Available online at http://ajol.info/index.php/ijbcs

Int. J. Biol. Chem. Sci. 5(2): 419-432, April 2011

International Journal of Biological and Chemical Sciences

ISSN 1991-8631

Original Paper

http://indexmedicus.afro.who.int

The importance of agricultural areas for bird conservation in the Korup region, south-western Cameroon

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ABSTRACT

Recent studies have shown that a relatively high number of individuals and species from the natural forest fauna can still be found in land use systems. To detect key parameters for population development and preconditions for long-term suitability of different land use systems for forest bird populations, we investigated patterns of species richness and abundance of understorey birds using mist-net data, in 24 study sites equally distributed over two types of natural and two types of agricultural habitats. We also assessed arthropod availability, nesting sites, parasite loads, and fault bars for trapped birds. We recorded high numbers of birds in all habitats but with a tendency for smaller species with increasing habitat modification. Our data support the idea that arthropod richness and density attract many understorey forest birds in agricultural areas but that environmental stress in these habitats might be high since numbers of bird species and individuals presenting fault bars were significantly higher in the agricultural matrix. In the Afrotropical context, the management of agricultural areas should consider preserving some aspects of natural habitats, and a fallow period of five to eight years, to avoid biodiversity loss.

Keywords: Afrotropical landscape, Central Africa, Forest habitats, Land use systems, Mist-netting, Understorey birds.

INTRODUCTION

The combination of rapid land use change and high diversity in the tropics has made these areas particularly vulnerable to species loss (Chapin et al., 2000; Brooks et al., 2002). The effects of tropical forest disturbance and clearance on biodiversity have been investigated recently in several studies using species richness data from various taxonomic groups, for e.g. invertebrates (Lawton et al., 1998; Stork et al., 2003), birds (Lawton et al., 1998; Waltert et al., 2004; Bobo, 2004; Waltert et al., 2005a), ungulates (Fritz et al., 2003), carnivores (Cuaron et al., 2004) and primates (Chapman and Lambert, 2000; Waltert et al., 2002). In general, degraded habitats have negative impacts on biodiversity (Bawa and Seidler, 1998) and affect the structure, distribution and abundance of flora and fauna (Van Gemerden, 2004; Waltert et al., 2005a).

In the last decade, worldwide, several studies have investigated the effects of tropical forest clearance on biodiversity, but have been criticized partly because the potential value of agricultural areas for the survival of tropical forest species was not acknowledged (Pimentel et al., 1992; Poudevigne and Baudry, 2003). Recent studies have shown that a relatively high number of individuals and species from the natural forest fauna can still be found in agricultural areas (Lawton et al., 1998; Petit et al., 1999; Daily et al., 2001; Hughes et al., 2002; Zapfack et al., 2002; Schulze et al., 2004; Waltert et al., 2004; Waltert et al., 2005a, 2005b; Bobo et al., 2006a, 2006b). Even if richness changes little with disturbance, the trophic structure may alter and species characteristic of primary forest may be replaced by species associated with disturbed habitats (Lawton et al., 1998; Lindell et al., 2004; Bobo et al., 2006a, 2006b). Thus, a cautious interpretation of abundance and species richness data is necessary since deforestation is a relatively recent phenomenon and intensification of the agricultural land is still ongoing. So far only little information on the long term stability of faunal populations in land use systems is available (Donald, 2004).

This paper aimed at documenting the role of agricultural areas in bird conservation of tropical landscapes and detecting key parameters for bird population development and preconditions for long-term suitability of agricultural areas for forest bird populations. As well as assessing birds' abundance, it is also important to assess the condition of birds in degraded habitats, because these habitats may represent sink habitats (Van Horne, 1983). Therefore measures of feather development (Bortolotti et al., 2002), mass (Cresswell, 2009) and parasite load (Whiteman and Parker, 2004) may provide an index of whether degraded habitats are actually good habitats for birds.

MATERIALS AND METHODS

Study sites

The study was carried out in the North-eastern part of the Korup Support Zone (KSZ), precisely the area between Abat-Mgbegati-Basu-Bajo villages (Figure 1), Southwest Cameroon, within the Cameroon Gabon lowland rainforest. The habitats chosen are situated along a gradient of human disturbance, where near-primary forest (NF) serves as a reference. All sites outside the near-primary forest, i.e. secondary forest (SF), agroforestry systems represented by cocoa/coffee plantations (CF) and annual cultures made of open monoculture of manioc, remnant forest trees, oil palms, no planted shade trees, dead wood, *Chromolaena odorata* and farmbush thickets (AC), are located at the vicinity of the forest edge. For each of the land use types, six replicate sites were chosen (see Bobo et al., 2006a, 2006b for characteristics of habitat types). The avifauna is typical of that of a lowland rainforest, with more than 184 species restricted to this biome (Fishpool, 2000) and 420 species so far recorded (Rodewald et al., 1994; Bobo et al., 2005; Bobo et al., 2007).

Data collection

Mist-netting was conducted in each of the 24 study sites from January to April 2006 i.e. between the mid dry season and the beginning of the rainy season. A combination of 6 and 12 m long mist-nets, 2.5 m high with 16 mm mesh, was used to produce a single 102 m net line for which narrow trails were cut. The net line was opened for 22 hours in each study plot i.e. from 15h00 to 18h00 on the first day, from 6h00 to 18h00 on the second day and from 6h00 to 13h00 on the third day. The whole net line was then moved to the next plot, resulting in a total of six 102 m lines per habitat and 24 in total. Net lines were checked every hour. Birds were identified and the sides of their two tarsi were painted corresponding to each study site, with a waterproof bold marker, to be able to distinguish recaptured individuals. Birds found at 18h00 in mist-nets were kept in cotton bags until 7h00 the next day to avoid possible disorientation of animals when released in the dark.

All birds captured were closely examined for plumage and skin parasites (i.e. ectoparasites, e.g. chewing lice, mite, tick, order Mallophaga). The birds were weighed; biometrical measurements of commonly used morphological features (body, wing, tail and tarsus length) were also taken for both body sides. Apart from these commonly used biometrical data, the number of fault bars was counted (Stiefel, 1985) by examining tail feathers against sunlight.

At each study site, eight haphazardly chosen 5 m x 5 m quadrats were established within a circular plot of 50 m radius to collect data on invertebrates during the same study period as previously. Within each quadrat, arthropods were captured using repeated sweep net samples from the herb layer and selected understorey trees, sorted to order, measured to the nearest millimetre and released. Invertebrates of the leaf litter were also sampled: the litter and a few millimetres of the topsoil were shovelled, 10 times per quadrat, with a dustpan onto a sieve with 6 mm mesh width, placed on a bucket containing a plastic bag (Zimmermann and Noske, 2003). Invertebrates larger than the mesh were immediately sorted to order, measured to the nearest millimetre and released. Invertebrates passing through the mesh were collected, conserved in alcohol, examined later in the laboratory with a magnifying glass and sorted to order.

A search around the study site centres of 50 m radius was made for trees with nesting cavities. Each of such trees was identified to species. The distance from the base of each of these trees to the plot central point was measured in order to estimate the density of nesting cavity trees. Notes were taken on the number of cavities in each tree, the bird species entering into these cavities at any time, whether during the count period or the subsequent search within the plot.

Data analysis

Data were first sorted to separate recaptured individuals from the whole mist-netting data set. Observed understorey bird species richness and abundance for the overall mist-netted community, as well as for the group of insectivores, and then particularly for ant-followers, were calculated.

For each plot, the number of recaptured individuals i.e. an index of the number of adult territory owners was calculated; the proportion of recaptures to the number of individuals captured was also calculated. This was also done for one of the most abundant species, namely Yellow-whiskered Greenbul *Andropadus latirostris*.

Overall average body weight, as well as for *A. latirostris*, was calculated in each plot. The number of bird individuals and species carrying ectoparasites, as well as the proportion of infested individuals and species to the number of individuals and species checked were also calculated.

The number of bird individuals and species presenting fault bars on tail, as well as their proportion to the number of individuals checked were also calculated.

Concerning invertebrates as food resources for birds, sweep net data and data from the leaf litter were mixed. For each study site, we counted the total number of orders detected after the repeated surveys, here referred to as “observed” order richness. Like for species (see Nichols and Conroy, 1996), in most field studies, not all orders that are actually present are also recorded. Therefore, we also quantified an “estimated” order richness that takes into account that there are orders which are not actually recorded but whose presence can be inferred from the pattern of observed order occurrence. To calculate estimated order richness, we used the first-order jackknife method (Burnham and Overton, 1978, 1979). As for estimations of species richness (see Forrester, 1983; Colwell and Coddington, 1994; Boulinier et al., 1998; Chazdon et al., 1998; Nichols et al., 1998; Heltshe and Hughes et al., 2002), this model can equally be applied to estimations of order richness. We also calculated beta-diversity between different sites using the classic Soerensen (qualitative) index (Magurran, 1988). To calculate first-order jackknife estimates at each site and beta-diversity between different sites, we used the computer program EstimateSWin7.0.0 of Colwell (2000) by randomizing samples 100 times. Parameters were used in a one-way ANOVA in order to analyse effects of habitat type on order numbers and the effects of habitat type on order average length.

For each study site, we also counted the total number of bird nesting cavities, bird nesting trees and bird nesting tree species. These parameters were used in a one-way ANOVA in order to analyse the effects of habitat types.

For each parameter analysed, means are given with standard deviations if not mentioned otherwise. Tukey's Honest Significance Difference-Test (HSD test) was used for multiple comparisons of means. One-way ANOVA, Kruskal –Wallis ANOVA, and all other statistical analyses were performed using STATISTICA 6.0 (StatSoft, 2001).

RESULTS

Understorey bird species richness and abundance

In the 24 study sites, a total of 1,307 individuals (recaptured specimens excluded) belonging to 93 species, were trapped. Overall observed understorey bird species richness per study plot was significantly affected by habitat type: Highest bird species richness was found in AC with a mean number of 22.3 (± 6.2) species; it was slightly lower in SF (19.7 ± 2.1) and in CF (17.3 ± 3.2), and was significantly lower in NF (16.0 ± 1.8) (One-way ANOVA, $F_{3,20}$= 3.29, $P < 0.05$).

Understorey bird abundance was not significantly affected by habitat type (one-way ANOVA, $F_{3,20} = 0.65$, $P = 0.59$).

Observed species richness and abundance of insectivorous birds per study plot was marginally affected by habitat types (One-way ANOVA, for observed species richness: $F_{3,20}$= 0.66, $P = 0.08$; for abundance: $F_{3,20}$= 2.96, $P = 0.06$).

Highest understorey ant-following bird species richness was found in SF with a mean number of 6.5 (± 1.43) species; it was slightly lower in NF (5.3 ± 1.0) and was significantly lower in CF (3.5 ± 1.6) and in AC (1.3 ± 0.5) (One-way ANOVA, F3,20= 20.60, $P <$ 0.001). Highest number of understorey ant-following bird individuals was found in NF (21.2 ± 7.4) and SF (21.0 ± 5.9); it was significantly lower in CF (6.3 ± 3.6) and AC (1.7 ± 0.8) (One-way ANOVA, F3, 20= 23.49, $P < 0.001$).

Invertebrate order richness and abundance

In the 192 quadrats, a total of 17,712 invertebrate records (single detections of invertebrate individuals) belonging to 28 identified orders were obtained.

Jackknife order richness estimators revealed that compiling of the studied invertebrate orders were not yet completely recorded: completeness of the inventories at single sites ranged from an average of 89% in the six SF and CF sites to 91% in the six NF and AC sites. Observed order richness was significantly correlated with estimates ($r_s >$ 0.95, $P < 0.001$, N=24).

Invertebrate order richness showed an increasing pattern from natural to disturbed habitats: Highest order richness was found in CF with a mean number of 23.3 (± 2.6) orders; it was slightly lower in AC (22.6 ± 1.1) and in SF sites (20.8 ± 3.8), and was significantly lower in NF sites (17.1 ± 2.4) (One-way ANOVA, for estimated species: $F_{3,20}$= 6.65, $P < 0.01$).

Invertebrate abundance per study site was significantly affected by habitat type (One-way ANOVA, $F_{3,20}$= 39.82, $P < 0.001$). Invertebrate numbers showed a clear increasing pattern from NF to AC. Within the 50 m radius circular plot of each study site, the number of accumulated records after the eight quadrate surveys (replicates) was highest in AC (mean ± S.D., 1,244.2 ± 248.1), significantly lower in CF (828.2 ± 108.3), in SF (543.5 ± 101.9) and in NF (336.2 ± 97.4).

The average length of invertebrates showed a clearly increasing pattern with increasing habitat modification: Highest average length was found in AC (8.8 ± 1.4); it was slightly lower in CF (7.8 ± 1.5), and was significantly lower in SF (5.7 ± 0.6) and in NF sites (5.5 ± 1.3) (One-way ANOVA, $F_{3,20}$ = 9.93, $P < 0.001$).

Nesting sites for cavity nesters

In the 24 study sites, a total of 105, 34 and 14 bird nest cavities, bird nesting trees and bird nesting tree species records respectively (single detections of individual nesting cavities, nesting trees and nesting tree species) were obtained. Neither the number of bird nesting cavities, nor the number of bird nesting trees and the number of bird nesting tree species were significantly affected by habitat type (One-way ANOVA, for the number of bird nesting cavities $F_{3,20}$= 1.53, P = 0.24; for the number of bird nesting trees $F_{3,20}$= 0.70, P = 0.56; for the number of bird nesting tree species $F_{3,20}$= 0.76, P = 0.53) (Table 1).

Ectoparasites

The number of individuals infested with ectoparasites per study site was not significantly affected by habitat type (One-way ANOVA, $F_{3,20}$ = 2.06, P = 0.14). The number of species infested with ectoparasites per study site was also not significantly affected by habitat type (One-way ANOVA, $F_{3,20}$ = 2.29, P = 0.11).

Fault bars

The number of individuals showing fault bars was significantly affected by habitat type (One-way ANOVA, $F_{3,20}$ = 14.94, $P < 0.001$). A clearly increasing pattern was observed from near-primary forest to farmland: AC showed highest numbers of individuals with fault bars with a mean value of 6.3 (± 2.4); it was slightly lower in CF (4.0 ± 1.3), and was significantly lower in SF (3.7 ± 0.5) and NF (0.5 ± 1.2) (Figure 2A).

The number of species presenting fault bars per study site was also significantly affected by habitat type (One-way ANOVA, $F_{3,20}$ = 9.63, $P < 0.001$). A clear increasing pattern was found from near-primary forest to farmland. AC showed highest number of species with fault bars with a mean value of 3.8 (± 1.3); it was slightly lower in CF (3.7 ± 1.2) and SF (3.0 ± 1.1), and significantly lower in NF (0.5 ± 1.2) (Figure 2B).

Adult territory owners

The number of recaptured individuals i.e. the index of number of adult territory owners per study site, as well as the proportion of recaptures was not significantly affected by habitat type (One-way ANOVA, for recaptured individuals: $F_{3,20}$ = 2.22, P = 0.12; Kruskal–Wallis ANOVA, for proportion of recaptures: $H_{3,24}$ = 3.38, P = 0.34). No clearly defined patterns were observed (Table 2). *A. latirostris* recaptured individuals, as well as the proportion of recaptures, were significantly affected by habitat type (One-way ANOVA, for recaptured individuals: $F_{3,20}$ = 6.67, $P < 0.01$; Kruskal–Wallis ANOVA, for proportion of recaptures: $H_{3,24}$ = 12.42, $P <$ 0.01); still, NF had almost the lowest records (Table 2).

Body weight

The average body weight of individuals across species did not differ between sexes (t = 1.60, df = 23, P = 0.12). Overall average body weight (male and female mixed) was significantly affected by habitat types (One-way ANOVA, Overall: $F_{3,20}$ = 3.86, P = 0.025). A clear decreasing pattern was found from near-primary forest to annual cropland: Highest overall average body weight was found in NF; it was slightly lower in SF and CF, and was significantly lower in AC (Table 3).

Average body weigh of *A. latirostris* was not significantly affected by habitat modification (One-way ANOVA, $F_{3,19}$ = 2.11, P = 0.13), and no clear defined pattern was found (Table 3).

Table 1. Bird nesting tree species and abundance in different habitat types.

	Habitat					
Tree species	**NF**	**SF**	**CF**	**AC**	**Aspect**	**Bird family**
Albizia zygia	1	1	0	0	Dry	Tytonidae
Calpocalyx sp.	1	0	0	0	Dry	Capitonidae
Erithrophleum sp.	0	0	3	0	Dry	Capitonidae
Fagara macrophylla	1	0	0	0	Fresh	Cuculidae, Trogonidae
Ficus sp.	0	2	0	0	Dry	Capitonidae, Alcedinidae
Hylodendron sp.	0	0	1	0	Fresh	Trogonidae
Morinda lucida	0	2	0	0	Dry	Capitonidae, Tytonidae
Musanga cecropioides	0	0	1	0	Fresh/Dry	Capitonidae, Tytonidae
Picnanthus angolensis	1	0	0	0	Fresh	Tytonidae
Spathodea campanulata	0	0	1	0	Fresh	Alcedinidae
Terminalia ivorensis	1	0	0	2	Fresh	Cuculidae, Tytonidae
Terminalia superba	0	1	0	7	Dry	Capitonidae, Picidae, Dicruridae, Sturnidae, Bucerotidae
Oubanguia alata	1	0	0	0	Fresh	Bucerotidae
Xylopia aethiopica	0	3	0	4	Dry	Capitonidae
Total	**6**	**9**	**6**	**13**		

The dry or fresh aspect of the tree where birds used to dig the cavities is mentioned. Also, the corresponding bird families using the nesting cavities are presented.

Table 2: Number and percentage of recaptured individuals for the overall mist-net community, as well as for *Andropadus latirostris*.

		Habitat				$F_{3,20}$ $H_{3,24}$	P
		NF	**SF**	**CF**	**AC**		
Overall	Number of individuals	6.0(3.4)	11.3(3.0)	10.5(4.8)	8.8(4.1)	2.22	0.12
	% individuals	12.9(6.7)	19.7(5.6)	18.9(5.0)	17.6(9.7)	3.38	0.34
A. latirostris	Number of individuals**	0.3(0.8)	1.5(0.6)	0.8(0.7)	0.0(0.0)	6.67	0.0027
	% individuals**	6.6(16.3)	29.3(35.0)	14.6(18.8)	0.0(0.0)	12.42	0.0061

Mean values are given (± standard deviation). Results of one-way ANOVA and Kruskall Wallis ANOVA are also presented. Significant difference ** for $p<0.01$

Table 3: Average body weight (g) of all mist-netted birds, as well as for *Andropadus latirostris*.

	Habitat					
	NF	**SF**	**CF**	**AC**	$F_{3,20}$	**P**
Overall*	25.8(3.4)	23.7(6.7)	20.9(4.9)	19.2(3.2)	3.86	0.025
A. latirostris	26.2(1.6)	27.4(1.4)	26.3(1.3)	28.4(2.3)	2.11	0.13

Mean values are given (± standard deviation). Results of One-way ANOVA are also presented.
Significant difference * for $p < 0.05$.

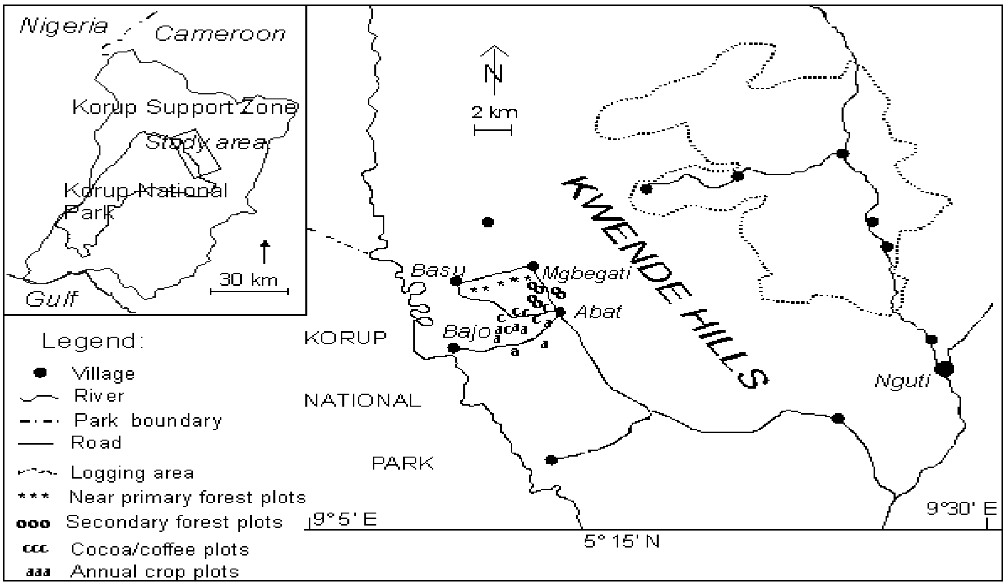

Figure 1: The study area.

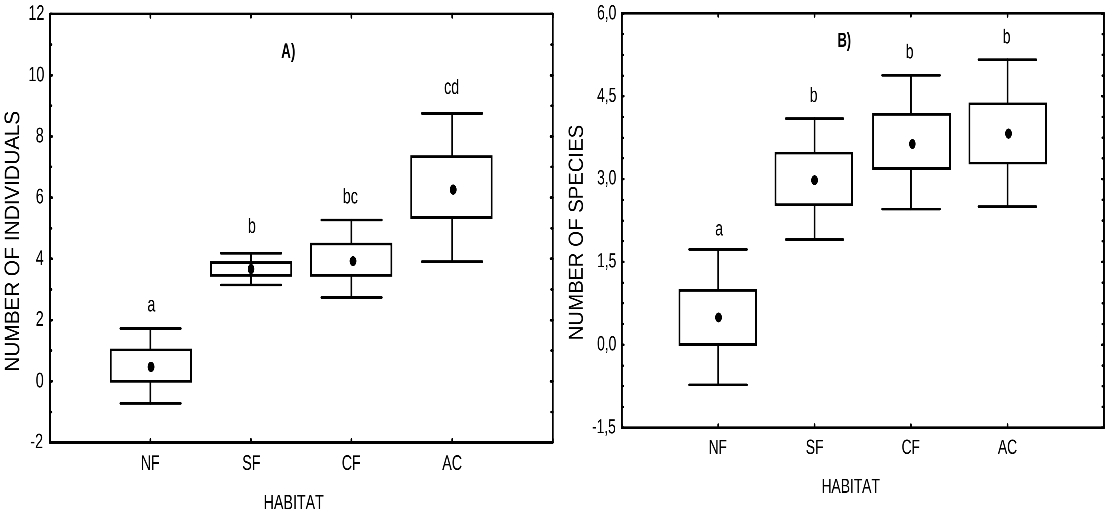

Figure 2: A) Number of infested individuals and B) Number of infested species. The points indicate the mean values; Error bars indicate (mean ± standard deviation) and the boxes indicate (mean ± standard error); Different letters indicate significant differences (Tukey's Honest Significant Difference-Test).

DISCUSSION

The present study revealed a pattern of increasing understorey bird species richness with increasing habitat modification, with highest overall richness in annual croplands. The abundance of understorey plants used as principal habitat by understorey birds in land use systems might explain this result (Bobo et al., 2006a). Similar results were found in Bossematié Forest Eastern Côte d'Ivoire where species richness and diversity of understorey birds at small spatial scales (2 - 8 ha) were higher in the disturbed than in the control forest, and were attributed to the occurrence of "tourists" in the sample, i.e. species that were occasionally captured in the disturbed compartment due to shifting vertical foraging niches to lower levels. This can be explained by the foraging behaviour of many midstorey and canopy species which follow the contour line of the canopy reaching ground level in gaps and along logging roads (Waltert, 2000a, 2006b). In the Gola forest in Sierra Leone, logged forest was richer than unlogged primary forest as far as Fisher's α and Simpson diversity indices are concerned (Allport et al., 1989). This pattern has also been reported for other bird studies (Andrade and Rubio-Torgler, 1994; Alvard and Winarni, 1999). But in the Malaysian rain forest, bird species richness and individual abundance were lower in the regenerating forest understory than in the virgin forest (Wong, 1986). In studies where only very few trees were present in the agricultural land, a marked decrease in richness was found from forest to land use systems (Lawton et al., 1998; Waltert et al., 2004; Schulze et al., 2004).

No significant difference was found in overall understorey bird abundance between habitat types, but overall lowest numbers of individuals were captured in near-primary forest as compared to modified habitats. Similar patterns were already described for the western West African region when data from heavily logged forests in Eastern Côte d'Ivoire (Waltert, 2000a, 2000b) are compared to unlogged primary forests in Sierra Leone (Allport et al., 1989) and also within forest areas, the number of individuals captured can be significantly higher in disturbed than in undisturbed forest compartments (Waltert, 2000a, 2000b). In Southeast Asia, forest modification did not show any negative impact on overall abundance of understorey birds either (Waltert et al., 2005b).

Understorey bird species richness and abundance patterns from our case study might also be explained by patterns found in invertebrates. In fact, overall invertebrate order richness, abundance and average length also showed clear increasing patterns with increasing habitat disturbance. The leaf-litter of disturbed habitats supported an assemblage of invertebrate orders even richer than that of undisturbed ones. In other words, invertebrates as food resources for understorey birds, particularly for insectivores, were significantly less abundant in natural than in agricultural habitats. Thus, arthropod might have play a great role by contributing in attracting many forest birds, even if just temporally, outside their normal territories, in the nearby agricultural areas. Similarly in Las Cruces Forest, southern Costa Rica, overall numbers of invertebrate individuals per sample were about 15% lower in the extensive forest than in small fragment samples, but the difference was not significant (Şekercioğlu et al., 2002). But, a previous study on fruit feeding butterflies (Lepidoptera) on our study sites indicated lowest species richness and abundance in annual croplands (Bobo et al., 2006b). Different results were also found in a Malaysian dipterocarp forest at Pasoh Forest Reserve (Negeri Sembilan, Peninsular Malaysia) where arthropods were less abundant in the regenerating than in the virgin forest (Wong, 1986).

The value of agricultural lands in the conservation of Afrotropical birds was also assessed through other parameters of which numbers of cavity nesting sites, parasite loads and numbers of presumed territory owners seemed to have been positively affected. In fact we found that these habitats provided important nesting sites for cavity nesters: bird nesting cavities, bird nesting trees and bird nesting tree species were more abundant in annual croplands as compared to other habitat types, probably because of more dead woods in agricultural habitats. But, Owls (Tytonidae), Hornbills (Bucerotidae) and Trogons (Trogonidae) were found using trees mostly from natural habitats. In agricultural areas, fewer bird species and individuals were infested with ectoparasites compared to natural habitats although no significant difference was found. Similarly, lower rates of ectoparatism in *Norops polylepis* (a lizard) were found along edges than in forest fragment interiors in Las Cruses, Costa Rica, and were attributed to specific biological requirements of each parasite taxon (Schlaepter and Gavin, 2001). Other studies also reported no difference in ectoparasites prevalence and intensity between degraded and natural forests (Sodhi, 2002; Sodhi et al., 2005). But, Robinson's study (1989) indicated an increase of parasitism when the forests are degraded (Mckay, 2006). Near-primary forest had the lowest recapture rate, but secondary forest the highest recapture rate compared to other habitat types, although no significant difference was found between them. This might be the results of habitat characteristics reducing recapture rate, or a larger population that is harder to catch, in primary forests. This is evident when looking at *A. latirostris* mist-net data that indicated no individual trapped in annual cropland and, just very few in Near-primary forest probably as they were more active above our mist-net. Contrary results were obtained in other studies (Winker et al., 1995; Dranzoa, 1998; Renner, 2003) indicating that there are more possible territories in natural forests compared to secondary forests (Renner, 2003). But, no significant difference was found in recapture rates between selectively logged and secondary forests in Linggoasri, Central Java (Sodhi et al., 2005). We therefore suspected that territories in our land use systems are smaller in size than those in natural habitats, probably as a result of a high competition for food that attract many forest birds outside their normal territory. This might also be influenced by the effect of vertical distribution in each of the studied habitats that have affected recapture rates.

On the contrary, the proportion of environmentally stressed birds might be higher in agricultural land, judged from the occurrence of fault bars and body weight. The fault bar parameter gradually increased with increasing habitat modification. Both the number and species presenting fault bars on tail were significantly lower in near-primary forest compared to other habitat types. The situation was similar in Singapore where more individuals had fault bars in forest fragments compared to those in continuous forests (Sodhi, 2002). But in Linggoasri, Central Java, the proportion of individuals with fault bars was not significantly different between selectively logged and secondary forests (Sodhi et al., 2005). In our case study, the occurrence of fault bars might have been caused by stressful conditions other than food scarcity as invertebrates were found to be even more abundant in agricultural habitats than in natural habitats. Similarly, no correlation was found between the incidence of fault bars and the food deprivation in pheasants (Solomon and Linder, 1978). However, since food resources might have to be shared between more individuals in land use systems compared to natural forests, stressful conditions for the average individual might have been higher, resulting in larger numbers of fault bars. Also, habitat structure could play a role in the occurrence of fault bars since birds from aviaries with cover tend to have fewer fault bars on primary feathers than birds from aviaries without cover (Witter and Lee, 1995). Body weight across species was significantly affected by habitat type and decreased with increasing habitat modification. This could be interpreted as if natural habitats are of higher quality for birds as compared to agricultural areas but it should be mentioned that one larger species that occurs only in pristine forest is driving this result, and intra-specific comparisons are needed to properly test this hypothesis. There was no effect on body mass by habitat within *A. latirostris*, suggesting that we did not have good evidence for an effect of habitat on body mass. Similar results were obtained in Sierra Yalijux, Alta Verapaz and Guatemala, where body mass in understorey bird community was higher in natural forest than in young secondary forests, and was attributed to better nutritional resources in the first habitat type (Renner, 2003). In our study case, food resources present in natural habitats, although fewer in abundance, are shared by a lower number of individuals observed and consequently, their body condition should be higher, as compared to those in agricultural habitats. Differently, habitat degradation did not negatively affect body condition in Linggoasri, Central Java (Sodhi et al., 2005).

Conclusion

Considering parameters such as body weight and fault bars, natural habitats could be of better quality for understorey birds compared to agricultural habitats. But as far as parasite loads and cavity nesting sites are concerned, and maybe also the numbers of presumed territory owners, this hypothesis was not supported. Higher food availability found in agricultural habitats attracts many forest birds and might create a higher competition for food and space, causing a reduction of territory sizes and a reduction of body weight than in natural habitats. In our study sites, there might have been intensive exchange of individuals between habitat types and many forest birds in agricultural lands might have been temporally outside their nearby normal territory in the search for food. The presence of birds in agricultural habitats is essentially also due to their closeness to natural habitats, their relatively complex structure and the near-natural understorey vegetation. Therefore in the Afrotropical context, the management of agricultural areas should consider preserving some aspects of natural habitats to avoid biodiversity loss. We propose that a considerable percentage (e.g. between 15 and 20%) of the original basal area and forest tree species should be maintained. Five to eight years of fallow period should also be essential in order to create temporal favourable microclimatic conditions suitable to attract many forest bird species (Lawton et al., 1998; Greenberg et al., 2000; Daily et al., 2001; Hughes et al., 2002; Waltert et al., 2004).

ACKNOWLEDGEMENTS

Our sincere thanks to Dr. Volker Dinse, Sven Baumon and Kirsten Heyer from the “Reit” ringing station in Hamburg and to Dr. Ulrich Querner from the Radolfzell ringing station, in Germany for providing mist nets. We also thank the German Society for Tropical Ornithology (GTO) for financial support. We will never forget the traditional councils of the villages Abat, Basu and Mgbegati for their co-operation and help, particularly the eco-monitoring team of Mgbegati for their help during data collection.

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