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Avian distribution and life-history strategies in Amazonian terra-firme and floodplain forests

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Abstract
The diversity of avian populations in the Madre de Dios region of Peru is currently threatened by deforestation and other anthropogenic factors. In this study we assessed differences in bird species composition in two major types of tropical forests: floodplain and terra-firme forest. Abundance of groups of behaviourally similar species showed a higher presence of certain feeding guilds in either floodplain forests or terra-firme forest, whereas no difference in species richness was found. Analysis of the relative reproductive investment (RRI) of these tropical birds showed significant differences between habitats and among families and feeding guilds. Comparison of these families and feeding guilds to their relatives in temperate regions showed that neotropical birds have a smaller RRI, due to both smaller clutch sizes and lower egg mass, even when there are more broods per season. Quantification of RRI as used in this study can be useful to indicate bird species’ susceptibility to anthropogenic factors in various habitats.

Keywords: tropical birds, Neotropical forest, avian distribution, relative reproductive investment, conservation
Introduction
Deforestation and many other anthropogenic factors currently threaten tropical rainforests, the richest terrestrial ecosystem on the planet [1,2]. Human activities affect the ecological integrity of the forest by changing carbon storage, river flow, water balance, and even the amelioration of infectious diseases [2-4]. Tropical rainforests consist of various habitats, including terra-firme forest and floodplain forest, which are affected differently by anthropogenic factors [5-7]. Different land access and use of oligotrophic terra-firme forest has resulted in dissimilar trophic cascades and human activities compared to eutrophic floodplain forests. As rainforests are one of the most biodiverse habitats on the planet, many different species are affected by these anthropogenic factors [2]. Among these are around four thousand species of birds that play important roles in the various habitats as top predators, pollinators, and seed dispersers [8]. Species composition of avian populations is likely to differ between terra-firme forest and floodplain forest, and despite studies in both terra-firme forest and floodplain forest, the differences in avian populations between these habitats are still poorly understood. This novel research assesses some of these differences [9-12].

The terra-firme forest is rainforest that is not inundated or flooded by rivers and is characteristic of upland forests. These forests are noticeably taller and more diverse (>400 tree species/hectare in some areas) than floodplain forest. They are found only on dry, well-drained soils and are characterized by many tropical hardwood trees [13]. Moreover, the tall Amazonian terra-firme forests enhance a larger vertical stratification within the bird community, where species of the different layers are more likely to forage in their respective storeys and thus in narrower strata [14].

Floodplain forests, on the other hand, are flooded seasonally and have relatively rich soils from the annual replenishment of nutrients from white-water rivers. In the Amazon, vast areas of such rainforests can be found. Floodplain forests, especially those located on river banks and islands, are often short-lived due to the meandering nature of tropical lowland
rivers, which eat away at the forests' base. Tropical floodplain forests are one of the most productive ecosystems and harbour a great diversity of (tree)species, if lower on average than terra-firme forest. Although aboveground woody biomass is consistently lower than terra-firme forests, biomass accumulation is high due to deposition of nutrient-rich sediments [15]. These diverse abiotic conditions might enhance a diverse avian species composition in floodplain forests. Both terra-firme and floodplain forests are rapidly disappearing due to deforestation for development of agricultural lands, gold mining, and cattle ranching [2].

Avian diversity is likely to differ between these habitats as the incidence of flowering and fruiting is much lower in terra-firme forests than in other neotropical forest habitats, possibly influencing the abundance of specific species(guilds) like frugivores and nectarivores [16]. Other species might flourish in terra-firme forest, such as mixed-species flock insectivores, especially leaf-gleaning insectivores that congregate in food-rich areas [17].

Bird species that prefer specific habitats might be severely affected by increasing deforestation. Analysis of life-history traits could identify species that are more susceptible to these anthropogenic factors. To compare the reproductive investment of species in various guilds in the two forest types, we used the Relative Reproductive Investment (RRI) [18]. The latter value, which uses clutch size, egg mass, and the number of clutches per season in relation to female body mass, gives an indication of annual reproductive effort. This effort is a good proxy for adult mortality levels, which are hard to obtain in these kind of biotopes. Adult mortality determines a species’ vulnerability to human impact, because when adult mortality is low (and thus also the RRI is low), additional mortality due to human impact can have more severe consequences to population levels compared to species with high reproductive effort (and usually already higher adult mortality).

In this paper, we address the following questions; (a) What is the difference in avian diversity among terra-firme forests and floodplain forests, and what are the possible causes? (b) What difference in life-history-trait, especially the RRI, exists between species in terra-firme forest and floodplain forest? (c) How do these differences in life-history traits relate to birds in temperate regions, in order to present a bigger reference for these RRI values?

Methods

Study area
This study was conducted within the Madre de Dios region of Peru at 18 sites of similar size: Fauna Forever House (AFF-House), Amazon Rainforest Conservation Center (ARCC), Rio Azul Ranger Station (AZUL), El Gato Homestay (BAL), Bozovich Concession (BOZ), Chuncho Clay Lick (CHUN), Los Amigos Research Center (CICRA), Explorer’s Inn (El), Limon Concession (LIMON), Malinowski Ranger Station (MALI), Campamento Pampa (PAMPA), Las Piedras Biodiversity Station (PIE), Reserva Amazonica Lodge (RA), Saona Lodge (SAONA), Sachavacayoc Centre (SC), Tambopata Ecolodge (TPL), Tambopata Research Center (TRC) and Wasai Lodge (WASAI). All of the sites are rainforest areas in the Amazon Basin, and six of them are located within the protected area complex of the Tambopata National Reserve and Bahuaja Sonene National Park (Fig. 1).
Distribution of avian populations using mist-netting

Eighteen sites with either floodplain or terra-firme forest were studied (Appendix 1), six of which are located within the protected area complex of the Tambopata National Reserve and Bahuaja Sonene National Park. Each site sampled with mist-nets covers a representative area of about 2,500 ha.

Birds were sampled by using mist-nets, which was justified as it allows similar and simultaneous sampling of various sites. Three mist-nets (each 12 m long, 3.5 m high, 5 shelves, and mesh size 36 mm) were placed consecutively (in a straight line) to provide a total net length of 36 m per sample point. At each site, sample points were located 50-300 m (mean 200 m) apart, for a total of 3-42 points per site. Sampling was spread over a five-year period (2009-2014), with 3-73 sample days per site. Intervals when no data was collected varied among sample periods at sites, and some sites were only sampled once during the aforementioned five-year period. During a mist-net operation at a site, nets were opened at three sample points simultaneously for the first few hours after dawn for three days. Netting-days were not always consecutive, due to weather conditions (sampling did not occur on rainy or very windy days). Open mist-nets were checked at least every half hour, and all captured birds, with the exception of hummingbirds, were banded with a numbered ring. After banding, female birds (based on plumage, cloacal protuberance and brood patch) were weighed. New captures and recaptures were recorded, although recaptures on the same day were released immediately.

Mist-nets focus on understory birds, but do not sample birds randomly [19-22]. As the effectiveness of mist-nets differs among different species, in this study only the capture rates of groups of behaviourally similar species were compared [19-21]. Therefore birds were
divided into guilds based on previous ecological classification [14,16,21,23]. Guilds included army ant followers (AA), solitary insectivores (I), solitary insectivore-frugivores (IF), mixed-species insectivore flocks (MFI), solitary frugivores (F), solitary frugivore-insectivores (FI), mixed-species insectivore-frugivore flocks (MFIF), and small vertebrates and large insects (SVLI) (Appendix 2 & 3).

Analysis
Capture rates were used as an index of abundance and presented as captures/1,000 net-hours, where a net-hour refers to 12 m of net open for one hour. Recaptures of birds during the same day were excluded. Species richness of the different habitats was determined with the program EstimateS (http://viceroy.eeb.uconn.edu/estimates/), using the classic formula for Chao 1 & Chao 2. Non-parametric richness and diversity estimators (MM Means, Jackknife, Chao, Bootstrap, ICE, Shannon and Simpson) were also assessed with EstimateS. Species richness estimators based on incidence data were Chao 2 and ICE, where the latter calculated the proportion of ‘infrequent’ species that were not ‘unique’. Jackknife 1 and 2 used both incidence and abundance data: Jackknife 2 used both ‘uniques’ and ‘duplicates’ and Jackknife 1 only ‘uniques’, but in combination with observed amount of species either corrected for repeated samples in incidence data. Chao 2 only used different factors for repeated sampling compared to Jackknife 2. Chao 1 and Bootstrap used abundance data again with ‘uniques’ and ‘duplicates’, but the Bootstrap estimator is based on the frequency distribution of the species found [24]. Diversity of species was assessed through the Shannon [25] and Simpson index [26].

Chi-square test of independence was performed to determine habitat specialists in terra-firme and floodplain forest. For analysis of capture rates between terra-firme forest and floodplain forest, which occurred per feeding guild, independent t-tests were conducted in SPSS (Version 16.0).

To get a comprehensive and comparable measure of reproductive investment, life-history traits like clutch size ($\bar{c}$), number of clutches per season ($N_c$) and egg mass ($m_{\text{egg}}$), divided by the female body mass ($m_{\text{female}}$) were used to assess the Relative Reproductive Investment (RRI) according to the following formula: $\text{RRI} = (\bar{c} \times N_c \times m_{\text{egg}}) / m_{\text{female}}$ [18]. Values were assessed for every individual species, to compare differences among habitats, between feeding guilds and phylogenetically related groups. For comparison with outlier values, data of life-history traits of West-European birds were included among phylogenetically related groups and among feeding guilds as well. Mann-Whitney U tests and Independent t-tests (SPSS, Version 16.0) were conducted to assess significant differences in life-history traits between related groups.

Results
Avian diversity in terra-firme and floodplain forests
After a total of 11,205 mist-net hours, 188 and 118 bird species were found in floodplain and terra-firme forests respectively. The species accumulation curves for the floodplain forest and terra-firme forest are presented in Figure 2. The x-axis is scaled by the number of accumulated samples and compares species density between the forest types. The species accumulation curves for the two habitats did not approach an asymptote, but the rate of accumulation of species with increasing sample numbers is decreasing (Fig. 2).
The floodplain forest has fewer species at comparable levels of sample accumulation. The number of species at 64 pooled samples (the maximum sample size of terra-firme forest) was 118 and 109.4 species for terra-firme forests and floodplain forest respectively. Accordingly, the observed species accumulation curve of the floodplain forest was within the 95% confidence intervals of the corresponding species accumulation curve of terra-firme forest, indicating no significant difference in species richness between floodplain forest and terra-firme forest.

More samples were taken from floodplain forests, with more observed species than in terra-firme forest (Table 1). Non-parametric species richness estimators for incidence and abundance data estimated the species richness of the two habitats (Table 1). The differences between the highest and lowest species estimators were 71.47 for floodplain forest (n=353), 47.11 for floodplain forest (n=64) and 42.29 for terra-firme forest. A total of 90 unique bird species were present in floodplain forest, and 20 unique species in terra-firme forest; 98 species were present in both habitats. Of course, a higher species richness in floodplain forest was found due to the greater number of samples; at the maximum sample size of terra-firme forest (n=64), species richness of almost all estimators, except for Chao 2, were higher in terra-firme forest. Diversity estimators were higher in terra-firme forest at all sample sizes (Table 1).

Estimation of preference of various bird species for specific habitats occurred by comparing abundance data in floodplain and terra-firme forests. Habitat associations were detected in 60 species (Appendix 4), chi-square tests showed that 30 species preferred floodplain forest and 30 terra-firme forest.

Preferences of certain feeding guilds for floodplain forest and terra-firme forest were estimated: solitary frugivore-insectivores (FP=3; TF=0) and mixed species flock insectivores (FP=7; TF=3) had more habitat specialists present in floodplain forest. Habitat specialists of solitary insectivores (FP=4; TF=17) preferred terra-firme forest.
Table 1: Species richness estimators. Number of samples and individuals, species observed and species richness (MM means, Chao 1, Chao 2, Jackknife 1, Jackknife 2, Bootstrap and ICE) and diversity (Shannon and Simpson) estimate values for floodplain and terra-firme forests.

|                      | Floodplain Forest | Terra Firme Forest |
|----------------------|-------------------|-------------------|
| No. of samples       | 353               | 64                |
| No. of Individuals   | 3,285             | 711.3±0.29        |
|                      | 79.4±1.28         | 19.9±0.03         |
| Unique species       | 188               | 118               |
|                      | 19.9±0.03         | 20                |

**Richness**

|                      | Floodplain Forest | Terra Firme Forest |
|----------------------|-------------------|-------------------|
| MM Means             | 192.3             | 144.68            |
| Chao 1               | 224.7±14.88       | 147.6±16.86       |
|                      | 153.9±15.61       |
| Chao 2               | 242.41±20.75      | 160.74±21.04      |
|                      | 157.57±15.91      |
| Jackknife 1          | 236.86±7.88       | 151.9±8.10        |
|                      | 160.3±6.74        |
| Jackknife 2          | 263.7±15.33       | 175.5±15.33       |
|                      | 180.06            |
| Bootstrap            | 210.07            | 128.42±7.51       |
|                      | 137.77            |
| ICE                  | 231.46            | 156.5±15.39       |
|                      | 163.59±0.02       |

**Diversity**

|                      | Floodplain Forest | Terra Firme Forest |
|----------------------|-------------------|-------------------|
| Shannon Index        | 4.16              | 3.98±0.08         |
| Simpson Index        | 26.79             | 25.82±3.5         |

Fig. 3: Abundance per sampling effort of various feeding guilds compared between floodplain (FP) and terra-firme forest (TF). See Table 2 for abbreviations of feeding guilds. Fault bars indicate Standard Error, **= P<0.01.
Abundances for the various feeding guilds per 1,000 mist-net hours (Fig. 3) showed significant differences among certain guilds. Significantly more present in floodplain forests were frugivores (Independent t-test, P=0.005) and insectivore-frugivores (Independent t-test, P=0.002), and a trend was shown by army-ant followers (Independent t-test, P=0.053). An opposite trend was found with insectivores (Independent t-test, P=0.072), which were more abundant in terra-firme forests.

**Life-history traits of tropical bird populations**

Average values of the specific life-history traits used to calculate the relative reproductive investment (RRI) have been estimated for the species in various families and feeding guilds (Table 2; Appendix 5 & 6).

**Table 2**: Average value (with standard error) for specific life-history traits of tropical birds, in various feeding guilds, used in the calculation of the relative reproductive investment.

| Feeding guild | Clutch size (g) | Broods per season | Egg mass (g) | Female body mass (g) | RRI      |
|---------------|----------------|-------------------|-------------|---------------------|----------|
| AA            | 1.80(0.09)     | 2                 | 7.05        | 52.16(3.66)         | 0.332    |
| F             | 2.38(0.03)     | 2.12(0.02)        | 4.29(0.37)  | 41.90(2.14)         | 0.588(0.056) |
| FI            | 2.36(0.02)     | 1.77(0.03)        | 6.18(0.32)  | 88.65(4.77)         | 0.474(0.064) |
| I             | 2.29(0.01)     | 1.94(0.01)        | 4.10(0.06)  | 29.42(0.31)         | 0.629(0.034) |
| IF            | 2.81(0.05)     | 1.85(0.02)        | 4.90(0.16)  | 49.39(1.90)         | 0.551(0.062) |
| MFI           | 2.15(0.02)     | 1.97(0.01)        | 2.84(0.17)  | 22.15(0.36)         | 0.675(0.099) |
| MFIF          | 3.00           | 2                 | 5.25(1.45)  | 97.88(45.5)         | 0.270    |
| N             | 2.00           | 2                 | 0.63(0.02)  | 4.950(0.07)         | 0.526(0.038) |
| SVLI          | 2.93(0.11)     | 1                 | 13.7(1.94)  | 121.3(12.5)         | 0.376(0.064) |

Feeding guilds based on classification in Henriques et al. [16]. AA = army ant followers, F = solitary frugivores, FI = solitary frugivore-insectivores, I = solitary insectivores, IF = solitary insectivore-frugivores, MFIF = mixed species insectivore-frugivore flocks, MFI = mixed species insectivore-frugivore, N = nectarivores, SVLI = small vertebrates and large insects.

Birds of different feeding guilds in the tropics all had similar clutch sizes and number of broods per season, so the difference in RRI was the result of egg and female body mass. For nectarivores, mostly hummingbirds, egg mass and female body mass were small. For frugivores these values were higher than in insectivores, resulting in an average lower RRI for frugivores than for insectivores (Table 2 & 3).

Estimation of the relative reproductive investment (RRI) has been calculated based on several life-history traits (Appendix 2 & 3). RRI was calculated per individual species and was combined per family and per feeding guild (Appendix 5 & 6). In the tropical regions, there was a broad range of RRI-values (0.253-0.814) among families with significant differences (Kruskal-Wallis: P=0.001). Among feeding guilds a trend was present (Kruskal-Wallis: P=0.079). In temperate regions significant differences were found in RRI-values both among families (Kruskal-Wallis: P<0.001) and feeding guilds (Kruskal-Wallis: P<0.001) (Appendix 5 & 6).

RRI among bird species with a preference for floodplain forest or terra-firme forest within feeding guilds was compared (Table 3). Only frugivores showed a significant higher RRI in floodplain forest compared to similar species in terra-firme forest (P=0.016; independent t-test) (Table 3). For comparison of life-history traits and RRI between the tropical and temperate region, families and feeding guilds present in both regions were compared (Table 4).
Table 3: Comparison of RRI from habitat specialists within feeding guilds. Average values (with Standard Error) and P-values for independent t-test and Mann Whitney U test are shown. See Table 2 for abbreviations of feeding guilds.

|                | Floodplain forest | Terra firme forest | T-test | Mann-Whitney U-test |
|----------------|-------------------|-------------------|--------|---------------------|
| F              | 0.724(0.074)      | 0.345(0.079)      |        | P=0.016             |
| FI             | 0.614(0.029)      | 0.633(0.044)      |        | P=0.922             |
| I              | 0.642(0.085)      | 0.457(0.015)      |        |                     |
| IF             | 0.556(0.100)      | 0.401             |        | P=0.667             |
| MFI            | 0.578(0.132)      | 0.509             |        | P=1.000             |
| SVLI           | 0.572(0.025)      |                   |        |                     |

Table 4: Comparison of relative reproductive investment between similar families and feeding guilds in the tropical and temperate regions. Average value (with Standard Error) is shown. Mann-Whitney U test and Independent T-test show significance of difference between these regions. See Table 2 for abbreviations of feeding guilds.

| Family         | Tropical     | Temperate    | T-test | Mann-Whitney U-test |
|----------------|--------------|--------------|--------|---------------------|
| Alcedinidae    | 0.572(0.025) | 1.435        |        | P=1.000             |
| Columbidae     | 0.297(0.062) | 0.290(0.096) | P=0.950| P=1.000             |
| Cuculidae      | 0.814        | 0.299        |        |                     |
| Emberizidae    | 0.666(0.071) | 0.991(0.077) | P=0.017| P=1.000             |
| Falconidae     | 0.304(0.037) | 0.373        |        |                     |
| Picidae        | 0.270        | 0.407(0.073) | P=0.508|                     |
| Troglodytidae  | 1.099(0.074) | 2.030        |        | P=1.000             |
| Turdidae       | 0.585(0.059) | 0.978(0.123) | P=0.012|                     |

| Feeding guild  | Tropical     | Temperate    | T-test |                  |
|----------------|--------------|--------------|--------|------------------|
| F              | 0.587(0.055) | 0.491(0.103) | P=0.399|                  |
| I              | 0.628(0.034) | 0.810(0.070) | P=0.024|                  |
| IF             | 0.550(0.061) | 0.770(0.069) | P=0.023|                  |
| MFI            | 0.675(0.099) | 1.317(0.318) | P=0.051|                  |
| MFIF           | 0.270        | 1.213(0.327) | P=0.305|                  |
| SVLI           | 0.376(0.064) | 0.412(0.041) | P=0.649|                  |

Life-history data in the tropical regions and in the temperate regions could be found only for the families presented in Table 4. For Emberizidae and Turdidae, a significant (P<0.05; independent t-test) difference between species in the tropics and temperate regions was found. In both families, species in the temperate regions have a higher RRI than related species in the tropics (Table 4).

Comparison of feeding guilds resulted in a significant difference between temperate and tropical regions for all insectivore-guilds: the RRI-value was higher in the temperate regions for insectivores, insectivore-frugivores, and mixed species flock insectivores. Other feeding guilds did not show a significant different RRI-value between these regions (Table 4). Army ant followers and nectarivores were not present in temperate regions.
The basic life-history traits in the significantly different RRs for families and feeding guilds showed that in all situations temperate clutches were larger and number of clutches hardly differed in Emberizidae and Turdidae, but was lower in temperate insectivores and insectivore-frugivores and higher in mixed species flock insectivores. Egg mass was lower in the tropics in all insectivorous feeding guilds and Emberizidae, but not in Turdidae where female body masses were much higher (Table 5).

**Discussion**

The variation in distribution of all tropical bird species in the Madre de Dios region might be due to specific abiotic factors within the floodplain and terra-firme forest. Although no significant difference was found in species richness and diversity, a trend suggested that these estimators were higher in terra-firme forest. This is in line with the idea that there is more stratification in terra-firme forest, as trees are taller, and more diversity and density of trees create more available niches for various bird species [13]. On the other hand, for most feeding guilds numbers are higher in the floodplain forest, so productivity may be higher there than in terra-firme forest (Fig. 3). Habitat associations were found for a large number of species that preferred either floodplain or terra-firme forest. Frugivore-insectivores and mixed species flock insectivores had more habitat specialists in floodplain forest, whereas insectivores had more in terra-firme forest. Comparison of total avian populations where division was based on feeding guilds showed a higher abundance of frugivores and insectivore-frugivores in floodplain forests, possibly because there is more flowering and fruiting of plants in floodplain forests [17], although for nectarivores no difference was found. Solitary insectivores, on the contrary, preferred terra-firme forests where the high diversity of trees is a source for a wide variety of insects [13].

Abundance of specific bird populations in habitats indicates an important role for different food availability in terra-firme and floodplain forest. Munn and Terborgh [17] and Henriques et al. [16] already suggested that insectivores were likely to be more abundant in terra-firme forest and frugivores more abundant in floodplain forest. This study supports those suggestions, with these specific feeding guilds being more abundant in their respective habitats. These habitats are threatened by deforestation, which increases fragmentation of areas and is detrimental to various bird species [27]. According to Gray et al. [10] insectivores and frugivores are the feeding guilds most prone to forest disturbance. As terra-firme and floodplain forests are severely reduced by deforestation in the Amazon, abundance of these feeding guilds is likely to decrease, affecting both trophic organization and ecological functioning of these areas. This ecological study was a pilot, as for certain species only trends

**Table 5:** Average value (with SE) of life-history traits used in calculation for RRI. Average clutch size (c), Number of broods per season (Nc) Egg mass in grams (megg) and Female body mass in grams (mfemale). See Table 2 for abbreviations of feeding guilds.

|        | Tropical | Temperate | Tropical | Temperate | Tropical | Temperate | Tropical | Temperate |
|--------|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| Emberizidae | 2.49(0.15) | 4.45(0.21) | 2.00(0.03) | 3.73(0.07) | 3.58(0.27) | 4.69(0.30) | 3.75(0.27) | 4.78(0.24) |
| Turdidae | 2.73(0.33) | 5.17(0.21) | 2.00(0.03) | 3.73(0.07) | 3.58(0.27) | 4.69(0.30) | 3.75(0.27) | 4.78(0.24) |
| I | 2.29(0.11) | 4.78(0.24) | 1.94(0.03) | 3.73(0.07) | 3.58(0.27) | 4.69(0.30) | 3.75(0.27) | 4.78(0.24) |
| IF | 2.81(0.19) | 5.45(0.25) | 1.85(0.08) | 3.73(0.07) | 3.58(0.27) | 4.69(0.30) | 3.75(0.27) | 4.78(0.24) |
| MFI | 2.16(0.11) | 4.59(0.61) | 1.97(0.03) | 3.73(0.07) | 3.58(0.27) | 4.69(0.30) | 3.75(0.27) | 4.78(0.24) |
have become visible a larger scale study might more precisely determine species composition within these habitats. Such future research could also include monitoring of food availability within these habitats to define habitat-feeding guild relationships with more power.

Comparison of the values for life-history traits, especially the RRI, among the various feeding guilds within the tropics showed differences, as frugivores had a relatively low relative reproductive investment compared to insectivores. Significant differences in RRI were found not only among feeding guilds but also among families, resulting in different tactics of reproduction and survival of these avian populations.

Floodplain forests are fast-changing habitats for tropical birds due to flooding, biomass deposition from rivers, and secondary growth of the forest. These conditions seemed to lead to a higher RRI-value, as has been reported for frugivores, than for similar species in terra-firme forest. Other feeding guilds showed a similar trend, but due to lack of values of life-history traits for a number of species, numbers were quite low to base a conclusion on. The increased RRI in floodplain forest compared to terra-firme forest indicates a shift in the balance of reproduction and survival towards higher reproduction, made possible by the more nutrient-rich conditions in the floodplains, probably compensating for a higher risk of loss of either broods or higher juvenile and/or adult mortality due to flooding, for instance. Neotropical families of birds, especially those with low RRI, are more prone to deforestation and other environmental changes as these species do not easily compensate for increased adult mortality. Species composition of avian populations in terra-firme forests consists of birds with a relatively low relative reproductive investment, which are more susceptible to these anthropogenic impacts from, for example, deforestation.

It has been long recognized that tropical birds differ fundamentally from temperate zone birds in their life-history traits. Tropical birds have high nest predation, high adult survival, and small clutch sizes [28,29]. Various other studies have questioned the validity of these differences [30,31]. This study showed that the RRI for comparable groups of behaviourally similar species is in most cases higher for species in the temperate regions than in the tropical regions. Significant differences were found between Emberizidae and Turdidae and insectivorous feeding guilds, in all of which the RRI was higher in the temperate species. As nest predation is high in tropical birds, these species invest less in offspring, resulting in a lower RRI; they may therefore have lower adult mortality and can spread the risks of failed broods over a longer time. In other words one may state that spring in the temperate regions gives the possibility of an increased investment in reproduction, due to its increased biomass production. The downside being the increased risk of either surviving winter or facing the costs and risks of migration.

Tropical birds have smaller clutches than temperate zone birds, which is in line with other studies [32,33]. Larger clutch sizes have reduced food delivery, higher predation risk, and lower juvenile recruitment. In temperate regions, the food limitation hypothesis suggests that daylength in temperate regions allows these birds to gather more food to sustain larger clutches [34]. Growth rate in the tropics is slower [35] and food delivery rates are low [36]. Most tropical birds will renest after a first brood failure or have multiple broods per season, especially as in the tropics a relatively high nest predation is present as about 80% of the nests are lost to predators [29,36]. This number is so high because there is a large number and
diversity of nest predators in the tropics [32,37]. Tropical birds seem to invest less in their offspring, as the egg mass of tropical species is lower compared to temperate species. Female body mass as such varies extremely, without clear patterns. Because tropical birds have a lower RRI and invest less in their offspring due to higher predation risk, food limitation, and spreading the risk over the years, their naturally higher adult survival renders them extra vulnerable to increased adult mortality from anthropogenic influences.

Fig. 4: Some bird species from the Amazon Basin within the Tambopata National Reserve and Bahuaja Sonene National Park. A. Band-tailed Manakin (Pipra fasciicauda) B. American Pygmy-kingfisher (Chloroceryle aenea) C. Plumbeous antbird (Myrmeciza hypertyhra) D. Green-and-gold Tanager (Tangara schrankii) (All photos by Alexis Diaz Campo).

**Implications for conservation**

Understanding distribution differences of behaviourally similar species among tropical forest types is important for identifying bird species prone to anthropogenic factors, as these forests are currently subjected to deforestation and fragmentation. The results in this study show specific foraging groups to be more abundantly present in either terra-firme or floodplain forests (Fig. 4). The species-specific life-history traits of these birds show that the relative reproductive effort is lower in terra-firme forest species. Which means that birds here invest less in reproduction and more in adult survival, these birds cannot compensate for the high adult mortality caused by deforestation, whereas floodplain forest species invest more in reproduction and can better cope with such anthropogenic factors. These values for
distribution and relative reproductive investment are important in understanding the differences in the ability of birds to cope with environmental changes and is therefore advised to be used in conservation activities.

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## Appendix 1

Classification of sites with terra-firme forest or floodplain forest (X indicates presence of forest type at location).

| Site    | Coordinates       | Terra-firme forest | Floodplain forest |
|---------|-------------------|--------------------|-------------------|
| AFF-House | S 12 36 42.6, W 69 11 44.9 | X                  |                   |
| ARCC     | S 12 2 47.6, W 69 40 37.0 |                    | X                 |
| AZUL     | S 13 2 40.1, W 69 54 37.1 |                    |                   |
| BAL      | S 12 51 0.3, W 69 27 27.0 |                    | X                 |
| BOZ      | S 11 35 12.8, W 69 38 56.9 | X                  |                   |
| CHUN     | S 12 58 18.0, W 69 30 12.1 |                    |                   |
| CICRA    | S 12 34 8.6, W 70 6 3.4 | X                  | X                 |
| EI       | S 12 50 13.3, W 69 17 36.4 |                    | X                 |
| LIMON    | S 12 32 20.9, W 68 51 42.1 | X                  |                   |
| MALI     | S 12 56 2.1, W 69 31 2.2 |                    |                   |
| PAMPA    | S 12 56 59.8, W 68 54 45.8 |                    | X                 |
| PIE      | S 12 3 23.5, W 69 31 43.4 | X                  |                   |
| RA       | S 12 32 26.6, W 69 3 11.1 |                    | X                 |
| SAONA    | S 12 44 45.6, W 69 14 0.1 |                    |                   |
| SC       | S 12 51 12.5, W 69 22 3.4 |                    |                   |
| TPL      | S 12 49 27.7, W 69 24 10.7 |                    |                   |
| TRC      | S 13 8 3.2, W 69 36 38.9 |                    |                   |
| WASAI    | S 12 51 2.1, W 69 28 9.3 |                    | X                 |
Appendix 2

Guild classification of captured bird species in Madre de Dios region, Peru based on Henriques et al. [16], Wunderle et al. [14] and Schulenberg et al. [23]. Life-history traits (average clutch size, number of broods per season, egg mass and female body mass) for estimation of the relative reproductive investment (RRI) based on Jetzt et al. [38], Del Hoyo et al. [39], Schönwetter and Meise [40] and field-data.

| Species[a] | English name[a] | Average clutch size | Number of broods per season | Egg mass (g) | Female body mass (g) | RRI | Feeding guild[a] |
|------------|-----------------|---------------------|-----------------------------|--------------|---------------------|-----|------------------|
| **Alcedinidae** | | | | | | | |
| Chloroceryle aenea | American Pygmy-kingfisher | 3.5 | 1 | 2.40 | 14.05 | 0.5979 | SVLI |
| Chloroceryle inda | Green-and-rufous Kingfisher | 3.9 | 1 | 7.40 | 52.75 | 0.6471 | SVLI |
| **Bucconidae** | | | | | | | |
| Bucco macrodactylus | Chestnut-capped Puffbird | | | | 25.00 | | I |
| Malacoptila seminicta | Semi-collared Puffbird | | 1 | 7.40 | 44.00 | | I |
| Monasa morphoeus | White-fronted Nunbird | 2.4 | 1 | 7.50 | 82.00 | 0.2195 | SVLI |
| Monasa nigrifrons | Black-fronted Nunbird | 3.0 | 1 | 7.90 | 83.00 | 0.2855 | SVLI |
| **Cardinalidae** | | | | | | | |
| Cyanocompsa cyanoides | Blue-black Grossbeak | 2.0 | 2 | | 27.87 | | FI |
| Saltator grossus | Slate-colored Grossbeak | 2.5 | 2 | | 47.00 | | FI |
| Saltator maximus | Buff-throated Saltator | 2.0 | 2 | | 49.10 | 0.4684 | FI |
| **Columbidae** | | | | | | | |
| Claravis pretiosa | Blue-Ground Dove | 2.0 | 3 | 3.80 | 93.50 | 0.2438 | F |
| Columbina talpacoti | Ruddy Ground-dove | 2.0 | 3 | 3.60 | 45.27 | 0.4771 | F |
| Geotrygon montana | Ruddy Quail-dove | 2.0 | 3 | 5.30 | 115.2 | 0.2760 | F |
| Leptotila rufaxilla | Grey-fronted Dove | 1.4 | 3 | 6.80 | 149.0 | 0.1917 | F |
| **Conopophagidae** | | | | | | | |
| Conopophaga peruviana | Ash-throated Gnateater | 2.0 | 2 | | 23.30 | | I |
| **Cotingidae** | | | | | | | |
| Lipaugus vociferans | Screaming Piha | | | | 82.60 | | FI |
| **Cuculidae** | | | | | | | |
| Crotophaga ani | Smooth-billed Ani | 2.9 | 2 | 13.2 | 94.00 | 0.8145 | I |
| **Emberizidae** | | | | | | | |
| Common Name | Scientific Name | Length | Bill | Weight | MCI | Notes |
|-------------|----------------|--------|------|--------|-----|-------|
| Yellow-browed Sparrow | Ammodramus aurifrons | 2.4 | 2 | 2.25 | 16.75 | 0.6448 | F |
| Pectoral Sparrow | Arryremon taciturnus | 2.0 | 2 | 3.50 | 26.50 | 0.5283 | IF |
| Chestnut-bellied Seed-finch | Oryzoborus angolensis | 2.5 | 2 | 2.03 | 12.32 | 0.8239 | F |
| Black-billed Seed-finch | Oryzoborus atrirostris | | | | 26.40 | F |
| Red-capped Cardinal | Paroaria gularis | 2.0 | 2 | 2.29 | 26.40 | 0.5283 | IF |
| Double-collared Seedeater | Sporophila caerulescens | 3.0 | 2 | 1.45 | 9.550 | 0.9110 | F |
| Chestnut-bellied Seedeater | Sporophila castaneiventris | 3.0 | 2 | 1.30 | 11.83 | 0.6593 | F |
| Black-billed Seedeater | Sporophila schistacea | 3.0 | 2 | 1.43 | 9.500 | 0.7526 | F |
| Blue-black Grassquit | Volatinia jacarina | 2.5 | 2 | | | |
| Lined Forest-falcon | Micrastur gilvicollis | 2.4 | 1 | 28.0 | 196.5 | 0.3420 | SVLI |
| Barred Forest-falcon | Micrastur ruficollis | 2.4 | 1 | 29.0 | 261.0 | 0.2667 | SVLI |
| Striated Antthrush | Chamaeza nobilis | 2.0 | 2 | 7.60 | 134.0 | 0.2269 | I |
| Black-faced Antthrush | Formicarius analis | 2.0 | 2 | 9.00 | 56.60 | 0.6360 | I |
| Rufous-capped Antthrush | Formicarius colma | 2.0 | 2 | 8.30 | 50.10 | 0.6627 | I |
| Dusky-cheeked Foliage-gleaner | Anabazenops dorsalis | | | | 39.00 | I |
| Chestnut-winged Hookbill | Ancistrops strigilatus | | | | 34.50 | MFI |
| Olive-backed Foliage-gleaner | Automolus infuscatus | | | | 40.50 | MFI |
| Brown-rumped Foliage-gleaner | Automolus melanopezus | | | | 29.50 | I |
| Buff-throated Foliage-gleaner | Automolus ochrolaemus | 2.4 | 2 | 5.56 | 38.00 | 0.7023 | I |
| Chestnut-crowned Foliage-gleaner | Automolus rufipileatus | | | | 34.50 | I |
| Red-billed Scythebill | Campylorhamphus trochilirostris | 2.0 | 2 | 5.85 | 42.50 | 0.5506 | I |
| Long-tailed Woodcreeper | Deconychura longicauda | 2.0 | 2 | | 47.80 | MFI |
| Cinnamon-throated Woodcreeper | Dendrexetastes rufigula | 2.4 | 2 | 7.35 | 70.00 | 0.5040 | I |
| Plain-brown Woodcreeper | Dendrocincla fuliginosa | 1.7 | 2 | 6.35 | 35.00 | 0.6169 | I |
| White-chinned Woodcreeper | Dendrocincla merula | | | | 40.00 | AA |
| Amazonian Barred Woodcreeper | Dendrocolaptes certhia | 1.0 | 2 | | 90.10 | AA |
| Black-banded Woodcreeper | Dendrocolaptes picumnus | 2.0 | 2 | 7.05 | 85.00 | 0.3318 | AA |
| Straight-billed Woodcreeper | Dendroplex picus | 2.5 | 2 | | 38.20 | MFI |
| Genus/Monotypic Species | English Name | Density (individuals/ha) | Size (mm) | Body Mass (g) | Index in MFI |
|------------------------|-------------|--------------------------|-----------|--------------|-------------|
| *Furnarius leucopus*   | Pale-legged Hornero | 2.0 | 2 | 4.95 | 49.00 | 0.4041 | I |
| *Glyphorrhynchus spirurus* | Wedge-billed Woodcreeper | 1.7 | 2 | 1.75 | 14.82 | 0.4015 | MFI |
| *Hylcostistes sublatus* | Striped Woodhaunter | | | 29.50 | | MFI |
| *Lepidocolaptes alboineatus* | Lineated Woodcreeper | 2 | | 4.74 | 19.25 | MFI |
| *Nasica longirostris* | Long-billed Woodcreeper | | | 85.00 | | I |
| *Philydor erythrocercum* | Rufous-rumped Foliage-gleaner | 2.0 | 2 | | 24.50 | MFI |
| *Philydor erythropterum* | Chestnut-winged Foliage-gleaner | | | 32.00 | | MFI |
| *Philydor pyrrhodes* | Cinnamon-rumped Foliage-gleaner | | | 29.50 | | MFI |
| *Philydor ruficaudatum* | Rufous-tailed Foliage-gleaner | 2 | 3.68 | | 26.50 | MFI |
| *Sclerurus albigularis* | Gray-throated Leaf-tosser | 2.0 | 2 | 5.41 | 40.00 | 0.5410 | I |
| *Sclerurus caudacutus* | Black-tailed Leaf-tosser | 2.0 | 2 | 5.58 | 38.00 | 0.5874 | I |
| *Sclerurus mexicanus* | Tawny-throated Leaf-tosser | 2.0 | 2 | | 27.00 | I |
| *Simoxenops ucayalae* | Peruvian Recurvebill | | | 51.10 | | I |
| *Sittasomus griseicapillus* | Olivaceous Woodcreeper | 3.0 | 2 | 2.35 | 12.00 | 1.1750 | MFI |
| *Synallaxis gujanensis* | Plain-crowned Spinetail | 2.4 | 2 | 2.93 | 17.50 | 0.8037 | I |
| *Synallaxis rutilans* | Ruddy Spinetail | 3.5 | 2 | 2.25 | 18.50 | 0.8514 | MFI |
| *Xenops minutus* | Plain Xenops | 2.0 | 2 | | 11.00 | | MFI |
| *Xiphocolaptes promeropirhynchus* | Strong-billed Woodcreeper | 2.5 | 2 | 13.3 | 140.0 | 0.4750 | I |
| *Xiphorhynchus elegans* | Elegant Woodcreeper | 2.0 | 1 | 8.10 | 61.00 | 0.3320 | IF |
| *Xiphorhynchus guttatus* | Buff-throated Woodcreeper | 1.7 | 2 | 7.46 | 56.00 | 0.4529 | MFI |
| *Xiphorhynchus ocellatus* | Ocellated Woodcreeper | | 2 | | 37.00 | | MFI |

**Galbulidae**

| Genus/Monotypic Species | English Name | Density (individuals/ha) | Size (mm) | Body Mass (g) | Index in MFI |
|------------------------|-------------|--------------------------|-----------|--------------|-------------|
| *Galbula cyanescens*   | Bluish-fronted Jacamar | 2.0 | 2 | 4.30 | 24.00 | 0.7167 | I |

**Icteridae**

| Genus/Monotypic Species | English Name | Density (individuals/ha) | Size (mm) | Body Mass (g) | Index in MFI |
|------------------------|-------------|--------------------------|-----------|--------------|-------------|
| *Clypicterus oseryi*   | Casqued Oropendola | | | 101.4 | | F |

**Momotidae**

| Genus/Monotypic Species | English Name | Density (individuals/ha) | Size (mm) | Body Mass (g) | Index in MFI |
|------------------------|-------------|--------------------------|-----------|--------------|-------------|
| *Baryphthengus martii* | Rufous Motmot | | | 146.6 | | IF |
| *Electron platyrhynchum* | Broad-billed Motmot | 2.5 | 1 | 8.10 | 61.00 | 0.3320 | IF |
| *Momotus momota*       | Amazonian Motmot | 3.5 | 1 | 7.50 | 140.0 | 0.1875 | IF |

**Parulidae**

| Genus/Monotypic Species | English Name | Density (individuals/ha) | Size (mm) | Body Mass (g) | Index in MFI |
|------------------------|-------------|--------------------------|-----------|--------------|-------------|
| *Dendroica petechia*   | Yellow Warbler | 4.5 | 1 | 1.35 | 11.70 | 0.5192 | I |
| Species                        | Common Name                      | Length (m) | Width (m) | Height (m) | Mass (kg) | Density |
|-------------------------------|----------------------------------|------------|-----------|------------|-----------|---------|
| Phaeothlypis fulvicauda       | Buff-rumped Warbler              | 2.0        | 1         | 2.39       | 14.90     | 0.3208  |
| Picidae                       |                                  |            |           |            |           |         |
| Celeus elegans                | Chestnut Woodpecker              | 3.0        | 2         | 7.30       | 162.2     | 0.2701  | MFIF    |
| Picumnus rufiventris          | Rufous-breasted Piculet          | 1.20       |           | 1.90       | 14.90     | 0.5622  | F       |
| Pipridae                      |                                  |            |           |            |           |         |
| Chiroxiphia pareola           | Blue-backed Manakin              | 2.0        | 2         | 2.40       | 21.05     | 0.4561  | F       |
| Lepidothrix coronata          | Blue-crowned Manakin             | 2.0        | 2         | 1.58       | 10.60     | 0.5962  | F       |
| Machaeropeterus pyrocephalus  | Fiery-capped Manakin             | 2.0        | 2         | 2.10       | 14.94     | 0.5622  | F       |
| Manacus manacus               | White-bearded Manakin            | 2.0        | 2         | 2.10       | 14.94     | 0.5622  | F       |
| Neopelma sulphureiventer      | Sulphur-bellied Tyrant-manakin   |            |           |            | 15.00     | IF      |         |
| Pipra chloromerus             | Round-tailed Manakin             |            |           |            | 16.10     | IF      |         |
| Pipra fasciicuda              | Band-tailed Manakin              | 2.0        | 2         | 2.75       | 16.73     | 0.6575  | F       |
| Pipra rubrocapilla            | Red-headed Manakin               | 2.0        | 2         | 1.96       | 14.65     | 0.5352  | F       |
| Piprites chloris              | Wing-barred Piprites             | 2.0        | 2         | 2.80       | 18.00     | IF      |         |
| Xenopipo atronitens           | Black Manakin                    |            |           |            | 15.25     | IF      |         |
| Psittacidae                   |                                  |            |           |            |           |         |
| Brotogeris versicolurus       | White-winged Parakeet            | 4.5        | 1         | 3.55       | 60.00     | 0.2663  | F       |
| Ramphastidae                  |                                  |            |           |            |           |         |
| Aulacorhynchus prasinus       | Emerald Toucanet                 | 2.2        | 2         | 170.0      | FI        |         |
| Pteroglossus azara            | Ivory-billed Aracari             | 2.8        | 2         | 142.0      | FI        |         |
| Pteroglossus beauharnaesii    | Curl-crested Aracari             |            |           |            | 222.0     | FI      |         |
| Selenidera reinwardtii        | Red-billed Toucanet              |            |           |            | 153.5     | FI      |         |
| Strigidae                     |                                  |            |           |            |           |         |
| Megascops watsonii            | Tawny-bellied Screech-owl        | 1.0        |           | 1.00       | 160.1     | SVLI    |         |
| Thamnophilidae                |                                  |            |           |            |           |         |
| Cercomacra nigrescens         | Blackish Antbird                 | 2.0        | 2         | 3.00       | 20.50     | I       |
| Cercomacra serva              | Black Antbird                    | 2.0        | 2         | 2.40       | 16.00     | 0.6000  | I       |
| Dichrozona cincta             | Banded Antbird                   |            |           |            | 14.75     | I       |
| Epinecrophylla haematonota    | Stipple-throated Antwren         |            |           |            | 10.10     | MFI     |         |
| Epinecrophylla leucophthalma  | White-eyed Antwren               |            |           |            | 9.420     | MFI     |         |
| Epinecrophylla ornata         | Ornate Antwren                   |            |           |            | 9.540     | MFI     |         |
| Scientific Name                  | Common Name               | MFI | 
|---------------------------------|---------------------------|-----|  
| Formicivora rufa                | Rusty-backed Antwren      | 2.0 |  
| Frederickena unduligera         | Undulated Antshrike       | 2.0 |  
| Gymnopithys salvini             | White-throated Antbird    | 2.0 |  
| Hylophylax naevius              | Spot-backed Antbird       | 1.7 |  
| Hypocnemis peruviana            | Peruvian Warbling-antbird | 2.0 |  
| Hypocnemis subflava             | Yellow-breasted Warbling-antbird | 2.0 |  
| Hypocnemoides maculicaua        | Band-tailed Antbird       | 2.0 |  
| Microhraphia quixensis          | Dot-winged Antwren        | 2.0 |  
| Myrmeciza atrothorax            | Black-throated Antbird    | 1.0 |  
| Myrmeciza fortis                | Sooty Antbird             | 2.0 |  
| Myrmeciza goeldii               | Goeldi’s Antbird          | 1.4 |  
| Myrmeciza hemimelaena           | Chestnut-tailed Antbird   | 2.0 |  
| Myrmeciza hyperthyra            | Plumbeous Antbird         | 2.0 |  
| Myrmoborus leucophrys           | White-browed Antbird      | 2.0 |  
| Myrmoborus myotherinurus        | Black-faced Antbird       | 2.0 |  
| Myrmotherula axillaris          | White-flanked Antwren     | 2.0 |  
| Myrmotherula hauxwelli          | Plain-throated Antwren    | 2.0 |  
| Myrmotherula iheringi           | Ihering’s Antwren         |     |  
| Myrmotherula longicauda         | Stripe-chested Antwren    |     |  
| Myrmotherula longipennis        | Long-winged Antwren       |     |  
| Myrmotherula menetriesii        | Gray Antwren              |     |  
| Neoctantes niger                | Black Bushbird            |     |  
| Percnostola lophotes            | White-lined Antbird       | 2.0 |  
| Phlegopsis erythroptera         | Reddish-winged Bare-eye   |     |  
| Phlegopsis nigromaculata        | Black-spotted Bare-eye    | 2.0 |  
| Pygiptila stellaris             | Spot-winged Antshrike     |     |  
| Rhegmatorhina melanosticta     | Hairy-crested Antbird     | 2.0 |  
| Sclateria naevia                | Silvered Antbird          | 2.0 |  
| Taraba major                    | Great Antshrike           | 2.4 |  
| Thamnomanes ardesiacus         | Dusky-throated Antshrike  | 2.0 |  
| Thamnomanes saturninus         | Saturnine Antshrike       |     |  

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| Common Name                   | Scientific Name       | Family         | MFI  | MFI  | MFI  |
|-------------------------------|-----------------------|----------------|------|------|------|
| Thamnomanes schistogynus      | Bluish-slate Antshrike | Thamnophilidae | 2.0  | 19.38| MFI  |
| Thamnophilus aethiops         | White-shouldered Antshrike | Thamnophilidae | 2.0  | 3.02 | 0.4788| MFI  |
| Thamnophilus doliatus         | Barred Antshrike       | Thamnophilidae | 1.7  | 3.60 | 0.4135| I    |
| Thamnophilus schistaceus      | Plain-winged Antshrike | Thamnophilidae | 2.0  | 3.50 | 0.7231| I    |
| Willisornis poecilinotus      | Scale-backed Antbird   | Thamnophilidae | 2.0  | 19.36| I    |
| Thamnophilus aethiops         | White-shouldered Antshrike | Thamnophilidae | 2.0  | 3.02 | 0.4788| MFI  |
| Thamnophilus doliatus         | Barred Antshrike       | Thamnophilidae | 1.7  | 3.60 | 0.4135| I    |
| Thamnophilus schistaceus      | Plain-winged Antshrike | Thamnophilidae | 2.0  | 3.50 | 0.7231| I    |
| Willisornis poecilinotus      | Scale-backed Antbird   | Thamnophilidae | 2.0  | 19.36| I    |

**Thraupidae**

| Common Name                   | Scientific Name       | Family         | MFI  | MFI  | MFI  |
|-------------------------------|-----------------------|----------------|------|------|------|
| Euphonia chlorotica           | Purple-throated Euphonia | Thraupidae | 3.9  | 1.15 | 11.15| 1.2067| F    |
| Habia rubica                  | Red-crowned Ant-tanager | Thraupidae | 2.5  | 4.00 | 31.11| 0.6429| F    |
| Lanio versicolor              | White-winged Shrike-tanager | Thraupidae | 2.0  | 3.30 | 27.30| 0.4835| I    |
| Ramphocelus carbo             | Silver-beaked Tanager  | Thraupidae | 2.0  | 3.60 | 29.60| 0.4135| I    |
| Tachyphonus cristatus         | Flame-crested Tanager  | Thraupidae | 2.0  | 3.50 | 19.36| 0.7231| I    |
| Tangara schrankii             | Green-and-gold Tanager | Thraupidae | 2.0  | 19.36| I    |

**Tinamidae**

| Common Name                   | Scientific Name       | Family         | MFI  | MFI  | MFI  |
|-------------------------------|-----------------------|----------------|------|------|------|
| Crypturellus bartletti        | Bartlett’s Tinamou   | Tinamidae      | 3    | 40.0 | 241.0| F    |

**Trochilidae**

| Common Name                   | Scientific Name       | Family         | MFI  | MFI  | MFI  |
|-------------------------------|-----------------------|----------------|------|------|------|
| Amazilia lactea               | Sapphire-spangled Emerald | Trochilidae | 2.0  | 0.46 | 3.60 | 0.5111| N    |
| Campylopterus largipennis     | Grey-breasted Sabrewing | Trochilidae | 2.0  | 7.00 | 7.00 | N    |
| Chlorostilbon mellisagus      | Blue-tailed Emerald   | Trochilidae | 2.0  | 0.40 | 3.97 | 0.4030| N    |
| Chrysuronia oenone            | Golden-tailed Sapphire| Trochilidae | 2.0  | 0.65 | 4.30 | 0.6047| N    |
| Florisuga mellivora           | White-necked Jacobin  | Trochilidae | 2.0  | 0.82 | 7.13 | 0.4600| N    |
| Glaucis hirsutus              | Rufous-breasted Hermit | Trochilidae | 2.0  | 0.72 | 5.66 | 0.5088| N    |
| Heliodoxa aurescens           | Gould’s Brilliant     | Trochilidae | 2.0  | 6.00 | 6.00 | N    |
| Hylocharis cyanus             | White-chinned Sapphire| Trochilidae | 2.0  | 3.15 | 3.15 | N    |
| Phaethornis hispidus          | White-bearded Hermit  | Trochilidae | 2.0  | 1.05 | 5.05 | 0.8317| N    |
| Phaethornis longirostris      | Long-billed Hermit    | Trochilidae | 2.0  | 5.25 | 5.25 | N    |
| Phaethornis malaris           | Great-billed Hermit   | Trochilidae | 2.0  | 6.10 | 6.10 | N    |
| Phaethornis filippii          | Needle-billed Hermit  | Trochilidae | 2.0  | 4.75 | 4.75 | N    |
| Phaethornis ruber             | Reddish Hermit        | Trochilidae | 2.0  | 0.38 | 4.50 | 0.3378| N    |
| Phaethornis superciliosus     | Long-tailed Hermit    | Trochilidae | 2.0  | 0.85 | 5.45 | 0.6239| N    |
| Phaethornis stuarti           | White-browed Hermit   | Trochilidae | 2.0  | 2.50 | 2.50 | N    |
| Polytymus guainumbi           | White-tailed Goldenthroat | Trochilidae | 2.0  | 0.70 | 4.76 | 0.5882| N    |
| Common Name                        | Scientific Name       | Length (cm) | Weight (g) | Wing (mm) | Tail (mm) | Status |
|-----------------------------------|-----------------------|-------------|------------|-----------|-----------|--------|
| Thalurania furcata                | Fork-tailed Woodnymph | 2.0         | 0.54       | 4.200     | 0.5143    | N      |
| Threnetes leucurus                | Pale-tailed Barbthroat| 2.0         | 0.56       | 5.730     | 0.3909    | N      |
| Trogodytidae                      |                       |             |            |           |           |        |
| Cyphorhinus arada                 | Musician Wren         | 2.0         | 2          | 26.14     | I         |        |
| Microcerculus marginatus          | Southern Nightingale-wren| 2.4    | 2          | 3.74      | 17.50     | I      |
| Thryothorus genibarbis            | Moustached Wren       | 2           | 2          | 2.00      | 19.50     | I      |
| Trogodytes aedon                  | Northern House Wren   | 5.7         | 2          | 1.38      | 13.40     | I      |
| Trogonidae                        |                       |             |            |           |           |        |
| Trogon collaris                   | Collared Trogon       | 2.4         | 1          | 8.50      | 53.22     | FI     |
| Trogon curucui                    | Blue-crowned Trogon   | 2.4         | 1          | 6.20      | 51.00     | FI     |
| Trogon melanurus                  | Black-tailed Trogon   | 2.4         | 1          | 7.00      | 70.00     | FI     |
| Turdidae                          |                       |             |            |           |           |        |
| Catharus ustulatus                | Swainson’s Thrush     | 3.5         | 2          | 3.60      | 35.00     | IF     |
| Turdus albicollis                 | White-throated Thrush | 2.4         | 2          | 6.45      | 53.00     | FI     |
| Turdus amaurochalinus             | Creamy-bellied Thrush | 3.0         | 2          | 6.30      | 62.50     | IF     |
| Turdus hauwelli                   | Hauxwell’s Thrush     |             |            |           | 71.25     | I      |
| Turdus ignobilis                  | Black-billed Thrush   | 2.0         | 2          | 7.20      | 66.90     | IF     |
| Turdus lawrencii                  | Lawrence’s Thrush     | 2           |            |           | 73.00     | IF     |
| Tyrannidae                        |                       |             |            |           |           |        |
| Attila bolivianus                 | Dull-capped Attila    | 2.0         | 2          | 4.65      | 42.50     | I      |
| Attila spadiceus                  | Bright-rumped Attila  | 2.8         | 2          | 3.80      | 37.70     | I      |
| Cnemotriccus fuscati              | Fuscous Flycatcher    | 3.0         | 2          | 2.48      | 11.90     | I      |
| Corythopis torquatus              | Ringed Antipit       | 2.0         | 2          | 16.00     | I        |
| Elaenia parvirostris              | Small-billed Elaenia  | 2.4         | 2          | 2.03      | 13.80     | F      |
| Elaenia spectabilis               | Large Elaenia        | 2.0         | 2          | 2.80      | 29.00     | F      |
| Elaenia strepera                  | Slaty Elaenia        | 2.0         | 2          | 2.88      | 19.00     | F      |
| Empidonax alnorum                 | Alder Flycatcher      | 3.5         | 2          | 1.82      | 13.00     | I      |
| Hemitriccuss flammulator          | Flammulated Pygmy-tyrant |         |            |           | 10.25     | I      |
| Hemitriccuss griseipectus         | White-bellied Tody-tyrant |        |            |           | 8.950     | I      |
| Inezia inornata                   | Plain Tyrannulet     | 2           | 1.30       | 5.750     | I        |
| Laniocera hypopyrra               | Cinereous Mourner    | 2.0         | 2          | 40.40     | IF       |
| Species                          | Common Name                  | Mass (g) | Length (cm) | Wing (cm) | Culmen (cm) | Body Mass Index | Feeding Guild |
|---------------------------------|-------------------------------|----------|-------------|-----------|-------------|-----------------|---------------|
| *Lathrotriccus euleri*          | Euler’s Flycatcher            | 2.4      | 2           | 1.77      | 11.00       | 0.7724          | I             |
| *Leptopogon amaurocephalus*     | Sepia-capped Flycatcher       | 2.4      | 2           | 2.17      | 11.20       | 0.9300          | MFI           |
| *Lophotriccus eulophotes*       | Long-crested Pygmy-tyrant     | 3.9      | 2           | 3.68      | 29.80       | 0.9632          | I             |
| *Mionectes macconnelli*         | McConnell’s Flycatcher        | 1.4      | 2           | 1.60      | 10.00       | 0.4480          | I             |
| *Mionectes oleagineus*          | Ochre-bellied Flycatcher      | 2.4      | 2           | 1.99      | 12.00       | 0.7960          | F             |
| *Mionectes olivaceus*           | Olive-striped Flycatcher      | 3.9      | 2           | 3.86      | 28.75       | 0.5643          | IF            |
| *Myiarchus ferox*               | Short-crested Flycatcher      | 3.9      | 2           | 3.68      | 29.80       | 0.9632          | IF            |
| *Myiarchus tyrannulus*          | Brown-crested Flycatcher      | 2.4      | 2           | 1.99      | 12.00       | 0.7960          | F             |
| *Myiophobus fasciatus*          | Bran-colored Flycatcher       | 2.0      | 2           | 1.76      | 12.52       | 0.5623          | I             |
| *Ochthornis littoralis*         | Drab Water-tyrant             | 3.5      | 2           | 1.76      | 12.52       | 0.5623          | I             |
| *Onychorhynchus coronatus*      | Royal Flycatcher              | 1.4      | 2           | 1.60      | 10.00       | 0.4480          | I             |
| *Pachyramphus minor*            | Pink-throated Becard          | 4.9      | 2           | 2.45      | 37.00       | 0.6489          | I             |
| *Pitangus sulphuratus*          | Great Kiskadee                | 3.9      | 2           | 5.80      | 60.50       | 0.7478          | IF            |
| *Platyrinchus coronatus*        | Golden-crowned Spadebill      | 2.0      | 2           | 9.20      | 12.25       | 0.7500          | I             |
| *Platyrinchus platyrhynchos*    | White-crested Spadebill       | 2.0      | 2           | 9.20      | 12.25       | 0.7500          | I             |
| *Platyrinchus saturatus*        | Cinnamon-crested Spadebill    | 2.0      | 2           | 9.20      | 12.25       | 0.7500          | I             |
| *Ramphotrigon fuscicauda*       | Dusky-tailed Flatbill         | 2.0      | 2           | 19.00     | 3.25        | 0.7800          | I             |
| *Ramphotrigon megacephalum*     | Large-headed Flatbill         | 2.0      | 2           | 2.62      | 14.00       | 0.7486          | I             |
| *Ramphotrigon ruficauda*        | Rufous-tailed Flatbill        | 3.0      | 2           | 19.75     | 0.6333      | 0.5600          | I             |
| *Rhynchocyclus olivaceus*       | Olivaceous Flatbill           | 2.4      | 2           | 2.45      | 21.00       | 0.5600          | I             |
| *Rhytipterna simplex*           | Greyish Mournier              | 3.9      | 2           | 35.50     | 0.6979      | 0.7478          | IF            |
| *Schifornis turdina*            | Thrush-like Mournier          | 2.0      | 2           | 4.01      | 31.00       | 0.5174          | I             |
| *Terenotriccus erythrurus*      | Ruddy-tailed Flycatcher       | 2.0      | 2           | 1.14      | 7.200       | 0.6333          | I             |
| *Tyrannus melancholicus*        | Tropical Kingbird             | 3.2      | 2           | 4.10      | 37.60       | 0.6979          | IF            |

**Vireonidae**

| Species                          | Common Name                  | Mass (g) | Length (cm) | Wing (cm) | Culmen (cm) | Body Mass Index | Feeding Guild |
|---------------------------------|-------------------------------|----------|-------------|-----------|-------------|-----------------|---------------|
| *Hylophilus hypoxanthus*         | Dusky-capped Greenlet         | 2.0      | 1           | 1.95      | 10.75       | 0.3628          | MFI           |
| *Hylophilus ochraceiceps*       | Tawny-crowned Greenlet        | 2.0      | 1           | 1.95      | 10.75       | 0.3628          | MFI           |

**Notes:**
- Species and English names based on Schulenberg et al. [23] and Del Hoyo et al. [39].
- Feeding guild: AA= army ant follower, F= solitary frugivore, FI= solitary frugivore-insectivore, I= solitary insectivore, IF= solitary insectivore-frugivore, MFI= mixed species insectivore flocks, MFIF= mixed species insectivore-frugivore flocks, N= nectarivore, SVLI= small vertebrates and large insects.
Appendix 3

Guild classification and life-history traits (average clutch size, number of broods per season, egg mass and female body mass) of West-European birds for estimation of the relative reproductive investment (RRI) based on Del Hoyo et al. [39] and field-data.

| Species[1] | English name[1] | Average clutch size | Number of broods per season | Egg mass (g) | Female body mass (g) | RRI | Feeding guild[a] |
|------------|-----------------|---------------------|----------------------------|--------------|----------------------|-----|-----------------|
| Accipitridae |                 |                     |                            |              |                      |     |                 |
| Accipiter gentilis | Northern Goshawk | 3.6 | 1 | 55.0 | 1206 | 0.1642 | SVLI |
| Accipiter nisus | Eurasian Sparrowhawk | 4.9 | 1 | 23.0 | 264.0 | 0.4269 | SVLI |
| Buteo buteo | Eurasian Buzzard | 2.8 | 1 | 53.2 | 915.0 | 0.1628 | SVLI |
| Circus aeruginosus | Western Marsh-harrier | 4.7 | 1 | 40.0 | 669.0 | 0.2810 | SVLI |
| Circus cyaneus | Hen Harrier | 4.5 | 1 | 31.0 | 527.0 | 0.2647 | SVLI |
| Circus pygargus | Montagu’s Harrier | 4.2 | 1 | 25.0 | 370.0 | 0.2838 | SVLI |
| Milvus migrans | Black Kite | 2.5 | 1 | 56.0 | 850.0 | 0.1647 | SVLI |
| Milvus milvus | Red Kite | 2.1 | 1 | 61.0 | 1213 | 0.1056 | SVLI |
| Pernis apivorus | European Honey-buzzard | 2.0 | 1 | 45.0 | 620.0 | 0.1452 | SVLI |
| Aegithalidae |                 |                     |                            |              |                      |     |                 |
| Aegithalos caudatus | Long-tailed Tit | 10 | 1 | 0.90 | 8.000 | 1.1363 | MFI |
| Alaudidae |                 |                     |                            |              |                      |     |                 |
| Alauda arvensis | Eurasian Skylark | 3.9 | 2.7 | 3.35 | 34.60 | 1.0195 | I |
| Galerida cristata | Crested Lark | 4.4 | 2 | 3.24 | 44.10 | 0.6465 | I |
| Lullula arborea | Woodlark | 4.0 | 2 | 3.40 | 32.10 | 0.8474 | I |
| Alcedinidae |                 |                     |                            |              |                      |     |                 |
| Alcedo atthis | Common Kingfisher | 6.7 | 2 | 4.20 | 39.20 | 1.4357 | SVLI |
| Anatidae |                 |                     |                            |              |                      |     |                 |
| Aix sponsa | Wood Duck | 10 | 1 | 45.7 | 672.0 | 0.6801 | FI |
| Aix galericulata | Mandarin Duck | 10 | 1 | 44.0 | 512.0 | 0.8594 | IF |
| Alopochen aegyptiacus | Egyptian Goose | 8.5 | 1 | 97.0 | 2040 | 0.4042 | FI |
| Anas crecca | Common Teal | 9.5 | 1 | 29.0 | 324.0 | 0.8503 | FI |
| Anas platyrhynchos | Mallard | 11 | 1 | 51.0 | 1096 | 0.5119 | SVLI |
| Species Name                      | Common Name                     | TLI | ID | IBI | ESI | SVLI |
|----------------------------------|---------------------------------|-----|----|-----|-----|------|
| Anas platyrhynchos domesticus    | Domestic Duck                   |     | 1  |     |     | SVLI |
| Anas acuta                       | Northern Pintail                | 8.0 | 1  | 43  | 735 | 0.4680 |
| Anas querquedula                 | Garganey                        | 8.5 | 1  | 28  | 351 | 0.6781 |
| Anas clypeata                    | Nolthern Shoveler               | 10  | 1  | 40  | 575 | 0.6957 |
| Anas albifrons                   | Greater White-fronted Goose     | 5.5 | 1  | 114 | 1905| 0.3291 |
| Anser anser                      | Greylag Goose                   |     | 1  | 149 | 3108| 0.2397 |
| Anser anser domesticus           | Domestic Goose                  |     | 1  |     |     | F    |
| Anser indicus                    | Bar-headed Goose                | 5.0 | 1  | 135 | 2500| 0.2700 |
| Aythya ferina                    | Common Pochard                  | 9.0 | 1  | 65  | 832 | 0.7031 |
| Aythya nyroca                    | Ferruginous Duck                | 9.0 | 1  | 36  | 545 | 0.5945 |
| Aythya fuligula                  | Tufted Duck                     | 9.5 | 1  | 53  | 867 | 0.5807 |
| Branta canadensis                | Canada Goose                    | 5.9 | 1  | 220 | 4390| 0.2957 |
| Branta leucopsis                 | Barnacle Goose                  | 4.5 | 1  | 103 | 1499| 0.3092 |
| Bucephala clangula               | Common Goldeneye                | 9.3 | 1  | 60  | 787 | 0.7090 |
| Cairina moschata                 | Muscovy Duck                    | 10  | 1  | 69  | 1285| 0.5389 |
| Cygnus olor                      | Mute Swan                       | 6.0 | 1  | 345 | 9600| 0.2156 |
| Cygnus atratus                   | Black Swan                      | 5.0 | 1  | 260 | 5450| 0.2385 |
| Mareca penelope                  | Eurasian Wigeon                 | 9.0 | 1  | 42  | 700 | 0.5400 |
| Mareca strepera                  | Gadwall                         | 10  | 1  | 44  | 700 | 0.6286 |
| Mergus serrator                  | Red-breasted Merganser          | 9.0 | 1  | 73  | 984 | 0.6677 |
| Netta rufina                     | Red-crested Pochard             | 9.0 | 1  | 56  | 1100| 0.4582 |
| Oxyura jamaicensis               | Ruddy Duck                      | 8.0 | 1  | 76  | 510 | 1.1922 |
| Somateria mollissima             | Common Eider                    | 5.0 | 1  | 109 | 2142| 0.2544 |
| Tadorna ferruginea               | Ruddy Shelduck                  | 8.5 | 1  | 83  | 1213| 0.5819 |
| Tadorna tadorna                  | Common Shelduck                 | 8.6 | 1  | 78  | 1043| 0.6431 |
| Apodidae                         |                                 |     |    |     |     |      |
| Apus apus                        | Common Swift                    | 2.4 | 1  | 3.60| 40.30| 0.2144 |
| Ardeidae                         |                                 |     |    |     |     |      |
| Ardea cinerea                    | Grey Heron                      | 4.5 | 1  | 60  | 1361| 0.1984 |
| Ardea purpurea                   | Purple Heron                    | 4.2 | 1  | 50  | 830 | 0.2530 |
| Botaurus stellaris               | Eurasian Bittern                | 5.5 | 1  | 40  | 900 | 0.2444 |
| Family          | Species                          | Scientific Name               | Sexes | Breeding | Nest Site | Nest Material | Clutch Size | Incubation (Days) | Nestling (Days) | fledging Rate | SVLI  |
|-----------------|----------------------------------|------------------------------|-------|----------|-----------|---------------|-------------|-------------------|----------------|---------------|-------|
| Bubulcus ibis   | Cattle Egret                     | Bubulcus ibis               | 4.5   | 1        | 28.0      | 304.0         | 0.4145      | 491.0             | 0.2305          |               |       |
| Casmerodius albus| Great Egret                      | Casmerodius albus            | 4.0   | 1        | 960.0     | 495.0         | 0.4332      | 28.0              | 0.2305          |               |       |
| Egretta garzetta| Little Egret                     | Egretta garzetta            | 4.0   | 1        | 495.0     | 495.0         | 0.2305      | 28.0              | 0.2305          |               |       |
| Ixobrychus minutus| Common Little Bittern           | Ixobrychus minutus          | 5.5   | 1        | 11.5      | 146.0         | 0.2305      | 28.0              | 0.2305          |               |       |
| Nycticorax nycticorax| Black-crowned Night-heron    | Nycticorax nycticorax       | 4.0   | 1        | 34.0      | 590.0         | 0.2305      | 28.0              | 0.2305          |               |       |
| Burhinidae      | Burhinus oedicnemus             | Burhinus oedicnemus         | 1.9   | 1        | 36.0      | 449.0         | 0.1523      | 28.0              | 0.1523          |               |       |
| Camprimulgidae  | Camprimulgus europaeus          | Camprimulgus europaeus      | 2.0   | 2        | 8.20      | 164.0         | 0.3237      | 28.0              | 0.3237          |               |       |
| Certhiidae      | Certhia brachydactyla           | Certhia brachydactyla       | 5.7   | 2        | 1.16      | 9.700         | 1.3633      | 28.0              | 1.3633          |               |       |
| Certhia familiaris| Eurasian Treecreeper            | Certhia familiaris          | 5.4   | 2        | 1.14      | 9.100         | 1.3530      | 28.0              | 1.3530          |               |       |
| Charadriidae    | Charadrius alexandrines         | Charadrius alexandrines     | 3.0   | 1        | 9.00      | 47.10         | 0.5732      | 28.0              | 0.5732          |               |       |
| Charadrius dubius| Little Ringed Plover            | Charadrius dubius           | 3.9   | 2        | 7.70      | 39.20         | 1.5321      | 28.0              | 1.5321          |               |       |
| Charadrius hiaticula| Common Ringed Plover           | Charadrius hiaticula       | 3.8   | 2        | 12.0      | 66.40         | 1.3945      | 28.0              | 1.3945          |               |       |
| Vanellus vanellus| Northern Lapwing                | Vanellus vanellus           | 3.9   | 1        | 25.5      | 189.0         | 0.5262      | 28.0              | 0.5262          |               |       |
| Ciconiidae      | Ciconia ciconia                 | Ciconia ciconia             | 4.0   | 1        | 111.0     | 3325          | 0.1335      | 28.0              | 0.1335          |               |       |
| Cisticolidae    | Cisticola juncidis              | Cisticola juncidis          | 4.8   | 2        | 1.08      | 6.500         | 1.5951      | 28.0              | 1.5951          |               |       |
| Columbidae      | Columba livia                    | Columba livia               | 1.9   | 5        | 18.0      | 267.5         | 0.6393      | 28.0              | 0.6393          |               |       |
| Columba oena    | Rock Dove                       | Columba oena                | 2.3   | 2.5      | 17.0      | 298.0         | 0.3228      | 28.0              | 0.3228          |               |       |
| Columba palumbus| Common Woodpigeon               | Columba palumbus            | 1.9   | 1        | 18.5      | 500.0         | 0.0703      | 28.0              | 0.0703          |               |       |
| Streptopelia decaocto| Eurasian Collared-dove       | Streptopelia decaocto      | 2.0   | 2        | 14.0      | 197.0         | 0.1920      | 28.0              | 0.1920          |               |       |
| Streptopelia turtur| European Turtle-dove           | Streptopelia turtur        | 1.9   | 2        | 8.00      | 134.5         | 0.2260      | 28.0              | 0.2260          |               |       |
| Corvidae        | Corvus corax                    | Corvus corax                | 4.8   | 1        | 28.8      | 1147          | 0.1205      | 28.0              | 0.1205          |               |       |
| Corvus cornix   | Hood Crow                       | Corvus cornix               | 4.3   | 1        | 19.8      | 490.0         | 0.1738      | 28.0              | 0.1738          |               |       |
| Corvus corone   | Carrion Crow                    | Corvus corone               | 4.3   | 1        | 19.8      | 490.0         | 0.1738      | 28.0              | 0.1738          |               |       |
| Species                        | Common Name          | Mean | Min | Max | Length (cm) | Mass (g) | Index |
|-------------------------------|----------------------|------|-----|-----|-------------|----------|-------|
| Corvus frugilegus             | Rook                 | 3.8  | 1   | 16.0| 443.3       | 0.1372   | IF    |
| Corvus monedula               | Eurasian Jackdaw     | 4.7  | 1   | 11.1| 230.0       | 0.2268   | F     |
| Corvus splendens              | House Crow           | 4.0  | 1   | 13.7| 269.7       | 0.2032   | IF    |
| Garrulus glandarius           | Eurasian Jay         | 5.4  | 1   | 8.50| 161.4       | 0.2844   | IF    |
| Pica pica                     | Common Magpie        | 5.7  | 1   | 9.90| 197.8       | 0.2853   | SVLI  |
| Cuculidae                     |                      |      |     |     |             |          |       |
| Cuculus canorus               | Common Cuckoo        | 9.2  | 1   | 3.40| 112.0       | 0.2793   | I     |
| Emberizidae                   |                      |      |     |     |             |          |       |
| Emberiza citrinella           | Yellowhammer         | 3.9  | 2   | 3.00| 26.80       | 0.8731   | MFIF  |
| Emberiza hortulana            | Ortolan Bunting      | 4.6  | 2   | 2.48| 19.10       | 1.1946   | IF    |
| Emberiza schoeniclus          | Reed Bunting         | 4.9  | 1.7 | 2.19| 17.90       | 1.0311   | IF    |
| Miliaria calandra             | Corn Bunting         | 4.4  | 2   | 3.91| 39.60       | 0.8689   | FI    |
| Falconidae                    |                      |      |     |     |             |          |       |
| Falco peregrinus              | Peregrine Falcon     | 3.2  | 1   | 850.0|            |          | SVLI  |
| Falco subbuteo                | Eurasian Hobby       | 3.0  | 1   | 240.5|            |          | SVLI  |
| Falco tinnunculus             | Common Kestrel       | 4.7  | 1   | 20.0| 252.0       | 0.3730   | SVLI  |
| Fringillidae                  |                      |      |     |     |             |          |       |
| Carduelis cabaret             | Lesser Redpoll       | 4.6  | 2   | 1.21| 10.60       | 1.0502   | FI    |
| Carduelis cannabina           | Common Linnet        | 4.7  | 2   | 1.66| 18.50       | 0.8435   | F     |
| Carduelis carduelis           | European Goldfinch   | 4.5  | 2   | 1.53| 14.80       | 0.9304   | FI    |
| Carduelis spinus              | Eurasian Siskin      | 4.3  | 2   | 1.29| 13.20       | 0.8405   | FI    |
| Carpodacus erythrinus         | Common Rosefinch     | 5.1  | 1   | 2.25| 23.90       | 0.4801   | FI    |
| Chloris chloris               | European Greenfinch  | 5.0  | 2   | 2.17| 25.90       | 0.8378   | F     |
| Coccothraustes coccothraustes | Hawfinch             | 4.5  | 1   | 3.89| 52.90       | 0.3309   | FI    |
| Fringilla coelebs             | Common Chaffinch     | 4.6  | 1   | 2.16| 18.50       | 0.5371   | IF    |
| Fringilla montifringilla      | Brambling            | 5.8  | 1   | 2.14| 23.60       | 0.5259   | FI    |
| Loxia curvirostra             | Red Crossbill        | 3.7  | 1   | 2.95| 38.90       | 0.2806   | FI    |
| Loxia leucoptera              | Two-barred Crossbill | 4.0  | 1   | 2.53| 31.60       | 0.3203   | FI    |
| Loxia pytyopsittacus          | Parrot Crossbill     | 3.8  | 1   | 3.26| 50.30       | 0.2463   | F     |
| Pyrrhula pyrrhula             | Eurasian Bullfinch   | 5.0  | 2   | 2.41| 22.50       | 1.0711   | FI    |
| Serinus serinus               | European Serin       | 3.8  | 2   | 1.21| 12.30       | 0.7476   | FI    |
| Taxonomy | Species | Common Name | Size (mm) | Weight (g) | SVLI | Z | I |
|----------|---------|-------------|-----------|------------|------|---|---|
| Gruidae  | Grus grus | Common Crane | 2.0       | 163        | 5200 | 0.0704 | SVLI |
| Haematopodidae | Haematopus ostralegus | Eurasian Oystercatcher | 2.8       | 47.0       | 632.5 | 0.2081 | I |
| Hirudinidae | Delichon urbica | Northern House Martin | 4.3       | 1.64       | 19.50 | 0.7233 | I |
| Hirundo rustica | Barn Swallow | 4.6       | 1.90       | 18.70      | 0.9348 | I |
| Riparia riparia | Collared Sand Martin | 4.8       | 1.43       | 13.60      | 0.5026 | I |
| Laniidae | Lanius collurio | Red-backed Shrike | 5.0       | 3.15       | 32.50 | 0.4846 | SVLI |
| Lanius excubitor | Great Grey Shrike | 5.8       | 5.30       | 64.50      | 0.4766 | SVLI |
| Laridae | Chlidonias hybridus | Whiskered Tern | 2.7       | 16.0       | 86.00 | 0.5023 | SVLI |
| Chlidonias niger | Black Tern | 2.9       | 11.0       | 64.00      | 0.5002 | SVLI |
| Larus argentatus | European Herring Gull | 2.6       | 51.0       | 864.0      | 0.4207 | I |
| Larus canus | Mew Gull | 3.0       | 81.0       | 755.0      | 0.4250 | I |
| Larus graellsii | Lesser Black-backed Gull | 3.0       | 117.0      | 1486.0     | 0.4258 | SVLI |
| Larus marinus | Great Black-backed Gull | 2.9       | 42.0       | 282.5      | 0.4460 | I |
| Larus melanocephalus | Mediterranean Gull | 3.0       | 35.0       | 220.5      | 0.2540 | SVLI |
| Larus michahellis | Yellow-legged Gull | 3.0       | 19.0       | 98.00      | 0.4207 | I |
| Larus minutus | Little Gull | 2.2       | 19.0       | 98.00      | 0.4207 | I |
| Larus ridibundus | Black-headed Gull | 2.7       | 10.0       | 267.0      | 0.4207 | I |
| Sterna albifrons | Little Tern | 2.2       | 21.0       | 126.0      | 0.4207 | I |
| Sterna hirundo | Common Tern | 2.8       | 19.0       | 107.0      | 0.4207 | I |
| Sterna paradisaea | Arctic Tern | 2.0       | 19.0       | 220.5      | 0.2540 | SVLI |
| Sterna sandvicensis | Sandwich Tern | 1.6       | 35.0       | 220.5      | 0.2540 | SVLI |
| Motacillidae | Anthus campestris | Tawny Pipit | 4.5       | 2.73       | 28.00 | 0.6189 | I |
| Anthus pratensis | Meadow Pipit | 5.2       | 2.06       | 19.50      | 1.0987 | I |
| Anthus trivialis | Tree Pipit | 4.8       | 2.30       | 20.70      | 0.6000 | I |
| Motacilla alba | White Wagtail | 5.4       | 2.30       | 20.70      | 0.6000 | I |
| Scientific Name                  | Common Name                          | Length (cm) | Wing Span (cm) | Bill (cm) | Weight (g) | DB Index |
|--------------------------------|--------------------------------------|-------------|---------------|-----------|------------|----------|
| Motacilla cinerea              | Grey Wagtail                         | 5.2         | 1.91          | 17.20     | 1.1549     | I        |
| Motacilla flava                | Yellow Wagtail                       | 5.2         | 1.80          | 14.80     | 0.6324     | I        |
| Motacilla flavissima           | Yellowish-crowned Wagtail            | 5.2         | 1.90          |           |            | I        |
| Motacilla yarrellii            | Pied Wagtail                         | 5.4         | 2.35          | 20.00     | 0.6345     | I        |
| *Motacilla*                    |                                      |             |               |           |            |          |
| Muscicapa striata              | Spotted Flycatcher                   | 4.2         | 1.90          | 16.55     | 0.4822     | MFI      |
| Ficedula hypoleuca             | European Pied Flycatcher             | 6.4         | 1.70          | 11.20     | 0.9714     | I        |
| Muscicapidae                   |                                      |             |               |           |            |          |
| Oriolus oriolus                | Eurasian Golden Oriole               | 3.7         | 7.30          | 69.20     | 0.3903     | IF       |
| Oriolidae                      |                                      |             |               |           |            |          |
| Panurus biarmicus              | Bearded Parrotbill                  | 5.6         | 1.68          | 14.40     | 1.9600     | I        |
| Paridae                        |                                      |             |               |           |            |          |
| Parus ater                     | Coal Tit                             | 8.5         | 2             | 9.5000    |           | MFI      |
| Parus caeruleus                | Common Blue Tit                      | 11          | 1.8           | 1.17      | 10.70      | 2.1290   | MFIF     |
| Parus cristatus                | European Crested Tit                | 6.5         | 1             | 12.75     |           | MFI      |
| Parus major                    | Great Tit                            | 7.8         | 2             | 17.80     |           | MFI      |
| Parus montanus                 | Willow Tit                           | 8.1         | 1             | 9.800     |           | MFI      |
| Parus palustris                | Marsh Tit                            | 7.6         | 1             | 1.28      | 11.90      | 0.8175   | MFI      |
| Passeridae                     |                                      |             |               |           |            |          |
| Passer domesticus              | House Sparrow                       | 4.1         | 2.1           | 2.89      | 30.20      | 0.8239   | FI       |
| Passer montanus                | Eurasian Tree Sparrow               | 4.9         | 2             | 2.11      | 20.80      | 0.9941   | FI       |
| Phalacrocoracidae              |                                      |             |               |           |            |          |
| Phalacrocorax carbo            | Great Cormorant                      | 3.5         | 1             | 53.0      | 2123       | 0.0874   | SVLI     |
| Phasianidae                    |                                      |             |               |           |            |          |
| Alectoris rufa                 | Red-legged Partridge                | 13          | 1             | 21.0      | 439.0      | 0.6075   | FI       |
| Coturnix coturnix              | Common Quail                         | 10          | 1             | 8.00      | 103.0      | 0.7922   | FI       |
| Perdix perdix                  | Grey Partridge                      | 16          | 1             | 14.5      | 386.0      | 0.6010   | FI       |
| Phasianus colchicus            | Common Pheasant                      | 12          | 1             | 33.0      | 989.0      | 0.3937   | FI       |
| Tetrao tetrix                  | Black Grouse                        | 7.9         | 1             | 35.5      | 945.0      | 0.2968   | FI       |
| Picidae                        |                                      |             |               |           |            |          |
| Dendrocopos major              | Great Spotted Woodpecker            | 5.5         | 1             | 4.90      | 72.70      | 0.3707   | IF       |
| Family               | Species                  | Common Name                        | L | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |
|----------------------|--------------------------|------------------------------------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **Dendrocopos**      | *Dendrocopos medius*     | Middle Spotted Woodpecker          | 5.6| 1  | 4.00| 58.80| 0.3810| IF |
|                      | *Dendrocopos minor*      | Lesser Spotted Woodpecker          | 5.0| 1  | 2.00| 22.50| 0.4444| MFIF |
|                      | *Dryocopus martius*      | Black Woodpecker                   | 4.8| 1  | 12.4| 255.0| 0.2334| I |
| Jynx                 | *Jynx torquilla*         | Eurasian Wryneck                   | 8.5| 1.2| 2.60| 35.90| 0.7387| I |
| Picus                | *Picus viridis*          | Eurasian Green Woodpecker          | 6.1| 1  | 8.50| 186.0| 0.2788| IF |
| **Podicipedidae**    | *Podiceps cristatus*     | Great Crested Grebe                | 3.5| 1  | 42.0| 830.0| 0.1771| SVLI |
|                      | *Podiceps griseogena*    | Red-necked Grebe                   | 4.5| 1  | 31.0| 476.0| 0.2931| SVLI |
|                      | *Podiceps nigrigollis*   | Black-necked Grebe                 | 3.5| 1  | 21.0| 357.5| 0.2056| SVLI |
|                      | *Tachybaptus ruficollis* | Little Grebe                       | 5.0| 2  | 14.0| 187.0| 0.7487| SVLI |
| **Prunellidae**      | *Prunella modularis*     | Dunnock                            | 5.1| 2  | 2.13| 21.10| 1.0297| I |
| **Psittacidae**      | *Psittacula krameri*     | Rose-ringed Parakeet               | 3.0| 1  | 158.0| F |
| **Rallidae**         | *Crex crex*              | Corncrake                          | 8.9| 1  | 13.0| 138.0| 0.8384| IF |
|                      | *Fulica atra*            | Common Coot                        | 7.2| 1  | 38.0| 688.0| 0.3977| FI |
|                      | *Gallinula chloropus*    | Common Moorhen                     | 6.6| 2  | 25.0| 289.0| 1.1419| IF |
|                      | *Porzana parva*          | Little Crake                       | 6.8| 2  | 8.00| 49.50| 2.1980| IF |
|                      | *Porzana porzana*        | Spotted Crake                      | 10| 2  | 6.00| 87.50| 1.4126| IF |
|                      | *Porzana pusilla*        | Baillon’s Crake                    | 7.4| 1  | 6.00| 46.00| 0.9652| SVLI |
|                      | *Rallus aquaticus*       | Western Water Rail                 | 8.5| 2  | 13.0| 104.0| 2.1250| SVLI |
| **Recurvirostridae** | *Himantopus himantopus*  | Black-winged Stilt                 | 4.0| 1  | 22.0| 185.5| 0.4744| SVLI |
|                      | *Recurvirostra avosetta* | Pied Avocet                        | 3.9| 1  | 32.0| 325.3| 0.3837| I |
| **Regulidae**        | *Regulus ignicapillus*   | Common Firecrest                   | 8.8| 2  | 0.69| 5.300| 2.2980| I |
|                      | *Regulus regulus*        | Goldcrest                          | 10| 2  | 0.77| 5.600| 2.7500| MFIF |
| **Remizidae**        | *Remiz pendulinus*       | Eurasian Penduline-tit             | 4.5| 1  | 0.95| 10.25| 0.4171| I |
| **Scolopacidae**     |                         |                                    |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Common Name            | Scientific Name            | Common Name | Scientific Name            |
|------------------------|----------------------------|-------------|----------------------------|
| Actitis hypoleucos     | Common Sandpiper           | 4.0         | 12.0                      |
| Calidris alpina        | Dunlin                     | 3.9         | 10.0                      |
| Gallinago gallinago    | Common Snipe               | 3.9         | 17.0                      |
| Limosa limosa          | Black-tailed Godwit        | 3.9         | 41.0                      |
| Numenius arquata       | Eurasian Curlew            | 3.8         | 77.0                      |
| Philomachus pugnax     | Ruff                       | 3.7         | 22.0                      |
| Scolopax rusticola     | Eurasian Woodcock          | 3.8         | 22.0                      |
| Tringa totanus         | Common Redshank            | 3.9         | 22.0                      |
| Sittidae               |                            |             |                           |
| Sitta europaea         | Eurasian Nuthatch          | 7.1         | 2.25                      |
| Strigidae              |                            |             |                           |
| Aegolius funereus      | Boreal Owl                 | 5.8         | 12.5                      |
| Asio flammeus          | Short-eared Owl            | 6.0         | 21.0                      |
| Asio otus              | Northern Long-eared Owl    | 4.4         | 22.0                      |
| Athene noctua          | Little Owl                 | 3.9         | 17.6                      |
| Bubo bubo              | Eurasian Eagle-owl         | 2.7         | 73.0                      |
| Strix aluco            | Tawny Owl                  | 2.9         | 40.0                      |
| Sturnidae              |                            |             |                           |
| Sturnus vulgaris       | Common Starling            | 5.1         | 7.00                      |
| Sylviidae              |                            |             |                           |
| Acrocephalus arundinaceus | Great Reed-warbler      | 4.8         | 3.15                      |
| Acrocephalus palustris | Marsh Warbler              | 4.5         | 1.85                      |
| Acrocephalus schoenobaenus | Sedge Warbler             | 5.3         | 1.65                      |
| Acrocephalus scirpaceus | Eurasian Reed-warbler    | 3.9         | 1.75                      |
| Cettia cetti           | Cetti’s Warbler            | 4.6         | 1.80                      |
| Hippolais icterina     | Icterine Warbler           | 4.7         | 1.76                      |
| Hippolais polyglotta   | Melodious Warbler          | 4.3         | 1.60                      |
| Locustella fluviatilis | River Warbler              | 5.5         | 2.36                      |
| Locustella luscinioides | Savi’s Warbler            | 4.1         | 1.3                       |
| Locustella naevia      | Western Grasshopper-warbler | 5.2        | 1.73                      |
| Phylloscopus collybita | Common Chiffchaff          | 5.5         | 1.21                      |
| Species                          | English Name          | Feeding Guild | Weight (g) | Standard Deviation | Number of Observations | Feeding Guild Details |
|---------------------------------|-----------------------|---------------|------------|--------------------|------------------------|-----------------------|
| *Phylloscopus sibilatrix*       | Wood Warbler          |               | 5.9        | 1                  | 1.32                   | 10.10                 | 0.7711 MFIF           |
| *Phylloscopus trochilus*        | Willow Warbler        |               | 6.6        | 1                  | 1.20                   | 9.100                 | 0.8651 IF             |
| *Sylvia atricapilla*            | Blackcap              |               | 4.6        | 1                  | 2.19                   | 19.20                 | 0.5247 IF             |
| *Sylvia borin*                  | Garden Warbler        |               | 4.3        | 1                  | 2.38                   | 18.90                 | 0.5415 IF             |
| *Sylvia communis*               | Greater Whitethroat   |               | 4.7        | 1                  | 1.78                   | 14.40                 | 0.5810 IF             |
| *Sylvia curruca*                | Lesser Whitethroat    |               | 4.9        | 1                  | 1.40                   | 12.40                 | 0.5532 I              |
| **Threskiornithidae**           |                       |               |            |                    |                        |                       |                       |
| *Platalea leucorodia*           | Eurasian Spoonbill    |               | 3.5        | 1                  | 76.0                   | 1130                  | 0.2354 SVLI           |
| **Troglodytidae**               |                       |               |            |                    |                        |                       |                       |
| *Troglodytes troglodytes*       | Northern Wren         |               | 6.0        | 2                  | 1.32                   | 7.800                 | 2.0308 I              |
| **Turdidae**                    |                       |               |            |                    |                        |                       |                       |
| *Erithacus rubecula*            | European Robin        |               | 5.0        | 2                  | 2.40                   | 18.50                 | 1.2973 IF             |
| *Luscinia luscinia*             | Thrush Nightingale    |               | 4.8        | 1                  | 3.18                   | 25.50                 | 0.5986 IF             |
| *Luscinia megarhynchos*         | Common Nightingale    |               | 4.9        | 1                  | 2.65                   | 19.40                 | 0.6693 IF             |
| *Luscinia svecica*              | Bluethroat            |               | 6.2        | 1                  | 2.02                   | 18.60                 | 0.6733 IF             |
| *Oenanthe oenanthe*             | Northern Wheatear     |               | 6.0        | 2                  | 2.83                   | 23.90                 | 1.4209 IF             |
| *Phoenicurus ochrurus*          | Black Redstart        |               | 4.9        | 2                  | 2.16                   | 16.20                 | 1.3067 IF             |
| *Phoenicurus phoenicurus*       | Common Redstart       |               | 6.2        | 2                  | 1.90                   | 15.00                 | 1.5707 IF             |
| *Saxicola torquata rubicula*    | Common Stonechat      |               | 5.2        | 2.5                | 1.97                   | 14.80                 | 1.7304 IF             |
| *Saxicola rubetra*              | Whinchat              |               | 6.0        | 1                  | 2.06                   | 16.70                 | 0.7401 IF             |
| *Turdus merula*                 | Common Blackbird      |               | 4.0        | 3                  | 7.20                   | 99.80                 | 0.8657 IF             |
| *Turdus philomelos*             | Song Thrush           |               | 4.8        | 2.5                | 6.00                   | 71.50                 | 1.0070 IF             |
| *Turdus pilaris*                | Fieldfare             |               | 5.2        | 1                  | 6.53                   | 103.4                 | 0.3284 IF             |
| *Turdus viscivorus*             | Mistle Thrush         |               | 4.0        | 2                  | 7.80                   | 123.2                 | 0.5065 IF             |
| **Tytonidae**                   |                       |               |            |                    |                        |                       |                       |
| *Tyto alba*                     | Common Barn-owl       |               | 5.7        | 2                  | 22.0                   | 309.0                 | 0.8117 SVLI           |
| **Upuidae**                     |                       |               |            |                    |                        |                       |                       |
| *Upupa eops*                    | Common Hoopoe         |               | 7.0        | 1                  | 4.45                   | 67.50                 | 0.4615 SVLI           |

1Species and English names based on Del Hoyo et al. [39]. 2Feeding guild: F= solitary frugivore, FI= solitary frugivore-insectivore, I= solitary insectivore, IF= solitary insectivore-frugivore, MFI= mixed species insectivore flocks, MFIF= mixed species insectivore-frugivore flocks, SVLI= small vertebrates and large insects.
Appendix 4

Species of birds captured more frequently in floodplain (FP) or terra-firme forest (TF). Test statistics and P-values are provided for Chi-square tests. Abundance data corrected per sampling effort.

| Species[¹]          | English name[¹]          | No. of captures | Chi-squared | Feeding guild[²] |
|---------------------|--------------------------|-----------------|-------------|-----------------|
| *Amazilia lactea*   | Sapphire-spangled Emerald| 14 0 14.00 1    | <0.001 N   | N 0.551         |
| *Automolus infuscatus* | Olive-backed Foliage-gleaner | 56 44 17.18 7   | 0.03 NFI   | MFI             |
| *Chloroceryle aenea* | American Pygmy-kingfisher| 29 16 8.79 2    | 0.02 SVLI  | 0.598           |
| *Chloroceryle inda*  | Green-and-rufous Kingfisher| 16 0 16.00 2    | <0.001 SVLI| 0.547           |
| *Columbina talpacoti* | Ruddy Ground-dove       | 11 0 11.00 1    | 0.002 F    | 0.477           |
| *Dendrocincula merula* | White-chinned woodcreeper| 88 66 26.78 8   | 0.001 AA   |                |
| *Habia rubica*      | Red-crowned Ant-tanager | 56 44 17.18 5   | 0.008 FI   | 0.643           |
| *Hylophylax naevius* | Spot-backed Antbird     | 31 5 12.20 2    | 0.004 I    | 0.583           |
| *Hypocneomoides maculicauda* | Band-tailed antbird | 19 0 19.00 3    | <0.001 I   | 0.877           |
| *Myrmeciza hyperithra* | Plumbeous Antbird       | 14 0 14.00 5    | 0.03 I     | 0.631           |
| *Myrmotherula axillaris* | White-flanked Antwren  | 77 44 23.32 8   | 0.005 MFI  | 0.657           |
| *Myrmotherula hauxwelli* | Plain-throated Antwren | 196 82 62.54 7  | <0.001 MFI| 0.456           |
| *Myrmotherula longipennis* | Long-winged Antwren | 60 33 18.24 6   | 0.011 MFI  |                |
| *Oryzoborus angolinensis* | Chestnut-bellied Seed-finch | 7 0 7.00 1     | 0.016 F    | 0.824           |
| *Perconstola lophotes* | White-lined Antbird    | 7 0 7.00 1     | 0.016 I    | 0.477           |
| *Phaethornis hispidus* | White-bearded Hermit   | 79 44 23.99 8   | 0.005 N    | 0.832           |
| *Philydor ruficaudatum* | Rufous-tailed Foliage-gleaner | 9 0 9.00 2     | 0.02 MFI   |                |
| *Phlegopsis nigromaculata* | Black-spotted Bare-eye | 83 33 26.84 8   | 0.002 AA   |                |
| *Pipra fasciculata* | Band-tailed Manakin    | 496 121 181.50 9 | <0.001 F  | 0.658           |
| *Platyrinchus coronatus* | Golden-crowned Spadebill | 61 16 21.75 9   | 0.02 I     |                |
| *Pteroglossus beaumanaeis* | Curl-crested Aracari    | 9 0 9.00 1     | 0.005 FI   |                |
| *Ramphocelus carbo*  | Silver-beaked Tanager  | 27 0 27.00 2    | <0.001 IF  | 0.484           |
| *Sporophila caerulescens* | Double-collared Seedeater | 17 3 6.47 1    | 0.02 F     | 0.911           |
| *Tangara schrankii* | Green-and-gold Tanager | 20 0 20.00 4    | <0.001 MFI|                |
| *Thamnomanes ardesiacus* | Dusky-throated Antshrike| 72 55 21.97 7   | 0.005 MFI  |                |
| *Threnetes leucurus* | Pale-tailed Barbthroat | 43 27 12.94 5   | 0.047 N    | 0.391           |
| *Turdus albicollis* | White-throated Thrush | 64 16 23.10 6   | 0.002 FI   | 0.584           |
| Species                  | Common Name                      |硬度 | 多样性 | F | P值 | 多样性 | F | P值 |
|------------------------|----------------------------------|-----|-------|---|-----|-------|---|-----|
| Turdus hauxwelli       | Hauxwell’s Thrush                | 22  | 0     | 22.00 | 0.002 | IF |
| Turdus ignobilis       | Black-billed Thrush              | 18  | 0     | 18.00 | <0.001 | IF |
| Volatinia jacarina     | Blue-black Grassquit             | 32  | 0     | 32.00 | <0.001 | F |
| Chiroxiphia pareola    | Blue-backed Manakin              | 2   | 16    | 6.97  | 0.016 | F |
| Cratophaga ani         | Smooth-billed Ani                | 0   | 17    | 17.00 | <0.001 | I |
| Dendrocincla fuliginosa| Plain-brown Woodcreeper          | 45  | 61    | 18.41 | 0.01  | I |
| Dichroza cincta        | Banded Antbird                   | 4   | 17    | 6.06  | 0.027 | I |
| Elaeenia spectabilis   | Large Elaenia                    | 2   | 17    | 6.97  | 0.016 | F |
| Epinecrophylla leucophtalma| White-eyed Antwren        | 12  | 72    | 28.52 | <0.001 | MFI |
| Formicarius analis     | Black-faced Antthrush            | 48  | 66    | 20.03 | 0.005 | I |
| Galbula cyanescens     | Bluish-fronted Jacamar           | 7   | 17    | 5.27  | 0.043 | I |
| Glaucis hirsutus       | Rufous-breasted Hermit           | 42  | 132   | 45.27 | <0.001 | N |
| Glyphorynchus spirurus | Wedge-billed Woodcreeper         | 133 | 165   | 50.95 | <0.001 | MFI |
| Gymnopithys salvini    | White-throated Antbird           | 114 | 182   | 54.76 | <0.001 | AA |
| Hemitriccus flamulatus | Flammulated Pygmy-tyrant         | 5   | 28    | 10.79 | 0.099 | I |
| Hylophilus ochraceiceps| Tawny-crowned Greenlet           | 2   | 17    | 6.97  | 0.016 | I |
| Hypocnemis subflava    | Yellow-breasted Warbling-antbird | 4   | 22    | 8.63  | 0.02  | I |
| Lathrotriccus euleri   | Euler’s Flycatcher               | 1   | 33    | 15.81 | <0.001 | I |
| Lepidothrix coronata   | Blue-crowned Manakin             | 27  | 39    | 11.65 | 0.04  | F |
| Leptotila rufaxilla    | Grey-fronted Dove                | 0   | 6     | 6.00  | 0.028 | F |
| Myiophobus fasciatus   | Bran-colored Flycatcher          | 2   | 17    | 6.97  | 0.017 | I |
| Myrmeciza fortis       | Sooty Antbird                    | 0   | 11    | 11.00 | 0.002 | I |
| Myrmeciza hemimelaena  | Southern Chestnut-tailed Antbird | 37  | 77    | 23.96 | 0.001 | I |
| Myrmoborus myotherinus | Black-faced Antbird              | 25  | 121   | 46.17 | <0.001 | I |
| Myrmothorula longicauda| Stripe-chested Antwren           | 0   | 11    | 11.00 | 0.001 | I |
| Neopelma sulphureiventer| Sulphur-bellied Tyrant-manakin   | 0   | 11    | 11.00 | 0.002 | IF |
| Phaethornis malari      | Great-billed Hermit              | 2   | 22    | 9.68  | 0.004 | N |
| Phlegopsis erythroptera | Reddish-winged Bare-eye          | 0   | 11    | 11.00 | 0.002 | AA |
| Pipra chloromeros      | Round-tailed Manakin             | 19  | 50    | 16.19 | 0.046 | F |
| Ramphatorhinus fuscicaua| Dusky-tailed Flatbill            | 5   | 17    | 5.73  | 0.033 | I |
| Rhegmatotherina melanoctica| Hairy-crested Antbird           | 4   | 17    | 6.06  | 0.027 | AA |
| Willisornis poecilinotus| Scale-backed Antbird             | 53  | 72    | 21.75 | 0.002 | I |

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| Xiphorhynchus elegans | Elegant Woodcreeper | 41 | 72 | 21.69 | 9 | 0.02 | MFI |

Species and English names based on Schulenberg et al. [23] and Del Hoyo et al. [39]. Feeding guild based on classification in Henriques et al. [16]. AA = army ant follower, F = solitary frugivore, FI = solitary frugivore-insectivore, I = solitary insectivore, IF = solitary insectivore-frugivore, MFI = mixed species insectivore flocks, N = nectarivore, SVLI = small vertebrates and large insects.
Appendix 5

Relative reproductive investments of tropical region birds per family and per feeding guild. Value of RRI with Standard Error and number of species used is shown.

**Tropical regions**

| Family          | RRI(SE)      | n  | Family          | RRI(SE)      | n  |
|-----------------|--------------|----|-----------------|--------------|----|
| Alcedinidae     | 0.572(0.025) | 2  | Piciidae        | 0.270        | 1  |
| Bucconidae      | 0.253(0.033) | 2  | Pipridae        | 0.561(0.033) | 5  |
| Cardinalidae    | 0.468        | 1  | Psittacida      | 0.266        | 1  |
| Columbidae      | 0.297(0.062) | 4  | Rhampastidae    |              |    |
| Conopophagidae  |              |    |                 |              |    |
| Cotingidae      |              |    |                 |              |    |
| Cuculidae       | 0.814        | 1  |                 |              |    |
| Emberizidae     | 0.667(0.071) | 7  |                 |              |    |
| Falconidae      | 0.304(0.037) | 2  |                 |              |    |
| Formicariidae   | 0.508(0.141) | 3  |                 |              |    |
| Furnariidae     | 0.600(0.059) | 14 |                 |              |    |
| Galbulidae      |              |    |                 |              |    |
| Icteridae       |              |    |                 |              |    |
| Momotidae       | 0.260(0.072) | 2  |                 |              |    |
| Parulidae       | 0.420(0.099) | 2  |                 |              |    |
| Alcedinidae     | 0.572(0.025) | 2  | Piciidae        | 0.270        | 1  |
| Bucconidae      | 0.253(0.033) | 2  | Pipridae        | 0.561(0.033) | 5  |
| Cardinalidae    | 0.468        | 1  | Psittacida      | 0.266        | 1  |
| Columbidae      | 0.297(0.062) | 4  | Rhampastidae    |              |    |
| Conopophagidae  |              |    |                 |              |    |
| Cotingidae      |              |    |                 |              |    |
| Cuculidae       | 0.814        | 1  |                 |              |    |
| Emberizidae     | 0.667(0.071) | 7  |                 |              |    |
| Falconidae      | 0.304(0.037) | 2  |                 |              |    |
| Formicariidae   | 0.508(0.141) | 3  |                 |              |    |
| Furnariidae     | 0.600(0.059) | 14 |                 |              |    |
| Galbulidae      |              |    |                 |              |    |
| Icteridae       |              |    |                 |              |    |
| Momotidae       | 0.260(0.072) | 2  |                 |              |    |
| Parulidae       | 0.420(0.099) | 2  |                 |              |    |

**Feeding guild**

| Feeding guild | RRI(SE)      | n  |
|---------------|--------------|----|
| AA            | 0.332        | 1  |
| F             | 0.588(0.056) | 20 |
| FI            | 0.474(0.064) | 5  |
| I             | 0.629(0.034) | 38 |
| IF            | 0.551(0.062) | 12 |
| MFI           | 0.675(0.099) | 8  |
| MFIF          | 0.270        | 1  |
| N             | 0.526(0.038) | 12 |
| SVLI          | 0.376(0.064) | 6  |

Feeding guilds based on classification in Henriques et al. [16]. AA= army ant followers, F= solitary frugivores, FI= solitary frugivore-insectivores, I= solitary insectivores, IF= solitary insectivore-frugivores, MFI= mixed species insectivore flocks, MFIF= mixed species insectivore-frugivore flocks, N= nectarivores, SVLI= small vertebrates and large insects.
Appendix 6

Relative reproductive investments of temperate region birds per family and per feeding guild. Value of RRI with Standard Error and number of species used is shown.

### Temperate regions

| Family               | RRI(SE)   | n  | Family               | RRI(SE)   | n  |
|----------------------|-----------|----|----------------------|-----------|----|
| Accipitridae         | 0.222(0.033) | 9  | Muscicapidae         | 0.726(0.244) | 2  |
| Aegithalidae         | 1.136     | 1  | Oriolidae            | 0.390     | 1  |
| Alaudidae            | 0.837(0.107) | 3  | Paradoxornithidae    | 1.960     | 1  |
| Alcedinidae          | 1.435     | 1  | Paridae              | 1.473(0.656) | 2  |
| Anatidae             | 0.540(0.043) | 28 | Passeridae           | 0.909(0.085) | 2  |
| Apodidae             | 0.214     | 1  | Phalacrocoracidae    | 0.873     | 1  |
| Ardeidae             | 0.296(0.041) | 6  | Phasianidae          | 0.538(0.087) | 5  |
| Burhinidae           | 0.152     | 1  | Picidae              | 0.407(0.073) | 6  |
| Camprinulgidae       | 0.323     | 1  | Podicipedida         | 0.356(0.133) | 4  |
| Certhidae            | 1.358(0.005) | 2  | Prunellidae          | 1.029     | 1  |
| Charadriidae         | 1.006(0.265) | 4  | Psittacidae          |           |    |
| Ciconiidae           | 0.133     | 1  | Rallidae             | 1.296(0.251) | 7  |
| Cisticolidae         | 1.595     | 1  | Recurvirostridae     | 0.429(0.045) | 2  |
| Columbidae           | 0.290(0.096) | 5  | Regulidae            | 2.253(0.226) | 2  |
| Corvidae             | 0.200(0.021) | 8  | Remizidae            | 0.417     | 1  |
| Cuculidae            | 0.279     | 1  | Scolopacidae         | 0.634(0.087) | 7  |
| Emberizidae          | 0.991(0.077) | 4  | Sittidae             | 0.722     | 1  |
| Falconidae           | 0.373     | 1  | Strigidae            | 0.301(0.064) | 5  |
| Fringillidae         | 0.645(0.077) | 14 | Sturnidae            | 0.911     | 1  |
| Gruidae              | 0.070     | 1  | Sylviiidae           | 0.754(0.084) | 16 |
| Haematopodidae       | 0.208     | 1  | Threskionithidae     | 0.235     | 1  |
| Hirundinidae         | 0.720(0.124) | 3  | Troglodytidae        | 2.031     | 1  |
| Laniidae             | 0.480(0.004) | 2  | Turdidae             | 0.978(0.123) | 13 |
| Laridae              | 0.395(0.028) | 11 | Tytonidae            | 0.811     | 1  |
| Motacillidae         | 0.789(0.107) | 6  | Upupidae             | 0.461     | 1  |

| Feeding guild | RRI(SE) | n |
|---------------|---------|---|
| AA            |         |   |
| F             | 0.491(0.103) | 7  |
| FI            | 0.541(0.050) | 32 |
| I             | 0.810(0.070) | 46 |
| IF            | 0.770(0.070) | 42 |
| MFI           | 1.317(0.318) | 6  |
| MFIF          | 1.213(0.327) | 5  |
| N             |         |   |
| SVLI          | 0.376(0.064) | 62 |

Feeding guilds based on classification in Henriques et al. [16]. AA= army ant followers, F= solitary frugivores, FI= solitary frugivore-insectivores, I= solitary insectivores, IF= solitary insectivore-frugivores, MFI= mixed species insectivore flocks, MFIF= mixed species insectivore-frugivore flocks, N= nectarivores, SVLI= small vertebrates and large insects.