 4.5**). I also found positive relationships (*P* < 0.05) (though inconsistent across phylogenies) between predation impacts and brain size, dietary preference (the proportion of a species diet comprising vertebrate prey) and residence time (**Table 4.5**). Multivariate analysis for predation impacts revealed a positive relationship (*P* < 0.001) with dietary preference (the proportion of a species diet comprising animal matter), which was recovered across all 100 phylogenies used. This analysis also identified positive effects of alien range size, relative brain size and residence time, along with a negative effect of native range size, albeit that these relationships were not recovered across all phylogenies used (**Table 4.6**).

Univariate analysis did not reveal any significant relationships between interaction (alien seed dispersal) impacts and predictor variables (**Table 4.5**). However, in multivariate analysis, a consistent negative relationship (*P* < 0.01) with alien range size was identified, along with a positive relationship (*P* < 0.05) with diet breadth (**Table 4.6**).

Table 4.5: Univariate analysis showing relationships between the types of impacts generated by alien birds and predictor variables. All parameters in this table derive from phylogenetic linear regression using the phylolm package in R (Ho & Ane, 2014) to account for potential autocorrelation among species due to their phylogenetic relatedness. Results are the mean for 100 phylogenies (lower and upper confidence limits (2.5% & 97.5%) are also provided in parentheses). Significant relationships (*P* < 0.05) are highlighted in bold. Nine of the 12 formal EICAT impact mechanisms were discounted from the analysis because they either had low numbers of impacts allocated to them, or none: Hybridisation (13 allocated impacts), Grazing / herbivory / browsing (10), Transmission of disease to native species (seven), Parasitism (one), Chemical impact on ecosystem (one), Structural impact on ecosystem (one), Poisoning / toxicity (none), Biofouling (none) and Physical impact on ecosystem (none). Sample size: Competition = 59 allocated impacts; Predation = 25 allocated impacts; Interaction with other alien species (alien seed dispersal) = 18 allocated impacts.

EICAT impact mechanism	Predictor variable	Estimate	Std. Error	P
Competition	Alien range size	-0.034 (-0.091 – -0.001)	0.019 (0.017 – 0.021)	0.205 (< 0.001 *** – 0.862)
	Body mass	-0.177 (-0.401 – 0.090)	0.173 (0.146 – 0.208)	0.337 (0.020 * – 0.874)
	Brain size	-0.225 (-0.447 – -0.069)	0.133 (0.123 – 0.153)	0.148 (0.003 ** – 0.601)
	Diet breadth	-0.053 (-0.117 – -0.020)	0.036 (0.032 – 0.043)	0.193 (0.004 ** – 0.578)
	Habitat breadth	0.017 (-0.008 – 0.060)	0.031 (0.027 – 0.036)	0.596 (0.102 – 0.946)
	Native range size	-0.041 (-0.097 – -0.009)	0.053 (0.047 – 0.062)	0.488 (0.080 – 0.878)
	Residence time	0.024 (-0.010 – 0.054)	0.074 (0.055 – 0.095)	0.738 (0.470 – 0.958)
Predation	**Alien range size**	**0.053** (0.033 – 0.075)	**0.012** (0.010 – 0.013)	**< 0.001 ***** (< 0.001 *** – 0.002)
	Body mass	0.131 (0.075 – 0.184)	0.113 (0.093 – 0.131)	0.259 (0.151 – 0.439)
	Brain size	**0.206** (0.140 – 0.273)	**0.085** (0.071 – 0.098)	**0.022 *** (0.003 ** – 0.057)
	Diet preference (animal matter)	**0.009** (0.007 – 0.011)	**0.002** (0.002 – 0.002)	**< 0.001 ***** (< 0.001 *** – < 0.001 ***)
	Diet preference (vertebrates)	**0.010** (0.008 – 0.011)	**0.005** (0.004 – 0.005)	**0.040 *** (0.015 * – 0.074)
	Habitat breadth	-0.001 (-0.009 – 0.007)	0.020 (0.016 – 0.024)	0.865 (0.658 – 0.985)
	Native range size	-0.026 (-0.043 – -0.012)	0.035 (0.028 – 0.041)	0.462 (0.265 – 0.726)
	Residence time	**0.103** (0.052 – 0.171)	**0.047** (0.035 – 0.056)	**0.049 *** (0.002 ** – 0.168)
Interaction (alien seed dispersal)	Alien range size	-0.025 (-0.038 – -0.015)	0.012 (0.010 – 0.014)	0.057 (0.004 ** – 0.187)
	Brain size	-0.047 (-0.064 – -0.028)	0.086 (0.074 – 0.099)	0.583 (0.467 – 0.745)
	Diet breadth	0.037 (0.023 – 0.050)	0.023 (0.019 – 0.026)	0.121 (0.055 – 0.233)
	Habitat breadth	-0.003 (-0.011 – 0.005)	0.020 (0.016 – 0.023)	0.822 (0.617 – 0.994)
	Native range size	0.023 (0.002 – 0.044)	0.034 (0.028 – 0.040)	0.521 (0.239 – 0.910)
	Residence time	0.008 (-0.003 – 0.020)	0.047 (0.036 – 0.057)	0.857 (0.717 – 0.983)

Estimate = Estimated Coefficient; Std. Error = Standard Error; Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

Table 4.6: Multivariate analysis showing significant relationships (*P* < 0.05) following model simplification, between predation and interaction (alien seed dispersal) impacts and predictor variables. All parameters in this table derive from phylogenetic linear regression using the phylolm package in R (Ho & Ane, 2014) to account for potential autocorrelation among species due to their phylogenetic relatedness. Results are the mean for 100 phylogenies (lower and upper confidence limits (2.5% & 97.5%) are also provided in parentheses). Sample size: Predation = 25 allocated impacts; Interaction with other alien species (alien seed dispersal) = 18 allocated impacts.

EICAT impact mechanism	Predictor variable	Estimate	Std. Error	P
Predation	Alien range size	0.031 (0.013 – 0.044)	0.013 (0.011 – 0.015)	< 0.001 *** (< 0.001 *** – 0.218)
	Brain size	0.119 (0.079 – 0.164)	0.074 (0.065 – 0.082)	< 0.001 *** (< 0.001 *** – 0.251)
	Diet preference (animal matter)	0.008 (0.006 – 0.009)	0.002 (0.002 – 0.002)	< 0.001 *** (< 0.001 *** – < 0.001 ***)
	Native range size	-0.042 (-0.064 – -0.018)	0.033 (0.028 – 0.038)	< 0.001 *** (< 0.001 *** – 0.574)
	Residence time	0.077 (0.028 – 0.129)	0.055 (0.046 – 0.063)	< 0.001 *** (< 0.001 *** – 0.618)
Interaction (alien seed dispersal)	Alien range size	-0.037 (-0.052 – -0.025)	0.013 (0.010 – 0.014)	0.009 ** (< 0.001 *** – 0.045 *)
	Diet breadth	0.063 (0.039 – 0.084)	0.024 (0.020 – 0.027)	0.015 * (0.001 ** – 0.062)

Estimate = Estimated Coefficient; Std. Error = Standard Error; Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

4.5 Discussion

Due to increasing globalisation and international trade, the number of animals and plants being introduced to new environments has increased markedly over the last century (Perrings *et al*. 2002; Hulme *et al*. 2009). Studies suggest this development is set to continue (Levine & D'Antonio, 2003), that we have yet to reach a global saturation point for alien introductions (Seebens *et al*. 2017), and that birds are no exception to this trend (Dyer *et al*. 2017b). Given that the environmental impacts of some alien birds can be severe, causing declines in populations of native species, and in some cases contributing to native species extinctions (Evans *et al*. 2016), it is important that we develop and implement a full range of measures to identify and manage their impacts (Kumschick *et al*. 2015a). Regional studies in Europe and Australia (Kumschick & Nentwig, 2010; Kumschick *et al*. 2013; Evans *et al*. 2014) have linked the impacts of alien birds to the traits that they possess. Here I extend this research by identifying traits that correlate with alien bird impacts on a global scale. Of the variables tested, I find that alien range size and habitat breadth are strongly associated with impact severity – it is widely distributed, generalist alien birds that have the most severe environmental impacts.

Alien range size was found to be the strongest predictor of impact severity, with positive relationships found during both univariate and multivariate analyses (**Tables 4.3** & **4.4**, **Figure 4.1**). This result was presaged by the equation proposed by Parker *et al*. (1999) whereby the impact of an alien species depends on its alien geographic range size, abundance and per capita impact. Of the 37 species causing the most severe impacts globally (Moderate (**MO**), Major (**MR**) or Massive (**MV**)), 26 have comparatively large alien ranges of over 30,000km^2. This suggests that widely distributed alien birds have greater opportunity to cause environmental impacts, increasing the chances that some of these impacts will be severe. For example, the common myna (*Acridotheres tristis*) is a widely distributed alien species (alien range = *c*.2.3 million km^2) that generates a range of environmental impacts. In Australia, it competes with native birds including the crimson rosella (*Platycercus elegans*) (Grarock *et al*. 2012); in Tahiti, it predates upon the eggs of the Tahiti flycatcher (*Pomarea nigra*) (Blanvillain *et al*. 2003); and in Hawaii, it spreads the seeds of the alien banana poka (*Passiflora* *mollissima*) (Lever, 2005). I also found a positive association between alien range size and predation impacts in both univariate and multivariate analysis (**Tables 4.5** & **4.6**). On average, alien bird predation impacts have been found to be more severe than for other impact mechanisms (Evans *et al*. 2016), which may in part explain why alien range size is associated with impact severity.

Habitat generalism was also found to be positively associated with impact severity in both univariate and multivariate analysis, and across all the phylogenetic hypotheses analysed (**Tables 4.3** & **4.4**, **Figure 4.1**). Alien bird species have more severe impacts if they occupy a broader range of habitats in their native range. Previous studies have found habitat generalism to be associated with more severe alien bird impacts in Europe (Shirley & Kark, 2009; Kumschick & Nentwig, 2010; Kumschick *et al*. 2013) and Australia (Evans *et al*. 2014), and here I confirm this result globally. Of those species causing more severe impacts (Moderate (**MO**), Major (**MR**) or Massive (**MV**)), more than 75% are habitat generalist species occupying four or more of the 10 habitat types identified for analysis. The effect of habitat breadth is likely to arise because habitat generalist birds are able to survive in a broader range of environments, and therefore have more opportunity to generate impacts. Habitat generalist species with documented impacts include the swamp harrier (*Circus approximans*), which is implicated in the extinction of the Polynesian Imperial-pigeon (*Ducula aurorae wilkesii*) and the extirpation of blue lorikeet (*Vini peruviana*) populations on Tahiti (Shine *et al*. 2003). Univariate analysis also identified relationships between impact severity and other measures of generalism (native range size and diet breadth: **Table 4.3**, **Figure 4.1**), albeit that these did not retain their effects in multivariate analysis.

My analyses suggest that the extent of an alien bird species distribution (both in terms of range size and diversity of habitats occupied) increases the likelihood that it has more severe documented environmental impacts. Given that distributional extent is generally correlated with abundance in native (Gaston & Blackburn, 2000; but see Novolosov *et al*. 2017) and alien birds (Blackburn *et al*. 2001), I would also expect to see a relationship between impact severity and abundance, were sufficient data available to analyse it. I find less evidence for a likely effect of per capita impact. Notably, there is no effect of body mass on impact severity in univariate or multivariate analysis (**Tables 4.3** & **4.4**), or indeed on the likelihood that species impose deleterious predation, competition or interaction impacts on their new environment (**Tables 4.5** & **4.6**). Body mass is positively associated with per capita resource requirements across species (Peters, 1983), but the effect of this variation may be minor compared to the effects of variation in the numbers of alien individuals exploiting native resources.

The tendency for the impacts of alien birds to be more severe on islands when compared to continents (Evans *et al*. 2016) may also partly explain the positive effect of range size on impact severity. All nine bird species that have caused native species extirpations and extinctions (Major (**MR**) or Massive (**MV**) impacts) have done so on islands. Of the 26 species with large alien ranges (>30,000km^2), nearly 60% cause impacts on islands. These species include the red-whiskered bulbul (*Pycnonotus jocosus*; alien range = 76,111km^2) which, through predation, is considered to be responsible for the disappearance of large spiders of the genus *Neophilia* on Mauritius (Diamond, 2009; Linnebjerg *et al*. 2010), and the barn owl (*Tyto alba*; 36,947km^2), which, through competition, is implicated in the extinction of the Lord Howe Island boobook (*Ninox novaeseelandiae albaria*) (Garnett *et al*. 2011). Therefore, alien range size may also be correlated with impact severity because widely distributed alien birds are more likely to have been introduced to islands.

However, the strong positive relationship between alien range size and impact severity may arise because widely distributed alien birds are more likely to have their impacts identified and recorded. A recent study (Evans *et al*. 2018a) found alien range size to be a strong predictor of the availability of impact data for alien birds, with more data available for species with larger alien ranges. Larger alien range size may increase the likelihood that a species is introduced to regions of the world that are hotspots of invasive species research. For example, more than half of the alien bird species identified as causing the most severe impacts globally (Major (**MR**) or Massive (**MV**) impacts) do so in Australia or New Zealand. Both of these countries have been severely affected by the impacts of alien species (see Allen & Lee, 2006; Invasive Animals CRC, 2017). It is possible that a climate of heightened awareness and sensitivity to the impacts of alien species, within a developed region with capacity for alien species research, has resulted in the careful scrutiny of alien species impacts in these regions. The impacts of alien birds may not necessarily be higher there than elsewhere, but may be more likely to be studied.

With regard to impact mechanisms, the effect of alien geographic range size on data availability may also explain its positive relationship with predation impacts, but not its negative relationship with interaction (alien seed dispersal) impacts (**Table 4.6**). The average alien range size for species with interaction impacts in my dataset is approximately five times smaller than that for all alien bird species. Almost a quarter of the birds with seed dispersal impacts have alien ranges restricted solely to islands, including the silvereye (*Zosterops lateralis*; Tahiti and Kiribati), the Japanese bush-warbler (*Cettia diphone*; Hawaii) and the smooth-billed ani (*Crotophaga ani*; the Galapagos Islands). It seems unlikely that alien birds only disperse alien plant seeds on islands, but it is possible that this dispersal has larger negative effects on islands where the native flora is depauperate, and where extinctions may have disproportionately removed native seed dispersers. Szabo *et al*. (2012) found avian bird extinctions to be most severe on islands, with specific foci for extinctions including the Hawaiian Islands, Mascarene Islands and French Polynesia. Island ecosytems are considered to be particularly vulnerable to the loss of seed dispersal agents, because of their often highly asymetric seed-dispersal networks (Schleuning *et al*. 2014). For example, in Hawaii, a recent study showed that patterns of seed dispersal have been significantly altered following the eradication of native frugivores. In their absence, alien species do not serve as functional replacements, instead dispersing the seeds of an invasive alien plant and fewer seeds of native plants (90% of seeds being from two ubiquitous species) (Pejchar, 2015). Seed disperal impacts were also found to be positively associated with diet breadth. This may be because alien birds with catholic diets are more likely to consume seeds and berries, and are therefore more likely to become seed dispersal agents.

Predation impacts were found to be most strongly associated with the amount of animal matter (both invertebrate and vertebrate) consumed by a species, a relationship that is recovered in both univariate and multivariate analysis, and across all 100 phylogenies used in the analysis (**Tables 4.5** & **4.6**). This relationship is unsurprising as predation is, by definition, the consumption of animal matter. However, predation impacts were more strongly associated with species consuming both vertebrates and invertebrates than for species whose diet consists solely of vertebrate prey (**Tables 4.5** & **4.6**). This suggests that predation impacts are not confined just to 'classic' carnivores such as owls, hawks and falcons, but that more catholic or omnivorous bird species may be a threat to native faunas. For example, the diet of the African sacred ibis (*Threskiornis aethiopicus*) includes insects, amphibians, reptiles, fish and small mammals (BirdLife International, 2016a), and this species is on the list of invasive alien species of European Union concern (European Commission, 2016). The impacts of omnivorous alien birds can be severe – for example, the great kiskadee (*Pitangus sulphuratus*) and the red-whiskered bulbul are both reported to have eradicated invertebrates (Department of Environment and Natural Resources (Bermuda), 2017; Diamond, 2009; Linnebjerg *et al*. 2010). The impacts of alien birds on invertebrates may be underestimated, as species extinctions in these groups are not widely reported, and the threat status of invertebrate species is often poorly understood in comparison to other taxa (Bland *et al*. 2017). The impacts of catholic species may also explain why diet breadth was found to be a strong indicator of impact severity in univariate analysis (**Table 4.3**), albeit not when controlling for other variables (**Table 4.4**).

I also identified positive relationships between predation impacts and relative brain size and residence time in multivariate analysis, although these relationships were not recovered for all 100 phylogenies used (**Table 4.6**). Predatory birds such as owls and crows tend to be large-brained (in my dataset these species include the Australian masked-owl (*Tyto novaehollandiae*) and the American crow (*Corvus brachyrhynchos*)). Being long-lived (Rowe, 2008), birds of prey often have relatively slow life histories, and possibly require longer time periods, when compared to other bird orders, to establish populations and cause impacts. However, if the latter effect was true, we might expect to find an effect of body mass on predation impacts, as larger bird species also tend to be longer lived (Peters, 1983). Therefore, residence time may be associated with predation impacts because alien birds with longer residence times are more likely to be noticed and recorded. I also find a counterintuitive negative relationship between predation impacts and native range size in multivariate analysis (**Table 4.6**). The reason for this is not immediately obvious, but some alien birds with predation impacts have restricted native ranges. For example, the weka (*Gallirallus* *australis*) has a native range of 36,830km^2 (200 times smaller than the average native range size), on the east coast of the North Island of New Zealand. It was translocated to its alien range because of declining population numbers (BirdLife International, 2016b).

4.6 Conclusions

This study represents one of the first formal analyses of alien species impacts undertaken using data generated by an EICAT assessment (Evans *et al*. 2016). It demonstrates that EICAT data can be used to provide useful insights regarding the factors that drive the severity and type of impacts generated by alien species. My findings of expected relationships, such as that between predation impacts and the consumption of animal matter, is reassuring of the ability of my analyses to detect robust associations between impacts and traits. Taken together, my results indicate that it is widely distributed, generalist alien birds that cause the most severe impacts to the environment. In contrast, my analyses found little evidence for an effect of per capita impact on impact severity. The effects of alien range size and generalism may arise because these species have greater opportunity to cause environmental impacts through their sheer numbers, but I cannot rule out an effect of the likelihood that the impacts of such species are identified and studied. Should the former be the case, this study provides support for the improvement of risk assessments and other procedures to minimise the global distribution of alien birds.

The results of this study may also assist in predicting which species (including those which currently do not have alien populations, and those alien species currently categorised as Data Deficient (**DD**) under EICAT) may have damaging impacts. For example, the New Caledonian crow (*Corvus moneduloides*) is a Data Deficient (**DD**) species, and is a habitat and diet generalist (being reported to occupy forest, shrubland, grassland and artificial terrestrial habitats, and being omnivorous; BirdLife International, 2016c). It belongs to a family of birds found to be associated with more severe impacts (Corvidae; Evans *et al*. 2016), and is present as an alien on an island (Maré, Loyalty Islands), where the impacts of alien birds have been found to be more acute (Evans *et al*. 2016). I would predict, on the basis of my analyses, that the impacts of this species are going unnoticed.

Chapter 5

Determinants of spatial variation in the severity of alien bird impacts

5.1 Abstract

Aim: To produce global maps of the impacts generated by alien birds, and to identify the factors that influence spatial variation in the severity of these impacts across regions, in order to improve our ability to predict which regions are likely to sustain more severe alien bird impacts.

Location: Global.

Methods: Information on factors hypothesised to influence spatial variation in the severity of alien bird impacts were collated for 58 regions of the world with actual, recorded alien bird impacts, and 241 regions with potential alien bird impacts. These data were analysed using mixed effects models.

Results: The actual, recorded impacts of alien birds are generally restricted to temperate, developed regions of the world, but their potential impacts are far more widespread. The severity of impacts generated by alien bird species is not randomly distributed across regions. For regions with actual impacts, factors relating to the duration and frequency of alien bird invasions are key in determining whether the impacts sustained by a region will be damaging. Characteristics of alien birds, and of the receiving environment, also influence the severity of impacts sustained by a region. Many of these factors also influence impact severity amongst regions with potential impacts, although alien bird residence time and islands ($<100km^2$) did not. Competition influenced impact severity amongst regions with potential but not actual impacts.

Main conclusions: Data from EICAT assessments can be used to map the impacts of alien species, a process that is replicable for other taxonomic groups, including those with damaging alien species such as mammals. The unified EICAT data enable direct comparisons to be made across regions, which facilitates the identification of regions which currently sustain damaging impacts, and those with the potential for such impacts. Early interventions, and the prevention of new invasions, are strategies that may effectively minimise the impacts of alien birds. The maps, and the data underpinning them, can be used to identify regions of the world that are characterised by the variables found to be

associated with impact severity. This may assist in directing management interventions to regions where they are most needed.

5.2 Introduction

There are more than 400 species of alien birds with self-sustaining populations worldwide, with particular hotspots of alien bird richness in Europe, former European colonies and areas associated with the trade in cage-birds (Su *et al*. 2016; Dyer *et al*. 2017a; Dyer *et al*. 2017b). Many of these hotspots are the result of historical introductions associated with European colonial expansion during the 19th and 20th centuries, but the rate of introductions shows no sign of slowing (Seebens *et al*. 2017). Indeed, more than a quarter of all dated alien bird introductions recorded from 1500 – 2000 AD occurred after 1983 (Dyer *et al*. 2017a). This is a concern, because alien species can have a range of environmental impacts, degrading habitats, homogenising communities, driving declines in the populations of native species and in some cases leading to native species extinctions (Ricciardi *et al*. 2013). Birds are no exception (Evans *et al*. 2016). For example, predation by the introduced great horned owl *(Bubo virginianus)* on Hiva-Oa (French Polynesia) has resulted in declining populations of all native bird species on the island, particularly the Marquesan kingfisher *(Todiramphus godeffroyi)*, and has contributed to the extinction of the red-moustached fruit dove *(Ptilinopus mercierii)* (Shine *et al*. 2003).

Recent studies have improved our understanding of the severity and type of environmental impacts generated by alien species. Global impact assessments have been undertaken for alien amphibians (Measey *et al*. 2016), plants (Pyšek at al. 2012) and birds (Baker *et al*. 2014; Martin-Albarracin *et al*. 2015; Evans *et al*. 2016; Evans *et al*. 2018b), all providing useful insights. For example, amongst alien amphibian species for which we have impact data, impacts tend to be more severe for those that are larger and have more offspring, and also for species from the Bufonidae (true toads) and Pipidae (tongueless frogs) (Measey *et al*. 2016). For alien plants, species traits including life form and pollination syndrome may be useful predictors of impact severity (Pyšek at al. 2012). For alien birds, widely-distributed, generalist alien birds have been shown to generate more severe environmental impacts (Evans *et al*. 2018b). The results of these studies may improve our ability to predict which alien species are likely to have damaging impacts as aliens, and may therefore facilitate timely management interventions to mitigate alien species impacts.

However, less progress has been made in understanding the potential for spatial variation in the severity of impacts generated by alien species, and of the drivers that may cause this variation. This represents a significant gap in our understanding of biological invasions in general, as being able to identify regions that are more likely to be affected by alien species, and to predict which regions are likely to be affected by invasions in the future, could potentially enable the prioritisation of resources to address the impacts of alien species where they are most needed. Yet, as far as I am aware, there are no studies that formally examine these drivers. Here, I combine a recently developed, standardised method for quantifying and categorising the impacts of alien species (Blackburn *et al*. 2014) with a comprehensive database on the distribution of alien bird species (Dyer *et al*. 2017a) to produce the first global distribution maps of alien species impacts. I then use the data underlying these maps to test hypotheses for drivers of spatial variation in the severity of alien bird impacts, to understand why specific regions are more likely to be affected by the impacts of alien species.

There are at least four broad reasons why the severity of alien bird impacts may vary across regions. First, factors that influence how frequently and for how long a region is subject to invasions may cause variation in impact severity across regions. For example, impacts are likely to be more severe within regions with greater numbers of alien bird species, as by chance alone higher levels of alien species richness will increase the chances for impacts. Impacts are also likely to be more severe within regions that have been subject to alien bird introductions for longer periods of time, as these species will have had greater opportunity to establish, spread and generate impacts. I therefore propose the following hypotheses: the severity of alien bird impacts is greater for (H1) regions with greater alien bird species richness; (H2) regions with longer alien bird residence times.

Second, characteristics of the receiving environment may cause spatial variation in impact severity. A key characteristic here may be insularity: alien species impacts have generally been found to be more severe on islands than on continental regions (Russell *et al*. 2017), including those generated by alien birds (Evans *et al*. 2016). One likely reason is that islands often support endemic native species, which have evolved over long time-periods in the absence of natural predators. These species may lose their anti-predator response mechanisms, leaving them highly susceptible to the impacts of alien species (CBD, 2017). Island species are also likely to be less resilient to introduced pathogens and diseases (Furlan *et al*. 2012; MacPhee & Greenwood, 2013), and may be poorer competitors when compared to species invading from continental locations, which are likely have evolved in competition with a broader range of species (Carlquist, 1965). The extinction of the Lord Howe southern boobook (*Ninox novaeseelandiae albaria*) on Lord Howe Island (Australia) is believed to have been partly due to competition resulting from the introduction of two alien owl species (Department of the Environment (Australia), 2018). I therefore propose the following hypothesis: the severity of alien bird impacts is greater for (H3) islands than continents.

Varying levels of invasion resistance across regions may also cause spatial variation in impact severity. For example, species-poor regions may suffer more acutely from the impacts of alien species in comparison to species-rich regions, where native species are more likely to have evolved in competition with a broader range of species and thus be better able to compete with alien species. Communities characterised by high levels of competition may be more difficult to invade, as intense competition limits invasion possibilities (Case, 1990). Abiotic factors that influence the severity of environmental conditions within a region may also cause spatial variation in impact severity. For example, species introduced to arid environments are less likely to survive than native populations, unless they possess specific traits that enable survival in dry conditions. I therefore propose the following hypotheses: the severity of alien bird impacts is greater for (H4) regions with lower levels of species richness; (H5) regions with less extreme environmental conditions.

Third, variation in the characteristics and identities of established alien bird species may cause spatial variation in the severity of their impacts. For example, traits associated with ecological flexibility have been found to be consistent drivers of impact severity: species with large native breeding ranges (range size being a proxy for habitat generalism) have more severe impacts in Europe (Kumschick *et al*. 2013); habitat generalist species have more severe impacts in Europe (Shirley and Kark, 2009; Kumschick *et al*. 2013), Australia (Evans *et al*. 2014) and globally (Evans *et al*. 2018b); and diet generalist species have more severe impacts in Australia (Evans *et al*. 2014) and globally, though not when controlling for other variables (Evans *et al*. 2018b). Range size has been found to be positively correlated with abundance for both native and alien birds (Gaston *et al*. 2000; Blackburn *et al*. 2001; but see Novosolov *et al*. 2017), while Parker *et al*. (1999) consider both alien range size and abundance to be key components of the potential impact of an alien species, along with per capita impact. Therefore, I expect to find regions invaded by species with large ranges to be more severely affected by the impacts of alien birds, because these species are likely to be more widespread are more abundant. I therefore propose the following hypotheses: the severity of alien bird impacts is greater for (H6) regions which support habitat generalist or (H7) diet generalist alien bird species; (H8) regions which support bird species with large native ranges or (H9) large alien ranges.

Studies also identify variation in the severity of impacts generated by alien birds through different impact mechanisms. Hybridisation was found to be the most damaging impact mechanism by Martin-Albarracin *et al*. (2015), whilst predation was found to be the most damaging impact mechanism, and competition the least, by Evans *et al*. (2016). In both studies, impact mechanisms were also found to be associated with certain orders or families of alien birds: hybridisation with Anatidae (ducks, geese and swans) and Phasianidae (pheasants and allies) (Martin-Albarracin *et al*. 2015), predation with birds of prey (as would be expected), and competition with the Psittaciformes (parrots) (Evans *et al*. 2016). This suggests that impact severity may vary across regions depending on the types of birds that are introduced to them. I therefore propose the following hypothesis: the severity of alien bird impacts is greater for (H10) regions which support alien bird species associated with damaging impact mechanisms.

Fourth, factors may influence the availability of data on the impacts of alien birds across regions, and this may cause apparent spatial variation in impact severity. In this case, alien bird impacts within a region may not actually be more severe than for other regions, but they are more frequently identified and recorded. For example, residence times vary amongst alien bird species (Dyer *et al*. 2017a), and we are likely to have more impact data for species with longer residence times (Evans *et al*. 2018a). Further, characteristics of human societies may influence whether the impacts of alien birds are noticed and recorded. Most invasion research is being undertaken in developed regions of the world (Pyšek *et al*. 2008; Bellard & Jeschke, 2015; Martin-Albarracin *et al*. 2015), probably because comparatively wealthy countries have greater capacity to undertake research. Thus, the Human Development Index (HDI) is positively associated with the availability of data on alien bird impacts (Evans *et al*. 2018a). The impacts of alien birds may also be recorded more frequently where such species are located in close proximity to human population centres. For example, we have more data on the impacts of Psittaciformes than any other bird order, most likely because many alien parrot populations are found in large urban centres in developed countries (Evans *et al*. 2016). Therefore, in addition to (H2) above, I also propose the following hypotheses: the severity of alien bird impacts is greater for (H11) highly developed regions; (H12) densely populated regions.

The environmental impacts of alien species can be severe, yet studies indicate that across all taxonomic groups we generally lack quantitative data on their impacts (Kumschick *et al*. 2015a; Wilson *et al*. 2016a). Birds are no exception, with over 70% of alien bird species lacking any sort of impact data (Evans *et al*. 2016). The global alien bird impact map that I produce here illustrates this issue: we have no impact data for many countries across the globe which support self-sustaining alien bird populations. Therefore, in addition, I combine impact severity scores for alien birds with data on their global distribution, to map the potential impacts of alien birds for regions where they are present but where we know nothing about their impacts. These maps help to identify data deficient regions of the world at risk to the impacts of alien birds.

5.3 Methods

5.3.1 Data

The data underpinning this study were taken from a recent global assessment of the impacts of alien birds (Evans *et al*. 2016). During this assessment, the recently developed Environmental Impact Classification for Alien Taxa (EICAT; Blackburn *et al*. 2014) protocol was used to categorise and compare the environmental impacts of alien birds. Each species was allocated to one of five EICAT impact categories based on the severity of its environmental impacts: Minimal Concern (**MC**), Minor (**MN**), Moderate (**MO**), Major (**MR**), Massive (**MV**) (see Evans *et al*. (2016) (Supporting Information: Table S2) for an overview of the assessment results for each species). I converted these data to numeric values (**MC** = 1, **MN** = 2, **MO** = 3, **MR** = 4, **MV** = 5), producing individual numerical impact scores for each alien bird species. I then created two dependent variables for the analyses: A_{max}, the most severe individual impact score sustained by a region (i.e. a number between 1 and 5 for each region); A_{ave}, the average impact score sustained by a region (calculated by summing the individual impact scores for all alien bird species present in a region and dividing the total by the number of species). I excluded the rock dove (*Columba livia*) from my analysis, as this species is widely distributed across the globe and significant uncertainty remains regarding the regions where this species is native and where it has been introduced.

I collected data on the following 13 predictor variables (numbered v1 to v13) to test the hypotheses listed in the Introduction:

H1: I tested whether impacts are more severe for regions with greater alien species richness using records on the presence of alien bird species within a region, taken from Evans at al. (2016) and GAVIA (Dyer at al. 2017a). I used these data to create regional alien bird species richness scores (v1), calculated by summing the number of different alien bird species present within a region.

H2: To test whether impacts are more severe for regions with longer alien bird residence times, I used data from GAVIA (Dyer *et al*. 2017a) on the number of years since an alien bird was first recorded in a region. I calculated regional residence time scores by summing individual residence times for each alien bird species present within a region. This score was divided by the number of species to produce an average residence time score for each region (v2). The methods used to calculate residence times for individual alien bird species are described in Dyer *et al*. (2017a).

H3: To determine whether the impacts of alien birds are more severe on islands than continents, I compiled a list of islands for which we have impact data for alien birds, defining islands as any area of land under 100km^2 and surrounded by water. This definition differs from the standard definition of an island, being any area of land smaller than a continent and surrounded by water (Britannica, 2017), which would therefore include countries and territories such as the United Kingdom and Greenland. My approach broadly aligns with the island conservation principles adopted by the Convention on Biological Diversity (CBD), which focus on oceanic islands and Small Island Developing States (SIDS), which are generally considered to be more vulnerable to the impacts of alien species (CBD, 2017). I compared regional EICAT impact scores for islands (v3) with those for the remainder of the regions in my dataset.

H4: I tested whether alien bird impacts are more severe for regions with lower levels of native species richness by creating regional native species richness scores (v4), calculated by summing the number of different native bird species present within a region, using data from BirdLife International's Country Profiles (http://datazone.birdlife.org/country) downloaded on 13 March 2018. Here I use native birds as a proxy for overall native species richness. Where these data were not available for a region, I took regional native bird numbers from Avibase (https://avibase.bsc-eoc.org) downloaded on 13 March 2018.

H5: I tested whether alien bird impacts are more severe for regions with less extreme environmental conditions by calculating the average monthly temperature (v5) and average monthly rainfall (v6) for each region, using a 25-year dataset (1991 – 2015) downloaded from the World Bank Group's Climate Change Knowledge Portal (http://sdwebx.worldbank.org/climateportal) on 8 March 2018. Where these data were unavailable for a region, I used a 10-year dataset (2005 – 2015) downloaded from timeanddate.com (https://www.timeanddate.com/weather) on 8 March 2018.

H6 & H7: Following Kumschick *et al*. (2013), to determine whether regions supporting habitat or diet generalist alien bird species have more severe impacts, I calculated habitat and diet generalism scores for each alien bird species. To do this, I summed the number of broad habitat types occupied by a species in its native range and the number of broad food types consumed by a species (for a list of habitat and food types see **Chapter 4**, **Table 4.1**). I calculated total habitat generalism and total diet generalism scores for each region by summing individual habitat generalism and diet generalism scores for all species present in a region, and then divided the totals by the number of species to produce an average habitat (v7) and average diet (v8) generalism score for each region.

H8 & H9: To determine whether regions supporting species with larger native ranges have more severe impacts, I used native range size data (km^2) taken from GAVIA (Dyer *et al*. 2017a) to calculate the geometric mean of the individual native range sizes for all species present within a region (v9). The same process was adopted to calculate the geometric mean for alien range size (v10), using alien range size data from GAVIA (Dyer *et al*. 2017a). The methods used to calculate native and alien range sizes for individual alien bird species are described in Dyer *et al*. (2017a). Range size has been found to be positively correlated with abundance for both native and alien birds (Gaston & Blackburn, 2000; Blackburn *et al*. 2001). I would therefore also expect to find an effect of abundance on impact severity. However, data on alien bird abundance is unavailable for the majority of the species in my dataset, so I did not pursue this analysis.

H10: I tested whether impacts are more severe for regions supporting alien birds with specific impact mechanisms by calculating the proportion of the total impact score for a region that was attributable to each impact mechanism (v11). During the alien bird EICAT assessment (Evans *et al*. 2016), impacts were allocated to nine of the 12 EICAT impact mechanisms. For two of these nine mechanisms (Structural impact on ecosystem and Parasitism) impacts were only recorded in one region and resulted from impacts generated by one species – these mechanisms were therefore discounted from the analysis. For the remaining seven mechanisms, impacts for Competition were recorded in 34 regions; Predation in 20; Grazing / herbivory / browsing and Hybridisation in 16; Chemical impact on ecosystem in 9; Interaction with other alien species (for alien birds this relates to the spread of seeds of alien plants) in 8; and Disease transmission to native species in 6.

H11: I tested whether impacts are more severe for highly developed regions by allocating Human Development Index (HDI) scores to each region (v12), downloaded from http://hdr.undp.org/en/composite/HDI on 14 January 2018. Higher HDI scores infer greater levels of human development. Where HDI scores were unavailable for a region, they were taken from their associated nation (e.g. Easter Island (HDI = Chile); Lord Howe Island, Cocos (Keeling) Islands, Tasmania, Macquarie Island (HDI = Australia); Galapagos Islands (HDI = Ecuador).

H12: I tested whether impacts are more severe for densely populated regions by assigning population density scores for each region (v13), calculated by dividing the human population of a region by its size (km^2), using data from the Central Intelligence Agency's World Fact Book (https://www.cia.gov/library/publications/the-world-factbook) downloaded on 18 March 2018.

A list of regions with actual and potential impacts, including the data for all predictor variables described above is provided in **Appendix F**, **Table F1**.

5.3.2 Analysis

My primary analysis concerned 58 regions of the world for which I had data on the actual impacts of alien birds. I undertook secondary analysis for 241 regions of the world with potential alien bird impacts. These are regions that support alien birds that have been found to have actual, recorded impacts elsewhere, but where no impacts of these species have yet been recorded. I took the most severe actual impact score for each alien bird present in the region with potential impacts, to calculate both the most severe potential individual impact score sustained by a region (P_{max}) and the average potential impact score sustained by a region (P_{ave}).

I use the most severe impact score for a species in order to account for the worst-case scenario (the maximum damage caused by a species).

Regions were delineated following the Natural Earth mapping dataset (1:10 million, map subunits: http://www.naturalearthdata.com/downloads/10m-cultural-vectors, downloaded 13 January 2018), which identifies regions that are not contiguous but part of the same country, including islands. Thus, for example, mainland Australia, Tasmania and Macquarie Island represent three separate regions. For a complete list of regions see **Appendix F**, **Table F1**.

The relationships between the severity of impacts sustained by each region (A_{max} and A_{ave}, P_{max} and P_{ave}) and the 13 predictor variables were assessed using generalised linear mixed effects models using the lme4 package (Bates *et al*. 2015). A random effect for continent was included to account for potential autocorrelation within regions. The relationship between each dependent variable (A_{max}, A_{ave}, P_{max}, P_{ave}) and each predictor variable was analysed independently, followed by multivariate analysis of each dependent variable incorporating all predictor variables. I used the dredge function in the MuMIn package (Bartoń, 2018) to rank models by AICc and obtained relative importance values for each variable (the sum of the Akaike weights over all models for each variable) using the Importance function. I obtained marginal R^2 (the variance explained by fixed factors) and conditional R^2 (the variance explained by both fixed and random factors (i.e. the entire model)) for the best models for A_{max}, A_{ave}, P_{max} and P_{ave} using the r.squaredGLMM function (MuMIn package).

I used the car package (Fox and Weisberg, 2011) to check for multicollinearity amongst my predictor variables. For regions with actual impacts I found evidence of multicollinearity associated with four predictor variables (competition, predation, hybridisation, grazing / herbivory / browsing); for regions with potential impacts I also found evidence of multicollinearity associated with four predictor variables (competition, predation, interaction with other alien species, grazing / herbivory / browsing). As grazing / herbivory / browsing was not associated with any of the response variables in univariate analysis (see Results), I removed this predictor variable for the multivariate analysis. This reduced multicollinearity amongst the remaining predictor variables (**Table 5.1**).

Table 5.1: Variance Inflation Factors for predictor variables (calculated using the car package in R; Fox and Weisberg, 2011).

	Actual impacts		Potential impacts	
Predictor variable	**VIF**	**VIF (grazing removed)**	**VIF**	**VIF (grazing removed)**
H1: Alien bird species richness	3.17	3.01	2	2
H2: Residence time	1.77	1.64	1.27	1.27
H3: Islands <100km^2	2.46	2.46	1.7	1.7
H4: Native bird species richness	2.3	2.25	1.62	1.62
H5: Average monthly temperature	2.97	2.3	1.95	1.88
H5: Average monthly rainfall	1.73	1.72	1.18	1.18
H6: Habitat breadth	1.55	1.46	2.88	2.82
H7: Diet breadth	2.49	2.38	1.74	1.68
H8: Native range size	2.23	2.13	2.68	2.54
H9: Alien range size	2.84	2.84	2.59	2.57
H10: Competition	7.81	3.16	11.75	3.53
H10: Predation	7.4	3.35	5.03	2.04
H10: Hybridisation	4.04	2.21	2.9	1.69
H10: Interaction with other alien species	2.18	1.78	5.45	2.22
H10: Disease transmission	2.68	2.51	1.81	1.43
H10: Grazing / herbivory / browsing	4.47	NA (removed)	5.02	NA (removed)
H10: Chemical impact on ecosystem	1.49	1.43	1.42	1.36
H11: Human Development Index	2.26	1.85	2	1.98
H12: Population density	3.16	2.8	1.38	1.37

Data for alien bird residence time, native and alien bird species richness, monthly average temperature and rainfall, native and alien range size, HDI and human population density were $\log_{10}$ transformed for analysis. All statistical analyses were undertaken using RStudio version 1.1.383 (R Core Team, 2017).

5.3.3 Mapping

Alien bird actual impact maps were created by mapping the most severe individual impact score reported for a region (A_{max}), and the average impact score reported for a region (A_{ave}). These maps show the severity of impacts across regions where we have existing data on the impacts of alien birds. However, the alien bird species for which those impacts were recorded are distributed more widely than just the regions where they have been studied. Potential alien bird impact maps were created by mapping the most severe potential individual impact score sustained by a region (P_{max}), and the average potential impact score sustained by a region (P_{ave}).

All maps were produced in R using the Natural Earth mapping dataset (1:10m cultural vectors: http://www.naturalearthdata.com/downloads/10m-cultural-vectors), and the following packages: sp (Bivand *et al*. 2013), rgeos (Bivand &

Rundel. 2017a), rgdal (Bivand *et al*. 2017b), raster (Hijmans, 2016) and maptools (Bivand & Lewin-Koh, 2017c).

5.4 Results

Negative environmental impacts of alien birds have been reported from 58 regions of the world (regions with actual impacts). However, the alien bird species for which those impacts were recorded are distributed more widely, being present in 241 regions (regions with potential impacts). The most severe impact scores for regions with actual impacts (A_{max}) are shown in **Figure 5.1**, and for regions with potential impacts (P_{max}) in **Figure 5.2**. The average impact scores for regions with actual impacts (A_{ave}) are shown in **Figure 5.3**, and for regions with potential impacts (P_{ave}) in **Figure 5.4**. Islands (<100km^2) with above average impact scores cannot easily be seen on the maps, and so are highlighted in bold italics in the figure legend.

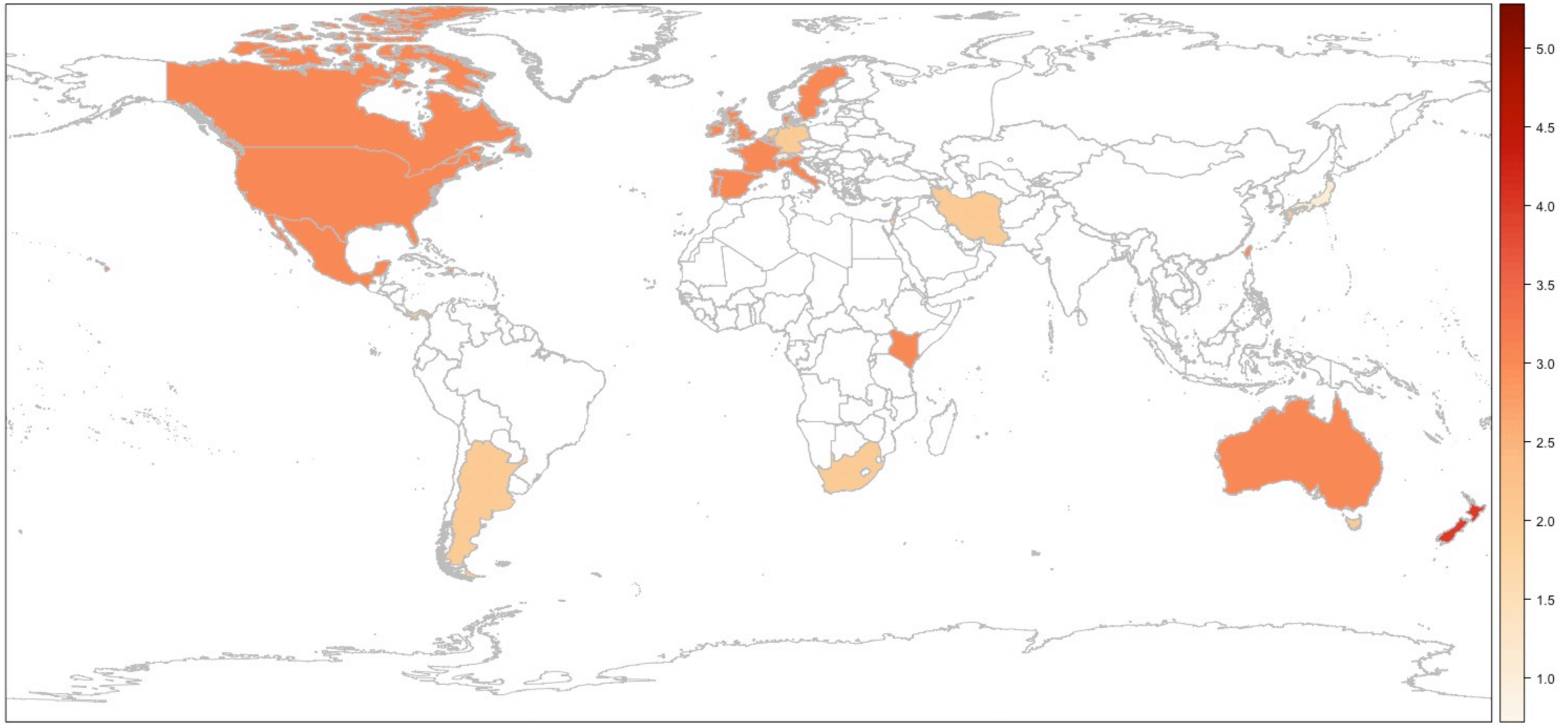

Figure 5.1: The most severe individual impact score sustained by each region resulting from alien birds with actual impacts. Regions shaded white = no alien bird impact data (Data Deficient (**DD**) regions). The average impact score for all regions = 2.79; the median = 3. Regions with above average impact scores: ***Amirante Islands (Seychelles)***, ***Bermuda***, Hiva-Oa (French Polynesia), ***Lord Howe Island (Australia)*** (most severe impact score = 5); ***Cocos (Keeling) Islands (Australia)***, Mauritius, New Zealand North and South Islands (4); Australia, Belgium, Canada, Chatham Islands (New Zealand), ***Codfish Island (New Zealand)***, Denmark, Easter Island (Chile), England, France, ***Fregate Island (Seychelles)***, Haiti, Hawaii, Ireland, Italy, Kenya, ***Kharku Island (Iran)***, Macquarie Island (Australia), Mexico, Northern Ireland, Portugal, Puerto Rico, Rodrigues Island (Mauritius), ***Rota (Northern Mariana Islands)***, Scotland, Singapore, Spain, Sweden, Tahiti (French Polynesia), Taiwan, United States of America, Wales (3). Total regions with impact data: n = 58. Regions listed in ***bold italcs*** = Islands (<100km^2). Regional alien bird impact scores were calculated using data from Evans *et al*. (2016).

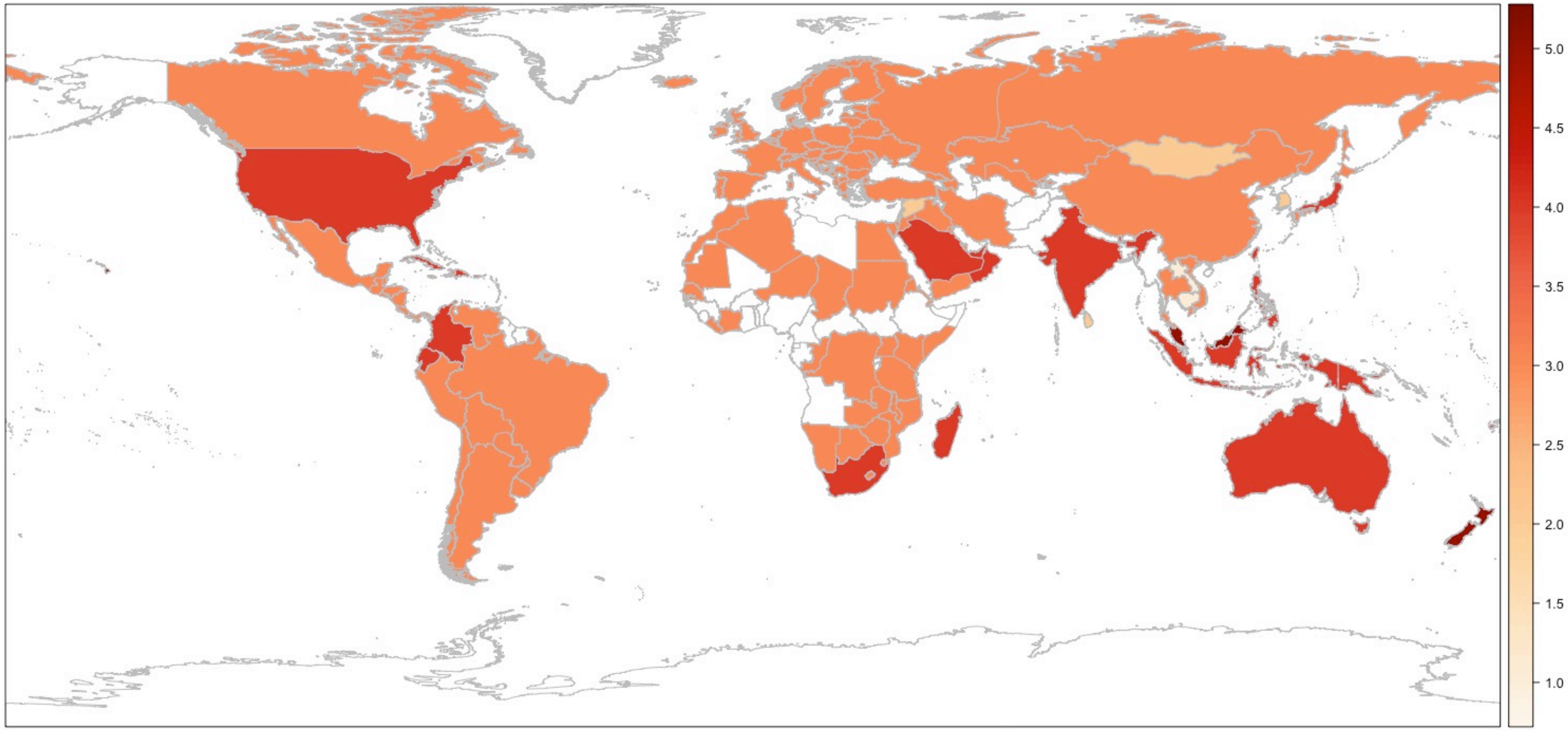

Figure 5.2: The most severe impact score sustained by each region resulting from alien birds with potential impacts. Regions shaded white = no alien bird impact data (Data Deficient (**DD**) regions). The average potential impact score for all regions = 3.2; the median = 3. Regions with above average potential impact scores: ***Agalega Islands (Mauritius)***, ***Bermuda***, ***British Indian Ocean Territory***, Cape Verde, Comoros, Hawaii, Mahe Island (Seychelles), Malaysia, Mauritius, Mayotte, New Zealand North and South Islands, ***Praslin Island (Seychelles)***, Reunion, Singapore (5); ***Anguilla***, ***Assumption Island (Seychelles)***, Auckland Islands (New Zealand Subantarctic Islands), Australia, Barbados, Brunei, Campbell Island (New Zealand Subantarctic Islands), Chatham Islands (New Zealand), Christmas Island (Australia), Colombia, Cuba, Dominican Republic, East Falkland (Falkland Islands), Ecuador, ***'Eua (Tonga)***, Fiji, French Southern Atlantic Lands, Grand Cayman (Cayman Islands), ***Grand Turk (Turks and Caicos Islands)***, Guam, ***Ha'apai (Tonga)***, Hong Kong, Honshu (Japan), India, Kamorta Island (Nicobar Islands, India), Kiribati, ***Kwajalein Atoll (Marshall Islands)***, ***Lord Howe Island (Australia)***, Macquarie Island (Australia), Madagascar, ***Maldives***, Montserrat, ***Nancowry Island (Nicobar Islands, India)***, ***Norfolk Island (Australia)***, Oman, Papua New Guinea, Philippines, Puerto Rico, ***Raratonga (Cook Islands)***, ***Rota (Northern Mariana Islands)***, Saint Helena, Samoa, Saudi Arabia, South Africa, Sulawesi (Indonesia), Sumatra (Indonesia), Tahiti (French Polynesia), Taiwan, Tasmania, ***Trinket Island (Nicobar Islands, India)***, United Arab Emirates, United States of America, Vanuatu, ***Vava'u (Tonga)***, Yap (Micronesia) (4). Total regions with impact data: n = 241. Regions listed in ***bold italcs*** = Islands (<100km^2). Regional alien bird potential impact scores were calculated using data from Evans *et al*. (2016). Alien bird distribution data were taken from the Global Avian Invasions Atlas (GAVIA: Dyer *et al*. 2017a).

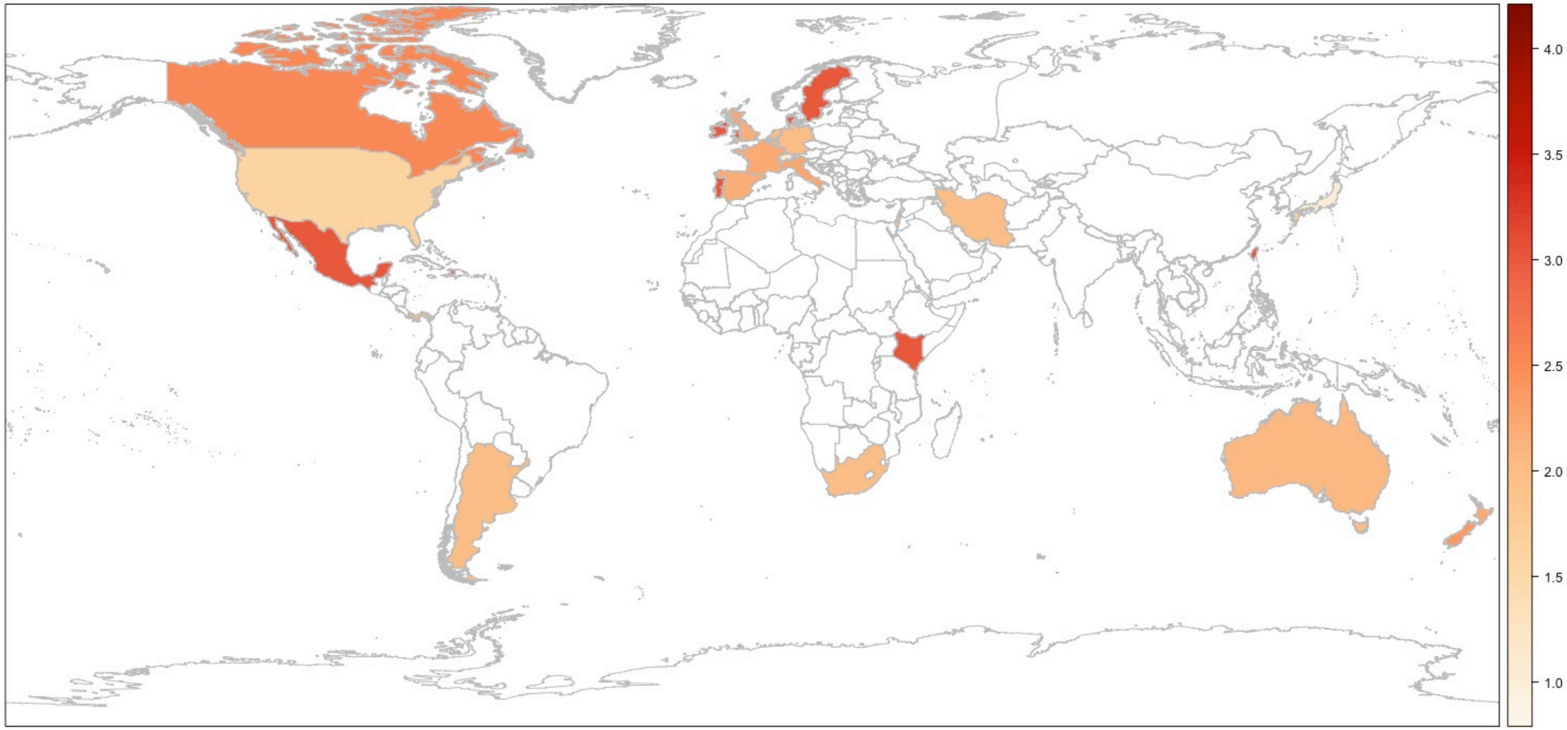

Figure 5.3: The average impact score sustained by each region resulting from alien birds with actual impacts. Regions shaded white = no alien bird impact data (Data Deficient (**DD**) regions). The average impact score for all regions = 2.5; the median impact score for all regions = 2.25. Regions with above average impact scores: Hiva-Oa (French Polynesia) (average impact score = 5); ***Amirante Islands (Seychelles)***, ***Bermuda***, ***Cocos (Keeling) Islands (Australia)***, ***Lord Howe Island (Australia)***, Mauritius (4); Chatham Islands (New Zealand), ***Codfish Island (New Zealand)***, Denmark, Easter Island (Chile), ***Fregate Island (Seychelles)***, Haiti, Ireland, Kenya, ***Kharku Island (Iran)***, Macquarie Island (Australia), Mexico, Northern Ireland, Portugal, Puerto Rico, Rodrigues Island (Mauritius), ***Rota (Northern Mariana Islands)***, Sweden, Taiwan, Wales (3); Tahiti (French Polynesia) (2.83). Total regions with impact data: n = 58. Regions listed in ***bold italcs*** = Islands (<100km^2). Regional alien bird impact scores were calculated using data from Evans *et al*. (2016).

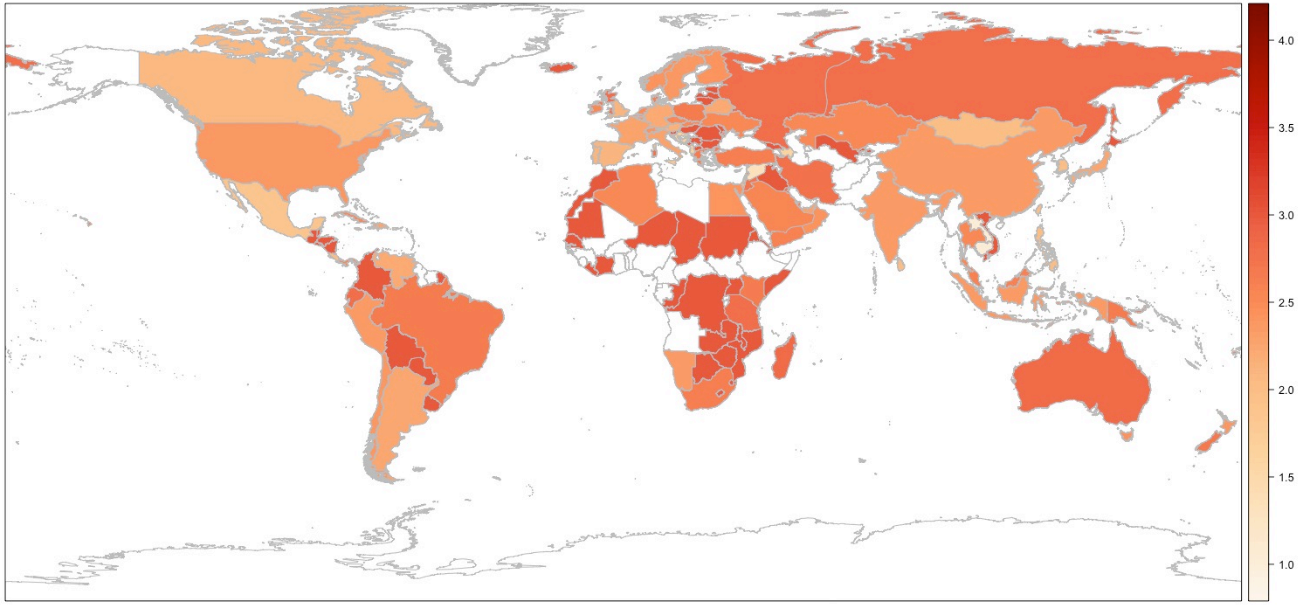

Figure 5.4: The average impact score sustained by each region resulting from alien birds with potential impacts. Regions shaded white = no alien bird impact data (Data Deficient (**DD**) regions). The average potential impact score for all regions = 2.6; the median = 2.7. Regions with above average potential impact scores: ***Anguilla***, ***Ha'apai (Tonga)***, ***Nancowry Island (Nicobar Islands, India)***, ***Rota (Northern Mariana Islands)***, ***Trinket Island (Nicobar Islands, India)***, ***Vava'u (Tonga)*** (4); Christmas Island (Australia), East Falkland (Falkland Islands), ***Grand Turk (Turks and Caicos Islands)***, Kamorta Island (Nicobar Islands, India), ***Lord Howe Island (Australia)*** (3.5); Comoros, Mayotte (3.4); ***Bermuda***, Brunei, ***'Eua (Tonga)***, ***Raratonga (Cook Islands)*** (3.3); Auckland Islands (New Zealand Subantarctic Islands), Campbell Island (New Zealand Subantarctic Islands), Macquarie Island (Australia), Maldives (3.2); ***Agalega Islands (Mauritius)***, Aland Islands (Finland), ***Antipodes Islands (New Zealand Subantarctic Islands)***, ***Aore (Vanuatu)***, Belize, Bolivia, Bonin Islands (Japan), Botswana, ***Bounty Islands (New Zealand Subantarctic Islands)***, Bulgaria, Cape Verde, ***Cayman Brac (Cayman Islands)***, Chad, Colombia, ***Corvo (Azores, Portugal)***, Democratic Republic of Congo, Djibouti, El Salvador, Eleuthera (Bahamas), Eritrea, Espiritu Santo (Vanuatu), Estonia, French Guiana, Gambia, Georgia, Grand Terre (New Caledonia), ***Grand Turk (Turks and Caicos Islands)***, Guadalcanal (Solomon Islands), Guatemala, Hiva-Oa (French Polynesia), Hokkaido (Japan), Honduras, Hungary, Iceland, Iraq, Ivory Coast, Jersey, Kiribati, Latvia, Lesotho, Liberia, Liechtenstein, Lithuania, Luxembourg, ***Macao (China)***, Macedonia, Makira (Solomon Islands), Malaita (Solomon Islands), Malawi, Mauritania, ***Midway Atoll (United States of America)***, Moldova, Montenegro, Montserrat, Morocco, Mozambique, Nicaragua, Niger, ***Niuafo'ou (Tonga)***, Paraguay, ***Praslin Island (Seychelles)***, Raoul Island (Kermadec Islands, New Zealand), Republic of Congo, Romania, Saint Lucia, Saint Pierre and Miquelon (France), Sandoy (Faeroe Islands), Sao Miguel (Azores, Portugal), Sarawak (Indonesia), Senegal, Serbia, Slovenia, ***Snares Islands (New Zealand Subantarctic Islands)***, Somalia, Sudan, Suduroy (Faroe Islands), Swaziland, Tongatapu (Tonga), Tristan da Cunha (Saint Helena, Ascension and Tristan da Cunha), Tutuila (American Samoa), Uganda, Uraquay, Uzbekistan, Vietnam, Zambia, Zimbabwe (3); ***British Indian Ocean Territory***, ***Kwajalein Atoll (Marshall Islands)***, ***Norfolk Island (Australia)*** (2.9); Australia, Chatham Islands (New Zealand), Ecuador, Iran, Kuwait, Madagascar, ***Mahe Island (Seychelles)***, Russia, Samoa, Sardinia (Italy), Tanzania, Wales (2.8); Barbados, Brazil, Greece, Guam, Jordan, Kenya, Mo'orea (French Polynesia), New Zealand South Island, Northern Ireland, Papua New Guinea, Poland, Qutar, Raiatea (French Polynesia), Saint Helena (Saint Helena, Ascension and Tristan da Cunha), Scotland, ***Tubuai (French Polynesia)*** (2.7). Total regions with impact data: n = 241. Regions listed in ***bold italcs*** = Islands (<100km^2). Regional alien bird potential impact scores were calculated using data from Evans *et al*. (2016). Alien bird distribution data was taken from the Global Avian Invasions Atlas (GAVIA: Dyer *et al*. 2017a).

5.4.1 Actual impacts

Univariate analysis of spatial variation in the most severe actual impact score sustained by a region (A_{max}) revealed positive relationships between impact severity and alien bird residence time, whether or not impacts were on islands, native range size, and the proportion of impacts resulting from predation or hybridisation. A_{max} was negatively related to the proportion of impacts resulting from competition, and native bird species richness (**Table 5.2**, **Figure 5.5**). For the average impact score sustained by a region (A_{ave}), univariate analysis revealed positive relationships between impact severity and alien bird residence time, whether or not impacts were on islands, the proportion of impacts resulting from predation, and habitat breadth. A_{ave} was negatively related to native and alien bird species richness, and the proportion of impacts resulting from competition or disease transmission (**Table 5.2**, **Figure 5.6**).

Table 5.2: Univariate analysis displaying the relationships between the severity of actual impacts across regions and predictor variables for A_{max} (the most severe individual actual impact score sustained by a region) and A_{ave} (the average actual impact score sustained by a region). All parameters in this table derive from generalised linear mixed effects models using the lme4 package (Bates *et al.* 2015), with a random effect for continent included to account for potential autocorrelation among regions. *P* values were obtained using the lmerTest package (Kuznetsova *et al.* 2017). Significant relationships (*P* < 0.05) are highlighted in bold. Total sample size = 58 regions.

	A_{max}		**A_{ave}**	
Predictor variable	Estimated coefficient	Standard error	Estimated coefficient	Standard error
H1: Alien bird species richness	-0.049	0.267	**-0.578**	**0.224 ***
H2: Residence time	**0.955**	**0.35 ****	**0.908**	**0.306 ****
H3: Islands <100km^2	**0.853**	**0.317 ****	**0.846**	**0.277 ****
H4: Native bird species richness	**-0.743**	**0.316 ***	**-1.01**	**0.26 *****
H5: Average monthly temperature	0.371	0.787	0.624	0.695
H5: Average monthly rainfall	0.224	0.398	0.13	0.354
H6: Habitat breadth	0.131	0.076	**0.151**	**0.067 ***
H7: Diet breadth	0.119	0.088	0.147	0.077
H8: Native range size	**0.466**	**0.172 ****	0.209	0.16
H9: Alien range size	0.089	0.085	-0.01	0.076
H10: Competition	**-0.876**	**0.262 ****	**-0.653**	**0.24 ****
H10: Predation	**0.806**	**0.335 ***	**0.972**	**0.284 ****
H10: Hybridisation	**1.14**	**0.423 ****	0.592	0.392
H10: Interaction with other alien species	-0.006	1.092	-1.511	0.948
H10: Disease transmission	2.208	4.307	**-7.564**	**3.678 ***
H10: Grazing / herbivory / browsing	0.067	0.502	-0.053	0.447
H10: Chemical impact on ecosystem	-0.592	1.689	-1.754	1.482
H11: Human Development Index	2.613	2.84	-0.422	2.481
H12: Population density	-0.172	0.211	-0.191	0.186

Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

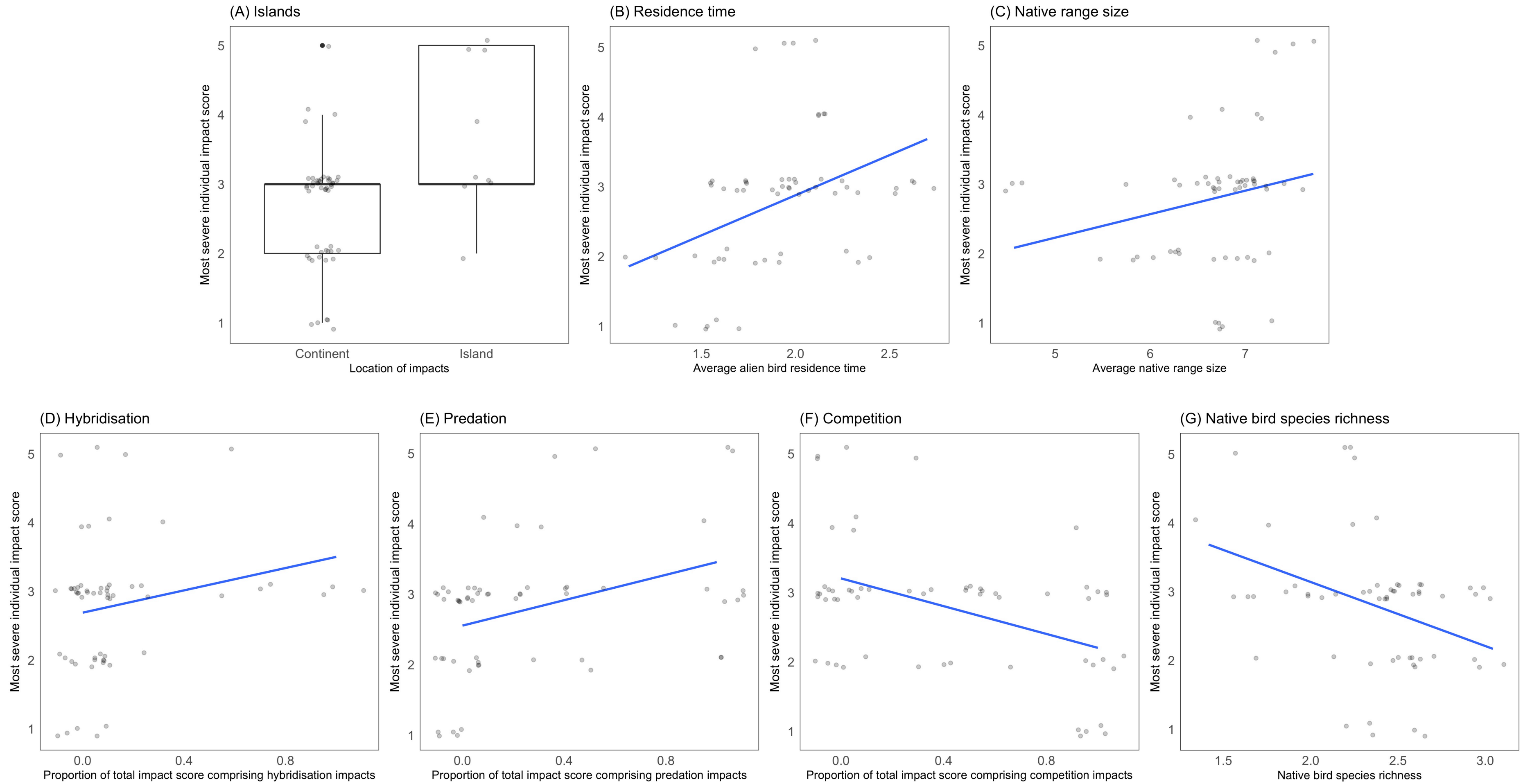

Figure 5.5: The relationship between the most severe individual impact score sustained by a region (A_{max}) and: (A) the location of impact (either continent or island (<100km²)); (B) average alien bird residence time for a region; (C) average native range size for a region; (D) the proportion of the total impact score sustained by a region comprising hybridisation impacts; (E) the proportion of the total impact score sustained by a region comprising predation impacts; (F) the proportion of the total impact score sustained by a region comprising competition impacts; (G) native bird species richness of a region. Total sample size: n = 58 regions (continental regions: n = 49, island regions: n = 9). Jitter used to add random noise to the data to prevent overplotting. Boxplots show the median and first and third quartiles (the 25th and 75th percentiles), with outliers plotted individually in bold.

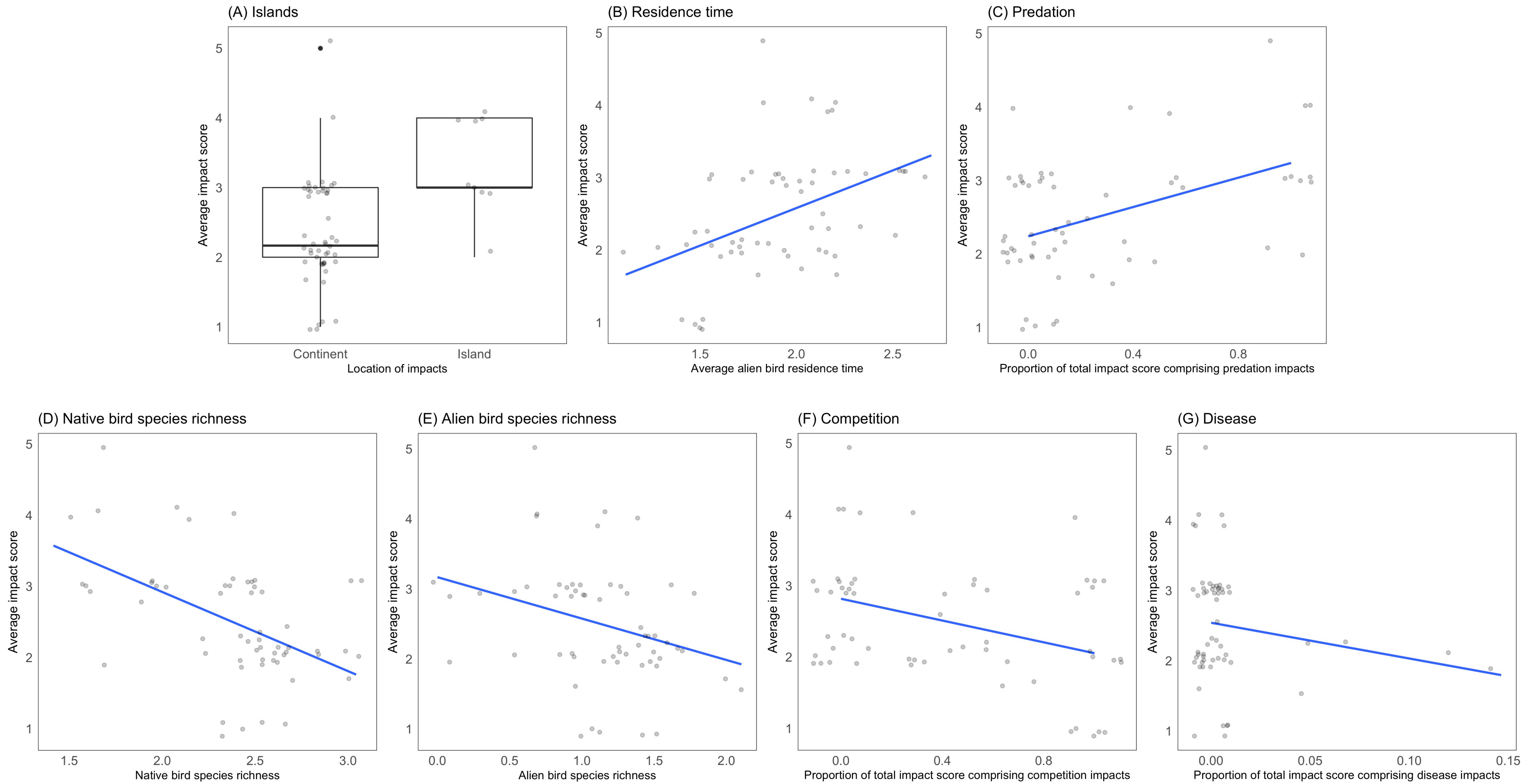

Figure 5.6: The relationship between the average impact score sustained by a region (A_{ave}) and: (A) the location of impact (either continent or island (<100km^2)); (B) average alien bird residence time for a region; (C) the proportion of the total impact score sustained by a region comprising predation impacts; (D) native bird species richness of a region; (E) alien bird species richness of a region; (F) the proportion of the total impact score sustained by a region comprising competition impacts; (G) the proportion of the total impact score sustained by a region comprising disease impacts. Total sample size: n = 58 regions (continental regions: n = 49, island regions: n = 9). Jitter used to add random noise to the data to prevent overplotting. Boxplots show the median and first and third quartiles (the 25th and 75th percentiles), with outliers plotted individually in bold.

Following model simplification, the best multivariate model for A_{max} indicated that the most severe impact sustained by a region tends to be higher if a region supports alien birds with longer residence times and larger native ranges, or if it has higher levels of alien bird species richness or lower levels of native bird species richness. The most severe impact score also tends to be higher for regions where the proportion of impacts resulting from predation or hybridisation is higher, if a region is an island (<100km^2), or if it is less densely populated (**Table 5.3**). The highest relative importance values were shown by the residence time, native range size and alien bird species richness variables (0.98, 0.92 and 0.84, respectively). In addition, hybridisation, predation and native bird species richness variables all had relative importance values exceeding 0.7 (**Table 5.3**; a complete list of relative importance values is given in **Table 5.4**). The marginal and conditional R^2 for the best model did not differ (0.65; **Table 5.3**).

Following model simplification, the best multivariate model for A_{ave} indicated that the average impact score sustained by a region tends to be higher if a region supports alien birds with longer residence times, if it has lower levels of native species richness, if it supports birds with larger native ranges, if the proportion of impacts resulting from predation or hybridisation is higher, or if the proportion of impacts resulting from interaction with other alien species is lower (**Table 5.3**). The highest relative importance value was again shown by the residence time variable (0.98), followed by the native bird species richness and native range size variables (0.92 and 0.7, respectively; **Table 5.3**). The marginal and conditional R^2 values again did not differ (0.59; **Table 5.3**).

Table 5.3: The best multivariate models, as ranked by AICc (calculated using the dredge function in the MuMIn package (Bartoń, 2018)), displaying the relationships between predictor variables and A_{max} (the most severe actual impact score sustained by a region) and A_{ave} (the average actual impact score sustained by a region). Relative importance values (the sum of the Akaike weights over all models for each predictor variable) were obtained using the Importance function (MuMIn). Estimated coefficients ± standard error (s.e.) derive from generalised linear mixed effects models using the lme4 package (Bates *et al.* 2015), with a random effect for continent included to account for potential autocorrelation among regions. Marginal R^2 (the variance explained by fixed factors) and conditional R^2 (the variance explained by both fixed and random factors (i.e. the entire model)) were obtained using the r.squaredGLMM function (MuMIn). Total sample size = 58 regions.

	A_{max}		**A_{ave}**	
Predictor variable	Coefficient ± s.e.	Relative importance	Coefficient ± s.e.	Relative importance
(Intercept)	-1.21 ± 1.08		0.54 ± 0.97	
H1: Alien bird species richness	0.77 ± 0.21	0.84		
H2: Residence time	0.89 ± 0.23	0.98	0.83 ± 0.21	0.98
H3: Islands <100km^2	0.49 ± 0.26	0.66		
H4: Native bird species richness	-0.66 ± 0.26	0.73	-0.73 ± 0.21	0.92
H8: Native range size	0.46 ± 0.12	0.92	0.27 ± 0.11	0.7
H10: Predation	1.08 ± 0.24	0.78	0.94 ± 0.21	0.66
H10: Hybridisation	1.01 ± 0.29	0.75	0.79 ± 0.28	0.59
H10: Interaction with other alien species			-1.12 ± 0.63	0.53
H12: Population density	-0.27 ± 0.13	0.4		

A_{max}: AIC = 119.8; BIC = 142.4; logLik = -48.9; deviance = 97.8; df residual = 47; Marginal R^2 = 0.65; Conditional R^2 = 0.65.
A_{ave}: AIC = 109.7; BIC = 128.2; logLik = -45.8; deviance = 91.7; df residual = 49; Marginal R^2 = 0.59; Conditional R^2 = 0.59.

Table 5.4: Relative importance values (the sum of the Akaike weights over all models for each predictor variable) obtained using the Importance function in the MuMIn package (Bartoń, 2018). Values highlighted in bold are for predictor variables within the best model for regions with actual impacts (A_{max} and A_{ave}).

Predictor variable	**A_{max}**	**A_{ave}**
H1: Alien bird species richness	**0.84**	0.2
H2: Residence time	**0.98**	**0.98**
H3: Islands <100km^2	**0.66**	0.3
H4: Native bird species richness	**0.73**	**0.92**
H5: Average monthly temperature	0.18	0.24
H5: Average monthly rainfall	0.18	0.25
H6: Habitat breadth	0.37	0.4
H7: Diet breadth	0.33	0.25
H8: Native range size	**0.92**	**0.7**
H9: Alien range size	0.19	0.2
H10: Competition	0.5	0.59
H10: Predation	**0.78**	**0.66**
H10: Hybridisation	**0.75**	**0.59**
H10: Interaction with other alien species	0.18	**0.53**
H10: Disease transmission	0.21	0.38
H10: Grazing / herbivory / browsing	NA (removed)	NA (removed)
H10: Chemical impact on ecosystem	0.2	0.32
H11: Human Development Index	0.19	0.24
H12: Population density	**0.36**	0.24

5.4.2 Potential impacts

Univariate analysis of spatial variation in the most severe potential impact score sustained by a region (P_{max}) revealed positive relationships between impact severity and alien bird species richness, native and alien range size, the proportion of impacts resulting from predation and hybridisation, alien bird residence time, and human development. P_{max} was negatively related to the proportion of impacts resulting from interaction impacts (**Table 5.5**). For the average potential impact score sustained by a region (P_{ave}), univariate analysis revealed positive relationships between impact severity and diet and habitat breadth, native and alien range size and the proportion of impacts resulting from competition and predation. P_{ave} was negatively related to the proportion of impacts resulting from interactions with other aliens and disease transmission, alien bird species richness, and human development (**Table 5.5**).

Table 5.5: Univariate analysis displaying the relationships between the severity of potential impacts across regions and predictor variables for P_{max} (the most severe potential individual impact score sustained by a region) and P_{ave} (the average potential impact score sustained by a region). All parameters in this table derive from generalised linear mixed effects models using the lme4 package (Bates *et al.* 2015), with a random effect for continent included to account for potential autocorrelation among regions. *P* values were obtained using the lmerTest package (Kuznetsova *et al.* 2017). Significant relationships (*P* < 0.05) are highlighted in bold. Total sample size = 241 regions.

	P_{max}		**P_{ave}**	
Predictor variable	Estimated coefficient	Standard error	Estimated coefficient	Standard error
H1: Alien bird species richness	**0.793**	**0.093 *** **	**-0.236**	**0.075 ***
H2: Residence time	**0.359**	**0.127 ***	-0.12	0.092
H3: Islands <100km^2	-0.197	0.136	-0.069	0.098
H4: Native bird species richness	-0.263	0.14	-0.012	0.105
H5: Average monthly temperature	-0.162	0.4	-0.515	0.293
H5: Average monthly rainfall	0.131	0.132	-0.035	0.096
H6: Habitat breadth	0.033	0.036	**0.139**	**0.024 *** **
H7: Diet breadth	3.008e-03	5.851e-02	**0.235**	**0.039 *** **
H8: Native range size	**0.638**	**0.158 *** **	**0.815**	**0.106 *** **
H9: Alien range size	**0.25**	**0.048 *** **	**0.245**	**0.033 *** **
H10: Competition	0.248	0.185	**0.652**	**0.127 *** **
H10: Predation	**1.155**	**0.274 *** **	**0.82**	**0.209 *** **
H10: Hybridisation	**2.308**	**0.417 *** **	0.141	0.317
H10: Interaction with other alien species	**-2.163**	**0.258 *** **	**-2**	**0.165 *** **
H10: Disease transmission	-1.074	0.657	**-1.186**	**0.468 * **
H10: Grazing / herbivory / browsing	-0.476	0.326	-0.263	0.244
H10: Chemical impact on ecosystem	0.836	1.618	-2.034	1.162
H11: Human Development Index	**1.834**	**0.644 ***	**-1.132**	**0.456 * **
H12: Population density	0.115	0.088	-0.131	0.063

Significance codes: '***' P < 0.001 '**' P < 0.01 '*' P < 0.05.

Following model simplification, the best multivariate model for P_{max} indicated that the most severe potential impact sustained by a region tends to be higher if a region has higher levels of alien species richness and lower levels of native species richness, if the proportion of impacts resulting from hybridisation, predation and competition is higher, or the proportion of impacts from interaction and chemical impacts on ecosystem are lower. P_{max} also tends to be higher if a region is characterised by higher rainfall, or if it supports birds with larger native ranges or broader dietary preferences (**Table 5.6**). The highest relative importance values were shown by the alien and native bird species richness, hybridisation and interaction variables (all with a relative importance value of 1), along with the predation, chemical impact on ecosystem and average monthly rainfall variables (all with relative importance values exceeding 0.9) (**Table 5.6**; a complete list of relative importance values is given in **Table 5.7**). The marginal and conditional R^2 for the best model were 0.56 and 0.59, respectively; **Table 5.6**).

Following model simplification, the best multivariate model for P_{ave} indicated that the average impact score sustained by a region tends to be higher if a region has lower levels of alien species richness and native species richness, if the proportion of impacts resulting from predation and hybridisation is higher, or the proportion of impacts resulting from interaction, disease transmission or chemical impacts on ecosystem are lower. P_{ave} also tends to be higher if a region supports birds with larger native and alien ranges, those with broader dietary preferences, or if it is less densely populated (**Table 5.6**). The highest relative importance values were shown by the predation, interaction with other alien species, and alien bird species richness variables (all with a relative importance value of 1), along with native bird species richness, native range size and hybridisation (all with relative importance values exceeding 0.9) (**Table 5.6**). The marginal and conditional R^2 for the best model were 0.59 and 0.64, respectively; **Table 5.6**).

Table 5.6: The best multivariate models, as ranked by AICc (calculated using the dredge function in the MuMIn package (Bartoń, 2018)), displaying the relationships between predictor variables and P_{max} (the most severe potential impact score sustained by a region) and P_{ave} (the average potential impact score sustained by a region). Relative importance values (the sum of the Akaike weights over all models for each predictor variable) were obtained using the Importance function (MuMIn). Estimated coefficients ± standard error (s.e.) derive from derive from generalised linear mixed effects models using the lme4 package (Bates *et al*. 2015), with a random effect for continent included to account for potential autocorrelation among regions. Marginal R^2 (the variance explained by fixed factors) and conditional R^2 (the variance explained by both fixed and random factors (i.e. the entire model)) were obtained using the r.squaredGLMM function (MuMIn). Total sample size = 241 regions.

	P_{max}		P_{ave}	
Predictor variable	Coefficient ± s.e.	Relative importance	Coefficient ± s.e.	Relative importance
(Intercept)	-0.08 ± 0.90		-0.04 ± 0.61	
H1: Alien bird species richness	0.77 ± 0.08	1	-0.29 ± 0.06	1
H4: Native bird species richness	-0.41 ± 0.10	1	-0.29 ± 0.07	0.99
H5: Average monthly rainfall	0.3 ± 0.09	0.96		
H7: Diet breadth	0.08 ± 0.05	0.58	0.08 ± 0.03	0.87
H8: Native range size	0.34 ±0.12	0.81	0.41 ± 0.09	0.99
H9: Alien Range size			0.07 ± 0.03	0.79
H10: Competition	0.65 ± 0.19	0.89		
H10: Predation	0.94 ± 0.25	0.98	0.62 ± 0.15	1
H10: Hybridisation	2 ± 0.36	1	0.66 ± 0.23	0.91
H10: Interaction with other alien species	-1.1 ± 0.26	1	-1.43 ± 0.17	1
H10: Disease transmission			-0.67 ± 0.33	0.69
H10: Chemical impact on ecosystem	-3.25 ± 1.17	0.93	-1.33 ± 0.80	0.53
H12: Population density			-0.07 ± 0.04	0.53

P_{max}: AIC = 398.6; BIC = 443.9; logLik = -186.3; deviance = 372.6; df residual = 228; Marginal R^2 = 0.56; Conditional R^2 = 0.59.
P_{ave}: AIC = 223.6; BIC = 272.4; logLik = -97.8; deviance = 195.6; df residual = 227; Marginal R^2 = 0.59; Conditional R^2 = 0.64.

Table 5.7: Relative importance values (the sum of the Akaike weights over all models for each predictor variable) obtained using the Importance function in the MuMIn package (Bartoń, 2018). Values highlighted in bold are for predictor variables within the best model for regions with potential impacts (P_{max} and P_{ave}).

Predictor variable	P_{max}	P_{ave}
H1: Alien bird species richness	**1**	**1**
H2: Residence time	0.25	0.32
H3: Islands <100km²	0.25	0.26
H4: Native bird species richness	**1**	**0.99**
H5: Average monthly temperature	0.53	0.39
H5: Average monthly rainfall	**0.96**	0.34
H6: Habitat breadth	0.36	0.26
H7: Diet breadth	**0.58**	**0.87**
H8: Native range size	**0.81**	**0.99**
H9: Alien range size	0.62	**0.79**
H10: Competition	**0.89**	0.32
H10: Predation	**0.98**	**1**
H10: Hybridisation	**1**	**0.91**
H10: Interaction with other alien species	**1**	**1**
H10: Disease transmission	0.28	**0.69**
H10: Grazing / herbivory / browsing	NA (removed)	NA (removed)
H10: Chemical impact on ecosystem	**0.93**	**0.53**
H11: Human Development Index	0.26	0.26
H12: Population density	0.38	**0.53**

5.5 Discussion

Understanding the potential for spatial variation in the impacts of alien species, and the drivers that cause this variation, represents a significant gap in our understanding of biological invasions. Being able to identify regions that are more likely to be affected by alien species, and to predict which regions are likely to be affected by invasions in the future, could potentially enable the prioritisation of resources to address the impacts of alien species where they are most needed. Here, I combine a recently developed, standardised method for quantifying and categorising the impacts of alien species (Blackburn *et al*. 2014) with a comprehensive database on the distribution of alien bird species (Dyer *et al*. 2017a) to produce the first global distribution maps of alien species impacts. I use the data underlying these maps to test hypotheses for drivers of spatial variation in the severity of alien bird impacts, to understand why specific regions are more likely to be affected by the impacts of alien species. I find that factors affecting the length and frequency of invasions, characteristics of alien birds, and characteristics of the receiving environment, all play a part in influencing the severity of impacts sustained across regions.

Factors that influence how frequently and for how long a region has been subject to invasions cause notable variation in impact severity across regions. Indeed, alien bird residence time (hypothesis H2) was found to be the strongest predictor of actual impacts (**Tables 5.2** & **5.3**). Average residence times vary substantially across regions: for all 58 regions with actual impacts the arithmetic mean is 115 years, and the median is 85 years. Regions with above average residence times and severe impacts include Puerto Rico (154 years; most severe impact = 3, average impact = 3) and Mauritius (133; 4, 4). Alien birds with longer residence times have had greater opportunity to establish and spread, and indeed have been found to have larger alien ranges (Dyer *et al*. 2016). Such species have also had more time to develop damaging impacts, and this is reflected in the spatial distribution of actual impacts.

Interestingly, residence time was not found to be a predictor of variation in potential impacts across regions (**Tables 5.5** & **5.6**). One clear possibility is that we are overlooking the impacts of damaging species in regions where they have been present for a long time, but not studied. If so, we may have yet to witness the full extent of impacts generated by alien birds (*sensu* Rouget *et al*. 2016). However, an alternative possibility is that species with actual impacts do not generate these impacts in regions with potential impacts (i.e. where the species is present but no impacts have been recorded), regardless of residence time. Given the impacts of alien species are context dependent, this is possible: a species may be impactful in one location, but not another. If this is the case, the potential impact data presented in this study would need to be considered on a region by region basis, rather than making broad generalisations about the potential impacts of alien birds. The fact that the average residence time for regions with actual impacts is longer than that for regions with potential impacts (115 and 78 years, respectively) suggests that some regions with potential impacts genuinely lack the impacts of species with actual impacts, but those impacts may be coming as species establish and spread. If so, it may be possible to identify areas where management could pre-empt imminent impacts.

Regions with greater alien species richness (hypothesis H1) tend to be home to alien birds with more severe actual (**Table 5.3**) and potential (**Tables 5.5** & **5.6**) impacts. Conversely, average actual (**Table 5.2**) and potential (**Tables 5.5** & **5.6**) impacts tend to be negatively related to alien species richness. This patterning suggests a sampling effect. The distribution of impact scores is highly skewed for alien birds: most species have low impact scores (species with **MC** or **MN** impacts = 82; species with **MO**, **MR** or **MV** impacts = 37). If an area has more alien bird species, the likelihood that one of those species has a high actual or potential impact will be greater, leading to a positive relationship between alien species richness and most severe impact (A_{max}, P_{max}). However, where more alien species are present, more species with low potential or actual impacts are likely to be present, potentially leading to a negative relationship with average impact (A_{ave}, P_{ave}). Nonetheless, these results suggest that minimising the number of alien birds introduced to a region is a key strategy to minimising the potential for severe impacts: simply, the more alien species present, the more likely that at least one will be damaging. This likelihood increases the longer they have been present (see above).

Variation in the characteristics of established alien bird species also causes spatial variation in the severity of their impacts. For actual and potential impacts, native range size (hypothesis H8) is a consistent predictor of both average and most severe impact across regions (**Tables 5.2** & **5.3**, **5.5** & **5.6**). Native range size is an indicator of habitat generalism, as species with larger native ranges tend to be able to occupy a broader range of habitats. Such species also tend to establish larger alien ranges (Dyer *et al*. 2016), and there is some indication that they are more likely to have damaging impacts, albeit not once other factors are controlled for (Evans *et al*. 2018b). Thus, species with large native ranges may have more opportunity to generate impacts when introduced as aliens. Interestingly, native range size is a more consistent predictor of spatial variation in impacts than is alien range size: the latter is only a positive correlate of potential impacts, and then has a strong effect just in univariate analysis (**Table 5.5**). Alien range size is strongly positively related to whether or not a species has impacts (Evans *et al*. 2018b), but not to spatial variation in those impacts. Thus, a characteristic of species with high impacts is not necessarily a characteristic of regions where impacts are high. The likely reason for the lack of a spatial effect is that the 18 regions with the largest average alien range size scores support only one alien species: the house sparrow (*Passer domesticus*). This species has the largest alien range in my dataset (>36 x 10^6km^2), and an impact score of 3, close to both the average impact score (2.6) and average most severe impact score (3.2) for all regions with potential impacts. The effect of this species will be to flatten the relationship between impact score and alien range size across regions. Potential impacts were found to be more severe for regions with high average diet breadth scores (hypothesis H7), which is another indicator of generalism (**Table 5.6**).

Regions tend to sustain more damaging actual and potential impacts where a greater proportion of those impacts are the result of predation and hybridisation (hypothesis H10) (**Tables 5.2** & **5.3**, **5.5** & **5.6**). These results concur with those of previous studies which found the impacts of species to be greater via these mechanisms (Evans *et al*. (2016) and Martin-Albarracin *et al*. (2015), respectively): I show that impacts are also greater within regions where species having these impacts occur. Actual predation and hybridisation impacts can be severe: on Lord Howe Island (Australia), predation by the introduced Australian masked owl (*Tyto novaehollandiae*) has contributed to the extinction of the native Lord Howe Island Boobook (*Ninox novaeseelandiae albaria*) (Garnett *et al*. 2011); on the Amirante Islands (Seychelles), hybridisation with the introduced Madagascar turtle-dove (*Nesoenas picturatus*) has resulted in the extinction of the native subspecies (*Streptopelia picturata aldabrana*) (BirdLife International, 2016d).

A key question, however, is whether we can expect predation and hybridisation impacts to occur in regions that support species with those impacts, but where no such impacts have been recorded. Here, the potential for impacts will depend on specific characteristics of the recipient community, such as the presence of species susceptible to predation impacts, and species that are suitable for hybridisation. For example, Singapore supports five species with potential predation impacts (the average for regions with potential predation impacts = <1 species), including the common myna (*Acridotheres tristis*), which adversely affects populations of the native Tahiti flycatcher (*Pomarea nigra*) on Tahiti (Blanvillain *et al*. 2003), and the red-whiskered bulbul (*Pycnonotus jocosus*) which is responsible for the extirpation of large spiders (genus *Neophilia*) on Mauritius (Diamond, 2009). It is plausible to assume that Singapore may be at risk to the impacts of predatory alien birds. However, Singapore also supports numerous similar predatory bird species, which means that the local fauna may be well inured to the effects of such species. Similarly, Hawaii supports four species with potential hybridisation impacts, including the mallard (*Anas platyrhynchos*), which hybridises with the native Pacific black duck (*Anas superciliosa*) across New Zealand (Taysom *et al*. 2014) and Chinese hwamei (*Garrulax canorus*) which hybridises with the Taiwan hwamei (*Garrulax taewanus*) (Li *et al*. 2010). Hawaii may be at risk from hybridisation impacts from the mallard: indeed, reports indicate that it is hybridising with the native Hawaiian duck (*Anas wyvilliana*) (Uyehara *et al*. 2007). However, Hawaii is unlikely be at risk from hybridisation impacts from the Chinese hwamei, given the absence of any native species in this bird family. Therefore, the effects of different mechanisms on actual impacts may not be generalisable to potential impacts, at least in cases where impacts are clearly context-dependent.

Potential impacts are also more severe for regions where a greater proportion of impacts result from competition. Yet EICAT scores tend to be lower for species with competition impacts than for other impact mechanisms (Evans *et al*. 2016), and impacts were not more severe in regions with a higher proportion of actual competition impacts (**Tables 5.2** & **5.3**). This suggests that the global threat posed by alien birds with competition impacts may be underestimated if we only consider their actual impacts. Over 40% of the species in my dataset with competition impacts (taken from a recent global alien bird EICAT assessment: Evans *et al*. 2016) are Psittaciform (parrot) species, which tend to have minor (**MC** and **MN**) impacts as aliens in the USA, and are generally not widely distributed as aliens elsewhere. These low impact species therefore have relatively few potential competition impacts. However, some of the species in my dataset have more severe competition impacts (**MO** or higher) and are widely distributed (e.g. the common starling (*Sturnus vulgaris*)) and therefore have many potential competition impacts. Indeed, alien birds with competition impacts are in general broadly distributed across the globe, being present in over 87% of regions with actual or potential alien bird impacts, while alien birds with predation and hybridisation impacts are present in just 45% and 27%, respectively. Due to their widespread distribution, and the fact that alien birds generally have greater opportunity to generate impacts through competition than through other impact mechanisms (Evans *et al*. 2016), alien birds with competition impacts may represent a more significant threat than their generally low EICAT scores would suggest.

Regions with a higher proportion of interaction impacts (for alien birds this relates solely to the spread of the seeds of alien plants by frugivorous alien birds), chemical impacts on ecosystems (in the case of alien birds this relates to nutrient loading of water bodies with droppings) and disease transmission impacts tend to have lower impact scores (**Tables 5.2** & **5.3**, **5.5** & **5.6**). All three mechanisms tend to be assessed as less severe under EICAT (often categorised as **MC** or **MN**: none to date categorised as **MR** or **MV**), and there are also few species with these impacts. Regions with high proportions of species with the potential for these impacts may therefore have few species with other, more concerning potential impacts, such as predation. However, the effects of these mechanisms may in fact be a simple result of the fact that the proportions of species with different impact mechanisms must sum to 1. Thus, the positive effects of some mechanisms on potential (and actual) impact scores across regions will inevitably lead to negative effects for other mechanisms. The generally weak and inconsistent effects of most of these mechanisms suggests that we should not read too much into them.

Characteristics of the receiving environment may cause spatial variation in impact severity. Notably, regions with lower native species richness (as measured by the number of native bird species: hypothesis H4) are consistently associated with more severe actual and potential impacts (**Tables 5.2**, **5.3** & **5.6**). Approximately half of the regions in my dataset with low native species richness are islands (<100km^2). Islands are generally considered to be particularly susceptible to the impacts of alien species (Russell *et al*. 2017; CBD, 2017), and I found actual impacts to be more severe on islands in both univariate and multivariate analyses (hypothesis H3) (**Tables 5.2** & **5.3**). All of the most severe alien bird impacts (those causing species extirpations and extinctions: **MR** or **MV** impacts) are sustained on islands. However, the island effect overall is relatively weak and inconsistent in the multivariate analysis, especially relative to native species richness (**Table 5.3**). Potential impacts are also not higher on islands, although there is a strong effect of native species richness in the multivariate analysis at least (**Table 5.6**). These results suggest that areas that are low in native species tend to see higher alien impacts expressed, regardless of whether or not those areas are on islands. That said, the additional (weak) island effect on actual impacts may reflect the fact that island ecosystems often support endemic species that are especially vulnerable to the impacts of alien species. Hence, maximum impacts tend to be high on islands, for a given species richness, where aliens have frequently caused extinctions (Bellard *et al*. 2016a). In this regard, it may be of concern that 44 of the 241 regions (18%) supporting alien birds with potential impacts are small island ecosystems (<100km^2), and these are home to alien birds that are known to have severe environmental impacts, including Corvidae (crows and allies), Strigiformes (owls) and Accipitriformes (diurnal birds of prey) (Evans *et al*. 2016). A list of islands (<100km^2) with actual and potential impacts is provided in **Appendix F**, **Table F1**.

5.6 Conclusions

Here, I present the first global maps of the impacts generated by alien species from an entire taxonomic class. In so doing, I demonstrate how data from EICAT assessments can be used to map the impacts of alien species, a process that is replicable for other taxonomic groups, including those with damaging alien species such as mammals. The unified EICAT data enables direct comparisons to be made across regions, which facilitates the identification of regions which currently sustain damaging impacts, and those with the potential for such impacts. The maps illustrate that whilst the recorded impacts of alien birds are generally restricted to temperate, developed regions of the world, their potential impacts are far more widespread.

This study is also the first to identify the factors that influence spatial variation in the severity of impacts generated by alien birds. The results suggest that factors influencing the duration and frequency of alien bird invasions are key in determining whether the impacts sustained by a region will be damaging: the length of time a species is present in a region, and the number of species that are introduced, are significant determinants of impact. This reinforces previous suggestions (Shirley & Kark, 2009; Kumschick & Nentwig, 2010; Evans *et al*. 2018b) that early interventions, and the prevention of new invasions, are strategies that may effectively minimise the impacts of alien birds. In addition, the results indicate that characteristics of alien birds, and of the receiving environment, also influence the severity of impacts sustained by a region.

This study has clear implications for impact prediction and the management of alien species, as the maps, and the data underpinning them, can be used to identify regions of the world that are characterised by the variables found to be associated with impact severity. This may assist in directing management interventions to regions where they are most needed. For example, the small island ecosystem of the Maldives supports several generalist alien birds with potential impacts across a range of damaging impact mechanisms. They have also been present on the Maldives for a relatively short period of time, which suggests these species may yet to have caused their most severe impacts. In regions like this, the opportunity to minimise the potential future impacts of alien birds may be greatest.

Chapter 6

Discussion

6.1 In summary

In this thesis, I have used the Environmental Impact Classification for Alien Taxa (EICAT) to further our understanding of the environmental impacts generated by alien birds. We now have a global, directly comparable dataset which provides information on the types of alien birds that cause the most damage, and the ways in which they generate impacts. Crucially, this dataset reveals the species and locations for which we have no impact data, which may assist in directing future research. We also know more about the factors that influence whether we have impact data for alien bird species, and the results of this research indicate that damaging impacts generated by some alien birds are likely to be going unnoticed. We also know more about the factors that influence the severity of impacts generated by alien birds, and this information can be used to inform risk assessments for potentially damaging alien bird species. Finally, we also understand more about the factors that influence spatial variation in the impacts of alien birds, having produced the first global alien bird impact maps, which can be used to identify regions of the world at risk to the impacts of alien birds.

6.2 The applicability of this research and future directions

6.2.1 Alien species impact data

A continuing challenge to the effective management of alien species is a lack of data on their impacts (Kumschick *et al*. 2015a; Hoffmann & Courchamp, 2016; Wilson *et al*. 2016a), and in this thesis, I have shown that we have no data on the environmental impacts of over 70% of alien bird species. The results of the EICAT assessment presented in **Chapter 2** and **Chapter 5** may therefore direct attention to those species, mechanisms and regions for which we lack impact data. Studies informing EICAT assessments for these species, mechanisms and regions would assist in meeting global conservation targets as stipulated under Aichi Target 9 of the Strategic Plan for Biodiversity 2011-2020 (https://www.cbd.int/sp) and Target 5 of the European Union 2020 Biodiversity Strategy (http://ec.europa.eu/environment/nature/biodiversity/strategy).

6.2.2 Quantifying and categorising the socio-economic impacts of alien birds

This thesis has improved our understanding of the environmental impacts generated by alien birds, but it does not paint a complete picture. Their impacts, and those of alien species in general, extend beyond the environment and biodiversity, affecting the wellbeing and livelihoods of people across the globe. A recent assessment of the economic costs of alien species in the EU came to €12.5 billion / year (Kettunen *et al*. 2009). Indeed, there are more data describing the socio-economic impacts of alien species in Europe than there is for their environmental impacts (Vilà *et al*. 2010). For alien birds, economic losses resulting from their impacts in just six countries (UK, USA, Australia, South Africa, India and Brazil) have been estimated at US$2.4 billion / year (Pimentel, 2002), and in Australia, the socio-economic impacts of alien birds have been found to be more severe than their environmental impacts (Evans *et al*. 2014). For example, the common blackbird (*Turdus merula*) and Eurasian starling (*Sturnus vulgaris*) cause significant damage to vineyards and orchards in Victoria (Tracey & Saunders, 2003).

The Socio-Economic Impact Classification for Alien Taxa (SEICAT: Bacher *et al*. 2018) has recently been proposed in order to quantify and categorise the impacts of alien species to human wellbeing. SEICAT has been designed to be structurally similar to EICAT, adopting the same five impact categories (**MC** – **MV**). Based on the capability approach from welfare economics (*sensu* Kuklys & Robeyns, 2005), it focusses on the ways in which alien taxa can adversely affect human wellbeing, using changes in people's activities as a common metric for quantifying impacts (Bacher *et al*. 2018). So far it has been successfully applied to quantify and categorise the impacts of amphibians (Bacher *et al*. 2018), but it has yet to be applied to alien birds.

Undertaking a global alien bird SEICAT assessment would produce the first directly comparable, global dataset on the socio-economic impacts of alien birds, improving our understanding as to how and why alien birds may adversely affect human wellbeing within communities across the globe. When combined with the alien bird EICAT data presented in this thesis, it would form the first complete dataset on alien species impacts for an entire taxonomic class. Using an approach similar to that adopted in this thesis, the data generated by a global alien bird SEICAT assessment could be used to undertake further studies to identify the traits associated with alien birds which influence the severity of their impacts to human wellbeing. This would be an important step in improving our ability to manage the impacts of biological invasions, potentially enabling the identification of species that possess these damaging traits, informing risk assessments to minimise their introduction to new environments, and management actions to mitigate their impacts where they have already been introduced. Due to the structural similarity of EICAT and SEICAT, direct comparisons regarding the environmental and socio-economic impacts of alien birds would also be possible, adding an extra dimension to our impact prediction capabilities, by enabling the identification of alien bird species that may pose a specific threat to the environment or human wellbeing in different regions of the world. The combined EICAT / SEICAT data could also be used to produce the first global impact maps that incorporate the complete range of impacts generated by alien species for an entire taxonomic class.

6.2.3 Using EICAT to identify the factors that increase the vulnerability of native species to the impacts of alien birds

This thesis has improved our knowledge of the identity and characteristics of impactful alien birds. However, we know less about the traits associated with native species that increase their vulnerability to the impacts of alien birds (or alien species in general). Yet, knowledge of these traits is important because it may improve our impact prediction and risk assessment capabilities, in turn helping to improve biosecurity measures against alien species. One obvious avenue for future research would be to use EICAT to undertake a native species vulnerability assessment. Focussing on traits of the invaded species rather than those of the invading species would be novel, as it has yet to be undertaken using impact data for an entire taxonomic class of alien species (alien birds). This may be because until the completion of the alien bird EICAT assessment presented in this thesis, there was no standardised, directly comparable, global dataset on the impacts of alien birds with which to undertake the analysis.

Applying EICAT impact scores (**MC** – **MV**) to the impacted native species relating to each alien bird EICAT assessment would create an impact severity dataset for these native species. This would enable a series of hypotheses to be tested to identify potential causes of variation in the vulnerability of native species to the impacts of alien birds (as measured by the severity of the impacts they sustain). For example, native species with habitat or dietary requirements similar to those of their alien invader may be more vulnerable to the impacts of alien birds due to their propensity for competition impacts (e.g. Strubbe *et al*. 2009); specialist species may be more vulnerable due to their reduced ability to adapt or disperse when faced with competition or predation (*sensu* Clavel *et al*. 2011); species that are taxonomically similar to their alien invader may be more vulnerable due to their propensity for hybridisation and competition impacts (e.g. Tracey *et al*. 2008); species that are endemic or less widespread may be more vulnerable due to their increased likelihood of extinction (e.g. Department of Environment and Natural Resources (Bermuda), 2017); species from communities with low levels of competition may be more vulnerable because they are less able to compete (*sensu* Carlquist, 1965); smaller species may be more vulnerable due to their propensity for predation impacts (e.g. Fanchette, 2012); and invertebrate species may be more vulnerable because they form a key component of many bird species' diet, and are therefore predisposed to predation impacts (e.g. Linnebjerg *et al*. 2010). From these hypotheses, data on predictor variables would be gathered for each impacted native species (examples of potential predictor variables include taxonomy, diet breadth, habitat breadth, native breeding range size, taxonomic similarity of native / alien species, habitat requirements, location of impact (e.g. island / continent) and body mass), and relationships between each of the predictor variables and the severity of impacts to native species examined. This process would enable the identification of factors that most strongly influence the vulnerability of native species to the impacts of alien birds, and this information could be useful in identifying sensitive receptors and specific threats in regions at risk to alien bird invasions.

6.3 In conclusion

This thesis has demonstrated how quantifying and categorising the impacts of alien species enables the exploration of key hypotheses about variation in the severity and type of impacts that they generate. I have shown that we still have much to learn about the impacts of alien birds, as we have no impact data for the majority of bird species with alien populations. To further our understanding of the impacts of alien birds, I suggest that the EICAT data presented in this thesis should be used to direct research towards those species, mechanisms and regions for which impact information is lacking. Further, in order to obtain a more complete picture of the impacts of alien birds, I also suggest that an assessment of their socio-economic impacts should be undertaken, using the recently proposed SECIAT protocol to quantify and categorise their impacts to human wellbeing. The results of the EICAT and SEICAT assessment could then be combined to produce the first global maps displaying the complete set of impacts generated by alien species from an entire taxonomic class. Finally, I suggest that the EICAT data should be used to identify the factors that increase the vulnerability of native species to the impacts of alien birds, as this information could be used to identify sensitive receptors and specific threats in regions at risk to alien bird invasions.

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Appendix A

Literature review protocol

A1.1 Search protocol

An exhaustive literature review was undertaken to identify sources of data describing the impacts of each alien bird species. Following an initial search using online databases (see below), a search for references listed in the articles/data sources found through the initial search was undertaken. This process was repeated to a point where no new sources of data were identified.

A1.2 Search terms

Online searches were undertaken using the following search terms within a search string, in conjunction with the species scientific and common name: “introduced species”, “invasive species”, “invasive alien species”, “IAS”, “alien”, “non-native”, “non-indigenous”, “invasive bird”, “pest”, “feral” and “exotic”. Thus, the search string for the species Eurasian blackbird was (“introduced species” OR “invasive species” OR “invasive alien species” OR “IAS” OR “alien” OR “non-native” OR “non-indigenous” OR “invasive bird” OR “pest” OR “feral” OR “exotic”) AND (“Eurasian blackbird” OR “blackbird” OR “Turdus merula”).

A1.3 Data sources

Databases searched included:

- Web of Science (http://apps.webofknowledge.com/).
- Google (https://www.google.co.uk).
- Google Scholar (https://scholar.google.co.uk).
- UCL Explore (https://www.ucl.ac.uk/library/electronic-resources/about-explore), which provides access to a range of online publication databases including JSTOR (http://www.jstor.org), Springer Link (http://link.springer.com), Wiley Online Library (http://onlinelibrary.wiley.com), Cambridge University Press (http://www.cambridge.org), Oxford University Press

(http://www.oxfordjournals.org/en/), The Royal Society (https://royalsociety.org/library/collections/journals/) and ProQuest (http://www.proquest.com/libraries/academic/databases/).

Other online resources searched included the IUCN Red List of Threatened Species (http://www.iucnredlist.org), Delivering Alien Invasive Species Inventories for Europe (DASIE) (http://www.europe-aliens.org), CABI's Invasive Species Compendium (http://www.cabi.org/isc/) and the Global Invasive Species Database (GISD) of the Invasive Species Specialist Group (ISSG) (http://www.issg.org/database/welcome/).

Key texts on avian invasions were used to guide the assessment process, including Long (1981), Lever (2005) and Blackburn *et al*. (2009).

A1.4 Reference documents

Relevant data sources and articles were selected according to the information provided in the titles and abstracts, based on the search terms above, and the EICAT impact mechanisms and criteria. The following reference documents were used to collate data on alien bird impacts during the EICAT assessment:

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Appendix B

Table B1: Total impacts allocated to each alien bird order by EICAT impact category and EICAT impact mechanism.

EICAT impact mechanism	**EICAT impact category**	Accipitriformes	Anseriformes	Apodiformes	Apterygiformes	Casuariiformes	Cathartiformes	Charadriiformes	Ciconiiformes	Columbiformes	Coraciiformes	Cuculiformes	Falconiformes	Galliformes	Gruiformes	Passeriformes	Pelecaniformes	Phoenicopt-eriformes	Piciformes	Podicipedi-formes	Psittaciformes	Pteroclidiformes	Rheiformes	Strigiformes	Struthioniformes	Suliformes	Tinamiformes	**Total (imp cat.)**	**Total (impact mechanism)**
(1) Competition	MC		1							1				1		6					19							**28**	**63**
	MN		3							3				1	1	7					6							**21**	
	MO		1											1		7					2							**11**	
	MR													2														**2**	
	MV																							1				**1**	
(2) Predation	MC																												**26**
	MN										1	1		1	1	5	1				1							**11**	
	MO	1											1		1	6	1							1				**11**	
	MR															1												**1**	
	MV															1								2				**3**	
(3) Hybridisation	MC									1																		**1**	**15**
	MN		5											1				1			1							**8**	
	MO		1											2		1												**4**	
	MR		1																									**1**	
	MV									1																		**1**	
(4) Transmission of disease to native species	MC															1					1							**2**	**7**
	MN									2						1												**3**	
	MO									1						1												**2**	
(5) Parasitism	MO															1												**1**	**1**
(8) Grazing / herbivory / browsing	MN		2											1	1	1					2							**7**	**10**
	MO		3																									**3**	
(9) Chemical impact	MN		4																									**4**	**4**
(11) Structural impact	MN															1												**1**	**1**
(12) Interaction with other alien species	MC									1				6		2												**9**	**19**
	MN									1		1		1		3			1									**7**	
	MO															3												**3**	
Total (impact category / order)	MC		1							3				7		9					20							**40**	**146**
	MN		14							6	1	2		5	3	18	1	1	1		10							**62**	
	MO	1	5							1			1	3	1	19	1				2			1				**35**	
	MR		1											2		1												**4**	
	MV									1						1								3				**5**	
Total impact allocations		1	21							11	1	2	1	17	4	48	2	1	1		32			4				**= 146**	
Total Data Deficient (DD) sp.		2	22	2	3	2	2	4	1	20		1	1	39	4	145	5	3		1	32	1	1	1	1	2	1	**= 296**	
Total impacts and DD species		3	43	2	3	2	2	4	1	31	1	3	2	56	8	193	7	4	1	1	64	1	1	5	1	2	1	**= 442**	

Appendix C

Table C1: Alien bird EICAT assessment (species summary).

Key

Impact categories: DD = Data Deficient; **MC** = Minimal Concern; **MN** = Minor; **MO** = Moderate; **MR** = Major; **MV** = Massive

Impact mechanisms: (1) Comp = Competition; (2) Pred = Predation; (3) Hybr = Hybridisation; (4) Dis = Transmission of disease to native species; (5) Para = Parasitism; (8) Graz = Grazing / herbivory / browsing; (9) Chem = Chemical impact on ecosystem; (11) Struc = Structural impact on ecosystem; (12) Int = Interaction with other alien species

Summary Totals

Species: 415; **Orders:** 26

Species DD: 296; **Species with impacts:** 119; **Assigned impacts:** 146

Impacts assigned to impact categories: MC = 40; **MN** = 62; **MO** = 35; **MR** = 4; **MV** = 5

Impacts assigned to impact mechanisms: (1) Comp = 63; (2) Pred = 26; (3) Hybr = 15; (4) Dis = 7; (5) Para = 1; (8) Graz =10; (9) Chem = 4; (11) Struc = 1; (12) Int = 19

Confidence ratings: High = 53; Medium = 42; Low = 51

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Accipitriformes	Accipitridae	Accipiter gentilis	Northern goshawk	DD		
Accipitriformes	Accipitridae	Milvus milvus	Red kite	DD		
Accipitriformes	Accipitridae	Circus approximans	Swamp harrier	MO	(2) Pred	Low
Anseriformes	Anatidae	Dendrocygna autumnalis	Black-bellied whistling-duck	DD		
Anseriformes	Anatidae	Cereopsis novaehollandiae	Cape barren goose	DD		
Anseriformes	Anatidae	Fulica americana	American coot	DD		
Anseriformes	Anatidae	Anser anser	Greylag goose	DD		
Anseriformes	Anseranatidae	Anseranas semipalmata	Magpie goose	DD		
Anseriformes	Anatidae	Anas melleri	Meller's duck	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Anseriformes	Anatidae	Anas acuta	Northern pintail	DD		
Anseriformes	Anatidae	Anas clypeata	Northern shoveler	DD		
Anseriformes	Anatidae	Netta rufina	Red-crested pochard	DD		
Anseriformes	Anatidae	Cygnus buccinator	Trumpeter swan	DD		
Anseriformes	Anatidae	Chloephaga picta	Upland goose	DD		
Anseriformes	Anatidae	Anser indicus	Bar-headed goose	MN	(8) Graz	Medium
Anseriformes	Anatidae	Anser indicus	Bar-headed goose	MN	(9) Chem	Medium
Anseriformes	Anatidae	Dendrocygna viduata	White-faced whistling-duck	DD		
Anseriformes	Anatidae	Branta leucopsis	Barnacle goose	MN	(3) Hybr	Medium
Anseriformes	Anatidae	Branta leucopsis	Barnacle goose	MN	(8) Graz	Medium
Anseriformes	Anatidae	Branta leucopsis	Barnacle goose	MN	(9) Chem	Medium
Anseriformes	Anatidae	Aix sponsa	Wood duck	DD		
Anseriformes	Anatidae	Anser fabalis	Bean goose	DD		
Anseriformes	Anatidae	Cygnus atratus	Black swan	MO	(8) Graz	High
Anseriformes	Anatidae	Branta hutchinsii	Cackling goose	MN	(3) Hybr	Medium
Anseriformes	Anatidae	Branta canadensis	Canada goose	MO	(8) Graz	High
Anseriformes	Anatidae	Mergus merganser	Common merganser	DD		
Anseriformes	Anatidae	Aythya ferina	Common pochard	DD		
Anseriformes	Anatidae	Alopochen aegyptiaca	Egyptian goose	MN	(1) Comp	Medium
Anseriformes	Anatidae	Alopochen aegyptiaca	Egyptian goose	MN	(9) Chem	Medium
Anseriformes	Anatidae	Dendrocygna bicolor	Fulvous whistling-duck	DD		
Anseriformes	Anatidae	Anas strepera	Gadwall	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Anseriformes	Anatidae	Anas platyrhynchos	Mallard	MR	(3) Hybr	High
Anseriformes	Anatidae	Aix galericulata	Mandarin duck	MN	(1) Comp	High
Anseriformes	Anatidae	Cairina moschata	Muscovy duck	MN	(3) Hybr	Low
Anseriformes	Anatidae	Cairina moschata	Muscovy duck	MN	(9) Chem	Low
Anseriformes	Anatidae	Cygnus olor	Mute swan	MO	(1) Comp	High
Anseriformes	Anatidae	Cygnus olor	Mute swan	MO	(8) Graz	High
Anseriformes	Anatidae	Tadorna variegata	Paradise shelduck	DD		
Anseriformes	Anatidae	Anser brachyrhynchus	Pink-footed goose	DD		
Anseriformes	Anatidae	Callonetta leucophrys	Ringed teal	DD		
Anseriformes	Anatidae	Oxyura jamaicensis	Ruddy duck	MO	(3) Hybr	High
Anseriformes	Anatidae	Tadorna ferruginea	Ruddy shelduck	MC	(1) Comp	Low
Anseriformes	Anatidae	Anser caerulescens	Snow goose	MN	(3) Hybr	Low
Anseriformes	Anatidae	Anser cygnoides	Swan goose	MN	(1) Comp	High
Anseriformes	Anatidae	Dendrocygna arcuata	Wandering whistling-duck	MN	(3) Hybr	Medium
Anseriformes	Anatidae	Anas bahamensis	White-cheeked pintail	DD		
Apodiformes	Apodidae	Collocalia vanikorensis	Uniform swiftlet	DD		
Apodiformes	Apodidae	Collocalia bartschi	Guam swiftlet	DD		
Apterygiformes	Apterygidae	Apteryx haastii	Great spotted kiwi	DD		
Apterygiformes	Apterygidae	Apteryx owenii	Little spotted kiwi	DD		
Apterygiformes	Apterygidae	Apteryx australis	Southern brown kiwi	DD		
Casuariiformes	Dromaiidae	Dromaius novaehollandiae	Emu	DD		
Casuariiformes	Casuariidae	Casuarius casuarius	Southern cassowary	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Cathartiformes	Cathartidae	Cathartes aura	Turkey vulture	DD		
Cathartiformes	Cathartidae	Gymnogyps californianus	California condor	DD		
Charadriiformes	Scolopacidae	Limosa limosa	Black-tailed godwit	DD		
Charadriiformes	Charadriidae	Charadrius dubius	Little ringed plover	DD		
Charadriiformes	Jacanidae	Jacana jacana	Wattled jacana	DD		
Charadriiformes	Turnicidae	Turnix nigricollis	Madagascar buttonquail	DD		
Ciconiiformes	Ciconiidae	Ciconia ciconia	White stork	DD		
Columbiformes	Columbidae	Geopelia humeralis	Bar-shouldered dove	DD		
Columbiformes	Columbidae	Streptopelia risoria	Barbary dove (ringed dove)	MC	(1) Comp	Low
Columbiformes	Columbidae	Streptopelia risoria	Barbary dove (ringed dove)	MC	(3) Hybr	Low
Columbiformes	Columbidae	Streptopelia roseogrisea	African collared-dove	DD		
Columbiformes	Columbidae	Leptotila jamaicensis	Caribbean dove	DD		
Columbiformes	Columbidae	Phaps chalcoptera	Common bronzewing	DD		
Columbiformes	Columbidae	Columbina passerina	Common ground-dove	DD		
Columbiformes	Columbidae	Geopelia cuneata	Diamond dove	DD		
Columbiformes	Columbidae	Chalcophaps indica	Emerald dove	DD		
Columbiformes	Columbidae	Streptopelia bitorquata	Island collared-dove	DD		
Columbiformes	Columbidae	Oena capensis	Namaqua dove	DD		
Columbiformes	Columbidae	Geopelia placida	Peaceful dove	DD		
Columbiformes	Columbidae	Streptopelia tranquebarica	Red collared-dove	DD		
Columbiformes	Columbidae	Streptopelia capicola	Ring-necked dove	DD		
Columbiformes	Columbidae	Patagioenas squamosa	Scaly-naped pigeon	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Columbiformes	Columbidae	Gallicolumba stairi	Shy ground-dove	DD		
Columbiformes	Columbidae	Turtur tympanistria	Tambourine dove	DD		
Columbiformes	Columbidae	Goura cristata	Western crowned-pigeon	DD		
Columbiformes	Columbidae	Streptopelia decaocto	Eurasian collared-dove	MN	(1) Comp	High
Columbiformes	Columbidae	Streptopelia senegalensis	Laughing dove	MN	(4) Dis	Low
Columbiformes	Columbidae	Nesoenas picturata	Madagascar turtle-dove	MV	(3) Hybr	High
Columbiformes	Columbidae	Columba livia	Rock dove	MO	(4) Dis	Low
Columbiformes	Columbidae	Streptopelia chinensis	Spotted dove	MN	(1) Comp	Low
Columbiformes	Columbidae	Streptopelia chinensis	Spotted dove	MN	(4) Dis	Low
Columbiformes	Columbidae	Streptopelia chinensis	Spotted dove	MN	(12) Int	Low
Columbiformes	Columbidae	Zenaida asiatica	White-winged dove	MN	(1) Comp	Low
Columbiformes	Columbidae	Leucosarcia melanoleuca	Wonga pigeon	DD		
Columbiformes	Columbidae	Geopelia striata	Zebra dove	MC	(12) Int	Low
Columbiformes	Columbidae	Ocyphaps lophotes	Crested pigeon	DD		
Columbiformes	Columbidae	Zenaida macroura	Mourning dove	DD		
Columbiformes	Columbidae	Caloenas nicobarica	Nicobar pigeon	DD		
Coraciiformes	Halcyonidae	Dacelo novaeguineae	Laughing kookaburra	MN	(2) Pred	High
Cuculiformes	Cuculidae	Eudynamys scolopaceus	Asian koel	DD		
Cuculiformes	Cuculidae	Crotophaga ani	Smooth-billed ani	MN	(2) Pred	High
Cuculiformes	Cuculidae	Crotophaga ani	Smooth-billed ani	MN	(12) Int	High
Falconiformes	Falconidae	Milvago chimango	Chimango caracara	MO	(2) Pred	Medium
Falconiformes	Falconidae	Falco peregrinus	Peregrine falcon	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Galliformes	Phasianidae	Francolinus francolinus	Black francolin	MC	(12) Int	Low
Galliformes	Odontophoridae	Callipepla californica	California quail	MC	(12) Int	Low
Galliformes	Megapodiidae	Alectura lathami	Australian brush-turkey	DD		
Galliformes	Phasianidae	Alectoris barbara	Barbary partridge	DD		
Galliformes	Phasianidae	Tetrao tetrix	Black grouse	DD		
Galliformes	Phasianidae	Coturnix chinensis	Blue quail	DD		
Galliformes	Phasianidae	Coturnix ypsilophora	Brown quail	DD		
Galliformes	Phasianidae	Francolinus capensis	Cape francolin	DD		
Galliformes	Phasianidae	Bambusicola thoracicus	Chinese bamboo-partridge	DD		
Galliformes	Phasianidae	Francolinus pintadeanus	Chinese francolin	DD		
Galliformes	Phasianidae	Coturnix coturnix	Common quail	DD		
Galliformes	Odontophoridae	Colinus cristatus	Crested bobwhite	DD		
Galliformes	Phasianidae	Alectoris chukar	Chukar	MO	(3) Hybr	High
Galliformes	Phasianidae	Perdix dauurica	Daurian partridge	DD		
Galliformes	Phasianidae	Dendragapus obscurus	Dusky grouse	DD		
Galliformes	Odontophoridae	Callipepla douglasii	Elegant quail	DD		
Galliformes	Odontophoridae	Callipepla gambelii	Gambel's quail	DD		
Galliformes	Phasianidae	Phasianus versicolor	Green pheasant	DD		
Galliformes	Phasianidae	Bonasa bonasia	Hazel grouse	DD		
Galliformes	Numididae	Numida meleagris	Helmeted guineafowl	DD		
Galliformes	Phasianidae	Pavo cristatus	Common peafowl	MC	(1) Comp	Low
Galliformes	Phasianidae	Pavo cristatus	Common peafowl	MC	(12) Int	Low

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Galliformes	Phasianidae	Phasianus colchicus	Common pheasant	MO	(1) Comp	High
Galliformes	Phasianidae	Francolinus hildebrandti	Hildebrandt's francolin	DD		
Galliformes	Phasianidae	Tetraogallus himalayensis	Himalayan snowcock	DD		
Galliformes	Phasianidae	Perdicula asiatica	Jungle bush-quail	DD		
Galliformes	Phasianidae	Chrysolophus amherstiae	Lady amherst's pheasant	DD		
Galliformes	Phasianidae	Margaroperdix madagascariensis	Madagascar partridge	DD		
Galliformes	Megapodiidae	Macrocephalon maleo	Maleo	DD		
Galliformes	Odontophoridae	Oreortyx pictus	Mountain quail	DD		
Galliformes	Odontophoridae	Colinus virginianus	Northern bobwhite	DD		
Galliformes	Cracidae	Ortalis vetula	Plain chachalaca	DD		
Galliformes	Megapodiidae	Megapodius pritchardii	Polynesian megapode	DD		
Galliformes	Phasianidae	Francolinus adspersus	Red-billed francolin	DD		
Galliformes	Phasianidae	Alectoris rufa	Red-legged partridge	DD		
Galliformes	Phasianidae	Francolinus afer	Red-necked spurfowl	DD		
Galliformes	Phasianidae	Syrmaticus reevesii	Reeves's pheasant	DD		
Galliformes	Phasianidae	Alectoris graeca	Rock partridge	DD		
Galliformes	Phasianidae	Bonasa umbellus	Ruffed grouse	DD		
Galliformes	Phasianidae	Francolinus erckelii	Erckel's francolin	MC	(12) Int	Low
Galliformes	Cracidae	Ortalis ruficauda	Rufous-vented chachalaca	DD		
Galliformes	Odontophoridae	Callipepla squamata	Scaled quail	DD		
Galliformes	Phasianidae	Lophura nycthemera	Silver pheasant	DD		
Galliformes	Phasianidae	Dendragapus canadensis	Spruce grouse	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Galliformes	Phasianidae	Chrysolophus pictus	Golden pheasant	MN	(1) Comp	Low
Galliformes	Phasianidae	Chrysolophus pictus	Golden pheasant	MN	(2) Pred	Low
Galliformes	Phasianidae	Gallus varius	Green junglefowl	MR	(1) Comp	Low
Galliformes	Phasianidae	Francolinus pondicerianus	Grey francolin	MC	(12) Int	Low
Galliformes	Phasianidae	Perdix perdix	Grey partridge	MO	(3) Hybr	High
Galliformes	Phasianidae	Coturnix japonica	Japanese quail	MN	(3) Hybr	High
Galliformes	Phasianidae	Lophura leucomelanos	Kalij pheasant	MN	(12) Int	Medium
Galliformes	Phasianidae	Polyplectron napoleonis	Palawan peacock-pheasant	DD		
Galliformes	Phasianidae	Gallus gallus	Red junglefowl	MR	(1) Comp	Low
Galliformes	Phasianidae	Tetrao urogallus	Western capercaillie	MN	(8) Graz	Low
Galliformes	Phasianidae	Lagopus leucura	White-tailed ptarmigan	DD		
Galliformes	Phasianidae	Meleagris gallopavo	Wild turkey	MC	(12) Int	Low
Gruiformes	Rallidae	Porphyrio flavirostris	Azure gallinule	DD		
Gruiformes	Rallidae	Gallinula chloropus	Common moorhen	DD		
Gruiformes	Rallidae	Gallirallus owstoni	Guam rail	DD		
Gruiformes	Rallidae	Gallinula mortierii	Tasmanian native-hen	DD		
Gruiformes	Rallidae	Porphyrio poliocephalus	Grey-headed swamphen	MN	(1) Comp	High
Gruiformes	Rallidae	Porphyrio poliocephalus	Grey-headed swamphen	MN	(2) Pred	High
Gruiformes	Rallidae	Porphyrio poliocephalus	Grey-headed swamphen	MN	(8) Graz	High
Gruiformes	Rallidae	Gallirallus australis	Weka	MO	(2) Pred	High
Passeriformes	Corvidae	Corvus brachyrhynchos	American crow	MO	(2) Pred	High
Passeriformes	Passeridae	Passer euchlorus	Arabian golden sparrow	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Artamidae	Gymnorhina tibicen	Australian magpie	MN	(2) Pred	High
Passeriformes	Dicruridae	Dicrurus macrocercus	Black drongo	MO	(2) Pred	Medium
Passeriformes	Corvidae	Pica pica	Black-billed magpie	MN	(2) Pred	Low
Passeriformes	Ploceidae	Ploceus melanocephalus	Black-headed weaver	MC	(1) Comp	High
Passeriformes	Oriolidae	Oriolus chinensis	Black-naped oriole	DD		
Passeriformes	Estrildidae	Estrilda troglodytes	Black-rumped waxbill	MC	(1) Comp	Low
Passeriformes	Estrildidae	Estrilda perreini	Black-tailed waxbill	DD		
Passeriformes	Sturnidae	Sturnus melanopterus	Black-winged starling	DD		
Passeriformes	Turdidae	Turdus merula	Blackbird	MO	(2) Pred	Medium
Passeriformes	Turdidae	Turdus merula	Blackbird	MO	(12) Int	High
Passeriformes	Thraupidae	Thraupis episcopus	Blue-grey tanager	DD		
Passeriformes	Leiothrichidae	Garrulax canorus	Chinese hwamei	MO	(3) Hybr	High
Passeriformes	Sturnidae	Acridotheres tristis	Common myna	MO	(1) Comp	High
Passeriformes	Sturnidae	Acridotheres tristis	Common myna	MO	(2) Pred	High
Passeriformes	Sturnidae	Acridotheres cristatellus	Crested myna	MN	(1) Comp	Medium
Passeriformes	Sturnidae	Acridotheres cristatellus	Crested myna	MN	(2) Pred	Medium
Passeriformes	Estrildidae	Stagonopleura guttata	Diamond firetail	DD		
Passeriformes	Regulidae	Regulus ignicapilla	Firecrest	DD		
Passeriformes	Estrildidae	Lonchura cantans	African silverbill	DD		
Passeriformes	Sylviidae	Paradoxornis alphonsianus	Ashy-throated parrotbill	DD		
Passeriformes	Tyrannidae	Pitangus sulphuratus	Great kiskadee	MV	(2) Pred	Low
Passeriformes	Sturnidae	Aplonis panayensis	Asian glossy starling	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Sturnidae	Sturnus contra	Asian pied starling	DD		
Passeriformes	Thraupidae	Cyanopica cyanus	Azure-winged magpie	DD		
Passeriformes	Sturnidae	Acridotheres ginginianus	Bank myna	DD		
Passeriformes	Ploceidae	Ploceus philippinus	Baya weaver	DD		
Passeriformes	Muscicapidae	Phoenicurus ochruros	Black redstart	DD		
Passeriformes	Sturnidae	Sturnus nigricollis	Black-collared starling	DD		
Passeriformes	Pycnonotidae	Pycnonotus melanicterus	Black-crested bulbul	DD		
Passeriformes	Leiothrichidae	Garrulax chinensis	Black-throated laughingthrush	DD		
Passeriformes	Passeridae	Pseudonigrita arnaudi	Grey-headed social-weaver	DD		
Passeriformes	Corvidae	Urocissa erythrorhyncha	Blue magpie	DD		
Passeriformes	Estrildidae	Uraeginthus angolensis	Blue-breasted cordonbleu	DD		
Passeriformes	Leiothrichidae	Minla cyanouroptera	Blue-winged minla	DD		
Passeriformes	Estrildidae	Lonchura cucullata	Bronze munia	DD		
Passeriformes	Fringillidae	Serinus canicollis	Cape canary	DD		
Passeriformes	Icteridae	Quiscalus lugubris	Carib grackle	DD		
Passeriformes	Cettiidae	Cettia cetti	Cetti's warbler	DD		
Passeriformes	Fringillidae	Fringilla coelebs	Chaffinch	DD		
Passeriformes	Estrildidae	Lonchura atricapilla	Chestnut munia	DD		
Passeriformes	Estrildidae	Lonchura castaneothorax	Chestnut-breasted munia	DD		
Passeriformes	Sturnidae	Sturnus malabaricus	Chestnut-tailed starling	DD		
Passeriformes	Leiothrichidae	Babax lanceolatus	Chinese babax	DD		
Passeriformes	Zosteropidae	Zosterops natalis	Christmas white-eye	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Corvidae	Corvus splendens	House crow	MO	(1) Comp	High
Passeriformes	Corvidae	Corvus splendens	House crow	MO	(2) Pred	High
Passeriformes	Fringillidae	Carpodacus mexicanus	House finch	MN	(1) Comp	High
Passeriformes	Fringillidae	Carpodacus mexicanus	House finch	MN	(4) Dis	High
Passeriformes	Passeridae	Passer domesticus	House sparrow	MO	(1) Comp	High
Passeriformes	Emberizidae	Emberiza cirlus	Cirl bunting	DD		
Passeriformes	Turdidae	Turdus grayi	Clay-coloured thrush	DD		
Passeriformes	Turdidae	Turdus poliocephalus	Island thrush	DD		
Passeriformes	Cettiidae	Cettia diphone	Japanese bush-warbler	MN	(12) Int	High
Passeriformes	Zosteropidae	Zosterops japonicus	Japanese white-eye	MO	(1) Comp	High
Passeriformes	Zosteropidae	Zosterops japonicus	Japanese white-eye	MO	(4) Dis	Low
Passeriformes	Zosteropidae	Zosterops japonicus	Japanese white-eye	MO	(12) Int	High
Passeriformes	Thraupidae	Diuca diuca	Common diuca-finch	DD		
Passeriformes	Fringillidae	Carduelis flammea	Common redpoll	DD		
Passeriformes	Estrildidae	Estrilda astrild	Common waxbill	DD		
Passeriformes	Thraupidae	Ramphocelus dimidiatus	Crimson-backed tanager	DD		
Passeriformes	Thraupidae	Tiaris canorus	Cuban grassquit	DD		
Passeriformes	Viduidae	Vidua paradisaea	Eastern paradise-whydah	DD		
Passeriformes	Corvidae	Corvus monedula	Eurasian jackdaw	DD		
Passeriformes	Ploceidae	Euplectes aureus	Golden-backed bishop	DD		
Passeriformes	Drepanididae	Telespiza cantans	Laysan finch	DD		
Passeriformes	Ploceidae	Ploceus jacksoni	Golden-backed weaver	DD		

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Passeriformes	Fringillidae	Carduelis carduelis	Goldfinch	DD		
Passeriformes	Thraupidae	Sicalis luteola	Grassland yellow-finch	DD		
Passeriformes	Paradisaeidae	Paradisaea apoda	Greater bird-of-paradise	DD		
Passeriformes	Leiothrichidae	Garrulax pectoralis	Greater necklaced laughingthrush	DD		
Passeriformes	Pycnonotidae	Pycnonotus sinensis	Light-vented bulbul	MN	(1) Comp	Low
Passeriformes	Fringillidae	Carduelis chloris	Greenfinch	DD		
Passeriformes	Pellorneidae	Alcippe morrisonia	Grey-cheeked fulvetta	DD		
Passeriformes	Leiothrichidae	Garrulax caerulatus	Grey-sided laughingthrush	DD		
Passeriformes	Ploceidae	Foudia madagascariensis	Madagascar red fody	MO	(1) Comp	Medium
Passeriformes	Prunellidae	Prunella modularis	Hedge accentor (dunnock)	DD		
Passeriformes	Estrildidae	Lonchura fringilloides	Magpie munia	DD		
Passeriformes	Monarchidae	Grallina cyanoleuca	Magpie-lark	DD		
Passeriformes	Sturnidae	Gracula religiosa	Hill myna	DD		
Passeriformes	Pycnonotidae	Pycnonotus leucogenys	Himalayan bulbul	DD		
Passeriformes	Fringillidae	Serinus canaria	Island canary	DD		
Passeriformes	Estrildidae	Padda oryzivora	Java sparrow	DD		
Passeriformes	Estrildidae	Lonchura leucogastroides	Javan munia	DD		
Passeriformes	Sturnidae	Acridotheres fuscus	Jungle myna	DD		
Passeriformes	Corvidae	Corvus macrorhynchos	Large-billed crow	DD		
Passeriformes	Estrildidae	Estrilda caerulescens	Lavender waxbill	DD		
Passeriformes	Fringillidae	Carduelis psaltria	Lesser goldfinch	DD		
Passeriformes	Ploceidae	Ploceus intermedius	Lesser masked weaver	DD		

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Passeriformes	Thraupidae	Oryzoborus angolensis	Lesser seed-finch	DD		
Passeriformes	Petroicidae	Petroica australis	New zealand robin	DD		
Passeriformes	Leiothrichidae	Garrulax perspicillatus	Masked laughingthrush	DD		
Passeriformes	Ploceidae	Foudia rubra	Mauritius fody	DD		
Passeriformes	Estrildidae	Lonchura hunsteini	Mottled munia	DD		
Passeriformes	Leiothrichidae	Garrulax cineraceus	Moustached laughingthrush	DD		
Passeriformes	Corvidae	Corvus moneduloides	New caledonian crow	DD		
Passeriformes	Mimidae	Mimus polyglottos	Northern mockingbird	MC	(12) Int	Low
Passeriformes	Meliphagidae	Manorina melanocephala	Noisy miner	DD		
Passeriformes	Atrichornithidae	Atrichornis clamosus	Noisy scrub-bird	DD		
Passeriformes	Cardinalidae	Cardinalis cardinalis	Northern cardinal	DD		
Passeriformes	Ploceidae	Euplectes franciscanus	Orange bishop	DD		
Passeriformes	Estrildidae	Estrilda melpoda	Orange-cheeked waxbill	DD		
Passeriformes	Muscicapidae	Copsychus saularis	Oriental magpie-robin	DD		
Passeriformes	Zosteropidae	Zosterops palpebrosus	Oriental white-eye	DD		
Passeriformes	Sturnidae	Acridotheres cinereus	Pale-bellied myna	DD		
Passeriformes	Thraupidae	Thraupis palmarum	Palm tanager	DD		
Passeriformes	Viduidae	Vidua macroura	Pin-tailed whydah	DD		
Passeriformes	Ploceidae	Euplectes orix	Red bishop	DD		
Passeriformes	Fringillidae	Carduelis cucullata	Red siskin	DD		
Passeriformes	Estrildidae	Lagonosticta senegala	Red-billed firefinch	DD		
Passeriformes	Monarchidae	Pomarea dimidiata	Rarotonga monarch	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Estrildidae	Amandava amandava	Red avadavat	MC	(1) Comp	Low
Passeriformes	Ploceidae	Quelea quelea	Red-billed quelea	DD		
Passeriformes	Estrildidae	Neochmia temporalis	Red-browed finch	DD		
Passeriformes	Estrildidae	Uraeginthus bengalus	Red-cheeked cordonbleu	DD		
Passeriformes	Thraupidae	Paroaria dominicana	Red-cowled cardinal	DD		
Passeriformes	Thraupidae	Paroaria coronata	Red-crested cardinal	DD		
Passeriformes	Thraupidae	Cyanerpes cyaneus	Red-legged honeycreeper	DD		
Passeriformes	Ploceidae	Ploceus galbula	Rueppell's weaver	DD		
Passeriformes	Leiothrichidae	Leiothrix lutea	Red-billed leiothrix	MN	(1) Comp	High
Passeriformes	Leiothrichidae	Leiothrix lutea	Red-billed leiothrix	MN	(12) Int	High
Passeriformes	Turdidae	Turdus rufopalliatus	Rufous-backed robin	DD		
Passeriformes	Icteridae	Sturnella militaris	Red-breasted blackbird	DD		
Passeriformes	Timaliidae	Stachyris ruficeps	Rufous-capped babbler	DD		
Passeriformes	Thraupidae	Paroaria gularis	Red-capped cardinal	DD		
Passeriformes	Callaeidae	Philesturnus carunculatus	Saddleback	DD		
Passeriformes	Ploceidae	Foudia sechellarum	Seychelles fody	DD		
Passeriformes	Timaliidae	Leiothrix argentauris	Silver-eared mesia	DD		
Passeriformes	Alaudidae	Alauda arvensis	Skylark	DD		
Passeriformes	Pycnonotidae	Pycnonotus aurigaster	Sooty-headed bulbul	DD		
Passeriformes	Ploceidae	Ploceus velatus	Southern masked-weaver	DD		
Passeriformes	Icteridae	Icterus pectoralis	Spot-breasted oriole	DD		
Passeriformes	Pycnonotidae	Pycnonotus cafer	Red-vented bulbul	MO	(1) Comp	High

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Pycnonotidae	Pycnonotus cafer	Red-vented bulbul	MO	(12) Int	Medium
Passeriformes	Pycnonotidae	Pycnonotus jocosus	Red-whiskered bulbul	MR	(2) Pred	Low
Passeriformes	Timaliidae	Pomatorhinus ruficollis	Streak-breasted scimitar-babbler	DD		
Passeriformes	Ploceidae	Ploceus manyar	Streaked weaver	DD		
Passeriformes	Passeridae	Passer montanus	Tree sparrow	DD		
Passeriformes	Estrildidae	Lonchura malacca	Tricoloured munia	DD		
Passeriformes	Corvidae	Corvus frugilegus	Rook	MN	(2) Pred	High
Passeriformes	Corvidae	Cyanocorax dickeyi	Tufted jay	DD		
Passeriformes	Paridae	Parus varius	Varied tit	DD		
Passeriformes	Icteridae	Icterus icterus	Venezuelan troupial	DD		
Passeriformes	Sylviidae	Paradoxornis webbianus	Vinous-throated parrotbill	DD		
Passeriformes	Ploceidae	Ploceus vitellinus	Vitelline masked-weaver	DD		
Passeriformes	Icteridae	Sturnella neglecta	Western meadowlark	DD		
Passeriformes	Fringillidae	Serinus dorsostriatus	White-bellied canary	DD		
Passeriformes	Leiothrichidae	Garrulax sannio	White-browed laughingthrush	DD		
Passeriformes	Estrildidae	Lonchura ferruginosa	White-capped munia	DD		
Passeriformes	Estrildidae	Lonchura punctulata	Scaly-breasted munia	MC	(1) Comp	Low
Passeriformes	Estrildidae	Lonchura punctulata	Scaly-breasted munia	MC	(12) Int	Low
Passeriformes	Leiothrichidae	Garrulax leucolophus	White-crested laughingthrush	DD		
Passeriformes	Estrildidae	Lonchura maja	White-headed munia	DD		
Passeriformes	Icteridae	Molothrus bonariensis	Shiny cowbird	MO	(5) Para	High
Passeriformes	Thraupidae	Tachyphonus rufus	White-lined tanager	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Estrildidae	Lonchura striata	White-rumped munia	DD		
Passeriformes	Estrildidae	Lonchura malabarica	White-throated munia	DD		
Passeriformes	Zosteropidae	Zosterops lateralis	Silvereye	MN	(12) Int	High
Passeriformes	Sturnidae	Acridotheres grandis	White-vented myna	DD		
Passeriformes	Turdidae	Turdus philomelos	Song thrush	MO	(2) Pred	Medium
Passeriformes	Ploceidae	Euplectes albonotatus	White-winged widowbird	DD		
Passeriformes	Fringillidae	Serinus flaviventris	Yellow canary	DD		
Passeriformes	Thraupidae	Gubernatrix cristata	Yellow cardinal	DD		
Passeriformes	Passeridae	Passer hispaniolensis	Spanish sparrow	MN	(1) Comp	Low
Passeriformes	Thraupidae	Paroaria capitata	Yellow-billed cardinal	DD		
Passeriformes	Paridae	Parus spilonotus	Yellow-cheeked tit	DD		
Passeriformes	Ploceidae	Euplectes afer	Yellow-crowned bishop	DD		
Passeriformes	Sturnidae	Sturnus vulgaris	Starling	MO	(1) Comp	High
Passeriformes	Thraupidae	Tiaris olivaceus	Yellow-faced grassquit	DD		
Passeriformes	Fringillidae	Carduelis yarrellii	Yellow-faced siskin	DD		
Passeriformes	Menuridae	Menura novaehollandiae	Superb lyrebird	MN	(11) Struc	High
Passeriformes	Fringillidae	Serinus mozambicus	Yellow-fronted canary	DD		
Passeriformes	Pycnonotidae	Pycnonotus goiavier	Yellow-vented bulbul	DD		
Passeriformes	Emberizidae	Emberiza citrinella	Yellowhammer	DD		
Passeriformes	Estrildidae	Taeniopygia guttata	Zebra finch	DD		
Passeriformes	Mimidae	Mimus gilvus	Tropical mockingbird	MN	(2) Pred	Medium
Passeriformes	Sittidae	Sitta frontalis	Velvet-fronted nuthatch	MC	(1) Comp	High

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Passeriformes	Viduidae	Vidua chalybeata	Village indigobird	DD		
Passeriformes	Ploceidae	Ploceus cucullatus	Village weaver	MN	(8) Graz	Low
Passeriformes	Sturnidae	Sturnus burmannicus	Vinous-breasted starling	MN	(1) Comp	High
Passeriformes	Muscicapidae	Copsychus malabaricus	White-rumped shama	MC	(1) Comp	Low
Passeriformes	Muscicapidae	Copsychus malabaricus	White-rumped shama	MC	(4) Dis	Low
Passeriformes	Leiothrichidae	Garrulax albogularis	White-throated laughingthrush	DD		
Passeriformes	Rhipiduridae	Rhipidura leucophrys	Willie-wagtail	DD		
Passeriformes	Sturnidae	Acridotheres albocinctus	Collared myna	DD		
Passeriformes	Estrildidae	Amandava formosa	Green avadavat	DD		
Passeriformes	Sturnidae	Acridotheres javanicus	Javan myna	DD		
Passeriformes	Alaudidae	Melanocorypha mongolica	Mongolian lark	DD		
Passeriformes	Locustellidae	Bowdleria punctata	New zealand fernbird	DD		
Passeriformes	Artamidae	Strepera graculina	Pied currawong	DD		
Passeriformes	Thraupidae	Sicalis flaveola	Saffron finch	MN	(1) Comp	Low
Passeriformes	Sturnidae	Sturnus erythropygius	White-headed starling	DD		
Pelecaniformes	Threskiornithidae	Threskiornis aethiopicus	African sacred ibis	MN	(2) Pred	High
Pelecaniformes	Ardeidae	Bubulcus ibis	Cattle egret	MO	(2) Pred	Medium
Pelecaniformes	Ardeidae	Nycticorax nycticorax	Black-crowned night-heron	DD		
Pelecaniformes	Threskiornithidae	Threskiornis melanocephalus	Black-headed ibis	DD		
Pelecaniformes	Ardeidae	Egretta garzetta	Little egret	DD		
Pelecaniformes	Pelecanidae	Pelecanus philippensis	Spot-billed pelican	DD		
Pelecaniformes	Ardeidae	Nyctanassa violacea	Yellow-crowned night-heron	DD		

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Phoenicopteriformes	Phoenicopteridae	Phoenicopterus chilensis	Chilean flamingo	MN	(3) Hybr	High
Phoenicopteriformes	Phoenicopteridae	Phoenicopterus ruber	American flamingo	DD		
Phoenicopteriformes	Phoenicopteridae	Phoenicopterus roseus	Greater flamingo	DD		
Phoenicopteriformes	Phoenicopteridae	Phoeniconaias minor	Lesser flamingo	DD		
Piciformes	Megalaimidae	Megalaima lineata	Lineated barbet	MN	(12) Int	Medium
Podicipediformes	Podicipedidae	Podiceps auritus	Horned grebe	DD		
Psittaciformes	Psittaculidae	Agapornis canus	Grey-headed lovebird	DD		
Psittaciformes	Psittaculidae	Agapornis fischeri	Fischer's lovebird	DD		
Psittaciformes	Psittaculidae	Agapornis personatus	Yellow-collared lovebird	DD		
Psittaciformes	Psittaculidae	Agapornis roseicollis	Rosy-faced lovebird	DD		
Psittaciformes	Psittacidae	Amazona aestiva	Blue-fronted amazon	DD		
Psittaciformes	Psittacidae	Amazona albifrons	White-fronted amazon	DD		
Psittaciformes	Psittacidae	Amazona amazonica	Orange-winged amazon	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Amazona autumnalis	Red-lored amazon	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Amazona finschi	Lilac-crowned amazon	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Amazona ochrocephala	Yellow-crowned amazon	DD		
Psittaciformes	Psittacidae	Amazona oratrix	Yellow-headed amazon	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Amazona ventralis	Hispaniolan amazon	DD		
Psittaciformes	Psittacidae	Amazona viridigenalis	Red-crowned amazon	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Ara ararauna	Blue-and-yellow macaw	DD		
Psittaciformes	Psittacidae	Ara severus	Chestnut-fronted macaw	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga acuticaudata	Blue-crowned parakeet	MC	(1) Comp	Medium

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Psittaciformes	Psittacidae	Aratinga canicularis	Orange-fronted parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga erythrogenys	Red-masked parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga holochlora	Green parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga mitrata	Mitred parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga pertinax	Brown-throated parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Aratinga weddellii	Dusky-headed parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittaculidae	Barnardius zonarius	Ringneck parrot	DD		
Psittaciformes	Psittacidae	Brotogeris chiriri	Yellow-chevroned parakeet	MC	(1) Comp	Medium
Psittaciformes	Psittacidae	Brotogeris versicolurus	White-winged parakeet	MC	(1) Comp	Medium
Psittaciformes	Cacatuidae	Cacatua alba	White cockatoo	DD		
Psittaciformes	Cacatuidae	Cacatua galerita	Sulphur-crested cockatoo	MN	(8) Graz	High
Psittaciformes	Cacatuidae	Cacatua goffiniana	Tanimbar cockatoo	MN	(1) Comp	Low
Psittaciformes	Cacatuidae	Cacatua leadbeateri	Major mitchell's cockatoo	DD		
Psittaciformes	Cacatuidae	Cacatua roseicapilla	Galah	DD		
Psittaciformes	Cacatuidae	Cacatua sanguinea	Little corella	MN	(1) Comp	Low
Psittaciformes	Cacatuidae	Cacatua sulphurea	Yellow-crested cockatoo	MC	(1) Comp	Low
Psittaciformes	Cacatuidae	Cacatua tenuirostris	Long-billed corella	MN	(1) Comp	Low
Psittaciformes	Cacatuidae	Cacatua tenuirostris	Long-billed corella	MN	(2) Pred	Low
Psittaciformes	Cacatuidae	Callocephalon fimbriatum	Gang-gang cockatoo	DD		
Psittaciformes	Psittaculidae	Cyanoramphus novaezelandiae	Red-fronted parakeet	MN	(3) Hybr	High
Psittaciformes	Psittaculidae	Eclectus roratus	Eclectus parrot	DD		
Psittaciformes	Psittaculidae	Eos bornea	Red lory	DD		

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Psittaciformes	Psittaculidae	Eos reticulata	Blue-streaked lory	DD		
Psittaciformes	Psittacidae	Forpus passerinus	Green-rumped parrotlet	DD		
Psittaciformes	Psittaculidae	Glossopsitta concinna	Musk lorikeet	DD		
Psittaciformes	Psittaculidae	Melopsittacus undulatus	Budgerigar	MC	(1) Comp	Low
Psittaciformes	Psittacidae	Myiopsitta monachus	Monk parakeet	MN	(1) Comp	Medium
Psittaciformes	Psittacidae	Nandayus nenday	Nanday parakeet	MC	(1) Comp	Medium
Psittaciformes	Cacatuidae	Nymphicus hollandicus	Cockatiel	DD		
Psittaciformes	Psittaculidae	Platycercus elegans	Crimson rosella	MN	(1) Comp	High
Psittaciformes	Psittaculidae	Platycercus eximius	Eastern rosella	MC	(1) Comp	Low
Psittaciformes	Psittaculidae	Platycercus eximius	Eastern rosella	MC	(4) Dis	Low
Psittaciformes	Psittacidae	Poicephalus crassus	Niam-niam parrot	DD		
Psittaciformes	Psittacidae	Poicephalus senegalus	Senegal parrot	DD		
Psittaciformes	Psittaculidae	Prosopeia splendens	Crimson shining-parrot	DD		
Psittaciformes	Psittaculidae	Prosopeia tabuensis	Red shining-parrot	DD		
Psittaciformes	Psittaculidae	Psittacula alexandri	Red-breasted parakeet	MO	(1) Comp	Medium
Psittaciformes	Psittaculidae	Psittacula eupatria	Alexandrine parakeet	MN	(8) Graz	High
Psittaciformes	Psittaculidae	Psittacula krameri	Rose-ringed parakeet	MO	(1) Comp	High
Psittaciformes	Psittacidae	Psittacus erithacus	Grey parrot	DD		
Psittaciformes	Psittacidae	Pyrrhura leucotis	Maroon-faced parakeet	DD		
Psittaciformes	Psittacidae	Rhynchopsitta pachyrhyncha	Thick-billed parrot	DD		
Psittaciformes	Strigopidae	Strigops habroptila	Kakapo	DD		
Psittaciformes	Psittaculidae	Tanygnathus lucionensis	Blue-naped parrot	DD		

Order	Family	Species	Common name	EICAT impact category	EICAT impact mechanism	Assessment confidence rating
Psittaciformes	Psittaculidae	Trichoglossus chlorolepidotus	Scaly-breasted lorikeet	DD		
Psittaciformes	Psittaculidae	Trichoglossus haematodus	Rainbow lorikeet	MN	(1) Comp	Medium
Psittaciformes	Psittaculidae	Vini kuhlii	Rimitara lorikeet	DD		
Psittaciformes	Psittaculidae	Vini ultramarina	Ultramarine lorikeet	DD		
Pteroclidiformes	Pteroclididae	Pterocles exustus	Chestnut-bellied sandgrouse	DD		
Rheiformes	Rheidae	Rhea pennata	Lesser rhea	DD		
Strigiformes	Tytonidae	Tyto novaehollandiae	Australian masked-owl	MV	(2) Pred	Medium
Strigiformes	Tytonidae	Tyto alba	Barn owl	MV	(1) Comp	Medium
Strigiformes	Strigidae	Bubo bubo	Eurasian eagle-owl	DD		
Strigiformes	Strigidae	Bubo virginianus	Great horned owl	MV	(2) Pred	Low
Strigiformes	Strigidae	Athene noctua	Little owl	MO	(2) Pred	Low
Struthioniformes	Struthionidae	Struthio camelus	Ostrich	DD		
Suliformes	Phalacrocoracidae	Phalacrocorax carbo	Great cormorant	DD		
Suliformes	Phalacrocoracidae	Phalacrocorax bougainvillii	Guanay cormorant	DD		
Tinamiformes	Tinamidae	Nothoprocta perdicaria	Chilean tinamou	DD		

Appendix D

Table D1: Data for all predictor variables used in the analysis for Chapter 3.
Key: H = hypothesis

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Accipitriformes	Accipitridae	Circus approximans	Swamp harrier	MO	Yes	0.791	752.5	0.29	6	0.32	1638.7	1	128
Anseriformes	Anatidae	Aix galericulata	Mandarin duck	MN	Yes	0.944	560.0	-0.21	6	0.3	120268.8	1	268
Anseriformes	Anatidae	Alopochen aegyptiaca	Egyptian goose	MN	Yes	0.923	1900.0	-0.94	3	0.82	105847.3	2	363
Anseriformes	Anatidae	Anas acuta	Northern pintail	DD	No	0.916	872.3	-0.71	4	0.34	106932.2	2	32
Anseriformes	Anatidae	Anas clypeata	Northern shoveler	DD	No	0.837	613.0	-0.80	4	0.44	314.2	1	18
Anseriformes	Anatidae	Anas melleri	Meller's duck	DD	No	0.777	973.3	-0.72	3	0.38	1868.4	1	163

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Anseriformes	Anatidae	Anas platyrhynchos	Mallard	MR	Yes	0.935	1121.0	-0.85	6	0.26	1484307.1	7	153
Anseriformes	Anatidae	Anas strepera	Gadwall	DD	No	0.907	850.0	-1.30	2	0.58	5468.9	1	163
Anseriformes	Anatidae	Anser anser	Greylag goose	DD	No	0.922	3308.5	-0.54	3	0.66	61475.1	1	78
Anseriformes	Anatidae	Anser indicus	Bar-headed goose	MN	Yes	0.922	2413.8	-0.58	5	1	75497.0	1	48
Anseriformes	Anatidae	Branta canadensis	Canada goose	MO	Yes	0.944	3984.5	-0.55	8	0.82	1660912.9	6	363
Anseriformes	Anatidae	Branta leucopsis	Barnacle goose	MN	Yes	0.944	1708.5	-0.45	4	0.82	63079.5	1	68
Anseriformes	Anatidae	Cairina moschata	Muscovy duck	MN	Yes	0.915	2228.0	-1.24	3	0.24	810046.9	2	118

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Anseriformes	Anatidae	Cereopsis novaehollandiae	Cape barren goose	DD	No	0.935	3770.0	-1.58	7	0.68	176.7	1	107
Anseriformes	Anatidae	Chen caerulescens	Snow goose	MN	Yes	0.907	2630.8	-0.05	6	0.82	3097.0	1	44
Anseriformes	Anatidae	Chloephaga picta	Upland goose	DD	No	0.89	2930.0	-1.33	2	0.68	423.3	1	33
Anseriformes	Anatidae	Cygnus atratus	Black swan	MO	Yes	0.922	5656.0	-1.07	4	1	376254.7	3	263
Anseriformes	Anatidae	Cygnus olor	Mute swan	MO	Yes	0.944	10230.0	-1.53	4	0.66	3858879.6	5	323
Anseriformes	Anatidae	Dendrocygna arcuata	Wandering whistling-duck	MN	Yes	0.912	776.7	-0.61	1	1	593.5	1	25
Anseriformes	Anatidae	Dendrocygna autumnalis	Black-bellied whistling-duck	DD	No	0.915	826.5	-0.80	2	0.82	16616.3	2	82

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Anseriformes	Anatidae	Dendrocygna bicolor	Fulvous whistling-duck	DD	No	0.915	743.0	-0.61	3	0.44	5634.0	1	63
Anseriformes	Anatidae	Dendrocygna viduata	White-faced whistling-duck	DD	No	0.777	674.0	-0.41	3	0.3	1868.4	1	203
Anseriformes	Anatidae	Netta rufina	Red-crested pochard	DD	No	0.907	1118.0	-0.71	2	0.58	38848.5	1	113
Anseriformes	Anatidae	Oxyura jamaicensis	Ruddy duck	MO	Yes	0.944	550.0	-0.80	4	0.52	90674.5	1	78
Anseriformes	Anatidae	Tadorna ferruginea	Ruddy shelduck	MC	Yes	0.93	1240.0	-1.33	3	0.42	10741.7	1	58
Apodiformes	Apodidae	Collocalia vanikorensis	Uniform swiftlet	DD	No	0.915	10.7	-1.43	2	1	1560.2	1	51
Apodiformes	Apodidae	Collocalia bartschi	Guam swiftlet	DD	No	0.915	7.3	-1.43	2	1	1560.2	1	51

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Casuariiformes	Dromaiidae	Dromaius novaehollandiae	Emu	DD	No	0.935	36200.0	-1.33	2	0.26	4524.0	1	87
Cathartiformes	Cathartidae	Cathartes aura	Turkey vulture	DD	No	0.865	1776.0	0.19	5	1	82772.6	1	133
Charadriiformes	Turnicidae	Turnix nigricollis	Madagascar buttonquail	DD	No	0.888	58.5	-1.57	4	0.5	2517.3	1	50
Columbiformes	Columbidae	Chalcophaps indica	Emerald dove	DD	No	0.91	137.0	-2.18	2	0.36	996.9	1	32
Columbiformes	Columbidae	Columbina passerina	Common ground-dove	DD	No	0.891	35.0	-1.16	4	0.42	68.0	1	313
Columbiformes	Columbidae	Geopelia cuneata	Diamond dove	DD	No	0.915	31.6	-1.17	2	0.54	10457.2	1	91
Columbiformes	Columbidae	Geopelia humeralis	Bar-shouldered dove	DD	No	0.915	128.7	-1.31	4	0.52	1560.2	1	91

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Columbiformes	Columbidae	Geopelia placida	Peaceful dove	DD	No	0.935	48.9	-1.23	3	0.68	4417.7	1	22
Columbiformes	Columbidae	Geopelia striata	Zebra dove	MC	Yes	0.935	51.9	-1.20	3	0.68	604841.3	4	263
Columbiformes	Columbidae	Goura cristata	Western crowned-pigeon	DD	No	0.684	2000.0	-1.42	1	0.58	17409.0	1	12
Columbiformes	Columbidae	Leptotila jamaicensis	Caribbean dove	DD	No	0.79	164.8	-1.07	3	0.68	217.5	1	93
Columbiformes	Columbidae	Leucosarcia melanoleuca	Wonga pigeon	DD	No	0.915	429.1	-1.58	3	0.36	10457.2	1	91
Columbiformes	Columbidae	Nesoenas picturata	Madagascar turtle-dove	MV	Yes	0.822	181.5	-1.42	2	0.54	6901.9	2	263
Columbiformes	Columbidae	Oena capensis	Namaqua dove	DD	No	0.894	40.6	-1.59	3	0.82	6445.1	1	6

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Columbiformes	Columbidae	Patagioenas squamosa	Scaly-naped pigeon	DD	No	0.785	311.8	-1.42	2	0.3	434.6	1	93
Columbiformes	Columbidae	Stigmatopelia chinensis	Spotted dove	MN	Yes	0.935	159.0	-1.55	5	1	1059154.1	6	244
Columbiformes	Columbidae	Stigmatopelia senegalensis	Laughing dove	MN	Yes	0.935	101.0	-1.07	4	0.52	665333.1	4	163
Columbiformes	Columbidae	Streptopelia bitorquata	Island collared-dove	DD	No	0.844	155.0	-1.44	3	1	873.3	1	263
Columbiformes	Columbidae	Streptopelia capicola	Ring-necked dove	DD	No	0.687	147.8	-1.44	5	0.26	1393.0	1	10
Columbiformes	Columbidae	Streptopelia decaocto	Eurasian collared-dove	MN	Yes	0.913	154.7	-1.34	4	0.3	87298.6	5	213
Columbiformes	Columbidae	Streptopelia roseogrisea	African collared-dove	DD	No	0.935	153.5	-1.94	4	0.54	170983.8	4	15

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Columbiformes	Columbidae	Streptopelia tranquebarica	Red collared-dove	DD	No	0.912	103.0	-1.44	3	0.52	57095.4	1	73
Columbiformes	Columbidae	Turtur tympanistria	Tambourine dove	DD	No	0.687	69.2	-1.23	3	0.46	2058.0	1	10
Columbiformes	Columbidae	Zenaida asiatica	White-winged dove	MN	Yes	0.915	153.0	-1.39	4	0.46	39572.9	1	54
Columbiformes	Columbidae	Caloenas nicobarica	Nicobar pigeon	DD	No	0.915	505.8	-1.17	2	0.5	10457.2	1	26
Columbiformes	Columbidae	Ocyphaps lophotes	Crested pigeon	DD	No	0.935	204.5	-1.42	5	0.42	15158.4	3	91
Columbiformes	Columbidae	Zenaida macroura	Mourning dove	DD	No	0.915	119.0	-1.52	4	0.82	10457.2	1	84
Coraciiformes	Halcyonidae	Dacelo novaeguineae	Laughing kookaburra	MN	Yes	0.935	340.3	0.44	5	0.54	254452.9	1	153

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Cuculiformes	Cuculidae	Crotophaga ani	Smooth-billed ani	MN	Yes	0.732	112.6	-0.45	5	0.26	8022.5	1	52
Cuculiformes	Cuculidae	Eudynamys scolopaceus	Asian koel	DD	No	0.912	209.5	-0.45	4	0.66	593.5	1	34
Falconiformes	Falconidae	Milvago chimango	Chimango caracara	MO	Yes	0.832	296.0	0.80	5	0.34	168.4	1	85
Galliformes	Phasianidae	Alectoris barbara	Barbary partridge	DD	No	0.876	418.5	-1.14	3	0.34	31265.7	1	563
Galliformes	Phasianidae	Alectoris chukar	Chukar	MO	Yes	0.935	535.5	-1.80	2	0.54	2508521.9	5	482
Galliformes	Phasianidae	Alectoris graeca	Rock partridge	DD	No	0.935	597.5	-2.48	2	0.58	124413.6	5	107
Galliformes	Phasianidae	Alectoris rufa	Red-legged partridge	DD	No	0.916	516.0	-2.25	3	0.42	180632.2	2	340

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Megapodiidae	Alectura lathami	Australian brush-turkey	DD	No	0.935	2330.0	-1.41	5	0.28	4417.7	1	77
Galliformes	Phasianidae	Bambusicola thoracicus	Chinese bamboo-partridge	DD	No	0.915	271.0	-1.59	3	0.38	67814.6	2	98
Galliformes	Phasianidae	Bonasa umbellus	Ruffed grouse	DD	No	0.915	532.0	-1.79	1	0.54	16863.8	1	113
Galliformes	Odontophoridae	Callipepla californica	California quail	MC	Yes	0.935	171.5	-1.71	5	0.5	660285.7	5	163
Galliformes	Odontophoridae	Callipepla douglasii	Elegant quail	DD	No	0.832	178.0	-1.70	3	0.34	143.8	1	6
Galliformes	Odontophoridae	Callipepla gambelii	Gambel's quail	DD	No	0.915	169.3	-1.68	3	0.42	17147.6	2	85
Galliformes	Odontophoridae	Callipepla squamata	Scaled quail	DD	No	0.915	191.0	-1.56	2	0.34	18390.2	1	32

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Phasianidae	Chrysolophus amherstiae	Lady amherst's pheasant	DD	No	0.907	714.0	-1.12	2	0.42	1262.9	2	163
Galliformes	Phasianidae	Chrysolophus pictus	Golden pheasant	MN	Yes	0.913	633.8	-1.20	2	0.82	28311.3	2	168
Galliformes	Odontophoridae	Colinus cristatus	Crested bobwhite	DD	No	0.863	136.5	-1.74	3	0.82	411.3	1	19
Galliformes	Odontophoridae	Colinus virginianus	Northern bobwhite	DD	No	0.915	173.3	-1.74	4	0.58	897667.5	4	313
Galliformes	Phasianidae	Coturnix chinensis	Blue quail	DD	No	0.935	44.5	-1.82	4	0.34	4505.0	2	119
Galliformes	Phasianidae	Coturnix coturnix	Common quail	DD	No	0.915	98.8	-1.74	2	0.68	10325.6	2	154
Galliformes	Phasianidae	Coturnix japonica	Japanese quail	MN	Yes	0.915	96.6	-1.81	3	0.58	17668.0	2	92

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Phasianidae	Coturnix ypsilophora	Brown quail	DD	No	0.935	107.5	-1.81	4	0.58	147023.5	2	153
Galliformes	Phasianidae	Francolinus adspersus	Red-billed francolin	DD	No	0.915	437.5	-1.26	3	0.3	10457.2	1	56
Galliformes	Phasianidae	Francolinus afer	Red-necked spurfowl	DD	No	0.688	559.3	-1.26	3	0.54	226.0	1	162
Galliformes	Phasianidae	Francolinus capensis	Cape francolin	DD	No	0.666	652.3	-1.26	2	0.26	6.3	1	48
Galliformes	Phasianidae	Francolinus erckelii	Erckel's francolin	MC	Yes	0.915	1263.0	-1.26	3	0.58	63537.1	2	65
Galliformes	Phasianidae	Francolinus francolinus	Black francolin	MC	Yes	0.915	453.0	-1.26	3	0.34	87900.6	4	54
Galliformes	Phasianidae	Francolinus hildebrandti	Hildebrandt's francolin	DD	No	0.521	622.0	-1.16	2	0.46	0.7	1	31

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Phasianidae	Francolinus pintadeanus	Chinese francolin	DD	No	0.793	354.3	-1.26	4	0.34	2868.9	2	263
Galliformes	Phasianidae	Francolinus pondicerianus	Grey francolin	MC	Yes	0.915	274.0	-1.70	3	0.3	227617.9	5	263
Galliformes	Phasianidae	Gallus gallus	Red junglefowl	MR	Yes	0.935	912.5	-1.49	2	0.26	367071.3	6	1513
Galliformes	Phasianidae	Gallus varius	Green junglefowl	MR	Yes	0.797	781.3	-1.49	3	0.34	83.3	1	8
Galliformes	Phasianidae	Lophura leucomelanos	Kalij pheasant	MN	Yes	0.915	1180.0	-1.67	3	0.28	10771.4	2	93
Galliformes	Phasianidae	Lophura nycthemera	Silver pheasant	DD	No	0.935	1250.0	-1.56	2	0.34	38.8	1	93
Galliformes	Megapodiidae	Macrocephalon maleo	Maleo	DD	No	0.684	1594.0	-1.74	4	0.52	560.6	1	16

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Phasianidae	Margaroperdix madagascariensis	Madagascar partridge	DD	No	0.822	232.5	-2.09	4	0.58	2512.7	1	173
Galliformes	Megapodiidae	Megapodius pritchardii	Polynesian megapode	DD	No	0.717	374.5	-1.74	2	1	22.7	1	20
Galliformes	Phasianidae	Meleagris gallopavo	Wild turkey	MC	Yes	0.935	5811.0	-2.21	4	0.28	115515.6	4	483
Galliformes	Numididae	Numida meleagris	Helmeted guineafowl	DD	No	0.935	1375.0	-1.75	5	0.3	753694.5	3	552
Galliformes	Odontophoridae	Oreortyx pictus	Mountain quail	DD	No	0.915	233.0	-1.56	3	0.36	40048.8	1	153
Galliformes	Cracidae	Ortalis ruficauda	Rufous-vented chachalaca	DD	No	0.72	608.0	-1.07	4	0.52	25.9	1	53
Galliformes	Cracidae	Ortalis vetula	Plain chachalaca	DD	No	0.915	560.0	-1.07	3	0.52	202.9	1	90

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Galliformes	Phasianidae	Pavo cristatus	Common peafowl	MC	Yes	0.935	4093.8	-2.10	3	0.3	172059.1	6	173
Galliformes	Phasianidae	Perdicula asiatica	Jungle bush-quail	DD	No	0.822	74.8	-1.55	3	0.68	2512.7	1	168
Galliformes	Phasianidae	Perdix dauurica	Daurian partridge	DD	No	0.798	270.0	-2.09	3	0.36	36.7	1	32
Galliformes	Phasianidae	Perdix perdix	Grey partridge	MO	Yes	0.923	405.5	-2.09	3	0.34	3589855.9	2	223
Galliformes	Phasianidae	Phasianus colchicus	Common pheasant	MO	Yes	0.944	1043.8	-1.97	3	0.28	17120596.4	6	963
Galliformes	Phasianidae	Phasianus versicolor	Green pheasant	DD	No	0.915	1000.0	-1.97	3	0.36	46760.6	3	263
Galliformes	Phasianidae	Polyplectron napoleonis	Palawan peacock-pheasant	DD	No	0.668	436.0	-1.65	1	0.42	1.1	1	7

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Galliformes	Phasianidae	Syrmaticus reevesii	Reeves's pheasant	DD	No	0.915	1239.0	-1.16	2	0.42	299715.8	2	163
Galliformes	Phasianidae	Tetraogallus himalayensis	Himalayan snowcock	DD	No	0.915	2427.8	-1.67	1	0.68	437.9	1	51
Gruiformes	Rallidae	Fulica americana	American coot	DD	No	0.915	620.5	-1.26	4	0.36	1560.2	1	80
Gruiformes	Rallidae	Gallinula chloropus	Common moorhen	DD	No	0.688	377.0	-1.58	4	0.18	126.4	1	32
Gruiformes	Rallidae	Gallinula mortierii	Tasmanian native-hen	DD	No	0.935	1313.3	-1.58	4	0.28	105.2	1	44
Gruiformes	Rallidae	Gallirallus australis	Weka	MO	Yes	0.935	893.5	-0.50	7	0.22	2721.1	1	113
Gruiformes	Rallidae	Gallirallus owstoni	Guam rail	DD	No	0.755	230.3	-0.50	4	0.2	89.8	1	17

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Gruiformes	Rallidae	Porphyrio flavirostris	Azure gallinule	DD	No	0.772	93.2	-1.26	1	0.5	4835.7	1	10
Gruiformes	Rallidae	Porphyrio porphyrio	Grey-headed swamphen	MN	Yes	0.915	850.0	-0.98	3	0.28	14449.9	3	37
Passeriformes	Sturnidae	Acridotheres cinereus	Pale-bellied myna	DD	No	0.912	85.0	0.57	1	0.68	26488.6	2	35
Passeriformes	Sturnidae	Acridotheres cristatellus	Crested myna	MN	Yes	0.915	116.5	0.57	3	0.42	56697.1	4	164
Passeriformes	Sturnidae	Acridotheres fuscus	Jungle myna	DD	No	0.912	85.0	0.57	2	0.3	56426.9	2	123
Passeriformes	Sturnidae	Acridotheres ginginianus	Bank myna	DD	No	0.882	71.0	0.57	3	0.26	43074.1	2	38
Passeriformes	Sturnidae	Acridotheres grandis	White-vented myna (great myna)	DD	No	0.882	99.0	0.57	3	0.44	44904.5	2	31

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Passeriformes	Sturnidae	Acridotheres tristis	Common myna	MO	Yes	0.935	113.5	0.57	4	0.22	2305628.9	6	255
Passeriformes	Alaudidae	Alauda arvensis	Skylark	DD	No	0.935	37.5	-0.42	5	0.36	597144.6	3	163
Passeriformes	Pellorneidae	Alcippe morrisonia	Grey-cheeked fulvetta	DD	No	0.91	15.1	0.12	2	0.44	275.9	1	18
Passeriformes	Estrildidae	Amandava amandava	Red avadavat	MC	Yes	0.915	9.6	-0.67	4	0.68	530818.1	6	363
Passeriformes	Sturnidae	Aplonis panayensis	Asian glossy starling	DD	No	0.935	56.3	0.43	3	0.44	2122.8	1	12
Passeriformes	Atrichornithidae	Atrichornis clamosus	Noisy scrub-bird	DD	No	0.935	41.5	0.12	3	0.82	705.6	1	30
Passeriformes	Leiothrichidae	Babax lanceolatus	Chinese babax	DD	No	0.91	32.0	0.12	3	0.5	814.4	1	54

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Passeriformes	Cardinalidae	Cardinalis cardinalis	Northern cardinal	DD	No	0.915	43.1	0.72	6	0.54	27017.8	2	313
Passeriformes	Fringillidae	Carduelis carduelis	Goldfinch	DD	No	0.935	16.0	-0.27	7	0.3	1325581.4	6	213
Passeriformes	Fringillidae	Carduelis chloris	Greenfinch	DD	No	0.935	27.7	-0.03	3	1	728219.3	4	156
Passeriformes	Fringillidae	Carduelis cucullata	Red siskin	DD	No	0.865	8.9	-0.11	3	0.44	7735.0	1	78
Passeriformes	Fringillidae	Carduelis flammea	Common redpoll	DD	No	0.935	13.0	0.09	3	0.34	262485.4	1	151
Passeriformes	Fringillidae	Carduelis psaltria	Lesser goldfinch	DD	No	0.769	9.1	-0.11	2	0.28	6411.6	1	32
Passeriformes	Fringillidae	Carpodacus mexicanus	House finch	MN	Yes	0.915	21.4	0.10	4	0.28	2855857.6	3	163

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Passeriformes	Cettiidae	Cettia diphone	Japanese bush-warbler	MN	Yes	0.915	14.4	0.12	3	1	5948.6	1	84
Passeriformes	Muscicapidae	Copsychus malabaricus	White-rumped shama	MC	Yes	0.915	29.7	-0.19	4	0.58	49430.7	2	82
Passeriformes	Muscicapidae	Copsychus saularis	Oriental magpie-robin	DD	No	0.915	36.8	0.28	5	0.52	38973.5	2	91
Passeriformes	Corvidae	Corvus brachyrhynchos	American crow	MO	Yes	0.891	453.0	1.38	5	0.16	68.0	1	175
Passeriformes	Corvidae	Corvus frugilegus	Rook	MN	Yes	0.913	453.5	1.40	5	0.28	31717.6	1	151
Passeriformes	Corvidae	Corvus monedula	Eurasian jackdaw	DD	No	0.736	246.0	1.26	5	0.28	2514.5	1	32
Passeriformes	Corvidae	Corvus moneduloides	New caledonian crow	DD	No	0.852	309.0	1.40	4	0.18	658.9	1	32

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Passeriformes	Corvidae	Corvus splendens	House crow	MO	Yes	0.922	312.0	1.58	4	0.32	213651.2	3	403
Passeriformes	Thraupidae	Cyanopica cyanus	Azure-winged magpie	DD	No	0.882	92.0	1.69	3	0.66	35970.4	1	4
Passeriformes	Dicruridae	Dicrurus macrocercus	Black drongo	MO	Yes	0.844	48.5	0.78	3	0.24	639.1	1	78
Passeriformes	Thraupidae	Diuca diuca	Common diuca-finch	DD	No	0.832	36.4	0.79	3	1	168.4	1	85
Passeriformes	Emberizidae	Emberiza cirlus	Cirl bunting	DD	No	0.913	25.3	-0.14	2	0.46	154544.0	1	144
Passeriformes	Emberizidae	Emberiza citrinella	Yellowhammer	DD	No	0.935	29.7	-0.37	4	0.46	240237.2	1	151
Passeriformes	Estrildidae	Estrilda astrild	Common waxbill	DD	No	0.915	8.2	-0.62	4	1	422398.8	7	363

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Passeriformes	Estrildidae	Estrilda caerulescens	Lavender waxbill	DD	No	0.915	8.9	-0.27	3	1	12017.4	1	53
Passeriformes	Estrildidae	Estrilda melpoda	Orange-cheeked waxbill	DD	No	0.915	7.7	-0.32	5	0.52	87241.2	5	183
Passeriformes	Estrildidae	Estrilda perreini	Black-tailed waxbill	DD	No	0.915	7.4	-0.36	2	0.52	12072.4	2	36
Passeriformes	Estrildidae	Estrilda troglodytes	Black-rumped waxbill	MC	Yes	0.915	7.6	-0.36	3	0.68	55583.8	3	53
Passeriformes	Ploceidae	Euplectes afer	Yellow-crowned bishop	DD	No	0.915	14.5	0.37	3	0.68	53972.1	3	48
Passeriformes	Ploceidae	Euplectes albonotatus	White-winged widowbird	DD	No	0.935	21.2	0.37	5	0.54	2695.4	2	32
Passeriformes	Ploceidae	Euplectes aureus	Golden-backed bishop	DD	No	0.865	21.0	0.37	3	0.5	9583.3	2	53

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Passeriformes	Ploceidae	Euplectes franciscanus	Orange bishop	DD	No	0.915	18.8	0.37	3	0.68	32746.3	2	53
Passeriformes	Ploceidae	Euplectes orix	Red bishop	DD	No	0.935	21.1	0.37	3	0.5	325.2	3	42
Passeriformes	Ploceidae	Foudia madagascariensis	Madagascar red fody	MO	Yes	0.915	16.2	0.36	5	0.54	7023.1	4	340
Passeriformes	Ploceidae	Foudia sechellarum	Seychelles fody	DD	No	0.772	17.2	0.36	3	0.52	4.3	1	3
Passeriformes	Fringillidae	Fringilla coelebs	Chaffinch	DD	No	0.935	22.6	-0.29	4	0.44	255577.4	1	163
Passeriformes	Leiothrichidae	Garrulax albogularis	White-throated laughingthrush	DD	No	0.915	97.0	0.45	3	0.44	195.9	1	94
Passeriformes	Leiothrichidae	Garrulax caerulatus	Grey-sided laughingthrush	DD	No	0.915	86.0	0.45	2	0.26	1560.2	1	85

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Passeriformes	Leiothrichidae	Garrulax canorus	Chinese hwamei	MO	Yes	0.915	66.0	0.45	5	0.52	66292.3	3	113
Passeriformes	Leiothrichidae	Garrulax chinensis	Black-throated laughingthrush	DD	No	0.91	78.6	0.45	3	0.54	36785.5	1	100
Passeriformes	Leiothrichidae	Garrulax cineraceus	Moustached laughingthrush	DD	No	0.891	49.0	0.45	2	0.54	308.0	1	7
Passeriformes	Leiothrichidae	Garrulax leucolophus	White-crested laughingthrush	DD	No	0.912	123.5	0.45	3	0.4	2158.1	1	34
Passeriformes	Leiothrichidae	Garrulax pectoralis	Greater necklaced laughingthrush	DD	No	0.915	145.0	0.45	3	0.58	3817.5	2	94
Passeriformes	Leiothrichidae	Garrulax perspicillatus	Masked laughingthrush	DD	No	0.891	118.0	0.45	3	0.66	4184.7	1	8
Passeriformes	Leiothrichidae	Garrulax sannio	White-browed laughingthrush	DD	No	0.91	67.8	0.45	3	0.52	7183.6	2	72

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Passeriformes	Sturnidae	Gracula religiosa	Hill myna	DD	No	0.915	193.5	0.85	2	0.42	16811.8	4	58
Passeriformes	Monarchidae	Grallina cyanoleuca	Magpie-lark	DD	No	0.935	79.9	-0.07	7	0.54	12034.9	2	91
Passeriformes	Thraupidae	Gubernatrix cristata	Yellow cardinal	DD	No	0.915	48.0	0.41	2	1	1560.2	1	52
Passeriformes	Artamidae	Gymnorhina tibicen	Australian magpie	MN	Yes	0.935	290.5	0.73	4	0.52	284567.4	2	152
Passeriformes	Icteridae	Icterus icterus	Venezuelan troupial	DD	No	0.865	67.1	0.36	4	0.42	10339.5	1	136
Passeriformes	Icteridae	Icterus pectoralis	Spot-breasted oriole	DD	No	0.915	47.3	0.36	4	0.52	11107.2	2	73
Passeriformes	Estrildidae	Lagonosticta senegala	Red-billed firefinch	DD	No	0.736	8.7	-0.39	4	0.44	87074.9	1	73

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Passeriformes	Timaliidae	Leiothrix argentauris	Silver-eared mesia	DD	No	0.91	28.4	0.44	3	0.44	814.4	1	43
Passeriformes	Leiothrichidae	Leiothrix lutea	Red-billed leiothrix	MN	Yes	0.916	21.5	0.44	3	0.66	162244.1	4	100
Passeriformes	Estrildidae	Lonchura atricapilla	Chestnut munia	DD	No	0.915	12.7	-0.33	4	1	120593.3	5	104
Passeriformes	Estrildidae	Lonchura cantans	African silverbill	DD	No	0.915	12.0	-0.35	3	0.82	25246.7	2	53
Passeriformes	Estrildidae	Lonchura castaneothorax	Chestnut-breasted munia	DD	No	0.935	13.3	-0.35	6	0.52	26150.8	2	163
Passeriformes	Estrildidae	Lonchura cucullata	Bronze munia	DD	No	0.915	9.1	-0.61	5	0.28	11035.4	2	484
Passeriformes	Estrildidae	Lonchura ferruginosa	White-capped munia	DD	No	0.78	12.8	-0.33	2	1	370.8	1	17

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Passeriformes	Estrildidae	Lonchura fringilloides	Magpie munia	DD	No	0.532	16.4	-0.35	4	0.34	308430.9	1	42
Passeriformes	Estrildidae	Lonchura hunsteini	Mottled munia	DD	No	0.64	13.3	-0.35	1	1	354.1	1	93
Passeriformes	Estrildidae	Lonchura leucogastroides	Javan munia	DD	No	0.912	11.5	-0.35	3	1	593.5	1	103
Passeriformes	Estrildidae	Lonchura maja	White-headed munia	DD	No	0.891	12.5	-0.33	2	0.82	36216.1	2	16
Passeriformes	Estrildidae	Lonchura malabarica	White-throated munia	DD	No	0.915	12.0	-0.35	4	0.54	64592.0	4	53
Passeriformes	Estrildidae	Lonchura malacca	Tricoloured munia	DD	No	0.935	12.6	0.13	4	1	302304.6	5	143
Passeriformes	Estrildidae	Lonchura punctulata	Scaly-breasted munia	MC	Yes	0.935	14.0	-0.35	5	0.34	304983.3	6	363

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Passeriformes	Estrildidae	Lonchura striata	White-rumped munia	DD	No	0.891	12.3	-0.35	4	0.82	2339.9	1	28
Passeriformes	Meliphagidae	Manorina melanocephala	Noisy miner	DD	No	0.506	60.6	0.77	4	0.28	12.6	1	56
Passeriformes	Menuridae	Menura novaehollandiae	Superb lyrebird	MN	Yes	0.935	980.0	1.87	1	0.66	867.7	1	102
Passeriformes	Mimidae	Mimus gilvus	Tropical mockingbird	MN	Yes	0.785	55.5	0.42	4	1	26239.8	1	81
Passeriformes	Leiothrichidae	Minla cyanouroptera	Blue-winged minla	DD	No	0.91	17.0	0.44	3	0.34	814.4	1	28
Passeriformes	Icteridae	Molothrus bonariensis	Shiny cowbird	MO	Yes	0.865	38.4	0.34	4	0.58	71461.3	1	154
Passeriformes	Estrildidae	Neochmia temporalis	Red-browed finch	DD	No	0.935	11.5	-0.03	2	0.68	35783.2	2	163

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Passeriformes	Oriolidae	Oriolus chinensis	Black-naped oriole	DD	No	0.912	82.6	0.12	3	0.42	593.5	1	74
Passeriformes	Thraupidae	Oryzoborus angolensis	Lesser seed-finch	DD	No	0.859	13.0	-0.13	3	0.44	1114.9	1	30
Passeriformes	Estrildidae	Padda oryzivora	Java sparrow	DD	No	0.915	24.8	0.06	4	0.82	864437.9	7	414
Passeriformes	Sylviidae	Paradoxornis alphonsianus	Ashy-throated parrotbill	DD	No	0.873	20.7	-0.32	4	1	312.1	1	18
Passeriformes	Sylviidae	Paradoxornis webbianus	Vinous-throated parrotbill	DD	No	0.91	10.9	-0.32	4	0.28	814.4	1	42
Passeriformes	Thraupidae	Paroaria capitata	Yellow-billed cardinal	DD	No	0.915	22.3	0.26	3	0.44	10457.2	1	83
Passeriformes	Thraupidae	Paroaria coronata	Red-crested cardinal	DD	No	0.915	38.8	0.19	2	0.44	36581.0	5	85

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Passeriformes	Thraupidae	Paroaria dominicana	Red-cowled cardinal	DD	No	0.777	31.1	0.33	2	0.44	25.4	1	113
Passeriformes	Thraupidae	Paroaria gularis	Red-capped cardinal	DD	No	0.915	24.8	0.26	3	0.44	1564.6	1	52
Passeriformes	Paridae	Parus spilonotus	Yellow-cheeked tit	DD	No	0.91	18.9	0.53	2	0.66	814.4	1	25
Passeriformes	Paridae	Parus varius	Varied tit	DD	No	0.915	17.0	0.59	2	0.54	1560.2	1	123
Passeriformes	Passeridae	Passer domesticus	House sparrow	MO	Yes	0.935	27.7	-0.06	8	0.46	36489228.2	8	169
Passeriformes	Passeridae	Passer hispaniolensis	Spanish sparrow	MN	Yes	0.876	24.2	-0.04	5	0.44	12375.2	1	203
Passeriformes	Passeridae	Passer montanus	Tree sparrow	DD	No	0.935	22.1	-0.03	4	0.52	1137677.5	5	413

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Passeriformes	Petroicidae	Petroica australis	New zealand robin	DD	No	0.913	33.1	0.12	3	0.68	4.8	1	22
Passeriformes	Callaeidae	Philesturnus carunculatus	Saddleback	DD	No	0.913	75.0	0.12	2	0.42	51.8	1	29
Passeriformes	Corvidae	Pica pica	Black-billed magpie	MN	Yes	0.891	189.0	1.64	5	0.26	69829.9	2	423
Passeriformes	Tyrannidae	Pitangus sulphuratus	Great kiskadee	MV	Yes	0.891	61.9	-0.45	5	0.28	362.3	2	63
Passeriformes	Ploceidae	Ploceus cucullatus	Village weaver	MN	Yes	0.873	37.6	0.55	4	0.28	80512.3	2	501
Passeriformes	Ploceidae	Ploceus galbula	Rueppell's weaver	DD	No	0.876	23.8	0.55	3	1	5029.8	1	10
Passeriformes	Ploceidae	Ploceus intermedius	Lesser masked weaver	DD	No	0.891	22.0	0.55	6	0.4	35970.4	1	29

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Passeriformes	Ploceidae	Ploceus jacksoni	Golden-backed weaver	DD	No	0.835	26.2	0.55	4	0.68	489.3	1	22
Passeriformes	Ploceidae	Ploceus manyar	Streaked weaver	DD	No	0.912	17.4	0.55	2	0.68	31411.3	2	42
Passeriformes	Ploceidae	Ploceus philippinus	Baya weaver	DD	No	0.91	26.5	0.55	4	0.54	814.4	1	20
Passeriformes	Ploceidae	Ploceus velatus	Southern masked-weaver	DD	No	0.894	29.2	0.55	6	0.3	854.8	1	3
Passeriformes	Monarchidae	Pomarea dimidiata	Rarotonga monarch	DD	No	0.728	23.0	0.12	1	1	29.5	1	12
Passeriformes	Timaliidae	Pomatorhinus ruficollis	Streak-breasted scimitar-babbler	DD	No	0.91	30.5	0.12	2	0.66	814.4	1	64
Passeriformes	Prunellidae	Prunella modularis	Hedge accentor (dunnock)	DD	No	0.913	20.2	-0.24	4	0.5	269091.6	1	146

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Passeriformes	Pycnonotidae	Pycnonotus aurigaster	Sooty-headed bulbul	DD	No	0.912	45.0	0.13	4	0.18	238418.7	2	90
Passeriformes	Pycnonotidae	Pycnonotus cafer	Red-vented bulbul	MO	Yes	0.935	41.3	0.13	4	0.18	83074.6	3	113
Passeriformes	Pycnonotidae	Pycnonotus goiavier	Yellow-vented bulbul	DD	No	0.684	27.8	0.13	6	0.34	30554.2	1	36
Passeriformes	Pycnonotidae	Pycnonotus jocosus	Red-whiskered bulbul	MR	Yes	0.935	27.7	0.13	5	0.2	76110.7	6	152
Passeriformes	Pycnonotidae	Pycnonotus leucogenys	Himalayan bulbul	DD	No	0.894	33.0	0.13	4	0.3	919.1	1	17
Passeriformes	Pycnonotidae	Pycnonotus melanicterus	Black-crested bulbul	DD	No	0.912	29.5	0.13	4	0.58	596.9	1	25
Passeriformes	Icteridae	Quiscalus lugubris	Carib grackle	DD	No	0.888	63.0	0.08	5	0.52	1024.4	1	108

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Passeriformes	Thraupidae	Ramphocelus dimidiatus	Crimson-backed tanager	DD	No	0.791	28.9	0.61	3	0.34	1053.1	1	83
Passeriformes	Rhipiduridae	Rhipidura leucophrys	Willie-wagtail	DD	No	0.915	27.0	-1.15	5	0.52	1560.2	1	87
Passeriformes	Fringillidae	Serinus canaria	Island canary	DD	No	0.915	21.0	-0.12	3	0.52	9006.2	3	103
Passeriformes	Fringillidae	Serinus canicollis	Cape canary	DD	No	0.822	15.2	0.29	3	0.54	2512.7	1	263
Passeriformes	Fringillidae	Serinus dorsostriatus	White-bellied canary	DD	No	0.521	15.7	0.21	4	1	1614.9	1	3
Passeriformes	Fringillidae	Serinus flaviventris	Yellow canary	DD	No	0.688	16.3	0.23	1	0.36	225.8	1	237
Passeriformes	Fringillidae	Serinus mozambicus	Yellow-fronted canary	DD	No	0.915	11.8	0.29	3	0.42	18272.3	3	263

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Passeriformes	Thraupidae	Sicalis luteola	Grassland yellow-finch	DD	No	0.859	16.1	-0.13	4	1	4811.5	1	113
Passeriformes	Sittidae	Sitta frontalis	Velvet-fronted nuthatch	MC	Yes	0.91	16.6	0.12	2	1	288.7	1	28
Passeriformes	Timaliidae	Stachyris ruficeps	Rufous-capped babbler	DD	No	0.91	10.0	0.12	1	0.68	814.4	1	28
Passeriformes	Estrildidae	Stagonopleura guttata	Diamond firetail	DD	No	0.915	17.6	-0.36	2	0.68	1560.2	1	52
Passeriformes	Icteridae	Sturnella neglecta	Western meadowlark	DD	No	0.915	97.7	0.08	3	0.5	4897.3	1	82
Passeriformes	Sturnidae	Sturnus contra	Asian pied starling	DD	No	0.891	83.5	0.11	3	0.18	3831.7	2	24
Passeriformes	Sturnidae	Sturnus malabaricus	Chestnut-tailed starling	DD	No	0.882	38.0	0.11	3	0.28	35989.8	1	7

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Passeriformes	Sturnidae	Sturnus melanopterus	Black-winged starling	DD	No	0.912	81.7	0.11	4	0.34	594.1	1	93
Passeriformes	Sturnidae	Sturnus nigricollis	Black-collared starling	DD	No	0.894	157.0	0.11	3	0.58	35971.1	1	14
Passeriformes	Sturnidae	Sturnus vulgaris	Starling	MO	Yes	0.935	77.7	0.29	8	0.2	19848761.0	5	173
Passeriformes	Thraupidae	Tachyphonus rufus	White-lined tanager	DD	No	0.836	34.3	0.25	4	0.46	211.0	1	14
Passeriformes	Estrildidae	Taeniopygia guttata	Zebra finch	DD	No	0.913	11.9	-0.62	6	1	22.2	1	149
Passeriformes	Drepanididae	Telespiza cantans	Laysan finch	DD	No	0.915	33.3	0.14	2	0.28	0.9	1	46
Passeriformes	Thraupidae	Thraupis episcopus	Blue-grey tanager	DD	No	0.915	35.0	0.41	4	0.42	5497.7	2	32

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Passeriformes	Thraupidae	Thraupis palmarum	Palm tanager	DD	No	0.772	38.3	0.41	4	0.42	308.3	1	10
Passeriformes	Thraupidae	Tiaris canorus	Cuban grassquit	DD	No	0.79	7.9	0.13	3	0.82	217.5	1	53
Passeriformes	Thraupidae	Tiaris olivaceus	Yellow-faced grassquit	DD	No	0.915	8.4	0.13	3	0.82	1777.7	2	43
Passeriformes	Turdidae	Turdus merula	Blackbird	MO	Yes	0.935	102.0	0.04	6	0.34	1466458.5	1	163
Passeriformes	Turdidae	Turdus philomelos	Song thrush	MO	Yes	0.935	68.8	0.05	4	0.34	295169.5	1	163
Passeriformes	Turdidae	Turdus rufopalliatus	Rufous-backed robin	DD	No	0.756	75.6	0.03	4	0.58	22620.7	1	63
Passeriformes	Estrildidae	Uraeginthus angolensis	Blue-breasted cordonbleu	DD	No	0.915	10.0	-0.45	3	0.58	4006.5	2	48

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Passeriformes	Estrildidae	Uraeginthus bengalus	Red-cheeked cordonbleu	DD	No	0.915	9.9	-0.45	3	0.68	12017.4	1	49
Passeriformes	Corvidae	Urocissa erythrorhyncha	Blue magpie	DD	No	0.915	166.3	0.95	2	0.26	36226.1	2	32
Passeriformes	Viduidae	Vidua chalybeata	Village indigobird	DD	No	0.915	12.4	-0.55	3	0.54	1564.6	1	52
Passeriformes	Viduidae	Vidua macroura	Pin-tailed whydah	DD	No	0.915	15.6	-0.55	3	0.68	12801.4	3	53
Passeriformes	Viduidae	Vidua paradisaea	Eastern paradise-whydah	DD	No	0.891	20.9	-0.55	3	1	2397.4	1	13
Passeriformes	Zosteropidae	Zosterops japonicus	Japanese white-eye	MO	Yes	0.915	11.3	0.17	3	0.34	29479.9	3	85
Passeriformes	Zosteropidae	Zosterops lateralis	Silvereye	MN	Yes	0.791	12.4	-0.26	4	0.3	1592.1	1	78

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Passeriformes	Zosteropidae	Zosterops natalis	Christmas white-eye	DD	No	0.935	10.7	-0.05	3	0.3	1.2	1	128
Passeriformes	Zosteropidae	Zosterops palpebrosus	Oriental white-eye	DD	No	0.915	8.6	-0.05	2	0.26	1560.2	1	84
Passeriformes	Estrildidae	Amandava formosa	Green avadavat	DD	No	0.538	8.3	-0.67	4	0.52	314.2	1	32
Passeriformes	Locustellidae	Bowdleria punctata	New zealand fernbird	DD	No	0.913	25.2	0.12	3	1	6.9	1	16
Passeriformes	Alaudidae	Melanocorypha mongolica	Mongolian lark	DD	No	0.915	54.5	-0.18	1	0.5	452.7	1	99
Passeriformes	Thraupidae	Sicalis flaveola	Saffron finch	MN	Yes	0.935	17.9	-0.13	3	1	34646.2	2	193
Passeriformes	Sturnidae	Sturnus erythropygius	White-headed starling	DD	No	0.609	81.7	0.11	3	0.34	138.6	1	15

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Pelecaniformes	Ardeidae	Bubulcus ibis	Cattle egret	MO	Yes	0.935	372.0	-0.03	5	0.4	30343.9	4	214
Pelecaniformes	Ardeidae	Nycticorax nycticorax	Black-crowned night-heron	DD	No	0.907	800.0	0.14	4	0.26	338.5	1	58
Pelecaniformes	Threskiornithidae	Threskiornis aethiopicus	African sacred ibis	MN	Yes	0.888	1530.0	0.48	8	0.52	107192.5	2	40
Pelecaniformes	Threskiornithidae	Threskiornis melanocephalus	Black-headed ibis	DD	No	0.912	1530.0	0.48	7	0.36	593.5	1	10
Pelecaniformes	Ardeidae	Nyctanassa violacea	Yellow-crowned night-heron	DD	No	0.891	682.5	0.14	4	0.46	68.0	1	10
Phoenicopteriformes	Phoenicopteridae	Phoenicopterus chilensis	Chilean flamingo	MN	Yes	0.922	2615.0	-0.44	2	1	8332.0	1	55
Phoenicopteriformes	Phoenicopteridae	Phoenicopterus ruber	American flamingo	DD	No	0.916	3043.5	-0.44	2	0.34	5196.2	2	83

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Psittaciformes	Psittaculidae	Agapornis canus	Grey-headed lovebird	DD	No	0.822	29.8	0.74	3	0.5	2969.5	1	107
Psittaciformes	Psittaculidae	Agapornis fischeri	Fischer's lovebird	DD	No	0.783	48.3	1.24	3	0.68	28255.7	2	54
Psittaciformes	Psittaculidae	Agapornis personatus	Yellow-collared lovebird	DD	No	0.888	52.5	1.00	1	1	29048.9	1	54
Psittaciformes	Psittaculidae	Agapornis roseicollis	Rosy-faced lovebird	DD	No	0.915	54.3	1.20	2	0.58	1604.5	2	16
Psittaciformes	Psittacidae	Amazona albifrons	White-fronted amazon	DD	No	0.756	209.0	1.62	4	0.38	1870.2	2	14
Psittaciformes	Psittacidae	Amazona amazonica	Orange-winged amazon	MC	Yes	0.915	370.0	2.27	4	1	5762.6	2	62
Psittaciformes	Psittacidae	Amazona autumnalis	Red-lored amazon	MC	Yes	0.915	411.5	1.86	1	1	76402.3	2	45

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Psittaciformes	Psittacidae	Amazona finschi	Lilac-crowned amazon	MC	Yes	0.915	302.0	2.13	1	0.5	1000.0	1	39
Psittaciformes	Psittacidae	Amazona ochrocephala	Yellow-crowned amazon	DD	No	0.865	432.2	2.18	1	0.34	14000.4	1	38
Psittaciformes	Psittacidae	Amazona oratrix	Yellow-headed amazon	MC	Yes	0.915	434.8	1.89	3	0.34	23161.7	2	68
Psittaciformes	Psittacidae	Amazona ventralis	Hispaniolan amazon	DD	No	0.865	235.5	1.47	3	0.5	5795.1	1	38
Psittaciformes	Psittacidae	Amazona viridigenalis	Red-crowned amazon	MC	Yes	0.915	319.0	1.77	2	0.34	151648.7	3	88
Psittaciformes	Psittacidae	Ara ararauna	Blue-and-yellow macaw	DD	No	0.865	1125.0	2.59	2	0.28	8729.0	1	32
Psittaciformes	Psittacidae	Ara severus	Chestnut-fronted macaw	MC	Yes	0.915	347.0	2.63	1	0.38	4411.3	1	35

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Psittaciformes	Psittacidae	Aratinga acuticaudata	Blue-crowned parakeet	MC	Yes	0.915	171.0	1.95	3	0.5	18549.9	2	32
Psittaciformes	Psittacidae	Aratinga canicularis	Orange-fronted parakeet	MC	Yes	0.915	83.3	1.94	3	0.5	14236.7	2	48
Psittaciformes	Psittacidae	Aratinga erythrogenys	Red-masked parakeet	MC	Yes	0.915	151.0	1.98	2	0.52	25066.3	2	30
Psittaciformes	Psittacidae	Aratinga holochlora	Green parakeet	MC	Yes	0.915	138.0	1.98	2	0.5	11651.8	1	28
Psittaciformes	Psittacidae	Aratinga mitrata	Mitred parakeet	MC	Yes	0.915	248.0	1.98	2	0.5	40188.0	3	34
Psittaciformes	Psittacidae	Aratinga pertinax	Brown-throated parakeet	MC	Yes	0.915	86.4	1.87	3	0.36	13578.3	2	213
Psittaciformes	Psittacidae	Brotogeris chiriri	Yellow-chevroned parakeet	MC	Yes	0.915	68.0	1.25	2	0.34	152578.0	1	48

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Psittaciformes	Psittacidae	Brotogeris versicolurus	White-winged parakeet	MC	Yes	0.915	69.6	1.45	1	0.5	56028.0	2	68
Psittaciformes	Cacatuidae	Cacatua galerita	Sulphur-crested cockatoo	MN	Yes	0.935	723.5	2.37	2	0.36	43030.4	3	113
Psittaciformes	Cacatuidae	Cacatua goffiniana	Tanimbar cockatoo	MN	Yes	0.912	275.0	2.19	2	0.42	36644.1	1	33
Psittaciformes	Cacatuidae	Cacatua leadbeateri	Major mitchell's cockatoo	DD	No	0.935	407.5	2.19	2	0.68	243.2	1	15
Psittaciformes	Cacatuidae	Cacatua roseicapilla	Galah	DD	No	0.935	305.5	1.43	4	1	10944.5	1	88
Psittaciformes	Cacatuidae	Cacatua sanguinea	Little corella	MN	Yes	0.935	515.0	1.96	4	0.42	0.5	1	38
Psittaciformes	Cacatuidae	Cacatua sulphurea	Yellow-crested cockatoo	MC	Yes	0.912	332.0	1.96	3	0.5	1687.9	1	87

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Psittaciformes	Cacatuidae	Callocephalon fimbriatum	Gang-gang cockatoo	DD	No	0.935	256.0	2.30	3	0.36	4418.3	1	15
Psittaciformes	Psittaculidae	Cyanoramphus novaezelandiae	Red-fronted parakeet	MN	Yes	0.913	275.0	1.72	3	0.28	6.7	1	39
Psittaciformes	Psittaculidae	Eclectus roratus	Eclectus parrot	DD	No	0.78	434.0	1.49	3	0.34	622.4	2	94
Psittaciformes	Psittaculidae	Eos bornea	Red lory	DD	No	0.912	156.0	1.72	3	0.68	36563.9	1	10
Psittaciformes	Psittaculidae	Eos reticulata	Blue-streaked lory	DD	No	0.684	113.3	1.72	2	0.28	1163.0	1	15
Psittaciformes	Psittacidae	Forpus passerinus	Green-rumped parrotlet	DD	No	0.785	24.0	0.77	5	0.34	11735.9	1	113
Psittaciformes	Psittaculidae	Glossopsitta concinna	Musk lorikeet	DD	No	0.935	70.8	1.59	3	0.28	262.0	1	38

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Psittaciformes	Psittaculidae	Melopsittacus undulatus	Budgerigar	MC	Yes	0.915	29.1	1.03	6	1	357336.9	4	78
Psittaciformes	Psittacidae	Myiopsitta monachus	Monk parakeet	MN	Yes	0.935	108.6	1.83	4	0.28	4231720.0	3	121
Psittaciformes	Psittacidae	Nandayus nenday	Nanday parakeet	MC	Yes	0.915	128.0	2.03	3	0.34	114213.4	3	113
Psittaciformes	Cacatuidae	Nymphicus hollandicus	Cockatiel	DD	No	0.935	90.0	0.97	4	1	27.4	1	20
Psittaciformes	Psittaculidae	Platycercus elegans	Crimson rosella	MN	Yes	0.935	129.8	1.53	4	0.28	3971.6	1	163
Psittaciformes	Psittaculidae	Platycercus eximius	Eastern rosella	MC	Yes	0.935	104.0	1.25	5	0.28	79559.2	1	103
Psittaciformes	Psittaculidae	Prosopeia splendens	Crimson shining-parrot	DD	No	0.727	237.3	1.25	3	0.42	10955.9	1	15

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Psittaciformes	Psittaculidae	Prosopeia tabuensis	Red shining-parrot	DD	No	0.717	237.3	1.25	4	0.82	92.6	1	263
Psittaciformes	Psittaculidae	Psittacula alexandri	Red-breasted parakeet	MO	Yes	0.912	148.8	1.52	2	0.58	178691.6	1	70
Psittaciformes	Psittaculidae	Psittacula eupatria	Alexandrine parakeet	MN	Yes	0.916	239.0	1.78	4	0.28	11552.7	1	24
Psittaciformes	Psittaculidae	Psittacula krameri	Rose-ringed parakeet	MO	Yes	0.922	127.3	1.51	6	0.34	937990.5	6	162
Psittaciformes	Psittacidae	Psittacus erithacus	Grey parrot	DD	No	0.555	333.0	2.07	4	0.5	854.8	1	31
Psittaciformes	Psittacidae	Pyrrhura leucotis	Maroon-faced parakeet	DD	No	0.755	11.5	1.63	3	0.28	1191.4	1	32
Psittaciformes	Psittaculidae	Tanygnathus lucionensis	Blue-naped parrot	DD	No	0.779	215.0	1.89	2	0.5	21201.6	1	52

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Psittaciformes	Psittaculidae	Trichoglossus chlorolepidotus	Scaly-breasted lorikeet	DD	No	0.935	87.0	1.41	6	0.46	2520.5	1	15
Psittaciformes	Psittaculidae	Trichoglossus haematodus	Rainbow lorikeet	MN	Yes	0.935	119.6	1.41	5	0.34	2683.1	2	48
Psittaciformes	Psittaculidae	Vini kuhlii	Rimitara lorikeet	DD	No	0.915	55.0	1.39	2	0.38	57.1	1	216
Psittaciformes	Psittaculidae	Vini ultramarina	Ultramarine lorikeet	DD	No	0.791	40.0	1.39	2	0.54	91.6	1	73
Psittaciformes	Cacatuidae	Cacatua alba	White cockatoo	DD	No	0.913	570.0	2.19	2	0.82	38826.3	2	15
Psittaciformes	Strigopidae	Strigops habroptila	Kakapo	DD	No	0.913	1750.0	1.72	2	0.38	50.7	1	16
Pteroclidiformes	Pteroclididae	Pterocles exustus	Chestnut-bellied sandgrouse	DD	No	0.915	192.0	-1.87	4	0.82	10771.4	2	52

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Rheiformes	Rheidae	Rhea pennata	Lesser rhea	DD	No	0.836	21500.0	-2.00	4	0.3	20920.4	1	77
Strigiformes	Strigidae	Athene noctua	Little owl	MO	Yes	0.913	169.0	1.10	4	0.54	186414.7	2	223
Strigiformes	Strigidae	Bubo bubo	Eurasian eagle-owl	DD	No	0.907	2533.0	1.53	4	0.66	19886.6	1	181
Strigiformes	Strigidae	Bubo virginianus	Great horned owl	MV	Yes	0.791	1377.3	1.53	7	0.82	319.4	1	86
Strigiformes	Tytonidae	Tyto alba	Barn owl	MV	Yes	0.915	381.6	1.43	6	0.66	36947.0	4	144
Strigiformes	Tytonidae	Tyto novaehollandiae	Australian masked-owl	MV	Yes	0.935	630.6	0.99	4	0.66	17.5	1	93
Struthioniformes	Struthionidae	Struthio camelus	Ostrich	DD	No	0.935	109250.0	-1.97	3	0.36	26085.3	1	144

Order	Family	Species	Common name	EICAT impact category	Impact data available?	H1: HDI	H2: Average body mass (g)	H3: Brain size (residual)	H4a: Habitat breadth (number of habitats occupied)	H4b: Diet breadth (Simpon's Diversity Index)	H5: Alien range size (km^2)	H6: Number of realms occupied	H7: Time since introduced (to 2013) (years)
Suliformes	Phalacrocoracidae	Phalacrocorax bougainvillii	Guanay cormorant	DD	No	0.756	2485.0	0.15	2	1	0.9	1	6
Tinamiformes	Tinamidae	Nothoprocta perdicaria	Chilean tinamou	DD	No	0.832	458.0	-1.60	3	0.3	168.4	1	128

Appendix E

Table E1: Data for all predictor variables used in the analysis for Chapter 4.

Key: H = hypothesis; v = predictor variable

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Accipitriformes	Accipitridae	Circus approximans	Swamp harrier	MO	752.5	2	6	2649252.7	100	70	1638.7	0.29	128	No	Yes	No
Anseriformes	Anatidae	Aix galericulata	Mandarin duck	MN	560.0	2	6	1795479.3	30	0	120268.8	-0.21	268	Yes	No	No
Anseriformes	Anatidae	Alopochen aegyptiaca	Egyptian goose	MN	1900.0	2	3	19179357.1	10	0	105847.3	-0.94	363	Yes	No	No
Anseriformes	Anatidae	Anas platyrhynchos	Mallard	MR	1121.0	4	6	43915660.5	60	10	1484307.1	-0.85	153	No	No	No
Anseriformes	Anatidae	Anser cygnoides	Swan goose	MN	3475.0	3	6	3548974.7	0	0	0.0	-0.72	38	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Anseriformes	Anatidae	Anser indicus	Bar-headed goose	MN	2413.8	4	5	3942585.8	0	0	75497.0	-0.58	48	No	No	No
Anseriformes	Anatidae	Branta canadensis	Canada goose	MO	3984.5	4	8	13982713.9	0	0	1660912.9	-0.55	363	No	No	No
Anseriformes	Anatidae	Branta leucopsis	Barnacle goose	MN	1708.5	2	4	71681.4	0	0	63079.5	-0.45	68	No	No	No
Anseriformes	Anatidae	Cairina moschata	Muscovy duck	MN	2228.0	3	3	13899019.7	50	10	810046.9	-1.24	118	No	No	No
Anseriformes	Anatidae	Chen caerulescens	Snow goose	MN	2630.8	5	6	566115.7	0	0	3097.0	-0.05	44	No	No	No
Anseriformes	Anatidae	Cygnus atratus	Black swan	MO	5656.0	2	4	3165275.0	0	0	376254.7	-1.07	263	No	No	No
Anseriformes	Anatidae	Cygnus olor	Mute swan	MO	10230.0	4	4	2152955.0	20	10	3858879.6	-1.53	323	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Anseriformes	Anatidae	Dendrocygna arcuata	Wandering whistling-duck	MN	776.7	3	1	2558490.6	0	0	593.5	-0.61	25	No	No	No
Anseriformes	Anatidae	Oxyura jamaicensis	Ruddy duck	MO	550.0	3	4	6211513.5	60	0	90674.5	-0.80	78	No	No	No
Anseriformes	Anatidae	Tadorna ferruginea	Ruddy shelduck	MC	1240.0	4	3	17926248.4	20	0	10741.7	-1.33	58	Yes	No	No
Columbiformes	Columbidae	Columba livia	Rock dove	MO	320.0	3	8	30709314.1	10	0	49993824.7	-1.31	963	No	No	No
Columbiformes	Columbidae	Geopelia striata	Zebra dove	MC	51.9	2	3	871399.0	20	0	604841.3	-1.20	263	No	No	Yes
Columbiformes	Columbidae	Nesoenas picturata	Madagascar turtle-dove	MV	181.5	3	2	590835.5	10	0	6901.9	-1.42	263	No	No	No
Columbiformes	Columbidae	Stigmatopelia chinensis	Spotted dove	MN	159.0	2	5	10096541.1	0	0	1059154.1	-1.55	244	Yes	No	Yes

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Columbiformes	Columbidae	Stigmatopelia senegalensis	Laughing dove	MN	101.0	2	4	25719114.8	10	0	665333.1	-1.07	163	No	No	No
Columbiformes	Columbidae	Streptopelia decaocto	Eurasian collared-dove	MN	154.7	2	4	24950646.8	10	0	87298.6	-1.34	213	Yes	No	No
Columbiformes	Columbidae	Zenaida asiatica	White-winged dove	MN	153.0	3	4	1410183.8	0	0	39572.9	-1.39	54	Yes	No	No
Coraciiformes	Halcyonidae	Dacelo novaeguineae	Laughing kookaburra	MN	340.3	2	5	2197292.0	100	20	254452.9	0.44	153	No	Yes	No
Cuculiformes	Cuculidae	Crotophaga ani	Smooth-billed ani	MN	112.6	4	5	14110784.7	80	40	8022.5	-0.45	52	No	Yes	Yes
Falconiformes	Falconidae	Milvago chimango	Chimango caracara	MO	296.0	2	5	3230533.4	100	30	168.4	0.80	85	No	Yes	No
Galliformes	Odontophoridae	Callipepla californica	California quail	MC	171.5	5	5	1030395.2	0	0	660285.7	-1.71	163	No	No	Yes

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Galliformes	Phasianidae	Alectoris chukar	Chukar	MO	535.5	3	2	10095137.0	20	0	2508521.9	-1.80	482	No	No	No
Galliformes	Phasianidae	Chrysolophus pictus	Golden pheasant	MN	633.8	5	2	969518.2	10	0	28311.3	-1.20	168	Yes	Yes	No
Galliformes	Phasianidae	Coturnix japonica	Japanese quail	MN	96.6	2	3	3674671.5	30	0	17668.0	-1.81	92	No	No	No
Galliformes	Phasianidae	Francolinus erckelii	Erckel's francolin	MC	1263.0	6	3	162216.0	30	0	63537.1	-1.26	65	No	No	Yes
Galliformes	Phasianidae	Francolinus francolinus	Black francolin	MC	453.0	6	3	2800583.9	10	0	87900.6	-1.26	54	No	No	Yes
Galliformes	Phasianidae	Francolinus pondicerianus	Grey francolin	MC	274.0	6	3	2585362.7	10	0	227617.9	-1.70	263	No	No	Yes
Galliformes	Phasianidae	Gallus gallus	Red junglefowl	MR	912.5	6	2	4600457.9	30	0	367071.3	-1.49	1513	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Galliformes	Phasianidae	Gallus varius	Green junglefowl	MR	781.3	4	3	175093.5	40	0	83.3	-1.49	8	Yes	No	No
Galliformes	Phasianidae	Lophura leucomelanos	Kalij pheasant	MN	1180.0	4	3	1219631.7	40	10	10771.4	-1.67	93	No	No	Yes
Galliformes	Phasianidae	Meleagris gallopavo	Wild turkey	MC	5811.0	4	4	4001120.0	20	0	115515.6	-2.21	483	No	No	Yes
Galliformes	Phasianidae	Pavo cristatus	Common peafowl	MC	4093.8	5	3	3051351.2	40	0	172059.1	-2.10	173	Yes	No	Yes
Galliformes	Phasianidae	Perdix perdix	Grey partridge	MO	405.5	3	3	9848833.1	30	0	3589855.9	-2.09	223	No	No	No
Galliformes	Phasianidae	Phasianus colchicus	Common pheasant	MO	1043.8	4	3	9469861.1	10	0	17120596.4	-1.97	963	Yes	No	No
Galliformes	Phasianidae	Tetrao urogallus	Western capercaillie	MN	2942.5	5	1	11122288.2	0	0	0.0	-2.52	101	No	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Gruiformes	Rallidae	Gallirallus australis	Weka	MO	893.5	7	7	36829.6	50	20	2721.1	-0.50	113	No	Yes	No
Gruiformes	Rallidae	Porphyrio porphyrio	Grey-headed swamphen	MN	850.0	3	3	16577063.1	30	20	14449.9	-0.98	37	Yes	Yes	No
Passeriformes	Artamidae	Gymnorhina tibicen	Australian magpie	MN	290.5	3	4	6542944.7	100	20	284567.4	0.73	152	No	Yes	No
Passeriformes	Cettiidae	Cettia diphone	Japanese bush-warbler	MN	14.4	2	3	1027357.3	100	0	5948.6	0.12	84	No	No	Yes
Passeriformes	Corvidae	Corvus brachyrhynchos	American crow	MO	453.0	4	5	11011175.7	70	20	68.0	1.38	175	No	Yes	No
Passeriformes	Corvidae	Corvus frugilegus	Rook	MN	453.5	4	5	20041845.0	60	20	31717.6	1.40	151	No	Yes	No
Passeriformes	Corvidae	Corvus splendens	House crow	MO	312.0	5	4	4651712.2	90	10	213651.2	1.58	403	Yes	Yes	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Passeriformes	Corvidae	Pica pica	Black-billed magpie	MN	189.0	4	5	37055855.8	80	40	69829.9	1.64	423	No	Yes	No
Passeriformes	Dicruridae	Dicrurus macrocercus	Black drongo	MO	48.5	4	3	9818170.3	70	20	639.1	0.78	78	No	Yes	No
Passeriformes	Estrildidae	Amandava amandava	Red avadavat	MC	9.6	2	4	3152298.6	20	0	530818.1	-0.67	363	Yes	No	No
Passeriformes	Estrildidae	Estrilda troglodytes	Black-rumped waxbill	MC	7.6	2	3	1962638.0	20	0	55583.8	-0.36	53	Yes	No	No
Passeriformes	Estrildidae	Lonchura punctulata	Scaly-breasted munia	MC	14.0	3	5	7565532.1	10	0	304983.3	-0.35	363	Yes	No	Yes
Passeriformes	Fringillidae	Carpodacus mexicanus	House finch	MN	21.4	4	4	4670533.0	10	0	2855857.6	0.10	163	Yes	No	No
Passeriformes	Icteridae	Molothrus bonariensis	Shiny cowbird	MO	38.4	3	4	13170111.7	70	0	71461.3	0.34	154	No	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Passeriformes	Leiothrichidae	Garrulax canorus	Chinese hwamei	MO	66.0	3	5	3091394.9	70	0	66292.3	0.45	113	No	No	No
Passeriformes	Leiothrichidae	Leiothrix lutea	Red-billed leiothrix	MN	21.5	3	3	3708540.3	80	0	162244.1	0.44	100	Yes	No	Yes
Passeriformes	Menuridae	Menura novaehollandiae	Superb lyrebird	MN	980.0	2	1	308395.0	90	10	867.7	1.87	102	No	No	No
Passeriformes	Mimidae	Mimus gilvus	Tropical mockingbird	MN	55.5	3	4	1526732.4	100	0	26239.8	0.42	81	No	Yes	No
Passeriformes	Mimidae	Mimus polyglottos	Northern mockingbird	MC	48.5	4	3	10145590.8	50	0	0.0	0.42	122	No	No	Yes
Passeriformes	Muscicapidae	Copsychus malabaricus	White-rumped shama	MC	29.7	2	4	4871302.7	70	0	49430.7	-0.19	82	Yes	No	No
Passeriformes	Passeridae	Passer domesticus	House sparrow	MO	27.7	5	8	34957580.6	10	0	36489228.2	-0.06	169	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Passeriformes	Passeridae	Passer hispaniolensis	Spanish sparrow	MN	24.2	2	5	5140760.5	20	0	12375.2	-0.04	203	Yes	No	No
Passeriformes	Ploceidae	Foudia madagascariensis	Madagascar red fody	MO	16.2	3	5	590835.5	20	0	7023.1	0.36	340	Yes	No	No
Passeriformes	Ploceidae	Ploceus cucullatus	Village weaver	MN	37.6	3	4	13674304.0	30	0	80512.3	0.55	501	No	No	No
Passeriformes	Pycnonotidae	Pycnonotus cafer	Red-vented bulbul	MO	41.3	5	4	4491825.5	20	0	83074.6	0.13	113	Yes	No	Yes
Passeriformes	Pycnonotidae	Pycnonotus jocosus	Red-whiskered bulbul	MR	27.7	4	5	5614660.7	20	0	76110.7	0.13	152	No	Yes	No
Passeriformes	Sittidae	Sitta frontalis	Velvet-fronted nuthatch	MC	16.6	1	2	5284006.0	100	0	288.7	0.12	28	Yes	No	No
Passeriformes	Sturnidae	Acridotheres cristatellus	Crested myna	MN	116.5	2	3	1873513.4	60	0	56697.1	0.57	164	Yes	Yes	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Passeriformes	Sturnidae	Acridotheres tristis	Common myna	MO	113.5	5	4	7161664.8	70	20	2305628.9	0.57	255	Yes	Yes	No
Passeriformes	Sturnidae	Sturnus burmannicus	Vinous-breasted starling	MN	81.7	2	4	890027.0	50	0	0.0	0.11	7	Yes	No	No
Passeriformes	Sturnidae	Sturnus vulgaris	Starling	MO	77.7	4	8	17554532.2	40	10	19848761.0	0.29	173	Yes	No	No
Passeriformes	Turdidae	Turdus merula	Blackbird	MO	102.0	2	6	15689912.0	60	0	1466458.5	0.04	163	No	Yes	Yes
Passeriformes	Turdidae	Turdus philomelos	Song thrush	MO	68.8	2	4	13392491.2	40	0	295169.5	0.05	163	No	Yes	No
Passeriformes	Tyrannidae	Pitangus sulphuratus	Great kiskadee	MV	61.9	3	5	16133507.4	70	20	362.3	-0.45	63	No	Yes	No
Passeriformes	Zosteropidae	Zosterops japonicus	Japanese white-eye	MO	11.3	2	3	3440196.7	40	0	29479.9	0.17	85	Yes	No	Yes

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Passeriformes	Zosteropidae	Zosterops lateralis	Silvereye	MN	12.4	3	4	2442042.6	40	0	1592.1	-0.26	78	No	No	Yes
Passeriformes	Thraupidae	Sicalis flaveola	Saffron finch	MN	17.9	2	3	6542091.3	0	0	34646.2	-0.13	193	Yes	No	No
Pelecaniformes	Ardeidae	Bubulcus ibis	Cattle egret	MO	372.0	3	5	51194307.4	100	20	30343.9	-0.03	214	No	Yes	No
Pelecaniformes	Threskiornithidae	Threskiornis aethiopicus	African sacred ibis	MN	1530.0	2	8	19946380.1	100	20	107192.5	0.48	40	No	Yes	No
Phoenicopteriformes	Phoenicopteridae	Phoenicopterus chilensis	Chilean flamingo	MN	2615.0	3	2	2937899.1	100	0	8332.0	-0.44	55	No	No	No
Psittaciformes	Cacatuidae	Cacatua galerita	Sulphur-crested cockatoo	MN	723.5	4	2	3669866.4	0	0	43030.4	2.37	113	No	No	No
Psittaciformes	Cacatuidae	Cacatua goffiniana	Tanimbar cockatoo	MN	275.0	4	2	4371.3	10	0	36644.1	2.19	33	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Psittaciformes	Cacatuidae	Cacatua sanguinea	Little corella	MN	515.0	3	4	4709623.6	10	0	0.5	1.96	38	Yes	No	No
Psittaciformes	Cacatuidae	Cacatua sulphurea	Yellow-crested cockatoo	MC	332.0	4	3	259972.4	0	0	1687.9	1.96	87	Yes	No	No
Psittaciformes	Psittacidae	Amazona amazonica	Orange-winged amazon	MC	370.0	2	4	7419446.5	0	0	5762.6	2.27	62	Yes	No	No
Psittaciformes	Psittacidae	Amazona autumnalis	Red-lored amazon	MC	411.5	3	1	854051.5	0	0	76402.3	1.86	45	Yes	No	No
Psittaciformes	Psittacidae	Amazona finschi	Lilac-crowned amazon	MC	302.0	3	1	194152.5	0	0	1000.0	2.13	39	Yes	No	No
Psittaciformes	Psittacidae	Amazona oratrix	Yellow-headed amazon	MC	434.8	4	3	281383.3	0	0	23161.7	1.89	68	Yes	No	No
Psittaciformes	Psittacidae	Amazona viridigenalis	Red-crowned amazon	MC	319.0	3	2	83605.7	0	0	151648.7	1.77	88	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Psittaciformes	Psittacidae	Ara severus	Chestnut-fronted macaw	MC	347.0	4	1	5770148.4	0	0	4411.3	2.63	35	Yes	No	No
Psittaciformes	Psittacidae	Aratinga acuticaudata	Blue-crowned parakeet	MC	171.0	4	3	2332010.1	0	0	18549.9	1.95	32	Yes	No	No
Psittaciformes	Psittacidae	Aratinga canicularis	Orange-fronted parakeet	MC	83.3	5	3	269544.9	0	0	14236.7	1.94	48	Yes	No	No
Psittaciformes	Psittacidae	Aratinga erythrogenys	Red-masked parakeet	MC	151.0	3	2	106451.2	0	0	25066.3	1.98	30	Yes	No	No
Psittaciformes	Psittacidae	Aratinga holochlora	Green parakeet	MC	138.0	3	2	240171.4	0	0	11651.8	1.98	28	Yes	No	No
Psittaciformes	Psittacidae	Aratinga mitrata	Mitred parakeet	MC	248.0	4	2	251262.9	0	0	40188.0	1.98	34	Yes	No	No
Psittaciformes	Psittacidae	Aratinga pertinax	Brown-throated parakeet	MC	86.4	4	3	1656485.6	0	0	13578.3	1.87	213	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Psittaciformes	Psittacidae	Aratinga weddellii	Dusky-headed parakeet	MC	108.2	4	2	2260162.2	0	0	0.0	1.95	29	Yes	No	No
Psittaciformes	Psittacidae	Brotogeris chiriri	Yellow-chevroned parakeet	MC	68.0	3	2	3435041.9	0	0	152578.0	1.25	48	Yes	No	No
Psittaciformes	Psittacidae	Brotogeris versicolurus	White-winged parakeet	MC	69.6	3	1	635604.4	0	0	56028.0	1.45	68	Yes	No	No
Psittaciformes	Psittacidae	Myiopsitta monachus	Monk parakeet	MN	108.6	5	4	2820305.8	10	0	4231720.0	1.83	121	Yes	No	No
Psittaciformes	Psittacidae	Nandayus nenday	Nanday parakeet	MC	128.0	4	3	259643.7	0	0	114213.4	2.03	113	Yes	No	No
Psittaciformes	Psittaculidae	Cyanoramphus novaezelandiae	Red-fronted parakeet	MN	275.0	4	3	20587.6	0	0	6.7	1.72	39	No	No	No
Psittaciformes	Psittaculidae	Melopsittacus undulatus	Budgerigar	MC	29.1	2	6	5434713.0	0	0	357336.9	1.03	78	Yes	No	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Psittaciformes	Psittaculidae	Platycercus elegans	Crimson rosella	MN	129.8	6	4	798097.7	10	0	3971.6	1.53	163	Yes	No	No
Psittaciformes	Psittaculidae	Platycercus eximius	Eastern rosella	MC	104.0	6	5	965830.6	10	0	79559.2	1.25	103	Yes	No	No
Psittaciformes	Psittaculidae	Psittacula alexandri	Red-breasted parakeet	MO	148.8	2	2	3095797.5	0	0	178691.6	1.52	70	Yes	No	No
Psittaciformes	Psittaculidae	Psittacula eupatria	Alexandrine parakeet	MN	239.0	6	4	4885095.5	0	0	11552.7	1.78	24	No	No	No
Psittaciformes	Psittaculidae	Psittacula krameri	Rose-ringed parakeet	MO	127.3	6	6	7911588.7	0	0	937990.5	1.51	162	Yes	No	No
Psittaciformes	Psittaculidae	Trichoglossus haematodus	Rainbow lorikeet	MN	119.6	4	5	2377205.2	0	0	2683.1	1.41	48	Yes	No	No
Strigiformes	Strigidae	Athene noctua	Little owl	MO	169.0	2	4	26465175.6	100	30	186414.7	1.10	223	No	Yes	No

Order	Family	Species	Common name	EICAT impact category	H1 (v1): Av body mass (g)	H2 (v2): Diet breadth (number of major food types consumed)	H2 (v3): Habitat breadth (number of habitats occupied)	H2 (v4): Native range size (km^2)	H3 (v5): Proportion of diet comprising animal matter	H3 (v6): Proportion of diet comprising vertebrate prey	H4 (v7): Alien range size (km^2)	H5 (v8): Brain size (residual)	H6 (v9): Time since intro (to 2013) (years)	H7a: Comp impact?	H7b: Pred impact?	H7c: Int impact?
Strigiformes	Strigidae	Bubo virginianus	Great horned owl	MV	1377.3	2	7	26125963.8	100	90	319.4	1.53	86	No	Yes	No
Strigiformes	Tytonidae	Tyto alba	Barn owl	MV	381.6	1	6	58192564.8	100	90	36947.0	1.43	144	Yes	No	No
Strigiformes	Tytonidae	Tyto novaehollandiae	Australian masked-owl	MV	630.6	2	4	429653.7	100	90	17.5	0.99	93	No	Yes	No

Appendix F

Table F1a: Regions with actual alien bird impacts, including their most severe and average impact scores, and the data for all predictor variables used in the analysis for Chapter 5.
Key: H = hypothesis; v = predictor variable

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Haiti	9	501	0	256	24.9	119.3	4.0	3.0	13674304.0	80512.3	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.493	395.7	3.0	3.0
Africa	Kenya	7	66	0	1059	25.1	55.9	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.555	83.5	3.0	3.0
Africa	Mauritius	29	133	0	56	23.8	146.5	5.0	4.0	5614660.7	76110.7	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.781	620.2	4.0	4.0
Africa	Mauritius Rodrigues Island	8	148	0	49	23.8	146.5	5.0	3.0	590835.5	7023.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.781	351.9	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Seychelles Amirante Islands	5	164	1	140	27.3	142.4	7.0	6.0	51785142.9	37245.8	0.00	0.38	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.782	8.7	5.0	4.0
Africa	Seychelles Fregate Island	2	193	1	108	27.3	142.4	4.5	4.0	29177986.1	1167986.4	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.782	107.0	3.0	3.0
Africa	South Africa	20	63	0	759	18.2	38.6	3.0	2.0	6542091.3	34646.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.666	46.8	2.0	2.0
Asia	Hong Kong SAR China	26	28	0	219	24.0	115.8	2.0	1.0	5284006.0	288.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.917	2674.2	1.0	1.0
Asia	Iran	6	16	0	474	17.9	17.8	4.0	6.0	4885095.5	11552.7	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.774	49.2	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Israel	20	13	0	388	20.3	20.6	4.0	2.0	890027.0	1.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.899	400.7	2.0	2.0
Asia	Japan Honshu	21	28	0	441	15.4	151.5	6.0	2.0	5434713.0	357336.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.903	456.2	1.0	1.0
Asia	Japan Kyushu	9	161	0	441	17.6	164.9	4.7	3.0	15399703.0	196470.3	0.60	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.903	363.9	2.0	1.7
Asia	Japan Ryukyu Islands	11	37	0	441	23.7	178.1	3.0	2.0	2286229.4	1207.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.903	280.4	2.0	2.0
Asia	Japan Shikoku	10	28	0	441	17.0	133.3	6.0	2.0	5434713.0	357336.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.903	204.5	1.0	1.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Iran Kharku Island	1	43	1	41	26.0	17.1	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.774	0.0	3.0	3.0
Asia	Singapore	37	46	0	364	27.9	213.5	2.2	3.0	1710805.3	43642.1	0.60	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.925	8155.5	3.0	2.0
Asia	Taiwan	44	38	0	379	23.5	29.9	5.0	3.0	3091394.9	66292.3	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.882	667.2	3.0	3.0
Europe	Belgium	21	37	0	263	10.5	72.7	4.3	3.8	7495733.3	1334659.3	0.54	0.00	0.00	0.15	0.15	0.00	0.00	0.15	0.00	0.896	374.4	3.0	2.2
Europe	Canary Islands	17	203	0	369	19.2	20.1	5.0	2.0	5140760.5	12375.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.884	281.4	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Denmark	8	80	0	275	8.7	61.7	3.0	3.0	9848833.1	3589855.9	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.925	133.0	3.0	3.0
Europe	England	32	341	0	265	10.2	72.4	4.3	3.8	8289479.9	4326259.4	0.38	0.00	0.00	0.15	0.15	0.00	0.00	0.31	0.00	0.909	420.5	3.0	2.2
Europe	France	41	41	0	358	12.0	70.1	3.6	2.6	10110621.5	690352.3	0.00	0.18	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.897	117.6	3.0	2.2
Europe	Germany	31	40	0	311	9.6	60.2	5.0	3.0	2521080.6	46192.5	0.25	0.00	0.00	0.25	0.25	0.00	0.00	0.25	0.00	0.926	229.9	2.0	2.0
Europe	Ireland	11	424	0	208	9.6	98.5	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.923	67.8	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Italy	27	50	0	355	12.6	76.2	3.3	3.0	5904131.4	867229.0	0.00	0.00	0.00	0.56	0.22	0.00	0.00	0.22	0.00	0.887	201.8	3.0	2.3
Europe	Netherlands	27	43	0	270	10.3	67.2	4.0	3.0	11560971.4	90672.1	0.33	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.924	505.2	2.0	2.0
Europe	Northern Ireland	4	413	0	266	9.3	75.0	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.909	132.8	3.0	3.0
Europe	Portugal	20	63	0	310	15.3	70.2	2.0	3.0	10095137.0	2508521.9	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.843	112.8	3.0	3.0
Europe	Scotland	24	178	0	266	8.8	89.0	4.0	4.0	5738436.1	4310990.8	0.56	0.00	0.00	0.22	0.22	0.00	0.00	0.00	0.00	0.909	67.5	3.0	2.3

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Spain	46	44	0	381	13.9	49.6	3.2	2.8	7519642.3	538492.3	0.08	0.00	0.00	0.62	0.15	0.00	0.00	0.15	0.00	0.884	90.3	3.0	2.2
Europe	Sweden	12	84	0	277	2.5	55.8	8.0	4.0	13982713.9	1660912.9	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.913	24.2	3.0	3.0
Europe	Switzerland	12	38	0	284	7.4	127.0	3.0	4.0	17926248.4	10741.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	205.3	1.0	1.0
Europe	Wales	7	428	0	266	10.4	86.8	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.909	150.1	3.0	3.0
North America	Bermuda	16	116	1	147	21.7	121.6	5.0	4.5	13572341.5	215.2	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.981	1153.2	5.0	4.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Canada	24	123	0	517	-6.0	39.1	3.5	3.0	2013234.2	1957788.4	0.50	0.20	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.92	3.7	3.0	2.5
North America	Guadeloupe	13	42	0	187	25.4	274.6	4.0	2.3	4226822.9	297128.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.822	276.1	1.0	1.0
North America	Hawaii	109	109	0	267	24.5	36.1	3.6	3.8	6760770.2	346455.5	0.22	0.15	0.49	0.00	0.00	0.15	0.00	0.00	0.00	0.92	50.4	3.0	1.8
North America	Mexico	21	103	0	1104	21.2	62.4	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.762	66.4	3.0	3.0
North America	Panama	3	81	0	886	25.5	210.8	4.0	3.0	1526732.4	26239.8	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.788	55.1	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Puerto Rico	48	154	0	268	25.4	178.8	4.0	3.0	13170111.7	71461.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.905	413.0	3.0	3.0
North America	United States of America	127	61	0	829	7.6	56.1	3.1	3.5	5709132.1	2568320.7	0.71	0.04	0.00	0.04	0.14	0.04	0.00	0.04	0.00	0.92	40.0	3.0	1.6
Oceania	Australia	55	108	0	715	21.9	40.4	4.5	3.5	8274301.7	2210698.2	0.52	0.16	0.13	0.00	0.06	0.13	0.00	0.00	0.00	0.939	3.2	3.0	2.1
Oceania	Chatham Islands	16	108	0	162	11.6	62.6	7.0	7.0	36829.6	2721.1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.6	3.0	3.0
Oceania	Cocos (Keeling) Islands	5	134	1	26	26.8	165.2	2.5	5.0	2387775.7	183577.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	38.2	4.0	4.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Codfish Island	1	100	1	40	9.5	90.0	7.0	7.0	36829.6	2721.1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.0	3.0	3.0
Oceania	French Polynesia Hiva-Oa	4	86	0	45	24.5	123.7	7.0	2.0	26125963.8	319.4	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.895	6.9	5.0	5.0
Oceania	French Polynesia Tahiti	14	88	0	81	24.5	123.7	4.5	3.8	4186196.4	597983.5	0.35	0.35	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.895	181.4	3.0	2.8
Oceania	Lord Howe Island	12	78	1	193	19.1	88.6	5.2	2.2	26324056.4	656579.9	0.25	0.55	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.939	23.8	5.0	4.0
Oceania	Macquarie Island	9	146	0	103	4.9	81.3	7.0	7.0	36829.6	2721.1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	0.0	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	New Zealand North	33	137	0	212	13.8	92.9	4.6	3.4	12023578.3	502543.5	0.05	0.30	0.15	0.20	0.25	0.05	0.00	0.00	0.00	0.915	32.3	4.0	2.2
Oceania	New Zealand South	30	120	0	212	11.0	135.7	4.6	3.6	18141289.0	651954.0	0.07	0.21	0.21	0.29	0.14	0.07	0.00	0.00	0.00	0.915	7.4	4.0	2.3
Oceania	Norfolk Island	10	183	1	42	19.0	30.4	4.0	6.0	798097.7	3971.6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	50.5	2.0	2.0
Oceania	Northern Mariana Islands Rota	8	78	1	96	27.5	44.7	3.0	4.0	9818170.3	639.1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.875	29.1	3.0	3.0
Oceania	Tasmania	30	102	0	350	13.3	33.9	1.0	2.0	308395.0	867.7	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.939	7.6	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
South America	Argentina	16	93	0	1003	14.6	48.6	2.5	4.5	1094574.9	19541.3	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.827	16.0	2.0	2.0
South America	Easter Island	3	85	0	74	20.5	89.2	5.0	2.0	3230533.4	168.4	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.847	47.4	3.0	3.0
South America	Galapagos Islands	1	52	0	173	23.0	24.0	5.0	4.0	14110784.7	8022.5	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.739	3.3	2.0	2.0
South America	Tobago	9	32	0	413	26.6	133.4	4.0	3.0	1526732.4	26239.8	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	202.9	2.0	2.0

Table F1b: Regions with potential alien bird impacts, including their most severe and average impact scores, and the data for all predictor variables used in the analysis for Chapter 5.
Key: H = hypothesis; v = predictor variable

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Algeria	4	214.0	0	318	23.4	7.0	4.5	2.5	38456711.1	347838.5	0.00	0.60	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.745	17.2	3.0	2.5
Africa	Botswana	4	57.0	0	532	22.4	31.4	6.7	4.7	19891259.2	19547872.7	0.75	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.698	3.8	3.0	3.0
Africa	Cape Verde	8	109.7	0	86	23.1	29.3	5.8	3.4	23975359.7	7511410.6	0.87	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.648	139.1	5.0	3.0
Africa	Chad	1	12.0	0	523	27.3	28.3	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.396	9.4	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Congo Dem Rep	1	38.0	0	1106	24.5	122.8	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.435	35.5	3.0	3.0
Africa	Djibouti	2	56.0	0	287	28.2	21.5	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.473	37.3	3.0	3.0
Africa	Egypt Arab Rep	5	132.7	0	379	23.1	2.6	4.5	3.8	10166561.6	442439.6	0.75	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.691	96.9	3.0	2.4
Africa	Eritrea	1	63.0	0	539	26.9	22.0	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	50.3	3.0	3.0
Africa	Gambia	1	23.0	0	453	26.0	22.2	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.452	181.5	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Glorioso Islands	3	41.0	1	19	14.0	74.4	4.0	2.5	731117.3	305932.2	0.75	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.897	0.0	3.0	2.0
Africa	Haiti	9	15.5	0	256	24.9	119.3	6.0	3.6	24174049.1	7711385.9	0.29	0.21	0.07	0.00	0.21	0.00	0.00	0.00	0.21	0.493	395.7	3.0	2.3
Africa	Kenya	7	53.5	0	1059	25.1	55.9	6.0	5.3	15229825.0	13886312.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.555	83.5	3.0	2.7
Africa	Lesotho	2	126.5	0	244	13.3	62.1	6.0	5.0	21059622.7	19397428.6	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.497	64.5	3.0	3.0
Africa	Liberia	1	15.0	0	538	25.6	201.8	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.427	42.1	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Madagascar	9	130.3	0	244	23.7	118.5	5.3	4.3	24983481.4	10272302.8	0.35	0.18	0.00	0.35	0.00	0.00	0.00	0.12	0.00	0.512	42.7	4.0	2.8
Africa	Madeira	4	21.0	0	337	20.0	43.7	4.0	3.0	7305310.8	8566485.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.843	334.3	3.0	2.5
Africa	Malawi	1	46.0	0	635	22.4	84.0	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.476	162.0	3.0	3.0
Africa	Mauritania	1	52.0	0	464	28.5	8.1	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.513	3.6	3.0	3.0
Africa	Mauritius	29	179.9	0	56	23.8	146.5	4.4	3.4	11611816.4	2837505.8	0.40	0.12	0.10	0.17	0.10	0.08	0.00	0.04	0.00	0.781	620.2	5.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Mauritius Agalega Islands	6	189.5	1	19	22.0	127.7	3.5	3.3	2303683.7	731098.8	0.40	0.20	0.07	0.33	0.00	0.00	0.00	0.00	0.00	0.781	12.0	5.0	3.0
Africa	Mauritius Rodrigues Island	8	163.0	0	49	23.8	146.5	4.5	4.5	11394001.8	9906829.1	0.55	0.27	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.781	351.9	3.0	2.2
Africa	Mayotte	8	9.8	0	72	26.7	121.8	4.8	4.0	10825229.0	9702195.5	0.53	0.18	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.653	685.9	5.0	3.4
Africa	Morocco	2	21.5	0	336	18.0	25.4	3.5	3.5	7840687.3	8605635.4	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.647	76.1	3.0	3.0
Africa	Mozambique	3	38.0	0	674	24.2	79.5	5.3	5.0	15590319.2	13002836.1	0.60	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.418	33.2	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Namibia	4	37.0	0	597	20.7	22.5	7.3	3.7	19315608.6	18898442.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	3.0	3.0	2.3
Africa	Niger	1	12.0	0	435	27.9	14.7	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.353	15.2	3.0	3.0
Africa	Reunion	26	161.9	0	44	30.2	156.9	4.0	3.8	7075306.2	3949282.4	0.52	0.16	0.11	0.16	0.05	0.00	0.00	0.00	0.00	0.75	344.8	5.0	2.4
Africa	Sao Tome and Principe Sao Tome	9	79.5	0	89	24.0	179.7	4.0	2.5	19696709.4	372922.7	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.574	201.2	2.0	2.0
Africa	Senegal	1	43.0	0	553	28.6	59.7	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.494	74.6	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Seychelles Amirante Islands	5	79.0	1	140	27.3	142.4	5.3	4.7	12711259.6	12241289.8	0.86	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.782	8.7	3.0	2.3
Africa	Seychelles Assumption Island	3	37.0	1	88	27.3	142.4	4.0	3.0	3243029.9	340476.0	0.00	0.80	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.782	1.7	4.0	2.5
Africa	Seychelles Farquhar	2	50.0	1	57	27.3	142.4	4.0	2.5	731117.3	305932.2	0.75	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.782	1.5	3.0	2.0
Africa	Seychelles Mahe	8	32.0	0	163	27.3	142.4	3.3	2.8	3988022.4	357203.3	0.27	0.00	0.09	0.64	0.00	0.00	0.00	0.00	0.00	0.782	489.5	5.0	2.8
Africa	Seychelles Praslin	5	32.0	1	153	27.3	142.4	3.8	2.8	13311844.4	162277.5	0.25	0.25	0.08	0.42	0.00	0.00	0.00	0.00	0.00	0.782	196.2	5.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Somalia	2	27.0	0	570	27.0	23.0	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.285	17.3	3.0	3.0
Africa	South Africa	20	113.8	0	759	18.2	38.6	4.7	4.2	11867243.2	6481485.2	0.62	0.13	0.02	0.13	0.06	0.00	0.00	0.04	0.00	0.666	46.8	4.0	2.6
Africa	South Africa Robben Island	6	49.0	1	150	17.0	17.8	2.5	4.0	6573244.1	1340290.5	0.20	0.00	0.20	0.60	0.00	0.00	0.00	0.00	0.00	0.666	23.2	3.0	1.7
Africa	St. Helena	14	258.9	0	58	18.1	48.5	3.8	4.0	9736565.8	7425363.9	0.67	0.13	0.08	0.13	0.00	0.00	0.00	0.00	0.00	0.797	37.2	4.0	2.7
Africa	Sudan	1	123.0	0	917	27.3	36.4	4.0	5.0	4651712.2	213651.2	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	20.1	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Africa	Swaziland	2	47.5	0	461	20.4	67.1	6.0	5.0	21059622.7	19397428.6	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.541	84.5	3.0	3.0
Africa	Tanzania	12	92.8	0	1075	23.0	81.2	5.5	4.5	18309999.1	9576550.7	0.64	0.21	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.531	57.0	3.0	2.8
Africa	Uganda	1	31.0	0	998	23.6	104.0	6.0	6.0	7911588.7	937990.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.493	164.2	3.0	3.0
Africa	Zambia	2	48.0	0	732	22.3	79.5	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.579	21.2	3.0	3.0
Africa	Zimbabwe	1	57.0	0	625	21.9	52.8	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.516	35.3	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Andaman Islands Ross Island	2	145.0	1	221	28.0	160.7	3.0	5.0	3051351.2	172059.1	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.624	10.0	1.0	1.0
Asia	Andaman Islands South Andaman	6	144.0	0	221	28.0	160.7	4.4	5.2	10481534.3	7881637.1	0.56	0.33	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.624	166.1	3.0	2.3
Asia	Bahrain	14	38.0	0	222	27.8	6.1	4.4	4.1	8220231.6	638215.4	0.51	0.23	0.11	0.09	0.06	0.00	0.00	0.00	0.00	0.824	1856.5	3.0	2.5
Asia	Bonin Islands	1	4.0	0	178	23.0	106.4	3.0	2.0	3440196.7	29479.9	0.33	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.903	27.7	3.0	3.0
Asia	British Indian Ocean Territory	8	92.4	1	40	27.4	202.6	4.0	4.1	12819055.4	5004832.1	0.50	0.23	0.08	0.19	0.00	0.00	0.00	0.00	0.00	0.909	0.0	5.0	2.9

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Cambodia	1	17.0	0	510	27.5	157.3	3.0	2.0	871399.0	604841.3	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.563	89.5	1.0	1.0
Asia	Christmas Island	4	120.0	0	47	26.0	214.8	5.0	5.5	19779019.3	18428149.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	16.3	4.0	3.5
Asia	Georgia	2	35.0	0	281	7.1	77.5	3.5	4.5	8315762.9	9713112.6	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.769	70.7	3.0	3.0
Asia	Hokkaido	1	83.0	0	441	7.0	44.0	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.903	65.6	3.0	3.0
Asia	Hong Kong SAR China	26	85.8	0	219	24.0	115.8	4.5	4.1	4640007.2	507166.6	0.56	0.37	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.917	2674.2	4.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	India	6	59.0	0	1209	24.5	84.9	4.0	5.3	4433446.7	58521.4	0.00	0.57	0.14	0.00	0.29	0.00	0.00	0.00	0.00	0.624	390.0	4.0	2.3
Asia	Indonesia Bangka Kalimantan	6	113.0	0	604	26.2	239.1	3.3	2.3	3844242.9	362838.7	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.689	27.5	3.0	1.5
Asia	Indonesia Sarawak	1	23.0	0	581	26.2	239.1	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.689	22.3	3.0	3.0
Asia	Indonesia Sulawesi	10	128.0	0	500	26.2	239.1	3.3	3.3	5189466.0	677022.2	0.55	0.00	0.27	0.00	0.00	0.18	0.00	0.00	0.00	0.689	102.1	4.0	2.2
Asia	Indonesia Sumatra	11	66.0	0	743	26.2	239.1	4.4	3.6	6135375.5	837072.6	0.39	0.43	0.09	0.00	0.00	0.09	0.00	0.00	0.00	0.689	114.8	4.0	2.6

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Iran Islamic Rep	6	23.5	0	474	17.9	17.8	4.4	4.6	5473818.0	814232.6	0.59	0.27	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.774	49.2	3.0	2.8
Asia	Israel	20	55.3	0	388	20.3	20.6	3.8	4.1	8426468.4	918078.3	0.48	0.18	0.03	0.06	0.06	0.06	0.00	0.12	0.00	0.899	400.7	3.0	2.1
Asia	Japan Honshu	21	43.0	0	441	15.4	151.5	3.9	2.7	6729047.7	512176.2	0.50	0.19	0.08	0.12	0.12	0.00	0.00	0.00	0.00	0.903	456.2	3.0	2.4
Asia	Japan Kyushu	9	53.7	0	441	17.6	164.9	3.8	2.8	4396767.0	4443601.0	0.55	0.18	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.903	363.9	3.0	2.2
Asia	Jordan	8	21.2	0	331	19.3	8.4	4.4	4.8	10065835.2	826831.3	0.47	0.32	0.00	0.00	0.11	0.11	0.00	0.00	0.00	0.741	114.7	3.0	2.7

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Kazakhstan	3	55.7	0	438	6.7	21.4	3.0	4.0	14667689.3	990320.6	0.30	0.30	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.794	6.8	3.0	2.5
Asia	Kuwait	7	36.5	0	292	26.2	10.2	4.4	4.6	5473818.0	814232.6	0.59	0.27	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.8	161.4	3.0	2.8
Asia	Lao PDR	1	8.0	0	695	23.9	152.8	3.0	2.0	871399.0	604841.3	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.586	30.1	1.0	1.0
Asia	Lebanon	2	46.0	0	295	16.4	45.3	5.0	4.0	16815351.7	801661.8	0.60	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.763	599.0	3.0	2.5
Asia	Macao SAR China	1	111.0	1	40	23.1	172.6	6.0	6.0	7911588.7	937990.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.905	21346.4	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Malaysia	18	138.5	0	715	25.8	258.7	4.2	3.4	11976107.4	3742242.6	0.64	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.789	95.1	5.0	2.6
Asia	Maldives	4	18.3	1	84	28.2	177.8	5.0	5.5	13657823.0	10024979.7	0.81	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.701	1317.8	4.0	3.2
Asia	Nicobar Islands Kamorta	4	235.5	0	176	28.0	160.7	3.7	5.0	5792261.1	916270.3	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.624	28.2	4.0	3.5
Asia	Nicobar Islands Nancowry	2	235.5	1	176	28.0	160.7	3.5	5.0	5107559.3	221591.0	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.624	21.7	4.0	4.0
Asia	Nicobar Islands Trinket	2	235.5	1	176	28.0	160.7	3.5	5.0	5107559.3	221591.0	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.624	0.2	4.0	4.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Oman	16	36.4	0	324	26.0	7.3	4.3	4.3	7758903.5	646706.1	0.44	0.28	0.14	0.08	0.06	0.00	0.00	0.00	0.00	0.796	14.9	4.0	2.4
Asia	Philippines	11	128.2	0	592	25.9	211.3	4.2	3.5	5866655.3	542785.7	0.65	0.10	0.15	0.00	0.00	0.10	0.00	0.00	0.00	0.682	347.5	4.0	2.0
Asia	Qatar	9	36.5	0	211	27.9	5.1	4.3	4.0	9242469.7	927643.2	0.56	0.22	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.856	199.8	3.0	2.7
Asia	Russia	6	16.3	0	661	-5.2	36.9	4.8	3.8	14083338.6	5438117.8	0.43	0.21	0.00	0.00	0.21	0.14	0.00	0.00	0.00	0.804	8.3	3.0	2.8
Asia	Saudi Arabia	17	35.6	0	390	25.4	5.9	4.6	4.4	9696169.7	669385.0	0.42	0.30	0.15	0.12	0.00	0.00	0.00	0.00	0.00	0.847	13.3	4.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	Singapore	37	87.4	0	364	27.9	213.5	4.4	3.4	11757580.7	331046.9	0.48	0.29	0.08	0.06	0.04	0.06	0.00	0.00	0.00	0.925	8155.5	5.0	2.6
Asia	Sri Lanka	3	12.0	0	375	27.2	143.0	5.0	2.0	10096541.1	1059154.1	0.33	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.766	341.6	2.0	2.0
Asia	Syria	2	1532.0	0	347	18.4	22.7	3.5	3.5	14385233.0	418696.1	0.25	0.00	0.25	0.00	0.00	0.50	0.00	0.00	0.00	0.536	97.4	2.0	1.3
Asia	Taiwan	44	26.5	0	379	23.5	29.9	4.5	3.5	7565377.4	347568.0	0.53	0.37	0.00	0.00	0.07	0.03	0.00	0.00	0.00	0.882	667.2	4.0	2.0
Asia	Thailand	5	53.0	0	931	26.7	128.5	4.3	4.3	5314884.2	1282820.2	0.60	0.30	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.74	133.3	3.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Asia	United Arab Emirates	39	63.3	0	295	27.6	4.8	4.1	4.2	9250296.4	729982.2	0.35	0.21	0.12	0.12	0.16	0.00	0.00	0.04	0.00	0.84	112.4	4.0	2.3
Asia	Uzbekistan	1	48.0	0	352	13.1	17.3	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.701	66.5	3.0	3.0
Asia	West Bank	2	5.0	0	388	21.0	15.4	4.0	6.0	4885095.5	11552.7	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.899	468.9	2.0	2.0
Asia	Yemen Rep	5	100.0	0	342	23.9	14.2	3.5	4.8	10791877.8	457131.9	0.46	0.23	0.00	0.00	0.15	0.15	0.00	0.00	0.00	0.482	53.1	3.0	2.6
Europe	Aland Islands	3	60.0	0	307	6.0	14.5	5.0	4.0	8535176.7	7546796.3	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.895	18.4	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Austria	13	129.6	0	304	7.2	97.7	4.3	3.7	8197315.5	2757939.4	0.39	0.00	0.04	0.25	0.18	0.00	0.00	0.14	0.00	0.893	104.4	3.0	2.2
Europe	Azores Corvo	1	27.0	1	334	18.0	29.4	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.843	27.5	3.0	3.0
Europe	Azores Sao Miguel	4	7.0	0	334	18.0	29.4	7.0	5.5	21434584.6	18713609.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.843	185.3	3.0	3.0
Europe	Balearic Islands	5	28.0	0	407	17.0	8.9	5.0	5.5	5365947.3	2584855.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.884	221.8	3.0	2.5
Europe	Belgium	21	73.3	0	263	10.5	72.7	4.9	3.5	8347810.7	2343257.1	0.31	0.07	0.00	0.10	0.45	0.00	0.00	0.07	0.00	0.896	374.4	3.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Bulgaria	2	30.0	0	334	11.2	53.5	5.5	4.0	11726287.5	9390754.6	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.794	64.0	3.0	3.0
Europe	Canary Islands	17	26.2	0	369	19.2	20.1	5.6	4.1	11213125.2	6363330.0	0.72	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.884	281.4	3.0	2.3
Europe	Corsica	2	257.5	0	347	16.0	16.1	4.0	4.5	5250128.1	8890441.0	0.75	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.897	0.0	3.0	2.0
Europe	Cyprus	5	15.0	0	275	19.4	38.6	3.4	3.0	13120330.6	4952495.6	0.56	0.00	0.00	0.17	0.17	0.00	0.00	0.11	0.00	0.856	132.0	3.0	2.6
Europe	Czech Republic	3	495.0	0	286	8.7	56.4	3.5	4.5	6145083.4	10676158.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.878	135.4	3.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Denmark	8	67.5	0	275	8.7	61.7	4.3	3.7	8969451.1	4511438.4	0.48	0.00	0.00	0.14	0.29	0.00	0.00	0.10	0.00	0.925	133.0	3.0	2.6
Europe	England	32	116.3	0	265	10.2	72.4	4.0	3.9	7705474.2	748473.3	0.29	0.12	0.02	0.24	0.24	0.00	0.00	0.10	0.00	0.909	420.5	3.0	2.1
Europe	Faeroe Islands Sandoy	1	29.0	0	120	6.6	144.3	8.0	4.0	13982713.9	1660912.9	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.95	9.9	3.0	3.0
Europe	Faeroe Islands Suduroy	1	73.0	0	120	6.6	144.3	4.0	4.0	2152955.0	3858879.6	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.95	28.1	3.0	3.0
Europe	Finland	8	57.3	0	263	2.3	46.7	5.0	3.8	5030985.5	3797010.4	0.25	0.00	0.00	0.17	0.42	0.00	0.00	0.17	0.00	0.895	16.3	3.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	France Metropolitan	41	169.1	0	358	12.0	70.1	4.2	3.7	6774940.4	1875849.7	0.40	0.09	0.05	0.09	0.26	0.00	0.00	0.11	0.00	0.897	117.6	3.0	2.3
Europe	Germany	31	180.9	0	311	9.6	60.2	3.8	3.6	7582570.8	1869411.8	0.43	0.00	0.07	0.17	0.24	0.00	0.00	0.10	0.00	0.926	229.9	3.0	2.2
Europe	Greece	6	40.0	0	346	14.3	52.9	4.2	3.8	7012851.0	4956665.0	0.63	0.00	0.00	0.19	0.19	0.00	0.00	0.00	0.00	0.866	81.6	3.0	2.7
Europe	Hungary	2	513.0	0	285	10.9	52.0	3.5	4.0	5811408.0	10489738.0	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.836	105.9	3.0	3.0
Europe	Iceland	2	38.0	0	108	2.3	92.8	6.0	3.5	10097113.7	875793.7	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.921	3.3	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Ireland	11	60.0	0	208	9.6	98.5	5.0	3.4	8413782.0	1148295.5	0.40	0.00	0.00	0.20	0.40	0.00	0.00	0.00	0.00	0.923	67.8	3.0	2.5
Europe	Italy	27	36.1	0	355	12.6	76.2	4.3	4.0	6051437.1	1997700.1	0.41	0.12	0.10	0.12	0.24	0.00	0.00	0.00	0.00	0.887	201.8	3.0	2.3
Europe	Jersey	1	15.0	0	265	12.0	36.1	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.985	852.1	3.0	3.0
Europe	Latvia	3	46.5	0	267	6.7	55.8	3.5	4.0	5811408.0	10489738.0	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.83	30.1	3.0	3.0
Europe	Lithuania	3	15.0	0	242	7.3	55.0	5.0	4.0	8535176.7	7546796.3	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.848	43.2	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Luxembourg	3	14.0	0	186	10.2	78.4	5.0	4.0	8535176.7	7546796.3	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.898	229.7	3.0	3.0
Europe	Macedonia FYR	1	17.0	0	320	10.5	53.7	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.748	81.8	3.0	3.0
Europe	Malta	3	31.0	0	205	19.3	35.4	5.0	4.0	16815351.7	801661.8	0.60	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.856	1317.5	3.0	2.5
Europe	Moldova	2	15.0	0	237	10.3	43.4	3.5	4.0	5811408.0	10489738.0	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.699	102.6	3.0	3.0
Europe	Monaco	2	15.5	0	23	10.7	81.4	4.5	3.0	5632670.2	8620432.6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.956	15322.5	3.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Montenegro	1	15.0	0	310	9.6	94.9	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.807	46.5	3.0	3.0
Europe	Netherlands	27	44.2	0	270	10.3	67.2	0.8	0.5	2964262.3	2608848.2	0.45	0.12	0.00	0.17	0.21	0.00	0.00	0.05	0.00	0.924	505.2	3.0	2.5
Europe	Northern Ireland	4	96.0	0	266	9.3	75.0	6.0	3.0	7329902.2	623952.1	0.25	0.00	0.00	0.38	0.38	0.00	0.00	0.00	0.00	0.909	132.8	3.0	2.7
Europe	Norway	9	95.6	0	254	1.7	90.3	5.0	3.5	4774113.2	2874125.7	0.28	0.00	0.00	0.24	0.34	0.00	0.00	0.14	0.00	0.949	16.4	3.0	2.4
Europe	Poland	4	11.7	0	290	8.6	50.3	5.7	3.3	8416018.1	6300592.7	0.63	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.855	123.1	3.0	2.7

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Portugal	20	23.7	0	310	15.3	70.2	4.4	3.6	7067941.5	2578779.0	0.62	0.24	0.05	0.00	0.10	0.00	0.00	0.00	0.00	0.843	112.8	3.0	2.1
Europe	Romania	2	363.0	0	322	9.6	55.4	3.5	4.0	5811408.0	10489738.0	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.802	90.3	3.0	3.0
Europe	Sardinia	6	9.5	0	355	16.0	15.3	5.0	3.5	15918426.4	4806898.5	0.27	0.18	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.887	69.0	3.0	2.8
Europe	Scotland	24	153.3	0	266	8.8	89.0	4.0	3.4	9998206.7	1334366.3	0.29	0.14	0.00	0.26	0.26	0.00	0.00	0.06	0.00	0.909	67.5	3.0	2.7
Europe	Serbia	2	15.0	0	311	11.1	62.7	3.5	4.0	5811408.0	10489738.0	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.776	91.8	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Sicily	8	65.4	0	355	19.0	29.3	4.2	4.7	4530838.9	3928218.5	0.82	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.887	197.7	3.0	1.8
Europe	Slovak Republic	2	15.0	0	293	8.4	63.2	3.5	4.5	6145083.4	10676158.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.845	111.1	3.0	2.5
Europe	Slovenia	3	15.0	0	289	9.7	110.3	4.3	4.0	6848908.2	6144947.2	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.89	97.3	3.0	3.0
Europe	Spain	46	31.7	0	381	13.9	49.6	3.8	3.4	6181097.9	1636035.6	0.55	0.09	0.09	0.04	0.15	0.00	0.00	0.08	0.00	0.884	90.3	3.0	2.1
Europe	Sweden	12	131.0	0	277	2.5	55.8	4.0	3.4	6430362.8	3113440.9	0.26	0.00	0.00	0.32	0.23	0.00	0.00	0.19	0.00	0.913	24.2	3.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Europe	Switzerland	12	115.2	0	284	7.4	127.0	4.4	3.2	8647332.1	2602185.9	0.38	0.00	0.00	0.10	0.38	0.00	0.00	0.14	0.00	0.939	205.3	3.0	2.4
Europe	Turkey	7	26.4	0	392	11.6	47.5	4.1	4.0	12329926.4	3031296.4	0.52	0.14	0.00	0.14	0.10	0.10	0.00	0.00	0.00	0.767	103.2	3.0	2.6
Europe	Ukraine	8	33.0	0	317	9.1	46.9	4.2	3.8	9594916.9	4205858.2	0.35	0.00	0.00	0.15	0.40	0.00	0.00	0.10	0.00	0.743	73.0	3.0	2.5
Europe	Wales	7	62.8	0	266	10.4	86.8	5.6	3.4	11273294.2	599252.3	0.36	0.21	0.00	0.21	0.21	0.00	0.00	0.00	0.00	0.909	150.1	3.0	2.8
North America	Bahamas Andros Island	3	20.0	0	242	26.0	64.6	4.0	2.5	19060379.3	79379.9	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.792	1.2	3.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Bahamas Eleuthera	2	53.0	0	246	26.0	64.6	3.0	4.0	9469861.1	17120596.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.792	24.1	3.0	3.0
North America	Bahamas Great Exuma	1	58.0	0	210	26.0	64.6	3.0	5.0	3051351.2	172059.1	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.792	43.8	1.0	1.0
North America	Bahamas Little Exuma	1	63.0	1	210	26.0	64.6	3.0	5.0	3051351.2	172059.1	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.792	238.9	1.0	1.0
North America	Bahamas New Providence	8	76.0	0	243	26.0	64.6	5.0	3.3	17550256.6	6645353.2	0.83	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.792	1325.6	3.0	2.0
North America	Barbados	13	68.2	0	208	26.7	187.9	4.7	3.5	13359175.5	436072.6	0.25	0.13	0.00	0.44	0.00	0.00	0.00	0.00	0.19	0.795	679.9	4.0	2.7

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Belize	1	36.0	0	549	25.7	173.1	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.706	15.7	3.0	3.0
North America	Bermuda	16	86.5	1	147	21.7	121.6	5.5	4.0	28227731.1	9704385.8	0.75	0.00	0.05	0.20	0.00	0.00	0.00	0.00	0.00	0.981	1153.2	5.0	3.3
North America	British Virgin Islands Anegada	1	86.0	1	147	26.0	199.0	3.0	4.0	10145590.8	0.5	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.945	7.5	1.0	1.0
North America	British Virgin Islands Tortola	2	149.5	1	147	26.0	199.0	3.0	4.0	5901038.2	6789.1	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.945	426.9	1.0	1.0
North America	British Virgin Islands Virgin Gorda	1	86.0	1	147	26.0	199.0	3.0	4.0	10145590.8	0.5	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.945	187.1	1.0	1.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Canada	24	101.9	0	517	-6.0	39.1	4.3	4.1	11138194.3	7948280.4	0.56	0.00	0.12	0.24	0.00	0.08	0.00	0.00	0.00	0.92	3.7	3.0	2.1
North America	Cayman Islands Cayman Brac	1	21.0	1	174	27.5	108.4	8.0	4.0	17554532.2	19848761.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.983	55.2	3.0	3.0
North America	Cayman Islands Grand Cayman	6	25.0	0	225	27.5	108.4	4.8	4.0	12037743.8	1407284.1	0.64	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.983	268.4	4.0	2.2
North America	Costa Rica	3	39.0	0	858	25.1	250.1	4.5	4.0	17796592.5	18272628.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.776	96.5	3.0	2.0
North America	Cuba	16	163.0	0	313	25.7	112.7	5.2	4.0	18608624.0	7765723.3	0.63	0.10	0.03	0.07	0.10	0.00	0.00	0.07	0.00	0.775	100.6	4.0	2.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Dominica	3	27.0	0	206	25.3	265.4	3.0	4.0	1656485.6	13578.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.726	98.4	1.0	1.0
North America	Dominican Republic	16	81.9	0	245	24.3	121.7	4.5	3.7	14318681.1	5524563.1	0.56	0.11	0.04	0.00	0.19	0.00	0.00	0.00	0.11	0.722	220.6	4.0	2.3
North America	El Salvador	1	41.0	0	500	24.4	147.0	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	293.3	3.0	3.0
North America	Guadeloupe	13	32.3	0	187	25.4	274.6	4.8	3.5	13831640.6	6875103.9	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.822	276.1	3.0	2.0
North America	Guatemala	1	43.0	0	709	24.0	214.1	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	142.0	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Hawaii	109	164.2	0	267	24.5	36.1	4.1	3.5	10228840.3	3405322.3	0.60	0.05	0.04	0.16	0.11	0.03	0.00	0.00	0.00	0.92	50.4	5.0	2.5
North America	Honduras	1	36.0	0	704	24.0	161.2	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.625	80.6	3.0	3.0
North America	Jamaica	14	66.3	0	185	25.5	181.1	6.0	3.3	14172467.8	8395332.8	0.59	0.00	0.06	0.00	0.18	0.00	0.00	0.00	0.18	0.73	272.1	3.0	2.1
North America	Martinique	15	27.0	0	217	25.4	255.3	3.9	2.7	9447431.0	163462.2	0.50	0.00	0.08	0.00	0.17	0.00	0.00	0.00	0.25	0.813	341.8	3.0	1.5
North America	Mexico	21	72.8	0	1104	21.2	62.4	3.8	3.5	5263078.4	4022803.1	0.61	0.07	0.07	0.11	0.00	0.14	0.00	0.00	0.00	0.762	66.4	3.0	1.9

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Montserrat	2	11.5	0	197	26.1	219.0	3.0	4.0	14775552.4	227184.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.821	51.9	4.0	3.0
North America	Nicaragua	1	36.0	0	678	25.3	196.1	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.645	46.2	3.0	3.0
North America	Panama	3	54.5	0	886	25.5	210.8	5.5	3.5	20749835.9	18261937.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.788	55.1	3.0	2.5
North America	Puerto Rico	48	48.2	0	268	25.4	178.8	4.2	3.7	8479804.7	3434865.8	0.80	0.09	0.03	0.00	0.09	0.00	0.00	0.00	0.00	0.905	413.0	4.0	1.8
North America	St Kitts and Nevis	2	15.0	0	199	25.3	197.6	4.0	2.0	24950646.8	87298.6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.765	202.0	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	St Lucia	2	8.0	0	209	26.8	203.1	4.0	3.0	13170111.7	71461.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.735	267.8	3.0	3.0
North America	St. Pierre and Miquelon	1	8.0	0	199	7.0	83.0	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.762	25.1	3.0	3.0
North America	Turks and Caicos Islands Caicos	2	10.0	0	243	26.5	112.6	5.0	3.0	51194307.4	30343.9	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.873	83.3	3.0	3.0
North America	Turks and Caicos Islands Grand Turk	3	18.0	1	243	26.5	112.6	3.5	4.5	27897382.7	198707.6	0.57	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.873	208.3	4.0	3.5
North America	United States of America	127	88.0	0	829	7.6	56.1	4.3	3.8	10374559.8	1975037.6	0.42	0.17	0.16	0.11	0.07	0.06	0.00	0.02	0.00	0.92	40.0	4.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
North America	Virgin Islands US St Croix	11	18.5	0	148	25.9	199.0	5.5	3.8	12209022.6	10341343.3	0.71	0.00	0.18	0.00	0.00	0.12	0.00	0.00	0.00	0.894	241.0	3.0	1.9
North America	Virgin Islands US St John	4	104.7	1	148	25.9	199.0	4.7	4.3	15586552.4	12167602.2	0.80	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.894	80.2	3.0	1.7
North America	Virgin Islands US St Thomas	6	89.3	1	148	25.9	199.0	4.3	3.8	12180573.8	9139597.6	0.83	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.894	622.1	3.0	1.5
Oceania	American Samoa Tutuila	3	44.0	0	43	27.5	259.7	4.0	5.0	5826745.2	1194351.7	0.50	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.827	390.0	3.0	3.0
Oceania	Australia	55	129.5	0	715	21.9	40.4	4.6	3.9	13229334.8	4382421.0	0.41	0.24	0.10	0.14	0.12	0.00	0.00	0.00	0.00	0.939	3.2	4.0	2.8

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Chatham Islands	16	121.4	0	162	11.6	62.6	5.8	3.5	18718461.4	7581522.8	0.24	0.32	0.16	0.16	0.12	0.00	0.00	0.00	0.00	0.915	0.6	4.0	2.8
Oceania	Cook Islands Rarotonga	2	562.0	1	36	24.4	155.5	3.0	5.5	5881061.4	1336350.1	0.70	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.829	157.8	4.0	3.3
Oceania	Fiji	12	120.0	0	107	24.2	219.1	4.4	3.9	7657180.7	3497010.8	0.57	0.18	0.18	0.00	0.00	0.07	0.00	0.00	0.00	0.736	50.4	4.0	2.5
Oceania	French Polynesia Marquesas Hiva-Oa	4	95.0	0	45	24.5	123.7	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.895	6.9	3.0	3.0
Oceania	French Polynesia Society Islands Bora Bora	3	74.0	1	47	27.0	117.2	4.0	3.0	2442042.6	1592.1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.895	346.6	2.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	French Polynesia Society Islands Moorea	5	103.0	0	53	27.0	123.7	4.0	4.0	4801853.7	1153610.5	0.38	0.38	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.895	120.8	3.0	2.7
Oceania	French Polynesia Society Islands Raiatea	4	74.0	0	45	27.0	123.7	4.0	4.0	4801853.7	1153610.5	0.38	0.38	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.895	74.8	3.0	2.7
Oceania	French Polynesia Society Islands Tahiti	14	69.0	0	81	24.5	123.7	4.0	3.0	13187675.8	484722.3	0.24	0.00	0.35	0.24	0.00	0.18	0.00	0.00	0.00	0.895	181.4	4.0	2.1
Oceania	French Polynesia Tubuai	2	83.0	1	35	27.0	123.7	4.0	4.0	4801853.7	1153610.5	0.38	0.38	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.895	27.0	3.0	2.7
Oceania	Guam	8	52.0	0	103	27.6	628.1	2.7	5.3	5739737.4	151870.3	0.50	0.38	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.901	307.6	4.0	2.7

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Kermadec Is Raoul	6	106.0	1	115	17.0	48.4	6.0	2.7	15545645.1	7203463.0	0.25	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.0	3.0	3.0
Oceania	Kiribati	5	8.0	0	38	27.5	91.3	3.3	4.7	4734721.8	891430.7	0.58	0.25	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.588	133.3	4.0	3.0
Oceania	Lord Howe Island	12	89.0	1	193	19.1	88.6	5.0	5.0	11077495.1	10107916.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.939	23.8	4.0	3.5
Oceania	Macquarie Island	9	79.0	0	103	4.9	81.3	6.0	3.0	22638149.0	5773674.0	0.19	0.38	0.19	0.25	0.00	0.00	0.00	0.00	0.00	0.939	0.0	4.0	3.2
Oceania	Marshall Islands Kwajalein Atoll	6	20.3	1	62	28.0	136.8	4.2	4.8	13022109.7	8011010.0	0.57	0.13	0.13	0.09	0.00	0.00	0.00	0.09	0.00	0.738	62.5	4.0	2.9

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Micronesia Yap	3	34.0	0	125	27.1	298.5	3.5	4.5	6082995.0	336027.3	0.83	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.638	11.4	4.0	2.0
Oceania	Midway Islands	2	26.0	1	172	24.0	11.7	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.0	3.0	3.0
Oceania	New Caledonia Grand Terre	3	14.7	0	125	22.3	116.9	5.3	5.0	15537023.6	12959310.6	0.60	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.789	1.1	3.0	3.0
Oceania	New Caledonia Mare	2	32.0	0	125	22.3	116.9	5.0	2.0	10096541.1	1059154.1	0.33	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.789	8.8	2.0	2.0
Oceania	New Zealand North	33	108.9	0	212	13.8	92.9	4.9	3.7	14909621.2	5883146.5	0.56	0.14	0.12	0.07	0.07	0.05	0.00	0.00	0.00	0.915	32.3	5.0	2.4

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	New Zealand South	30	128.2	0	212	11.0	135.7	5.1	3.6	18298147.8	6090632.8	0.46	0.23	0.06	0.09	0.17	0.00	0.00	0.00	0.00	0.915	7.4	5.0	2.7
Oceania	New Zealand SubAntarctic Islands Antipodes	5	63.0	1	73	12.0	62.6	8.0	4.0	17554532.2	19848761.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.0	3.0	3.0
Oceania	New Zealand SubAntarctic Islands Auckland	11	64.0	0	108	10.0	90.0	6.4	3.4	25102035.3	11916784.9	0.32	0.32	0.16	0.21	0.00	0.00	0.00	0.00	0.00	0.915	0.0	4.0	3.2
Oceania	New Zealand SubAntarctic Islands Bounty	1	16.0	1	55	12.0	62.6	8.0	4.0	17554532.2	19848761.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.0	3.0	3.0
Oceania	New Zealand SubAntarctic Islands Campbell	11	70.4	0	94	10.0	90.0	6.4	3.4	25102035.3	11916784.9	0.32	0.32	0.16	0.21	0.00	0.00	0.00	0.00	0.00	0.915	0.0	4.0	3.2

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	New Zealand SubAntarctic Islands Snares	9	96.8	1	116	10.0	90.0	6.5	3.3	20398629.0	14524904.3	0.40	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.915	0.0	3.0	3.0
Oceania	Norfolk Island	10	97.0	1	42	19.0	30.4	6.2	3.7	21090095.3	10040701.7	0.30	0.30	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.939	50.5	4.0	2.9
Oceania	Palau Babeldaob	3	64.0	0	113	27.9	261.1	5.0	3.0	7565532.1	304983.3	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.788	15.1	1.0	1.0
Oceania	Palau Eil Malk	2	26.0	1	113	27.9	261.1	2.0	4.0	3669866.4	43030.4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.788	0.0	2.0	2.0
Oceania	Palau Koror	4	29.0	1	113	27.9	261.1	3.5	3.5	5617699.3	174006.9	0.25	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.00	0.788	777.8	2.0	1.3

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Papua New Guinea	3	40.5	0	743	25.0	254.6	3.7	4.3	7286221.3	1243951.4	0.56	0.19	0.13	0.00	0.00	0.13	0.00	0.00	0.00	0.516	14.9	4.0	2.7
Oceania	Samoa	5	38.0	0	46	27.5	259.7	3.8	4.5	6587622.3	953732.2	0.55	0.14	0.23	0.00	0.00	0.09	0.00	0.00	0.00	0.704	67.7	4.0	2.8
Oceania	Solomon Islands Guadalcanal	1	93.0	0	243	25.6	251.4	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.515	20.6	3.0	3.0
Oceania	Solomon Islands Makira	2	83.0	0	243	25.6	251.4	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.515	3.1	3.0	3.0
Oceania	Solomon Islands Malaita	1	12.0	0	243	25.6	251.4	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.515	31.9	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Tasmania	30	112.9	0	350	13.3	33.9	4.9	3.8	12765868.2	4749263.7	0.38	0.33	0.14	0.07	0.05	0.03	0.00	0.00	0.00	0.939	7.6	4.0	2.4
Oceania	Tonga Eua	4	29.7	1	50	25.2	142.4	4.7	5.0	8882271.9	2255434.1	0.77	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.721	57.7	4.0	3.3
Oceania	Tonga Haapai	1	18.0	1	50	25.2	142.4	2.0	6.0	4600457.9	367071.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.721	60.7	4.0	4.0
Oceania	Tonga Niuafoou	1	85.0	1	50	25.2	142.4	4.0	5.0	4491825.5	83074.6	0.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.721	43.3	3.0	3.0
Oceania	Tonga Tongatapu	2	55.0	0	50	25.2	142.4	6.0	4.5	11023178.9	9965917.8	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.721	290.1	3.0	3.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
Oceania	Tonga Vavau	1	15.0	1	50	25.2	142.4	2.0	6.0	4600457.9	367071.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.721	108.1	4.0	4.0
Oceania	Vanuatu Aore	2	128.0	1	86	24.1	213.6	4.0	5.0	7161664.8	2305628.9	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.597	9.6	3.0	3.0
Oceania	Vanuatu Efate	4	69.7	0	86	24.1	213.6	5.3	4.0	15090514.7	13108558.4	0.70	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.597	73.1	3.0	2.5
Oceania	Vanuatu Espiritu Santo	6	92.0	0	86	24.1	213.6	6.0	5.0	21059622.7	19397428.6	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.597	10.0	3.0	3.0
Oceania	Wake Atoll	2	19.0	1	50	27.0	26.1	3.0	6.0	2800583.9	87900.6	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.0	1.0	1.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
South America	Argentina	16	81.0	0	1003	14.6	48.6	4.8	4.0	10535548.4	9902771.5	0.67	0.28	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.827	16.0	3.0	2.3
South America	Aruba	2	35.0	0	182	29.0	67.0	5.5	3.5	20749835.9	18261937.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.908	639.6	3.0	2.5
South America	Bolivia	1	85.0	0	1438	20.9	90.8	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.674	10.1	3.0	3.0
South America	Brazil	9	77.0	0	1810	25.5	147.9	5.3	4.3	16982666.1	13597469.8	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.754	24.3	3.0	2.7
South America	Caribbean Netherlands Curacao	7	38.8	0	213	28.3	55.7	4.3	3.7	12851621.3	6281706.8	0.62	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.23	0.924	361.1	3.0	2.2

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
South America	Caribbean Netherlands Saba	1	15.0	1	213	28.3	55.7	3.0	4.0	1656485.6	13578.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.924	153.2	1.0	1.0
South America	Caribbean Netherlands Saint Maarten	7	10.8	1	213	28.3	55.7	5.8	3.5	22840444.8	14308833.7	0.67	0.00	0.00	0.17	0.00	0.00	0.00	0.17	0.00	0.924	908.4	3.0	2.4
South America	Chile	8	105.8	0	442	8.4	51.4	4.6	4.0	18077368.8	8487668.9	0.42	0.16	0.05	0.11	0.00	0.00	0.00	0.11	0.16	0.847	23.5	3.0	2.4
South America	Ecuador	5	47.5	0	1621	21.5	181.5	5.0	4.5	26215782.7	9223666.5	0.50	0.36	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.739	57.5	4.0	2.8
South America	Falkland Islands East Falkland	3	86.0	0	122	6.2	45.3	7.0	4.5	39436620.5	18986767.7	0.43	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.933	0.3	4.0	3.5

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
South America	French Guiana	1	19.0	0	709	25.8	221.1	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.739	3.0	3.0	3.0
South America	Paraguay	1	93.0	0	690	23.6	96.3	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.693	17.1	3.0	3.0
South America	Peru	4	52.5	0	1856	19.7	130.7	4.7	3.7	28929164.1	12191866.7	0.57	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	24.1	3.0	2.3
South America	Tobago	9	55.0	0	413	26.6	133.4	3.5	2.5	9856101.5	53053.8	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.78	202.9	3.0	2.5
South America	Trinidad	13	55.0	0	413	26.6	133.4	3.8	2.8	21085882.8	41466.8	0.63	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	285.2	3.0	2.0

Continent	Region	H1 (v1): Alien bird species richness	H2 (v2): Av res time (years)	H3 (v3): Island <100km^2	H4 (v4): Native bird species richness	H5 (v5): Monthly av temp (c)	H5 (v6): Monthly av rain (mm)	H6 (v7): Av habitat breadth score	H7 (v8): Av diet breadth score	H8 (v9): Av native range size (km^2)	H9 (v10): Av alien range size (km^2)	H10 (v11a): Comp (prop)	H10 (v11b): Pred (prop)	H10 (v11c): Int (prop)	H10 (v11d): Hyb (prop)	H10 (v11e): Graz (prop)	H10 (v11f): Dis (prop)	H10 (v11g): Struc (prop)	H10 (v11h): Chem (prop)	H10 (v11i): Para (prop)	H11 (v12): HDI	H12 (v13): Pop density (per km^2)	Most severe impact score	Av impact score
South America	Uruguay	3	123.0	0	408	17.9	110.4	8.0	5.0	34957580.6	36489228.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.795	19.1	3.0	3.0
South America	Venezuela RB	9	20.0	0	1393	25.8	165.4	5.6	4.2	12959698.4	8419357.6	0.82	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.767	34.3	3.0	2.2