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CAN CHECKLIST PROGRAMS BE USED TO MONITOR POPULATIONS OF BIRDS RECORDED DURING THE MIGRATION SEASON?

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ABSTRACT.—Quebec's ÉPOQ program compiles birders' "checklists," each of which reports numbers of birds seen on one day at one site. We analyzed ÉPOQ data from the migration season alone (1971–92), to see if these unstandardized counts might monitor trends in populations that nest farther north. Two sets of trends were computed for each of 58 species, from annual indices based either on abundance or on frequency of detection. Both spring ÉPOQ trends were significantly correlated with Breeding Bird Survey trends for Quebec, while only those based on abundance performed well in fall. There was a positive bias in magnitude of ÉPOQ trends, but negative ÉPOQ trends were reliable indicators of negative BBS trends. Analysis of sub-sets of the data showed that sample size had little qualitative effect. Checklist data should not be relied on for quantitative population monitoring, but they do contain useful information for detection or corroboration of negative trends. *Received 27 Aug. 1995, accepted 22 Jan. 1996.*

Most songbirds that breed in North America are monitored by the Breeding Bird Survey (BBS), a breeding season roadside survey along randomly chosen routes across the continent (Peterjohn 1994). Certain species are poorly covered by BBS, however, either because they nest too sparsely or locally to be covered by an adequate number of routes (many raptors and colonial birds, for example) or because they breed in remote areas where BBS routes are largely lacking (e.g., many northern boreal forest breeders). Counting of birds during their migratory passage has been suggested as a means of monitoring some of the species missed by BBS and as a means of corroborating trends detected by other programs. Relatively standardized daily counts of birds at bird observatories and hawk look-outs have been shown to document long-term trends in bird numbers similar to those reported by BBS (reviewed in Dunn and Hussell 1995).

Checklist compilation programs potentially offer another source of data on population trends of migrants. Checklists are pre-printed lists of species on which observers can record their observations for an area of any size and during a period of any length. Compilations of checklist data have several strong points: they cover broad areas where other data might be lacking, and they harness the energy of the myriad birders who already keep careful records of what they see. On the negative side, there is a

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great deal of "noise" in the data, because observations are made opportunistically at any site on any date without any limits on duration of observation or skill of observers. Birders may concentrate on "productive" locations, and likely are not distributed evenly in time (favoring weekends and peak migration periods). There is also potential for consistent bias over time; for example, as bird distribution and abundance change, birders may move to new locations and/or change their search strategies to keep their birding interesting. Moreover, steady improvement in birders' skills and optical aids may have increased detectability of certain species over the years.

Despite these features of checklist data that might obscure any changes in bird populations, it is possible that they still contain useful trend information. Cyr and Larivée (1993) looked for evidence of this, analyzing spring and fall data from the Étude des Populations d'Oiseaux du Québec (ÉPOQ). This is North America's longest-running and largest checklist compilation program, and data are collected according to guidelines designed to maximize scientific value of such projects (Dunn 1995). The ÉPOQ trends in Cyr and Larivée's (1993) study had the same sign (positive or negative) as BBS trends for Quebec in 62% of the 74 species analyzed. These results are not strong, but the analysis was of simple presence/absence data which are limited in ability to detect trends (Bart and Klosiewski 1989).

The aim of this paper is to examine more closely whether checklists might contain useful information on population trends and to determine whether further analyses would be worthwhile.

METHODS

ÉPOQ data are semi-standardized in that each record contains the number of birds seen or heard on a single day's visit to a single locality (within one minute of latitude and longitude, or roughly 3.2 km^2; Cyr and Larivée 1993, 1995). Most lists are submitted by experienced birders, and the vast majority come from the whole length of the St. Lawrence corridor in southern Quebec (map in Cyr and Larivée 1995). Data are quite well distributed over all possible dates (individual days within a year). Although there are fewer than 30 checklists for most dates (54% of spring dates, 89% of fall dates), there are only 29 dates in the 22-year analysis period with no checklists at all (0.2% of spring dates and 1.2% of fall dates), all in the early 1970s. The average number of lists per date increased from 4.5 to 25.4 over the study period. We analyzed all available data within the chosen date limits (see below) regardless of geographic location, length of daily birding trips, number of observers or weather conditions, but did take into account the seasonal pattern in numbers of birds seen, as described below.

We selected data from the spring and fall migration "windows" for each of 58 songbirds (Table 1) for the period 1971–92. This ensured that observations of breeding birds were not mixed with observations of migrants, as could occur if we used data from a single period covering the migration periods of all species. To determine these windows, average daily abundance was plotted against date for each species. Dates were then chosen that included

TABLE 1

SPECIES AND CODES FOR FIGURES, QUEBEC BBS TRENDS, AND ÉPOQ TRENDS (BASED ON ABUNDANCE, FULL DATA SET)[a]

Species	Code (for figures)	ÉPOQ trend		BBS trend
		Spring	Fall	
Chimney Swift (*Chaetura pelagica*)	a	−0.4	−1.8	−3.5
Ruby-throated Hummingbird (*Archilochus colubris*)	b	1.8*	1.7*	1.0
Northern Flicker (*Colaptes auratus*)	c	−0.7+	0.2	−2.1+
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	d	0.3	−0.6	−0.2
Great Crested Flycatcher (*Myiarchus crinitus*)	e	0.3	−0.5	−2.5
Eastern Wood-Pewee (*Contopus virens*)	f	−0.1	−1.0	−1.4
Eastern Phoebe (*Sayornis phoebe*)	g	0.1	2.0+	0.9
Least Flycatcher (*Empidonax minimus*)	h	0.6	−0.9	−2.3
Yellow-bellied Flycatcher (*E. flaviventris*)	i	1.4	−0.3	4.5
House Wren (*Troglodytes aedon*)	j	−0.8	0.5	−3.8+
Winter Wren (*T. troglodytes*)	k	0.7	2.3+	3.5
Golden-crowned Kinglet (*Regulus satrapa*)	l	1.2+	4.0*	−2.0
Wood Thrush (*Hylocichla mustelina*)	m	−1.3*	−4.9*	−3.5
Veery (*Catharus fuscescens*)	n	−0.0	−0.9	−0.1
Swainson's Thrush (*C. ustulatus*)	o	−0.0	−3.2*	−2.3
Hermit Thrush (*C. guttatus*)	p	0.6	−0.1	−0.7
American Robin (*Turdus migratorius*)	q	1.0	1.0	1.0
Gray Catbird (*Dumatella carolinensis*)	r	−2.2*	−1.6+	−5.5*
Brown Thrasher (*Toxostoma rufum*)	s	−2.4*	−2.6	−4.6*
Solitary Vireo (*Vireo solitarius*)	t	0.6	4.5*	8.6+
Red-eyed Vireo (*V. olivaceus*)	u	1.4*	2.0*	2.3*
Warbling Vireo (*V. gilvus*)	v	2.2*	1.9	1.7
Philadelphia Vireo (*V. philadelphicus*)	w	2.0*	−0.1	5.2
Tennessee Warbler (*Vermivora peregrina*)	x	0.5	−1.3	−4.7
Nashville Warbler (*V. ruficapilla*)	y	0.4	−1.9+	−4.2
Northern Parula (*Parula americana*)	z	0.4	3.7*	−0.3
Black-and-white Warbler (*Mniotilta varia*)	A	1.1+	2.0*	4.7+
Black-thrt. Blue Warbler (*Dendroica caerulescens*)	B	0.1	2.6*	1.3
Blackburnian Warbler (*D. fusca*)	C	0.5	4.5*	3.7
Chestnut-sided Warbler (*D. pensylvanica*)	D	0.5	1.8+	−6.5
Cape May Warbler (*D. tigrina*)	E	−1.3*	0.5	−0.2
Magnolia Warbler (*D. magnolia*)	F	1.3*	1.4	5.8
Yellow-rumped Warbler (*D. coronata*)	G	0.5	0.4	2.8+
Black-throated Green Warbler (*D. virens*)	H	0.6	2.0*	0.0
Bay-breasted Warbler (*D. castanea*)	I	−1.3+	−0.5	−9.0
Yellow Warbler (*D. petechia*)	J	0.8*	0.2	2.9+
Mourning Warbler (*Oporornis philadelphia*)	K	0.4	0.0	0.2
Canada Warbler (*Wilsonia canadensis*)	L	0.7	−0.4	−0.6
Ovenbird (*Seiurus aurocapillus*)	M	1.2*	−0.0	−0.4
Northern Waterthrush (*S. noveboracensis*)	N	1.4*	−0.7	−0.5
Common Yellowthroat (*Geothlypis trichas*)	O	0.4	0.2	−2.2+
American Redstart (*Setophaga ruticilla*)	P	1.2*	1.5*	−2.0

TABLE 1
CONTINUED

Species	Code (for figures)	ÉPOQ trend Spring	Fall	BBS trend
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	Q	−0.2	−2.9*	−4.8*
Vesper Sparrow (*Pooecetes gramineus*)	R	−0.3	−1.0	−6.8*
Savannah Sparrow (*Passerculus sandwichensis*)	S	−0.8*	−0.6	−2.3*
Song Sparrow (*Melospiza melodia*)	T	−0.6	0.4	−0.2
Chipping Sparrow (*Spizella passerina*)	U	1.1*	2.0*	1.4
Dark-eyed Junco (*Junco hyemalis*)	V	1.3	1.9+	−3.7
White-throated Sparrow (*Zonotrichia albicollis*)	W	−0.6	−0.6	−1.9*
Lincoln's Sparrow (*Melospiza lincolnii*)	X	1.7*	1.6*	−4.0*
Swamp Sparrow (*M. georgiana*)	Y	0.3	1.1	−5.0
Bobolink (*Dolichonyx oryzivorus*)	Z	−1.8*	−1.2+	−6.2*
Eastern Meadowlark (*Sturnella magna*)	2	−1.5*		−5.3*
Red-winged Blackbird (*Agelaius phoeniceus*)	3	−3.5*		−3.5*
Brown-headed Cowbird (*Molothrus ater*)	4	−4.3*		−7.2*
Common Grackle (*Quiscalus quiscula*)	5	−0.0		0.0
Northern Oriole (*Icterus galbula*)	6	−0.4	−1.6	−2.1
Scarlet Tanager (*Piranga olivacea*)	7	−0.6	−1.7	−1.8

[a] Significance of trends (1971–92) shown by: + = $0.05 < P < 0.10$, * = $P < 0.05$.

the seasonal rise and fall of numbers except for about one week at each end of the season, thus excluding the transitions between migration and stable numbers of either breeding or wintering birds. Of the 58 species analyzed, migration windows for 50 had also been calculated for Long Point, Ontario (Hussell et al. 1992). Timing of peaks and early/late dates differed between the provinces, but the "windows" (which excluded extreme dates) were very similar in both data sets. For convenience, the Long Point dates were used when available. Fall migration windows in Quebec were not clearly definable from ÉPOQ data for Eastern Meadowlark, Red-winged Blackbird, Brown-headed Cowbird, and Common Grackle; (scientific names in Table 1) so these species were excluded from fall analyses.

We calculated annual indices of abundance for each season for each species, using a regression procedure that adjusted the daily total of a species according to date within the season (adapted from the method described in Hussell et al. 1992). If we had merely calculated mean daily count, results would be heavily influenced by numbers seen in peak migration periods and especially by records from "fall-outs" (when heavy migration is halted by a weather front). Instead our approach determines whether the average count for each date (a single day in a single year) is higher or lower than the long-term average count for that date. The resulting annual index of abundance, therefore, reflects the average degree of positive or negative deviation from the expected daily values across the *entire* season.

We did not attempt to correct the data for weather effects or uneven distribution of observers throughout the season or the province. Such factors introduce variability to annual indices, but our assumption was that they did not change systematically through time and, therefore, should not contribute to spurious trends in bird numbers. Those factors most likely to produce consistent bias over time—improvement of skills or change in birders' search behavior, see introduction—cannot in any case be mitigated by data selection or analysis procedures.

Analysis details were as follows. The dependent variable in the regression (run separately for each species for each season) was log (mean daily count + 1), where "daily count" was number of birds per hour in the field for a single checklist, and one was added to the mean to allow log transformation of zeros. Each case was weighted by the number of checklists used to calculate daily mean abundance. Use of "birds/hr" helps standardize values from field trips of different lengths. Log transformation addresses the assumptions of the regression procedure by changing multiplicative to additive effects and by bringing the distribution of daily counts closer to normality (raw counts are skewed).

Independent variables included first to sixth order terms for day (day = 0 for a day near the center of the species-specific migration window) and dummy variables for each year except for one reference year (e.g., Y89 = 1 if year is 1989, otherwise Y89 = 0). The date terms allowed modelling of a relatively complicated seasonal pattern without adding so many terms as to produce overfit. Annual abundance indices were calculated from the coefficients of the dummy variables for year that were estimated in the regression. The annual abundance index was the value of the adjusted mean for year plus one-half of the error variance of the regression (so that corrected estimates in the original scale represent the mean instead of the median; see references in Hussell et al. 1992) back-transformed to the original scale by exponentiating and subtracting one.

A second analysis, similar to the above, was used to calculate annual indices based on frequency (the daily proportion of checklists on which the species was reported present). The only differences were that the dependent variable in the regression was the square root of the arcsin-transformed daily proportion, with appropriate adjustment prior to transformation of proportions equal to 0 or 1 (Snedecor and Cochran 1967:327–328), and we did not add half the error of the variance prior to back-transformation. We refer to this as the "date-adjusted frequency" index.

Trends were calculated separately for spring and fall indices. Those based on abundance were calculated from weighted linear regression of the log of the annual indices on year. (There was no need to add a constant before transformation because annual indices were never equal to zero.) Trends based on frequency were calculated with weighted linear regression of the square root of arcsin-transformed annual indices. In all trend calculations, weights were proportional to the number of checklists contributed each season during the species-specific migration period.

The number of lists compiled by ÉPOQ has increased steadily over the period analyzed from about 2,000 to about 10,000 annually (Cyr and Larivée 1995). In an attempt to circumvent possible bias from this source, as well as to determine what sample size might be sufficient, we reran all procedures on data sets consisting of 1000, then 500, cases selected randomly from each season each year.

ÉPOQ trends were compared to trends from the Breeding Bird Survey (BBS) for Quebec for the same set of years. BBS is a standardized roadside survey in which volunteers make 50 3-min stops every 0.8 km along prescribed routes, recording all birds seen and heard (Peterjohn 1994). Geographical coverage of Quebec is roughly equivalent in BBS and ÉPOQ. BBS trends were calculated using the Canadian Wildlife Survey version of the route regression analysis method (Erskine et al. 1992). All species analyzed were present on at least 22 BBS routes in Quebec during the study period. (The recommended number for meaningful analysis is 15.)

RESULTS

Full data set.—ÉPOQ trends based on abundance indices, both in spring and fall, were significantly correlated with BBS trends (Table 2).

TABLE 2

SPEARMAN RANK CORRELATION COEFFICIENTS BETWEEN ÉPOQ AND BBS TRENDS FOR QUEBEC, 1971–1992[a]

	ÉPOQ indices calculated as:			
Season	Abundance (Birds/hr)	(N)	Date-adjusted frequency	(N)
		Full data set		
Spring	0.58***	(45,578)	0.51***	(66,821)
Fall	0.55***	(27,682)	0.48***	(39,842)
		1000 cases per season		
Spring	0.53***	(19,804)	0.38**	(21,864)
Fall	0.47***	(17,334)	0.32*	(20,253)
		500 cases per season		
Spring	0.50***	(10,728)	0.35**	(11,000)
Fall	0.43***	(10,536)	0.09	(10,959)

[a] See methods for definition of the two ÉPOQ trend calculations. 58 species in spring, 54 in fall. Significance of correlation (two-tailed tests): * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$. Total sample size in parentheses.

However, scatter plots showed that correspondence between the programs was not entirely one-to-one (Figs. 1A and 1B); that is, points were not evenly distributed about the dashed line representing equality of trends. ÉPOQ produced markedly more positive trends than BBS in those species that BBS showed to be declining. Significance of trend in ÉPOQ did not reflect significance in BBS (Table 3), although trends that were significant in both programs agreed in sign in all cases but one.

ÉPOQ trends based on date-adjusted frequency indices were also significantly correlated with BBS trends in both seasons (Table 2). The magnitude of trends based on frequency cannot be compared directly to BBS magnitude because the scales differ (BBS trends are expressed as annual percent change in abundance; ÉPOQ trends are the annual change in arcsin transformed annual proportions of checklists with the species present). However, if the two programs monitor the same phenomena, then the directions of trends should agree. This was largely the case for trends based on date-adjusted frequency indices for spring (Fig. 2A, which has a similar pattern to the spring abundance trends in Fig. 1A). However, fall frequency trends based on ÉPOQ data were much more likely to be negative than were BBS trends (Fig. 2B) and were also more negative than ÉPOQ trends based on abundance (Fig. 1B). Significance of ÉPOQ trends based on frequency did not reflect significance in BBS (Table 3).

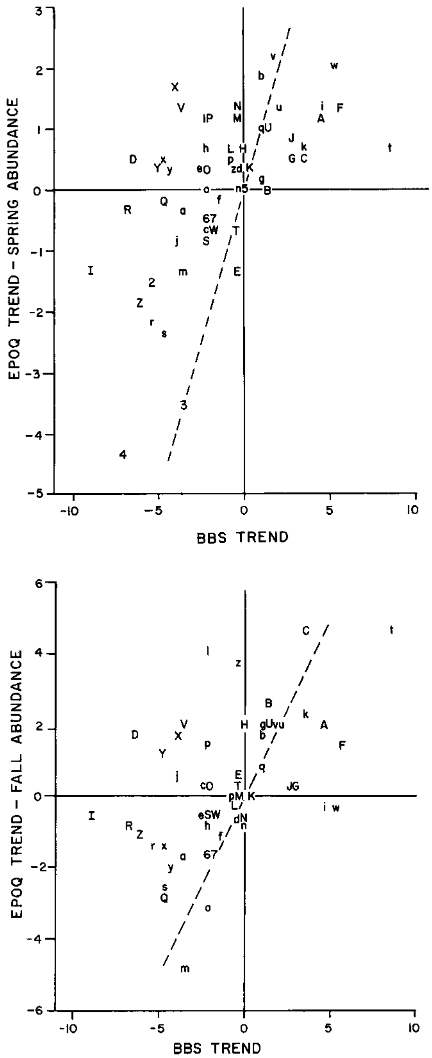

FIG. 1. Trends in ÉPOQ abundance indices for spring (Part A, top) and fall (Part B, bottom) plotted against BBS trends. Trends expressed as annual percent change in abundance. Dashed line shows one-to-one correspondence. See Table 1 for species codes.

Reduced data set.—When the data set was reduced, analyses gave qualitatively similar results to all those presented above. Correlation coefficients were reduced, however (Table 2), due to increased scatter in ÉPOQ trends.

TABLE 3
NUMBER OF SPECIES WITH SIGNIFICANT OR MARGINALLY SIGNIFICANT ($P < 0.1$) TRENDS IN QUEBEC BBS AND ÉPOQ (FULL DATA SET)

Trend significant in:	ÉPOQ abundance trend		ÉPOQ frequency trend	
	Spring	Fall	Spring	Fall
ÉPOQ only	12	15	15	15
Both ÉPOQ and BBS	11	7	14	9
BBS only	7	9	5	8

DISCUSSION

Comparison of analyses.—ÉPOQ indices based on abundance of birds gave the best correspondence to BBS, producing trends that showed the highest level of agreement in direction and magnitude in both seasons.

Bart and Klosiewski (1989) found that BBS trends based on frequency indices generally had the same sign as trends based on abundance (positive or negative), but the two types of trends did not compare well in magnitude. We had similarly expected that ÉPOQ trends based on frequency would not correspond as well to BBS trends as those based on abundance, but this was borne out only by fall results (compare Fig. 1B with Fig. 2B).

Evaluation of checklists in monitoring populations.—The primary uses made of checklist data do not include population monitoring but rather a wealth of other applications such as documentation of range, timing of occurrence in a given region, unusual appearances, and site-specific species composition. These applications do not depend on standard observation protocol and appropriate sampling framework, whereas population monitoring does if it is to be statistically defensible. Nonetheless, our results suggest that checklist data, even when uncorrected for likely sources of spurious variability, do contain information on population trends, albeit biased. (We assume for the purpose of this discussion that BBS is an accurate, unbiased indicator of trends, but of course we cannot be certain of this.)

The positive bias in ÉPOQ trends (Fig. 1) is just what we might expect of checklist data as a result of improving skills and optical aids (see Sauer et al. 1994) or as a result of shifts by birders to more productive birding spots as species decline in previously-favored sites. The positive bias of ÉPOQ trends means that they are less reliable indicators of magnitude than are BBS trends. Analysis procedures could be altered to reduce variation introduced to ÉPOQ indices by factors such as uneven temporal and geographic distribution of observers, but this would likely help only to

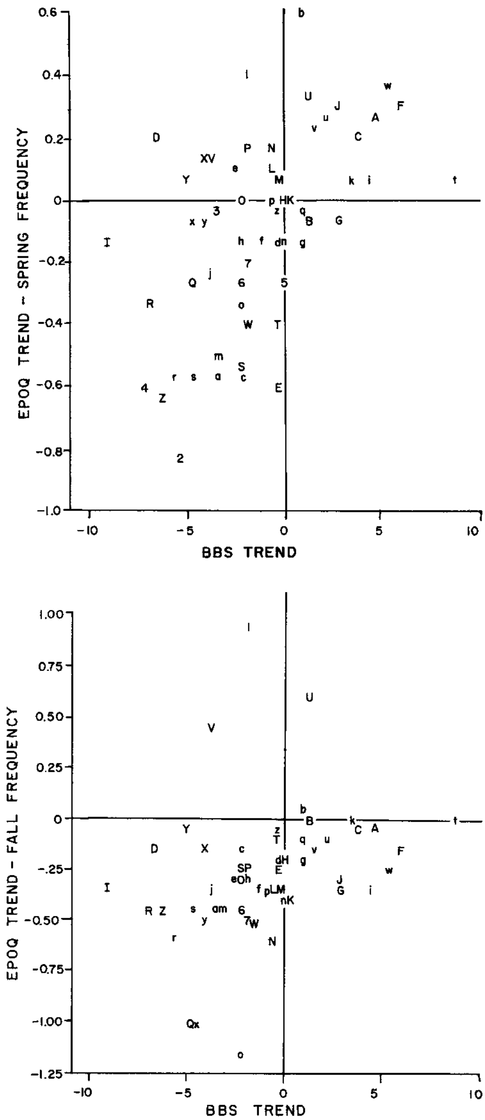

FIG. 2. Trends in date-adjusted frequency indices from ÉPOQ for spring (Part A, top) and fall (Part B, bottom) plotted against BBS trends. Trends expressed as annual percent change in abundance (BBS) and annual change in arcsin transformed annual percentages (see text). See Table 1 for species codes.

improve precision of trend estimates without altering long-term bias and, therefore, may not be worth the effort involved. Despite the bias, however, ÉPOQ abundance indices produced very few "false negatives" (Fig. 1). Thus, while an increasing trend in ÉPOQ does not necessarily indicate a true increase, a negative ÉPOQ trend based on abundance is evidently quite a reliable indicator that some kind of decline is actually taking place. (ÉPOQ frequency indices produced false negatives much more often; Fig. 2.) Declines are of more interest for conservation alerts than are increases, and checklist programs appear to offer a means of detecting some (though not all) declines in species that are poorly covered by standard population monitoring programs. It should therefore be of value to analyze ÉPOQ data from the migration season for species that breed primarily in tundra or northern boreal zones and for which we have no other data on population trend.

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