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THE UTILITY OF BIRDS AS BIOINDICATORS : CASE STUDIES IN EQUATORIAL AFRICA

by

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SUMMARY

When site quality cannot be fully studied, due to lack of time or available specialists, the use of particular species as indicators has been proposed. However, species which indicate species-richness are needed for appreciation of biodiversity, whereas widespread stenotopic species are appropriate for habitat quality. Birds are potential bioindicators, uniting inherent biological and methodological advantages. Birds can only be bioindicators of habitat quality if they occur in the same habitat in all the sites under consideration.

Standard bird counts and captures, and standard measurements of habitat-characteristics taken along chosen transects, yield avifaunal composition and relative density in pristine and man-changed areas in equatorial Africa, in two complex areas situated in the historical forest belt (Zaire and Cameroon). The use of these data for bioindication was examined. Segregation was found to be highest in undisturbed sites within the mosaic of present-day habitats. The present study proposes, for this particular region, the use of proportions in relative density of four common species among a particular family, the bulbuls, which all are well-characterized according to habitat. Nevertheless, the authors are fully aware that this indicator cannot be extended to other regions.

Keywords : bioindicators, bird populations, monitoring, environmental change, rainforest, Africa.

INTRODUCTION

FURNESS *et al.* (1993) reviewed the use of specific bioindicators to elucidate the effects of climatic change, change due to pollution, or habitat change. However, given the rapidity with which the habitat changes, there may be insufficient time to assimilate the relevant descriptive data and assess the bioindicatory implications of that information. Hence, this raises the question as to whether there is a need for bioindicators to measure habitat change. This study considers sites in Africa where detailed studies are almost lacking (but from which we have obtained several simple data-sets) and where local changes are often fast. Therefore, the demand for rapid decisions on the protection of sites or choice among sites is great. Consequently, the use of particular plant or animal species as bioindicatory parameters could be useful. Nevertheless, in contrast, a more detailed analytical study is preferable when time and specialists are available because, in essence, each individual organism will respond differently to secondary effects of a primary cause or, at best, it will be specific enough only to be an indicator for itself. These caveats were discussed by MORRISON (1986) and RISEBROUGH (1991), particularly in an ornithological context. Also, OLIVER and BEATTIE (1994) recently investigated the use of a set of selected organisms (mosses, spiders, ants and polychaetes) for rapid assessment of total biodiversity but concluded that « trials of all groups deemed to be useful... needed to be evaluated » and « taxonomic specialists are considered indispensable to train personnel », this makes their system far too complicated to hope for « rapid assessment ».

Birds are considered to be potential bioindicators (FURNESS and GREENWOOD, 1993). The advantages of using birds are that they are either at or near the top of the food chain. Moreover, both specialist and generalist species exist among related taxa, see below), they are easy to identify, they are often common and day-active, their ecology and behaviour is often well studied and extensive data are available, and there is an important public interest in birds (i.e. collaboration of amateur ornithologists). As well as the very characteristic species of a given ecotope, there are also some more wide-ranging species which are promising as indicators for the quality of the habitats in which they occur, assuming that observed variations in bird population parameters are directly related to a change in a factor of the environment. A further advantage of using birds might be that, due to their mobility beyond the studied transect, well-selected species can also indicate, to some extent, the quality of the surrounding area of the observation spot (cf. organisms of weak mobility); this should enable a better appreciation of the quality of the site. The foregoing discussion pertains essentially to the temperate regions, with at least one available textbook study linking bird population dynamics and forestry (AVERY and LESLIE, 1990).

The peculiarities needed to define an indicator are a function of the question being analyzed : unique species indicating species-richness are needed for appreciation of biodiversity, whereas stenotopic species are appropriate for habitat quality.

There is some hope that the use of Geographic Information Systems will enable faster and more accurate compilation of data files in ornithology (SHAW and ATKINSON, 1990). However, the gathering and input of census data by biologists or persons instructed by biologists will, even under ideal conditions, impose some delay and a « bottle-neck » in data input. Under present conditions, and recognizing that this subject requires more than simply notifying the presence or absence of species, this study investigates the potential of quantitative data as descriptive parameter for habitats in tropical regions.

MATERIAL AND METHODS

The authors recognize the relatively low sampling effort in both Zaire and Cameroon and the absence of replications in space and time. Despite this, and because of the lack of other available information, the field data obtained for population studies is analyzed for their bioindicatory utility :

1) Standard bird captures in mist-nets and standard measurements of habitat characteristics in the Masako nature reserve, 14 km north of Kisangani, Zaire and at sites situated at 0, 40, 152 and 333 km from Kisangani along the new Kisangani-Bukavu road (constructed through the equatorial rainforest) from February to August 1989. These sites are all situated in a habitat mosaic, but those furthest away from Kisangani possess a large surrounding buffer zone of almost intact rainforest (the largest remaining equatorial forest block in Africa). The localities along the road are composed of a first set of nets at 500 m from the road (sites 9, 11, 12 in Table 1) and other sets at 5 km from the road, beyond the heavily disturbed zone. This area holds about 350 bird species (Bijnens and Upoki, 1992). Table 1 gives dominance rank at each site, whereby rank = 1 if the species is the most abundant, etc. (0.5 if shared with another species).

TABLE 1

Dominance rank of selected bulbuls, showing replacement, at thirteen sites in and near Kisangani, Zaire. (NR : Masako nature reserve near Kisangani)

Site	*Good forest*			*Secondary growth*					*Edge of clearings*			*Cultivation*	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Distance from Kisangani	333	333	NR	152	NR	152	40	40	333	NR	40	152	0
Number of birds caught	144	138	281	95	305	63	60	56	86	175	72	100	75
Dominance Rank													
Phyllastrephus icterinus :	6	5	6	13.5	24.5	—	—	—	—	—	—	—	—
Andropadus latirostris :	1.5	1	1	2	1	1	1.5	2	1	2	—	—	—
Andropadus virens :	8	3	3	3.5	3	3.5	3	4	2	1	2	17.5	—
Pycnonotus barbatus :	—	—	—	—	—	—	—	—	9.5	25	5.5	8	4.5

2) Standard bird counts (by song recognition during fifteen minutes at the most favourable periods of the day in the months of April to August 1989 and 1991) and standard measurements of habitat-characteristics along four chosen sites, several km distant from each other, near Yaoundé, Cameroon (transects from 6 or 8 counting stations along forest paths about 3 km long). These yield avifauna composition

and abundance in a mosaic of pristine and man-changed habitats situated in the historical forest block. This area holds about 350 bird species (FOTSO, 1994). Table 2 gives the frequency index (number of contacts/ number of counts) of four selected bulbuls. Figure 1 gives the projection of the most frequent species (according to presence or absence) according to the first and the second axis in a factor correspondence analysis, maximizing correlations between habitat variables and species variables.

TABLE 2

Frequency indices of selected bulbuls, showing distribution profile and replacement along the transects at four sites near Yaoundé, Cameroon. Number of dominant bird species : Eloumden : 36 ; Kala : 56 ; Messa : 46 ; Nkol-Yeye : 47

Site	*Transect stations*								*Dominance rank*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	
Phyllastrephus icterinus :									
Eloumden	0	0.3	0.9	1.0	0.6	0.7	0.8	0.1	7
Kala	0	0	0.2	0.8	0.4	0.5	0.3	0.3	15
Messa	0	0	0	0	0	0	—	—	—
Nkol-Yeye	0	0	0	0	0	0	—	—	—
Andropadus latirostris :									
Eloumden	1.4	1.2	1.2	1.2	1.2	1.2	1.2	0.5	1
Kala	0.8	0.6	0.9	1.0	1.1	0.8	1.0	1.0	2
Messa	0.1	0.3	0.8	0.6	0.3	0.5	—	—	10
Nkol-Yeye	0.5	1.0	0.2	0.1	0.7	0.4	—	—	9
Andropadus virens :									
Eloumden	1.1	1.2	0.5	0.4	0.7	0.6	0.7	0.6	4
Kala	1.2	1.1	1.0	0.9	0.7	0.9	0.9	0.9	1
Messa	1.5	1.5	1.4	1.5	1.5	1.6	—	—	1
Nkol-Yeye	1.2	1.3	1.2	1.3	1.1	1.1	—	—	1
Pycnonotus barbatus :									
Eloumden	0	0	0	0	0	0	0	0	—
Kala	0.4	0	0	0	0	0	0	0	37
Messa	1.6	1.4	1.3	1.1	0.6	0.8	—	—	3
Nkol-Yeye	1.2	1.2	1.1	0.8	0.7	0.9	—	—	2

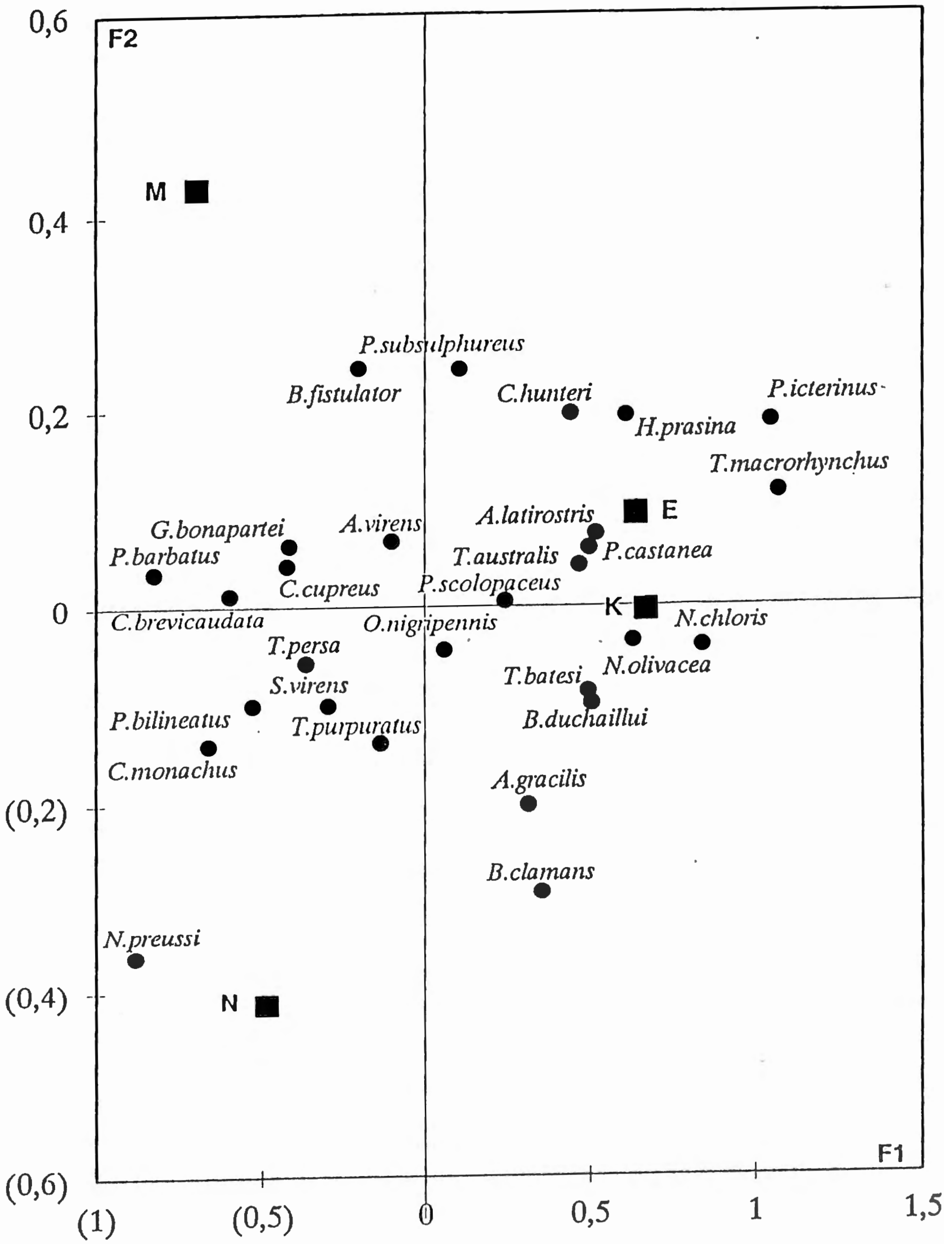

Fig. 1. — Projection of scores of the most common bird species from counts during the breeding seasons 1989-1992, on the first and the second axis in a multifactor correspondence analysis. The general position of the four counting sites (increasing deforestation from Eloumden, Kala, Messa, to Nkol-Yeye) at the forest/savanna border (Yaoundé, Cameroon) is also indicated.

The scientific names for birds used in this paper follow SIBLEY and MONROE (1990).

RESULTS

Habitat and altitude differences will be apparent for particular birds exclusive to the forest and non-forest zones ; this study is restricted to selected lowland « forests ».

Not all species of birds are prone to capture by netting and although there are certainly interspecific differences (further information in BUB, 1991), we assume that these are minimal among the low-flying small birds of mesic environments and especially in the bulbul family Pycnonotidae, which are the group of birds in our Zaire sites considered in more detail here. This family counts for 51.7 % of all birds captured at this site (UPOKI, 1992). According to the dominance rank per species in each of the thirteen Zairean stations, *Andropadus virens* Cassin 1858 is the most common bird, being present in twelve of the stations (Table 1) ; it is only absent at the city site. It is the only common bird to show a significant, positive relationship between its rank and the vegetation parameters, « Vegetation Volume Index », « Foliage Height Diversity » and the principal component in a total complex of all measured vegetation parameters ; its numbers augment with these parameters, indicating its preference for secondary vegetation in forest, because the primary forest itself has less undergrowth (BIJNENS and UPOKI, unpublished). *Andropadus virens* and its congener, *Andropadus latirostris* Strickland 1844, very often rank among the five most common species caught, but with differences according to degree of degradation (Table 1). In fact, while *A. virens* is most common in terms of being present at all but one site, *A. latirostris* is more « common » in terms of being the dominant species at most of the sites. The habitat preference and commonness is not unexpected because BROSSET and ERARD (1986) have found a situation in the forest in Gabon where proportions of these congeners vary according to site, but where it is clear that *A. latirostris* prefers less disturbed zones. Among other bulbuls appearing in the nets, according to vegetation cover, *Phyllastrephus icterinus* (Bonaparte) 1850 is present almost exclusively in prime forest whereas *Pycnonotus barbatus* (Desfontaines) 1789 is found only in disturbed habitats.

Not surprisingly, segregation of the birds in Cameroon's present-day mosaic of vegetation is most distinct, though still incomplete, in undisturbed sites. Total bird diversity augments initially with degradation. However, stability of a site is best indicated using proportions of relative density among certain genera of frugivores and insectivores (FOTSO, 1994). Figure 1 shows that the four bulbul species, already studied in the Zaire example, here are well separated also along the first axis in a multifactor correspondence analysis. Some of the other well-separated species, such as *Tauraco macrorhynchus* (Fraser) 1839, *Centropus monachus* Rüppell 1837 and *Nectarinia preussi* (Reichenow) 1892, have a restricted range in equatorial Africa and cannot be used as general habitat indicators. The ranks obtained at the four

Cameroonian study sites and the frequency values along the transects (Table 2) indicate the following habitat preferences : *Phyllastrephus icterinus* is a stenotopic forest species ; *Andropadus latirostris* prefers forest, tolerating a more heterogenous fringing zone ; *Andropadus virens* is more of a generalist, being more abundant at the edge of high-grade forest ; *Pycnonotus barbatus* avoids forest and is more abundant at the edge of degraded forest. These results corroborate the Zairean results and bring some refinement to the interpretation of the effects of border. The local conditions, such as the mosaic of very large vegetation zones, suggest segregation is to be found only in undisturbed sites.

DISCUSSION

The four selected species of bulbul show that a group of related birds can provide information on site quality, even without a detailed study of the forests themselves. The birds presence or absence and the proportion of their abundance would doubtless be useful for the appreciation of any site in this zoogeographical region in Africa. In practice, as far as application by non-specialists is concerned, recognition in the field may present a problem. Nevertheless, a mistnetting programme would enable the identification in the hand of the bulbul species discussed here; probable exceptions are *Andropadus virens* and *Phyllastrephus icterinus*, which can be confused with congeners, not mentioned here (the other two bulbuls are easily identified in the hand).

Other quantitative bird data are rare or nonexistent for equatorial Africa (see references in Bibby *et al.*, 1992) or have not yet been adequately analyzed (Brosset, 1989). One study indicates the minimum size of forest fragments necessary to hold breeding pairs of birds in Malawi (Dowsett-Lemaire and Dowsett, 1984). Prodon (1992) has shown the use of correlation methods in measuring and modelling the compositional dynamics along forest successions ; this is achieved by linking the vegetation dynamics and the induced animal (i.e., bird) turnovers and computing the variations of community characteristics along successions. While this method could be employed here, it is difficult to see what would be its advantage ; we prefer to select the individual species, or a group of related species, which are most significant in a habitat comparison.

As a general, provisional conclusion, it appears that particular forest birds, if selected among species-rich taxa with finely-tuned niches, could be useful as bioindicators for rapid evaluation of site (i.e., habitat) quality in continuous habitat.

Conversely, we do not find such a use for characteristic species with restricted ranges solely. These latter certainly give information about biodiversity, but they are not potential indicators of general habitat. Prendergast *et al.* (1993) have shown that habitats that are species-rich for one taxon are not necessarily species-rich for others, nor that rare species are to be found necessarily in species-rich habitats. Moreover, while presence of such birds might be indicative of site quality, this information is impossible to use generally.

Diversity, in itself, can be used to predict the structural aspects of habitats and *vice versa* (CODY, 1985). In the, often common case of complex habitat mosaics, a rapid method as tested here gives the necessary crude information. Nevertheless, we are aware that it would be dangerous to extrapolate conclusions too extensively from the results.

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REFERENCES

AVERY, M. and R. LESLIE (1990) — *Birds and Forestry*. Poyser, London. 299 pp.

BIBBY, C.J., N.D. BURGESS and D.A. HILL (1992) — *Bird census techniques*. Academic Press, London. 257 pp.

BIJNENS, L. and D. AGENONG'A UPOKI (1992) — Preliminary report of an ecological bird survey in virgin forest near Kisangani (Zaire). *Proceedings Seventh Pan-African Ornithological Congress*, Nairobi : 475-480.

BROSSET, A. (1989) — Population dynamics of birds in a northeastern Gabon forest. *Ostrich* Supp. **14** : 1-6.

BROSSET, A. and C. ERARD (1986) — *Les Oiseaux des régions forestières du nord-est du Gabon*. Société Nationale de protection de la nature, Paris. 297 pp.

BUB, H. (1991) — *Bird trapping and bird banding*. Cornell University Press, Ithaca, New York. 330 pp.

CODY, M.L. (1985) — An introduction to habitat selection in birds. *In : Habitat selection in birds*. CODY, M.L. (ed). Academic Press, Orlando, Florida : 4-56.

DOWSETT-LEMAIRE, F. and R. DOWSETT (1984) — The effect of forest size on montane bird populations. *Proceedings Fifth Pan-African Ornithological Congress*, Southern African Ornithological Society, Johannesburg : 237-248.

FOTSO, R.C. (1994) — *Dynamique des peuplements d'oiseaux dans les séries écologiques de la région de Yaoundé (Sud Cameroun)*. Doctorate thesis, Katholieke Universiteit Leuven, Belgium. 141 pp. and annexes.

FURNESS, R.W., J.J.D. GREENWOOD and P.J. JARVIS (1993) — Can birds be used to monitor the environment ? In : *Birds as monitors of environmental change*. FURNESS, R.W. and J.J.D. GREENWOOD (eds). Chapman & Hall, London : 1-41.

FURNESS, R.W. and J.J.D. GREENWOOD (1993) — *Birds as monitors of environmental change*. Chapman & Hall, London. 356 pp.

MORRISON, P. (1986) — Bird populations as indicators of environmental change. *Current Ornithology* **3** : 429-451.

OLIVER, I and A.J. BEATTIE (1994) — A possible method for the rapid assessment of biodiversity. *In : Systematics and conservation evaluation.* FOREY, P.L., C.J. HUMPHRIES and R.I. VANE-WRIGHT (eds). Clarendon Press, Oxford : 133-136.

PRENDERGAST, J.R., R.M. QUINN, J.H. LAWTON, B.C. EVERSHAM and D.W. GIBBONS (1993) — Rare species, the coincidence of diversity hotspots and conservation strategies. *Nature* **365** : 335-337.

PRODON, R. (1992) — Animal communities and vegetation dynamics : measuring and modelling animal community dynamics along forest successions. *In : Responses of forest ecosystems to environmental changes.*. TELLER, A., P. MATHY and J.N.R. JEFFERS (eds). Elsevier, London & New York : 126-141.

RISEBROUGH, R.W. (1991) — Indicator species, birds, toxic contaminants, and global change. *Acta XX Congressus Internationalis Ornithologicus* : 2480-2486.

SHAW, D.M. and S.F. ATKINSON (1990) — An introduction to the use of Geographic Information Systems for ornithological research. *Condor* **92** : 564-570.

SIBLEY, C.G. and B.L. MONROE (1990) — *Distribution and taxonomy of birds of the world.* Yale University Press, New Haven & London. 1111 pp.

UPOKI, A. (1992) Les bulbuls de la réserve forestière de Masako. *Abstracts Eighth Pan-African Ornithological Congress, Bujumbura*, Burundi, 55.