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BIODIVERSITY RESEARCH

Rapid assessment in conservation research: a critique of avifaunal assessment techniques illustrated by Ecuadorian and Madagascan case study data

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ABSTRACT

The urgency of conservation concerns in the tropics, linked with the limitations imposed on research efforts by the tropical environment has resulted in the development of methods for rapid assessment of biological communities. One such method, the MacKinnon list technique, has been increasingly applied in avifaunal surveys worldwide. Using paired tropical bird data sets from Ecuadorian cloud forest and Madagascan littoral forest, we compare the performance of the MacKinnon list with that of the more standard method of point counts in indicating when a site has been adequately surveyed, estimating the magnitude of species richness, quantifying relative species abundance, and providing an α-index of diversity. In species-rich Ecuadorian cloud forest, neither method produced data indicating adequate survey effort, despite extensive sampling, whereas in the relatively species-poor Madagascan littoral forests, data collected by both methods indicated that the area had been sufficiently surveyed with comparable sampling effort. Species richness estimates generated from MacKinnon list data provided a more accurate estimate of the magnitude of the species richness for the Ecuadorian avifauna, whereas estimates for the Madagascan avifauna stabilised with relatively few samples using either method. Data collected by each method reflected different patterns of relative abundance among the five most abundant species, with MacKinnon list data showing a bias towards solitary and territorial species and against monospecific flocking species relative to the point count data. As a consequence of this bias, MacKinnon list data also fail to reflect accurately the structure of communities as quantified by an index of community evenness. Point counts, on the other hand, failed to capture the full species complement of the species-rich Ecuadorian study area. As techniques for the rapid assessment of unsurveyed areas, both methods are subject to biases that limit their value, if used alone, in collecting data of scientific and management value. We propose a hybrid rapid assessment methodology that capitalises on the strengths of both techniques while compensating for their weaknesses.

Keywords

Birds, community structure, conservation, Ecuador, MacKinnon lists, Madagascar, point counts, rapid assessment, species richness, tropical forest.

INTRODUCTION

The challenge of obtaining scientific information on previously unknown ecosystems and ensuring the comparability of such information across study areas has led to the development of several techniques for rapid assessment. These have found particular application in the tropics, where researchers often have to contend with heavily vegetated, steep, and otherwise inaccessible terrain, high species diversity and clustered species distributions, which make the application of systematic field methodologies developed in temperate areas difficult, if not impossible. Rapid assessment techniques acknowledge these constraints and provide means of accelerating the collection of scientific data in understudied areas.

One recently developed approach to rapid assessment, the 'MacKinnon list' method of avifaunal assessment (MacKinnon & Phillips, 1993), has been increasingly adopted for tropical bird studies worldwide, from Indonesia (MacKinnon & Phillips, 1993; Trainor, 2002a,b), to mainland Africa (Fjeldsa, 1999), Madagascar (James Watson, unpublished data) and South America (Poulsen *et al.*, 1997a,b). It has also been promoted as a potentially useful technique in a recent manual on bird census methods (Bibby *et al.*, 2000). Poulsen *et al.* (1997b: 65) claim that the method is 'suitable for judging (a) when a site is adequately surveyed (b) the magnitude of the species richness (c) the relative abundance of each species and (d) an α-index of diversity.' Researchers employing MacKinnon lists argue that the method is subject to no more bias than other survey methods (Poulsen *et al.*, 1997b; Fjeldsa, 1999), and that it is less biased than mist-netting (Fjeldsa, 1999). The advantages claimed for the technique relative to more widely used point counts or transects include time efficiency and relatively greater observer independence; the entire available time period is used to collect data and, hence, there is far less 'data loss' than in other survey methods. While a basic familiarity with the resident avifauna is necessary to ensure that reliable results are obtained, the method allows for a certain degree of difference in observer ability, since the data collection is not timed and therefore more time can be spent searching out and identifying unknown birds. Authors have recommended the adoption of this straightforward technique for examining the impacts of habitat modification in the tropics (Fjeldsa, 1999; Trainor, 2002b).

Another technique frequently employed in studies of tropical ecosystems that have not previously been formally surveyed is the point count methodology (Poulsen & Krabbe, 1998; Marsden *et al.*, 2000). Point counts are a powerful method of measuring relative abundances efficiently (Whitman *et al.*, 1997). They are also the traditionally preferred avian survey method where inferences are to be drawn about habitat associations because bird data collected can be directly related to the habitat measured (Bibby *et al.*, 2000).

In this paper we make use of paired tropical bird data sets from two localities, Ecuadorian cloud forest and Madagascan littoral forest, to assess the effectiveness of the MacKinnon list and point count methods. Specifically, we assess their relative performance in: (i) providing a reliable measure of effort, indicating when a site has been adequately surveyed; (ii) providing a robust estimation of the magnitude of species richness; (iii) accurately reflecting species abundance distributions; and (iv) providing an α-index of diversity. Overall, our purpose is to address this question: if practicality dictates the need for rapid assessment, which of these methods will provide more informative and ultimately useful data?

METHODS

Study areas

The Madagascar study site is located near the township of Fort Dauphin in the south-east of the island (24°47′ S, 47°12′ E). This region has a semitropical climate with mean annual precipitation ranging from 1000 to 1600 mm and daily minimum and maximum air temperature averaging 15–28 °C (Goodman *et al.*, 1997). The study covered an area of approximately 5000 ha with an altitudinal range between 0 and 50 m a.s.l. Due to its location, the region possesses a distinct precipitation gradient, with the eastern coast having a tropical damp climate and the west having a semiarid climate (Lewis Environmental Consultants, 1990; Goodman *et al.*, 1997). The littoral forests grow as a series of remnants along a narrow band of sand and alluvium along the coast of the region, and are considered Madagascar's most intact littoral forests (Dumetz, 1999).

The matrix surrounding these forests includes *Melaleuca* swamp forest, plantations of *Eucalyptus citriodora* Hook and *E. robusta* Blakely, and heath-type vegetation consisting predominately of *Erica* spp. (formerly *Phillippia* spp.) (Ramanamanjato & Ganzhorn, 2001). These forests have never been extensively surveyed (Goodman *et al.*, 1997), so the purpose of these surveys was to determine their avian species composition.

The Ecuadorian study site was located in the Maquipucuna and Santa Lucia Reserves and adjacent lands (0°7′ S, 78°36′ W) on the western slope of the Andes in the Pichincha province of northern Ecuador. The study covered an area of approximately 3000 ha with an altitudinal range between 1100 and 1850 m a.s.l. Mean annual precipitation is 3200 mm and daily minimum and maximum air temperature average 17–26 °C at 1200 m a.s.l., with little seasonal change (Rhoades & Coleman, 1999). Following Holridge *et al.* (1971), the natural vegetation can be classified as lower montane wet forest. The forest vegetation of the area is a mixture of mature and 20-year-old-regrowth forest embedded within a matrix of agricultural land, including pastures, sugar cane fields and fruit tree plantations. Compiling records from various sources as well as data from a year of weekly survey work, Parsons (1996) listed 326 bird species for the area.

Field methods

In the Madagascar case study area, 14 littoral forest remnants, as well as sites in the surrounding matrix, were surveyed for birds using both point counts and the MacKinnon list methodology in November and December 2001. In Ecuador, forest and sites in agricultural land were surveyed using both point counts and MacKinnon lists in June and July 2002.

Proposed by MacKinnon & Phillips (1993), the MacKinnon list methodology is a standardised rapid assessment technique for tropical bird communities, providing an index of effort for bird encounters recorded opportunistically. Using this methodology, all species seen or heard are grouped into consecutive lists of equal length and a species accumulation curve is generated from adding those species not recorded on any previous list to the total species number. This number is then plotted as a function of list number. In the present study, we used 10-species lists, recommended by Herzog *et al.* (2002) as representing the best compromise between stable richness estimation curves and robust sample size. Thus, in each habitat sampled, we consecutively recorded each new species encountered, starting a new list once

10 different species had been recorded. All species seen or heard were recorded on the lists. We compiled MacKinnon lists while slowly walking trails through forested and open land, stopping periodically to search out and record individual species or flocks.

Point counts are a more widely used method of avifaunal assessment in which birds are recorded at fixed stations separated by fixed distances (Bibby *et al.*, 2000). The point count stations in both of our study areas had a radius of 25 m and were located at least 100 m apart to minimize the risk of counting the same individual twice. Ten minutes were spent at each station, allowing for the identification of all birds present while minimising the likelihood of double-counting individuals arriving or moving during the count period. Bird species recorded in the point counts were also recorded in MacKinnon lists to ensure maximum sampling using the MacKinnon list methodology. In Madagascar, surveys were confined to the periods 0600–1000 h and 1500–1900 h. In Ecuador, the point counts were confined to 0600–1000 h, while MacKinnon lists were compiled from 1400 to 1600 h as well as in the morning period. All surveys were conducted on days without rain or strong wind.

All point count and MacKinnon List surveys in Ecuador and Madagascar were conducted by N. O'Dea and J. Watson, respectively. Thus, problems associated with biases attributed to differences among observers were avoided. Compact disks of all bird species that could occur in each study area were produced before the study commenced, and both observers trained to recognise the recorded songs of all species that could be encountered in each study area. In addition to this training, local ornithologists accompanied each observer for a period of a week to ensure that the observer was familiar with all bird species (and their calls) within the study area, before surveying began. In the Ecuadorian case study area, a local ornithologist accompanied the observer throughout the survey period.

Analysis

Simple species accumulation curves are generated and compared for data collected using the two methods for forest habitat in each study area. A plateau in the species accumulation is defined here as the point where the rate of species accumulation over a 10-sample interval falls below 0.10. The Chao 2 (Chao, 1987) species richness estimator was also calculated for these data:

$$S_{Chao} = S_{obs} + F_1^2/2F_2 \quad (1)$$

where S_{obs} is the number of species observed, F_1 is the number of species with exactly one individual and F_2 is the number of species with exactly two individuals. Several authors recommend Chao 2 as the most robust estimator of species richness where most species are infrequent (Colwell & Coddington, 1994; Chazdon *et al.*, 1998). Curves generated indicate whether sufficient sampling effort has been undertaken to capture the total species richness of the habitat in question. They also indicate whether differences exist in the expected total species richness of these habitats. Both species accumulation and species richness estimator curves represent the average values from 50 randomisations of sample order. We analyse the recorded distributions of species abundances by comparing the rank abundances of the five most abundant species recorded in forest habitats using each method. Indices of α-diversity are only comparable where the method of data collection is held constant. In order to compare the performance of the two methods in providing an α-index of diversity, we compare the rank diversity of communities in forest and nonforest habitat within each study area as recorded by each method. For this purpose we apply the log-series α index, weighted towards species richness and the Brillouin E index, weighted towards community evenness, to examine how data from each method reflects these aspects of diversity (Melo *et al.*, 2003). Equations used to calculate these indices are available in Krebs (1989). The significance of differences in diversity between habitats was determined by Bootstrap analysis with 10 000 random permutations. All analyses were performed using Species Diversity and Richness, version 3.02 (Pisces Conservation, 2002).

RESULTS

Sampling effort

In both the Ecuador and Madagascar study areas, considerably more hours were spent in the collection and subsequent entry of data for MacKinnon lists (Table 1). In Ecuador, 132 additional hours, including time spent on 14 additional survey days, were spent compiling MacKinnon lists than were spent conducting point counts, while in Madagascar, an additional 60 h were spent on MacKinnon list compilation.

Table 1 Summary of the sampling effort using MacKinnon list and point count methodologies in the littoral forests of Madagascar and the cloud forests of Ecuador. MacKinnon lists were compiled continuously, including during point counts

	Ecuador		Madagascar	
	MacKinnon Lists	Point Counts	MacKinnon Lists	Point Counts
Number of counts/lists	200	120	255	90
Time spent in data collection	180 h in 24 days	48 h in 12 days	90 h in 15 days	30 h in 12 days
Time spent in data entry*	16 h 40 min	10 h	38 h 45 min	7 h 30 min
Species Count Total	222	144	74	73

* The time spent in data entry was calculated at the rate of 5 min per list.

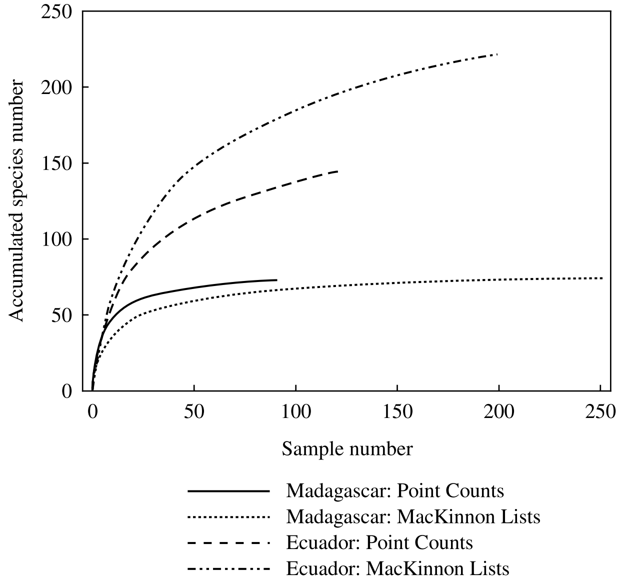

Figure 1 Species accumulation curves for bird communities in the Ecuadorian cloud forests and Madagascan littoral forests using MacKinnon list (1 sample = 1 10-species list) and point count (1 sample = 1 point count) methodologies. Each curve represents the average values of 50 randomisations of sampling order.

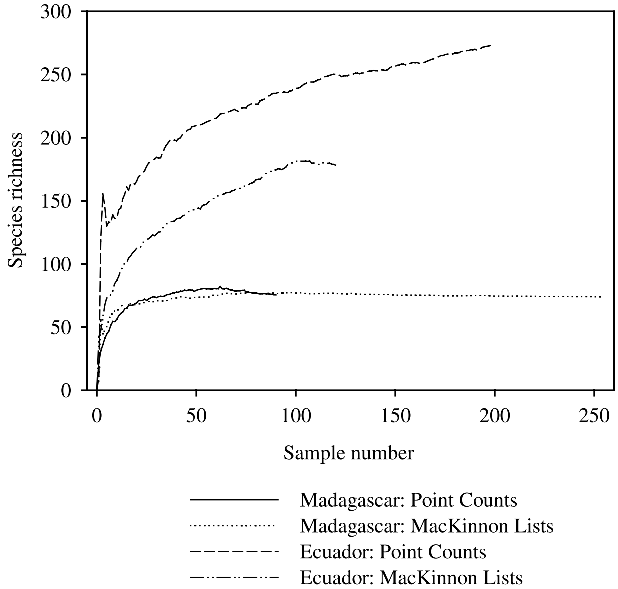

Figure 2 Species estimation curves using Chao 2 estimator (Chao, 1987) for bird communities in the Ecuadorian cloud forests and Madagascan littoral forests using MacKinnon list (1 sample = 1 10-species list) and point count (1 sample = 1 point count) methodologies. Each curve represents the average values of 50 randomisations of sampling order.

In Ecuador, 78 species in addition to those recorded during the point count survey were recorded using the MacKinnon list method (Table 1), while in Madagascar only one additional species was recorded using the MacKinnon list method. In the Ecuadorian data there is no plateau in the species accumulation curves despite recording 120 individual point counts and 200 10-species lists (Fig. 1). In the Madagascan data, the rate of species accumulation drops below 0.10 (plateaus) with relatively few samples: 69 point counts and 91 MacKinnon lists. In contrast to the Ecuadorian data, the Madagascan point count survey accumulates more species per sample than the MacKinnon list survey and reaches a plateau at a smaller sample size.

Total species richness estimation

Figure 2 shows the change in the estimation of total species richness calculated by the Chao 2 estimator as sample size increases in both study areas. In the Madagascar case study, species richness is estimated at 75 after 90 point counts and 74 after 255 MacKinnon lists. These numbers are close, and for MacKinnon list data identical, to the actual number of species encountered (Table 1, Fig. 2). The curves for both point count and MacKinnon list data plateau after approximately 50 samples. Standard deviations in the Chao 2 estimate fall to below 5% of the estimated species richness within 83 point counts and 107 MacKinnon lists.

For the Ecuadorian data, total species richness is estimated at 274 species after 200 MacKinnon lists and 180 species after 120 point counts (Fig. 2). The richness estimate appears to stabilise between 100 and 120 samples for the point count survey, However, as for the simple species accumulation curve, no plateau in the estimate of total richness was achieved for the MacKinnon list data. Standard deviations remain above 5% of the estimated species richness for both data sets.

Relative abundance

Comparing the rank abundance of the five most abundant species for each study area as recorded using the MacKinnon list and point count methodologies, differences were apparent (Table 2). For Madagascan littoral forests, the two top-five lists shared four species, although with differing relative abundances. The Madagascar Bulbul *Hypsipetes madagascariensis* Müller and Souimanga Sunbird *Nectarinia souimanga* Gmelin were similarly abundant, each holding either the first or second position in the abundance ranking in data for each method. The Common Jery, *Neomixis tenella* Hartlaub is a gregarious, flocking species; it was the third most abundant bird in littoral forests as recorded using the point count methodology but only sixth as recorded in the MacKinnon lists. The Madagascar Bee-eater *Merops superciliosus* L., a nomadic insectivore, was among the five most abundant species in MacKinnon list data but was not among the five most abundant species in the point count data.

In the Ecuadorian data, while the overall ordering of abundances is similar, one species appears among the top five most abundant species in data for each methodology that does not appear in that of the other. For point count data this species was the monospecific flocking Plumbeous Pigeon *Columba plumbea* Vieillot, recorded as the fourth most abundant species, whereas for MacKinnon lists, it was the territorial and largely solitary Scale-crested Pygmy-Tyrant *Lophotriccus pileatus* Tschudi, recorded as second most abundant.

Table 2 Comparison of the five most abundant species recorded in point counts and MacKinnon lists in the Ecuador and Madagascan study areas. The numerical abundances as recorded by each method, followed in brackets by the rank abundances, are reported for each species. * indicates equal rank abundance

Ecuador			Madagascar		
Species Name	Point Counts	MacKinnon Lists	Species Name	Point Counts	MacKinnon Lists
Henicorhina leucophrys Tschudi	119 (1)	79 (1)	*Hypsipetes madagascariensis* Müller	271 (1)	187 (2)
Euphonia xanthogaster Tschudi	106 (2)	58 (3*)	*Nectarinia souimanga* Gmelin	264 (2)	198 (1)
Basileutris tristriatus Tschudi	92 (3)	58 (3*)	*Neomixis tenella* Hartlaub	240 (3)	131 (6)
Columba plumbea Vieillot	75 (4)	47 (7)	*Streptopelia picturata* Temminck	203 (4)	156 (4)
Parula pitiayumi Vieillot	70 (5)	49 (4)	*Centropus toulou* Müller	196 (5)	177 (3)
Lophotriccus pileatus Tschudi	68 (8)	64 (2)	*Merops superciliosus* L.	146 (8)	143 (5)

Table 3 A summary of the diversity index values, recorded using species list and point count methodologies in the cloud forests of Ecuador and the littoral forests of Madagascar. Significance tested by Bootstrap analysis with 10 000 random permutations. * higher diversity (at $P < 0.05$)

		Ecuador		Madagascar	
Diversity Index	Method	Forest	Nonforest	Forest	Nonforest
Log-series a	Point Counts	36.78*	25.65	16.43*	7.99
	MacKinnon Lists	63.84*	50.59	14.28*	4.55
Brillouin E	Point Counts	0.8510*	0.8214	3.65*	2.57
	MacKinnon Lists	0.8843	0.9186*	3.51*	2.84

Diversity indices

Using the log-series α index of diversity, we found that both data collection methods provide the same ranking of diversity between forest and nonforest habitats (Table 3). Despite differences in the actual values calculated, data obtained by both methods rank the forest bird communities as significantly more diverse than the nonforest communities at $P < 0.05$. However, results were inconsistent for the Brillouin E index, which reflects evenness in the distribution of species abundances in the community. In the Ecuadorian study area, the forest community was ranked as significantly more even than the nonforest community for point counts, but was less even according to the MacKinnon list data ($P < 0.05$). In the Madagascan case study area the results were consistent in ranking evenness at $P < 0.05$, but the Brillouin E index values derived from MacKinnon list data were more similar between forest and nonforest habitats than those for the point count data (Table 3).

DISCUSSION

In the cloud forests of north-west Ecuador, a species-rich environment, a total of 222 species were recorded during the course of MacKinnon list surveys, while 144 species were recorded during point counts. Differences were also apparent in the indices of total species richness and relative abundance. In the littoral forests of south-eastern Madagascar, a relatively species-poor environment, we recorded approximately the same number of species, but found differences in the relative abundances of species, using the two methods. Inconsistencies also emerged in ranking the evenness of communities in forest and nonforest habitats within each study area. Such differences are indicative of biases implicit in data collected using both the MacKinnon list and point count methodologies. Below, we discuss the nature of these biases and their influence on the relative usefulness of each approach in the context of rapid assessment in previously unsurveyed areas.

Sampling effort

Because the entire period of the point count survey as well as time outside this period could be used for compiling MacKinnon lists, the MacKinnon list method allowed a greater proportion of the available field time to be spent collecting bird data than did point counts. Consistent with other authors (Poulsen *et al.*, 1997b; Herzog *et al.*, 2002), we found the MacKinnon list method suitable for determining when a site has been adequately sampled. In the relatively species-poor Madagascan study area, species accumulation curves for littoral forest remnants plateau at the same species number for both MacKinnon list and point count data. By contrast, in Ecuador no plateau was reached within the confines of available sampling for either method. Therefore, even with 200 lists or 120 point counts, sampling effort was still insufficient to capture the heterogeneity and diversity of this particular bird community. The 200 MacKinnon lists compiled in the Ecuadorian survey was a far greater number than that needed to achieve asymptotic species accumulation curves in other MacKinnon list studies (Poulsen *et al.*, 1997b; Fjeldsa, 1999). This attests to the difficulty of applying any rapid assessment technique in such a species-rich environment. It should be noted, however, that the MacKinnon list species accumulation curve approached the recorded species richness of the area far more closely.

Species richness estimation

In the littoral forests of Madagascar, the Chao 2 estimator applied to the Mackinnon List data set estimated the exact number of species actually recorded in the remnants surveyed and estimated one additional species using the point count data set. This is because the Chao 2 estimate of total species richness will equal the recorded richness once all species have been recorded more than once (equation 1). Thus, in a relatively species-poor environment, both techniques were effective and time efficient for estimating total species richness.

In the Ecuadorian cloud forest, the estimate of total species richness did not stabilise within the available sampling effort for either data set because we continued to encounter new species throughout the sampling period. As such, it is not possible to state with confidence the magnitude of species richness for the area based on the data, even after extensive sampling. However, if we take the Parsons (1996) inventory of 326 species as representative of the area's total species richness, the Chao 2 estimate for the MacKinnon list data approached this number more rapidly than that for the point count data. In fact, the point count data appeared to plateau at approximately 180 species between 100 and 120 samples, indicating a systematic under-sampling of the avian community relative to MacKinnon lists. This is a known property of the point count technique (Bibby & Buckland, 1987; Whitman *et al.*, 1997; Pagen *et al.*, 2002), since certain species, particularly those which are nocturnal or crepuscular, will often not be represented. As well, the MacKinnon list method may better record rare and vagrant species because it allows continuous recording and active searching. Notably, of species only recorded in MacKinnon lists, 77% were encountered only once or twice, including six additional restricted-range species and seven additional at-risk species. At its simplest, and recognizing that the actual richness of birds present in the Ecuadorian study area at the time of the 2001 sampling is unknowable (as is the number of breeding species); all we can state with confidence is that the number of species that were present must have fallen somewhere between the 222 species observed in the study and the figure of 326 species comprising all records (including vagrants) for the reserve. On this basis, where the purpose of a survey is simply to assess the overall species richness of an area, MacKinnon lists appear to be the more effective tool.

Relative abundance

Differences in the rank abundance of species as determined by MacKinnon list and point count methods illustrate a tendency of the MacKinnon list method to weight regularly spaced territorial species as more abundant than flocking species. For example, in Ecuador, when abundance at each encounter was recorded in the point count survey, the Scale-crested Pygmy Tyrant *L. pileatus* had only 57% of the abundance of the most abundant species, *H. leucophrys* and was the eighth most abundance species (Table 2). However, when recorded on MacKinnon lists, the abundance of this solitary and highly territorial *L. pileatus*, jumped to 82% of that of *H. leucophrys*, becoming the second most abundant species (Table 2). Thus, even if, as suggested by other authors (Poulsen *et al.*, 1997b; Herzog *et al.*, 2002), obviously territorial species are not double-counted, the method still overestimates their relative abundance. In Madagascar, even though abundant species were being encountered at much greater rates than in Ecuador, similar weighting occurred. Species that readily form flocks, like *H. madagascariensis* and *N. tenella* (Langrand, 1990; Eguchi *et al.*, 1993a; Eguchi *et al.*, 1993b), ranked lower in abundance for MacKinnon list data.

While MacKinnon list data are weighted towards territorial species, it could be argued that point count data are similarly weighted towards monospecific flocking species, which might be present at fewer sites, but in greater abundance. However, unlike MacKinnon list data, point count data record both abundance at sites and ubiquity (presence/absence) across sites, representing two facets of relative abundance. There is the further possibility that the same widely and rapidly ranging flocks could be recorded in different point counts (Raman, 2003), again weighting them as more abundant. The systematic separation in space and short duration of consecutive point counts are means of reducing this bias, but this provides no guarantee against double counting on different days. Nevertheless, the MacKinnon list method is subject to the same bias and provides no systematic way of controlling for it.

Poulsen *et al.* (1997a, 1997b) acknowledged that relative abundances recorded by MacKinnon lists may be biased and call for further investigation. In a recently published study, Herzog *et al.* (2002) modelled the behaviour of data collected using the MacKinnon list methodology. They support Poulsen *et al.*'s (1997b) contention that MacKinnon lists are appropriate for judging sampling effort and magnitude of species richness, but argue that differences in detectability of species mean that relative abundances can only be compared within species across habitats or sites. We concur, but argue further, that the incomparability of relative abundances is due not only to differences in detectability, but also to biases in the technique of recording abundance. Point counts do not provide a perfect measure of abundance either. They are biased relative to the very time-consuming spot-mapping method (Raman, 2003), considered the only reliable means of determining absolute abundance (Terborgh *et al.*, 1990; Stratford & Stouffer, 1999). However, the advantage of point counts relative to MacKinnon lists is that their spatial and temporal standardisation means that their biases are more readily quantifiable and controllable.

Diversity indices

Due to the bias in measuring relative abundance, Herzog *et al.* (2002) argue that MacKinnon list data are also unsuitable for the

Table 4 Summary of study findings comparing MacKinnon list and point count survey techniques in Madagascar and Ecuador

	MacKinnon lists	Point Counts
Percentage of field time spent in data collection	more	less
Time spent in data collection	more	less
Continuous recording?	yes	no
Total species count	more	less
Individual birds recorded at every sighting?	no	yes
Bias in relative abundance estimate	more	less
Bias in α-diversity estimate	more	less
Observation weighted to rare/novel species?	yes	no
Minimum unit of standardization	habitat/fragment	point
Minimum unit of comparison with environmental landscape variables	habitat/fragment	point

calculation of diversity indices. The distribution of abundances within the community will appear more even for MacKinnon list data than for point count data because the abundance of a species at a given encounter is not quantified. Thus, in both our case study areas, while the log-series α index, weighted towards species richness, consistently identified the forest bird community as more diverse than nonforest bird communities for both point count and MacKinnon list data, the Brillouin E, reflecting community evenness, provided inconsistent results; MacKinnon list data failed to capture the greater unevenness in the nonforest bird community resulting from the presence of a few hyper-abundant flocking species. In order to provide more information than the simple species richness, all α-diversity indices incorporate this relative abundance into their formulae. As such, we consider MacKinnon list data suboptimal for the calculation of diversity indices and recommend the use of point count data for this purpose.

General discussion

Table 4 summarises our findings relating to the use of the MacKinnon list and point count survey techniques in species-rich cloud forests of north-west Ecuador and species-poor littoral forests of south-east Madagascar. Without the constraints imposed by timed counts, the MacKinnon list technique allowed a greater proportion of the available field time to be spent in the field collecting bird survey data. More species were recorded using the MacKinnon list technique in the Ecuadorian case study. This is due to the flexibility of the technique in continuously recording data and actively searching out new species. However, we caution that this searching may introduce an additional bias into the data: the act of searching out a potentially new species, which is evading detection, may distract the data recorder from registering more commonly encountered species in his or her surroundings. Trainor (2002b) expressed similar concerns. Such bias towards novel species could account for the steeper species accumulation curve observed and for the greater number of restricted-range and at-risk species recorded. This bias is controlled in the point count technique because the observer's objective is to record accurately everything seen and heard from a standing position within a fixed time period.

Herzog *et al.* (2002) suggest that the abundance of species be recorded for the MacKinnon list technique in order to ensure maximum flexibility in the choice of list length. While this may be practicable for certain species, recording a monospecific flock of 20 individuals would be excessively time consuming if each one had to be noted in its order of appearance relative to other species present. Moreover, another bias is introduced in that the sequence of recording can have a potentially large influence on the relative abundance calculated for a given species. For instance, if two individuals of a species occur at the end and beginning of consecutive lists, their relative abundance will double relative to that if they fell in the middle of a list sequence.

Fjeldsa (1999) and Trainor (2002b) advocated the application of MacKinnon lists as a standardised design for examining the impacts of habitat disturbance on bird communities. We feel that for this purpose, among the most important in conservation research, conducting MacKinnon list surveys may not be enough. Authors applying the MacKinnon list method acknowledge that comparison across sites can only be made if habitat diversity, altitude and size of surveyed areas are held constant (Poulsen *et al.*, 1997b; Fjeldsa, 1999; Trainor, 2002b). This is difficult to achieve in the field and directly undermines surveys aimed at examining the effect of these variables. The lack of sampling standardisation in a MacKinnon list survey makes it difficult to relate observed patterns within avian communities to patterns in the environment. Whereas in a point count survey, the sampling protocol can be standardised to correct for environmental heterogeneity, in a MacKinnon list survey the lack of standardisation in the sampling protocol necessitates standardising the environmental heterogeneity. Further, point counts allow for the direct comparison of bird and environmental data at each point, because bird and environmental data can be collected for each point (Bibby *et al.*, 2000). On the other hand, a point count survey alone may fail to provide an accurate indication of an area's species richness, particularly in extremely species-rich areas.

Given the advantages and limitations of each method for the rapid assessment of previously unsurveyed areas, we propose a synthetic method combining the best qualities of both. We argue that research efforts should focus on conducting systematic point count surveys to examine aspects of bird community structure and species composition, and their relation to environmental factors (Thiollay, 1997; Galetti & Aleixo, 1998; Estades & Temple, 1999; Saab, 1999; Reynaud & Thioulouse, 2000). However, if, as suggested by Herzog *et al.* (2002), birds encountered during, between, and after point counts are recorded in MacKinnon lists, these additional data can be use to generate a comparative index of sampling effort and to ensure a more accurate assessment of the magnitude of species richness in an area.

The concerns raised here, while focused on birds, may not be restricted to the rapid assessment of birds. Rapid assessment techniques are used in the study of many tropical taxa, from butterflies to reptiles (Lande *et al.*, 2000; Thompson & Withers, 2003). We propose that rapid assessments should wherever possible set out to generate data suitable for estimating both richness and other aspects of community structure, such as equitability, as well as data concerning the habitat relationships of species. Thereby, rapid assessments can generate high quality data sets to inform conservation policy for understudied and relatively unknown tropical areas.

CONCLUSIONS

Authors who have assessed the efficacy and biases of the MacKinnon list approach argue it to be a 'best compromise' approach, given limitations of time, funding and personnel, and the urgency of conservation needs (Poulsen *et al.*, 1997b; Fjeldsa, 1999; Herzog *et al.*, 2002). While evaluations of species richness have value in guiding conservation efforts, we would caution that the type of information these surveys provide on their own contributes relatively little to our understanding of how or what to conserve. As acknowledged by Poulsen *et al.* (1997b), MacKinnon list surveys, when standardised, are neither easier nor superior to point counts; what they provide is an efficient means of determining species richness in a species-rich environment, as well as cataloguing the species systematically missed by point counts.

Research efforts must concentrate on understanding the causes of species loss rather than merely cataloguing the species that are about to disappear. MacKinnon lists provide a first step in conservation research, offering an inventory of species present, a robust measure of the adequacy of sampling effort, and a means of estimating the magnitude of species richness. However, the need for rapid assessment is driven by constraints of time and funding. As such, initial rapid assessment surveys should not only document the bird species (or indeed other taxa) of new areas, but should also set out to improve our scientific understanding of mechanisms driving their distribution and abundance. We therefore argue that for birds, use of the Mackinnon list method *in conjunction* with point counts should be recommended, as this may provide robust rapid-survey data, including both an accurate assessment of species richness as well as compositional and relative abundance data that can be directly related to environmental variables.

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