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Do McKinnon lists provide reliable data in bird species frequency? A comparison with transect-based data

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ABSTRACT

Although occurrence-based listing methods could provide reliable lists of species composition for a site, the effective reliability of this method to provide more detailed information about species frequency (and abundance) has been rarely tested. In this paper, we compared the species frequencies obtained for the same set of species-rich sites (wetlands of central Italy) from two different methods: McKinnon lists and line transects. In all sites we observed: (i) rapid cumulating curves of line transect abundance frequencies toward the asymptote represented by the maximum value in McKinnon occurrence frequency; (ii) a large amount of species having a low frequency with line transect method showing a high range of variation in frequency obtained by McKinnon lists; (iii) a set of species having a subdominant (> 0.02- < 0.05) and dominant species (> 0.05) frequency with line transect showed all the highest value in McKinnon frequency. McKinnon lists provides only a coarse-grained proxy of species frequency of individuals distinguishing only between common species (having the highest values of McKinnon frequency) and rare species (all the other species). Although McKinnon lists have some points of strength, this method does not discriminate the frequencies inside the subset of common species (subdominant and dominant species). Therefore, we suggest a cautionary approach when McKinnon frequencies should be used to obtain complex univariate metrics of diversity.

1. Introduction

Several field methods are used to estimate both absolute and relative bird abundance and frequency (Bibby et al., 2000; Sutherland et al., 2004). These methods differ in terms of research effort and expertise necessary to their carrying out. For example, although mapping methods (o spot-mapping; Williamson, 1964) and line transects (Järvinen and Väisänen, 1983) allow to obtain fine-grained data, they may be expensive in terms of effort time, budget and individual skills (Sutherland, 2006). Unfortunately, time, budget and expertise are often not available in many contexts of conservation concern (for example, threatened species-rich ecosystems). Therefore, it may be necessary in the most fragile environments to apply un-expensive methods that could provide reliable data in a short time span.

In the last decades, the McKinnon lists (or MacKinnon or X species lists; Bibby et al., 2000) have been used as a rapid and simple field method designed to sample bird data in species-rich environments (e.g. tropical forests: McKinnon and Phillips, 1993). This method, belonging to the group of 'occurrence-based methods' (Bart and Klosiewski, 1989; Sutherland, 2006) is based on compiling a list the first 20 species encountered along a random trail without any limit on the time taken to fill it. When the first list is completed, a second list is started until it also reaches the number of 20 species listed. In this second list, presumably, some species will be repeated from the first list. Hence, all recorded species are grouped in replicated lists of equal length. This process is continued until reaching a representative number of species lists for the

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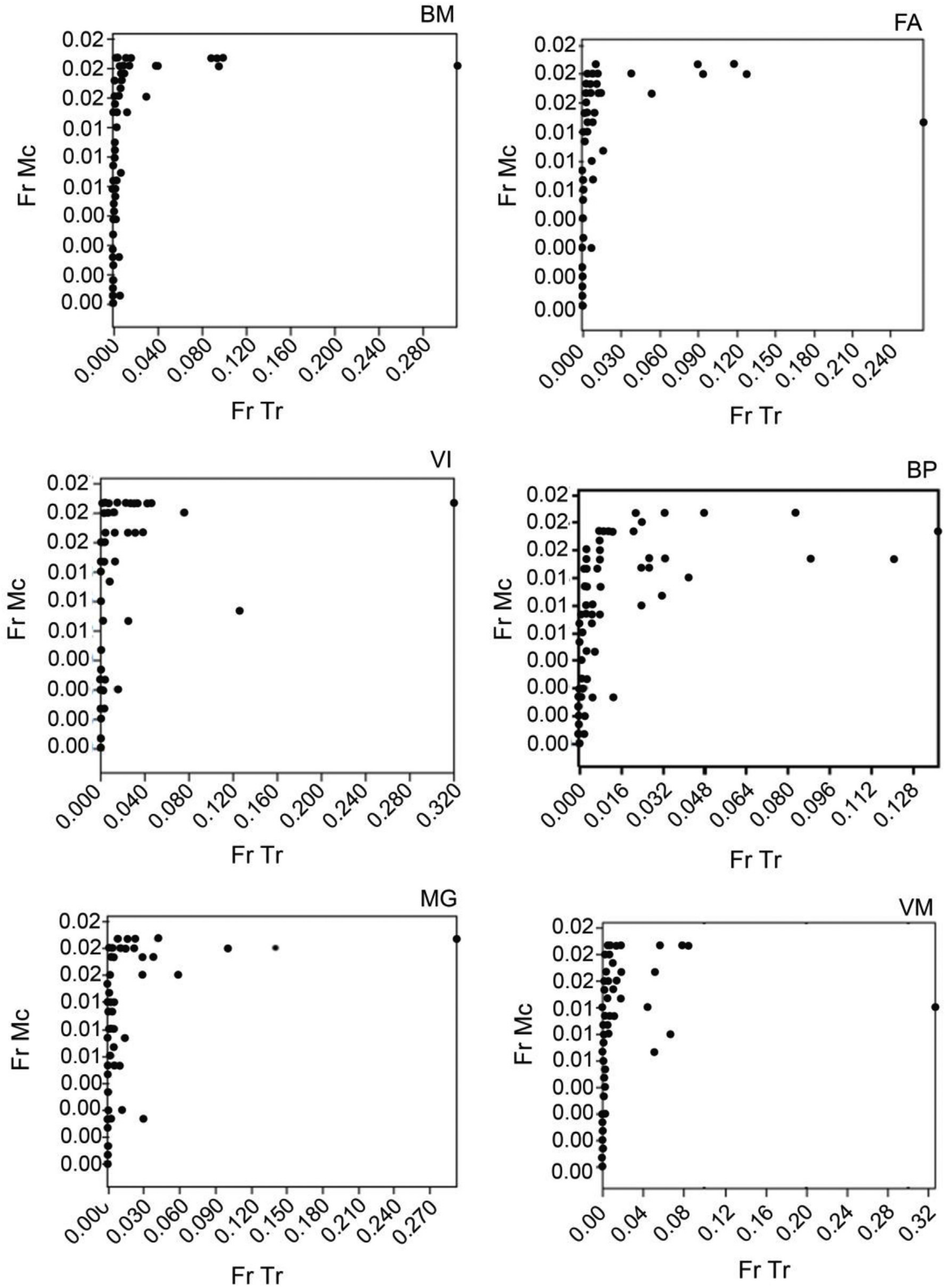

Fig. 1. Relationships between LTM dataset (x-axis: Fr Tr) and MKL dataset (y-axis: FrMc) in the six study sites.

given study site. The relative abundance measure (or 'reporting rate'; Harrison et al., 1997) for each species is the proportion (frequency) of lists it occurs in, assuming that common species will occur on many lists and rare species on only a few (Bibby et al., 2000; Sutherland et al., 2004).

It has been highlighted that McKinnon lists (hereby MKL) may have important strengths. Indeed, other than its simplicity, this method allows (i) to overcome the differences in experience and capabilities of the detectors (less experienced observers simply compile less lists for the same amount of time; Sutherland et al., 2004) and (ii) to maximize the time useful for surveys even when the weather condition is sub-optimal and/or the hourly interval is not appropriate. In this latter case, given that time is not a standardization unit in this method, the negative outcome is simply compile less lists in the time unit (Bibby et al.,

Table 1
Statistics of the correlation analyses between LTM dataset and MKL dataset for each study area (for abbreviations, see Methods).

	χ^2	AIC	R^2	F	p
BM	0.007652	6.2341	0.31075	24.121	< 0.001
BP	0.0071529	6.2336	0.29034	21.889	< 0.001
FA	0.007864	6.2343	0.28341	21.16	< 0.001
MG	0.0041111	6.2305	0.509	55.462	< 0.001
VI	0.0073193	6.2337	0.28611	21.442	< 0.001
VM	0.0063341	6.2327	0.28017	20.823	< 0.001

2000).

MKL has been applied in several geographical contexts, including South America (e.g. South Andean forests; Poulsen et al., 1997; Bolivia: Herzog et al., 2002; Herzog et al., 2005; MacLeod et al., 2011; Ecuador: O'Dea et al., 2004; Brazil: Ruiz-Esparza et al., 2015), Africa (Tanzania; Fjeldså, 1999; Rija et al., 2015; Madagascar: Watson et al., 2005; O'Dea et al., 2004) and Australasia (Papua New Guinea: Dawson et al., 2011; Nepal: Basnet et al., 2005; Chaudhari et al., 2009; Indonesia: Purnomo et al., 2012). As a general rule, most authorities suggested that the length of each list (i.e. the number of species included in a list) should change according to the relative richness of the site: for instance, in species-poor sites (temperate regions), the number of species per list should be lower (15 species in Chaudhari et al., 2009; 10 species in Poulsen et al., 1997; Herzog et al., 2002; Dawson et al., 2011) than in species-rich sites such as in the tropics.

Many authors acknowledged that MKL could assess accurately the species composition of a given site, and it may also provide a quantitative assessment of species richness by accumulation curves (MacLeod et al., 2011). However, whether MKL data are positively correlated with abundance-based methods (for instance transect-line and/or point counts) has not been carefully tested up to now. Thus, the ecological implications of using one method instead of the other remain largely debatable. O'Dea et al. (2004) compared in a same study site the MKL species frequency with abundance-based species frequency data (point counts), and concluded that species richness estimates generated from MKL data provided a more accurate estimate of the magnitude of the species richness, whereas it failed to reflect accurately the structure of communities as quantified by an index of community evenness.

In this paper, we compare the species frequencies obtained for a same set of sites (Mediterranean wetlands in central Italy) by MKL and an abundance-based method (line-transect method; hereby LTM). Analogously to the point-count method, LTM allows to obtain frequencies that highly reflect the 'true' frequencies of species in a site (Järvinen and Väisänen, 1983). In this regard, our hypothesis is that species frequencies obtained by MKL (i.e. the proportion of lists on which each species was recorded) do correlate with species frequency obtained by LTM, that has been traditionally used to obtained relative abundance of birds in the wild. This study represents the first application of MKL in the European context.

2. Materials and methods

2.1. Study area

Our study was carried out in the Litorale Romano nature state reserve (LRNR), that is considered an Important Bird Area, established in 1996, extending over an area of 16,214.65 ha, in the municipalities of Rome and Fiumicino along the Tyrrhenian coast (central Italy), at an elevation of 0–10 m a.s.l. This area is characterized by the presence of ecosystems that in origin were high nature valleys but that nowadays are fragmented and isolated from an important road network, small urban sites, commercial and industrial infrastructures. Since this area is part of a large land reclaimed landscape (Bonifica di Maccarese), there are a large number of remnant wetland that represent sites of stop-over for migratory water-related birds, especially during the winter period (Brunelli et al., 2009).

2.2. Protocol

Inside the LRNR, we selected six ecologically different wetland remnant patches described below:

- Vasche di Maccarese (VM; WWF Oasis) and adjacent fields and adjacent fields (269500 E, 4638700 N). The area located within a large landscape matrix of cultivated fields extends for 292 ha, and is occupied partly by five artificial basins (33 ha) now naturalized with aquatic vegetation, Eucalyptus patches (*Eucalyptus globulus, Eucalyptus camaldulensis*), reed beds with *Phragmites australis* and synantropic vegetation (*Rubus fruticosus*).
- Macchiagrande di Focene (MG; WWF Oasis) and adjacent fields (268900 E, 4634400 N). The area extends for 421 ha and include the Macchiagrande Oasis, a Special Area of Conservation (code IT6030023; 92/43/CEE 'Habitat' Directive; 300 ha) that encompasses environments such as dunes, Mediterranean retrograde bush, hygrophilous forests, pine forests and meadows. From the sea inward, vegetation follows the typical succession of coastal ecosystems.
- Bosco Foce dell'Arrone (FA; WWF Oasis) and hygrophilous wood 'Le Cesoline' (266600 E, 4638800 N). Near the river Arrone, in the area between Maccarese and Fregene, there are patches of Mediterranean bush and hygrophilous woods in *Fraxinus angustifolia*, *Ulmus minor* and *Cornus mas* covering an area of 67 ha
- Bonifica di Maccarese (BM; 270800 E, 4636400 N) and Bonifica delle Pagliete (BP; 268200 E, 4641600 N). The two areas extend respectively for 1584 and 947 ha and are characterized by a landscape matrix with intensive crops and a network of land reclaimed channels for drainage and irrigation. Along these channels tree species (*Eucalyptus globulus, Eucalyptus camaldulensis, Platanus hybrida* and *Populus alba*) are present.
- Le Vignole (VI; 274900 E, 4632500 N). This area has been affected during recent years by extensive development from both commercial and residential urbanization. It extends for about 477 ha; despite the massive anthropogenic component, it maintains environments with a certain naturalness: ponds, ditches and channels, trenches, flooded fields. The prevailing vegetation is made up of herbaceous layers of synanthropic origin and arboreal-bushy shrubs (*Eucalyptus* sp. and *Tamarix* sp.).

We carried out the field sampling during the wintering period from 1 December 2015 and 31 January 2016. Five researchers (MC, RS, MC, MR, RDG) carried out the data sampling: to control a possible 'inter-observer effect' (that could affect data reliability; Battisti et al., 2014) researchers randomly selected each transect session in each site, alternating them so that each transect was sampled by all of them.

In each area, data were collected concomitantly through both LTM (Järvinen and Väisänen, 1983) and MKL (McKinnon and Phillips, 1993). Therefore, in each study area we carried out both of methods, covering the same proportion of habitat types locally occurring.

In MKL, differently from LTM, the research effort (used to normalize data) is expressed in terms of number of lists of species of predetermined length compiled, rather than time spent in the field. In our case, MKL method, during each visit, was based on lists consisting of 40 species. Since the number of species for each list is not fixed but it depends from the species richness of the studied communities (Poulsen et al., 1997; Bibby et al., 2000: 123), we decided that 40 species/list was most appropriate and representative for these species-rich wet ecosystems. When the first list was completed, a second list of the same length, including both new species and those already found and included in previous list, was filled. Overall, we compiled 200 lists (total number of occurrences detected: 8000; 445.2 h of field observations).

Therefore, we obtained a relative frequency of each species in each area by computing the ratio between the species' occurrence in the lists and the total number of occurrences in all the lists.

Regarding LTM, we counted the total number of individuals for each species that were observed along 1 km transect, that was covered by walk in 30 min (58 km of semi-quantitative linear transects). We did not set limits in fixed width for the transects. These routes, appropriately spaced apart so as to avoid recounting of a same individual bird, and covering the different environments and sectors of each area, were made from half an hour after dawn and up to an hour before sunset. We did not include bird concentrations in roosts. LTM was suspended during strong rains and heavy wind, in order to avoid unfavourable conditions (Bibby et al., 2000). Overall, we carried out 29 h of field observations. All collected data were archived in 'ornitho.it', an online freely-available ornithological web platform with all databases being made with Access 2007 (Microsoft Corporation, USA).

2.3. Data analysis

We obtained for each site the species-specific frequency of occurrence ('reporting rate'; Harrison et al., 1997) from MKL as the proportion of occurrences of a given species (n. occurrences/[total number of lists x 40]). We obtained for each site the species-specific frequency of abundance from line transects as the ratio between the number of detected individuals and the total number of individuals detected.

Correlation analyses were performed between MKL and LTM datasets for each study area. Small-sample Akaike Information Criterion (AICc) scores for each correlation model were calculated. Alpha was set at 5%. Past 3.0 software was used for all analyses.

3. Results

We detected 110 species with MKL and 83 species with LTM (Supplementary materials, Table S1). Once corrected per field effort unit, LTM reached higher numbers of detected species than MKL (respectively, 1.14 species per hour versus 0.25 species per hour). Obviously, this difference in numbers of species per hour by methods also depended on that the percentage of detected species was much higher in MKL, thus showing that the plateau phase in the number of detected species was reached in one case and not in the other (our unpublished data). The summarized correlations between MKL and LTM datasets are given in Fig. 1. AICc scores for each correlation analysis were similar, thus showing that the datasets are comparable among the various study areas (Table 1), and in all cases, the two methods provided highly significant positively correlated datasets (Table 1 and Fig. 1). However, in all six areas, the shape of the relationship was clearly not linear. There was an asymptotic trend with a rapid accumulation of the data points since the early transect frequencies; thus, it is sufficient a small increase in commonness along the transect lines to observe a much larger increase in MKL frequencies. In a few sites, there were some species that were outliers compared to the general trend (Fig. 1).

4. Discussion

Our study showed that:

(i) in all sites, the correlation patterns between the two studied methods was similar, with rapid cumulating curves of LTM frequencies toward the asymptote represented by the maximum value in MKL frequency;
(ii) a large amount of species having a low frequency by LTM showed a high range of variation in MKL frequency;
(iii) the set of LTM subdominant (> 0.02- < 0.05) and dominant species (> 0.05) frequencies showed the highest value in MKL frequency.

However, there was no linear correlation between the frequencies of rare species obtained with LTM and MKL, and this pattern was due to the higher survey effort with the latter method, both in terms of time spent in the field and in terms of spatial coverage of the study area. Thus, with MKL, there was a higher chance to detect rare species merely because more time was spent to survey the study area by this method.

The occurrence of outliers in a few sites can be interpreted with the fact that these points are relative to flocking species, i.e. those species showing an aggregated behaviours (i.e., for a single occurrence there are many individuals and, therefore, an higher abundance). Obviously, it should be reminded that MKL values do indicate frequencies of occurrence in the lists, whereas LTM values do indicate an abundance-based frequency estimate. Therefore, the observed patterns should reflect this comparison. Indeed, O'Dea et al. (2004) highlighted as MKL may show a bias towards solitary and territorial species and against flocking species when compared to point count methods. Consequently, this method appear more suitable when species are evenly distributed across the landscape (Sutherland, 2006).

Therefore when comparing these different methods, MKL provides only a coarse-grained proxy of species frequency of individuals distinguishing only between common species (having the highest values of MKL frequency) and rare species (all the other species). Moreover, MKL does not properly discriminate the frequency inside the set of common species (sub-dominant and dominant species). That is, common species having a different LTM frequency have the same value of MKL frequency. Also Fjeldså (1999) noticed that MKL does not allow to properly distinct the intra-site frequencies within the common species subset. In this sense, although it has been suggested that frequencies obtained by MKL can be used for defining more complex univariate metrics of diversity (Shannon index, evenness; see Bibby et al., 2000: 118), we suggest that this may introduce considerable biases in the outcomes and should therefore be avoided.

MKL had however some strength aspects that should be remarked. To begin with, MKL allows to carry out rapid assessments of full species composition in species-rich habitats that are relatively unknown and when rapid surveys are necessary, allowing to visit a large number of site in a short period of time, without require a study plot (Poulsen et al., 1997; O'Dea et al., 2004). In addition, it allows a meaningful comparison of species frequencies across sites (Bibby et al., 2000), as it minimizes the observer's biases. Indeed, MKL, not normalized to time effort, is less sensitive to difference in ability between observers or even loss of concentration by an observer throughout the surveying process. Therefore, MKL significantly reduces any observer's bias, compensating for the fact that less skilled observers will take longer times to accumulate species lists (Bibby et al., 2000). MKL also identifies the minimum amount of research effort needed to survey a study site, since a plateau is achieved when fewer (or no one) species are discovered with continuing effort (McKinnon and Phillips, 1993), and it allows a greater proportion of the available field time to be spent collecting bird data when compared to more expensive methods (e.g. point counts or line transects).

Further studies should test the reliability of MKL to predict relative abundances also when compared to other approaches (e.g. mapping method; time species count; Pomeroy and Dranzoa, 1997) with implication also for other taxonomic groups, since it has already been used, for instance, with amphibians (Muir and Muir, 2011).

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.actao.2018.04.002.

References

Basnet, Y.R., Tamang, B., Benu, G., 2005. Bird Diversity and Their Habitat Status at Raja Rani Community Forest, Bhogteny, Morang, Nepal. Bird Conservation Nepal, Katmandu, Nepal.
Battisti, C., Dodaro, G., Franco, D., 2014. The data reliability in ecological research: a proposal for a quick self-assessment tool. Nat. Hist. Sci. 1 (2), 75–79.
Bibby, C.J., Burgess, N.D., Hill, D.A., Mustoe, S.H., 2000. Bird Census Techniques, second ed. Academic Press, London.
Bart, J., Klosiewski, S.P., 1989. Use of presence-absence to measure changes in avian density. J. Wildl. Manag. 53, 847–852.
Brunelli, M., Corbi, F., Sarrocco, S., Sorace, A., 2009. L'avifauna acquatica svernante nelle zone umide del Lazio. Edizioni ARP (Agenzia Regionale Parchi), Edizioni Belvedere, Latina.
Chaudhari, U.K., Kafle, G., Baral, H.S., 2009. Avifaunal diversity of Khata Corridor forest. J. Wetl. Ecol. 2, 48–56.
Dawson, J., Turner, C., Pileng, O., Farmer, A., McGary, C., Walsh, C., Tamblyn, A., Yosi, C., 2011. Bird communities of the lower Waria valley, Morobe Province, Papua New Guinea: a comparison between habitat types. Trop. Conserv. Sci. 4, 317–348.
Fjeldså, J., 1999. The impact of human forest disturbance on the endemic avifauna of the Udzungwa Mountains, Tanzania. Bird. Conserv. Int. 9, 47–62.
Harrison, J.A., Allen, D.G., Underhill, L.G. (Eds.), 1997. The Atlas of Southern African Birds. BirdLife, Johannesburg, South Africa.
Herzog, S.K., Kessler, M., Cahill, T., 2002. Estimating species richness of tropical bird communities from rapid assessment data. Auk 119, 749–769.
Herzog, S.K., Kessler, M., Bach, K., 2005. The elevation gradient in Andean bird species richness at the local scale: a foothill peak and a high-elevation plateau. Ecography 28, 209–222.
Järvinen, O., Väisänen, R.O., 1983. Correction coefficients for line transect censuses of breeding birds. Ornis Fenn. 60, 97–104.
MacLeod, R., Herzog, S.K., Maccomick, A., Ewing, S.R., Bryce, R., Evans, K.L., 2011. Rapid monitoring of species abundance for biodiversity conservation: consistency and reliability of the MacKinnon technique. Biol. Conserv. 144, 1374–1381.
McKinnon, J.R., Phillips, K., 1993. A Field Guide to the Birds of Borneo, Sumatra, Java, and Bali, the Greater Sunda Islands. Oxford University Press, Oxford.
Muir, A.P., Muir, M., 2011. A new rapid assessment technique for amphibians: introduction of the species list technique from san José de Payamino, Ecuador. Herpetol. Rev. 42, 184–186.
O'Dea, N., Watson, J.E.M., Whittaker, R.J., 2004. Rapid assessment in conservation research: a critique of avifaunal assessment techniques illustrated by Ecuadorian and Madagascan case study data. Divers. Distrib. 10, 55–63.
Pomeroy, D., Dranzoa, C., 1997. Methods of studying the distribution, diversity and abundance of Birds in East Africa – some quantitative approaches. Afr. J. Ecol. 35, 110–123.
Poulsen, B.O., Krabbe, F., Frolander, A., Hinojosa, M., Quiroga, C., 1997. A rapid assessment of Bolivian and Ecuadorian montane avifaunas using 20-species lists: efficiency, biases and data gathered. Bird. Conserv. Int. 7, 53–67.
Purnomo, H., Mulyani, Y.A., Mardiastuti, A., 2012. Bird diversity in several habitat types in Pondok Ambung research station, Tanjung Puting National Park, central Kalimantan. J. Biol. Indonesia 8, 211–216.
Rija, A.A., Mgelwa, A.S., Modest, R.B., Hassan, S.N., 2015. Composition and functional diversity in bird communities in a protected humid coastal savanna. Adv. Zool. 1–7 ID864219.
Ruiz-Esparza, J., Silva dos Santos, C., Alves da Cunha, M., Pinheiro Bitencurti Ruiz-Esparza, D., da Rocha, P.A., Beltrão-Mendes, R., Ferrari, S.F., 2015. Diversity of Birds in the Mata do Junco State Wildlife Refuge, a Remnant of the Atlantic Forest of Northeastern Brazil. Check List 11, Article 1647.
Sutherland, W.J., 2006. Ecological Census Techniques. A Handbook, second ed. Cambridge University Press, Cambridge.
Sutherland, W.J., Newton, I., Green, R., 2004. Bird Ecology and Conservation. A handbook of techniques. Oxford University Press, Oxford.
Watson, J.E., Whittaker, R.J., Dawson, T.P., 2005. The importance of littoral forest remnants for indigenous bird conservation in south-eastern Madagascar. Biodivers. Conserv. 14, 523–545.
Williamson, K., 1964. Bird census work in woodlands. Hous. Theor. Soc. 11, 1–22.