

Research Article

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

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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-traits, 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), Bozovitch Concession (BOZ), Chuncho Clay Lick (CHUN), Los Amigos Research Center (CICRA), Explorer's Inn (EI), 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).

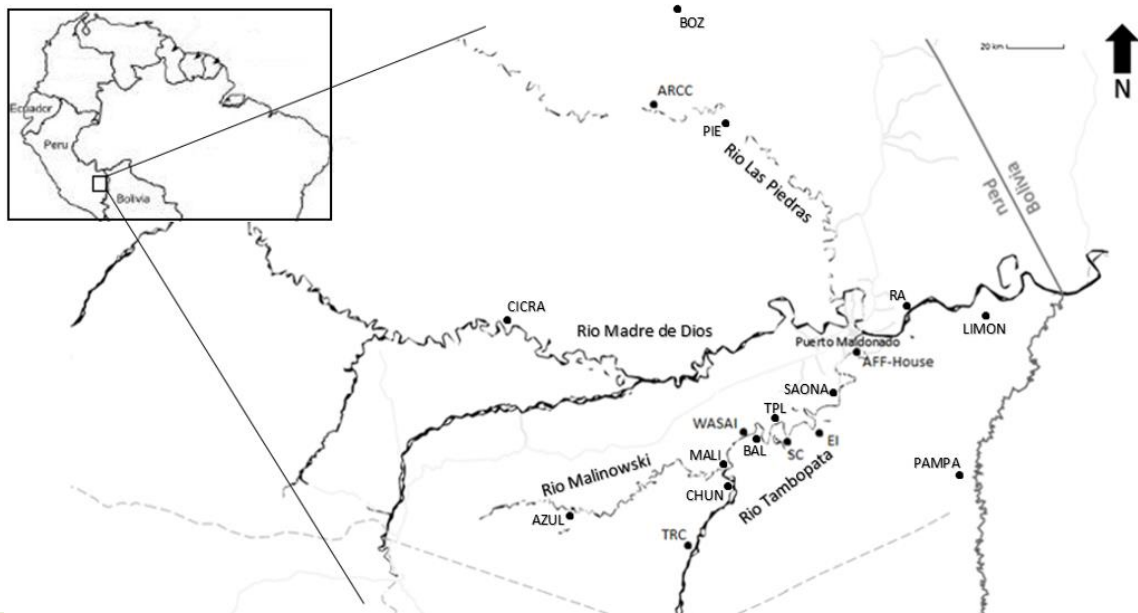


Fig. 1: Map of sampling sites in the Madre de Dios region, Peru. All of the sites are within the Amazon Basin and six are within the protected area complex of the Tambopata National Reserve and Bahuaja Sonene National Park.

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 (\hat{c}), number of clutches per season (N_c) and egg mass (m_{egg}), divided by the female body mass (m_{female}) were used to assess the Relative Reproductive Investment (RRI) according to the following formula: $RRI = (\hat{c} * N_c * m_{egg}) / m_{female}$ [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.

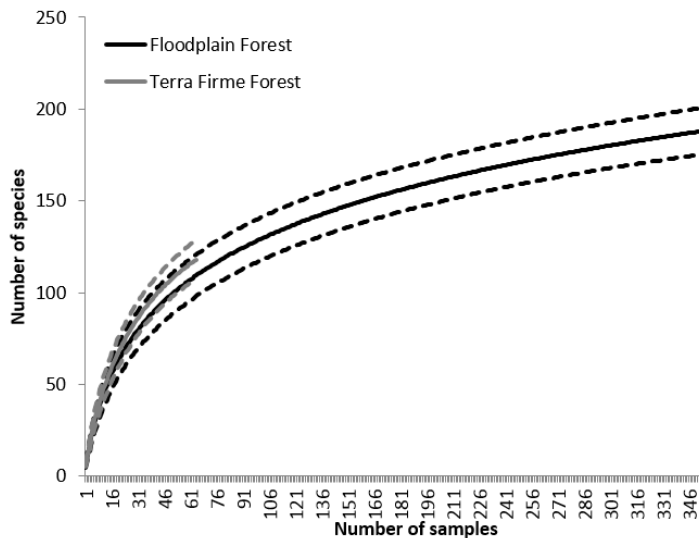


Fig. 2: Species accumulation curves. Grey line represents species richness in terra firme forest, black line in floodplain forest. Continuous lines surrounded by dashed lines represent cumulative number of species and confidence intervals of the respective habitats.

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	64
No. of Individuals	3,285	711.3±0.29	541
S_{obs}	188	79.4±1.28	118
Unique species	90	19.9±0.03	20
Richness			
MM Means	192.3	144.68	161.87
Chao 1	224.74±14.88	147.68±16.86	153.96±15.61
Chao 2	242.41±20.75	160.74±21.04	157.57±15.91
Jackknife 1	236.86±7.88	151.91±8.10	160.33±6.74
Jackknife 2	263.77	175.53±15.33	180.06
Bootstrap	210.07	128.42±7.51	137.77
ICE	231.46	156.51±15.39	163.59±0.02
Diversity			
Shannon Index	4.16	3.98±0.08	4.26
Simpson Index	26.79	25.82±3.5	46.67

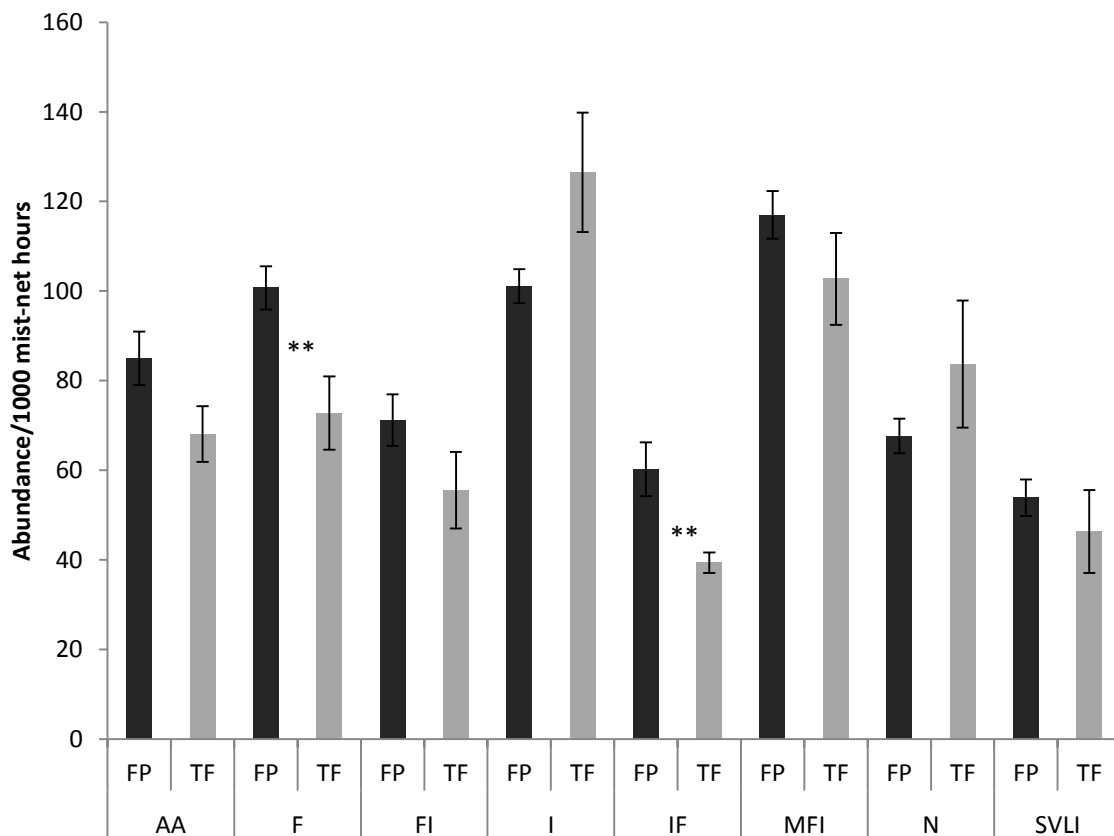


Fig. 3: Abundance per sampling effort of various feeding guilds compared between floodplain (FP) and terra-firme forest (TF). See Table 2 for abbreviations of feeding guilds. Fault bars indicate Standard Error, **= P<0.01.

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.

	Clutch size	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, MFI = mixed species insectivore flocks, MFIF = mixed species insectivore-frugivore flocks, 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)			
I	0.642(0.085)	0.633(0.044)	$P=0.922$	
IF	0.457(0.015)			
MFI	0.556(0.100)	0.401		$P=0.667$
N	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)	$P=0.950$	
Cuculidae	0.814	0.279		$P=1.000$
Emberizidae	0.666(0.071)	0.991(0.077)	$P=0.017$	
Falconidae	0.304(0.037)	0.373		$P=1.000$
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.

Table 5: Average value (with SE) of life-history traits used in calculation for RRI. Average clutch size (\hat{c}), Number of broods per season (N_c) Egg mass in grams (m_{egg}) and Female body mass in grams (m_{female}). See Table 2 for abbreviations of feeding guilds.

	\hat{c}		N_c		m_{egg}		m_{female}	
	Tropical	Temperate	Tropical	Temperate	Tropical	Temperate	Tropical	Temperate
Emberizidae	2.49(0.15)	4.45(0.21)	2	1.93(0.07)	1.94(0.27)	2.90(0.38)	16.34(2.66)	5.85(4.99)
Turdidae	2.73(0.33)	5.17(0.21)	2	1.77(0.19)	5.89(0.79)	3.75(0.62)	60.28(5.84)	3.58(11.2)
I	2.29(0.11)	4.78(0.24)	1.94(0.03)	1.39(0.08)	4.10(0.42)	12.0(2.46)	29.42(2.79)	110(22.1)
IF	2.81(0.19)	5.45(0.25)	1.85(0.08)	1.37(0.09)	4.90(0.57)	11.4(3.32)	49.39(8.48)	174(59.6)
MFI	2.16(0.11)	4.59(0.61)	1.97(0.03)	2.78(0.17)	2.84(0.57)	3.04(0.16)	22.15(2.12)	4.31(1.19)

The basic life-history traits in the significantly different RRIs 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

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.

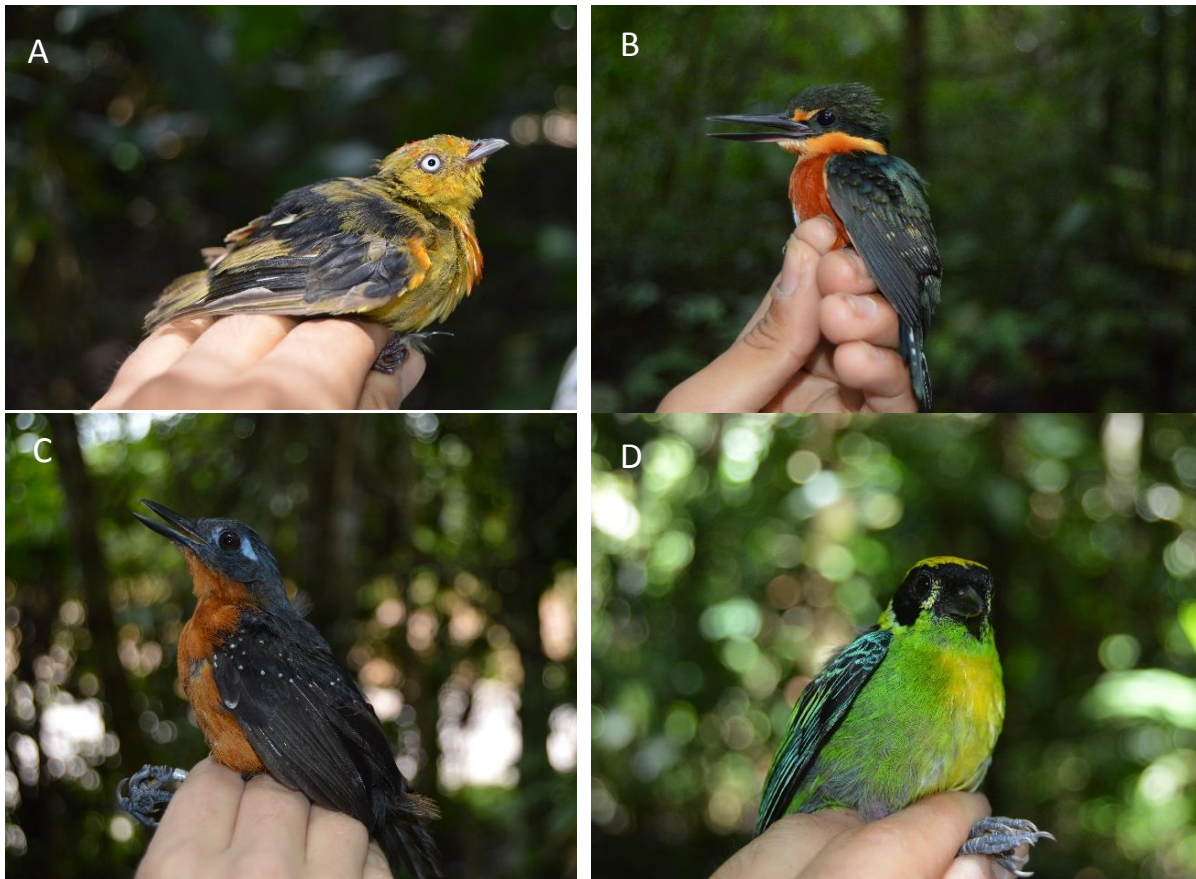


Fig. 4: Some bird species from the Amazon Basin within the Tambopata National Reserve and Bahuaja Sonene National Park. A. Band-tailed Manakin (*Pipra fasciicauda*) B. American Pygmy-kingfisher (*Chloroceryle aenea*) C. Plumbeous antbird (*Myrmeciza hyperythra*) D. Green-and-gold Tanager (*Tangara schrankii*) (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	X
AZUL	S 13 2 40.1, W 69 54 37.1		X
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		X
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		X
PAMPA	S 12 56 59.8, W 68 54 45.8		X
PIE	S 12 3 23.5, W 69 31 43.4	X	X
RA	S 12 32 26.6, W 69 3 11.1		X
SAONA	S 12 44 45.6, W 69 14 0.1		X
SC	S 12 51 12.5, W 69 22 3.4		X
TPL	S 12 49 27.7, W 69 24 10.7	X	
TRC	S 13 8 3.2, W 69 36 38.9		X
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 ^[1]	English name ^[1]	Average clutch size	Number of broods per season	Egg mass (g)	Female body mass (g)	RRI	Feeding guild ^[a]
Alcedinidae							
<i>Chloroceryle aenea</i>	American Pygmy-kingfisher	3.5	1	2.40	14.05	0.5979	SVLI
<i>Chloroceryle inda</i>	Green-and-rufous Kingfisher	3.9	1	7.40	52.75	0.6471	SVLI
Bucconidae							
<i>Bucco macrodactylus</i>	Chestnut-capped Puffbird				25.00		I
<i>Malacoptila semicineta</i>	Semicollared Puffbird		1	7.40	44.00		I
<i>Monasa morphoeus</i>	White-fronted Nunbird	2.4	1	7.50	82.00	0.2195	SVLI
<i>Monasa nigrifrons</i>	Black-fronted Nunbird	3.0	1	7.90	83.00	0.2855	SVLI
Cardinalidae							
<i>Cyanocompsa cyanoides</i>	Blue-black Grosbeak	2.0	2		27.87		FI
<i>Saltator grossus</i>	Slate-colored Grosbeak	2.5	2		47.00		FI
<i>Saltator maximus</i>	Buff-throated Saltator	2.0	2	5.75	49.10	0.4684	FI
Columbidae							
<i>Claravis pretiosa</i>	Blue-Ground Dove	2.0	3	3.80	93.50	0.2438	F
<i>Columbina talpacoti</i>	Ruddy Ground-dove	2.0	3	3.60	45.27	0.4771	F
<i>Geotrygon montana</i>	Ruddy Quail-dove	2.0	3	5.30	115.2	0.2760	F
<i>Leptotila rufaxilla</i>	Grey-fronted Dove	1.4	3	6.80	149.0	0.1917	F
Conopophagidae							
<i>Conopophaga peruviana</i>	Ash-throated Gnateater	2.0	2		23.30		I
Cotingidae							
<i>Lipaugus vociferans</i>	Screaming Piha				82.60		FI
Cuculidae							
<i>Crotophaga ani</i>	Smooth-billed Ani	2.9	2	13.2	94.00	0.8145	I
Emberizidae							

<i>Ammodramus aurifrons</i>	Yellow-browed Sparrow	2.4	2	2.25	16.75	0.6448	F
<i>Arremon taciturnus</i>	Pectoral Sparrow	2.0	2	3.50	26.50	0.5283	IF
<i>Oryzoborus angolensis</i>	Chestnut-bellied Seed-finch	2.5	2	2.03	12.32	0.8239	F
<i>Oryzoborus atrirostris</i>	Black-billed Seed-finch				26.40		F
<i>Paroaria gularis</i>	Red-capped Cardinal	2.0	2	2.29	26.40	0.3470	IF
<i>Sporophila caerulescens</i>	Double-collared Seedeater	3.0	2	1.45	9.550	0.9110	F
<i>Sporophila castaneiventris</i>	Chestnut-bellied Seedeater			1.28	7.800		F
<i>Sporophila schistacea</i>	Slate-colored Seedeater	3.0	2	1.30	11.83	0.6593	F
<i>Volatinia jacarina</i>	Blue-black Grassquit	2.5	2	1.43	9.500	0.7526	F
Falconidae							
<i>Micrastur gilvicollis</i>	Lined Forest-falcon	2.4	1	28.0	196.5	0.3420	SVLI
<i>Micrastur ruficollis</i>	Barred Forest-falcon	2.4	1	29.0	261.0	0.2667	SVLI
Formicariidae							
<i>Chamaeza nobilis</i>	Striated Antthrush	2.0	2	7.60	134.0	0.2269	I
<i>Formicarius analis</i>	Black-faced Antthrush	2.0	2	9.00	56.60	0.6360	I
<i>Formicarius colma</i>	Rufous-capped Antthrush	2.0	2	8.30	50.10	0.6627	I
Furnariidae							
<i>Anabazenops dorsalis</i>	Dusky-cheeked Foliage-gleaner				39.00		I
<i>Ancistrops strigilatus</i>	Chestnut-winged Hookbill				34.50		MFI
<i>Automolus infuscatus</i>	Olive-backed Foliage-gleaner				40.50		MFI
<i>Automolus melanopezus</i>	Brown-rumped Foliage-gleaner				29.50		I
<i>Automolus ochrolaemus</i>	Buff-throated Foliage-gleaner	2.4	2	5.56	38.00	0.7023	I
<i>Automolus rufipileatus</i>	Chestnut-crowned Foliage-gleaner				34.50		I
<i>Campylorhamphus trochilirostris</i>	Red-billed Scythebill	2.0	2	5.85	42.50	0.5506	I
<i>Deconychura longicauda</i>	Long-tailed Woodcreeper	2.0	2		47.80		MFI
<i>Dendrexetastes rufigula</i>	Cinnamon-throated Woodcreeper	2.4	2	7.35	70.00	0.5040	I
<i>Dendrocincla fuliginosa</i>	Plain-brown Woodcreeper	1.7	2	6.35	35.00	0.6169	I
<i>Dendrocincla merula</i>	White-chinned Woodcreeper				40.00		AA
<i>Dendrocolaptes certhia</i>	Amazonian Barred Woodcreeper	1.0	2		90.10		AA
<i>Dendrocolaptes picumnus</i>	Black-banded Woodcreeper	2.0	2	7.05	85.00	0.3318	AA
<i>Dendroplex picus</i>	Straight-billed Woodcreeper	2.5	2		38.20		MFI

<i>Furnarius leucopus</i>	Pale-legged Hornero	2.0	2	4.95	49.00	0.4041	I
<i>Glyphorhynchus spirurus</i>	Wedge-billed Woodcreeper	1.7	2	1.75	14.82	0.4015	MFI
<i>Hyloctistes subulatus</i>	Striped Woodhaunter				29.50		MFI
<i>Lepidocolaptes albolineatus</i>	Lineated Woodcreeper		2	4.74	19.25		MFI
<i>Nasica longirostris</i>	Long-billed Woodcreeper				85.00		I
<i>Philydor erythrocercum</i>	Rufous-rumped Foliage-gleaner	2.0	2		24.50		MFI
<i>Philydor erythropterum</i>	Chestnut-winged Foliage-gleaner				32.00		MFI
<i>Philydor pyrrhodes</i>	Cinnamon-rumped Foliage-gleaner				29.50		MFI
<i>Philydor ruficaudatum</i>	Rufous-tailed Foliage-gleaner		2	3.68	26.50		MFI
<i>Sclerurus albigularis</i>	Gray-throated Leaf-tosser	2.0	2	5.41	40.00	0.5410	I
<i>Sclerurus caudacutus</i>	Black-tailed Leaf-tosser	2.0	2	5.58	38.00	0.5874	I
<i>Sclerurus mexicanus</i>	Tawny-throated Leaf-tosser	2.0	2		27.00		I
<i>Simoxenops ucayalae</i>	Peruvian Recurvebill				51.10		I
<i>Sittasomus griseicapillus</i>	Olivaceous Woodcreeper	3.0	2	2.35	12.00	1.1750	MFI
<i>Synallaxis gujanensis</i>	Plain-crowned Spinetail	2.4	2	2.93	17.50	0.8037	I
<i>Synallaxis rutilans</i>	Ruddy Spinetail	3.5	2	2.25	18.50	0.8514	MFI
<i>Xenops minutus</i>	Plain Xenops	2.0	2		11.00		MFI
<i>Xiphocolaptes promeropirhynchus</i>	Strong-billed Woodcreeper	2.5	2	13.3	140.0	0.4750	I
<i>Xiphorhynchus elegans</i>	Elegant Woodcreeper	2.0	2		36.86		MFI
<i>Xiphorhynchus guttatus</i>	Buff-throated Woodcreeper	1.7	2	7.46	56.00	0.4529	MFI
<i>Xiphorhynchus ocellatus</i>	Ocellated Woodcreeper		2		37.00		MFI
Galbulidae							
<i>Galbula cyanescens</i>	Bluish-fronted Jacamar	2.0	2	4.30	24.00	0.7167	I
Icteridae							
<i>Clypicerus oseryi</i>	Casqued Oropendola				101.4		F
Momotidae							
<i>Baryphthengus martii</i>	Rufous Motmot				146.6		IF
<i>Electron platyrhynchum</i>	Broad-billed Motmot	2.5	1	8.10	61.00	0.3320	IF
<i>Momotus momota</i>	Amazonian Motmot	3.5	1	7.50	140.0	0.1875	IF
Parulidae							
<i>Dendroica petechia</i>	Yellow Warbler	4.5	1	1.35	11.70	0.5192	I

<i>Phaeothlypis fulvicauda</i>	Buff-rumped Warbler	2.0	1	2.39	14.90	0.3208	I
Picidae							
<i>Celeus elegans</i>	Chestnut Woodpecker	3.0	2	7.30	162.2	0.2701	MFIF
<i>Picumnus rufiventris</i>	Rufous-breasted Piculet			1.20	19.78		I
Pipridae							
<i>Chiroxiphia pareola</i>	Blue-backed Manakin	2.0	2	2.40	21.05	0.4561	F
<i>Lepidothrix coronata</i>	Blue-crowned Manakin	2.0	2		10.85		F
<i>Machaeropterus pyrocephalus</i>	Fiery-capped Manakin	2.0	2	1.58	10.60	0.5962	F
<i>Manacus manacus</i>	White-bearded Manakin	2.0	2	2.10	14.94	0.5622	F
<i>Neopelma sulphureiventer</i>	Sulphur-bellied Tyrant-manakin				15.00		IF
<i>Pipra chloromeros</i>	Round-tailed Manakin				16.10		F
<i>Pipra fasciicauda</i>	Band-tailed Manakin	2.0	2	2.75	16.73	0.6575	F
<i>Pipra rubrocapilla</i>	Red-headed Manakin	2.0	2	1.96	14.65	0.5352	F
<i>Piprites chloris</i>	Wing-barred Piprites		2	2.80	18.00		I
<i>Xenopipo atronitens</i>	Black Manakin				15.25		IF
Psittacidae							
<i>Brotogeris versicolurus</i>	White-winged Parakeet	4.5	1	3.55	60.00	0.2663	F
Ramphastidae							
<i>Aulacorhynchus prasinus</i>	Emerald Toucanet	2.2	2		170.0		FI
<i>Pteroglossus azara</i>	Ivory-billed Aracari	2.8	2		142.0		FI
<i>Pteroglossus beauharnaesii</i>	Curl-crested Aracari				222.0		FI
<i>Selenidera reinwardtii</i>	Red-billed Toucanet				153.5		FI
Strigidae							
<i>Megascops watsonii</i>	Tawny-bellied Screech-owl		1		160.1		SVLI
Thamnophilidae							
<i>Cercomacra nigrescens</i>	Blackish Antbird		2	3.00	20.50		I
<i>Cercomacra serva</i>	Black Antbird	2.0	2	2.40	16.00	0.6000	I
<i>Dichrozona cincta</i>	Banded Antbird				14.75		I
<i>Epinecrophylla haematonota</i>	Stipple-throated Antwren				10.10		MFI
<i>Epinecrophylla leucophthalma</i>	White-eyed Antwren				9.420		MFI
<i>Epinecrophylla ornata</i>	Ornate Antwren				9.540		MFI

<i>Formicivora rufa</i>	Rusty-backed Antwren	2.0	2		13.60		I
<i>Frederickena unduligera</i>	Undulated Antshrike	2.0	2		80.00		I
<i>Gymnopithys salvini</i>	White-throated Antbird	2.0	2		26.65		AA
<i>Hylophylax naevius</i>	Spot-backed Antbird	1.7	2	2.15	12.54	0.5829	I
<i>Hypocnemis peruviana</i>	Peruvian Warbling-antbird	2.0	2	2.20	12.70	0.6929	I
<i>Hypocnemis subflava</i>	Yellow-breasted Warbling-antbird	2.0	2	2.40	12.00	0.8000	I
<i>Hypocnemoides maculicauda</i>	Band-tailed Antbird	2.0	2	2.50	11.40	0.8772	I
<i>Microrhopias quixensis</i>	Dot-winged Antwren	2.0	2	1.50	9.500	0.6316	I
<i>Myrmeciza atrothorax</i>	Black-throated Antbird	1.0	2		16.00		I
<i>Myrmeciza fortis</i>	Sooty Antbird	2.0	2		45.00		I
<i>Myrmeciza goeldii</i>	Goeldi's Antbird	1.4	2		48.14		I
<i>Myrmeciza hemimelaena</i>	Chestnut-tailed Antbird	2.0	2	2.55	15.06	0.6773	I
<i>Myrmeciza hyperythra</i>	Plumbeous Antbird	2.0	2	5.25	33.29	0.6308	I
<i>Myrmoborus leucophrys</i>	White-browed Antbird	2.0	2		20.16		I
<i>Myrmoborus myotherinus</i>	Black-faced Antbird	2.0	2	2.25	19.40	0.4639	I
<i>Myrmotherula axillaris</i>	White-flanked Antwren	2.0	2	1.42	8.650	0.6567	MFI
<i>Myrmotherula hauxwelli</i>	Plain-throated Antwren	2.0	2	1.30	11.41	0.4557	MFI
<i>Myrmotherula iheringi</i>	Ihering's Antwren				8.250		MFI
<i>Myrmotherula longicauda</i>	Stripe-chested Antwren				8.750		I
<i>Myrmotherula longipennis</i>	Long-winged Antwren				9.700		MFI
<i>Myrmotherula menetriesii</i>	Gray Antwren		2	1.15	7.600		MFI
<i>Neotantes niger</i>	Black Bushbird				30.30		I
<i>Percnostola lophotes</i>	White-lined Antbird	2.0	2	3.41	28.56	0.4773	I
<i>Phlegopsis erythroptera</i>	Reddish-winged Bare-eye				54.00		AA
<i>Phlegopsis nigromaculata</i>	Black-spotted Bare-eye	2.0	2		37.55		AA
<i>Pygoptila stellaris</i>	Spot-winged Antshrike				26.02		I
<i>Rhegmatorhina melanosticta</i>	Hairy-crested Antbird	2.0	2		31.80		AA
<i>Sclateria naevia</i>	Silvered Antbird	2.0	2	3.28	24.00	0.5467	I
<i>Taraba major</i>	Great Antshrike	2.4	2	6.80	60.70	0.5377	I
<i>Thamnomanes ardesiacus</i>	Dusky-throated Antshrike	2.0	2		17.40		MFI
<i>Thamnomanes saturninus</i>	Saturnine Antshrike				20.00		MFI

<i>Thamnomanes schistogynus</i>	Bluish-slate Antshrike	2.0	2		19.38		MFI
<i>Thamnophilus aethiops</i>	White-shouldered Antshrike	2.0	2	3.02	25.23	0.4788	MFI
<i>Thamnophilus doliatus</i>	Barred Antshrike	1.7	2	3.60	29.60	0.4135	I
<i>Thamnophilus schistaceus</i>	Plain-winged Antshrike	2.0	2		22.07		MFI
<i>Willisornis poecilinotus</i>	Scale-backed Antbird	2.0	2	3.50	19.36	0.7231	I
Thraupidae							
<i>Euphonia chlorotica</i>	Purple-throated Euphonia	3.9	3	1.15	11.15	1.2067	F
<i>Habia rubica</i>	Red-crowned Ant-tanager	2.5	2	4.00	31.11	0.6429	FI
<i>Lanio versicolor</i>	White-winged Shrike-tanager	2.0	2		18.15		MFI
<i>Ramphocelus carbo</i>	Silver-beaked Tanager	2.0	2	3.30	27.30	0.4835	IF
<i>Tachyphonus cristatus</i>	Flame-crested Tanager		2	3.20	33.60		MFIF
<i>Tangara schrankii</i>	Green-and-gold Tanager	2.0	2		19.67		MFI
Tinamidae							
<i>Crypturellus bartletti</i>	Bartlett's Tinamou		3	40.0	241.0		F
Trochilidae							
<i>Amazilia lactea</i>	Sapphire-spangled Emerald	2.0	2	0.46	3.600	0.5111	N
<i>Campylopterus largipennis</i>	Grey-breasted Sabrewing	2.0	2		7.000		N
<i>Chlorostilbon mellisugus</i>	Blue-tailed Emerald	2.0	2	0.40	3.970	0.4030	N
<i>Chrysuronia oenone</i>	Golden-tailed Sapphire	2.0	2	0.65	4.300	0.6047	N
<i>Florisuga mellivora</i>	White-necked Jacobin	2.0	2	0.82	7.130	0.4600	N
<i>Glaucis hirsutus</i>	Rufous-breasted Hermit	2.0	2	0.72	5.660	0.5088	N
<i>Heliodoxa aurescens</i>	Gould's Brilliant	2.0	2		6.000		N
<i>Hylocharis cyanus</i>	White-chinned Sapphire	2.0	2		3.150		N
<i>Phaethornis hispidus</i>	White-bearded Hermit	2.0	2	1.05	5.050	0.8317	N
<i>Phaethornis longirostris</i>	Long-billed Hermit	2.0	2		5.250		N
<i>Phaethornis malaris</i>	Great-billed Hermit	2.0	2		6.100		N
<i>Phaethornis philippii</i>	Needle-billed Hermit				4.750		N
<i>Phaethornis ruber</i>	Reddish Hermit	2.0	2	0.38	4.500	0.3378	N
<i>Phaethornis superciliosus</i>	Long-tailed Hermit	2.0	2	0.85	5.450	0.6239	N
<i>Phaethornis stuarti</i>	White-browed Hermit				2.500		N
<i>Polytmus guainumbi</i>	White-tailed Goldenthrout	2.0	2	0.70	4.760	0.5882	N

<i>Thalurania furcata</i>	Fork-tailed Woodnymph	2.0	2	0.54	4.200	0.5143	N
<i>Threnetes leucurus</i>	Pale-tailed Barbthroat	2.0	2	0.56	5.730	0.3909	N
Troglodytidae							
<i>Cyphorhinus arada</i>	Musician Wren	2.0	2		26.14		I
<i>Microcerculus marginatus</i>	Southern Nightingale-wren	2.4	2	3.74	17.50	1.0258	I
<i>Thryothorus genibarbis</i>	Moustached Wren		2	2.00	19.50		I
<i>Troglodytes aedon</i>	Northern House Wren	5.7	2	1.38	13.40	1.1740	I
Trogonidae							
<i>Trogon collaris</i>	Collared Trogon	2.4	1	8.50	53.22	0.3833	FI
<i>Trogon curucui</i>	Blue-crowned Trogon	2.4	1	6.20	51.00	0.2918	FI
<i>Trogon melanurus</i>	Black-tailed Trogon	2.4	1		70.00		FI
Turdidae							
<i>Catharus ustulatus</i>	Swainson's Thrush	3.5	2	3.60	35.00	0.7200	IF
<i>Turdus albicollis</i>	White-throated Thrush	2.4	2	6.45	53.00	0.5842	FI
<i>Turdus amaurochalinus</i>	Creamy-bellied Thrush	3.0	2	6.30	62.50	0.6048	IF
<i>Turdus hauxwelli</i>	Hauxwell's Thrush				71.25		IF
<i>Turdus ignobilis</i>	Black-billed Thrush	2.0	2	7.20	66.90	0.4305	IF
<i>Turdus lawrencii</i>	Lawrence's Thrush		2		73.00		IF
Tyrannidae							
<i>Attila bolivianus</i>	Dull-capped Attila	2.0	2	4.65	42.50	0.4376	I
<i>Attila spadiceus</i>	Bright-rumped Attila	2.8	2	3.80	37.70	0.5645	I
<i>Cnemotriccus fuscatus</i>	Fuscous Flycatcher	3.0	2	2.48	11.90	1.2504	I
<i>Corythopis torquatus</i>	Ringed Antpipit	2.0	2		16.00		I
<i>Elaenia parvirostris</i>	Small-billed Elaenia	2.4	2	2.03	13.80	0.7061	F
<i>Elaenia spectabilis</i>	Large Elaenia	2.0	2	2.80	29.00	0.3862	F
<i>Elaenia strepera</i>	Slaty Elaenia	2.0	2	2.88	19.00	0.6063	F
<i>Empidonax alnorum</i>	Alder Flycatcher	3.5	2	1.82	13.00	0.9800	I
<i>Hemitriccus flammulatus</i>	Flammulated Pygmy-tyrant				10.25		I
<i>Hemitriccus griseipectus</i>	White-bellied Tody-tyrant				8.950		I
<i>Inezia inornata</i>	Plain Tyrannulet		2	1.30	5.750		I
<i>Laniocera hypopyrra</i>	Cinereous Mourner	2.0	2		40.40		IF

<i>Lathrotriccus euleri</i>	Euler's Flycatcher	2.4	2	1.77	11.00	0.7724	I
<i>Leptopogon amaurocephalus</i>	Sepia-capped Flycatcher	2.4	2	2.17	11.20	0.9300	MFI
<i>Lophotriccus eulophotes</i>	Long-crested Pygmy-tyrant				7.250		I
<i>Mionectes macconnelli</i>	McConnell's Flycatcher	3.0	2		11.00		IF
<i>Mionectes oleagineus</i>	Ochre-bellied Flycatcher	3.2	2		13.00		IF
<i>Mionectes olivaceus</i>	Olive-striped Flycatcher	2.4	2	1.99	12.00	0.7960	F
<i>Myiarchus ferox</i>	Short-crested Flycatcher	2.4	2	3.38	28.75	0.5643	IF
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher	3.9	2	3.68	29.80	0.9632	IF
<i>Myiophobus fasciatus</i>	Bran-colored Flycatcher	1.4	2	1.60	10.00	0.4480	I
<i>Ochthornis littoralis</i>	Drab Water-tyrant	3.5	2		13.40		I
<i>Onychorhynchus coronatus</i>	Royal Flycatcher	2.0	2	1.76	12.52	0.5623	I
<i>Pachyrampus minor</i>	Pink-throated Becard	4.9	2	2.45	37.00	0.6489	I
<i>Pitangus sulphuratus</i>	Great Kiskadee	3.9	2	5.80	60.50	0.7478	IF
<i>Platyrinchus coronatus</i>	Golden-crowned Spadebill	2.0	2		9.200		I
<i>Platyrinchus platyrhynchos</i>	White-crested Spadebill				12.25		I
<i>Platyrinchus saturatus</i>	Cinnamon-crested Spadebill				10.60		I
<i>Ramphotrigon fuscicauda</i>	Dusky-tailed Flatbill	2.0	2		19.00		I
<i>Ramphotrigon megacephalum</i>	Large-headed Flatbill	2.0	2	2.62	14.00	0.7486	I
<i>Ramphotrigon ruficauda</i>	Rufous-tailed Flatbill	3.0	2		19.75		I
<i>Rhynchocyclus olivaceus</i>	Olivaceous Flatbill	2.4	2	2.45	21.00	0.5600	I
<i>Rhytipterna simplex</i>	Greyish Mourner				35.50		I
<i>Schiffornis turdina</i>	Thrush-like Mourner	2.0	2	4.01	31.00	0.5174	I
<i>Terenotriccus erythrurus</i>	Ruddy-tailed Flycatcher	2.0	2	1.14	7.200	0.6333	I
<i>Tyrannus melancholicus</i>	Tropical Kingbird	3.2	2	4.10	37.60	0.6979	IF
Vireonidae							
<i>Hylophilus hypoxanthus</i>	Dusky-capped Greenlet				17.00		MFI
<i>Hylophilus ochraceiceps</i>	Tawny-crowned Greenlet	2.0	1	1.95	10.75	0.3628	I

^[1]Species and English names based on Schulenberg et al. [23] and Del Hoyo et al. [39]. ^[a]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							
<i>Accipiter gentilis</i>	Northern Goshawk	3.6	1	55.0	1206	0.1642	SVLI
<i>Accipiter nisus</i>	Eurasian Sparrowhawk	4.9	1	23.0	264.0	0.4269	SVLI
<i>Buteo buteo</i>	Eurasian Buzzard	2.8	1	53.2	915.0	0.1628	SVLI
<i>Circus aeruginosus</i>	Western Marsh-harrier	4.7	1	40.0	669.0	0.2810	SVLI
<i>Circus cyaneus</i>	Hen Harrier	4.5	1	31.0	527.0	0.2647	SVLI
<i>Circus pygargus</i>	Montagu's Harrier	4.2	1	25.0	370.0	0.2838	SVLI
<i>Milvus migrans</i>	Black Kite	2.5	1	56.0	850.0	0.1647	SVLI
<i>Milvus milvus</i>	Red Kite	2.1	1	61.0	1213	0.1056	SVLI
<i>Pernis apivorus</i>	European Honey-buzzard	2.0	1	45.0	620.0	0.1452	SVLI
Aegithalidae							
<i>Aegithalos caudatus</i>	Long-tailed Tit	10	1	0.90	8.000	1.1363	MFI
Alaudidae							
<i>Alauda arvensis</i>	Eurasian Skylark	3.9	2.7	3.35	34.60	1.0195	I
<i>Galerida cristata</i>	Crested Lark	4.4	2	3.24	44.10	0.6465	I
<i>Lullula arborea</i>	Woodlark	4.0	2	3.40	32.10	0.8474	I
Alcedinidae							
<i>Alcedo atthis</i>	Common Kingfisher	6.7	2	4.20	39.20	1.4357	SVLI
Anatidae							
<i>Aix sponsa</i>	Wood Duck	10	1	45.7	672.0	0.6801	FI
<i>Aix galericulata</i>	Mandarin Duck	10	1	44.0	512.0	0.8594	IF
<i>Alopochen aegyptiacus</i>	Egyptian Goose	8.5	1	97.0	2040	0.4042	FI
<i>Anas crecca</i>	Common Teal	9.5	1	29.0	324.0	0.8503	FI
<i>Anas platyrhynchos</i>	Mallard	11	1	51.0	1096	0.5119	SVLI

<i>Anas platyrhynchos domesticus</i>	Domestic Duck							SVLI
<i>Anas acuta</i>	Northern Pintail	8.0	1	43.0	735.0	0.4680		SVLI
<i>Anas querquedula</i>	Garganey	8.5	1	28.0	351.0	0.6781		SVLI
<i>Anas clypeata</i>	Nothern Shoveler	10	1	40.0	575.0	0.6957		I
<i>Anser albifrons</i>	Greater White-fronted Goose	5.5	1	114	1905	0.3291		FI
<i>Anser anser</i>	Greylag Goose	5.0	1	149	3108	0.2397		F
<i>Anser anser domesticus</i>	Domestic Goose							F
<i>Anser indicus</i>	Bar-headed Goose	5.0	1	135	2500	0.2700		FI
<i>Aythya ferina</i>	Common Pochard	9.0	1	65.0	832.0	0.7031		SVLI
<i>Aythya nyroca</i>	Ferruginous Duck	9.0	1	36.0	545.0	0.5945		SVLI
<i>Aythya fuligula</i>	Tufted Duck	9.5	1	53.0	867.0	0.5807		IF
<i>Branta canadensis</i>	Canada Goose	5.9	1	220	4390	0.2957		FI
<i>Branta leucopsis</i>	Barnacle Goose	4.5	1	103	1499	0.3092		F
<i>Bucephala clangula</i>	Common Goldeneye	9.3	1	60.0	787.0	0.7090		SVLI
<i>Cairina moschata</i>	Muscovy Duck	10	1	69.3	1285	0.5389		SVLI
<i>Cygnus olor</i>	Mute Swan	6.0	1	345	9600	0.2156		SVLI
<i>Cygnus atratus</i>	Black Swan	5.0	1	260	5450	0.2385		FI
<i>Mareca penelope</i>	Eurasian Wigeon	9.0	1	42.0	700.0	0.5400		FI
<i>Mareca strepera</i>	Gadwall	10	1	44.0	700.0	0.6286		FI
<i>Mergus serrator</i>	Red-breasted Merganser	9.0	1	73.0	984.0	0.6677		SVLI
<i>Netta rufina</i>	Red-crested Pochard	9.0	1	56.0	1100	0.4582		SVLI
<i>Oxyura jamaicensis</i>	Ruddy Duck	8.0	1	76.0	510.0	1.1922		I
<i>Somateria mollissima</i>	Common Eider	5.0	1	109	2142	0.2544		IF
<i>Tadorna ferruginea</i>	Ruddy Shelduck	8.5	1	83.0	1213	0.5819		SVLI
<i>Tadorna tadorna</i>	Common Shelduck	8.6	1	78.0	1043	0.6431		SVLI
Apodidae								
<i>Apus apus</i>	Common Swift	2.4	1	3.60	40.30	0.2144		I
Ardeidae								
<i>Ardea cinerea</i>	Grey Heron	4.5	1	60.0	1361	0.1984		SVLI
<i>Ardea purpurea</i>	Purple Heron	4.2	1	50.0	830.0	0.2530		SVLI
<i>Botaurus stellaris</i>	Eurasian Bittern	5.5	1	40.0	900.0	0.2444		SVLI

<i>Bubulcus ibis</i>	Cattle Egret	4.5	1	28.0	304.0	0.4145	SVLI
<i>Casmerodius albus</i>	Great Egret	4.0	1		960.0		SVLI
<i>Egretta garzetta</i>	Little Egret	4.0	1		495.0		SVLI
<i>Ixobrychus minutus</i>	Common Little Bittern	5.5	1	11.5	146.0	0.4332	SVLI
<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	4.0	1	34.0	590.0	0.2305	SVLI
Burhinidae							
<i>Burhinus oedicephalus</i>	Eurasian Thick-knee	1.9	1	36.0	449.0	0.1523	SVLI
Camprimulgidae							
<i>Camprimulgus europaeus</i>	European Nightjar	2.0	1.5	8.20	76.00	0.3237	I
Certhiidae							
<i>Certhia brachydactyla</i>	Short-toed Treecreeper	5.7	2	1.16	9.700	1.3633	MFI
<i>Certhia familiaris</i>	Eurasian Treecreeper	5.4	2	1.14	9.100	1.3530	MFI
Charadriidae							
<i>Charadrius alexandrinus</i>	Kentish Plover	3.0	1	9.00	47.10	0.5732	I
<i>Charadrius dubius</i>	Little Ringed Plover	3.9	2	7.70	39.20	1.5321	I
<i>Charadrius hiaticula</i>	Common Ringed Plover	3.8	2	12.0	65.40	1.3945	I
<i>Vanellus vanellus</i>	Northern Lapwing	3.9	1	25.5	189.0	0.5262	I
Ciconiidae							
<i>Ciconia ciconia</i>	White Stork	4.0	1	111	3325	0.1335	SVLI
Cisticolidae							
<i>Cisticola juncidis</i>	Zitting Cisticola	4.8	2	1.08	6.500	1.5951	I
Columbidae							
<i>Columba livia</i>	Rock Dove	1.9	5	18.0	267.5	0.6393	F
<i>Columba oena</i>	Stock Dove	2.3	2.5	17.0	298.0	0.3228	F
<i>Columba palumbus</i>	Common Woodpigeon	1.9	1	18.5	500.0	0.0703	FI
<i>Streptopelia decaocto</i>	Eurasian Collared-dove	2.0	2	9.60	197.0	0.1920	FI
<i>Streptopelia turtur</i>	European Turtle-dove	1.9	2	8.00	134.5	0.2260	FI
Corvidae							
<i>Corvus corax</i>	Common Raven	4.8	1	28.8	1147	0.1205	SVLI
<i>Corvus cornix</i>	Hood Crow	4.3	1	19.3	476.1	0.1743	SVLI
<i>Corvus corone</i>	Carrion Crow	4.3	1	19.8	490.0	0.1738	SVLI

<i>Corvus frugilegus</i>	Rook	3.8	1	16.0	443.3	0.1372	IF
<i>Corvus monedula</i>	Eurasian Jackdaw	4.7	1	11.1	230.0	0.2268	FI
<i>Corvus splendens</i>	House Crow	4.0	1	13.7	269.7	0.2032	IF
<i>Garrulus glandarius</i>	Eurasian Jay	5.4	1	8.50	161.4	0.2844	IF
<i>Pica pica</i>	Common Magpie	5.7	1	9.90	197.8	0.2853	SVLI
Cuculidae							
<i>Cuculus canorus</i>	Common Cuckoo	9.2	1	3.40	112.0	0.2793	I
Emberizidae							
<i>Emberiza citrinella</i>	Yellowhammer	3.9	2	3.00	26.80	0.8731	MFIF
<i>Emberiza hortulana</i>	Ortolan Bunting	4.6	2	2.48	19.10	1.1946	IF
<i>Emberiza schoeniclus</i>	Reed Bunting	4.9	1.7	2.19	17.90	1.0311	IF
<i>Miliaria calandra</i>	Corn Bunting	4.4	2	3.91	39.60	0.8689	FI
Falconidae							
<i>Falco peregrinus</i>	Peregrine Falcon	3.2	1		850.0		SVLI
<i>Falco subbuteo</i>	Eurasian Hobby	3.0	1		240.5		SVLI
<i>Falco tinnunculus</i>	Common Kestrel	4.7	1	20.0	252.0	0.3730	SVLI
Fringillidae							
<i>Carduelis cabaret</i>	Lesser Redpoll	4.6	2	1.21	10.60	1.0502	FI
<i>Carduelis cannabina</i>	Common Linnet	4.7	2	1.66	18.50	0.8435	F
<i>Carduelis carduelis</i>	European Goldfinch	4.5	2	1.53	14.80	0.9304	FI
<i>Carduelis spinus</i>	Eurasian Siskin	4.3	2	1.29	13.20	0.8405	FI
<i>Carpodacus erythrinus</i>	Common Rosefinch	5.1	1	2.25	23.90	0.4801	FI
<i>Chloris chloris</i>	European Greenfinch	5.0	2	2.17	25.90	0.8378	F
<i>Coccothraustes coccothraustes</i>	Hawfinch	4.5	1	3.89	52.90	0.3309	FI
<i>Fringilla coelebs</i>	Common Chaffinch	4.6	1	2.16	18.50	0.5371	IF
<i>Fringilla montifringilla</i>	Brambling	5.8	1	2.14	23.60	0.5259	FI
<i>Loxia curvirostra</i>	Red Crossbill	3.7	1	2.95	38.90	0.2806	FI
<i>Loxia leucoptera</i>	Two-barred Crossbill	4.0	1	2.53	31.60	0.3203	FI
<i>Loxia pytyopsittacus</i>	Parrot Crossbill	3.8	1	3.26	50.30	0.2463	F
<i>Pyrrhula pyrrhula</i>	Eurasian Bullfinch	5.0	2	2.41	22.50	1.0711	FI
<i>Serinus serinus</i>	European Serin	3.8	2	1.21	12.30	0.7476	FI

Gruidae							
<i>Grus grus</i>	Common Crane	2.0	1	183	5200	0.0704	SVLI
Haematopodidae							
<i>Haematopus ostralegus</i>	Eurasian Oystercatcher	2.8	1	47.0	632.5	0.2081	I
Hirundinidae							
<i>Delichon urbica</i>	Northern House Martin	4.3	2	1.64	19.50	0.7233	I
<i>Hirundo rustica</i>	Barn Swallow	4.6	2	1.90	18.70	0.9348	I
<i>Riparia riparia</i>	Collared Sand Martin	4.8	1	1.43	13.60	0.5026	I
Laniidae							
<i>Lanius collurio</i>	Red-backed Shrike	5.0	1	3.15	32.50	0.4846	SVLI
<i>Lanius excubitor</i>	Great Grey Shrike	5.8	1	5.30	64.50	0.4766	SVLI
Laridae							
<i>Chlidonias hybridus</i>	Whiskered Tern	2.7	1	16.0	86.00	0.5023	SVLI
<i>Chlidonias niger</i>	Black Tern	2.9	1	11.0	64.00	0.5002	SVLI
<i>Larus argentatus</i>	European Herring Gull	2.6	1		864.0		SVLI
<i>Larus canus</i>	Mew Gull	3.0	1	51.0	360.0	0.4250	I
<i>Larus graellsii</i>	Lesser Black-backed Gull	3.0	1	81.0	755.0	0.3219	SVLI
<i>Larus marinus</i>	Great Black-backed Gull	2.9	1	117	1486	0.2283	SVLI
<i>Larus melanocephalus</i>	Mediterranean Gull	3.0	1	42.0	282.5	0.4460	I
<i>Larus michahellis</i>	Yellow-legged Gull		1				SVLI
<i>Larus minutus</i>	Little Gull	2.2	1	19.0	98.00	0.4207	I
<i>Larus ridibundus</i>	Black-headed Gull	2.7	1		267.0		I
<i>Sterna albifrons</i>	Little Tern	2.2	1	10.0	51.67	0.4258	SVLI
<i>Sterna hirundo</i>	Common Tern	2.8	1	21.0	126.0	0.4667	SVLI
<i>Sterna paradisaea</i>	Arctic Tern	2.0	1	19.0	107.0	0.3551	SVLI
<i>Sterna sandvicensis</i>	Sandwich Tern	1.6	1	35.0	220.5	0.2540	SVLI
Motacillidae							
<i>Anthus campestris</i>	Tawny Pipit	4.5	1.4	2.73	28.00	0.6189	I
<i>Anthus pratensis</i>	Meadow Pipit	5.2	2	2.06	19.50	1.0987	I
<i>Anthus trivialis</i>	Tree Pipit	4.8	1		25.10		I
<i>Motacilla alba</i>	White Wagtail	5.4	1	2.30	20.70	0.6000	I

<i>Motacilla cinerea</i>	Grey Wagtail	5.2	2	1.91	17.20	1.1549	I
<i>Motacilla flava</i>	Yellow Wagtail	5.2	1	1.80	14.80	0.6324	I
<i>Motacilla flavissima</i>	Yellowish-crowned Wagtail	5.2	2	1.90			I
<i>Motacilla yarrellii</i>	Pied Wagtail	5.4	1	2.35	20.00	0.6345	I
Muscicapidae							
<i>Ficedula hypoleuca</i>	European Pied Flycatcher	6.4	1	1.70	11.20	0.9714	I
<i>Muscicapa striata</i>	Spotted Flycatcher	4.2	1	1.90	16.55	0.4822	MFI
Oriolidae							
<i>Oriolus oriolus</i>	Eurasian Golden Oriole	3.7	1	7.30	69.20	0.3903	IF
Paradoxornithidae							
<i>Panurus biarmicus</i>	Bearded Parrotbill	5.6	3	1.68	14.40	1.9600	I
Paridae							
<i>Parus ater</i>	Coal Tit	8.5	2		9.500		MFI
<i>Parus caeruleus</i>	Common Blue Tit	11	1.8	1.17	10.70	2.1290	MFIF
<i>Parus cristatus</i>	European Crested Tit	6.5	1		12.75		MFI
<i>Parus major</i>	Great Tit	7.8	2		17.80		MFI
<i>Parus montanus</i>	Willow Tit	8.1	1		9.800		MFI
<i>Parus palustris</i>	Marsh Tit	7.6	1	1.28	11.90	0.8175	MFI
Passeridae							
<i>Passer domesticus</i>	House Sparrow	4.1	2.1	2.89	30.20	0.8239	FI
<i>Passer montanus</i>	Eurasian Tree Sparrow	4.9	2	2.11	20.80	0.9941	FI
Phalacrocoracidae							
<i>Phalacrocorax carbo</i>	Great Cormorant	3.5	1	53.0	2123	0.0874	SVLI
Phasianidae							
<i>Alectoris rufa</i>	Red-legged Partridge	13	1	21.0	439.0	0.6075	FI
<i>Coturnix coturnix</i>	Common Quail	10	1	8.00	103.0	0.7922	FI
<i>Perdix perdix</i>	Grey Partridge	16	1	14.5	386.0	0.6010	FI
<i>Phasianus colchicus</i>	Common Pheasant	12	1	33.0	989.0	0.3937	FI
<i>Tetrao tetrix</i>	Black Grouse	7.9	1	35.5	945.0	0.2968	FI
Picidae							
<i>Dendrocopos major</i>	Great Spotted Woodpecker	5.5	1	4.90	72.70	0.3707	IF

<i>Dendrocopos medius</i>	Middle Spotted Woodpecker	5.6	1	4.00	58.80	0.3810	IF
<i>Dendrocopos minor</i>	Lesser Spotted Woodpecker	5.0	1	2.00	22.50	0.4444	MFIF
<i>Dryocopus martius</i>	Black Woodpecker	4.8	1	12.4	255.0	0.2334	I
<i>Jynx torquilla</i>	Eurasian Wryneck	8.5	1.2	2.60	35.90	0.7387	I
<i>Picus viridis</i>	Eurasian Green Woodpecker	6.1	1	8.50	186.0	0.2788	IF
Podicipedidae							
<i>Podiceps cristatus</i>	Great Crested Grebe	3.5	1	42.0	830.0	0.1771	SVLI
<i>Podiceps grisegena</i>	Red-necked Grebe	4.5	1	31.0	476.0	0.2931	SVLI
<i>Podiceps nigricollis</i>	Black-necked Grebe	3.5	1	21.0	357.5	0.2056	SVLI
<i>Tachybaptus ruficollis</i>	Little Grebe	5.0	2	14.0	187.0	0.7487	SVLI
Prunellidae							
<i>Prunella modularis</i>	Dunnock	5.1	2	2.13	21.10	1.0297	I
Psittacidae							
<i>Psittacula krameri</i>	Rose-ringed Parakeet	3.0	1		158.0		F
Rallidae							
<i>Crex crex</i>	Corncrake	8.9	1	13.0	138.0	0.8384	IF
<i>Fulica atra</i>	Common Coot	7.2	1	38.0	688.0	0.3977	FI
<i>Gallinula chloropus</i>	Common Moorhen	6.6	2	25.0	289.0	1.1419	IF
<i>Porzana parva</i>	Little Crake	6.8	2	8.00	49.50	2.1980	IF
<i>Porzana porzana</i>	Spotted Crake	10	2	6.00	87.50	1.4126	IF
<i>Porzana pusilla</i>	Baillon's Crake	7.4	1	6.00	46.00	0.9652	SVLI
<i>Rallus aquaticus</i>	Western Water Rail	8.5	2	13.0	104.0	2.1250	SVLI
Recurvirostridae							
<i>Himantopus himantopus</i>	Black-winged Stilt	4.0	1	22.0	185.5	0.4744	SVLI
<i>Recurvirostra avosetta</i>	Pied Avocet	3.9	1	32.0	325.3	0.3837	I
Regulidae							
<i>Regulus ignicapillus</i>	Common Firecrest	8.8	2	0.69	5.300	2.2980	I
<i>Regulus regulus</i>	Goldcrest	10	2	0.77	5.600	2.7500	MFI
Remizidae							
<i>Remiz pendulinus</i>	Eurasian Penduline-tit	4.5	1	0.95	10.25	0.4171	I
Scolopacidae							

<i>Actitis hypoleucos</i>	Common Sandpiper	4.0	1	12.0	51.00	0.9412	I
<i>Calidris alpina</i>	Dunlin	3.9	1	10.0	48.30	0.8075	I
<i>Gallinago gallinago</i>	Common Snipe	3.9	1	17.0	107.0	0.6196	I
<i>Limosa limosa</i>	Black-tailed Godwit	3.9	1	41.0	370.0	0.4322	I
<i>Numenius arquata</i>	Eurasian Curlew	3.8	1	77.0	1127	0.2596	IF
<i>Philomachus pugnax</i>	Ruff	3.7	1	22.0	109.0	0.7468	I
<i>Scolopax rusticola</i>	Eurasian Woodcock	3.8	2		302.0		I
<i>Tringa totanus</i>	Common Redshank	3.9	1	22.0	135.0	0.6356	I
Sittidae							
<i>Sitta europaea</i>	Eurasian Nuthatch	7.1	1	2.25	22.10	0.7229	I
Strigidae							
<i>Aegolius funereus</i>	Boreal Owl	5.8	1	12.5	167.0	0.4341	SVLI
<i>Asio flammeus</i>	Short-eared Owl	6.0	1	21.0	312.0	0.4038	SVLI
<i>Asio otus</i>	Nothorn Long-eared Owl	4.4	1	22.0	278.0	0.3482	SVLI
<i>Athene noctua</i>	Little Owl	3.9	1		176.0		SVLI
<i>Bubo bubo</i>	Eurasian Eagle-owl	2.7	1	73.0	2438	0.0808	SVLI
<i>Strix aluco</i>	Tawny Owl	2.9	1	40.0	486.0	0.2387	SVLI
Sturnidae							
<i>Sturnus vulgaris</i>	Common Starling	5.1	2	7.00	78.30	0.9119	IF
Sylviidae							
<i>Acrocephalus arundinaceus</i>	Great Reed-warbler	4.8	1	3.15	28.40	0.5324	IF
<i>Acrocephalus palustris</i>	Marsh Warbler	4.5	1	1.85	11.40	0.7303	IF
<i>Acrocephalus schoenobaenus</i>	Sedge Warbler	5.3	1	1.65	11.50	0.7604	IF
<i>Acrocephalus scirpaceus</i>	Eurasian Reed-warbler	3.9	1	1.75	11.80	0.5784	IF
<i>Cettia cetti</i>	Cetti's Warbler	4.6	1	1.80	13.00	0.6369	I
<i>Hippolais icterina</i>	Icterine Warbler	4.7	1	1.76	13.20	0.6267	IF
<i>Hippolais polyglotta</i>	Melodious Warbler	4.3	1	1.60	11.00	0.6255	IF
<i>Locustella fluviatilis</i>	River Warbler	5.5	1	2.36	18.70	0.6941	I
<i>Locustella luscinioides</i>	Savi's Warbler	4.1	1.3		17.30		I
<i>Locustella naevia</i>	Western Grasshopper-warbler	5.2	2	1.73	15.00	1.1995	I
<i>Phylloscopus collybita</i>	Common Chiffchaff	5.5	2	1.21	7.200	1.8486	MFIF

<i>Phylloscopus sibilatrix</i>	Wood Warbler	5.9	1	1.32	10.10	0.7711	MFIF
<i>Phylloscopus trochilus</i>	Willow Warbler	6.6	1	1.20	9.100	0.8651	IF
<i>Sylvia atricapilla</i>	Blackcap	4.6	1	2.19	19.20	0.5247	IF
<i>Sylvia borin</i>	Garden Warbler	4.3	1	2.38	18.90	0.5415	IF
<i>Sylvia communis</i>	Greater Whitethroat	4.7	1	1.78	14.40	0.5810	IF
<i>Sylvia curruca</i>	Lesser Whitethroat	4.9	1	1.40	12.40	0.5532	I
Threskiornithidae							
<i>Platalea leucorodia</i>	Eurasian Spoonbill	3.5	1	76.0	1130	0.2354	SVLI
Troglodytidae							
<i>Troglodytes troglodytes</i>	Northern Wren	6.0	2	1.32	7.800	2.0308	I
Turdidae							
<i>Erithacus rubecula</i>	European Robin	5.0	2	2.40	18.50	1.2973	IF
<i>Luscinia luscinia</i>	Thrush Nightingale	4.8	1	3.18	25.50	0.5986	IF
<i>Luscinia megarhynchos</i>	Common Nightingale	4.9	1	2.65	19.40	0.6693	IF
<i>Luscinia svecica</i>	Bluethroat	6.2	1	2.02	18.60	0.6733	IF
<i>Oenanthe oenanthe</i>	Northern Wheatear	6.0	2	2.83	23.90	1.4209	IF
<i>Phoenicurus ochruros</i>	Black Redstart	4.9	2	2.16	16.20	1.3067	IF
<i>Phoenicurus phoenicurus</i>	Common Redstart	6.2	2	1.90	15.00	1.5707	IF
<i>Saxicola torquata rubicula</i>	Common Stonechat	5.2	2.5	1.97	14.80	1.7304	IF
<i>Saxicola rubetra</i>	Whinchat	6.0	1	2.06	16.70	0.7401	IF
<i>Turdus merula</i>	Common Blackbird	4.0	3	7.20	99.80	0.8657	IF
<i>Turdus philomelos</i>	Song Thrush	4.8	2.5	6.00	71.50	1.0070	IF
<i>Turdus pilaris</i>	Fieldfare	5.2	1	6.53	103.4	0.3284	IF
<i>Turdus viscivorus</i>	Mistle Thrush	4.0	2	7.80	123.2	0.5065	IF
Tytonidae							
<i>Tyto alba</i>	Common Barn-owl	5.7	2	22.0	309.0	0.8117	SVLI
Upupidae							
<i>Upupa epops</i>	Common Hoopoe	7.0	1	4.45	67.50	0.4615	SVLI

^[1]Species and English names based on Del Hoyo et al. [39]. ^[a]Feeding 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		X_1^2	Chi-squared		Feeding guild ^[a]	
		FP	TF		df	P(Chi ²)		RRI
<i>Amazilia lactea</i>	Sapphire-spangled Emerald	14	0	14.00	1	<0.001	N	0.551
<i>Automolus infuscatus</i>	Olive-backed Foliage-gleaner	56	44	17.18	7	0.03	MFI	
<i>Chloroceryle aenea</i>	American Pygmy-kingfisher	29	16	8.79	2	0.02	SVLI	0.598
<i>Chloroceryle inda</i>	Green-and-rufous Kingfisher	16	0	16.00	2	<0.001	SVLI	0.547
<i>Columbina talpacoti</i>	Ruddy Ground-dove	11	0	11.00	1	0.002	F	0.477
<i>Dendrocincla merula</i>	White-chinned woodcreeper	88	66	26.78	8	0.001	AA	
<i>Habia rubica</i>	Red-crowned Ant-tanager	56	44	17.18	5	0.008	FI	0.643
<i>Hylophylax naevius</i>	Spot-backed Antbird	31	5	12.20	2	0.004	I	0.583
<i>Hypocneomoides maculicauda</i>	Band-tailed antbird	19	0	19.00	3	<0.001	I	0.877
<i>Myrmeciza hyperythra</i>	Plumbeous Antbird	14	0	14.00	5	0.03	I	0.631
<i>Myrmotherula axillaris</i>	White-flanked Antwren	77	44	23.32	8	0.005	MFI	0.657
<i>Myrmotherula hauxwelli</i>	Plain-throated Antwren	196	82	62.54	7	<0.001	MFI	0.456
<i>Myrmotherula longipennis</i>	Long-winged Antwren	60	33	18.24	6	0.011	MFI	
<i>Oryzoborus angolensis</i>	Chestnut-bellied Seed-finch	7	0	7.00	1	0.016	F	0.824
<i>Percnostola lophotes</i>	White-lined Antbird	7	0	7.00	1	0.016	I	0.477
<i>Phaethornis hispidus</i>	White-bearded Hermit	79	44	23.99	8	0.005	N	0.832
<i>Philydor ruficaudatum</i>	Rufous-tailed Foliage-gleaner	9	0	9.00	2	0.02	MFI	
<i>Phlegopsis nigromaculata</i>	Black-spotted Bare-eye	83	33	26.84	8	0.002	AA	
<i>Pipra fasciicauda</i>	Band-tailed Manakin	496	121	181.50	9	<0.001	F	0.658
<i>Platyrinchus coronatus</i>	Golden-crowned Spadebill	61	16	21.75	9	0.02	I	
<i>Pteroglossus beauharnaesii</i>	Curl-crested Aracari	9	0	9.00	1	0.005	FI	
<i>Ramphocelus carbo</i>	Silver-beaked Tanager	27	0	27.00	2	<0.001	IF	0.484
<i>Sporophila caerulescens</i>	Double-collared Seedeater	17	3	6.47	1	0.02	F	0.911
<i>Tangara schrankii</i>	Green-and-gold Tanager	20	0	20.00	4	<0.001	MFI	
<i>Thamnomanes ardesiacus</i>	Dusky-throated Antshrike	72	55	21.97	7	0.005	MFI	
<i>Threnetes leucurus</i>	Pale-tailed Barbthroat	43	27	12.94	5	0.047	N	0.391
<i>Turdus albicollis</i>	White-throated Thrush	64	16	23.10	6	0.002	FI	0.584

<i>Turdus hauxwelli</i>	Hauxwell's Thrush	22	0	22.00	6	0.002	IF	
<i>Turdus ignobilis</i>	Black-billed Thrush	18	0	18.00	1	<0.001	IF	0.430
<i>Volatinia jacarina</i>	Blue-black Grassquit	32	0	32.00	1	<0.001	F	0.753
<i>Chiroxiphia pareola</i>	Blue-backed Manakin	2	16	6.97	1	0.016	F	0.456
<i>Crotophaga ani</i>	Smooth-billed Ani	0	17	17.00	1	<0.001	I	0.814
<i>Dendrocincla fuliginosa</i>	Plain-brown Woodcreeper	45	61	18.41	6	0.01	I	0.617
<i>Dichrozona cincta</i>	Banded Antbird	4	17	6.06	1	0.027	I	
<i>Elaenia spectabilis</i>	Large Elaenia	2	17	6.97	1	0.016	F	0.386
<i>Epinecrophylla leucopthalma</i>	White-eyed Antwren	12	72	28.52	3	<0.001	MFI	
<i>Formicarius analis</i>	Black-faced Antthrush	48	66	20.03	6	0.005	I	0.636
<i>Galbula cyanescens</i>	Bluish-fronted Jacamar	7	17	5.27	1	0.043	I	0.716
<i>Glaucis hirsutus</i>	Rufous-breasted Hermit	42	132	45.27	6	<0.001	N	0.509
<i>Glyphorhynchus spirurus</i>	Wedge-billed Woodcreeper	133	165	50.95	8	<0.001	MFI	0.401
<i>Gymnopithys salvini</i>	White-throated Antbird	114	182	54.76	7	<0.001	AA	
<i>Hemitriccus flamulatus</i>	Flammulated Pygmy-tyrant	5	28	10.79	2	0.009	I	
<i>Hylophilus ochraceiceps</i>	Tawny-crowned Greenlet	2	17	6.97	1	0.016	I	0.363
<i>Hypocnemis subflava</i>	Yellow-breasted Warbling-antbird	4	22	8.63	2	0.02	I	0.733
<i>Lathrotriccus euleri</i>	Euler's Flycatcher	1	33	15.81	1	<0.001	I	0.772
<i>Lepidothrix coronata</i>	Blue-crowned Manakin	27	39	11.65	4	0.04	F	
<i>Leptotila rufaxilla</i>	Grey-fronted Dove	0	6	6.00	1	0.028	F	0.192
<i>Myiophobus fasciatus</i>	Bran-colored Flycatcher	2	17	6.97	1	0.017	I	0.448
<i>Myrmeciza fortis</i>	Sooty Antbird	0	11	11.00	1	0.002	I	
<i>Myrmeciza hemimelaena</i>	Southern Chestnut-tailed Antbird	37	77	23.96	6	0.001	I	0.677
<i>Myrmoborus myotherinus</i>	Black-faced Antbird	25	121	46.17	5	<0.001	I	0.464
<i>Myrmotherula longicauda</i>	Stripe-chested Antwren	0	11	11.00	1	0.001	I	
<i>Neopelma sulphureiventer</i>	Sulphur-bellied Tyrant-manakin	0	11	11.00	1	0.002	IF	
<i>Phaethornis malaris</i>	Great-billed Hermit	2	22	9.68	1	0.004	N	
<i>Phlegopsis erythroptera</i>	Reddish-winged Bare-eye	0	11	11.00	1	0.002	AA	
<i>Pipra chloromeros</i>	Round-tailed Manakin	19	50	16.19	7	0.046	F	
<i>Ramphotrigon fuscicauda</i>	Dusky-tailed Flatbill	5	17	5.73	1	0.033	I	
<i>Rhegmatorhina melanosticta</i>	Hairy-crested Antbird	4	17	6.06	1	0.027	AA	
<i>Willisornis poecilinotus</i>	Scale-backed Antbird	53	72	21.75	6	0.002	I	0.723

<i>Xiphorhynchus elegans</i>	Elegant Woodcreeper	41	72	21.69	9	0.02	MFI
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^[1]Species and English names based on Schulenberg et al. [23] and Del Hoyo et al. [39]. ^[a]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	Picidae	0.270	1
Bucconidae	0.253(0.033)	2	Pipridae	0.561(0.033)	5
Cardinalidae	0.468	1	Psittacidae	0.266	1
Columbidae	0.297(0.062)	4	Rhampastidae		
Conopophagidae			Strigidae		
Cotingidae			Thamnophilidae	0.601(0.034)	12
Cuculidae	0.814	1	Thraupidae	0.777(0.219)	3
Emberizidae	0.667(0.071)	7	Tinamidae		
Falconidae	0.304(0.037)	2	Trochilidae	0.526(0.038)	12
Formicariidae	0.508(0.141)	3	Troglodytidae	0.587(0.074)	2
Furnariidae	0.600(0.059)	14	Trogonidae	0.337(0.045)	2
Galbulidae			Turdidae	0.584(0.059)	4
Icteridae			Tyrannidae	0.687(0.057)	20
Momotidae	0.260(0.072)	2	Vireonidae	0.363	1
Parulidae	0.420(0.099)	2			
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
Camprimulgidae	0.323	1	Podicipedidae	0.356(0.133)	4
Certhiidae	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
Fringilidae	0.645(0.077)	14	Sturnidae	0.911	1
Gruidae	0.070	1	Sylviidae	0.754(0.084)	16
Haematopodidae	0.208	1	Threskiornithidae	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
Motacilidae	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.