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Monitoring communities of small birds: a comparison between mist-netting and counting

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Capsule Counting and mist-netting provided different estimates of abundance.

Aims To compare the efficiency, constraint and bias of mist-netting versus line transects for the estimation of species richness and abundance of passerines.

Methods Mist-nets (126 linear metres) placed crossing a 420 m-long hedgerow line, open for four hours starting at dawn, four days per month from June 2006 to May 2007. During this same period, we conducted a transect parallel to a 1.3-km hedgerow line, four times per month.

Results Estimation of species richness did not vary between methods, even when controlling for ecological groups, whereas the abundance estimations did vary.

Conclusions Overall, line transects are better than mist-netting for estimating species richness and abundance since they are less costly, less invasive, and less time-consuming. However, if fine ecological analyses are required, including species abundance, mist-netting is preferred for solitary passerines that feed on insects and forage in the foliage, and line transects are better for gregarious passerines that feed on seeds or forage on the ground.

Studying bird communities is a common goal for ecological, management and conservation issues. However, the actual methods used to monitor bird communities and populations are of considerable importance (Ralph *et al.* 1993, Bibby *et al.* 2000, Ralph & Dunn 2004).

Bird counts are among the most widespread techniques used in studies of bird communities and populations (Bibby *et al.* 2000). Nevertheless, the use of data derived from mist-netting at ringing stations has become more common over the last decades (Ralph & Dunn 2004). Standardized mist-netting studies have been widely used to monitor population changes (Peach *et al.* 1996) or to assess parameters such as survival (Buckland & Baillie 1987, Peach *et al.* 1990) or productivity (Ralph & Dunn 2004).

A number of studies have been carried out with the aim of comparing the efficacy and accuracy of each methodology (Faaborg *et al.* 1978, Gram & Faaborg 1997, Whitman *et al.* 1997, Wang & Finch 2002). In contrast to mist-nets (MN), counts normally demand less sampling effort (Beehler *et al.* 1995, Whitman *et al.* 1997) and are less invasive as birds are not captured. One disadvantage, however, is that detection in counts is biased by observers' visual and auditory abilities (Karr 1981, 1990). Although MN solve this problem, they have some relevant biases that depend on the features and location of nets, weather and the spatial behaviour of birds (Karr 1981, Jenni *et al.* 1996). However, without targeted studies in a given place or habitat, it cannot be determined which method is better, since the accuracy can depend on additional parameters that vary with time, target species, or habitat/ecosystem structure and complexity (Gram & Faaborg 1997, Whitman *et al.* 1997).

Many studies that compare MN with other methods based on bird counts were developed in evergreen tropical and sub-tropical forest habitats (Gram & Faaborg 1997, Whitman *et al.* 1997, Wang & Finch 2002). In Europe, such analyses are rare (Poulin *et al.* 2000), although both MN and bird counts are widely used to survey the structures and dynamics of bird communities and populations (Bibby *et al.* 2000, Ralph & Dunn

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2004). Our aim was to compare the efficiency, constraint and bias of MN and counts at line transects (LT) to estimate the richness and abundance in a community of passerines in a European Atlantic shrubby habitat.

MATERIAL AND METHODS

Sampling area and monitoring techniques

Data were obtained in a 50-ha fenced area at Loza, northern Iberia (42° 50′ N, 01° 43′ W, 400 m asl), with meadows (75–80% of the surface), reed-beds (10%), and hedgerows and poplar groves (10–15%). Loza is used as a stopover site by several migratory species and, therefore, it is a target area for bird conservation at a local scale (Arizaga *et al.* 2009).

Five lines of MN (two of 24 m each, two of 12 m each and one of 54 m) were equally distributed across a 420-m length of hedgerow (Fig. 1). The hedgerow was composed of several woody species: brambles *Rubus* spp., rosebushes *Rosa* spp., elders *Sambucus* spp., hawthorns *Crataegus* spp., and some elms *Ulmus* spp. MN were open for four hours starting at dawn, four times per month, from June 2006 to May 2007. Once captured, each bird was ringed, measured (data not used in this work) and released.

During this same period, we conducted a LT parallel to a 1.3-km hedgerow line (which included the 420-m section sampled by MN) (Fig. 1), starting at dawn, four times per month. This transect was travelled at a speed of approximately 2 km/h. We only considered those birds detected within a band of 10 m from the LT, and only on one of the sides (hedgerow) along the LT (the habitat was hedgerow on one side and open field on the other, Fig. 1).

Both monitoring techniques were assumed to provide data representative of the community and, therefore, differences in the structure and the seasonal dynamics of the community should be attributed to methodological biases.

Species richness analyses

Dates were pooled into months, the time unit for the analyses. The means are given ± se, and the programs used were SPSS v. 13.0, PAST v. 1.6 (Hammer *et al.* 2001) and ESTIMATES v. 8.0 (Colwell 2006).

We studied whether species richness (and its time-dependent variation) and bird assemblage varied between the methods. Observed values of richness were not used to compare species richness between methods, because not all species are detected with the same likelihood, and this can also vary over time (Boulinier *et al.* 1998). To estimate species richness we used jackknife re-sampling, which assumes that detection likelihood differs between species (Smith & van Belle 1984). Jackknife was calculated using PAST software (Hammer *et al.* 2001). A *t*-test was used to compare species richness estimation between the two methods.

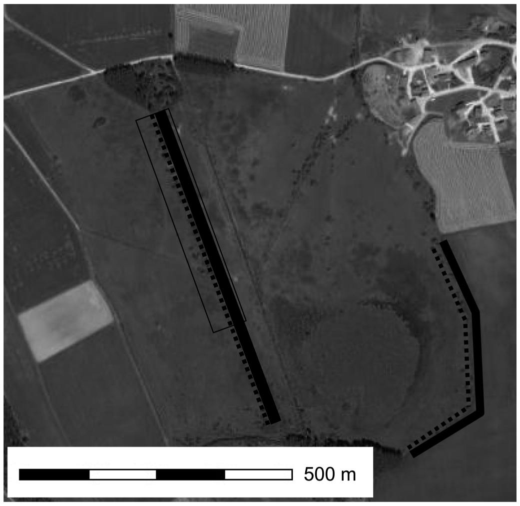

Figure 1. The sampling area and the location of mist-nets (open square), line transects (dotted line) and shrubs (black line).

Hierarchical analyses of clusters were run with the aim of estimating community assemblage over the whole annual cycle, using the UPGMA method with Jaccard similarity index based on species' presence/absence (Sneath & Sokal 1973). We also performed a Correspondence Analysis, in order to evaluate which species could explain the results of the Hierarchical Analysis of Clusters (i.e. the assemblages).

Complementarily, contingency tables (χ^2 tests) of months × ecological groups were used to see whether the number (proportion) of species grouped by a number of ecological criteria (Cramp 1988, 1992, Cramp & Perrins 1993, 1994a, 1994b) differed between the two methods. The ecological criteria used here were: degree of gregariousness (solitary – species which are solitary or form sparse flocks; gregarious – species that usually form flocks normally after breeding and during the winter); diet (invertebrates; seeds; fruits); foraging substrates (air; ground; foliage; tree bark) and body size (small – mean body mass <30 g; medium – mean body mass = 30–70 g; large – mean body mass >70 g) (Table 1).

Abundance analyses

Absolute abundances are not comparable between the two methods. Thus, absolute data (captures in MN, counts in LT) were transformed into a percentage, with 100% being the total number of captures or counts over the whole annual cycle within each method. However, to compare both methods we should assume constant detection likelihood across time. Even though this was unknown to us, we considered that such likelihood was not constant over time (e.g. some birds, such as several finch species, are solitary during breeding but gregarious, and thus more conspicuous, during the non-breeding period). Therefore, we used months to control for such a variation in detection likelihood, assuming that this likelihood was constant within a given month. We used method × months contingency tables on captures/counts in order to compare whether the yearly distributions of abundances were similar between methods. Moreover, we used contingency tables of method × ecological group in order to see whether the proportion of capture/counts of ecological groups (Table 1) differed between the two methods. In MN, each bird was considered once a month to avoid pseudo-replications. This is a bias that cannot be solved with counting data.

RESULTS

Species richness

Overall, 46 and 45 species were detected with MN and LT, respectively. A total of 35 species were shared by both methodological approaches; 11 were only detected in MN, and 10 only in LT (Table 1). Richness did not vary between methods (in a given month), except in September and January (Fig. 2), when more species were detected using LT.

The Hierarchical Analysis of Clusters generated two different bird assemblages (Fig. 3). While using MN the community was formed by a 'summer' assemblage from April to October and a 'winter' assemblage from November to March; in LT one of the clusters ranged from May to September and the other one from October to April. Therefore, with MN the 'summer' assemblage included more months (April and October) compared with LT.

Correspondence Analyses (Fig. 4) showed how species and months were correlated. As pointed out earlier, April was one of the two months included in the 'summer' assemblage for MN but in the 'winter' assemblage for LT. Species that explained this result were White Wagtails *Motacilla alba* and Zitting Cisticolas *Cisticola juncidis*, both undetected with MN, and were linked with March and April in LT. Although October appeared in the 'summer' assemblage for MN (Fig. 3), Correspondence Analysis showed that it tended to be more correlated with the 'winter' months, suggesting a weak difference with LT in this case.

Both methods had similar proportions of species when birds were grouped in relation to their gregariousness, diet, foraging substrates, and body size (Table 2).

Abundance

Overall, 2248 captures were obtained with MN (including 2055 new captures and 193 auto-recaptures). In LT, 2633 birds were counted.

The seasonal patterns of distribution of abundances varied between methods ($\chi^2 = 210.745$, df = 11, $P < 0.001$; Fig. 5), although such difference was due to only three months. In particular, the abundance was proportionally higher, both in June and July, for MN, but higher in November for LT (Fig. 5). Fig. 6 highlights that the two most frequent species captured with MN (in June, Eurasian Reed Warbler *Acrocephalus scirpaceus* and Blackcap *Sylvia atricapilla*; in July, Blackcap and European Greenfinch *Carduelis chloris*) were underrepresented in LT. By contrast, in November, almost all the most abundant birds detected with LT were underrepresented in MN.

Overall, 80.1% and 76.0% of the abundance for MN and LT, respectively, was due to the 10 most abundant passerines (Fig. 7). Six out of 10 were common to both methodologies, but their order was different, supporting the hypothesis of species-related differences between both methods for detecting abundance. Thus, Blackcaps were the most abundant bird with MN (26.7% of abundance), but it was ranked to eighth position (5.0% of abundance) for LT. By contrast, Greenfinches were the most abundant bird when we used LT (12.5% of captures), but was in third position for MN (10.6% of captures). There were four warbler (Sylviidae) species that were very abundant in MN, but not in LT (Garden Warblers *Sylvia borin*, Eurasian Reed Warblers *Acrocephalus scirpaceus*, Melodious Warblers *Hippolais polyglotta* and Common Chiffchaffs *Phylloscopus collybita*). Conversely, there were three seed-eaters (Greenfinches, Goldfinches *Carduelis carduelis* and Chaffinches *Fringilla coelebs*), together with Yellow Wagtails *Motacilla flava* that were very abundant in LT, but not in MN.

Abundances also varied between methods when species were grouped in relation to ecological criteria (Table 2). Thus, MN was better than LT in detecting

Table 1. Abundance of each bird species derived from mist-netting (MN) (each bird considered only once a month) or counting in a hedgerow line transect (LT) in northern Iberia for a whole annual cycle (from June 2006 to May 2007), and the way in which species were grouped according to body size and ecological criteria.

Family	Species	MN (captures)	LT (counts)	Gregariousness	Diet	Foraging substrates	Body size
Hirundinidae	*H. rustica*	3	19	Sol	In	Air	Small
	D. urbicum	2	30	Sol	In	Air	Small
Motacillidae	*A. trivialis*	–	4	Sol	In	Gr	Small
	A. spinoletta	1	–	Gre	In	Gr	Small
	M. flava	31	129	Gre	In	Gr + Air	Small
	M. alba	–	2	Gre	In	Gr + Air	Small
Prunellidae	*P. modularis*	17	4	Sol	In + Se	Fo + Gr	Small
Troglodytidae	*T. troglodytes*	13	30	Sol	In	Fo + Gr	Small
Turdidae	*E. rubecula*	102	218	Sol	In + Fr + Se	Gr	Small
	L. megarhynchos	56	54	Sol	In + Fr	Fo + Gr	Small
	L. svecica	1	–	Sol	In + Fr	Fo + Gr	Small
	P. phoenicurus	6	4	Sol	In	Fo + Air + Gr	Small
	S. rubetra	1	4	Sol	In + Se	Fo + Air + Gr	Small
	S. torquata	1	17	Sol	In	Gr	Small
	T. merula	82	133	Sol	In + Fr	Fo + Gr	Large
	T. pilaris	–	12	Gre	In + Fr	Fo + Gr	Large
	T. iliacus	4	–	Gre	In + Fr	Fo + Gr	Medium
	T. philomelos	109	233	Sol	In + Fr	Fo + Gr	Medium
Sylviidae	*C. cetti*	113	268	Sol	In	Gr	Small
	C. juncidis	–	3	Sol	In	Gr	Small
	L. naevia	3	–	Sol	In	Fo + Gr	Small
	A. schoenobaenus	1	–	Sol	In	Fo	Small
	A. scirpaceus	155	27	Sol	In	Fo + Air + Gr	Small
	A. arundinaceus	10	–	Sol	In + Ve + Fr	Fo + Air	Medium
	H. polyglotta	83	43	Sol	In + Fr	Fo	Small
	S. communis	13	4	Sol	In + Fr	Fo	Small
	S. borin	241	13	Sol	In + Fr	Fo + Air	Small
	S. atricapilla	601	132	Sol	In + Fr	Fo	Small
	P. collybita	76	46	Sol	In	Fo	Small

	P. ibericus	1	0	Sol	In	Fo	Small
	P. trochilus	22	4	Sol	In	Fo + Air	Small
	R. ignicapillus	2	0	Sol	In	Gr + Ba	Small
Muscicapidae	*M. striata*	9	24	Sol	In + Fr	Air	Small
	F. hypoleuca	43	38	Sol	In + Fr	Fo + Air + Gr	Small
Aegithalidae	*A. caudatus*	0	5	Gre	In	Fo	Small
Paridae	*C. caeruleus*	21	22	Gre	In + Fr + Se	Fo	Small
	P. major	29	74	Gre	In + Fr + Se	Fo	Small
Certhiidae	*C. brachydactyla*	4	2	Sol	In	Ba	Small
Oriolidae	*O. oriolus*	0	2	Sol	In + Fr	Fo + Air + Gr	Medium
Corvidae	*P. pica*	2	0	Gre	All	Fo + Gr	Large
Sturnidae	*S. vulgaris*	8	0	Gre	In + Fr + Se	Gr	Medium
	S. unicolor	0	54	Gre	In + Fr + Se	Gr	Medium
Laniidae	*L. collurio*	2	2	Sol	In + Ve	Gr	Medium
	L. meridionalis	1	1	Sol	In + Ve	Gr	Medium
Passeridae	*P. domesticus*	27	53	Gre	In + Fr + Se	Fo + Gr	Small
	P. montanus	0	1	Gre	In + Se	Fo + Gr	Small
	P. petronia	0	2	Gre	In + Fr + Se	Gr	Small
Fringillidae	*F. coelebs*	13	104	Gre	In + Se	Fo + Gr	Small
	S. serinus	25	20	Gre	In + Se	Fo + Gr	Small
	C. chloris	238	329	Gre	In + Se	Fo + Gr	Small
	C. carduelis	41	169	Gre	In + Se	Fo	Small
	C. cannabina	32	286	Gre	In + Se	Fo	Small
	P. pyrrhula	1	0	Sol	In + Fr + Se	Fo	Small
Emberizidae	*E. cirlus*	1	1	Gre	In + Se	Fo + Gr	Small
	E. schoeniclus	1	1	Gre	In + Se	Fo + Gr	Small
	E. calandra	0	10	Gre	In + Se	Gr	Medium

Sol, solitary; Gre, gregarious; In, invertebrates; Se, seeds; Fr, fruits; Ver, vertebrates; Gr, ground; Fo, foliage; Ba, tree bark.

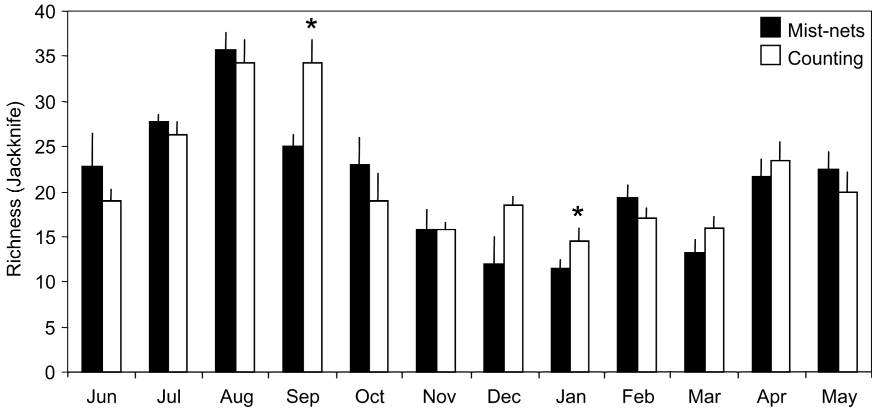

Figure 2. Richness estimation (jackknife ± se). Differences in richness between the two methods for a given month were tested with a *t*-test *Significant differences.

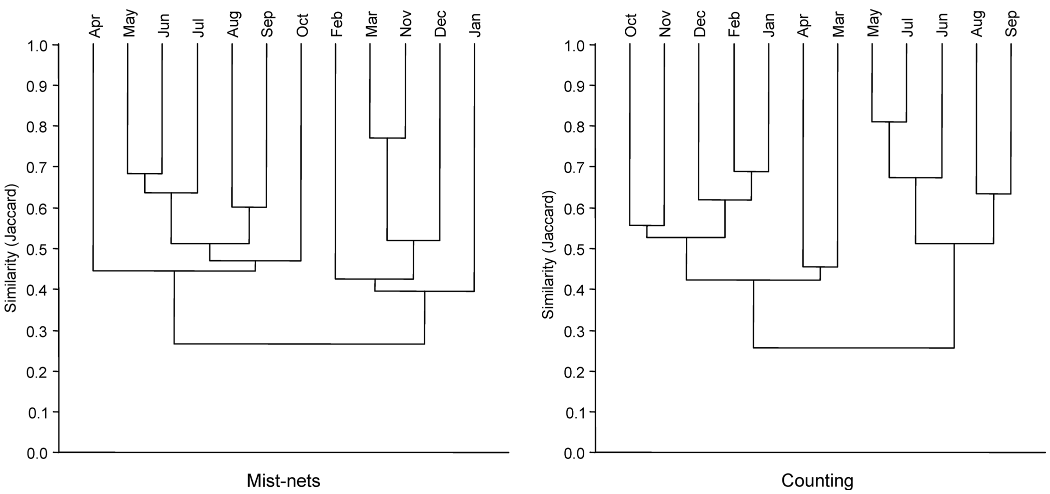

Figure 3. Cluster analyses used to assess the assemblage of passerines over the whole annual cycle.

abundances of taxa which are socially solitary (78.9% versus 51.6%), feed on insects (74.5% versus 48.5%), forage only or mostly in the foliage (87.5% versus 70.1%), and have small body size (90.3% versus 83.0%). In contrast, LT was better than MN in detecting abundances of taxa which form flocks (48.4% versus 21.1%), feed on seeds (51.4% versus 24.8%), forage only or mostly on ground (27.0% versus 11.6%) or in the air (2.8% versus 0.6%), and have a larger body size.

DISCUSSION

Species richness

Overall, MN and LT detected 46 and 45 species, respectively, suggesting that both methods were similar in the estimation of species richness. Furthermore, the proportion of species did not differ between methods, after pooling species into ecological groups in relation to their gregariousness, diet, foraging substrates and body size. This contrasts with other studies where species richness was found to be lower when using MN than when using bird counts (Whitman *et al.* 1997, Wang & Finch 2002). In other cases, however, MN have been reported to provide more species than bird counts (Gram & Faaborg 1997).

The first issue to consider is whether comparing our study with those comparing MN to point-counts could be incorrect, since these point-counts differ from LT. At least in some habitats, LT have been documented to find as many (Dobkin & Rich 1998) or more species than other bird count techniques, such as

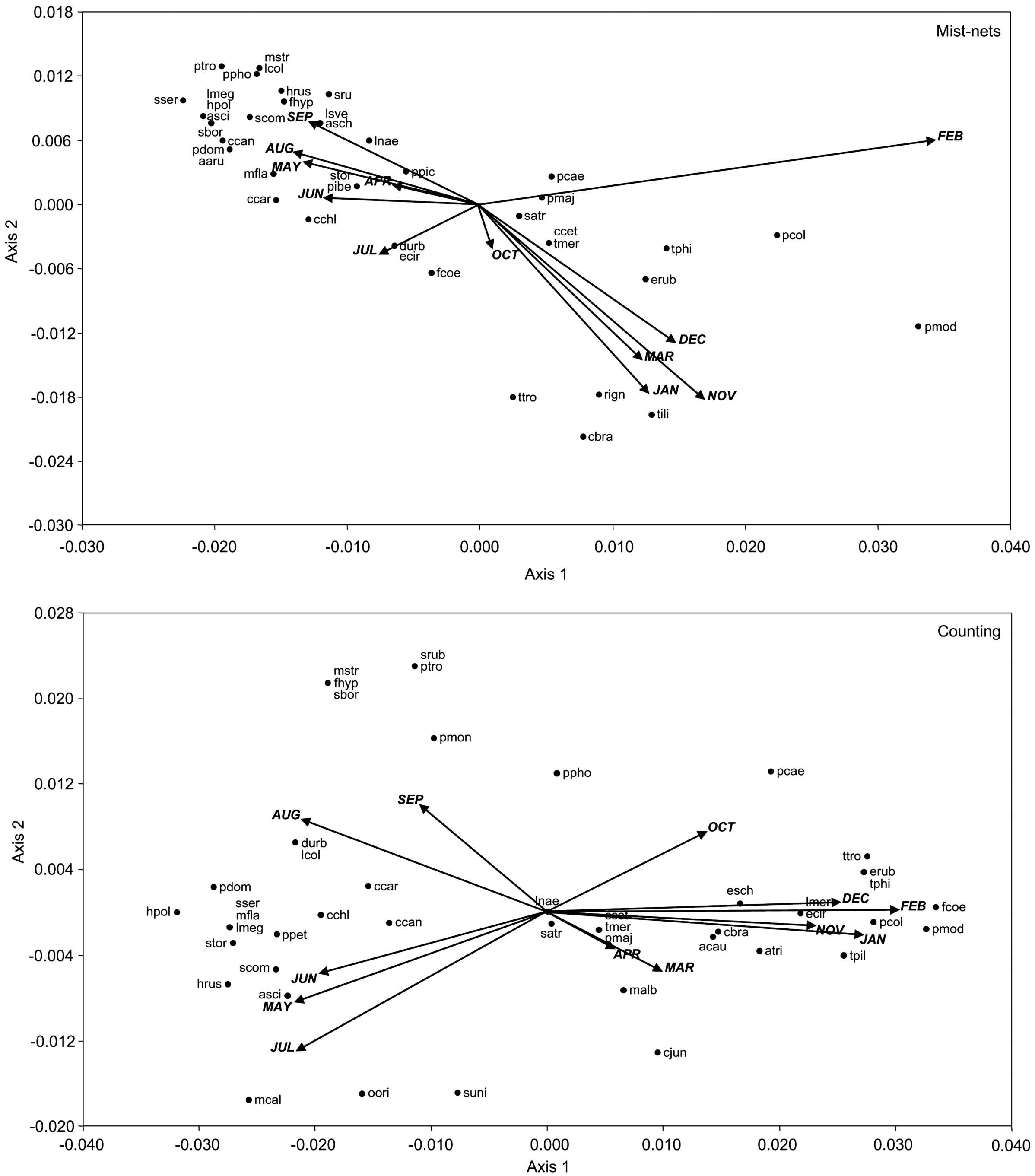

Figure 4. Correspondence analysis used to assess the relationship between species and months.

point-counts or roost-counts (Casagrande & Beissinger 1997, Wilson *et al.* 2000, cf. Verner & Ritter 1985).

However, when the data were analysed by months, small differences arose between methods: richness was relatively higher during September and January for LT. As such, each method gave rise to a different seasonal passerine assemblage. In particular, while in MN the assemblage was formed into clusters from April to October ('summer' community), and November to March ('winter' community), in LT the clusters included the months from October to April and May to September. Correspondence Analyses revealed that these small differences between methods were due to key species which were not equally detected. Thus, in LT, April

Table 2. Annual ecological group-associated richness and captures/counts (abundance) between the two methods, mist-nets (MN) and line transects/census (LT). Statistics used were method × ecological groups contingency tables.

Groups/category	Richness (observed) MN	Richness (observed) LT	Abundance MN	Abundance LT
Gregariousness	$\chi^2 = 0.538$, df $= 1$, $P = 0.463$		$\chi^2 = 393.182$, df $= 1$, $P < 0.001$	
Sol	67.4	60.0	78.9	51.6
Gre	32.6	40.0	21.1	48.4
Diet	$\chi^2 = 2.222$, df $= 6$, $P = 0.993$		$\chi^2 = 499.517$, df $= 6$, $P < 0.001$	
In	34.8	33.3	19.3	22.4
In + Fr	23.9	24.4	55.2	26.1
In + Se	19.6	24.4	16.4	35.3
In + Fr + Se	13.0	13.3	8.4	16.1
In + Ve	4.3	4.4	0.1	0.1
In + Ve + Fr	2.2	0.0	0.4	0.0
Other	2.2	0.0	0.1	0.0
Foraging substrates	$\chi^2 = 2.506$, df $= 8$, $P = 0.983$		$\chi^2 = 618.797$, df $= 8$, $P < 0.001$	
Fo	23.9	20.0	40.0	29.7
Fo + Gr	32.6	28.9	26.3	37.0
Fo + Air	6.5	4.4	12.1	0.6
Fo + Air + Gr	8.7	11.1	9.1	2.8
Gr	15.2	22.2	10.1	22.0
Gr + Air	2.2	4.4	1.4	5.0
Gr + Ba	2.2	0.0	0.1	0.0
Ba	2.2	2.2	0.2	0.1
Air	6.5	6.7	0.6	2.8
Body size	$\chi^2 = 0.002$, df $= 2$, $P = 0.999$		$\chi^2 = 56.740$, df $= 2$, $P < 0.001$	
Small	82.6	82.2	90.3	83.0
Medium	13.0	13.3	6.0	11.5
Large	4.3	4.2	3.7	5.5

Sol, solitary; Gre, gregarious; In, invertebrates; Se, seeds; Fr, fruits; Ver, vertebrates; Gr, ground; Fo, foliage; Ba, tree bark.

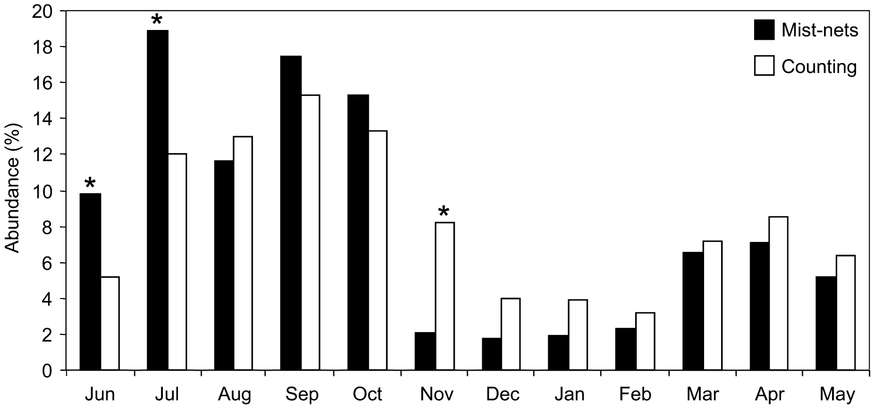

Figure 5. Captures or sightings (%) of passerines for the whole annual cycle.
*Months with a number of captures higher than expected, assuming a similar pattern of distribution of abundances between methods.

appeared as a 'winter' month owing to two species already counted during the winter period, and not detected in MN (White Wagtails and Zitting Cisticolas). Hence, fine conclusions about the community structure differed slightly between methods because of species detection-related biases.

Abundance

The seasonal patterns of distribution of abundances differed between methods. In both cases we found two peaks of abundance in September and March (due to the autumn and spring migrations [Newton 2008]) and

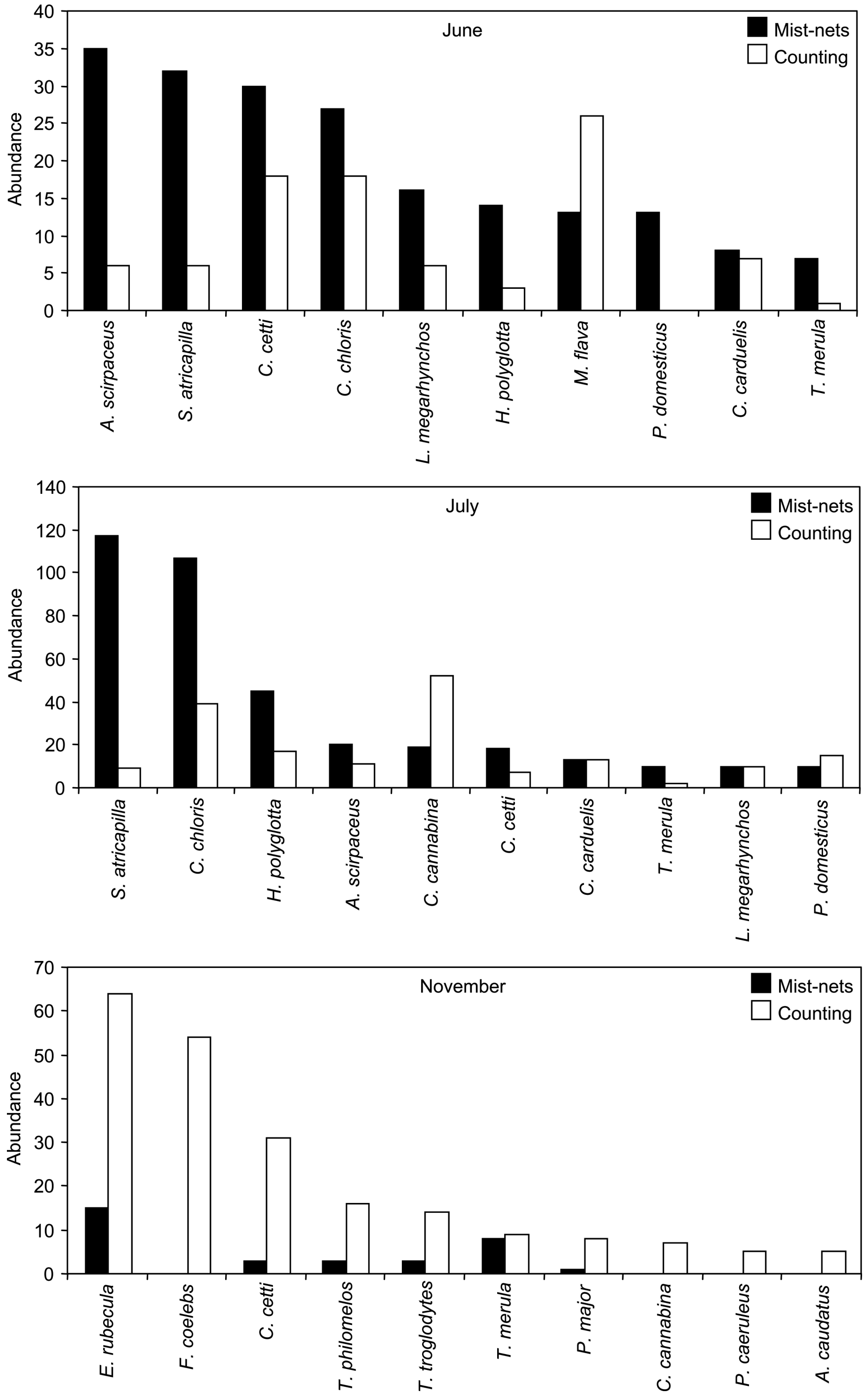

Figure 6. Number of captures of the 10 most abundant birds for the 3 months when the proportion of captures differed between methods (see Fig. 5).

minimum abundance during the winter. However, abundance was proportionally higher during June and July in MN, and in November in LT. Again, this was due to species-related biases; MN was better in detecting abundances of solitary, small insectivorous birds that foraged in foliage, such as many warbler species (Sylviidae). Conversely, LT better detected abundances of gregarious, seed-eaters that mostly fed on the ground, such

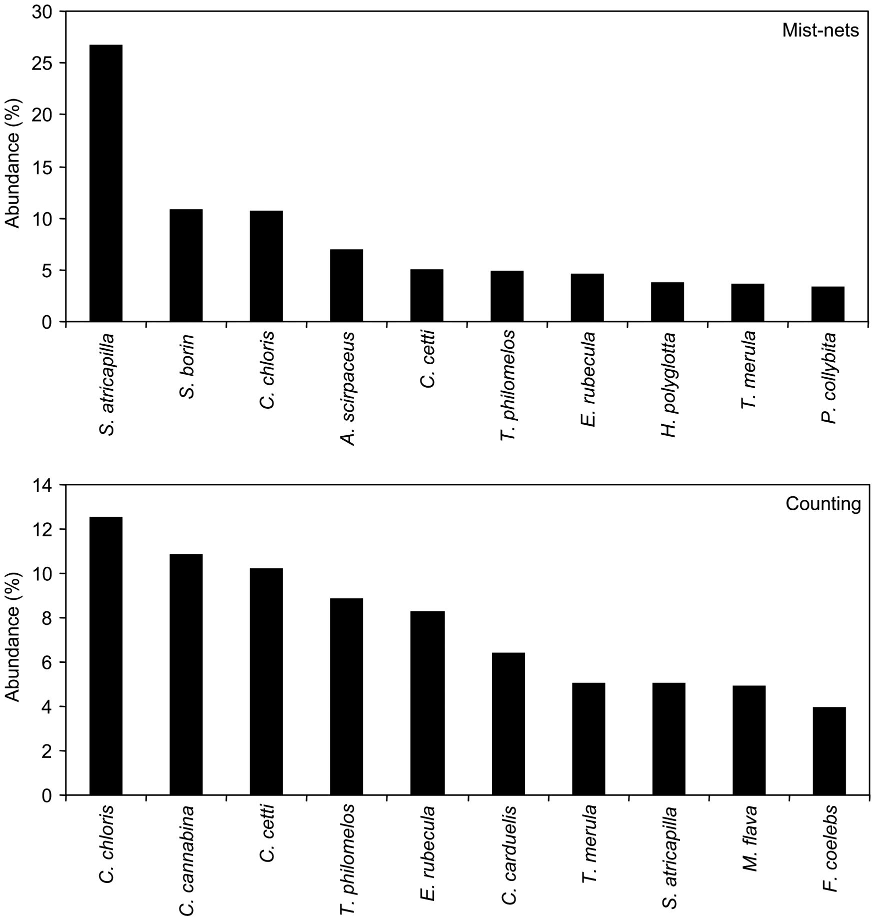

Figure 7. Number of captures (%) of the 10 most abundant birds for the two sampling approaches.

as several finch species (Fringillidae). Also, LT was better in detecting abundances of medium- to large-sized birds that, in contrast, were rarely caught in MN, to some extent due to the mesh size of the nets.

Conclusions

We detected methodologically associated biases in mainly abundance estimations. Thus, LT tended to be better than MN overall, since they are less costly, less invasive, and less time-consuming. However, if fine ecological analyses are required, including species-related abundance, MN is preferred for solitary small birds feeding on insects and foraging in the foliage, while LT are preferred for gregarious passerines that feed on seeds and forage on ground.

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