Migratory songbirds in the East Asian-Australasian Flyway: a review from a conservation perspective

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Summary

The East Asian-Australasian Flyway supports the greatest diversity and populations of migratory birds globally, as well as the highest number of threatened migratory species of any flyway, including passerines (15 species). However it is also one of the most poorly understood migration systems and little is known about the populations and ecology of the passerine migrants that breed, stopover and winter in the habitats along this flyway. We provide the first flyway-wide review of diversity, ecology, and conservation issues relating to 170 species of long-distance and over 80 short-distance migrants from 32 families. Recent studies of songbird migration movements and ecology is limited, and is skewed towards East Asia, particularly China, Taiwan, Russia, Japan and South Korea. Strong evidence of declines exists for some like Yellow-breasted Bunting (*Emberiza aureola*), but tends to be fragmentary, localised or anecdotal for many others. More species have small breeding ranges (<250,000km^2) and/or are dependent on tropical forests as wintering habitat than any other Eurasian migratory system, and are thus more vulnerable to habitat loss and degradation throughout their ranges. Uncontrolled hunting for food and the pet trade, invasive species and collisions with man-made structures further threaten migratory songbirds at a number of stopover or wintering sites, while climate change and habitat loss may be of increasing concern in the breeding ranges. A key conservation priority is to carry out intensive field surveys across the region while simultaneously tapping into citizen science datasets, to identify important stopover and wintering sites, particularly for poorly-known or globally threatened species across South-East Asia and southern China for targeted conservation actions. Additionally, the advent of miniaturised tracking technology, molecular and isotopic techniques can provide novel insights into migration connectivity, paths and ecology for species in this migration system, complementing data from banding exercises and observation-based surveys, and could prove useful in informing conservation priorities. However, until most states along the East Asian-Australasian flyway ratify the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and other cross-boundary treaties, the relative lack of cross-boundary cooperation, coordination and information sharing in the region will continue to present a stumbling block for effective conservation of migratory passerines.

Keywords

Songbirds, habitat loss, hunting, wintering range, long-distance migrants, East Asian Flyway, South-East Asian tropics, birdwatchers

Introduction

Annually, an estimated four billion migratory birds (Newton 2007), the majority of which are passerines or songbirds, migrate from temperate Eurasia to lower latitudes in Africa and Asia during the boreal winter, with some 2.1 billion bound for Africa alone (Hahn *et al*. 2009). Traditionally, the African-European, and Nearctic-Neotropical migratory systems as well as the ecology of its constituent species have been relatively well studied given the long history of ornithology in Europe, Russia and North America, and have been the focus of multiple reviews (see Moreau 1972, Dolnik 1987, Rappole *et al*. 1983, Bolshakov 2001). Although detailed life history studies of some species in their breeding ranges in East Asia exist (e.g. Wang *et al*. 2006b, Imanishi *et al*. 2009, Gluschenko *et al*. 2011), the migration connectivity, strategies, wintering distributions and ecology of many long-distance passerine migrants in the East Asian migration system remain poorly understood (Greenberg & Marra 2005, Nam *et al*. 2011, Moores 2012). This is despite their ecological significance in *both* temperate and tropical biomes, given their abundance and roles in trophic (e.g. herbivory, predation) and transport processes (e.g. nutrient, parasites) (Bauer & Hoye 2014). Much of what is known about songbird migration ecology come from birdwatcher observations (e.g. Anon 2007, Round 2010, Emmanuel & Yordan 2013, Li *et al*. 2013), large-scale but localised bird banding studies (Komeda & Ueki 2002, Du *et al*. 2006, Kwon *et al*. 2007, Round *et al*. 2007, Gluschenko *et al*. 2010, Pronkevich 2011, Heim *et al*. 2012) and incidental observations on ships (Abe & Kurosawa 1982, Ellis *et al*. 1990, Choi 2004, Mizuta *et al*. 2009). Furthermore, the publication of much ornithological research in East Asia in vernacular languages (e.g. Russian, Chinese, Korean and Japanese), and in local journals has rendered much material inaccessible to western researchers.

In the 1970s, the Migratory Animal Pathological Survey (MAPS) added considerable knowledge on the migration routes and survival of many species through its extensive ringing operations which banded over 1.2 million wild birds across India, East and South-East Asia (McClure 1974). However the project was designated primarily to understand pathogenic transmission by migratory wild birds (McClure & Ratanawarabhan 1973, McClure 1974), and was later discontinued. Similarly, many later studies of migratory birds, particularly waterbirds were driven by interest in Avian Influenza surveillance (e.g. Valchuk & Huettmann 2005, Liu *et al*. 2011, Sivay *et al*. 2012). Subsequently, a combination of factors including technological and logistical limitations, charisma value and rapid wetland conversion across East Asia meant that much migratory bird research in the countries within the East Asian-Australasian Flyway is skewed towards large-bodied waterbirds, ducks, waders, cranes (e.g. Higuchi 2011) and more recently, birds of prey. Conservation initiatives and collaborations in the region (e.g. Partnership for the East Asian-Australasian Flyway) are also designated primarily to conserve migratory waterbirds like Black-faced Spoonbill (EAAFP 2012, Yu *et al*. 2013). By contrast, there is limited research on the migration patterns, connectivity and strategies of many songbirds, or their status in the wintering ranges (e.g. Black-throated Blue Robin *Luscinia obscura* as highlighted in Song *et al*. 2013). For instance, Wang *et al*. (2006a) noted only 10 publications on songbird migration in China between 1924 and 1989, and none on stopover ecology of songbird migrants. Moreover, the fact that many songbirds are too small for conventional tracking devices, mostly migrate nocturnally and often across open stretches of sea (Berthold 1993, Newton 2007, McKinnon *et al*. 2013) makes this even more challenging to study.

In recent years, the technology to study songbird migration has rapidly advanced and is now available as lightweight, light-level geo-locators, complemented by molecular techniques and stable isotope analysis, all which are increasingly being used in North America and Europe (e.g. Chabot *et al*. 2012, McKinnon *et al*. 2013), However, there are hitherto no published studies of passerine migrants in East Asia using these methods. Existing field-based studies of summer-breeding passerine migrants, at least in Japan (e.g. Yamamoto & Seto 1997, Higuchi & Morishita 1998, Kurosawa & Askins 2003, Namba *et al*. 2010) and Fennoscandia (Dale & Hansen 2013) underscored a lack of knowledge on how habitat loss and hunting in south China and South-East Asia may have impacted wintering songbirds, many which are also affected by habitat loss and degradation in their breeding ranges (Kurosawa & Askins 2003). Others like Amano & Yamaura (2007) and Yamaura *et al*. (2009) have identified long-distance migration to the tropics as an ecological attribute linked to declining songbird species, at least in Japan. Some declines have been identified for summer-breeding passerine migrants in Finland, especially species that winter in south China (e.g. Rustic Bunting *Emberiza rustica*) (Dale & Hansen 2013, Laaksonen & Lehikoinen 2013).

In general, the paucity of long-term data collected over large spatial scales (see Moores 2012), particularly in South-East Asia, has prevented population trends and rates of decline of songbird migrants in the East Asian migratory system from being easily identified, as has been done in Europe (Sanderson *et al*. 2006, Vickery *et al*. 2014). However, increasing evidence of climate change impacts on African-European migrants (e.g. European Pied Flycatcher *Ficedula hypoleuca*) (Both *et al*. 2010), migration timing perturbations in some East Asian migrants (Harris *et al*. 2013), a continued loss and degradation of temperate (Kurosawa & Askins 2003) and Taiga forests, especially in the Russian Far East (Kondrashov 2004) and north-east China (Chen *et al*. 2003), and rapid deforestation in tropical, non-breeding areas (Wang *et al*. 2006a, Sodhi *et al*. 2010), indicates that it is timely to re-evaluate the conservation status of migratory songbirds in the East Asian migration system.

Since the importance of the East Asian-Australasian Flyway by waterbirds and its associated conservation issues are well addressed in the existing literature (e.g. Higuchi *et al*. 2005, Crosby & Chan 2006, Cao *et al*. 2008, Higuchi 2013), we aim to summarise recent knowledge on migratory songbirds in this flyway, and highlight conservation issues to songbirds in this migratory system. First, we reviewed the literature on published studies describing migratory songbirds, particularly that in local journals published in South Korea, Japan, China and the Russian Far East. Second, we describe avian diversity, distribution, wintering ecology and the conservation status of migratory songbirds that use the East Asian-Australasian Flyway, and compare this with the better known Western Palearctic-African (African-European) migration system which mirror East Asia in many bird families and genera. Third, we identified and discussed key threats faced by migratory songbirds in the Flyway, particularly species wintering in tropical south China and South-East Asia. We conclude by highlighting research and conservation directions that can improve the conservation of songbird migrants in the East Asian migratory system.

Methods

Definition of geographical scope

Asia is the largest and most important continent for migratory birds globally in terms of total abundance and diversity. Much of the continent overlaps with the Palearctic, the world's largest biogeographic region, and which is often subdivided into multiple subregions depending on the biota and geographical contexts used. Our review focuses on the East Asian-Australasian Flyway (Figure 1), which overlaps with all of East and South-East Asia, north-eastern India (e.g. Arunachal Pradesh) and Bangladesh. In our review, we defined 'East Asia' as the Asian continent east of Transbaikal Russia (c. 105° E), south to the eastern margin of the Qinghai-Tibetan Plateau and eastern Himalayas, which encompasses Brazil (2008)'s definition of 'East Asia'. The tropical regions of eastern Asia which are sometimes collectively defined as 'tropical East Asia' (Corlett 2009) extend from much of China south of the Yangtze River (c. 30° N) to all of political South-East Asia west of New Guinea. While we did not consider north-eastern India and Bangladesh in this review, we acknowledge that many wintering songbirds there are shared with South-East Asia. In classifying bird species as long or short distance migrants, and identifying their wintering grounds, we used the distribution maps and descriptions provided in Brazil (2008) for eastern Russia, Japan, Korea and China, Coates & Bishop (1997) for Sulawesi, the Moluccas and Lesser Sundas, Coates & Peckover (2001) for New Guinea, Kennedy *et al*. (2000) for the Philippine Archipelago, Knytaustas (1993) for Russia, MacKinnon & Phillipps (1993) for Borneo, Sumatra and Java, MacKinnon & Phillipps (1999) for east-central China, Wells (2006) for the Thai-Malay Peninsula, and Robson (2000) for mainland South-East Asia, in corroboration with range information available on 'datazone', the online BirdLife International database (BirdLife International 2013), the Xeno-canto bird sound database (www.xeno-canto.org) and data reviewed in Irwin & Irwin (2005). We rechecked the distribution of all songbird species in our review based on our data as we have field experiences with nearly all migratory songbird species in the flyway.

Compilation of dataset

In our review, we divide tropical East Asia, an important region for wintering songbirds, into six subregions of broadly similar climate and vegetation cover, namely: South China (south of the Yangtze River), mainland South-East Asia, Thai-Malay Peninsula, Greater Sundas, Philippines and Wallacea. Mainland South-East Asia largely follows that as defined in Robson (2000) which includes collectively the territories of Myanmar, Thailand, Lao PDR, Cambodia and Vietnam, but excludes the Thai-Malay Peninsula which is biogeographically Sundaic. Wallacea follows that as defined by Coates & Bishop (1997) and includes Sulawesi, the Lesser Sundas and the Moluccas. We omitted Australia, New Guinea and other Melanesian islands because most migratory songbirds there are either stragglers or vagrants (see Coates & Peckover 2001, Dingle 2004). Bird species are classified as latitudinal migrants if there is published evidence to show that they occur seasonally in one region as breeders, and regularly (autumn-winter) in a region of lower latitude as non-breeders. For instance, Siberian Blue Robin (*Luscinia cyane*) is considered a regular wintering migrant in the Thai-Malay Peninsula and the Greater Sunda islands based on the literature (Wells 2006, Jeyarajasingham & Pearson 2012), range descriptions in available databases and our field experience, while the paucity of records of Yellow-breasted Bunting (*Emberiza aureola*) from the same region indicates that it is not a regular winter migrant. The species-level taxonomy and nomenclature used in our review is based on that in the BirdLife checklist v. 6.1 (http://www.birdlife.org/datazone /info/taxonomy), from which we also compiled information on a species' breeding range size (in km^2), overall population trends (stable, decreasing or increasing) and the presence of at least one migratory population in the review region. For family-level taxonomy, we chose to adopt that of the International Ornithologists' Union (Gill & Donsker 2013) to be in line with recent advances in avian phylogeny, but not expected to have significant influence on the conservation status of individual species. Given incomplete knowledge of the breeding ranges of many species in East Asia and errors in range estimates for some species (e.g.

Arctic Warbler *Phylloscopus borealis*), we classified the breeding range data into size categories from 'tiny' to 'continental' to minimise the influence of these errors.

Since not all species of songbirds in the region are long-distance migrants, we only consider a songbird species a long-distance migrant if 1) at least one, some or all populations are known to migrate to lower latitudes in temperate East Asia (e.g. Lapland Longspur *Calcarius lapponicus*), tropical Southeast Asia (e.g. Common Stonechat *Saxicola torquata*) or a combination of both (e.g. White Wagtail *Motacilla alba*), and if 2) the species have at least one, some or all known populations breeding in Arctic East Asia (e.g. Asian Rosy-finch *Leucosticte arctoa*), temperate East Asia (Mugimaki Flycatcher *Ficedula mugimaki*) or mainland South-East Asia (Blue-winged Pitta *Pitta moluccensis*) (see online Supplementary Materials). Therefore, long-distance migrants in our review also include species termed as 'boreal' and 'intra-tropical' migrants in Kirby (2010). Species that are recognised as stragglers into our region of review but with significant, if not entire breeding populations (e.g. Large-billed Reed-warbler *Acrocephalus orinus*) outside are excluded, as are species with breeding populations but overwinter outside of the region (e.g. Northern Wheatear *Oenanthe oenanthe*).

Importance of East Asian-Australasian Flyway to migratory birds

(Figure 1)

Boere & Stroud (2006) defines a 'flyway' as the entire geographical range of a species, or aggregations of related species within which populations migrate from breeding to non-breeding areas. Although the flyway approach provides a useful generalisation for most (but not necessarily all) species that migrate within, Kirby (2010) acknowledged the usefulness of the 'flyway' concept in organising conservation actions between multiple countries. Using flyway definitions commonly used for waterbirds (Boere & Stroud 2006, Kirby 2010), up to five flyways overlap with Asia. The East Asian-Australasian Flyway (Figure 1) encompasses all of East Asia, South-East Asia, northeast India, Australia, the west Pacific islands and parts of Alaska (see Alerstam *et al*. 2008) and overlaps with the territories of 22 countries (EAFFP 2012). This migration system is recognised as the most species-rich flyway globally, hosting approximately 477 species of land birds and a further 201 waterbirds (Kirby *et al*. 2007), with increasing diversity and proportion of migrating species as latitude increases from its equatorial regions to northern Siberia (Kuo *et al*. 2013). The Flyway is especially important for waterbirds, of which more species, and species of conservation concern occur here than any other migration system (Crosby & Chan 2006). Not surprisingly, much of the research (e.g. Cao *et al*. 2008, Amano *et al*. 2010) and conservation directions for the East Asian-Australasian Flyway to date (EAAFP 2012) has focused on shorebirds, cranes (e.g. Shiu *et al*. 2006), birds-of prey (e.g. Germi *et al*. 2009, Higuchi 2013) and waterfowl, due largely to interest in migratory bird transmission of Avian Influenza (e.g. Zhao 2006, Cheng *et al*. 2011, Sivay *et al*. 2012). Despite this, it is still widely recognised as one of the World's most poorly understood flyway (Newton 2007).

(Table 1)

(Figure 2)

(Table 2)

In our review, we identified at least 254 species of songbirds that undertake some latitudinal migration in the East Asian-Australasian Flyway (see online Supplementary Materials). The majority (170 species or 67%) are long-distance migrants of which about 155 species have breeding populations in temperate/arctic East Asia. At least 83 additional species are short-distance migrants, many also altitudinal migrants that descend the Tibetan Plateau, eastern Himalayas and the region's uplands into nearby lowlands of central, east and south China, north-east India and mainland South-East Asia during winter. Given ongoing taxonomic revisions based on modern phylogenetic tools, it is certain that the total diversity of migratory songbirds recognised for this Flyway will increase, with some taxa having smaller distributions than before when consensus on certain species complexes (e.g. Lobkov 2011, Alström *et al*. 2011, Leader & Carey 2012) is achieved.

The 170 species of long-distance songbird migrants identified include, 1) species that breed in Arctic Russia, west Alaska and overwinter in temperate East Asia, 2) species that breed in temperate East Asia and Subarctic Russia that winter in the Asian tropics and/or the lower latitudes of East Asia or, 3) species that are 'intra-tropical migrants' that breed within the northern tropics and winter at equatorial latitudes. Temperate East Asia, which includes the eastern Russia from Transbaikalia to Yakutia, Chukotka and the Russian Far East, eastern Mongolia, northern China, the Korean Peninsula and the Japanese archipelago supports about 55 wintering species, and is especially important for granivorous migrants like buntings and finches. In the East Asian tropics, diversity of wintering songbirds is highest in southern China and mainland South-East Asia (Table 2, Figure 2), and decreases eastwards to the Philippine Archipelago and Wallacea. Collectively, Sulawesi, the Moluccas and Lesser Sundas support only 16 regular songbird migrants and no species reach continental Australia as regular winterers (Dingle 2004). New Guinea supports only about five wintering Palearctic songbirds. Similarly, few other non-passerine landbird migrants (i.e. cuckoos) reach New Guinea or Australia as regular wintering species (Dingle 2004). Consequently, the East Asian-Australasian Flyway is probably more appropriately termed as the 'East Asian' flyway, at least in the context of songbirds.

Taxonomic diversity of songbirds in the East-Asian Flyway

Most landbird migrants in the East Asian migration system are songbirds, with at least 254 species from 32 families (Table 1, see online Supplementary Materials), of which at least one population undertakes seasonal latitudinal migration. Of 170 long-distance migrants, 129 species have populations that overwinter in the tropics, with the greatest diversity of wintering songbirds in mainland South-East Asia (111 species) and southern China (101 species) (Table 2, Figure 2). This is a much higher total compared to West and East Africa (see Morel & Morel 1992, Pearson & Lack 1992), which when collectively considered, only supports 83 species from 14 families in a larger area.

The two East Asian families with the greatest diversity of migrants are the insectivorous Muscicapidae (flycatchers and chats) and Phylloscopidae (leaf warblers), of which the majority of constituent species are long-distance, tropical migrants. Both families are also well-represented in tropical Africa as migrants (Figure S3, see online Supplementary Materials), which supports at least 23 Muscicapid species although only four species of leaf warblers winter there. Additionally, Emberizidae (buntings) and Fringillidae (finches) are well-represented in the East Asian Flyway but the majority of species winter in temperate East Asia. For example, 14 of 22 buntings overwinter in temperate Asia while no species winter in the Thai-Malay Peninsula or the Greater Sundas. Similarly, finches are well-represented in temperate East Asia with at least 16 wintering species. These geographical patterns of winter distribution across migratory songbirds of different dietary guilds are likely to be tied to spatiotemporal variation of food resources in winter. Particularly, distributions of ectothermic arthropods are strongly influenced by temperature and are thus more abundant in warmer areas (Shiu & Lee 2003) at lower elevations and latitudes. Insectivores like *Phylloscopus* warblers migrate further south into the tropical belt where insect abundances are higher (Newton 2007), while granivores like buntings and finches can still forage for seeds in coniferous forests and woodland in temperate Asia during winter.

(Figure 3)

Songbird migration across the East Asian Flyway

Long-distance migrants which form the majority of songbird migrants include species with at least one (incomplete migrant), or all populations (complete migrant) that travel from temperate breeding grounds to tropical wintering grounds, or within temperate areas but at lower latitudes prior to the boreal winter. Populations of a few species of long-distance migrants (e.g. Lapland Longspur, Asian Rosy-finch) fly from breeding grounds above the Arctic Circle to overwinter in relatively warmer, temperate areas in East Asia (e.g. eastern China, Japan) (see Brazil 2009). Furthermore, some species with distributions that straddle temperate and tropical regions may have non-migratory and migratory populations (e.g. Asian Paradise-flycatcher *Terpsiphone paradisi*), resulting in leapfrog migration patterns.

A minority of the migratory songbirds in the Eastern Palearctic are recognised as short-distance migrants, especially species occurring at subtropical latitudes, high elevations and some granivorous temperate species (e.g. finches). Many species that breed in the high-elevation forests of the Eastern Himalayas, Tibetan Plateau, central China or northern Southeast Asia are short-distance and/or altitudinal migrants that descend to overwinter in the riverine plains of South-East Asia, especially that along the upper Ayeyarwaddy (see Tordoff *et al*. 2007) and northeast India, the Himalayan foothills and other habitats at lower elevations in mainland South-East Asia and south China (Luo *et al*. 2014). These short-distance migrants include many chats, thrushes and flycatchers.

In general, the migration routes taken by these songbirds are diverse, but are undertaken during both day and night and on broad fronts (Bruderer 1997, Chernetsov 2012, Moores 2012), sometimes involving large water crossings, especially for species breeding in the Alaskan Taiga, Sakhalin Island, Japan, Taiwan and islands in the Yellow Sea (e.g. Mizuka *et al*. 2009), species wintering in the islands of South-East Asia (e.g. Gibson-Hill 1950, Simpson 1983a, Ellis *et al*. 1990), or when migrating across mountainous regions (e.g. Du *et al*. 2006, Han *et al*. 2007). Moreover, migratory landbirds may be concentrated into bottlenecks of land and islands if sea crossings are involved. This is corroborated by observations of large concentrations of landbird migrants on particular small Yellow Sea islands like Socheong-do, Eocheong-do, Hong-do and Heuksan-do in Korea, as well as Hegurajima and the Ryukyu Islands in Japan (Kuroda 1971, Kim & Yoo 2010, Nam *et al*. 2011, Moores 2012) and in South-East Asia (e.g. Chasen 1932, McClure 1974). In South China in Yunnan, Jiangxi and Hunan provinces (Tang *et al*. 2003, Xiao *et al*. 2005, Han *et al*. 2007), and on the Thai-Malay Peninsula (Chasen 1932, McClure 1974), extensive nocturnal trapping exercises have also revealed details on the migratory dynamics of night-flying songbirds as they cross mountainous barriers, particularly the influence of weather conditions on migration (Yang *et al*. 2009).

(Figure 3)

Breeding and wintering ranges of migratory songbirds

Unlike songbirds breeding in temperate Europe and North Africa, many which have relatively large ranges extending into Central Asia and the Middle East (e.g. Common Nightingale *Luscinia megarhynchos*), East Asian migratory songbirds have generally smaller ranges. We found that breeding range sizes of long-distance migrants wintering in South-East Asia differed significantly from European species wintering in the Afrotropics (Z = -3.9432, Mann-Whitney U = 4762.5, $p < 0.001$) (Figure 3). 25 species of summer breeding songbirds in East Asia have small breeding ranges of less than 250,000 km^2, (Figures 3 and 4) compared to only five such species wintering in the Afrotropics. The insular geography of temperate East Asia, especially Sakhalin Island, the Japanese archipelago and a number of small island groups in the Yellow, East China Seas and the Sea of Japan (also known as the East Sea) has contributed to the evolution of a number of breeding endemics with relatively small ranges (Moores 2012), including Japanese Robin (*Luscinia akahige*), Pleske's Grasshopper-warbler (*Locustella pleskei*) and Sakhalin Leaf-warbler (*Phylloscopus borealoides*). Among these, some species have entire breeding ranges confined to a few small islands, notably Izu Leaf-warbler (*P. ijimae*) (Brazil 2009). Their relatively small populations indicate that these narrow-ranged species are likely to be more sensitive to threats at stopover or wintering sites.

(Figure 4)

There are few published data on the wintering distribution of many migratory songbirds in the Flyway and the entire wintering range of some species was unknown until recently (e.g. Sakhalin Leaf-warbler) (Yap *et al.* in press). However, the insular geography of much of South-East Asia implies that many species have naturally disjointed wintering populations spread across multiple landmasses, while a few have most, if not the entire wintering populations concentrated into one island. For instance, the abundant Siberian Blue Robin is known to winter across mainland South-East Asia, the Thai-Malay Peninsula, Sumatra, Borneo (Robson 2000, Wells 2006), including even small islands in the Riau Archipelago off Sumatra (Yong, D.L. unpublished data). Conversely, the entire population of the Fairy Pitta (*Pitta nympha*) is thought to winter only in Borneo (BirdLife International 2013).

There are also migratory songbirds that winter exclusively along the East Asian flyway, but draw from populations widely distributed across temperate Eurasia. The best example is the widespread Arctic Warbler (*P. borealis*), which breeds across the Russian Taiga to Fennoscandia (Laaksonen & Lehikoinen 2013), and across the Bering Sea into Alaska (Alerstam *et al*. 2006). The global population of this species is concentrated mostly into southern China, mainland South-East Asia, the Thai-Malay Peninsula, Philippines and the Greater Sundas in winter (BirdLife International 2013), and wintering Arctic Warblers can occupy diverse habitats from urban greenery, mangroves to evergreen forests to montane elevations (Robson 2000), and at relatively high densities (McClure 1967, Yong *et al*. 2013). While the migration routes, wintering ecology and distribution of each taxonomic unit remains poorly known, its abundance and high detectability indicate that Arctic Warblers may be a suitable model species for studying long-distance passerine migration between temperate Eurasia and the East Asian tropics.

Migration songbirds at stopover sites on the East Asian Flyway

East Asia

East Asia's habitats provides an important 'connecting region' in the form of staging or stopover sites for migrating songbirds moving between the temperate breeding and tropical wintering grounds for resting and refuelling, and which are critical to the life history and survival of these migrants (Bairlein 1985, Ma *et al*. 2005). Although stopover ecology has been less studied here than in Europe (see Chernetsov 2012), there is growing number of studies, in addition to a long history of regular bird banding exercises to document bird migration, especially in Japan (e.g. Yoshii *et al*. 1989, Komeda & Ueki 2002, Ozaki 2008), South Korea (e.g. Won *et al*. 1966) and China where a 30-year old national bird banding program exists (Wang *et al*. 2006a). Similar bird banding programmes also exist in the Russian Far East (e.g. Valchuk *et al*. 2005, Pronkevich *et al*. 2007, Heim *et al*. 2012). Socheong-do, Oeyeon-do, Eocheong-do, Heuksan-do and Hong-do islands in the Yellow Sea are particularly well-studied by South Korea-based researchers and much has been learnt on diverse aspects of seasonal migratory patterns (Park *et al*. 2008, Kim 2009, Won *et al*. 2010, Moores 2012, Choi *et al*. 2013), stopover mortality (Bing *et al*. 2013) and migration strategy (Nam *et al*. 2011). In Japan, species-specific studies like Nakamura & Ishizawa (1965) has documented migratory timings and speed for Gray's Grasshopper-warbler (*Locustella fasciolata*) through Honshu, as well as migration flocking behaviour. These studies revealed that migrants suffered high mortality rates during stopover, which arose from man-made causes including window strikes and predation by feral cats (*Felis catus*) (Bing *et al*. 2012), migrating raptors (Ellis *et al*. 1990) and other migrating songbirds (Hong *et al*. 2010).

There are fewer stopover ecology-type studies in mainland China or Taiwan, but those that exist are useful in understanding the migration ecology of some of the more abundant songbirds in the flyway. In Taiwan, Severinghaus (1996) sampled Brown Shrikes (*Lanius cristatus*), an abundant passage and wintering species at suburban sites and showed that the species experience heavy competition for hunting territories, resulting in territorial compressions. According to this study, 24% of transient Brown Shrikes passed before wintering birds arrived, thus avoiding competition, while territorial behaviours were very evident between birds present. In north China, Wang *et al*. (2006a) sampled Orange-flanked Bush-robin (*Tarsiger cyanurus*) at a stopover site in Heilongjiang and was able to document mass gains in birds on passage, as well as evidence of differential arrival timings of males and females, a pattern that might indicate temporal partitioning to reduce competition. Age or sex-related temporal partitioning within species as shown in Wang *et al*. (2006a) in China and Nam *et al*. (2011) in Korea, or between ecologically similar species can minimise competition during stopover, and may also result from differential latitudes of breeding range, as suggested in Imanishi *et al*. (2009) which studied autumn migration timings of three *Phylloscopus* warblers in Japan.

In the Russian Far East, the increasing numbers of surveys and bird ringing exercises are beginning to reveal the pathways, abundance, diversity and stopover ecology of songbird migrants that pass study sites there, especially in the Lower Amur region in Primorsky, Khabarovsk and Amur oblasts (e.g. Valchuk & Huettmann 2006, Gluschenko *et al*. 2007, Pronkevich *et al*. 2007, Pronkevich 2011, Heim *et al*. 2012). Bird ringing work at the well-studied Muraviovka Park, for instance has established it as a site of importance to songbirds on migration across the Amur region in autumn. Data from bird ringing at Muraviovka Park has allowed stopover timings for various species to be established and may be as short as one day for the Yellow-throated Bunting (*Emberiza elegans*) to more than two weeks for species like the Pallas's Bunting (*E. pallasi*) (Heim *et al*. 2012). Other studies like Valchuk *et al*. (2006) have established multiple migration routes of the Rustic Bunting connecting stopover sites in the Russian Far East and parts of Japan.

South-East Asia

Migratory songbird ecology in passage or stopover habitats (Ruth *et al*. 2012), and South-East Asia in particular remain poorly known (e.g. Mahood *et al*. 2013b). Ever since the extensive banding studies in the 1970s (e.g. McClure 1974) and bird surveys in Straits of Malacca islands (e.g. Gibson-Hill 1950), there are few recent studies examining aspects of stopover ecology of migratory songbirds in the East Asian tropics. Anecdotal observations and studies based on birdwatching data suggest that some species exhibit differential passage peaks during migration (e.g. Round 2010), used a relatively large breadth of habitats during stopover, including poor quality or small habitat patches on islands and in built-up areas (e.g. Anon 2007, Yong & Liu, in press) and suffered high mortality due to predation by migrant hawks (e.g. Ellis *et al*. 1990). For instance, Round (2010) analysed long-term birdwatching records of three migratory songbirds (Tiger Shrike *Lanius tigrinus*, Mugimaki *Ficedula mugimaki* and Yellow-rumped Flycatcher *F. zanthopygia*) on passage across Thailand and found differential passage timing peaks for three species, as well as differential arrival timings of male and females, suggesting protandrous migration patterns. Mahood *et al*. (2013b) reviewed passage records of songbirds in northern Vietnam and documented many species stopping over in apparently poor-quality urban habitats, especially in Hanoi city. Yong & Liu (in press) examined temporal variation of records of Brown-chested Jungle-flycatcher (*Rhinomyias brunneatus*) at stopover sites in Singapore over October-November and reported relatively high densities of the species across a habitat gradient from poor (secondary scrub) to good quality primary forest habitat, suggesting that stopover habitat quality may have less impact on transient birds.

Use of wintering habitats by migratory songbirds

Overview

Almost all terrestrial habitats across East and South-East Asia are used by wintering songbirds to some extent. Habitat use varies with species, with generalists like the Arctic Warbler occurring across a gradient of habitats, while species with narrower niches (e.g. forest, wetland specialists) occur mainly in limited habitat types (Johnson *et al*. 2006). Regular assemblages of migratory songbirds that form in wintering sites can attain relatively high densities and species richness (e.g. Karr 1976), with as many as 15 species in some lowland rainforests in the Thai-Malay Peninsula (Table 3). What remains unclear is how wintering songbird communities exploit, partition resources or interact with other species, as well as the demographic patterns within the wintering populations (e.g. Ornat & Greenberg 1990).

Agricultural land and urban areas

Cultivated land, which currently covers 48.2% of land area across East Asia (The World Bank database accessible at http://data.worldbank.org) is important to many species of wintering songbirds that otherwise depend on open country or scrub habitat, particularly some *Phylloscopus* and *Locustella* warblers, buntings, redstarts, shrikes and wagtails (e.g. Moores 2013), and may be increasingly so if other wintering habitats like forests are cleared (Johnson *et al*. 2006). However, farming intensity, farming methods, season and crop types (e.g. Dänhardt *et al*. 2010) are all likely to influence the composition of wintering songbirds therein, given species-specific habitats preferences and habitat breadths. Many shrikes, larks, wagtails, pipits and buntings have broad habitat preferences and may occur across a mosaic of agricultural landscapes while some species are dependent on finer-scale habitat features like presence of water bodies, shade or extent of shrub cover. Some *Locustella* warblers and buntings, for example, are associated with wetter habitats like flooded grassland and can utilise cultivated land like paddy fields (e.g. Fujioka *et al*. 2010).

Paddy fields, which are among the best sampled agricultural landscapes for wintering migrant birds in East Asia support six songbirds in Japan and Korea during winter, and a number of breeding migrants in summer (Fujioka *et al*. 2010, Stafford *et al*. 2010). In subtropical Hong Kong, studies using birdwatching data and regular surveys, like Carey *et al*. (2001) suggest that remnant paddy fields are important for wintering buntings and Common Stonechat (*Saxicola torquatus*). On the other hand, Azman *et al*. (2011) found few migratory songbirds in Peninsular Malaysia paddy fields, including the Barn Swallow (*Hirundo rustica*) and Brown Shrike.

Oil Palm plantations which increasingly cover much of Sundaic South-East Asia (Fitzherbert *et al*. 2008) support few migratory songbirds, and lack species dependent on forests like Siberian Blue Robins, as shown by Azman *et al*. (2011). Similarly, urban areas are also generally poor in wintering migrant bird diversity and abundance. Zhou *et al*. (2012) sampled bird diversities in Hong Kong and found few species of wintering songbirds in urban parks, and those that occurred were at lower densities than in secondary forests. No migrant species for example were among the top 10 most abundant species in urban parks, but Lemon-rumped Warbler (*Phylloscopus proregulus*), Inornate Warbler (*P. inornatus*) and Grey-backed Thrush (*T. hortulorum*) were among the most abundant birds in secondary forests in winter (Zhou *et al*. 2012). In urban areas in Singapore and Peninsular Malaysia, only two species regularly utilise urban parkland (Yong *et al*. 2013), notably Arctic Warbler and Asian Brown Flycatcher (*Muscicapa dauurica*).

(Table 3)

Natural wetlands

Natural wetlands, which include riparian forests, seasonally-flooded grasslands, freshwater marshes and coastal (salt) marshes are important wintering habitats for many long-distance migrants like swallows, buntings, *Acrocephalus* and *Locustella* warblers, *Luscinia* and *Saxicola* chats, and Chinese Penduline-tit (*Remiz consobrinus*) (e.g. Nisbet & Medway 1974, Carey *et al*. 2001, Gan *et al*. 2010). Even newly formed coastal wetlands can attract wintering buntings, warblers and robins, as shown by surveys of wetland on shoals in the Yangtze Estuary (Ma *et al*. 2007). Many species of robins, redstarts, shortwings and flycatchers that breed at high elevations in the Eastern Himalaya and mountain ranges of south-central China (e.g. Qinling and Sichuan mountains) also descend into the riparian wetlands of northern Myanmar, Thailand and northeast India in winter (see Rasmussen & Anderton 2005, Tordoff *et al*. 2007, Song *et al*. 2013), including two poorly known chats (i.e. Firethroat *Luscinia pectardens*, Black-throated Blue Robin [*L. obscura*])

Much knowledge on the usage and distribution of wintering songbirds in wetlands are based on birdwatching data, field surveys, past (e.g. Nisbet & Medway 1974, McClure 1974) and ongoing banding exercises (e.g. Round & Rumsey 2003, Round & Fisher 2009). McClure (1974) for example, banded hundreds of thousands of swallows and other wintering songbirds, including many Reed Warblers in reed beds fringing the Bung Boraphet Lake in central Thailand during the MAPS project. Recent surveys in riparian habitats and wetlands along the tributaries of the upper Ayeyarwaddy, northern Myanmar by Tordoff *et al*. (2007) also documented a number of long-distance migrants wintering there, including short-distance and altitudinal migrants like the Rusty-bellied Shortwing (*Brachypteryx hyperythra)*. Increasingly polluted, overfished, converted for agriculture or threatened by hydrological impacts of damming, some of the most important examples of large natural wetlands for wintering songbirds in the region include Chiang Saen and Bung Boraphet lakes in Thailand, wetlands fringing the Tonle Sap lake in Cambodia, riparian grassland and oxbow lakes along the upper Chindwin in Myanmar, the Dongting and Poyang lake systems of the Lower Yangtze floodplain, and coastal marshes on the Yangtze Estuary and Jiangsu-Zhejiang coast in China.

(Figure 5)

Forests

Broadleaved evergreen and mixed forests are of major importance as wintering habitats for migratory songbirds across south China and South-East Asia, and significantly more so compared to the Afrotropics (Figure 5) (e.g. Karr 1976). Compared to tropical Asia, many authors acknowledge that wintering songbirds in Africa are less forest-dependant (e.g. Moreau 1972, Morel & Morel 1992, Pearson & Lack 1992) despite the large extent of west, central and east African rainforest blocks (Malhi *et al*. 2013).

We identified over 50 migratory songbird species in South-East Asia that are dependent on broadleaved evergreen forests as wintering habitat, a proportion significantly higher than that of migratory songbirds using in the Afrotropics ($\chi^2 = 14.629$, d.f. = 1, $p < 0.001$). Lowland rainforests in the Thai-Malay Peninsula, for example can support species-rich assemblages of as many as 27 species of wintering warblers, flycatchers and thrushes (Table 3), with migrants forming 6-15% of total bird abundances (Karr 1976). Even higher wintering songbird diversities can also be expected in Indochinese evergreen forests in the lowlands and at submontane elevations. The well-studied submontane Mo Singto plot (c. 30 ha) at Khao Yai National Park, Thailand for example, supports about 29 species of wintering long-distance migrants and a smaller number of short-distance/altitudinal migrants (Round *et al*. 2011). Much of this wintering songbird diversity can be attributed to wintering *Phylloscopus* warblers (c. nine species) and which also contributes as much as 14% of bird abundances (Round *et al*. 2011).

In general, the proportion of wintering songbird diversity in forests is high, with up to 52.0% and 20.0% (Table 3) of migratory songbirds across insular South-East Asia utilising lowland evergreen forests as wintering habitats. Diversity and species richness of wintering assemblages decreases with elevation (Table 3) and is also demonstrated by surveys of forest migrant bird assemblages across elevation gradients in Taiwan (e.g. Shiu & Lee 2003). Moreover, there also appears to be variations in habitat preference for some species across the wintering range. For example, the Narcissus Flycatcher (*Ficedula narcissina*) winters in hilly to mid-elevation montane forest in Borneo but the subspecies *F. n. elisae* which winters in the Thai-Malay Peninsula, is dependent on lowland rainforest (Wells 2006). Besides some broad patterns highlighted here, we acknowledge that there is still a dearth of knowledge on the composition, community structure, population dynamics and turnover of wintering songbird assemblages across various forest types (e.g. coniferous, broadleaved evergreen, dry dipterocarp, mangroves) and across gradients of disturbance and degradation in the East Asian tropics.

(Figure 6)

Discussion

Conservation status of migratory songbirds in the East Asian Flyway

Of 254 species of migratory songbirds reviewed, 15 are presently listed by BirdLife International (2013) as threatened, the majority long-distance migrants (13 species) and the highest for any migration system (Table 2, 5). Seven species are near-threatened, mostly short-distance migrants. The higher proportion of threatened long-distance migrants appears consistent with reviews of other migration systems (e.g. Vickery *et al*. 2013). Additionally, 56 long-distance migratory songbirds are cited to show declining trends (Table 2, see also online Supplementary Materials) although the actual figure may be even higher. One species, the 'Critically Endangered' White-eyed River-martin (*Eurochelidon sirintarae*) has not been reliably recorded for three decades and may be extinct. Since 1994, six threatened or near-threatened species have been uplisted while only one was downlisted (Marsh Grassbird *Locustella pryeri*). A further 15 species threatened since 1994 showed no change in status, suggesting that conservation efforts for these species had limited effects in stemming their declines. While the number of 'Vulnerable' species has dropped, this has been offset by an increase in species recognised as 'Endangered' in the past two years (Figure 7).

(Figure 7)

Bird families with high proportions of declining species have members that are dependent on broadleaved evergreen forests (e.g. Pittidae) or freshwater wetlands as wintering grounds (e.g. Acrocephalidae, Locustellidae) (see also online Supplementary Materials), as well as some species of scrubby open habitats (e.g. Moores 2013). Rapid land use change across the region suggests that a serious and most apparent threat to migratory songbirds is habitat loss, given that migratory species spend more time in tropical habitats than elsewhere (Sherry & Holmes 1995). While hunting can affect songbirds at localised spots along the migration trajectory, utilisation of different habitat types across the breeding, stopover and wintering areas means migratory bird populations are susceptible, and thus limited by conditions in multiple sites along its migratory trajectory (Newton 2004). In the context of the East Asian Flyway, changing habitat conditions at migration stopover sites (Wang *et al.* 1998) and in the wintering grounds (Dale & Hanson 2013) is of particular concern given much documented habitat loss in East (e.g. Moores 2012) or South-East Asia (Table 5).

Declining trends of East Asian migratory songbirds

The long term population trends and rates of decline (if any) of migratory songbirds in the East Asian Flyway remain very poorly known. This is unlike that in the African-European flyway where comprehensive and established monitoring schemes across multiple countries in Europe (e.g. Pan European Common Bird Monitoring Scheme) and the availability of large datasets (e.g. Birds in Europe database) has allowed clear trends in declines of migratory songbirds to be identified, even at the continental-level (Vickery *et al.* 2014). Particularly, many European countries also have large-scale demographic monitoring programs using standardised mist-netting or nest monitoring to determine survival, productivity and recruitment rates which can then be used to explain changes in bird populations. Such coordinated databases and programmes are unavailable for East or South-East Asia. However, rapid deforestation and agricultural expansion across much of South-East Asia (Sodhi *et al.* 2010), increasing deforestation and degradation of temperate forests in Mongolia and eastern Russia by logging, mining and fires (Kondrashov 2004, Salovarov & Kuznetsova 2006, Bradshaw *et al.* 2007, Gombobaatar *et al.* 2011) and high levels of hunting (e.g. Alonzo-Pasicolan 1992, Liang *et al.* 2013) logically implies that many migratory songbirds must suffer from some levels of decline. Scattered studies at the local or national scale have also identified declines for some migratory songbirds.

In Japan where abundance and occurrence data of summer breeding songbirds are available, tropical (i.e. South-East Asian) wintering species like Japanese Paradise-flycatcher (*T. atrocaudata*) exhibited clear declines (Hirano 1996, Higuchi & Morishita 1999) or even disappeared completely from sites while non-migrants were seemingly unaffected (Yamamoto & Seto 1997). Similarly, a number of long-distance, tropical migrants like Eastern Crowned Warbler (*P. coronatus*) and Yellow-breasted Bunting have also shown some declines in South Korea (Moores 2012, Moores 2013). In Mongolia, the decline of some migratory songbirds, including the Tree Pipit (*Anthus trivialis*) has prompted its red-listing in the national conservation action plan (Gombobaatar *et al.* 2011). In particular, the rapid decline of the Rustic Bunting, a species dependant on agricultural areas and woodland in winter is now corroborated by data and field surveys across its Eurasian distribution in Finland (Laaksonen & Lehikoinen 2013), Japan (Ozaki 2008) and South Korea (Moores 2012). In South-East Asia, Round (2010) has also found possible declines in abundances of migrating Tiger Shrikes (*Lanius tigrinus*) in Thailand, relative to other songbird migrants. Not surprisingly, long-distance migration is now established as an attribute of declining songbirds (Amano & Yamaura 2007, Bairlein & Schaub 2009).

(Figure 8)

Threats faced by migratory songbirds

The threats faced by migratory songbirds are diverse and may interact in complex ways to drive declines across different parts of the world. For instance, Newton (2004) noted that the decline of Nearctic-Neotropical and African-European migrants have differing causes. While Afrotropical migrants from Europe have declined due to fluctuating climatic conditions in the Sahel where many species overwinter, habitat loss in breeding, wintering and stop-over sites (Sanderson *et al.* 2006, Vickery *et al.* 2011) and hunting in the Mediterranean rim (McCulloch *et al.* 1992), North American migrant declines have been largely attributed to forest loss and fragmentation in the wintering range (Sherry & Holmes 1995, Askins 2000, Rappole *et al.* 2003). Unlike either North America or Europe, we are unaware of published studies that have examined how different threats have affected songbird migrants along the East Asian migratory system although regional reviews do exist (e.g. Moores

2012). Available quantitative and anecdotal evidence suggests that habitat loss and hunting are the most significant threats. Other threats like invasive species and collision with structures are recognised, but with less evidence of their impacts across the region (Figure 8).

(Table 4)

(Table 5)

Habitat loss and degradation

Habitat loss, particularly that of broadleaved evergreen forests which are increasingly clear-cut, fragmented, or degraded by logging at large scales in South-East Asia is well known (e.g. Linkie *et al*. 2004, Miettinen *et al*. 2010) and its impacts on biodiversity patterns, especially resident bird communities are well documented (e.g. Sodhi *et al*. 2010). However, the impacts of habitat loss on migratory songbirds and rates of decline are not well understood. This is because there are few studies on the diversity, status or wintering ecology of flycatchers, warblers, robins and thrushes across much of the region, even though studies of resident bird communities do document some migratory songbirds (e.g. McClure 1967) while some mist-netting studies have examined the wintering ecology of few common migrants like Great Reed-warblers (*A. arundinaceus*) (e.g. Nisbet & Medway 1972) and Brown Shrike (Medway 1970). Countrywide reviews like Lim & Lim (2009) have also reported declining trends for some migrant songbirds in Singapore, but the limited spatial context of these findings mean that they are not necessarily reflect distribution-wide changes as decline patterns may also arise from fluctuations due to other factors (Newton 2004). Clearly, this lack of knowledge is of concern because the loss of wintering habitat has been shown to impact population declines more than habitat loss in breeding habitats (Sutherland 1996).

Given that many migratory songbirds in South-East Asia and south China depend on broadleaved evergreen forests as wintering habitat (see Tables 4 and 5), the rapid clearance and degradation of lowland and submontane rainforests across Cambodia, Sumatra, Borneo and the Philippines (Table 5) indicates that wintering songbirds there have lost large proportions of intact wintering habitats. Six forest dependant migratory songbirds are already listed as globally threatened (Table 6). Furthermore, currently 'Least Concern' species that winter predominantly in Sundaic forests like Narcissus Flycatcher, Siberian Blue Robin and Blue-and-white Flycatcher (*Cyanoptila cyanomelana*) may also have suffered declines as a result of widespread habitat loss across western Indonesia and Malaysia. A few species like the 'Vulnerable' Rufous-headed Robin (*Luscinia ruficeps*) is hypothesized to winter in South-east Asian's forests but its winter range remains unknown (Mahood *et al*. 2013a). On the contrary, the implementation of new forestry policies in China, particularly the Natural Forest Protection Plan (Li *et al*. 2007, IUCN-WCPA 2011) is expected increase forest cover across parts of eastern and southern China and may benefit some forest-dependant species, at least as demonstrated in Hong Kong (Kwok & Corlett 2000).

Many songbirds that breed or winter in wetland habitats will also be affected by land use change across their distributions. While some species of reed and bush warblers can utilise human-modified landscapes like paddy fields (Wells 2006), natural wetlands like freshwater and coastal marshes, as well as seasonally-flooded grasslands remain important as wintering habitats for most *Acrocephalus* and *Locustella* warblers, and are increasingly threatened by drainage, reclamation or conversion to agricultural land. The 'Vulnerable' Streaked Reed-warbler (*A. sorghiphilus*), for example is known to winter only in the Candaba marsh in central Luzon, a site increasingly drained for agricultural expansion (BirdLife International 2013), as are similar wetlands in the Philippines. Likewise, the 'Vulnerable' Manchurian Reed-warbler (*A. tangorum*) winters mostly in *Phragmites* reedbeds of Khao Sam Roi Yot National Park in Thailand and flooded grasslands by the Tonle Sap, Cambodia (Sam 1999, Round & Rumsey 2003). Habitats at both sites are being encroached (BirdLife International 2013). Its recent discovery in northern Peninsular Malaysia (Bakewell 2013) further reflects the poor state of knowledge of its winter distribution, and a similar scenario applies for the Pleske's Grasshopper-warbler (*Locustella pleskei*).

Hunting

One major threat shared by migratory songbirds in the East Asian and the African-European migratory systems is widespread hunting, an especially visible issue around the Mediterranean rim (e.g. McCulloch *et al*. 1992, Vickery *et al*. 2014) although the underlying motivations are different. While quantitative data is lacking, hunting of wild birds for food in rural areas and the pet trade remains rampant across many parts of South-East Asia (e.g. Shepherd 2006, Dinata *et al*. 2008), mainland China (Feng 2012, Li 2012, Liang *et al*. 2013) and until recently, Taiwan and the Ryukyus (Severinghaus 1996). These hunting pressures have been linked to the rapid decline of the Yellow-breasted Bunting, resulting in its IUCN threat status from being upgraded from 'Least Concern' to 'Vulnerable' in less than one decade (Chan 2004, BirdLife International 2013, Li 2013). The combined impact of harvesting for various reasons increases net mortality rates and can reduce returning populations of songbirds in spring considerably (Severinghaus 1996) and which has been shown in the declines detected during spring surveys in the breeding grounds of some species (e.g. Rustic Bunting in [Dale and Hansen 2013])

In parts of Cambodia, migratory songbirds including various swallows, Black-browed (*A. bistrigiceps*) and Great Reed-warblers are trapped in the tens to hundreds of thousands for religious 'mercy releases' (Gilbert *et al*. 2013) with high mortalities resulting. Similar practices are reported in Thailand where thousands of Yellow-breasted Buntings were caught for release (McClure and Chaiyaphun 1971), as well as in Hong Kong and Taiwan (Severinghaus and Chi 1999). Difficulty in enforcement of wildlife protection laws across the region (Corlett 2007), especially rural areas complicates the hunting problem. In western Indonesia where bird-keeping is a popular and deep-rooted practice, some long-distance migrants like the Siberian Thrush (*Zoothera sibirica*), Orange-headed Thrush (*Z. citrina*) and Purple-backed Starling (*Sturnus sturninus*) are trapped in large numbers for sale in bird markets (Nash 1993, Shepherd *et al*. 2004, Shepherd 2006). In a survey of the bird trade across South-East Asia and Hong Kong, Nash (1993) reported at least 30 species which are migratory songbirds, including a number of thrushes and flycatchers, while Purple-backed Starling occurred in more than half of surveys of bird shops conducted across Indonesia. Likewise, various migratory finches, warblers and thrushes are also caught for the pet trade in China where a tradition of keeping birds exist (Townsend 2013).

Deliberate or opportunistic trapping of birds for food remains rampant and prevalent across South-East Asia and south China, and is fuelled largely by local (e.g. Iqbal *et al*. 2014) or cross-border demands (e.g. Butler 2009). The easily availability of traps like mist nets (e.g. Bakewell 2007, Townsend 2012) facilitates this. The recovery of ringed Rustic Buntings from bird markets in China (Fransson *et al*. 2007) and recent documentation of mass hunting of Eyebrowed Thrushes (*Turdus obscurus*) in Sumatra (Iqbal *et al*. 2014) offers clear evidence of these hunting pressures. In well-documented Dalton's Pass, northern Luzon, local people continue to trap thousands of migrating birds at night using lighted traps for consumption (Alonzo-Pasicolan 1992), including threatened songbirds like Streaked Reed-warbler (BirdLife International 2013). Similar hunting approaches targeting migrating songbirds have also been documented across many parts of southern China, especially in Yunnan, Hunan and Jiangxi provinces (Xiao *et al*. 2004, Yang *et al*. 2009, Anon 2012). Large-scale trapping of birds in general is endemic in parts of south China, particularly Hainan where many species, including migrant songbirds are hunted by local people for meat and medicine using various trapping methods (Liang *et al*. 2013). The situation may be even worst in South-East Asia, particularly in the Lao PDR where once subsistence exploitation of wildlife for food has swollen to massive scale hunting to fulfil cross-border demands of bushmeat (Butler 2009). While the impacts of hunting on migratory songbird populations across the East Asian migratory system had not been well-studied, is has been attributed to the declines of some species, especially a number of buntings (e.g. Dale & Hansen 2013).

Other key threats

Two other poorly documented threats to migratory songbirds in East Asia are invasive species and collisions with man-made structures in cities across the region. Collision with man-made structures is known to be responsible for mortality in migratory songbirds in North America and Europe (Rich & Longcore 2005, Hüppop *et al*. 2006, Anderson 2011). Unlike other threats, collisions with glass are known to kill migrants non-selectively, and irrespective of fitness (Kirby 2011), detrimentally affecting songbird populations on migration in North America (Loss *et al*. 2014). Moreover, songbirds migrating at night are known to be strongly attracted to sources of artificial light, resulting in collisions which can lead to injury or death (Ogden 1996, Round 2010). A few examples are available from the East Asian flyway. In Hong-do Island, a key stopover site for migrating birds off the South Korean coast, collisions with windows and artificial structures is found to be the primary cause of bird mortality and especially so for migrating buntings, pipits and white-eyes (Bing *et al*. 2012). Window strikes as well as traffic accidents were also the most common cause of mortality of Fairy Pittas on Jeju Island in Korea (Kim *et al*. 2013). In eastern Hokkaido, Japan, 63 species were reported to be killed by window collisions from 1980 to 1997, with increased mortality during the migration period (Yanagawa & Shibuya 1998). In South-East Asia, data collected from birdwatcher reports in Singapore revealed higher mortalities of birds due to collisions with man-made structures in more the build-up areas (Low *et al*. in prep, Yong *et al*. 2013) and involves many migratory songbirds like pittas, thrushes, warblers and flycatchers (Low *et al*. in prep). Since the migration fronts of many songbirds traverse lighted offshore oil platforms during sea crossings (Simpson 1983b) and some of Asia's largest cities which are extensively lighted at night and have many high structures, especially Shanghai, Guangzhou and Hong Kong (China), Hanoi (Vietnam), Bangkok (Thailand) and Singapore, resulting mortalities may be very high. The increasing ubiquity of wind turbines, especially along the Chinese Yellow Sea coast (Chen 2009), a region important to migrating birds, could potentially worsen the problem of collisions (e.g. Hüppop *et al*. 2006)

Lastly, the impact of how invasive plants and animals affect stopover or wintering songbirds across the region has been little addressed by scientific studies, but available evidence shows that invasive species can prey on, compete with or modify habitats of migratory songbirds. We provide two examples: invasive corvids and plants. The invasive House Crow (*Corvus splendens*), a native of the Indian Subcontinent but established in Peninsular Malaysia and Singapore (Sodhi & Sharp 1999) is known to opportunistically prey on songbird migrants based on casual observations in Singapore (Yong, D.L. unpublished data). Along with native crows, Eurasian Magpies (*Pica pica*) that are introduced from mainland Korea to Jeju Island are also reported as nest predators of the Fairy Pitta (Kim *et al.* 2013). In coastal marshes of Shanghai municipality and Jiangsu, east China, the invasive cordgrass *Spartina alterniflora* is increasingly outcompeting and replacing beds of native *Phragmites* and reed species (Xie & Gao 2013), potentially resulting in habitat loss for wintering songbirds. By 2002, this invasive grass already covered 112,000 ha of China's east coast (Gan *et al*. 2010). At Chongming island, Shanghai, habitat dominated by *Spartina* was found to support lower food resources (e.g. arthropods), bird diversity and abundances of four wintering buntings known to be dependent on wetland, including the near-threatened Ochre-rumped Bunting (*E. yessoensis*) (Gan *et al*. 2010). Similar trends are documented for wintering buntings in shoal-wetlands on the Yangtze delta (Ma *et al*. 2007).

In general, the synergistic yet complex interaction of diverse threats, particularly habitat loss and degradation occurring in combination across passage sites, wintering and breeding ranges put many species at risk. Given that the impacts of climate change is likely to increasingly disrupt the breeding cycle or migratory activity of these passerines (Koike & Higuchi 2002, Both *et al*. 2006, Harris *et al*. 2013), it is clear that there is an urgent need for more empirical data on migratory songbirds, from where informed conservation priorities and decisions can be made. In the next section we identify key research and conservation priorities for migratory songbirds in the East Asian Flyway.

Conservation and research priorities

Research on migration songbird ecology and survival

Populations of many migrant songbirds are limited in part by conditions in winter (Sherry & Holmes 1996, Norris *et al*. 2004), which can in turn carry over to affect breeding and reproductive output in spring (Holmes 2007). Effective conservation and management therefore needs to take these limiting processes, patterns and dynamics into consideration (Holmes 2007). Since wintering distributions and density, habitat usage, demographics and survival rates of many songbirds in this region remain unclear, as are underlying drivers of decline, a conservation priority is thus to first establish what and where these habitats are, and document the assemblages and population patterns of songbirds in them, especially across the stopover/wintering zone in South-East Asia and southern China. Additionally, there is need for concerted efforts to identify wintering ranges of the most poorly-known songbirds in the region. Sampling the diversity, abundances and demographics of songbird migrants over the long term (Newton 2004, Holmes 2007, Round 2010) will be important to detect ecologically significant trends or fluctuations that indicate wider population patterns which can help identify causes of declines. Carefully designed field surveys or bird-banding exercises at the right places, and at appropriate time and spatial scales can obtain these data in a cost-effective way, and are already in place in few parts of South-East Asia (e.g. Ko Man Nai, Thailand) as well as China, Russia, South Korea and Japan. Many of these surveys sites are likely to involve small islands or continental sites containing known concentrations of migratory songbirds (Table 6, Figure 1), which can be sampled by a combination of judicious bird-banding (e.g. Ozaki 2008, Nam *et al*. 2009) and visual surveys of abundance using points or transects (e.g. Moores 2012). Research and monitoring at stopover or wintering sites must also be complemented by that in the breeding sites in East Asia (e.g. Hirano 1996). Adaptive monitoring programmes, if established, could enable meaningful population trends to be detected if these are carried out with standardised methodology, while taking into considerations uncertainties in the monitoring process.

Although funding for surveys is scarcer in many South-East Asian countries, a number of funding bodies and charities now avail grants to local conservationists and researchers, especially that in developing countries, and can be tapped on to support field projects to survey occurrence and abundances of migratory songbirds in poorly known areas. In fact, data on other migratory species, especially raptors and the endangered Spoon-billed Sandpiper (*Eurynorhynchus pygmaeus*) have been collected in South-East Asia (e.g. DeCandido *et al*. 2004, Bird *et al*. 2010) by birdwatchers in collaboration with local conservationists through these means.

(Table 6)

Research on migration routes and connectivity

Although standardised bird banding (e.g. McClure 1974) and to some extent, satellite tracking (e.g. Higuchi 2013) has been effectively used to gather data on aspects of stopover ecology in East and South-East Asia, many facets of the migration routes, connectivity, and stopover site usage of long-distance migratory songbirds across East Asia remain unknown and for some species, their entire wintering grounds remain unclear, especially the difficult to identify *Phylloscopus* warblers (Yap *et al.* in press). Mass ringing can give an indication of the movements and migratory connectivity for a few species that can be trapped in large numbers but miniaturisation in tracking technologies means that it is now possible to study movement of songbirds lighter than 20-30 grams using geolocators and archival Global Positioning System (GPS) tags (e.g. McKinnon *et al.* 2013). The drawback of using these units is the low recovery rates for species that do not show good site fidelity, high costs of procurement and location accuracy problems but the technology is advancing quickly. These methods can also be used in conjunction with molecular genetic data and stable isotopic ratio analysis (Marra *et al.* 1998, Holmes 2007) to learn about migration routes, flight rates, wintering sites and migratory connectivity.

Finally, radar technology has been used in some stopover ecology studies to show the relative importance of different habitats to migrant songbirds (e.g. Ruth *et al.* 2012) and diverse aspects of bird migration movements under different weather and light conditions (e.g. Bruderer 1997). While there are known limitations, radar technology can still be used to gather data on migration patterns and movements at night or during poor weather, and in complement with data gathered from other means.

Legal frameworks for conserving migratory birds

Given the large geographic ranges of migratory birds spanning multiple countries, effective conservation can be challenging (Kirby 2010, Bauer & Hoye 2014) and must protect all habitats used during the annual cycle to be successful (Norris *et al.* 2004). At a regional to continental scale, national government-linked conservation bodies and environmental ministries need to recognise that the conservation of migratory species traverses national boundaries, and enact legislation that explicitly protects migratory species (Sands 2003) to complement existing wildlife protection laws for sedentary or restricted-range species. Coordination of conservation efforts and knowledge sharing between the territories in the East Asian migratory system is needed if conservation actions are to be effective, and existing initiatives like the Partnership for the East Asian-Australian Flyway (see EAAFP 2012) do facilitate these actions to some extent even though its scope covers mainly waterbirds at present.

Unlike raptors, waders and large waterbirds like cranes, the poor visibility of songbirds means that they can be easily overlooked not only by conservationists, but also by the very policies designed to conserve migratory species in general. The Convention on the Conservation of Migratory Species of Wild Animals (CMS) or Bonn Convention, an important global agreement under the purview of the United Nations Environment Programme (UEDP) provides a legal framework and comprehensive guidelines for conserving migratory species (CMS 2014) worldwide, but targets mostly large charismatic taxa like mammals, sea- and waterbirds (Kirby 2010). Thus far, the only Memorandum of Understanding (MoU) concluded under the CMS for a migratory songbird targets the Aquatic Warbler (*Acrocephalus paludicola*), an African-European migrant. Besides its limited scope and coverage, only 119 parties have ratified the CMS as of February 2014 (CMS 2014), and this excludes the majority of states along the East Asian-Australasian Flyway. The lack of ratification by states with territories overlapping with the breeding, stopover or wintering ranges of so many migratory species continues to pose a stumbling block for cross-boundary coordination of conservation activities. Furthermore, its slow growth in membership suggests that the impact of the CMS on conserving migratory species is very limited. Given this, many of the species listed in Appendix I of the CMS remains symbolic (de Klemm 1994).

Filling in these policy gaps and discrepancies may be possible with the conclusion of new Memoranda of Understanding and other legally-binding agreements targeting threatened East Asian migratory songbirds. Additionally, some of the loopholes in these existing legal frameworks can be partly addressed by bilateral agreements for migratory species. For example, China and Russia, two of the most important countries in the Flyway for breeding, stopover and overwintering of many songbird migrants recently signed the China-Russia Migratory Bird Agreement (CRMBA) in 2012, on top of existing ones for Japan and South Korea (Boer *et al*. 1998, EAAFP 2012). Similar agreements exist between Japan and the U.S.A (U.S. Fish and Wildlife Service 2014), and between other Asian countries (see Boer *et al*. 1998) although follow-up actions for conservation are relatively limited. Furthermore, geopolitical disputes between countries in the East China Sea and Yellow Sea region (e.g. Valencia 2007), an important area for bird migration, may potentially complicate any transboundary arrangement to conserve migratory birds.

At the national level, better enforcement of existing wildlife protection laws will be needed to protect migratory birds and wildlife in general, although this has been plagued by limited government funding, corruption and poverty in many Asian countries (Corlett 2007). National and regional wildlife protection agencies will need to review and include listing of migratory songbirds in existing wildlife enactments, given that priorities in many listings have tended to focus on non-migratory, resident species (e.g. Sabah Wildlife Department 2004). These actions will be of greater importance in China, Indonesia, the Philippines, Lao PDR, Cambodia and Thailand where migratory songbirds have been heavily harvested for the pet bird trade, food or religious uses.

Conservation planning

Conservation of migratory species can be successful if adequate habitat is protected at breeding, stopover and wintering sites. The extensive network of reserves across countries in the East Asian Flyway, particularly East Asia where protected areas cover about 16% of the region (MacKinnon *et al*. 2005) means that most migratory songbirds have some fraction of the distributions protected, but to varying extents. If sites important to stopover or wintering songbirds are found to overlap with existing protected areas, then the priority will be to step up or maintain protection measures like enforcement of regulations to manage disturbance. If these sites are unprotected, they then should be evaluated for other biodiversity elements and identified under regional/national conservation frameworks for formal conservation actions. Inevitably, conserving songbird migrants will involve protecting patches of stopover habitat (Sheehy *et al*. 2011), some of little value to other biodiversity (e.g. Yong 2013). Particularly, studies using habitat and population parameters (e.g. density dependence) of North American migratory songbirds have developed models to optimise resource investments to conserve migratory songbirds (e.g. Sheehy *et al*. 2011), which in turn can inform conservation strategies targeting the wintering, breeding and stopover sites. These findings can provide insights in developing transboundary conservation plans targeting songbird migrants in East and South-East Asia if critical ecological data is available, and may be useful for initiating future MoUs for threatened species. Finally, since many wintering songbirds are dependent on tropical forests that are also of conservation importance to other biodiversity, we acknowledge that effective conservation of these targets are likely to benefit many migratory songbirds. What remains to be seen is whether resident species which are more readily surveyed can act as effective surrogates for conserving migratory songbirds.

Citizen science, education and the role of birdwatchers

The number of birdwatchers is rapidly increasing across Asia, especially in mainland China (Ma *et al*. 2013) and a number of Southeast Asian countries (e.g. Thailand, Indonesia, Philippines), given a fast growing middle class. Ma *et al*. (2013) also reports that there are now 36 birdwatching clubs distributed across mainland China while the total number of birdwatchers exceed 20,000. In Taiwan, South Korea and Japan there is already a well-established tradition of birdwatching, on top of established biodiversity or ornithological institutions (e.g. Migratory Birds Centre in Korea National Park Research Institute [South Korea], Yamashina Institute for Ornithology [Japan]). In the Russian Far East, non-governmental organisations like the Amur-Ussuri Centre for Avian Biodiversity support migratory bird research in the region and carry out important ornithological surveys.

Given that many amateur birdwatchers keep lists and records of their observations, much of which are deposited online, or compiled in annual bird reports (China Ornithologist's Society 2008), the collective output of data from birdwatchers if analysed, can reveal ecologically significant changes such as fluctuations in species population over short time-scales, distribution contractions or expansions, and other temporal trends (Round 2010, Li *et al*. 2013). Data from birdwatchers have not only contributed to studies like Yamamoto & Seto (1997) and Harris *et al*. (2013), but has also improved knowledge of the distribution and status of threatened songbird migrants such as the Rufous-headed Robin in Cambodia (Mahood *et al*. 2013a), Japanese Paradise-flycatcher in Java (Emmanuel & Yordan 2013), and the Brown-chested Jungle-flycatcher in north Vietnam (Mahood *et al*. 2013b) and Singapore (Yong & Liu, in press), all migrants with poorly known wintering ranges. While the problem of language barriers across various Asian countries could prove to be a hurdle for information-sharing, the 'eBird system' (Wood *et al*. 2011) could be a good model for transboundary data collection if birdwatchers across the region can be encouraged to participate. One likely pitfall is that distributional records will be biased to heavily visited sites and certain months of the year, while inaccessible areas may remain chronically under-surveyed, as is the case in western Indonesia (Yong & Liu, in press), Wallacea or Russia's boreal zone. Despite these shortcomings, there is much potential for collaborative research between birdwatchers and researchers in Asia, which unlike Europe or North America, is presently patchily distributed across the continent (Greenwood 2007). Such collaborations could allow researchers to tap into data collected by birdwatching organisations or hobbyist birdwatchers to understand migration ecology better, and identify significant populations, sites and trends for targeted conservation actions.

Furthermore, the increasing popularity of birdwatching as a pastime across East and South-East Asia means that birdwatchers and their organisations have the knowledge and capacity to increase awareness of migratory bird conservation through their activities to over 1.8 billion people who live in the region. An example of these conservation efforts led by birdwatchers is the 'Asian Bird Fair', which is now held annually across a number of East and South-East Asian countries, and coordinated by respective national birdwatching clubs (e.g. Wild Bird Club of the Philippines, Chinese Wild Bird Federation) (see Birdfair Asia 2011). This is on top of national-level birdwatching activities (e.g. Thailand Bird Fair, China Bird Festival) (e.g. Bird Conservation Society of Thailand 2013) held in the countries across the region. These efforts will surely complement the existing outreach, research and educational work of major conservation organisations like BirdLife International, and many regional and local non-government conservation organisations.

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Table 1

Family	Number of migratory species	Species with long-distance migratory populations
Ducks and geese	44	42
Divers	4	4
Waders	60	58
Cranes and buttonquail	7	7
Rails and bustards	12	12
Storks, spoonbills and pelican	6	6
Cormorants	4	1
Herons and bitterns	17	17
Grebes	5	5
Hawks and falcons	32	30
Gulls and terns	23	23
Cuckoos	11	10
Owls	4	4
Kingfishers, bee-eaters, rollers	7	7
Songbirds	254	170
Total species	490	396

Table 2

Geographical region	Number of wintering species (% of total pool)	Threatened/near-threatened	Declining trends recognised by Birdlife	Species limited as winterer to region
Temperate East Asia	55			
East Siberia	8 (14.5)	0	5	0
North China	22 (40.0)	1	14	0
Korean Peninsula	25 (45.5)	1	12	0
Japanese Archipelago	37 (67.3)	3	19	1
East China	47 (85.5)	4	17	0
Tropical East Asia	129			
South China	101 (78.3)	6	28	2
Philippine Archipelago	34 (26.4)	4	14	3
Mainland Southeast Asia	111 (86.0)	8	26	9
Thai-Malay Peninsula	56 (43.4)	3	16	1
Greater Sundas	43 (33.3)	3	16	1
Wallacea	16 (12.4)	0	4	0
Total	170	21	56	-

Table 3

Species richness/ (%)	Thai-Malay Peninsula	Sumatra	Borneo	Java	Luzon	Mindanao	Sulawesi
Lowland forest	27 (50.9)	16 (45.7)	14 (40.0)	13 (52.0)	10 (33.3)	6 (33.3)	3 (20.0)
Montane forest	14 (26.4)	11 (31.4)	8 (22.9)	9 (36.0)	8 (26.7)	5 (27.8)	3 (20.0)
Wetland	6 (11.3)	4 (11.4)	5 (14.3)	3 (12.0)	5 (16.7)	3 (16.7)	2 (13.3)
Habitat generalist	19 (35.8)	11 (31.4)	12 (34.3)	7 (28.0)	11 (36.7)	8 (44.4)	8 (53.3)
Total	53	35	35	25	30	18	16

Table 4

Species	Scientific name	IUCN threat level	Key threat(s)	Wintering habitat(s)
Streaked Reed-warbler***	*Acrocephalus sorghiphilus*	Endangered	Hunting, habitat loss	Freshwater wetland
Manchurian Reed-warbler*/**	*Acrocephalus tangorum*	Vulnerable	Habitat loss	Cultivation, freshwater wetland
Pleske's Grasshopper-warbler*	*Locustella pleskei*	Vulnerable	Habitat loss	Freshwater wetland, scrub
Rufous-backed Bunting	*Emberiza jankowskii*	Endangered	Habitat loss	Natural grassland
Yellow-breasted Bunting*	*Emberiza aureola*	Endangered	Hunting, habitat loss	Cultivation, scrub
Yellow Bunting***	*Emberiza sulphurata*	Vulnerable	Hunting, habitat loss	Cultivation, scrub
White-eyed River-martin*	*Eurochelidon sirintarae*	Critically endangered	Hunting, habitat loss	Freshwater wetland
Rufous-headed Robin**	*Luscinia ruficeps*	Endangered	Habitat loss	Unknown
Black-throated Blue Robin*	*Luscinia obscura*	Vulnerable	Habitat loss	Unknown
Brown-chested Jungle-flycatcher**	*Rhinomyias brunneatus*	Vulnerable	Habitat loss	Evergreen forest
Silver Oriole*	*Oriolus mellianus*	Endangered	Hunting, habitat loss	Evergreen forest
Izu Leaf-warbler***	*Phylloscopus ijimae*	Vulnerable	Habitat loss	Evergreen forest
Fairy Pitta**	*Pitta nympha*	Vulnerable	Hunting, habitat loss, introduced species	Evergreen forest
Grey-sided Thrush*	*Turdus feae*	Vulnerable	Habitat loss	Evergreen forest
Izu Thrush	*Turdus celaenops*	Vulnerable	Habitat loss, introduced species	Evergreen forest

* Winter visitor to Mainland Southeast Asia (Seven species)
** Winter visitor to Thai-Malay Peninsula and Greater Sundas (Three species)
*** Winter visitor to the Philippine Archipelago (Three species)

Table 5

Country	Total agriculture land cover (%)	Total paddy cover (ha) (2004)	Total forest cover (ha) (2005)	Total change forest cover (ha) (1990-2005)	Forest cover change per annum (%)
Brunei	2.2	0	278,000	-2333	-0.8
Cambodia	32.0	23,000,000	10,447,000	-166600	-1.09
Indonesia	30.1	117,527,000	88,495,000	-1871467	-1.61
Lao PDR	10.3	8,200,000	16,142,000	-78133	-0.45
Malaysia	24.0	6,700,000	20,890,000	-99067	-0.35
Myanmar	19.2	60,000,000	32,222,000	-466467	-1.19
Singapore	1.0	0.0	1,600	0.0	0.0
Timor Leste	24.2	NA	NA	NA	NA
Thailand	41.2	98,000,000	14,520,000	-96333	-0.72
Philippines	40.6	40,000,000	7,162,000	-227467	-2.48
Vietnam	35.0	74,000,000	12,931,000	237867	2.52

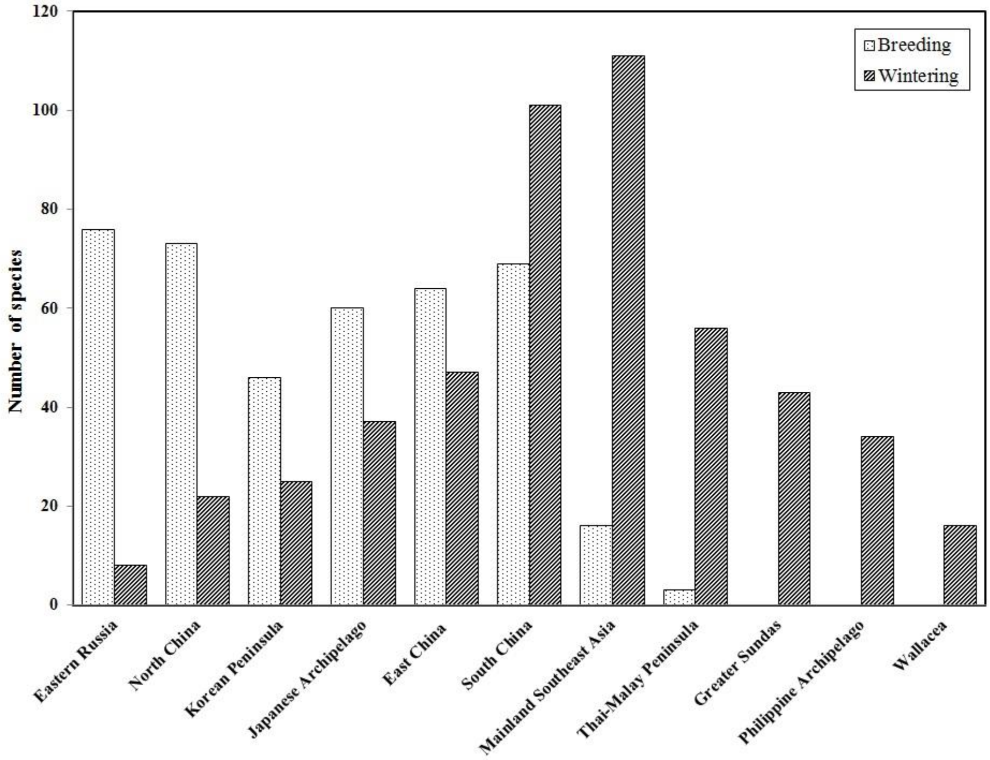
Table 6

Country	Site name and administrative region	Coordinates
Russia	Muraviovka Park, Amur Oblast	49°87’N, 127°70’E
	Bolshekhekhtsirsky Reserve, Khabarovsk Oblast	48°11’N, 134°40’E
	Litovka River, Nakhodka City, Primorsky Krai	42°96’N, 132°88’E
Japan	Hegura-jima, Ishikawa (Island)	37°51’N, 136°55’E
	Mishima (Island)	34°77’N, 131°14’E
	Ryukyu-shoto, Kagoshima (Islands)	26°30’N, 128°00’E
South	Socheong-do, Incheon (Island)	37°46’N, 124°44’E
Korea	Eocheong-do, Jeonbuk (Island)	36°70’N, 125°58’E
	Heuksan-do, Jeonnam (Island)	34°67’N, 125°42’E
	Hong-do, Jeonnam (Island)	34°42’N, 125°11’E
China	Beidaihe, Hebei	39°50’N, 119°29’E
	Laotieshan, Liaoning	38°46’N, 121°11’E
	Rudong, Jiangsu	32°18’N, 121°11’E
	Xiaoyangshan, Zhejiang (Island)	30°62’N, 122°06’E
	Daniao-ao, Hunan	27°06’N, 111°01’E
	Longqingguan, Yunnan	25°18’N, 100°21’E
	Ailaoshan, Yunnan	24°53’N, 100°19’E
	Fenghuangshan, Yunnan	23°57’N, 101°30’E
	Po Toi, Hong Kong (Island)	22°17’N, 114°27’E
Vietnam	Hanoi City	21°20’N, 105°51’E
	Con Lu, Nam Định (Island)	20°21’N, 106°55’E
Philippines	Babuyan Islands, Cagayan (Islands)	19°34’N, 121°48’E
	Dalton’s Pass, Nueva Vizcaya	16°73’N, 120°55’E
Thailand	Ko Man Nai, Rayong (Island)	12°01’N, 102°28’E
Malaysia	Mantanani and Mengalum, Sabah (Islands)	6°20’N, 115°59’E
	Fraser’s Hill, Pahang	3°73’N, 101°73’E
	One Fathom Bank, Selangor (Island)	2°53’N, 100°59’E
Singapore	Bidadari Park	1°34’N, 103°87’E
	St John’s (Island)	1°13’N, 103°50’E

Figures

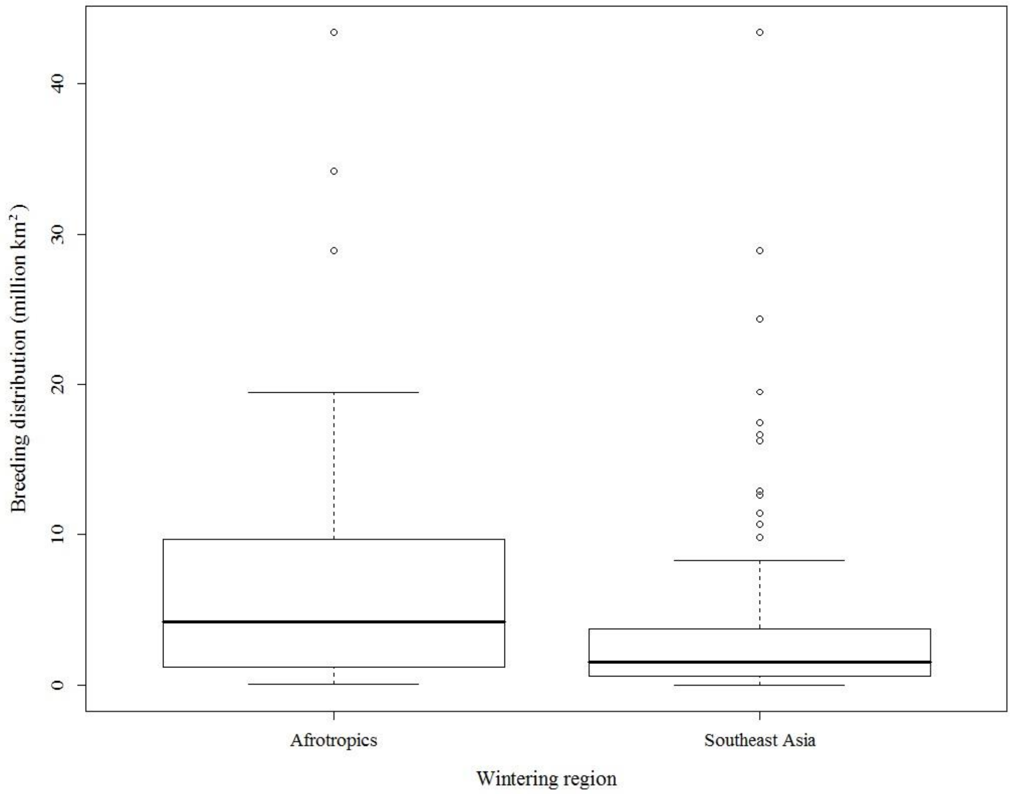
Figure 1

Figure 2



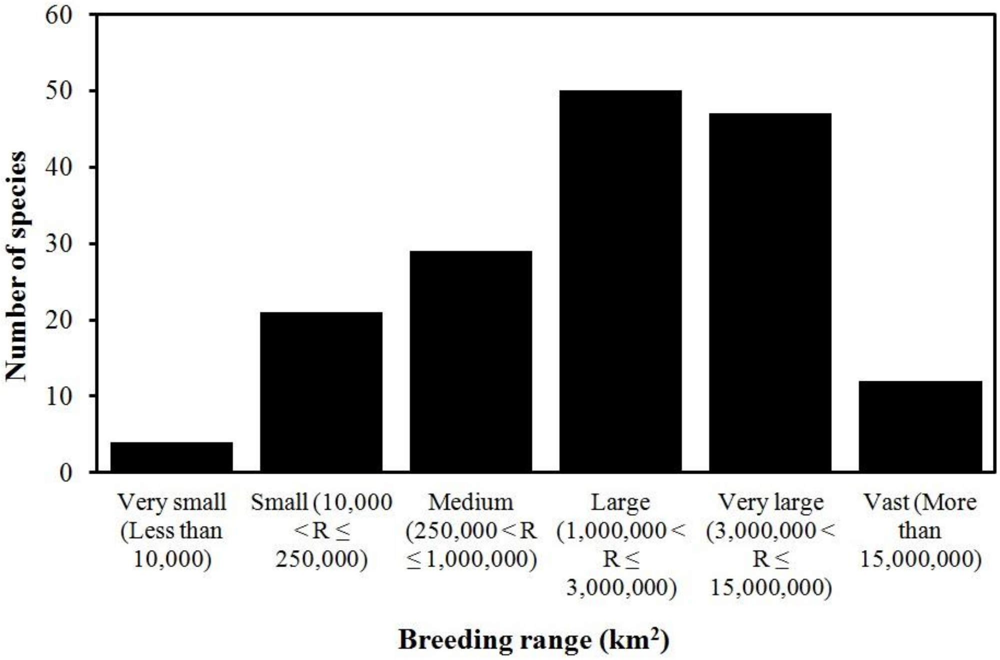
120
100
80
60
40
20
0
Number of species
Breeding
Wintering
Eastern Russia
North China
Korean Peninsula
Japanese Archipelago
East China
South China
Mainland Southeast Asia
Thai-Malay Peninsula
Greater Sundas
Philippine Archipelago
Wallacea

Figure 3



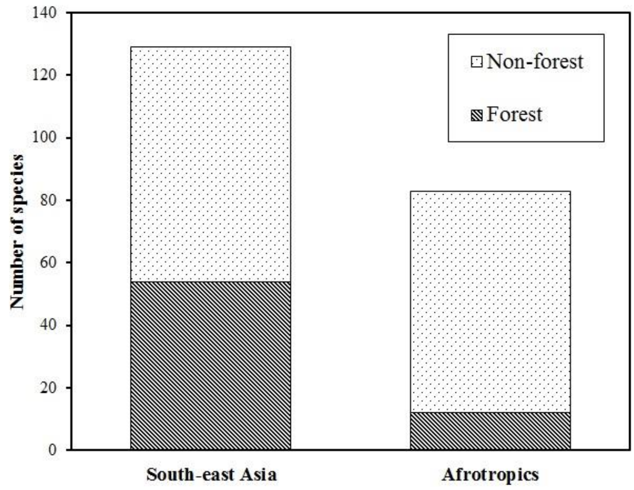
Breeding distribution (million km^2)
0
10
20
30
40
Afrotropics
Southeast Asia
Wintering region

Figure 4



60
50
40
30
20
10
0
Number of species
Very small (Less than 10,000)
Small (10,000 < R ≤ 250,000)
Medium (250,000 < R ≤ 1,000,000)
Large (1,000,000 < R ≤ 3,000,000)
Very large (3,000,000 < R ≤ 15,000,000)
Vast (More than 15,000,000)
Breeding range (km²)

Figure 5



140
120
100
80
60
40
20
0
Number of species
Non-forest
Forest
South-east Asia
Afrotropics

Figure 6

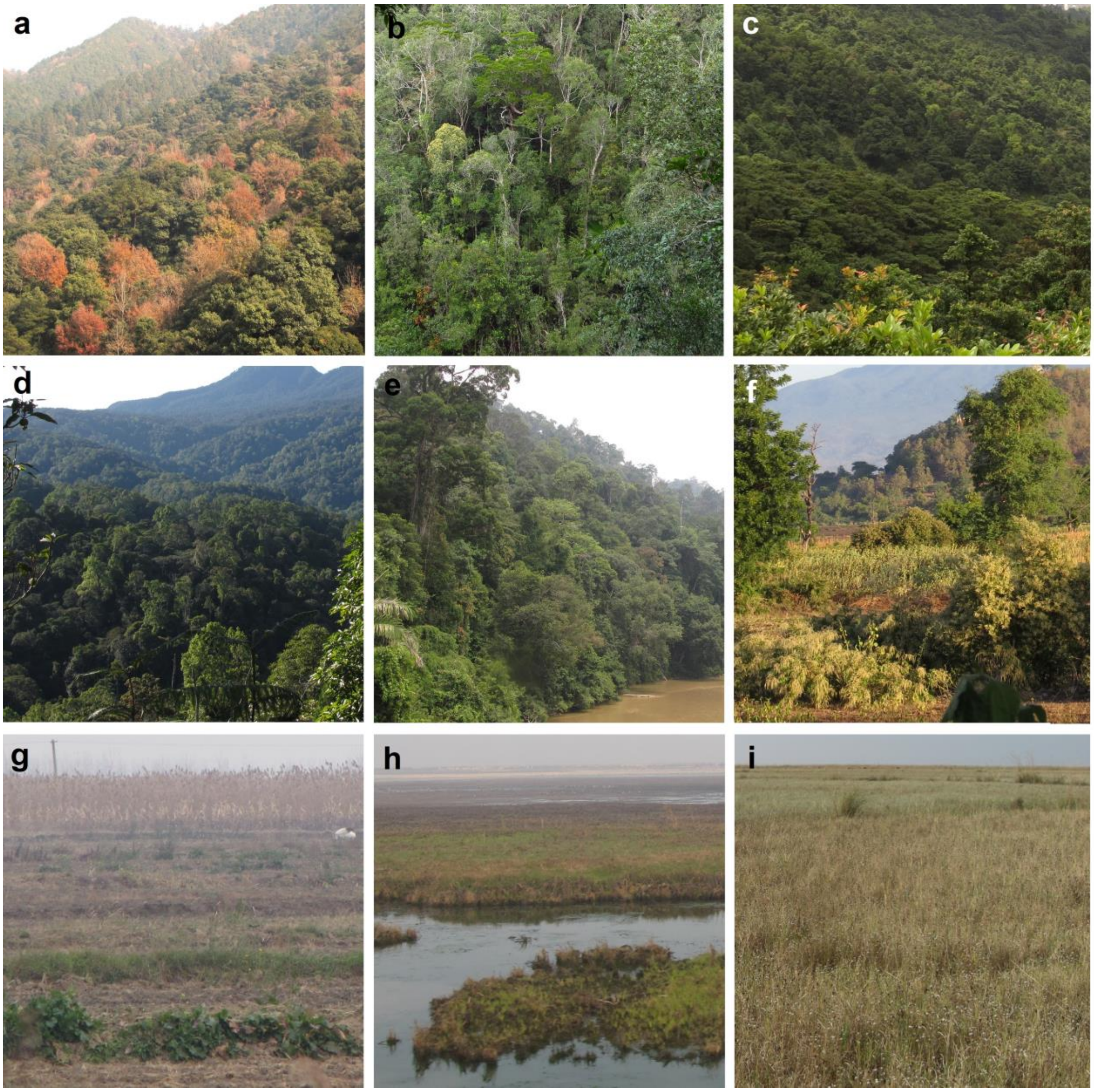
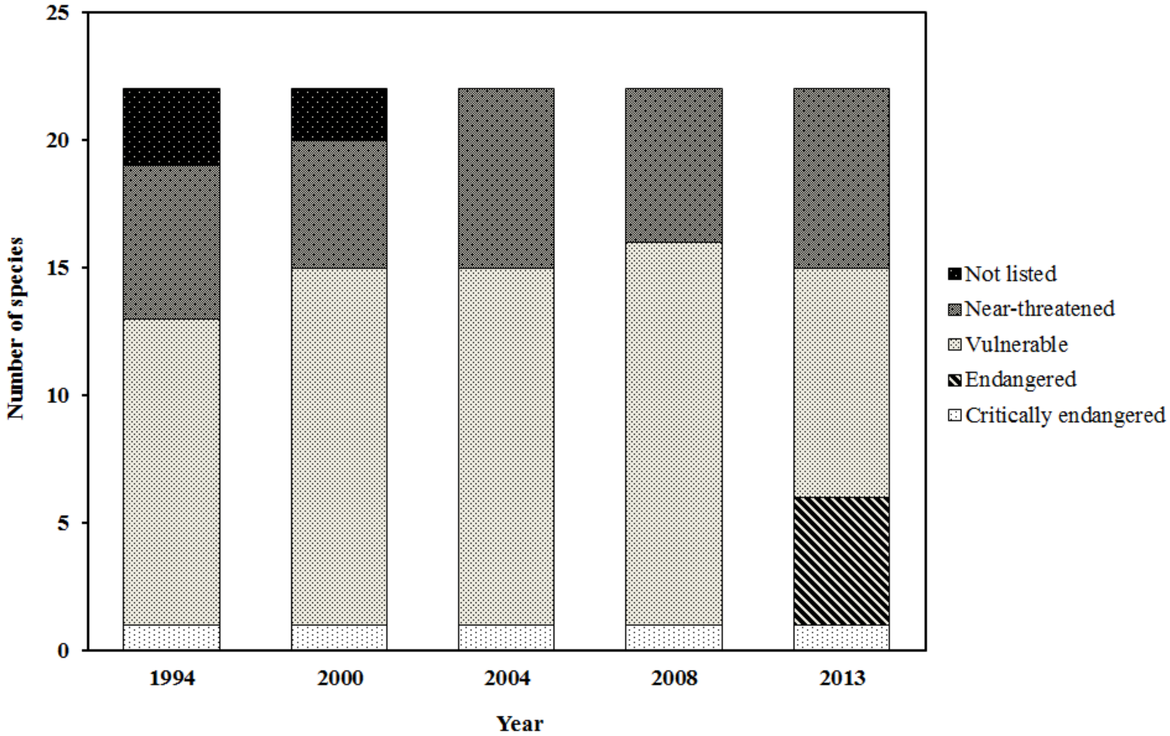


Figure 7



25
20
15
10
5
0
Number of species
1994
2000
2004
2008
2013
Year
Not listed
Near-threatened
Vulnerable
Endangered
Critically endangered

Figure 8