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2 The Biogeography of Avian Invasions: History, Accident and Market Trade

2.1 Introduction

Birds are the most accomplished dispersers of all the terrestrial vertebrates. Most bird species are volant (capable of flight) and birds have colonised and occupied all major landforms, oceans, and islands of the world. However, the approximately 9,993 extant species are not regularly distributed, in either number or identity (Jetz *et al.*, 2012), and there exist distinct biogeographic patterns that have developed over their evolutionary history in both their diversity (species richness) and endemism (evolutionary uniqueness). Most hotspots of bird species richness are located in the tropics and in mountainous areas of mainland continents, whereas hotspot regions of endemism tend to be on large islands and/or island archipelagos (Orme *et al.*, 2005). These natural distributions of bird species and the patterns of movement that led to them have subsequently been greatly affected by the actions and movement of people.

There is sparse but consistent evidence that people have been moving animals, either purposefully or inadvertently, for thousands of years, and across a wide range of regions and civilisations (Lever, 1979; Yalden, 1999). Ancient civilisations translocated both domesticated and non-domesticated species as sources of food, for ornamentation (of people or landscapes), for game hunting, or as pets (Hughes, 2010; Tella, 2011). One of the earliest domesticated (and liberated) bird species was the domestic fowl, the descendant of the Red Jungle Fowl (*Gallus gallus*). Jungle Fowl are a native of southeast Asia and archaeological and palaeoclimatic data suggest that they were transported to northern China c. 8,000 years ago (West & Zhou, 1989). They were subsequently introduced as poultry to other parts of Asia (China, Indonesia) around 5400 BC (Miao *et al.*, 2013) to Pacific islands by Polynesian colonisers in 1000 BC (Steadman *et al.*, 1990), and possibly to South America before the arrival of Europeans between 1321-1407 AD (Storey *et al.*, 2007). Domestic fowl were also transported across Europe during the Bronze and Iron Ages and were well established by the time of the Roman Empire's fall (Sykes, 2012). The principal motivation for their spread from Asia was to enhance the human diet, but they were also valued for their song, their eggs and feathers, and for the sport of cockfighting. In Western Africa, domestic fowl only became widespread after 1000 AD.

In the ancient Mediterranean region, there was keen interest in exotic species for exhibition in menageries and gardens, and for slaughter in the arenas. Many Greek and Roman temples had sacred groves that provided shelter to birds, fish, reptiles

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and mammals, among which were exotic species originating from far-off countries. Paradises in the ancient world, particularly areas set aside by affluent individuals, contained a variety of wild and exotic species. Alexander the Great's expedition from Greece to Persia and the north of the Indian subcontinent led to the importation of many species from India and other lands. Around 270 BC, Alexandria had zoological and botanical gardens that included many exotic species (and humans) from India as well as parts of Africa. A trade developed in particular species that could be maintained as pets. Among those kept in private households (or garden collections) were many bird species, including peacocks, pheasants, parrots, cranes, storks, flamingoes, rails, crows, starlings, magpies, thrushes and nightingales, that were housed individually or in aviaries; some were valued for their song, and others because they could be taught to talk (Jennison, 1937). The Common Pheasant (*Phasianus colchicus*), which takes its name from the River Phasis in the Transcaucasus, was first introduced to Europe by ancient Greeks and Romans in c. 1300 BC, and was subsequently introduced on many more occasions during the Middle Ages (Mason, 1984). Large-scale releases of pheasants continue in Europe to this day. The Helmeted Guineafowl (*Numida meleagris*) from Africa is first mentioned in Athens by Sophocles in the 5th century BC, while pheasants are mentioned in Aristophanes' play, 'The Birds,' first performed in 414 BC.

In pre-Columbian America, it has been proposed that there was extensive use of, and traffic in, exotic birds (Haemig, 1978). Before the arrival of Europeans, American cultures are believed to have bred and raised exotic birds in aviaries to supply the needs of the feather industry and pet trade. Long-distance merchants could have transported birds hundreds of kilometres outside their natural ranges, and these birds would have been a potential source for accidental or deliberate introductions. The best documented early example of an introduction in the Americas is that of the Great-tailed Grackle (*Quiscalus mexicanus*) to Mexico (Haemig, 1978; 2012), but there is some evidence that other species were introduced at the same time, including the Tufted Jay (*Cyanocorax dickeyi*) introduced to Mexico (Haemig, 1979; but see Bonaccorso *et al.*, 2010), and the Red-legged Thrush (*Turdus plumbeus*) introduced to the West Indies (Ricklefs & Bermingham, 2008).

Despite the long history of movements of bird species, the real 'golden age' of translocations did not start until the middle of the nineteenth century, at which point there was a step-change in the rate at which bird species introductions occurred worldwide (Blackburn *et al.*, 2009). Since then, we have identified two distinct periods of major activity in the transportation of bird species that overshadow all others in terms of their influence on bird introductions and invasions. We have defined these two periods as: (1) the era of the Acclimatisation Societies during the great European diaspora between the eighteenth and twentieth centuries; and (2) the era of the international trade in wild birds for bird-keeping from the late-twentieth century to the present. In the following sections we describe the activities that define

these two eras in detail, and discuss the very different influences that they have had on the biogeography (through establishment and spread, *sensu* Blackburn *et al.*, 2011) of exotic bird species.

2.2 Avian Translocations in the Age of Discovery

Since their dinosaurian origin (Zhou, 2004), bird species have (under their own effort) swum, walked, and flown around the globe. Given that birds are such a highly mobile and naturally widespread taxon, one might ask how much influence the re-distribution of species by humans can really have. The simple answer is: a lot!

Like birds, humans are also great colonisers. The greatest period of colonisation in human history, in terms of numbers of people moving their permanent home from one region to another distant region, was the European diaspora of the 19th and early-20th centuries. These movements of people sparked the transportation of many species, both large and small, in both directions across the oceans (Crosby Jr, 1972). Unfamiliar with their new colonized land, Europeans introduced plants and animals to make the alien environment feel more like home, to beautify their gardens, provide sport for hunters, and 'aggrandise' the colony. Above all, however, they wanted to make the land sustainable and economically productive. These motivations led to the first great period of activity in the deliberate transportation and introduction of birds: the founding of the Acclimatisation Societies (McDowall, 1994). The British were especially prominent in this activity. For example, c. 40% of all known bird introductions occurred as a result of activity relating to the British occupation of just four geopolitical regions: Hawaii, New Zealand, Australia, and the continental USA (Blackburn *et al.*, 2009). After 1863, New Zealand alone was home to more than half of the world's Acclimatisation Societies, with coverage of almost the entire country. The influence of the British (and other Europeans) in New Zealand is illustrated by the origin of birds introduced, with many species (and many successful species) coming from Europe and from New Zealand's closest colonial neighbour, Australia (Figure 2.1).

It is possible to quantitatively compare the rate of natural colonisation of areas by birds with the rate of anthropogenic introductions in the era of the Acclimatisation Societies, particularly for oceanic islands. For example, St Helena is a volcanic island in the South Atlantic Ocean that was first discovered by the Portuguese in 1502. By 1588 St Helena had experienced its first avian introductions (*Phasianus colchicus* and *Alectoris chukar*; Lever, 2005). Since then, at least 35 bird species have been introduced, of which nine have successfully established wild-breeding populations. This introduction history produces a rate of introduction of one bird species every 14 years, and a successful establishment of one new bird species every 55 years. In contrast, the minimum geological age of St Helena is estimated to be

c. 7 million years, which is the date of its last volcanic eruption (Chaffey *et al.*, 1989). St. Helena is known to have had at least 22 native bird species at the time of discovery, of which 12 are now extinct (Blackburn *et al.*, 2004). Natural colonisation therefore produced a success rate of one new bird species every 320,000 years. Even if we assume that 99% of naturally colonising species have subsequently gone extinct, the rate of exotic introduction was still more than 50 times greater than that of natural colonisation (Blackburn *et al.*, 2009).

The exotic bird species that were moved by humans (transported and introduced) during the period of the Acclimatisation Societies were clustered into a relatively limited set of bird taxa and were not a randomly selected (or distributed) set of species from all possible extant taxa (Blackburn *et al.*, 2009). Analysis of global introduction data has revealed that some families contain significantly more introduced bird species than expected. These are: the Phasianidae (pheasants, partridges and quails); Anatidae (ducks and waterfowl); Columbidae (pigeons and doves); Psittacidae (parrots); and Passeridae (Old World sparrows) (Blackburn & Duncan, 2001; Lockwood, 1999). More than half of all introduced species came from just these five families, despite the families including less than 15% of all extant bird species. Two other families with relatively high representation of introduced taxa are the Odontophoridae (New World quails) and Fringillidae (true finches). This taxonomic bias strongly reflected the purposeful introduction of birds to new locations for the provision of hunting, game and food (pheasants, partridges, ducks and pigeons), as well as for their aesthetic and/or domestic qualities (sparrows, finches, pigeons and parrots).

Even within the era of Acclimatisation, however, the identities of the species introduced were subject to change (Blackburn *et al.*, 2009). A high proportion of early introductions concerned game birds (Galliformes), but this order's representation in introduction events has steadily declined over time. In contrast, the proportion of events that relate to parrots (Psittaciformes) has increased steadily since the 1850s. Passerine introductions appeared to peak in the second half of the nineteenth century, while the proportion of introductions concerning waterfowl (Anseriformes) varied little throughout this period (Figure 2.2). This temporal variation in the taxonomic composition of bird introductions within the Acclimatisation period most likely reflects the changes in reasons for introducing bird species. Early introductions consisted of species regarded as beneficial to colonists for their survival and livelihood, particularly game birds and waterfowl. Passerine introductions peaked towards the end of the popularity of Acclimatisation Societies, when many small-bodied songbird species were introduced for aesthetic reasons to supplement native avifaunas with familiar and conspicuous garden species, sometimes under the guise of insect and horticultural biocontrol (Pipek *et al.*, 2015).

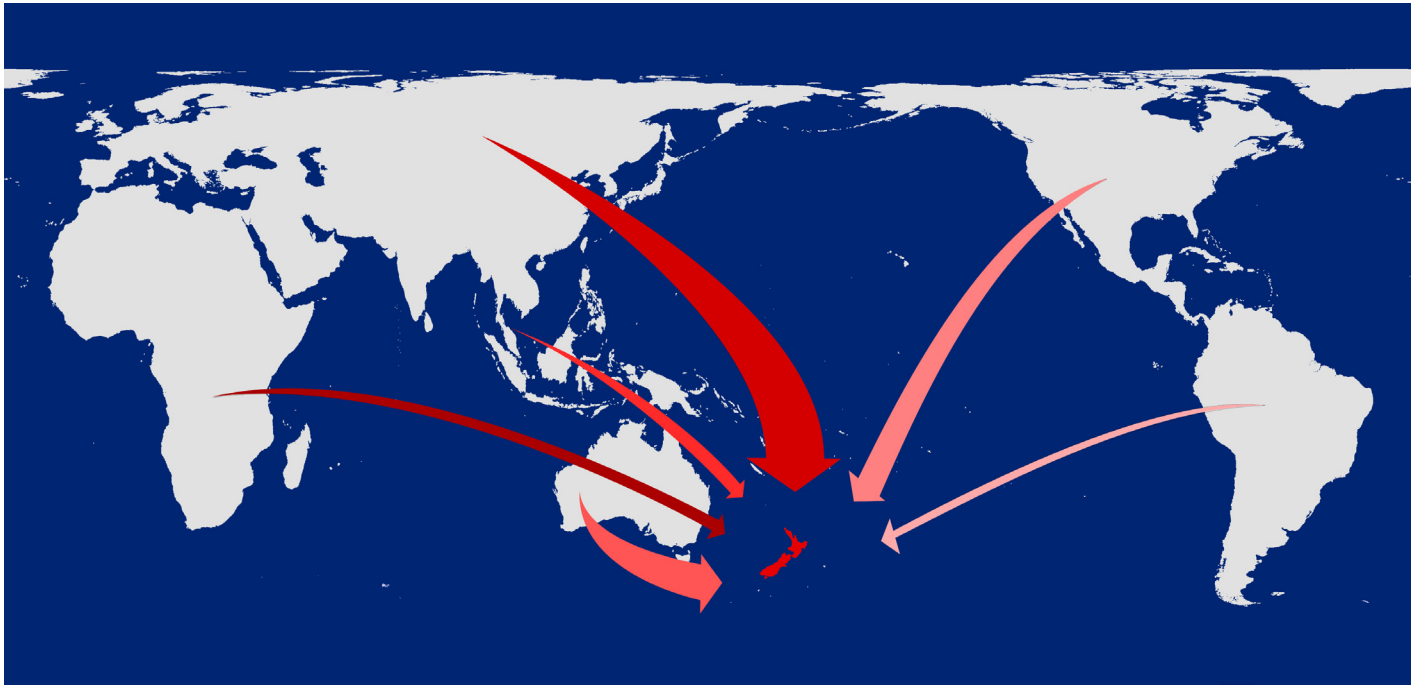

Fig. 2.1: Biogeographic sources of introduction for 125 extant bird species introduced to New Zealand during the period 1773–1952. Native breeding ranges were obtained from the ADHoC (Avian Diversity Hotspots Consortium) database, first published by Orme *et al.* (2005). Native ranges were projected using ESRI ArcMap GIS software (version 9.3, 2008), and allocated to a biogeographic realm (Nearctic, Neotropical, Palaearctic, Afrotropical, Indo-Malay, Australasian and Oceanic). Each realm was awarded a score depending on the proportion of a species' range that fell within its boundaries. For example, if the entire range was enclosed then it received a score of 1, if 50% of the range then 0.5, and so on. This process was repeated for all 125 species with the resultant scores as follows: Palaearctic = 57.66, Australasian = 30.16, Nearctic = 19.16, Indo-Malay = 9.66, Afrotropical = 2.16, Neotropical = 2.16, Oceanic = 1. The size of the directional arrows were weighted to represent the number of species from each biogeographic realm that have been introduced to New Zealand. The darkness of arrow colours corresponds to the rate of successful establishment ranging from zero in the Neotropics to 38.7% in the Afrotropics. The rate of successful establishment for the Palearctic (Europe, including the United Kingdom) was 34.7%.

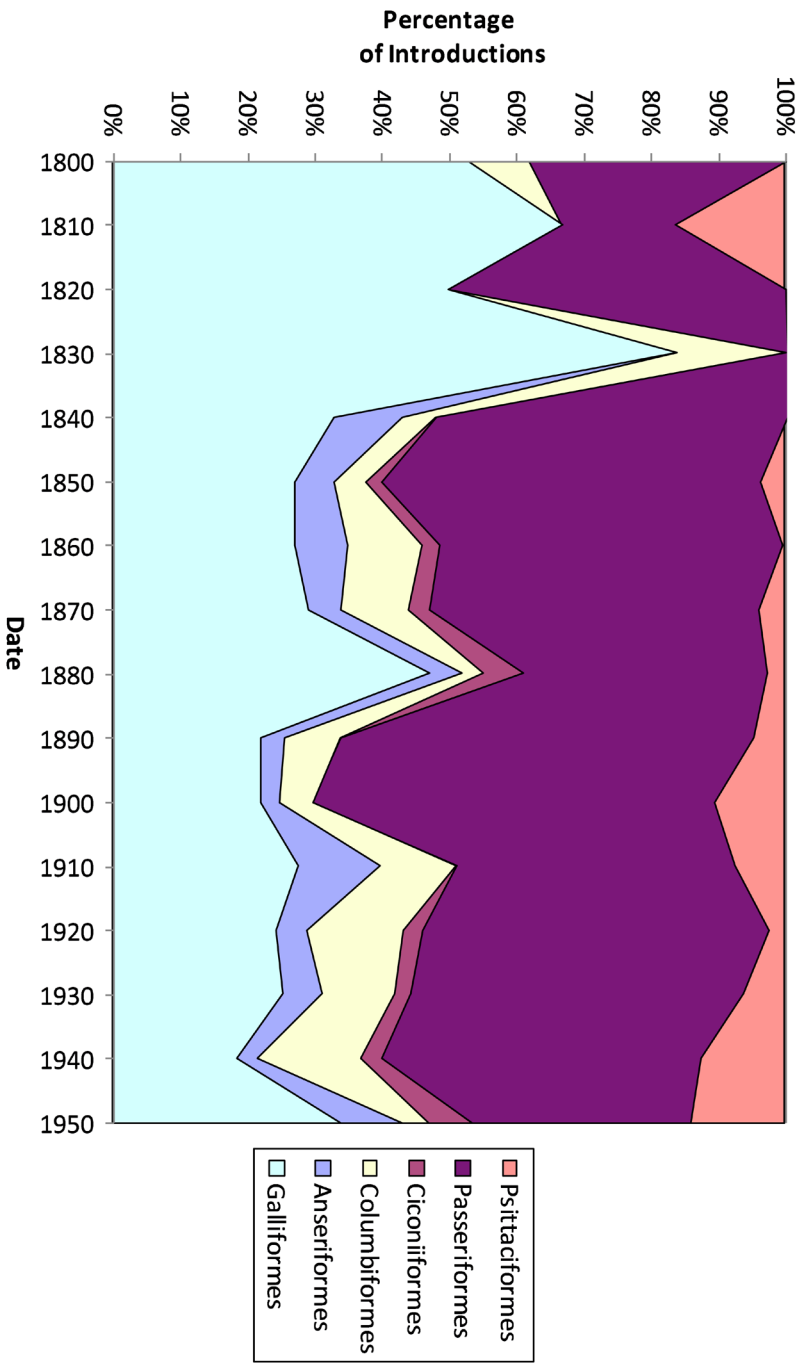

Fig. 2.2: The proportional taxonomic composition of avian introduction events in the period 1800-1950. Only the six bird orders with more than 30 introductions with an estimate of date of introduction are included. Reproduced with permission from Blackburn *et al.* (2009).

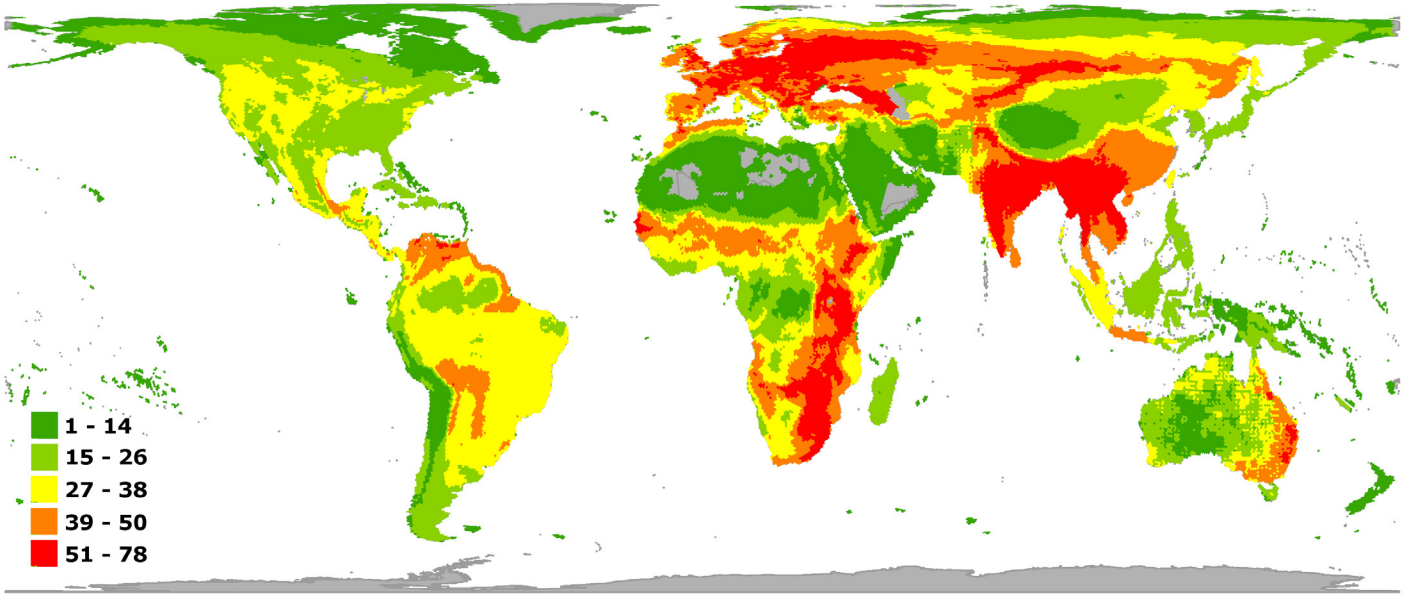

Fig. 2.3: Native breeding ranges for 639 extant bird species that have been introduced outside their native breeding ranges. Breeding ranges for species with three or more introduction records in the GAVIA (Global Avian Invasions Atlas) database (Dyer & Blackburn, unpublished data) were obtained from the ADHoC (Avian Diversity Hotspots Consortium) database, first published by Orme *et al*. (2005). All maps were created using ESRI ArcMap GIS software (version 9.3, 2008). In order to identify areas of high levels of introduction sources, a species richness map was created by projecting the native range maps onto a hexagonal grid of the world, resulting in a geodesic discrete global grid, defined on an icosahedron and projected onto the sphere using the inverse Icosahedral Snyder Equal Area projection. This resulted in a hexagonal grid composed of cells that retain their shape and area (2591.3 km^2) throughout the world. The colour then assigned to each hexagonal cell reflects the number of species' ranges that intersect that cell.

The era of the Acclimatisation Societies led to bird species being introduced to all major regions of the world, and to the majority of ice-free latitudes (Duncan *et al.*, 2003), but predominantly to islands (Cassey, 2003). Globally, more than two-thirds of all past avian introductions were to islands (Blackburn *et al.*, 2009), despite islands constituting only a small fraction of all land area around the globe. The location of these islands, primarily British colonies, largely dictates latitudinal variation in the distribution of exotic bird species moved in this period. For example, in the Northern Hemisphere, there were a relatively large number of introductions to low latitudes as a consequence of the geographic location of the Hawaiian and Caribbean Islands, whereas peaks of introduction in the Southern Hemisphere reflect the very large numbers of introductions to islands in the Pacific and Indian Oceans. Although species have been sourced from all major biogeographic regions, the Palaearctic region 'donated' the most species during this era and has one of the highest percentages of native breeding bird species introduced elsewhere. Other significant donor regions for exotic birds include sub-Saharan and southern Africa, the tropical regions of South America, and southern Asia, as well as Indonesia and eastern Australia (Figure 2.3). Eventually, however, it was recognised that the introduction of exotic species was ecologically unsound, and the practice slowly died out. For example, New Zealand Acclimatisation Societies had changed their role from introducing species to preventing further introductions of exotic species by the end of the Second World War (Simberloff & Rejmanek, 2011).

2.3 Sitting Around in Bars: the Influence of the Pet Trade on Current Avian Biogeography

Deliberate introductions were the main pathway of bird introductions during the era of Acclimatisation Societies, but are now in decline globally as scientific, conservation and political opinions have turned against them (Hulme *et al.*, 2008). However, bird invasions have not ceased; it is just that their primary cause has changed. Today, bird invasions are driven largely by the demand for caged birds. Most have accidental (e.g. pet birds escaping from cages) or recreational (e.g. for religious or festive reasons) origins, rather than resulting from deliberate establishment efforts (Eguchi & Amano, 2004; Leven & Corlett, 2004; Lever, 2005). In the current era of globalisation, the main driver of exotic introductions is therefore wildlife trade (Westphal *et al.*, 2008).

Throughout history, bird-keeping has predominantly been a pastime for the wealthy, and thus concerned relatively low numbers of birds. Only in the last century did the activity become generally popular, encouraged by accelerated economic growth in the developed world. The increase of the wealth of the middle classes, coupled with the improvement of international transport capacity, which permitted faster and cheaper trade between far distant regions, opened the door to the commer-

cial trade of millions of birds (Hulme, 2009). The demand for pets increased in the Communist Block after the collapse of the Soviet Union (Chiron *et al*., 2014), and has also grown in developing countries such as Brazil (Regueira & Bernard, 2012), Mexico (Cantu-Guzman *et al*., 2007) and South Africa (Goss & Cumming, 2013), as these societies progressively achieved higher living standards. In these cases, bird-keeping is a symbol of higher socio-economic status among increasingly urban societies (Jepson & Ladle, 2005). Most recently, the growth of the internet has facilitated the sale and circulation of species worldwide (Derraik & Phillips, 2009; Kikillus *et al*., 2012). The consequences of these trends are that more than one million birds, of over a thousand species, are legally traded around the world on an annual basis (Butchart, 2008; Gilardi, 2006; Karesh *et al*., 2005). Bird-keeping is currently one of the most popular hobbies in the world (Carrete & Tella, 2008), and social workers and other healthcare professionals believe that such pets help many people to lead healthier, happier lives (Anderson, 2003).

The greatest effect that wildlife trade has had on bird transportation has been the reversal of the direction of introduction, which in the era of Acclimatisation was from the Old World to the colonies (e.g. birds from Europe sent to America, Australasia and Africa; Figure 2.1). Now, transport is primarily from the former colonies (birds from South America, Africa, southeast Asia and Oceania) to the population centres of Europe, continental Asia and North America (Jeschke & Strayer, 2005). In South America, passerines (Passeriformes), parrots (Psittaciformes), doves (Columbiformes) and toucans (Piciformes) are the most frequently traded species, whereas tanagers (Thraupidae), New World sparrows (Emberizidae) and troupials (Icteridae) are the most commonly traded families (Alves & Brooks, 2010; Dauphine, 2008; Regueira & Bernard, 2012). From southeast Asia, the most commonly traded birds are small softbill cagebirds, such as babblers (Timalidae) and mynas (Sturnidae) (Nijman, 2010). The Chinese market has acted as a major hub for the re-export of birds to other parts of the world: for example, the Netherlands imports birds from African countries and re-exports them to Hong Kong (Lau *et al*., 1997). Live birds from China are mainly exported to Europe, other Asian countries and the USA. In the recent past, most native birds from these countries were exported to Europe; however, formal operations have been drastically reduced since the European Union (EU) imposed a ban on wild bird imports, resulting in the closure of this important market. This and other national and international regulations on wildlife trade (Cooper & Rosser, 2002) mean that in Western markets, such as the USA, Europe and Australia, the private demand for pet animals is usually satisfied by domestic trade (Anderson, 2003). Exotic animals legally traded in these markets are a combination of wild caught birds imported prior to the bans, birds imported with special permits, descendants of wild caught birds raised in captivity, and/or native birds exempt from trade regulations (Anderson, 2003). Legal international trade is directed mainly to Mexico, followed by Asia and Africa (FAO, 2011).

The consequence of modern bird translocations is the redistribution of species to 'new' biogeographical regions where these taxa were historically absent. One of the avian families that has particularly benefited from introductions is the parrots (Cassey, Blackburn, Russell, Jones, & Lockwood, 2004). The majority of birds currently in pet markets around the world are either parrots or passerines (Figure 2.4). These often wild caught birds are largely sourced from tropical areas of Africa and southeast Asia (Alves & Brooks, 2010; Dauphine, 2008; Li & Jiang, 2014; Nijman, 2010) with around 1,800 species. However, many species are now threatened by illegal capture and trade that is largely driven by the culture of keeping wild birds as pets. As a result of deliberate or accidental releases, the USA is now home to feral populations of several exotic species of parrots (Bull, 1973; Butler, 2005; Lever, 2005); The USA was originally home to two native parrot species, but these were driven to extinction during the 20th century (Butler, 2005). The best known examples of established exotic parrot species in the USA are the Monk Parakeet (*Myopsitta monachus*) (Russello *et al.*, 2008) and the Rose-ringed Parakeet (*Psittacula krameri*) (Butler, 2005), but there are presently at least seven other parrot species established there (Butler, 2005). Novel parrot species have also established successfully in Europe. Monk and Rose-ringed Parakeets have feral populations in the United Kingdom, Germany, France, Belgium, the Netherlands, Spain and Italy, among others (Sol *et al.*, 1997; Strubbe & Matthysen, 2009; Strubbe, 2009; Mori *et al.*, 2013). The Rose-ringed Parakeet is also established in several countries in the Middle East and Arabian Peninsula (Lever, 2005), and is the most common aviary escapee in Australia (Henderson *et al.*, 2011). Global transport and communication networks continue to increase. As a consequence, more goods are being traded and the type of species being transported has changed, as well as the associated risks.

Less is known about the extent of avian invasions in developing countries. In these emerging economies, mainly situated in tropical or subtropical climates, the number of recorded introduced species is still low compared to other regions. However, it is predicted that these areas should reach high exotic species richness, mainly due to their current increasing economic growth (Lin *et al.*, 2007) and their great ecological diversity (Levine, 2000). The number of introduced (and established) species is surely under-reported given the low research effort devoted to alien species compared with other global regions (Speziale *et al.*, 2012), and may be higher than is widely appreciated. For example, a recent study by Fontoura *et al.* (2013) identified 59 bird species that had been introduced to the large South American country of Brazil, of which 14 species have established or probably established non-native populations. The largely accidental establishment of new species in these regions is likely to increase, and may even exceed the rates of introduction during the era of the Acclimatisation Societies (Su *et al.*, 2014).

2.4 Future Trends

From a global perspective, the effect of the widespread and repeated introductions of certain bird species (particularly Old World sparrows and New World quails), combined with the endangerment and extinction of other species (particularly the rails, petrels and shearwaters) points to a general pattern of biotic homogenisation (Lockwood *et al.*, 2000). As this process continues we increasingly expect to find the same species, and very similar ecological communities, in localities thousands of kilometres apart (Blackburn *et al.*, 2009). In the most extreme situation, we could face a world where the zoogeographical realms are no longer identifiable (McKinney & Lockwood 1999; Rosenzweig, 2001).

A growing concern with the trade in live animals (including birds) is that, combined with the loss and degradation of habitats, the over-exploitation of wildlife can heavily deplete native populations and even bring some species close to extinction (Beissinger, 2001; Chapin *et al.*, 2000; Peres, 2001). This has motivated the creation of laws and international trade agreements to safeguard certain species from over-exploitation. The principal instrument for controlling international trade in wild species is the Convention on International Trade in Endangered Species (CITES), an agreement between governments with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival (Cooper & Rosser, 2002). Since its implementation, 180 member states have passed legislation to adhere to the Convention (http://www.cites.org/eng/disc/parties/index.php), effectively regulating wildlife trade in their country. Parallel to this, the strong evidence that invasive species cause declines in abundances of native species and undesirable changes in ecosystem function (Mack *et al.*, 2000; Sala *et al.*, 2000), as well as economic losses (Hulme *et al.*, 2010; Pimentel *et al.*, 2000), has promoted the implementation of legal tools to regulate invasive species.

The implementation of international restrictions on the global trade in wild birds reduced the trade from an estimated 7.5 million birds a year during the early 1970s to around 2.5 million in the 1990s (Inskipp, 1979; 1990; Leader-Williams & Tibanyenda, 1996). In the USA, the Lacey Act of 1900 provided jurisdiction to prohibit the importation and transport of wildlife included in a list considered 'injurious' (Anderson, 1995). Later, the legal trade of exotic birds into the USA was stopped by the Wild Bird Conservation Act of 1992, which banned the import of all CITES-listed birds (Pain *et al.*, 2006). In Australia, the Environment Protection and Biodiversity Conservation Act 1999 effectively prohibited the export of live wildlife and heavily regulated the import of all CITES-listed species (Alacs & Georges, 2008). In Europe, wildlife regulations were more strongly oriented towards preventing the spread of avian influenza and other pathogenic zoonotic diseases in human beings. The EU ban on live bird imports was adopted in 2007, motivated by the outbreak of Severe Acute Respiratory Syndrome (SARS) and avian influenza, both diseases being linked to wildlife trade (Chomel *et al.*, 2007; Karesh *et al.*, 2005). Laws protecting wildlife also appear in the countries of origin of the traded species (Alves & Brooks, 2010).

Fig. 2.4: Examples of (A) parrots and (B) passerines for sale in pet shops in Taiwan. The parrot species depicted are, from top to bottom and back to front, Military Macaw (*Ara militaris*), White Cockatoo (*Cacatua alba*), Blue-crowned Conure (*Aratinga acuticaudata*), Sun Conure (*Aratinga sostitialis*), Blue-crowned Lorikeet (*Vini australis*), Monk Parakeet (*Myopsitta monachus*) in green and blue colour-morphs, Yellow-bibbed Lory (*Lorius chlorocercus*), Red-shouldered Macaw (*Diopsittaca nobilis*), Australian King Parrot (*Alisterus scapularis*) and Blue-streaked Lory (*Eos bornea*); while the passerines are, from top to bottom and left to right, Japanese White-eye (*Zosterops japonicus*), Nutmeg Mannikin (*Lonchura punctulata)* and Taiwan Scimitar-babbler (*Pomatorhinus musicus*) (the bottom right cage contains two bantam chickens (*Gallus gallus*)). Photo credits: T.M. Blackburn.

Biological invasions by alien species are one of the consequences of human activities, and so it is important that we consider the economic and social dimensions of the problem when dealing with exotic species (Perrings *et al.*, 2005). In most cases, people are naïve about exotic birds, not even being able to recognize which species in the wild are non-native where they live. In the worst of cases, exotic species are highly valued by people for hunting, commercial or religious purposes, or for aesthetic reasons; for example, people enjoy seeing exotic parakeets at bird feeders (Butler, 2005). Popular exotic species can be so well integrated into public perception that in some cases even conservation organisations promote laws protecting them. This cultural attachment is detrimental for developing control and eradication programs. At the same time, people are often also not conscious of the impacts of exotic invasive species. This may become even more true in the future as the current younger generations are raised in a landscape filled with exotic species, unaware of the legacy of past biological invasions (Decocq, 2010; Papworth *et al.*, 2009).

Strategies to address the problems caused by biological invasions need to begin by educating people on the value of native biodiversity. At the same time, agencies can provide education on exotic species, not only on the problems that invasive species pose to native ecosystems, culture and economy (Pfeiffer & Voeks, 2008), but also on the positive impacts of a small number of exotic species. In a scenario of declining conservation budgets, efforts dedicated to environmental conservation are increasingly being redirected to actions that either produce clear (and immediate) benefits or that do not entail costs (Kareiva *et al.*, 2014). Conservation actions are also likely to be focussed increasingly on responses to climate change, for which suggested mitigation strategies include the controversial technique of assisted colonisation (Hoegh-Guldberg *et al.*, 2008; Loss *et al.*, 2011; Ricciardi & Simberloff, 2009; Wiegand *et al.*, 2005) – essentially, the introduction of exotic species for conservation purposes. Unfortunately, the consequence of these policies on exotic species management is that they are likely to enhance the chances of establishment and spread of new species. This will be particularly true for exotic bird species, for which we currently have little knowledge of the long-term impacts on environmental and human wellbeing (Baker *et al.*, 2014; Kumschick *et al.*, 2013; Shirley & Kark, 2009).

In a nutshell

- Since the earliest of times, civilisations have translocated bird species, both domesticated and non-domesticated, as sources of food, for ornamentation, for game hunting, or as pets.
- There are two distinct periods of major activity in the transportation of bird species: (1) the era of the Acclimatisation Societies, during the great European diaspora between the eighteenth and twentieth centuries; and (2) the era of the international trade in wild birds for bird-keeping from the late-twentieth century to the present.
- The direction of introductions has reversed between the two main periods of bird transportation: from the European 'motherland' to the colonies in the era of the Acclimatisation Societies (birds from Europe introduced to America, Australasia and Africa), to transport from the former colonies to the Old World (birds from South America, Africa, southeast Asia and Oceania introduced to Europe, continental Asia and North America) in the era of international trade.
- The legal international trade in birds has recently been curtailed in developed countries by legislation to restrict the distribution of avian infectious diseases.
- An enormous trade and economy still exists around keeping cage-birds, particularly in developing countries such as Brazil, Mexico and South Africa, and across China and southeast Asia.
- It is likely that the accidental establishment of new species in these regions will increase and may even exceed the rates of introduction during the era of the intentional introductions of the Acclimatisation Societies.

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