A FIELD VALIDATION OF SOME COMMON BIRDS CENSUS TECHNIQUES

Raymond J. O'Connor and J. H. Marchant

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*Nominated Officers:- NCC: Dr. D.R. Langslow,
Chief Scientist's Team,
Nature Conservancy Council,
Godwin House,
George Street,
Huntingdon PE18 6BU.

BTO: Dr. R.J. O'Connor
British Trust for Ornithology,
Beech Grove,
Tring,
Herts HP23 5NR.

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SECTION 1

INTRODUCTION

A comprehensive review of all aspects of the Common Birds Census of the British Trust for Ornithology was conducted by Milner and Hornby (1977), at the request of the NCC/ITE Visiting Group of November 1975 to the BTO. The terms of reference of the Milner-Hornby Report were described as:

a) To consider the methodology of the census and the validity of the CBC index.

b) To consider the relevance of the CBC to the needs of the NCC and ITE.

c) To consider alternative methods for monitoring bird populations in Britain.

Following their review Milner and Hornby concluded that the CBC is "as sound a method as could be reasonably achieved for monitoring bird populations, although we recognise it has limitations" and made ten recommendations largely directed at the cost-effectiveness of the scheme. These recommendations focussed on the needs (1) for greater use of computers in handling the large volumes of data generated by the scheme, (2) for greater range and intensity of habitat and regional studies, and (3) for on-going review of particular aspects of the observational and analytical work involved.

Action has been taken in the three areas covered by the Milner-Hornby recommendations since the issue of their Report. In 1979 the NCC provided a large part of the costs of a modern computer system for the BTO for use within the contract activities undertaken by the Trust for the NCC and in exchange for agreed reductions (of three man-years annually) in the level of contract staffing; the BTO provided the balance of the costs of the system. In its first twelve months of operation since full commissioning in August 1979, the system substantiated the expectations of Milner and Hornby. With the aid of computerization progress began towards the large-scale use of CBC data for habitat and regional populations requested by the Report (Cawthorne and Marchant 1980, Morgan and O'Connor 1980, Marchant and Hyde 1980a, O'Connor 1980a, b, 1981, Taylor, Woiwod and Perry 1980, O'Connor and Taylor in prep.). The present report is addressed to the third area covered by Milner and Hornby's recommendations, a review of particular aspects of the CBC procedures.

Scope of report

CBC background

The basis of the BTO Common Birds Census is as follows. Volunteer observers from the Trust's membership visit their defined census plots 8-10 times through the breeding season. On each visit they record accurately on a map (one per visit) the locations of all birds registered (seen or heard) using a standard notation to record all pertinent information (sex, song, territorial defence, breeding activities, flight paths, nest location). At the end of the breeding season the separate visit maps are collated to form a series of species maps for the census plot. In general the coincidence of registrations from the individual visits into discrete clusters suggests the presence of individually recognizable defended territories, but there are many sources of variation in the interpretation of such data e.g. Best (1975). Standard guide-lines to the interpretation of the registrations obtained have existed following international agreement by the International Bird Census Committee (Anon. 1969) and these provide a large measure of standardization in establishing cluster counts for a given census plot. When results for large numbers of census plots are available from year to year the percentage change in population level can be established and the population level monitored from year to year by the CBC index, adjusted to an arbitrary figure of 100 in 1966. Separate indices are computed for farmland and for woodland census plots e.g. Marchant and Hyde (1980a) - and a Scarce Species Index computed for the rarer species not adequately represented in either major category (ibid.). Between them these indices monitor the populations of some 60 species. A further 7 species are monitored using the "linear CBC" technique of the BTO Waterways Birds Survey (Williamson 1974a, Marchant and Hyde 1980b).

Copies of the current (1980) CBC Instructions and of the Guiding Principles for the analysis of CBC returns are appended (Appendix 1 and 2). A list of all species currently censussed within the CBC scheme is appended as Appendix 3.

Topics for special study

Milner and Hornby (1977) identified four areas of CBC procedures to which further study might usefully be directed. Firstly, they concurred in the general importance attached to observer consistency (as against accuracy) and recommended that their general support for the existance of adequate consistency as revealed in statistical analyses of CBC returns should be supplemented by field tests of such consistency. Secondly, they concluded that the standardization of CBC cluster analysis achieved by the CBC staff was a valuable feature of the CBC method but was worthy of further examination. Thirdly, they recommended that an investigation of the usefulness or otherwise of the then newly established Swedish point count system be conducted as a means of extending the monitoring of British bird populations into habitats currently hardly studied within the CBC scheme. Finally, they noted that estimates of the absolute accuracy of CBC work would be of interest, though the level of accuracy was not vital to the validity of the CBC Index and the work involved in calibration of CBC results against nest counts (for example) would be very substantial.

Observer consistency is critical to the CBC index and, as Milner and Hornby noted, has proved relatively difficult to check statistically. One specific test of CBC methods (Snow 1965) suggested that census accuracy varied markedly between observers, though there was some evidence that observer efficiency in this experiment was not typical of the CBC as a whole. If observers do indeed differ significantly in their census efficiency it is critically important that observers remain consistent in their individual efficiency between years. Milner and Hornby therefore recommended a field investigation of the influence or otherwise of observer census ability on the estimate of population change occurring between two successive years of fieldwork on a single plot. Section 4 of the present report presents the results of such an investigation.

Central analysis of the clusters on CBC returns was expected by Milner and Hornby to show valuable standardization of analysis as against the wide variations of interpretation demonstrated by Best (1975) whose analysts were of varied experience. Section 3 of the present report presents an experimental verification of this expectation.

Section 5 presents a comparison of the results of independently conducted point count and belt transect surveys with those of simultaneous CBC visits.

Section 6 examines the results of standard CBC surveys in relation to the results obtained through intensive mapping visits to the same site.

Section 7 uses the data gathered for the topics examined in the four preceding sections to examine the validity of CBC results gathered over a short period of census activity, as in censussing expeditions of habitats poor in access.

Section 8 similarly uses data gathered for the other purposes of this report to obtain an assessment of the influence of weather conditions on the results of the census.

Section 9 provides an extended summary of the major findings of the report.

SECTION 2

MATERIALS AND METHODS

The general approach adopted in the study was for four CBC observers to census independently a census plot on the Aston Rowant National Nature Reserve. Fieldwork was conducted in 1977 and 1978, thus providing estimates of population changes over the two years. The results were subsequently collated in a variety of ways to provide model data for the various tests desired. Analysis of the maps was performed by the regular analysts of the CBC scheme who received the independently collated species maps in sequences designed to minimize analyst bias. Full details of these precautions are presented in the appropriate sections of this report.

The fieldwork site

Choice of site

Beacon Hill, part of the Aston Rowant National Nature Reserve in Oxfordshire, was chosen as the fieldwork site at the suggestion of Milner and Hornby (1977). Although the habitat was not typical of woodland Common Birds Census sites (see Figure 2.1 and habitat description below), the 28.7 hectare site had the advantage (1) of having a densely populated and varied bird community, providing a severe test of observer and analyst consistency, and (2) of being relatively easily accessible to the team of census workers. CBC censusses had been conducted at the site since 1975.

General features of the site

Beacon Hill forms a prominence north-westwards from the Chiltern escarpment (which runs mainly south-west to north-east). From the top of the plot, at about 250 metres a.s.l., the ground slopes away with aspects varying from south-west to north-north-east towards the bottom edge of the plot (at about 150 metres a.s.l.). Plate 1 a-c shows several of these features from viewpoints indicated in Figure 2.2.

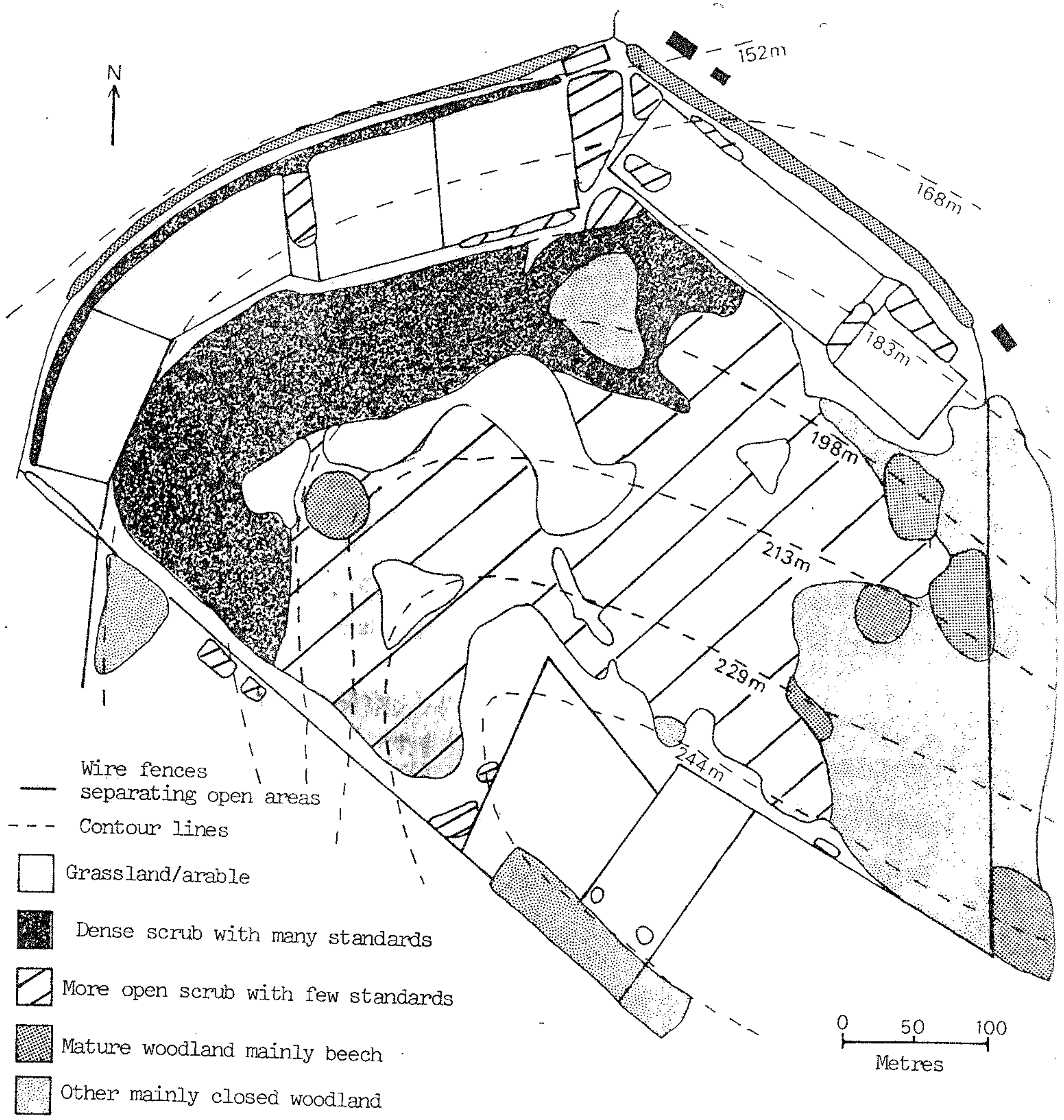
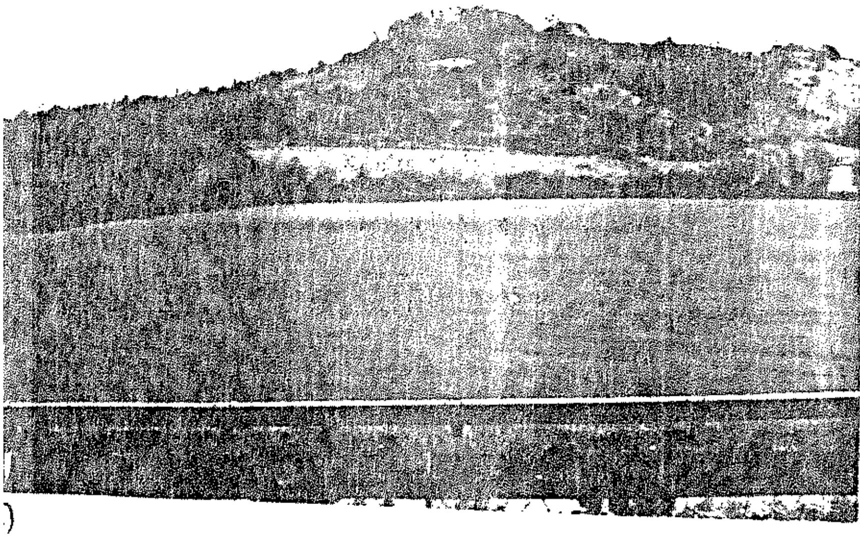


Figure 2:1 Map of the census site at Beacon Hill, Aston Rowant NNR, showing the major habitat features. Scrub areas include hawthorn, elder, common privet, hazel, wayfaring tree, juniper and blackthorn. Major standard trees include yew, ash, beech and birch.



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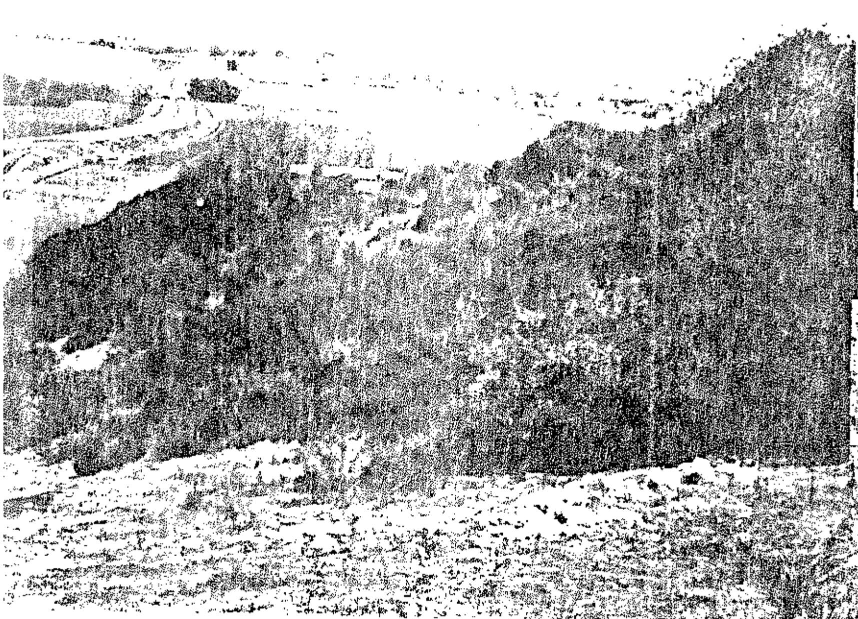

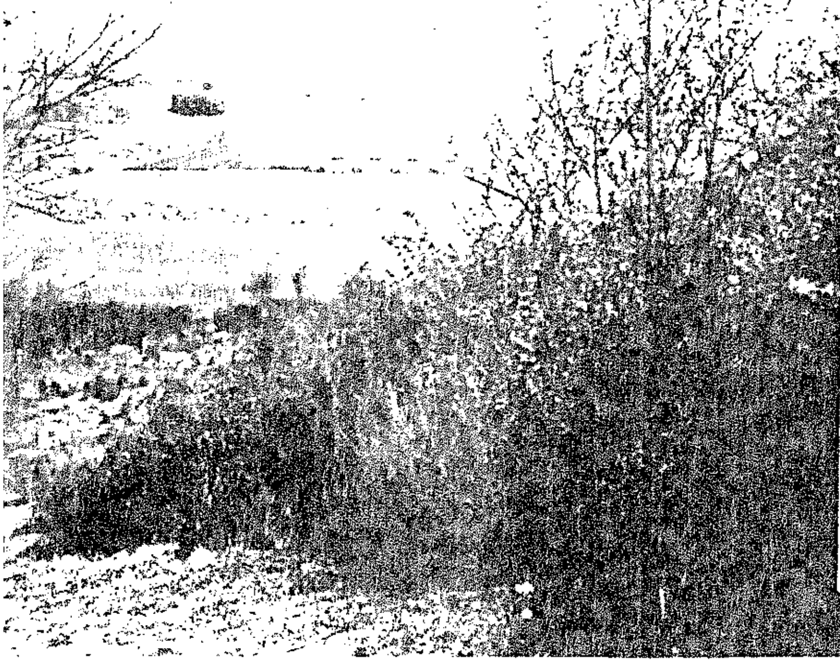

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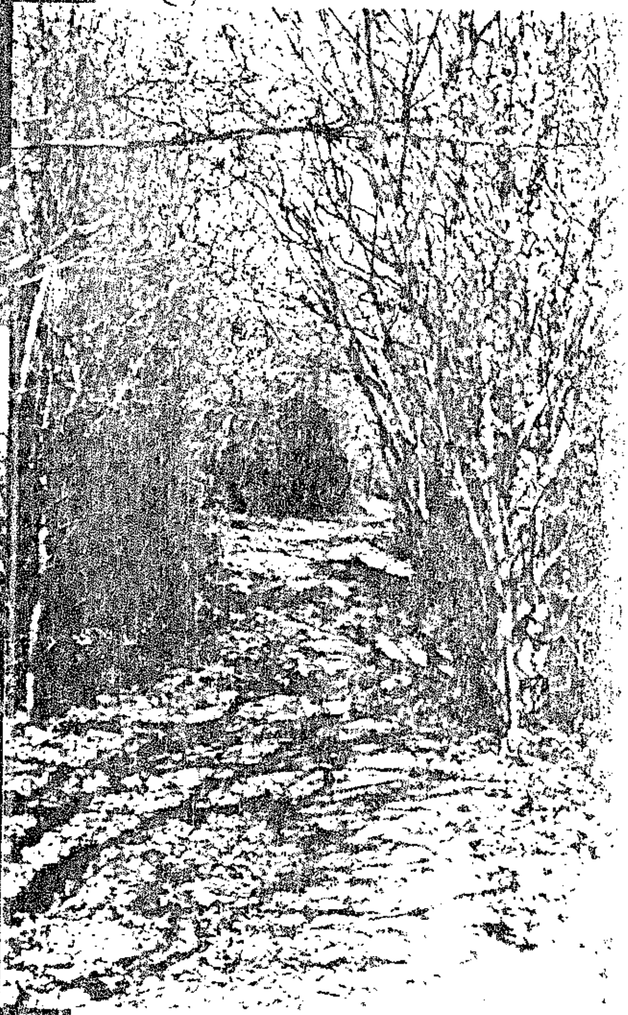
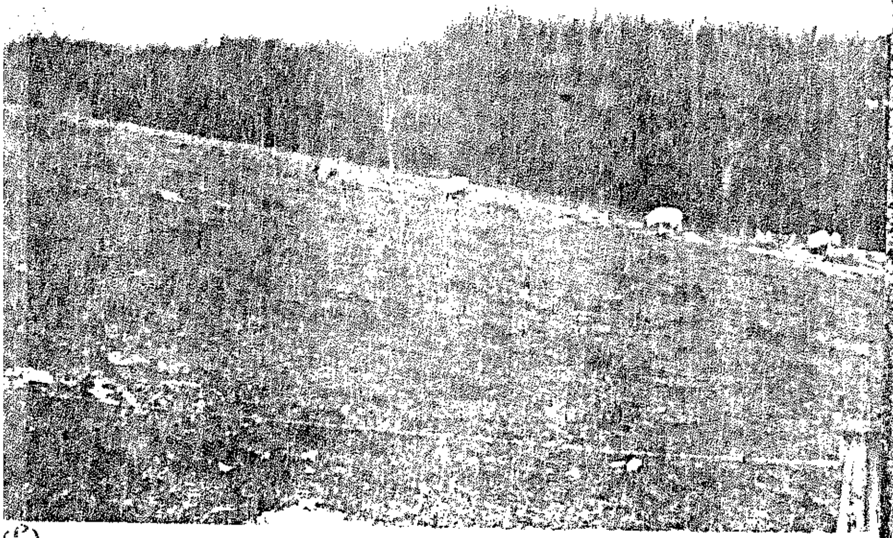


ATE 1. Photographs of the Aston Rowant plots (see key for angles at which photographs were tak



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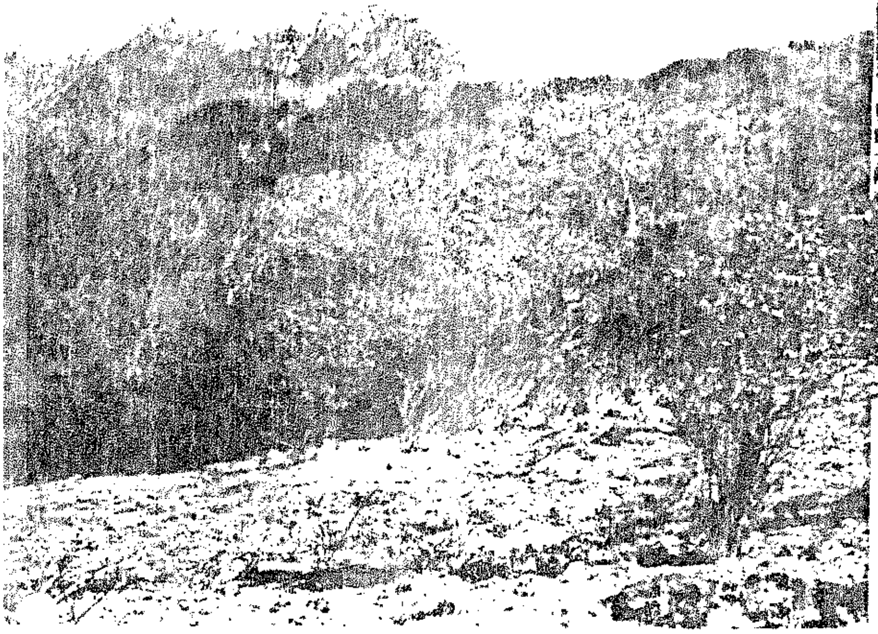

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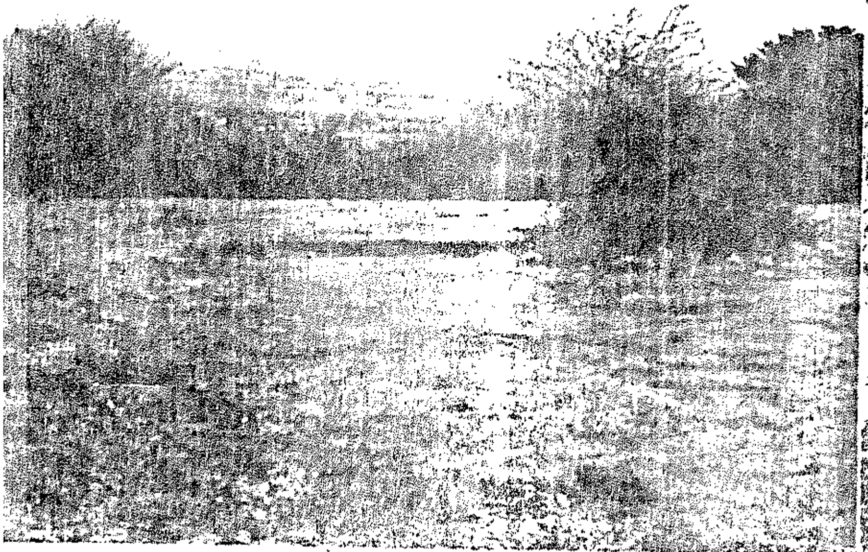

(i)

(j)

PLATE 1 (continued)

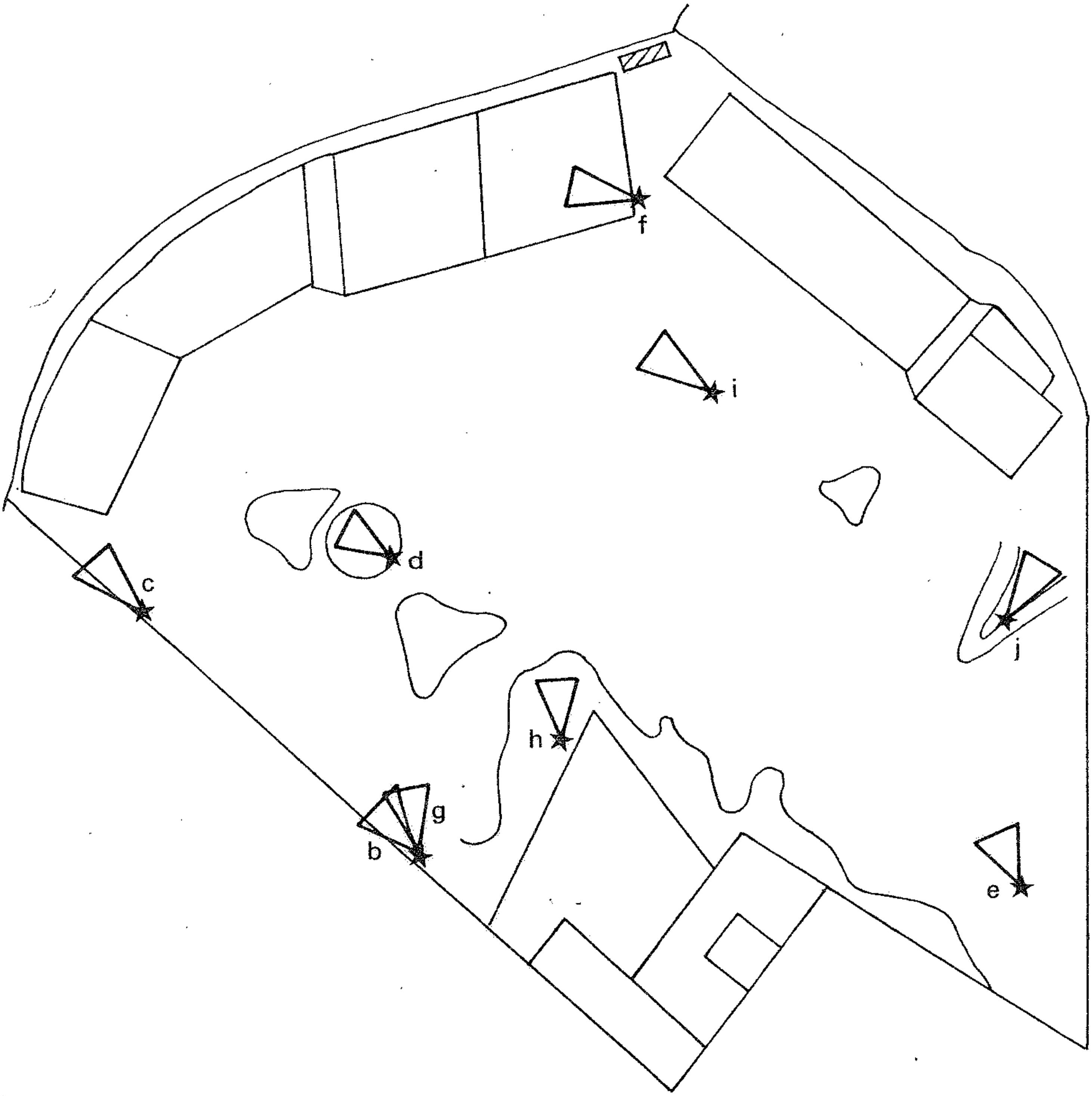

Figure 2.2 - PHOTOGRAPHIC KEY. The location of photographs in plate 1 are as shown. Plate 1a shows a general view of the plot from the west.

The escarpment itself forms a leading line for migrating birds and Beacon Hill, as a small obstacle to low-level migration along this route, attracts migrants of a variety of species. This in a sense was a disadvantage of this site for the comparison of census observers and different census methods, since all observers encountered a different sample of migrant birds.

As a census plot, Beacon Hill proved relatively easy to cover owing to the abundance of numbered marker posts and the network of paths. However, the general convexity of the hill precluded the registration of distant sight and sound records of birds except in the area of the paddocks around the bottom of the slope. A further disadvantage, evident on the south-western edge of the plot, was the considerable traffic noise from the M40 motorway 500 metres to the south-west. Bird sounds were often difficult to detect and to locate in this part of the census plot because of the background noise from the road.

The reserve is closed to the public on most days, and no human disturbance was encountered during census visits.

Habitat

The plot boundaries encompassed a wide range of habitats, from open well-grazed chalk grassland to rough grass paddocks, developing scrub (particularly elder) and mature closed beech woodland (Figure 2.1). This diversity of habitats is much greater than found in most CBC plots classified as woodland and was reflected in a particularly high number of territorial species and in particularly high populations of scrub and woodland edge species such as Willow Warbler and Dunnock. Plate 1 illustrates the diversity of habitats present on the reserve.

Aston Rowant NNR is maintained in reserve status for its chalk grassland. Short grass, maintained by the large numbers of rabbits present, was found in a number of open areas even within the scrub, particularly on the upper slopes of the hill, and also extensively beyond the southern edge of the plot. Areas of longer grass, particularly rich in chalk flowers and butterflies, were present in and around the paddocks along the northern side of the plot.

The chief scrub species in most parts of the plot was elder which, especially where mixed with other species of shrubs and bushes, formed areas which were effectively impenetrable except where paths had been cut. Standard trees were common in the scrubby areas; a number of deciduous species, notably birch and sycamore, were represented and there were also several large yew trees particularly in the southern part of the plot.

Where the scrub was particularly well developed and contained a number of standard tree species, the habitat was equivalent to open woodland. Closed woodland was restricted to two or three islands in the mainly scrubby areas and to the northern and eastern fringes of the site.

Closed woodland continued beyond the eastern boundary of the plot while to the north and west the plot was bordered by arable fields.

Mapping census methods

All four census workers carried out a standard ten-visit Common Birds Census in both 1977 and 1978, following the procedure described in the latest edition of the CBC instructions (Appendix 1). In 1977, P. Toynton made five extra early visits of which one was used in the preparation of multi-visit maps for that year. The dates and visit details for all census visits in 1977 and 1978 are given in Table 2.1. As far as possible, clashes in visit dates and times were avoided by arrangement amongst the observers. The census experience of the observers is discussed in Section 3.

Blank maps supplied to the observers were copies from a basic outline of the plot specially revised for this study. These maps incorporated extra features to enable observers new to the site to position themselves on the plot more accurately.

At the end of the season the census workers compiled their own species maps. Visit-letters were used in normal CBC fashion to denote which registrations had been made on particular visits. For the detailed multi-visit and expedition methodology studies, the 40 visits involved could not be uniquely coded by only 26 alphabetical letters. Species sheets for these studies were compiled using numbers to identify the separate visits. To distinguish these numbers from the counts of birds in group registrations the latter were recorded in brackets on the maps. The selection of visits used in multi-visit and expedition methodology studies is described in Sections 6 and 7.

The analysis of territories was performed in the standard manner according to the published CBC Guiding Principles (Williamson et al. 1968) except for the expedition methodology maps of Section 7 where the ten days rule (see Appendix 2) was necessarily waived. Three experienced CBC analysts shared the task of establishing the territorial clusters on the ca. 1350 species maps; their experience in census work and in cluster analysis are discussed in Section 3. Although there is normally a degree of consultation between analysts over such census maps as are difficult to cluster within the regular CBC work, in the present study consultation was studiously avoided.

Table 2.1. Schedule of CBC census visits at Aston Rowant

1977	Visit number	Date	Duration min.	Observer	1978	Visit number	Date	Duration min.	Observer
	5[a]	April 11	300	D		1	April 8	185	D
	6	14	180	B		2	10	180	A
	7	15	240	A		3	15	180	C
	8	16	150	C		4	17	140	B
	9	18	285	D		5	22	(180)	C
	10	21	205	B		6	24	165	B
	11	24	240	D		7	24	190	A
	12	24	180	C		8	27	150	C
	13	25	195	A		9	29	195	D
	14	27	195	B		10	May 4	180	C
	15	30	120	C		11	5	140	B
	16	30	270	D		12	5	145	A
	17	May 2	190	A		13	9	220	D
	18	3	200	B		14	9	230	A
	19	5	210	D		15	10	210	B
	20	7	180	C		16	10	180	C
	21	9	180	A		17	17	215	B
	22	10	235	B		18	17	195	A
	23	14	180	C		19	17	240	D
	24	19	185	B		20	22	180	A
	25	20	155	A		21	22	180	C
	26	22	210	C		22	25	200	B
	27	24	245	D		23	26	240	D

Table 2.1 cont...

	Visit number	Date	Duration min.	Observer		Visit number	Date	Duration min.	Observer
1977					1978				
	28	May 25	215	A		24	May 29	(180)	C
	29	26	120	C		25	30	185	A
	30	31	260	D		26	31	210	B
	31	June 1	195	B		27	June 1	230	D
	32	3	180	C		28	4	(180)	C
	33	3	205	A		29	11	240	D
	34	15	180	C		30	11	(180)	C
	35	16	200	B		31	15	210	B
	36	16	180	A		32	19	250	D
	37	17	265	D		33	19	180	A
	38	21	200	B		34	20	240	C
	39	22	210	A		35	26	235	B
	40	23	180	C		36	27	240	D
	41	24	195	B		37	27	225	A
	42	27	270	D		38	July 3	185	A
	43	July 2	180	C		39	7	230	D
	44	4	180	A		40	12	160	B
	45	6	265	D					

Notes

[a] Four earlier survey visits by observer C are not considered within the main analysis

[b] Figures in brackets were estimated, not measured

SECTION 3

EFFECTS OF OBSERVER AND ANALYST ON CENSUS RESULTS

Introduction

Considerable individual variation in census ability in the field is to be expected on the part of the many observers participating in the BTO Common Birds Census Scheme (Williamson and Homes 1964, Bailey 1967). By the same token, differences between analysts evaluating the census results and determining the number of territories held by each species of bird on each census plot might be expected (Best 1975, Svensson 1974). Several precautionary measures are, however, routinely applied in the analysis of data collected for the BTO scheme in order to reduce or eliminate such potential biases. Observer differences are controlled by admitting census results from individual observers only on a paired-year basis and the results used to calculate a percentage change in species totals between years (rather than an absolute species density) (Williamson and Homes 1964, Taylor 1965). In this way, any systematic bias on the part of one observer, either towards overestimating or underestimating the population of breeding birds present, is eliminated in estimating population change, provided only that the observer maintains the bias between years and that his efficiency does not change with the density of birds on the site. For this reason observers are strongly urged to maintain consistent census effort, at whatever level, between years and results for any census plot reporting marked changes in census effort are dropped from inclusion in the index calculations for the years concerned. In this way a reliable estimate of percentage change in population levels can be calculated, though the absolute density corresponding to any particular index value is known with considerably less certainty.

Precautions are similarly taken to control for variation in the annual evaluation of the census results. Although individual observers may make their own estimates of the positions of clusters on their census plot, it is the cluster total determined by professional analysts employed by the BTO which is included in the CBC index calculations. These analysts are trained in the interpretation of the CBC maps and work to standard guide-lines (Williamson et al. 1976) until they achieve consistency of analysis with more experienced analysts. Furthermore, even amongst the experienced and fully-trained analysts any "difficult" maps are discussed within the team so that a consensus of analysis is achieved in such cases. These measures are believed to reduce the possible sources of variation between analysts in a way not taken into account in Best's (1975) criticisms of the mapping method.

Despite these precautions, it is of interest to know the extent to which observers do in fact differ in census efficiency. An estimate of observer variability would indicate what precision might be attached to the absolute species densities estimated within the normal running of the CBC scheme, perhaps eventually allowing comparison of densities of particular species in different habitats (though note that absolute density estimates depend on observer accuracy, not just on consistency). A similar evaluation of the variation amongst analysts in evaluating the CBC results reaching them from the many field observers of the BTO would be of value in confirming the efficacy of the training procedures used by the BTO before newly-recruited staff are allowed to participate in the routine analysis of CBC maps. Such an evaluation of analyst variation is desirable both as justification for employing professional staff to undertake the analysis and to dispose of criticisms such as those of Best (1975) already cited. The present study therefore attempted such an evaluation of observer and analyst variability, using a team of four observers and three analysts visiting a single census plot at Aston Rowant in 1977.

Materials and methods

The experiment was conducted on the National Nature Reserve at Aston Rowant in 1977. Four observers independently visited the census plot, as far as possible doing so on different days, for a total of ten census visits apiece. In some cases additional earlier visits were made to the plot ahead of the main census work. The results from the sequence of visits made by each observer were collated into species maps, one for each observer, and two further copies of each map made for independent evaluation by each of three analysts. In this way a total of twelve observer-analyst combinations were evaluated.

The four observers differed amongst themselves in experience, both of CBC censussing and of the census plot itself. Observer A was an experienced professional ornithologist with much experience of CBC census work but no prior experience of the Aston Rowant census plot. Observer B was an experienced professional ornithologist but without previous experience of CBC censussing. Observer C was a professional ecologist with two years' previous experience of CBC census work on the Aston Rowant plot. Observer D was a team of two amateur ornithologists with much previous experience of CBC censussing but no previous experience of the Aston Rowant plot. During fieldwork these two workers kept together and recorded their observations on a common map (one for each visit). These four observers thus provided a cross-section of ornithologists such as are found within the national CBC scheme.

The CBC analysts used, similarly differed in experience. Analyst W was highly experienced in the interpretation of CBC maps and was one of the four observers undertaking the fieldwork (observer A). Best (1975) suggested that analysts who were familiar with the census plot and the distribution of birds on the plot during fieldwork,performed better in the evaluation of census maps than did other analysts. Analyst X was nearly as experienced in the evaluation of census maps and had some experience of the distribution of birds within the Aston Rowant plot through having conducted the point censusses and belt transects conducted in parallel with the evaluation of CBC methods. Analyst Y was a newly-trained member of the CBC analytical staff and was without field experience of the Aston Rowant census plot. An untrained analyst was not included in the analyst team since past experience within the BTO scheme and the study of Best (1975) both indicate that untrained analysts introduce major variation in cluster evaluation and have therefore never been used within the BTO scheme.

The species maps analysed were prepared from the field data independently of the analyst team. Copies for each of the three analysts were then arranged in random species sequence and evaluated independently by the three workers, operating to the CBC standard rules of analysis. Each analyst was aware of the species and dates of visits but had no direct evidence as to the identity of the observer whose maps he analysed. These evaluations thus generated a four-by-three observer-by-analyst matrix for each species. A total of 45 species were identified as territorial on the site but not all observers and not all analysts obtained the full species list.

Results

Table 3.1 summarizes the overall results of the CBC mapping censusses on Aston Rowant. In 1977 some 66 species were recorded during CBC fieldwork but only 57 were recorded again in 1978. The list shows that a wide variety of species was involved, including both typically woodland and typically farmland species (as might be expected in the scrub habitat of Aston Rowant), and covering a wide range of species densities. The cluster totals presented in this Table potentially (in practice they do not - see below) depend on analyst identity and so cannot be immediately compared between observers but the detection of species by different observers can be so compared. In 1977 the number of species recorded by individual observers varied from 50 to 55, not a significant effect ($X^2 = 1.34$, d.f. = 3, n.s.). In 1978 the variation was from 45 to 49 species detected (of a pooled list of 57), again not significant ($X^2 = 1.21$, d.f. = 3, n.s.). Thus, there were no significant differences between observers in their overall detection of species on the site (cf. Enemar 1962).

Table 3.2 presents the complete species listing of observer-analyst cluster totals obtained from the 1977 fieldwork. The Table contains only those species for which at least one observer obtained enough registrations of the species that at least one analyst determined a cluster from them. As can be seen from the Table, the cluster totals between observer-analyst cells showed considerable differences in variability, ranging from all twelve cells providing identical results e.g. Chiffchaff - to substantial variation amongst the cells e.g. Blue Tit. Statistical evaluation of the results was therefore essential.

Table 3.1. Results of CBC mapping censusses on Aston Rowant in 1977 and 1978. In this table the 1977 and 1978 results for any given observer-species combination were evaluated by the same analyst in both years. P = present but no cluster established.

Year	1977				1978			
Observer	A	B	C	D	A	B	C	D
Species								
Sparrowhawk	1	P	P	0	1	1	1	0
Kestrel	1	2	0	1	1	1	1	1
Red-legged Partridge	P	0	0	P	P	P	1	0
Grey Partridge	P	1	1	3	0	1	1	1
Pheasant	3	4	1	2	2	2	P	1
Lapwing	1	1	1	1	P	0	0	P
Stock Dove	1	1	0	P	P	1	0	P
Wood Pigeon	5	4	5	11	7	6	10	15
Collared Dove	2	2	3	2	2	3	2	3
Turtle Dove	1	1	1	1	P	2	P	0
Cuckoo	P	0	P	P	0	1	0	0
Little Owl	0	0	0	P	0	0	0	P
Tawny Owl	0	0	1	1	0	1	P	1
Swift	0	0	0	P	0	0	0	P
Green Woodpecker	P	P	P	0	1	1	2	1
Great Spotted Woodpecker	P	P	P	1	0	P	P	P
Skylark	1	1	1	1	P	P	P	2
Swallow	P	P	0	P	0	P	0	P
House Martin	0	0	0	P	P	0	0	0
Tree Pipit	2	1	1	2	P	P	P	0
Meadow Pipit	1	P	P	P	1	1	P	1
Yellow Wagtail	P	P	0	0	P	0	0	0
Pied Wagtail	0	1	0	P	0	0	0	0
Wren	19	14	24	21	20	20	33	26
Dunnock	19	21	23	19	18	14	19	19
Robin	30	20	27	32	17	20	26	29
Nightingale	P	0	P	0	0	0	0	0
Redstart	0	P	P	0	P	0	0	0
Wheatear	0	0	0	P	0	0	0	0
Ring Ousel	P	P	P	0	0	0	0	0
Blackbird	25	22	17	30	19	22	19	28
Song Thrush	10	9	12	13	7	8	9	9

Table 3.1 cont...

Year	1977				1978			
Observer	A	B	C	D	A	B	C	D
Species								
Mistle Thrush	4	4	3	4	4	2	6	5
Sedge Warbler	0	0	0	P	0	0	0	0
Lesser Whitethroat	3	2	2	2	3	2	1	2
Whitethroat	3	2	1	3	P	0	0	0
Garden Warbler	2	2	1	3	P	P	1	P
Blackcap	6	4	8	2	7	9	10	7
Chiffchaff	1	1	1	1	1	1	1	1
Willow Warbler	25	23	36	24	21	23	29	25
Wood Warbler	0	0	P	0	0	0	0	0
Goldcrest	14	10	13	13	6	6	6	9
Spotted Flycatcher	3	3	P	2	2	2	P	1
Long-tailed Tit	5	4	2	4	2	2	1	4
Marsh Tit	2	3	2	3	1	P	P	1
Willow Tit	0	0	P	0	0	0	P	0
Coal Tit	6	5	2	6	7	7	7	5
Blue Tit	14	18	8	19	13	18	10	13
Great Tit	13	10	7	11	9	6	8	12
Nuthatch	P	P	P	P	P	1	P	P
Treecreeper	P	P	0	P	P	P	P	0
Jay	P	P	0	P	1	1	0	0
Magpie	4	2	2	3	2	2	2	5
Jackdaw	P	1	P	P	P	0	P	P
Carrion Crow	1	1	1	2	P	1	2	1
Starling	1	3	1	1	1	P	P	P
House Sparrow	0	P	0	0	0	0	0	0
Tree Sparrow	0	P	0	0	0	0	0	0
Chaffinch	24	23	22	27	21	25	23	37
Greenfinch	4	4	2	3	4	5	5	8
Goldfinch	4	4	1	2	2	4	1	2
Linnet	2	5	3	2	P	3	2	3
Redpoll	1	1	1	0	P	1	P	0
Bullfinch	8	7	12	9	7	6	6	6
Yellowhammer	6	6	6	10	9	8	7	9
Corn Bunting	0	0	0	P	0	0	0	0

Table 3.2 Cluster totals for four observers as evaluated by each of three analysts. Data from 1977

Observer	A			B			C			D		
Analyst	W	X	Y	W	X	Y	W	X	Y	W	X	Y
Sparrowhawk	1	1	1	0	0	0	0	0	0	0	0	0
Kestrel	1	1	1	2	2	1	0	0	0	1	1	1
Grey Partridge	0	0	0	1	1	1	1	1	2	3	3	3
Pheasant	3	3	3	4	3	4	1	1	1	3	2	3
Lapwing	1	1	1	1	1	1	1	1	1	1	1	1
Stock Dove	1	1	1	1	1	1	0	0	0	0	0	0
Wood Pigeon	8	5	5	4	4	4	3	4	5	12	11	11
Turtle Dove	1	1	1	1	1	1	0	1	1	1	1	1
Collared Dove	2	2	2	3	2	4	3	2	3	2	3	2
Tawny Owl	0	0	0	0	0	0	1	1	1	1	1	1
Great Spotted Woodpecker	0	0	0	0	0	0	0	0	0	1	1	1
Skylark	1	1	1	0	1	1	0	1	1	0	1	1
Carrion Crow	2	1	1	1	1	1	1	1	1	2	2	2
Jackdaw	0	0	0	1	1	1	0	0	0	0	0	0
Magpie	3	4	4	3	2	2	1	2	2	3	3	3
Great Tit	15	16	13	12	12	10	7	7	8	14	11	12
Blue Tit	17	14	15	20	18	19	8	8	8	20	18	19

Table 3.2 cont...

Observer	A			B			C			D		
Analyst	W	X	Y	W	X	Y	W	X	Y	W	X	Y
Coal Tit	6	6	6	4	5	5	2	2	2	6	6	6
Marsh Tit	2	2	2	3	3	3	1	2	2	4	3	4
Long-tailed Tit	5	5	5	5	4	4	2	2	2	6	4	4
Wren	18	19	18	13	14	13	24	28	24	18	21	21
Mistle Thrush	6	4	4	5	3	4	3	3	2	6	4	6
Song Thrush	10	10	9	9	9	9	11	11	12	12	13	12
Blackbird	25	25	26	21	22	21	16	17	17	28	29	30
Robin	28	27	30	21	21	20	27	27	27	31	32	34
Blackcap	7	7	6	5	4	4	7	8	7	2	2	2
Garden Warbler	2	2	2	2	2	2	1	1	1	3	3	3
Whitethroat	3	3	3	1	2	2	1	1	1	3	3	3
Lesser Whitethroat	3	3	3	2	2	2	2	2	2	2	2	2
Willow Warbler	25	26	25	22	22	23	30	36	33	25	24	26
Chiffchaff	1	1	1	1	1	1	1	1	1	1	1	1
Goldcrest	15	13	14	12	10	10	14	13	12	16	13	16
Spotted Flycatcher	3	3	2	3	3	3	0	0	0	3	3	2

Table 3.2 cont....

Observer	A			B			C			D		
Analyst	W	X	Y	W	X	Y	W	X	Y	W	X	Y
Dunnock	19	18	19	19	20	21	23	23	23	21	19	21
Meadow Pipit	1	1	1	0	0	0	0	0	0	0	0	0
Tree Pipit	3	2	3	2	1	2	1	1	1	2	2	2
Pied Wagtail	0	0	0	1	1	1	0	0	0	0	0	0
Starling	1	1	1	2	3	3	1	1	1	0	1	0
Greenfinch	5	4	3	5	4	5	1	2	2	3	3	3
Goldfinch	5	4	4	4	2	4	1	1	1	2	2	2
Linnet	2	3	2	4	4	5	4	3	4	1	2	2
Redpoll	1	0	1	1	1	1	1	1	1	0	0	0
Bullfinch	11	9	8	10	11	7	11	12	9	11	9	10
Chaffinch	24	23	24	23	24	23	21	22	20	26	27	28
Yellowhammer	6	6	6	5	6	7	6	5	6	9	7	10

Variation between analysts

The results of Table 3.2 were used to evaluate the extent of difference between analysts by means of a Friedman two-way analysis of variance (Siegel 1956). Each observer's results in Table 3.2 provide an independent estimate of the analyst variation present. For each observer, three separate evaluations of each of his species maps were available and these can be ranked 1 to 3 within each species. In the absence of systematic differences between analysts the distribution of the rankings 1, 2 and 3 would be essentially randomly distributed under the analyst columns (Table 3.2), and the sum of ranks across the 45 species recorded would be statistically similar for the three analysts. The similarity of these rank totals was evaluated by Friedman's statistic X_r^2 with two degrees of freedom. Table 3.3 shows the distribution of rankings between analysts obtained for each of the four observers. As noted already, for some species individual observers failed to find territories for that species on the Aston Rowant plot and inclusion of triplets of zeros for the three analysts as a result of inclusion of these species could possibly introduce a bias tending to make the analysts appear more similar in evaluation efficiency than they in fact were. For this reason, the Friedman statistic was also calculated for the sub-set of species actually detected by each observer. Table 3.3 presents the results of these two statistical analyses for each of the four observers. With two degrees of freedom a X_r^2 value of 5.99 would be required for significance at the 5% level and a X_r^2 value of 4.60 would be required for significance at the 10% level; in no case were either of these values exceeded. The conclusion is therefore that there is no evidence of discrepancies in the general evaluation of CBC clusters by any of the analysts, despite their differing experience of map analysis and of the census plot.

Table 3.3 Rank sums and test statistics for Friedman two-way analysis of variance for differences between analysts in distribution of species totals for each of four observers. Data used are listed in Table 3.2

		Observer							
		A		B		C		D	
	Analyst	All species[a]	Presence only[b]	All species[a]	Presence only[b]	All species[a]	Presence only[b]	All species[a]	Presence only[b]
Rank sum	W	79.5	69.5	89.0	81.0	98.5	82.5	90.0	78.0
	X	94.5	84.5	92.5	84.5	84.0	68.0	96.5	84.5
	Y	96.0	86.0	88.5	80.5	87.5	71.5	83.5	71.5
Number of species		45	40	45	41	45	37	45	39
Friedman statistic χ_r^2		3.70	4.16	0.21	0.23	2.54	3.09	1.89	2.17
Significance level		0.1-0.2	0.1-0.2	0.8-0.9	0.8-0.9	0.2-0.3	0.2-0.3	0.3-0.5	0.3-0.5

Notes:

[a] Comparing the distributions of the species found on the census plot by at least one observer

[b] Excluding those species not established as breeding by the observer

Differences between observers

Table 3.4 presents a Friedman two-way analysis of variance by rank for differences between observers. With three separate evaluations of the maps from each observer there are three such analyses available. There were few cases in which all four observers failed to register a territorial species within the evaluation performed by a single analyst, so the Friedman statistic has been calculated for all 45 species in each case. Table 3.4 shows that in each case there was significant evidence of heterogeneity between observers in their censussing efficiency.

Examination of the three rank sums obtained for each observer in Table 3.4 shows that the three analysts agreed precisely as to the relative efficiencies of the four observers. Observer D (the team of two highly experienced amateur ornithologists) were the most successful at detecting territories, as might be expected with two people simultaneously scanning the census plot for registrations (Lack 1976, Preston 1979). Second in efficiency was observer A, who had most experience of the CBC scheme through extensive fieldwork and through extensive experience of analysing CBC maps. Observer B, a skilled professional ornithologist without previous CBC experience, was next in efficiency, whilst observer C, the worker with two years' previous experience of the Aston Rowant plot but no other censussing experience, was last in sequence. It should be emphasised that the differences in census efficiency here (effectively a census of relative abundances) were relatively small.

Table 3.4 Rank sums and test statistic for Friedman two-way analysis of variance for differences between observers in distribution of species totals, analysed for each of three analysts. Data used are those of Table 3.2

		Analyst		
	Observer	W	X	Y
Rank sum	A	98.5	104.0	106.0
	B	118.0	114.0	114.5
	C	136.5	133.5	133.0
	D	98.0	98.5	96.5
Number of species		45	45	45
Friedman statistic χ^2_r		13.90	9.49	9.63
Significance level		0.01	0.05	0.05

Table 3.5 presents the grand totals of clusters for each observer-analyst combination for the study, together with a parametric analysis of variance of the data. This confirms the absence of analyst differences in cluster totals evaluated and the presence of large between-observer differences ($F = 13.87$, $P < 0.01$). Examination of the observer averages in the Table shows that observer D (two fieldworkers operating as a team) obtained evidence for an average of 300 territories on the Aston Rowant plot, about 14% more than the average cluster total of 263 found by the single observers. The confidence limits for the difference of 38 clusters between observer D and the average of the other three are ± 15.5 (Snedecor and Cochran 1967, p. 301), indicating significant differences between the results obtained by the team of two individuals and those obtained by single observers. Similarly, comparison of the results obtained by the highly experienced observer A (average clusters = 282) against those of the less experienced observers B and C (cluster averages of 256 and 249 respectively) show differences exceeding the LSD (Snedecor and Cochran 1967, p. 302) of 18.9 for these data, showing that, amongst the single observers, extensive experience of CBC work can lead to an improved detection of breeding pairs on the census plot.

Species patterns

The previous analyses demonstrated that overall there were significant differences between observers but not between analysts in the detectability of breeding pairs on Aston Rowant. It is possible to investigate these trends within individual species in many cases. Table 3.6 presents a series of parametric two-way analyses of variance, for a total of 26 species.

Table 3.5 Two-way analysis of variance for 1977 territory totals (all species combined) with respect of observer and analyst (map interpreter). $**P < 0.01$

Data table

	Observer					
Analyst	A	B	C	D	Totals	Mean
W	292	259	239	305	1095	273.8
X	277	254	255	294	1080	270.0
Y	277	256	254	302	1089	272.2
Total	846	769	748	901	3264	
Mean	282.0	256.3	249.3	300.3		272.0

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	28.5	14.25	0.19
Observers	3	4986.0	1662.00	13.87**
Residuals	6	359.5	119.83	

Table 3.6. F ratio from two-way analysis of variance in respect of observer and analyst differences in cluster totals for individual species. The full data and ANOVA tables are presented in Appendix 5.

* P 0.05 ** P 0.01 *** P 0.001

Species	F-ratio	
	Analyst	Observer
Pheasant	3.00	34.75***
Woodpigeon	0.47	28.80***
Collared Dove	0.53	1.18
Magpie	0.27	7.27*
Great Tit	1.00	17.74**
Blue Tit	7.39*	193.60***
Coal Tit	1.00	128.00***
Marsh Tit	0.43	13.00**
Long-tailed Tit	2.45	18.18**
Wren	4.20	58.73***
Mistle Thrush	4.20	7.00**
Song Thrush	0.27	26.91***
Blackbird	3.54	275.91***
Robin	1.09	57.52***
Blackcap	1.50	79.38***
Whitethroat	1.00	36.00***
Willow Warbler	0.96	23.45***
Goldcrest	5.44*	13.78**
Dunnock	1.80	17.80**
Tree Pipit	3.00	13.00**
Greenfinch	0.16	9.68*
Goldfinch	1.62	17.85**
Linnet	0.69	12.31**
Bullfinch	1.91	1.00
Chaffinch	0.31	22.72**
Yellowhammer	2.28	8.44*

Other species were excluded from this analysis because of rather low cluster totals. Examination of the data in Table 3.6 shows that all species except Collared Dove and Bullfinch individually provided evidence for the presence of differences between observers in identifying territories on the site. For these two species, no differences between observers nor between analysts were detected. All other species except Blue Tit and Goldcrest also agreed in indicating no differences between analysts in their evaluation of the clusters from different observers. Differences both between observers and analysts were indicated in the results for Blue Tit and for Goldcrest, in both cases at the 5% significance level. This is perhaps not too surprising a finding, for one would expect in analysing the results for 26 species that one in 20 will generate a significant F at the 5% level by chance alone. It is perhaps significant, though, that Moss (1976) found particular difficulties in applying the CBC method to Goldcrest. It may also be noted that Blue Tit was the only species not to show any indication of levelling-off in the estimated number of territories on Aston Rowant as visit frequency was increased (Section 6). It may therefore be concluded that individual species analyses confirm the overall analyses presented above, showing that significant between-observer differences in censussing ability are present but that the analysts agreed closely in their techniques for evaluation of the census maps.

Table 3.7 assesses how observer differences in census efficiency vary between species. Observer variation was least in respect of Bullfinch (11 per cent), followed by Dunnock (15 per cent) and Chaffinch (18 per cent). A further seven species

Table 3.7 Observer variation in census efficiency for various species

Species	Mean[a] clusters	Observer RMS[b] clusters	Coefficient of variation,%
Pheasant	2.58	1.96	76.06
Woodpigeon	6.33	6.00	94.74
Collared Dove	2.50	0.75	29.83
Magpie	2.67	1.49	55.90
Great Tit	11.42	5.30	46.42
Coal Tit	3.33	3.27	97.98
Marsh Tit	2.58	1.59	61.54
Long-tailed Tit	4.00	2.36	58.93
Wren	19.25	8.57	44.51
Mistle Thrush	4.17	1.97	47.33
Song Thrush	10.67	2.87	26.88
Blackbird	23.08	9.18	39.78
Robin	27.08	8.38	30.96
Blackcap	5.08	4.20	82.62
Whitethroat	2.17	1.73	79.94
Willow Warbler	26.42	7.95	30.09
Goldcrest	13.17	3.21	24.41
Dunnock	20.50	3.14	15.34
Tree Pipit	1.88	1.20	64.10
Greenfinch	3.33	2.26	67.82
Goldfinch	2.33	2.54	108.79
Linnet	3.00	2.11	70.27
Bullfinch	10.17	1.10	10.87
Chaffinch	23.75	4.28	18.01
Yellowhammer	6.58	2.42	36.77

[a] Averaged from 1977 data for four observers each analysed in triplicate (Table 3.2)

[b] RMS = root mean square for observers in the ANOVA's of Table 3.6

[c] Computed as 100 RMS/Mean

fell between 20 and 40 per cent variation. The median value of variability was about 52 per cent. At the other end of the spectrum, the Goldfinch was the species most variably censussed (109 per cent) but Coal Tit, Woodpigeon and Blackcap all exceeded the 80 per cent level. These figures reflect the reliability (ignoring absolute bias) of densities estimated by individual observers (or observer teams) and not the uncertainty of the sample average.

Discussion

The most important conclusion from the results just presented is that there are no statistically significant differences between the analysts in their evaluation of their clusters on the CBC maps. This conclusion is directly contrary to that of Best (1975) and Svensson (1974) who found major differences between analysts as to the interpretation of the results from the mapping method. Svensson's investigation was the more substantial and reports the results of an experiment in census map evaluation by 58 ornithologists of varied experience. Each person was presented with a set of maps for six species - Chaffinch, Willow Warbler, Blackcap, Garden Warbler, Blackbird and Tree Pipit - and was requested to analyse them in accordance with the IBCC rules. Svensson found that the coefficients of variation in estimates varied between species, from 16 per cent for Willow Warbler to 36 per cent for Blackbird, reflecting species-specific difficulty in interpreting the maps. The difficulties could not be related to the number of registrations nor to the proportion of song or contemporary registrations.

Comparable coefficients of variation computed for the results from individual observers at Aston Rowant are presented in Table 3.8. For most of the species examined in Svensson's (1974) study, variation was lower at Aston Rowant. Over all 26 species listed the median coefficient of variation is only 6.0 per cent and in most cases this was due to a difference in assessment between analysts of only one cluster by one analyst. Table 3.9 shows that 66.3 per cent of all species-observer combinations agreed within this limit (i.e. an average discrepancy between the three analysts of 0.33 clusters). Analysts were slightly more variable over data from certain observers: for each of the observers A, B and C over 69 per cent of the assessments agreed at this level, but for observer D, only 50 per cent did so (Table 3.9). Nevertheless, the difference was not statistically significant between the four observers ($X^2 = 4.61$, d.f. = 3, n.s.), though it approached significance when the pooled results of three solo observers were compared against the observer team D ($X^2 = 3.23$, d.f. = 1, $0.05 < P < 0.10$). This result points to the possibility that maps from some observers may be relatively more difficult for the analysts to interpret, because of a scarcity of contemporaneous registrations, precision of plotting registrations, and other such factors.

Returning to Table 3.8, it is clear that maps of certain species are substantially more difficult to interpret than others. Mistle Thrush assessments were notably variable, with assessments for data from each of the four observers exceeding 20 per cent in variation. Magpie, Greenfinch and Linnet were other species that gave trouble. These species either have very large territories (perhaps not adequately surveyed by the

Table 3.8 Coefficients of variation (%) between three analysts for cluster totals for different species censused by four observers. Data from Table 3.6.

Species	A	B	C	D
Pheasant	0.00	15.74	0.00	21.65
Woodpigeon	28.87	0.00	25.00	5.09
Collared Dove	0.00	33.33	21.65	24.74
Magpie	15.74	24.74	34.64	0.00
Great Tit	10.41	10.19	7.87	12.38
Blue Tit	9.96	5.26	0.00	5.26
Coal Tit	0.00	12.37	0.00	0.00
Marsh Tit	0.00	0.00	34.64	15.74
Long-tailed Tit	0.00	13.32	0.00	24.74
Wren	3.15	4.33	9.11	8.66
Mistle Thrush	24.74	25.00	21.65	21.65
Song Thrush	5.97	0.00	4.56	5.09
Blackbird	2.28	2.71	3.46	3.45
Robin	5.39	2.79	0.00	4.72
Blackcap	8.66	13.32	7.87	0.00
Whitethroat	0.00	34.64	0.00	0.00
Willow Warbler	2.28	2.58	9.09	4.00
Goldcrest	7.14	10.82	7.69	11.55
Dunnock	3.09	5.00	0.00	5.68
Tree Pipit	19.25	28.87	0.00	0.00
Greenfinch	25.00	12.37	34.64	0.00
Goldfinch	13.32	34.64	0.00	0.00
Linnet	24.74	13.32	15.74	34.64
Bullfinch	16.37	5.41	14.32	10.00
Chaffinch	2.44	2.47	4.76	3.70
Yellowhammer	0.00	16.67	10.19	17.62

Table 3.9 Summary of analysts consistency within observer-species combinations

Number (per cent) of species map assessments	Observer A	B	C	D	Total
In exact agreement	7(26.9)	3(11.5)	9(34.6)	7(26.19)	26(25.0)
With one analyst one cluster different	11(42.3)	15(57.7)	11(42.3)	6(23.1)	43(41.3)
With two[a] or more cluster discrepancies	8(30.8)	8(30.8)	6(23.1)	13(50.0)	35(33.6)

χ^2 between lines (1) and (2) pooled and line (3) = 4.61, n.s.

[a] Irrespective of whether one analyst was two clusters different from the other two analysts or whether two analysts were each one cluster different from the average of the three analysts.

size of the census plot) or are semi-colonial birds (for which the exact number of breeding pairs present may be difficult to establish). No evidence is available to explain the between species variations in Table 3.8. For his study Svensson suggests that the distinctiveness or otherwise of the clusters was an important factor, though difficult to measure objectively. It may be significant that Goldcrest and Blue Tit - both of them often generating diffuse rather than distinct clusters (Moss 1976) - were the only two species to yield statistical differences between the BTO analysts as to the final cluster totals. Svensson also noted a small but statistically insignificant increase in estimates with analysts' experience. A major complaint of the participants in this experiment was that they lacked habitat details in conducting the evaluations, a point relevant to Best's (1975) finding that analysts familiar with the census plot achieved better results than did others. BTO analysts have access to habitat maps in the course of each census plot analysis and this must account at least in part for their performance being better than found by Best and by Svensson. It is clear that the method of training the CBC analysts used in the BTO national CBC scheme provides an adequate method of overcoming the other problems identified by Best and by Svensson. This is an important validation of the CBC practice within the BTO scheme, since any observer differences present are separately excluded by the process of pairing data from individual observers across years before including their results in the estimation of annual population changes (Section 4).

The formal ANOVAs presented above were all conducted in 1978 and based on a single season's (1977) fieldwork. However, it is worth noting that a check of analyst consistency made with a sub-set of the data for 1978 approximately twelve months after the present analyses were performed yielded equally consistent results (Table 4.1). The evidence thus suggests that no drift in analytical method occurred at least over a period of a year. In the course of the normal CBC working, of course, consultation between analysts constantly takes place as to the interpretation of "difficult" species-plot combinations, so that any drift would have to take place on the part of all analysts simultaneously. Whilst this seems unlikely, it does indicate that there is merit in maintaining a pool of analysts who participate each year in the evaluation of the CBC returns, thus rendering drift in time unlikely. The possibility of drift could also be systematically avoided by including in each year's CBC analysis copies of maps from previous years, to be analysed independently (and preferably "blind") by each analyst. Such a precaution would obviate the possibility of bias arising through one of the few channels of bias remaining following the validation of current practice obtained within the present study.

The present study clearly established that differences between observers in census efficiency were present. Enemar _et al_. (1978) note that few such studies of observer differences have been carried out in respect of the mapping method. However, Enemar (1962) has compared the census efficiency of six ornithologists in the course of a single census visit to a Swedish plot, a plot previously surveyed for several years by one observer but unfamiliar to the other five. He found considerable variation in the totals of the different observers but the highly experienced observer differed from the others systematically only in detecting more species (all other observers missing from three to six species) and in most frequently reporting the maximum count of six census workers for each individual species. On average two observers separately censussing an area in a single visit coincided as to 75 per cent of their birds.

The studies by Enemar (1962) on six observers and by Hogstad (1967) on four observers accord well with those predicted by a binomial theory with visit efficiency averaging 50 per cent (see Section 6). This is in line with two separate years' results by Enemar et al. (loc. cit.) using four and three observers. Results from Jensen (1971-72) on Danish marshland are also in agreement with this model. Chessex and Ribaut (1966) report that two independent surveys of a Lausanne cemetery park yielded very similar totals for 22 species (correlation $r = 0.990$, $P < 0.001$ for 21 species with the status of the remaining species, the House Sparrow, uncertain for both observers). Finally, Snow (1965) reports the results of paired censusses by independent observers of four English farms: for 11 common species the correlation coefficients between the pairs of observers were 0.860, 0.964, 0.938 and 0.824, pointing to observer ability as a rather small factor in the census results on two of the four farms. Enemar et al. (1978) in fact concluded that any averagely experienced ornithologist could adequately substitute for any other without introducing appreciable error in the census results.

In practice, these differences do not matter for the calculation of the annual CBC indices since it is shown elsewhere (Section 4) that these observer differences are cancelled out by the process of pairing of census plot results across years. That is, each observer acts as his own control in eliminating the effects of his own census efficiency, provided only that he is consistent in effort from year to year, and that his efficiency is independent of the population levels concerned. The present findings do indicate, however, that census plots covered by teams of people need consistency in respect of the size of group undertaking the field visits from year to year, since a striking difference between the results of observer D (two fieldworkers working as a team) and the other observers emerged (Table 3.5). Significant bias would therefore be introduced were a group census plot to be censussed systematically in one year by a group of two or three people working together on all visits but in a second year by only one member of the group. It is probable that this effect will be much less important if group size varies randomly amongst visits within a single year. It seems desirable to draw the presence of this bias to the attention of CBC workers undertaking communal study of CBC plots.

A relatively minor source of observer variation may be the difference in time of day between the census work of observer C and that of the other three observers, the former working 0600-0900 hrs, the latter group chiefly 0900-1330 hrs. Time of day certainly affects the results of avian census work, with early morning counts yielding more registrations of birds than do counts at other times of day (Robbins and van Velzen 1970). In Finnish experiments on the use of the line transect method, late morning census work achieved only 87 per cent of the density of estimates made in early morning; afternoon censusses achieved only 51 per cent, and evening censusses only 62 per cent of the early morning results (Järvinen, Väisänen and Haila 1977). Because of the cumulation of records into spatial clusters, the mapping method used in the CBC scheme should not be as sensitive to time of day. This was tested here by calculating the loss of clusters for an eight-visit CBC site if efficiency altered in line with the Finnish transect results. (An eight-visit census is considered to be the normal minimum for use in the national CBC index). If early morning census efficiency (i.e. proportion of territorial birds present actually registered) is 60 per cent (Enemar 1959, Lack 1976) the chances of failing to detect a territorial bird on at least three visits (as required by CBC rules) are as shown in Table 3.10. Thus with eight visits, CBC mapping at any time during the morning would give acceptable results if census efficiency is 60 per cent or higher; with lower efficiency more visits would be necessary. Afternoon and evening counts would be unacceptable for density estimation. (Note, though, that these figures refer only to errors in absolute densities: because of the across-year pairing procedure the CBC index would not be affected unless the time of censussing changed between years). The calculations of Table 3.10 predict slightly higher rather than lower efficiencies of bird detection on the part of observer C censussing in the early morning whilst Table 3.4 shows that he was in fact the observer with the lowest totals of the four. Enemar (1959) notes, however, that at very high densities of birds the greater registration frequencies of early morning work may actually be a disadvantage since individual singing males elsewhere were not then easily identified as such.

Another source of variation in observer efficiency appears to be experience of CBC work. Observer A had extensive experience of census work in a variety of habitats and over

Table 3.10 Census efficiency at different times of day when using the three-registration criterion with eight census visits.

Time of visits	Relative visit efficiency [a]	Absolute visit efficiency	Probability of including territory
Early morning	1.00	0.60	0.95
Late morning	0.87	0.52	0.88
Afternoon	0.51	0.31	0.47
Evening	0.62	0.37	0.63

Notes: [a] Based on line transect data of Järvinen *et al*. (1977).

many years and was also extremely well acquainted with the results of hundreds of CBC plots throughout the country in the course of his routine analysis of these maps. At Aston Rowant he showed high efficiency in accumulating evidence for breeding pairs on the census plot. On the other hand, there was little difference in census efficiency between observers B and C, despite the former not having had previous CBC experience and the latter having two previous years' experience on the Aston Rowant plot. It may be significant in this respect that Enemar et al. (1978) found no differences in census results obtained by four observers of "extensive and comparable experience of the mapping technique." It may be that individual differences in ability are more important than the extent of census experience as such, though the importance of the latter must not be dismissed lightly. The pair of fieldworkers designated as observer D had many years experience of CBC censussing, though this does not account for the difference between the results for them and observer A. It could be useful to further evaluate the effect of extent of census experience by analysis of the census results from some of the longer-running CBC plots in the national scheme, though care will be needed to avoid the results being confounded with long-term population changes in the species present.

Figure 3.1 suggests that the duration of fieldwork was a component in the better field performance of observer D. The CBC fieldwork guide-lines do not set down specific targets for field time though observer consistency of effort between years is requested. The Figure shows that observer D spent substantially longer on the plot both in 1977 and in 1978 and that their link with greater cluster totals was reflected in an overall (across years and observer) correlation with field tim

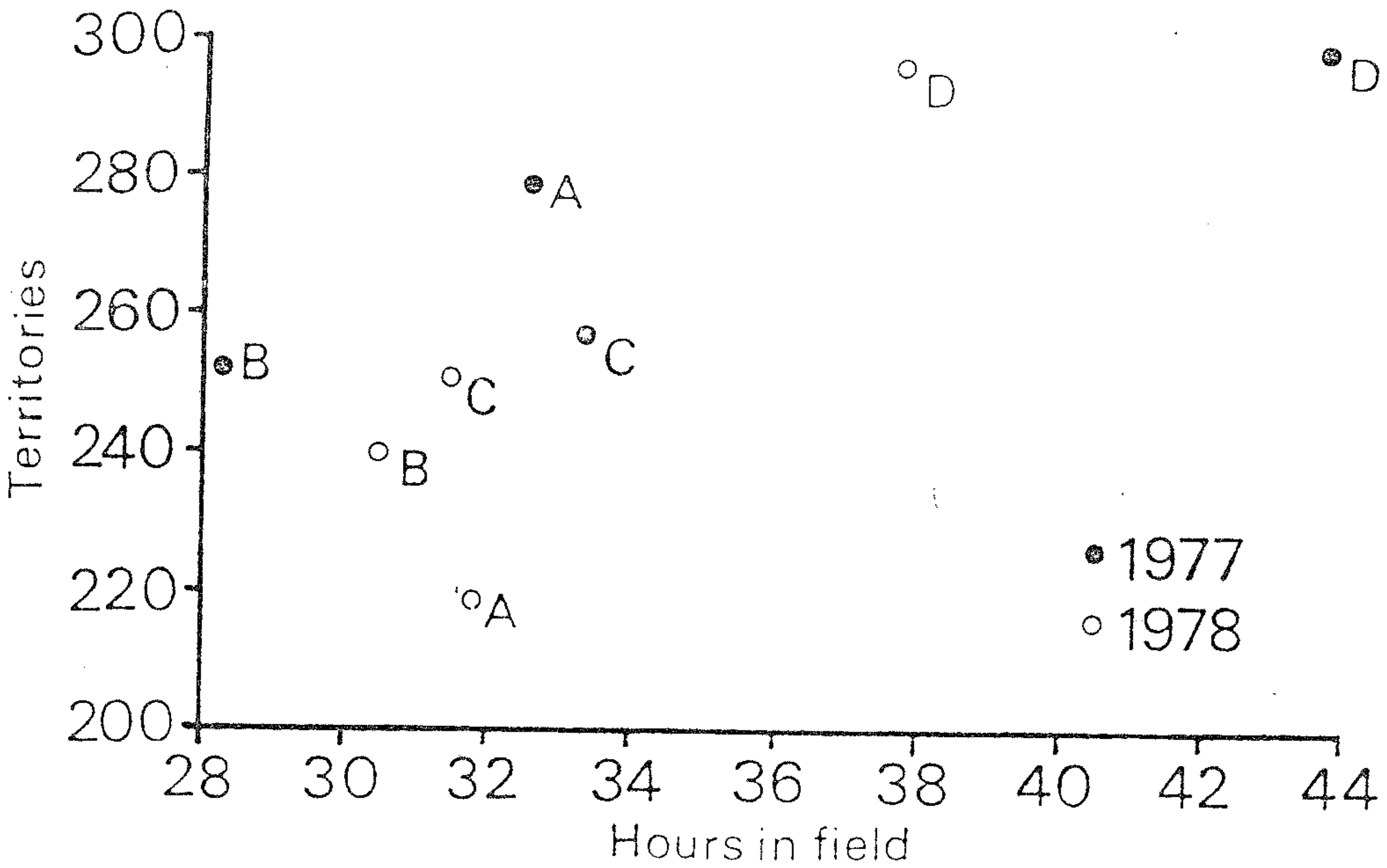

Figure 3:1 Clusters (all species pooled) established for individual observers in 1977 and in 1978 in relation to time spent in field on ten census visits. Data for "observer D" (the team of two fieldworkers) are based on the durations of their joint visits, not on total man-hours expended between them.

Since bird density on the site could (and did) vary between years there is no a priori requirement for overall correlation. Within each year the correlations were positive but not significant with only four data points (1977: $r = 0.802$, $P < 0.3$; 1978: $r = 0.870$, $P = 0.2$). Combining the within year correlations by z transformation (Snedecor and Cochran 1967) gave a pooled correlation corrected for differences in bird density of 0.840 ($P = 0.085$).

The link between observer efficiency and time in field indicated by Figure 3.1 is suggestive but, because of the confounding of variables present, not conclusive. Particularly interesting is the possibility that the confounding of time in field and previous census experience is genuine, with experienced observers deliberately spending more time over each visit. Svensson (1979) concluded that improving the effort of individual visits was the best option for improving the overall efficiency of a mapping census. In the same vein, Tomialojc (1980) recommended concentrating on acquiring high quality registrations (simultaneous song, territorial boundary disputes, etc.) in enhancing census efficiency, a point met by greater time per visit.

It is worth noting that the differences in total census efficiency amongst the observers A, B and C were only of the order of 15 per cent despite their range of census experience. Such a difference is comparable with the confidence limits of the annual CBC indices and would of course be reduced by the large sample of observers participating in the national scheme. (Williamson (1968a) suggests that the CBC index is sensitive to within five per cent for Blackbird and to within ten per cent for Skylark, Great Tit, Blue Tit, Song Thrush, Robin, Dunnock, Chaffinch and Yellowhammer; a little outside this limit are Partridge, Wren, Whitethroat, Willow Warbler and Linnet). The results in Table 3.7 support this broad ranking, except that Willow Warblers at Aston Rowant were censussed with less variability than suggested by Williamson. The figures indicate that perhaps half the commoner species on the plot were being censusse with adequate precision to permit one to ignore observer differences in assessing avian densities, even given only quite modest samples of census plots. Further, these figures could probably be improved upon given greater standardization of fieldwork time (cf. Figure 3.1).

The results of the Section provide useful reassurance that densities evaluated from the CBC returns may be used for comparisons between habitats or between years, to an acceptable approximation. Where sufficient replicates of particular habitats are available, which will often be the case with the large number of participants in the CBC scheme, the possible bias is correspondingly reduced. This side of CBC analysis has not been undertaken to any extent in the past, because of uncertainties as to the effect of observer error, but the present study suggests that the errors involved are tolerable. Possibly more important for such work are the edge effects described by Cousins (1977), who found that the incorporation of territories on the periphery of a census plot could lead to significant variations in estimated densities.

In summary of this Section, the present results confirm that the training process for CBC analysts effectively removes individual variation, so that the turn-over of analysts over the years has little or no effect upon the calculation of a

CBC index. Observer differences are present, however, and their effect on the CBC index calculations needs to be removed by the across-year pairing of census results. Significant sources of observer variation are probably the number of observers operating during a census visit and, possibly, extensive experience of census work. Whilst these effects do not influence the CBC index if held constant from year to year, they do have implications for the use of estimates of spatial densities of individual species recommended by Milner and Hornby (1977).

SECTION 4

ESTIMATION OF ANNUAL POPULATION CHANGES

An important assumption of the CBC methodology has been that much of the effects of observer differences in field censussing expertise is eliminated by the technique of pairing sites across years and including in the annual estimation of population change only those sites censussed for the species in both years (Williamson and Homes 1964, Taylor 1965). Milner and Hornby (1977) strongly emphasized the dependence of the validity of the CBC index on the consistency (and not on the accuracy) of the field observations from year to year and pointed to the strength of the statistical examinations of this consistency. They drew attention, however, to the absence of any field investigation of the assumption that plot retention across years ensured consistency and recommended that such a test be conducted. The work at Aston Rowant included an experimental test of the validity of the assumption.

Materials and methods

The census work at Aston Rowant was conducted both in 1977 and in 1978 by the same observers, so that with absolutely standardized analysis of the species maps each observer provided an independent estimate of the change in population level for each species. The extent to which these vary within each species is therefore a measure of the consistency of estimation of population change. If this variation is less than between observer variation in the absolute population estimates for each year, the power of the pairing procedure is also demonstrated

The ten-visit censusses of each observer for 1977 and for 1978 were used as the basis for the analysis. It was not possible to have one analyst process all the maps but this is unimportant since between analyst variation has already been shown to be small (Section 3). Instead, the 1978 species maps were independently prepared from visit maps by BTO staff not involved in the subsequent analysis and each species map assigned in stratified random order to one of two analysts, the stratification ensuring that each analyst evaluated exactly two of the four replicate (different observers) maps for each species. The two analysts had previously analysed duplicate copies of all the 1977 species maps. In this way, each analyst processed both years' maps for a given species-observer combination but analysed only half the species censussed by a given observer and only two of the four maps for any one species. These precautions minimized the effects of any residual of bias which might have existed between the two analysts. However, as a final check an additional twenty-two 1978 species maps for one observer were duplicated and analysed by both analysts, thereby providing a direct control against the possibility of their having drifted apart in analytical procedure since the earlier study of their mutual consistency.

The empirical results provided registrations for 66 species (Table 3.1), but not all of these were equally amenable to use in estimating the change in breeding populations between the 1977 and the 1978 breeding seasons. The statistical analyses applied therefore differed between species. Where the combined territory counts were large enough, a 2 x 4 contingency table for year and observer was constructed and tested using X^2 (Snedecor and Cochran 1967, pp. 240-241). This allowed analysis of data for 21 species, though some of these had rather low expected frequencies and need cautious acceptance. A further

16 species yielded too few registrations to allow adequate territory analysis. The remaining 29 species were too scarce on the plot to meet the assumptions of X^2 analysis, involving as they did only 1-3 territories in both years for at least one of the four observers. These low density species data were therefore pooled in a non-parametric analysis of variance distribution.

Results

Table 4.1 presents the results of duplicated analyses of a single observer's results and compares the resulting population change estimates within the analysts. The species used in the analysis provide a cross-section of those recorded on Aston Rowant during the census, providing checks over species density, size of population change, habitat requirements and breeding season. As with the 1977 data, the 1978 territory estimates were highly correlated between analysts (untransformed data $r = 0.9987$, $P < 0.001$), exact agreement being obtained for 18 out of 22 species. Comparison of the two analysts' estimates of population changes between 1977 and 1978 gave 17 species with identical estimates, four cases of estimates differing by only one cluster and one case (Wren) where the estimate differed by two territories. The discrepant cases divided almost equally as to sign between analysts, three being positive differences of one territory and two (one each of one territory and of two territories) being negative. There was thus excellent agreement between analysts in evaluating the 1978 data and in the overall estimation of population changes when observer identity was held constant. Analyst identity is therefore ignored in the following consideration of observer differences.

Table 4.1 Replicated analyses by two analysts on 1977 and 1978 data from a single observer and the resulting estimates of population change.

Species	Analyst X clusters			Analyst Y clusters			Difference in change
	1977	1978	Change	1977	1978	Change	(analyst X - analyst Y)
Sparrowhawk	0	1	1	P	1	1	0
Kestrel	0	1	1	0	1	1	0
Red-legged Partridge	0	1	1	0	1	1	0
Wood Pigeon	4	10	6	5	10	5	+1
Turtle Dove	1	P	-1	1	P	-1	0
Collared Dove	2	2	0	3	2	-1	+1
Carrion Crow	1	2	1	1	2	1	0
Jackdaw	0	P	0	P	P	0	0
Magpie	2	2	0	2	2	0	0
Blue Tit	8	10	2	8	10	2	0
Coal Tit	2	7	5	2	7	5	0
Willow Tit	0	P	0	P	P	0	0
Long-tailed Tit	2	1	-1	2	1	-1	0
Wren	28	35	7	24	33	9	-2
Blackbird	17	20	3	17	19	2	+1
Song Thrush	11	8	-3	12	9	-3	0
Garden Warbler	1	1	0	1	1	0	0
Chiffchaff	1	1	0	1	1	0	0
Spotted Flycatcher	0	P	0	P	P	0	0
Meadow Pipit	0	P	0	P	P	0	0
Greenfinch	2	4	2	2	5	3	-1
Yellowhammer	5	7	2	6	7	1	+1

Notes

P refers to registrations of the species too few in number to allow establishing a cluster on the basis of the standard CBC rules.

Table 4.2 presents a 2 x 4 contingency table for Willow Warbler, to illustrate the method of analysis. The 1977 and 1978 cluster totals were entered, according to observer identity, under one of the four columns for observations and row and column totals computed. The 1978 totals were then expressed as a proportion of the observer's 1977 plus 1978 total and a X^2 computed to test for consistency of this proportion between observers. Thus, had there been a 50 per cent drop in Willow Warblers between 1977 and 1978 and had the between-year observer pairing acted precisely, each observer would have recorded proportions $p_i = 0.333$, irrespective of the different field abilities of the observers as expressed in their respective combined totals (n_i) for the two years. The lower the X^2 value obtained, the more closely alike are the observers in their detection of percentage population change. With three degrees of freedom in the Table, X^2 must exceed a value of 7.81 before there is statistical evidence of discrepancies between observers. Conversely, though, X^2 values less than 0.35 are essential for statistical proof that the percentage changes estimated by the four observers are identical. The test is similar to that applied by Taylor (1965) in testing for differences in proportional change between CBC plots.

(It should be noted here that this use of contingency table analysis is not ideal for such testing. It is relatively easy to fail to demonstrate heterogeneity i.e. X^2 stay below 7.81 in the paragraph above - and this by itself does not prove homogeneity. Yet the requirement of agreement good enough to bring X^2 below 0.35 is extremely strong and difficult to meet).

Table 4.2. The year by observer contingency table for Willow Warbler illustrating the calculations involved.

Observer	A	B	C	D	Row total
Clusters recorded in 1977	25	23	36	24	108
Clusters recorded in 1978 (x_i)	21	23	29	25	98 (x)
Column total (n_i)	46	46	65	49	206 (N)
p_i ($=x_i/n_i$)	0.456	0.500	0.446	0.510	0.476 (p)

$\chi^2 = (\sum p_i x_i - px)/p(1-p)$

$= \left[(21)^2/46 + (23)^2/46 + (29)^2/65 + (25)^2/49 - (98)^2/206\right]/0.476(1-0.476)$

$= 0.64$

with $(4-1)\text{x}(2-1) = 3$ degrees of freedom

Table 4.3 presents the results of this analysis for the 21 species for which sufficient number of clusters were recorded over the two years. In no case was there any evidence of significant disparity between observers as to the percentage population change between years. On the other hand, no species displayed statistically identical population change estimates amongst the four observers; this presumably reflects the small sample size involved here. The important conclusion is that, in respect of statistical significance, the different observers do not disagree in their estimates of the population changes which occurred in these 21 species between 1977 and 1978.

The data from these 21 species may also be analysed collectively for evidence of observer difference in estimating population changes, by means of a Friedman two-way analysis of variance. For each species we have four estimates of the annual population change between 1977 and 1978 (measured as p) so that 21 matched sets of four estimates are available. Within each species the p_i can be ranked 1 to 4 in increasing size and the resulting ranks added for each observer to yield totals of 38, 58.5, 55 and 58.5 for observers A, B, C and D respectively, the fractional ranks originating where ranks were averaged when the p_i values of two observers were equal. Dividing these rank totals by 21 gives average ranks of 1.81, 2.78, 2.62 and 2.78 for the four observers, suggesting some tendency for observer A to achieve consistently low rank i.e. smaller percentage changes between the two years than estimated by the other three observers. Calculation of Friedman's two-way analysis of variance statistic X^2_r from these

Table 4.3 Census data for 2 x 4 year by observer contingency table analyses for 21 species with adequate cluster totals for all observers. Species marked with asterisks had expected values of at least 5 clusters for all observer totals and are thus quite robust under χ^2 analysis. Other species had at least one expected value below this (though above 1.0) and were therefore less satisfactory for χ^2 calculations: they are certainly adequate wherever the other seven cells had expected values above 5.0 (Snedecor and Cochran 1967, p. 241). With three degrees of freedom in all tables χ^2 must exceed 7.81 for statistical evidence of differences between observers.

Species	Year	Clusters recorded from observer				χ^2
		A	B	C	D	
Wood Pigeon	1977	5	4	5	11	
	1978	7	6	10	15	0.35
Collared Dove	1977	2	2	3	2	
	1978	2	3	2	3	0.55
Magpie	1977	4	2	2	3	
	1978	2	2	2	5	1.17
Great Tit *	1977	13	10	7	11	
	1978	9	6	8	12	1.37
Blue Tit *	1977	14	18	8	19	
	1978	13	18	10	13	1.16
Coal Tit	1977	6	5	2	6	
	1978	7	7	7	5	2.24
Long-tailed Tit	1977	5	4	2	4	
	1978	2	2	1	4	0.84
Wren *	1977	19	14	24	21	
	1978	20	20	33	26	0.55
Mistle Thrush	1977	4	4	3	4	
	1978	4	2	6	5	1.72
Song Thrush *	1977	10	9	12	13	
	1978	7	8	9	9	0.18

Table 4.3 cont...

Species	Year	Clusters recorded from observer A	B	C	D	χ^2
Blackbird *	1977	25	22	17	30	
	1978	19	22	19	28	0.80
Robin *	1977	30	20	27	32	
	1978	17	20	26	29	2.34
Blackcap	1977	6	4	8	2	
	1978	7	9	10	7	1.93
Lesser Whitethroat	1977	3	2	2	2	
	1978	3	2	1	2	0.28
Willow Warbler *	1977	25	23	36	24	
	1978	21	23	29	25	0.64
Goldcrest *	1977	14	10	13	13	
	1978	6	6	6	9	1.99
Dunnock *	1977	19	21	23	19	
	1978	18	14	19	19	0.37
Greenfinch	1977	4	4	2	3	
	1978	4	5	5	8	1.45
Bullfinch *	1977	8	7	12	9	
	1978	7	6	6	6	0.79
Chaffinch *	1977	24	23	22	27	
	1978	21	25	23	37	1.38
Yellowhammer *	1977	6	6	6	10	
	1978	9	8	7	9	0.61

data gave a value 8.24, not quite significant with three degrees of freedom ($X^2_r = 8.24$, $0.05 < P < 0.10$). The data thus come close to demonstrating a slight observer bias on the part of the observer A when the evidence from all 21 species is considered. Even so, the data do not formally substantiate bias and none of the individual species analysed (Table 4.3) provided evidence of discrepancies between observers. The analysis therefore indicates that any bias present is too slight to influence the normal calculation of species CBC indices.

The analyses of Table 4.3 suggest that the estimates of population change made for each species will be correlated between observers. The extent to which such agreement held was estimated by computing Kendall's coefficient of concordance for the four sets of 21 population changes (Siegel 1956). The coefficient obtained was $W = 0.642$ ($X^2 = 51.38$, d.f. = 20, $P < 0.001$), to be compared with the value of unity for perfect consistency. There was therefore very significant agreement between the four observers as to the population changes undergone by these 21 common species even though in Table 4.3 no single species could be formally proven to have a population change estimated homogeneously across observers.

These results apply to the 21 species listed in Table 4.3 and relatively numerous on the census plot. Table 4.4 treats the data from the remaining 45 species recorded by at least one observer in one year. Most of these species had only 0-2 territories identified on the census plot according to most of the four observers (Table 3.1), so that the X^2 analysis of Table 4.2 was inapplicable. The information was therefore tested for evidence as to differences between

Table 4.4 Comparison of frequency distribution of the range of estimates of the 1977-78 population changes made by each of four observers with the Poisson distribution, for 45 species for which cluster totals were individually too few to permit χ^2 analysis.

Range in estimate of population change	Observed frequency (O)	Expected frequency (E)^2	Deviation	χ^2 contribution
0	18	17.69	0.31	0.00_5
1	15	16.52	-1.52	0.14
2	9	7.71	1.29	0.22
3	3	2.40 } 3.08		
4(+)	0	0.68	-0.08	0.00_2

$\chi^2 = 0.37$, df = 2, $0.80 < P < 0.90$

observers in a different way. For each species the range of the four estimates of the 1977-1978 population change was calculated. If all observers were identical in the consistency of their (individually different) census efficiencies between the two years, the range of the four estimates would be zero, except in so far as the statistics of small numbers introduced rounding effects (i.e. the recorded territory totals can only take integer values). In the absence of any systematic bias on the part of any observer, the observed range of estimates for each species should deviate from zero values in a random manner and the distribution of the ranges computed for the 27 species studied should conform to a Poisson distribution. The results (Table 4.4) show that the observed distribution did not deviate significantly from the Poisson pattern ($X^2 = 0.36$, d.f. = 2, $0.80 < P < 0.90$). The results therefore do not prove the distribution was a Poisson one, failing to come within the five per cent level required for statistical goodness of fit to the distribution.

Irrespective of whether the Poisson model of Table 4.4 is in fact correct, the observer variation in estimation of these species population changes can be evaluated by pooling the data for the 45 species and using the Kruskal-Wallis non-parametric analysis of variance (Siegel 1956). For all 45 species the resulting statistic was $X^2 = 3.12$ (d.f. = 2, not significant), indicating absence of statistical significance to the between observer estimates of population change. It is possible, however, to argue that such an analysis is unduly weighted by the presence of results from the 16 species registered but not proven to hold territory on the plot (Table 3.1)

For this reason a separate analysis of the 29 territorial species was conducted, yielding $X^2 = 4.84$ (d.f. = 2, not significant). This pooled analysis for the scarcer species at Aston Rowant is thus consistent with the individual analyses of Table 4.3 in supporting the idea that estimates of population change between years are not influenced significantly by observer expertise.

Discussion

The finding of Table 4.3 was that there was no evidence of significant differences between observers in the estimates of population change made from their individual population censusses for the two years is a most important one. With the analysis for low density species it provides experimental evidence for the validity of a fundamental assumption of the Common Birds Census scheme, that heterogeneity of observer ability is not a source of bias for the annual CBC index. Statistical evidence to this effect has of course been provided previously by Taylor (1965) who showed that the population changes reported by a large number of observers were satisfactorily homogeneous within year-pair (see also Milner and Hornby 1977). The present study is particularly valuable confirmation of the CBC assumption because it has already been shown (Section 3) that the observers participating in the Aston Rowant study did in fact differ significantly in censusing ability. Thus, even though Table 4.3 provided little statistical evidence for homogeneity of population change, the mere fact that no heterogeneity could be demonstrated when given known heterogeneity of observer efficiency, demonstrates that the process of plot (observer) pairing between years adopted nationally is an effective means of eliminating observer ability as a factor influencing the estimate of annual population change.

Enemar _et al_. (1978) have reported a comparable analysis of the between year population changes detected for 13 species on a Swedish census plot surveyed independently by three observers: for nine species all three observers agreed as to the direction of change, for the remaining four, one observer disagreed with the other two. The correlation coefficients between the change measured by each observer were 0.88, 0.65 and 0.65 for the three pairings of observers. These coefficients are surprisingly comparable with the Aston Rowant data (Kendall concordance of 0.64), since the Swedish study found negligible differences between observers as to mean census efficiency.

Nilsson (1977) found that his estimates for population changes for titmice, Nuthatch and Treecreeper in two Swedish woodland plots were rather poorly correlated with the true changes (as detected by intensive mapping, colour-ringing and nest searching). He identified the reasons for these low correlations as (1) delay of one week in the timing of census visits on one plot, such that markedly less song activity was included within the census period, and (2) advancement of egg-laying by the titmice in one year, by some 10-14 days, resulting in egg-laying and its associated peak of song activity falling outside the normal census period. Slagsvold (1973a,b) likewise found that singing by the Song Thrush decreased seasonally and suggested that census visits should be timed each year according to phenological observations for that year.

Whilst this is undoubtedly a valid comment on intensive single species studies, it is not a practical response within national census schemes such as the CBC and the Swedish Breeding Birds Survey for which many species with diverse breeding seasons must be monitored (Milner and Hornby 1977, Svensson 1979). In addition, it seems that such seasonality is more pronounced at northern latitudes (Slagsvold 1977) and the results from seasonally concentrated visits to Aston Rowant do not support Slagsvold's (1973a, b) argument (Section 7, O'Connor 1980).

SECTION 5

A COMPARISON OF IPA AND BELT TRANSECT METHODS WITH THE CBC METHOD

The IPA system of point counts was first described by Blondel et al. (1970) and has been developed chiefly in France (Anon. 1977), while belt transect methodology has received a great deal of recent attention from Swedish and Finnish ornithologists (e.g. Järvinen and Väisänen 1975). Both systems offer considerable savings of time in comparison with the mapping method in obtaining results on population changes and on the ranking of dominance in the bird community, and enable much larger areas to be surveyed. However, neither provides the information on territory location afforded by the mapping method, and both are regarded as less accurate than the mapping method in assessing total population densities. Recent work (Dawson in prep.) suggests that point counts can be used even more effectively than is the case with the IPA system, but such considerations lay outside the scope of the present study at the time of its fieldwork.

The purpose of the present study was to assess the results of the two methods under British conditions in relation to an intensive mapping programme. For the IPA method a second aim was to investigate how its results varied with the time spent at each counting point.

Methods

The point count methodology as far as possible followed the recommended standard (Anon. 1977). However, only ten census points were used in the present study and this is a rather small sample by French IPA standards (Ferry, pers. comm.).

The ten points were chosen, distributed roughly equidistantly and at least 50 m inside the plot boundary; they were situated at an easily located geographical feature such as a marker post or a junction of footpaths. The habitat around the points varied considerably as to the density of the surrounding scrub and the amounts of open ground and open sky visible from the point, but the habitats sampled by the point counts were in roughly similar proportion to those of the total census area.

Two counts, one early and one late season, were made by an observer from each point in each of the seasons 1977 and 1978. In 1977 only, a second observer made five-minute counts from independently-selected ten points: two points were common to both observers and a further two were separated by less than 50 m. The distribution of both sets of points is shown in Figure 5.1.

Each count by the principal observer consisted of four sequential five-minute periods. All birds seen or heard were recorded only once during the twenty minutes, using the Common Birds Census symbols for species, sexes and activities. To reduce the chances of recording the same bird more than once, registrations were mapped around the point, giving their direction accurately but scaling down their distances from the point so that a tight cluster was formed. At the end of the count a boundary line was drawn to identify the registrations made at each point.

Visit dates and times are given in Table 5.1. Note that visits in the late morning and the afternoon are not recommended, at least for French conditions (Anon. 1977).

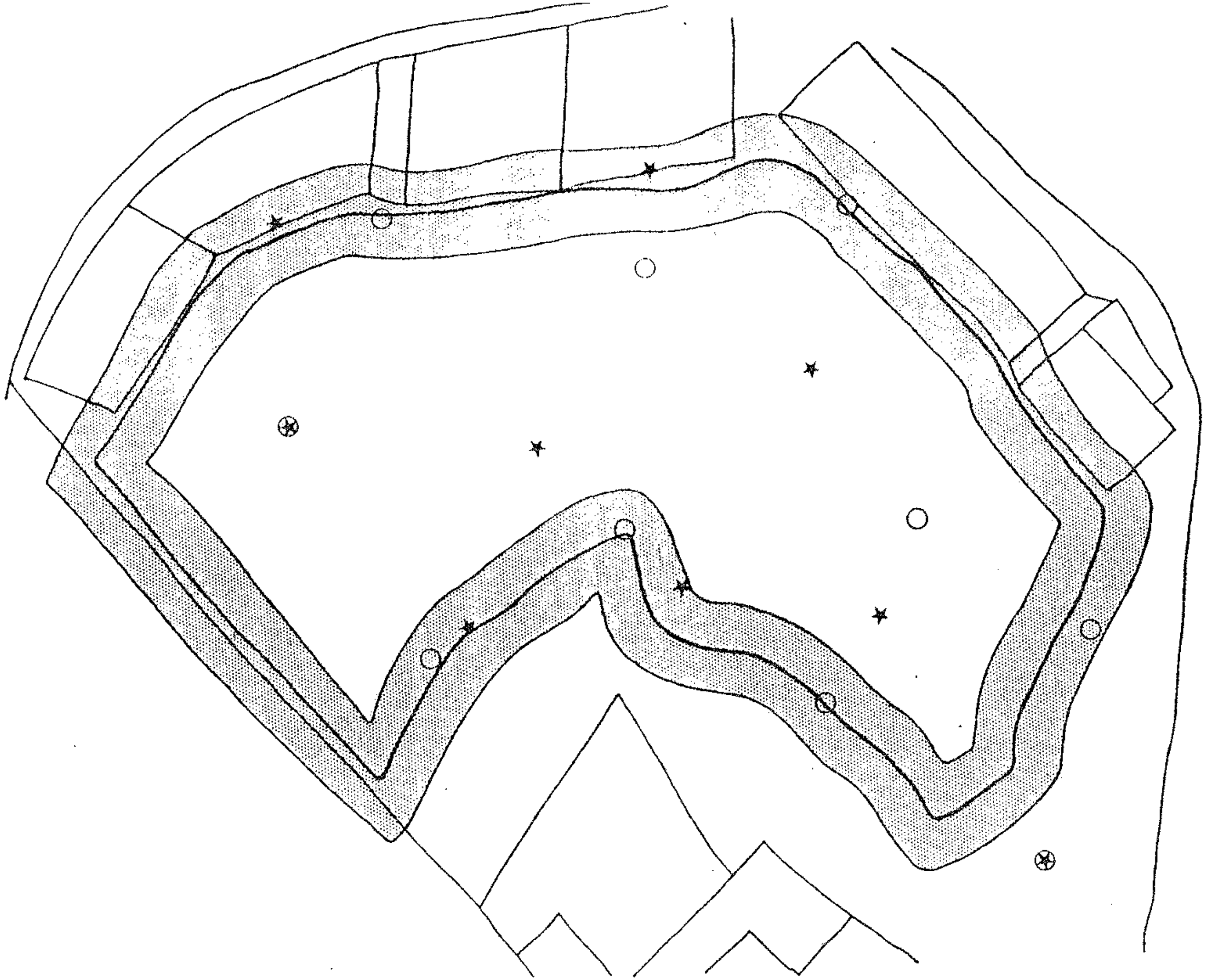

Figure 5:1 Location of IPA listening-points and of belt transect route in relation to the Common Birds Census plot at Aston Rowant. Open circles and stars show positions used by observers S and T respectively (see Table 5.1). Stippled area shows the belt survey strip.

Table 5.1 Dates of IPA census work at Aston Rowant

Year	Date	Time - (BST)	Observer	Points censused
1977	May 2	0945-1215	S	6
	May 4	0945-1125	S	4
	May 6	0900-1035	T	10
	June 1	0945-1240	S	7
	June 3	1000-1115	S	3
	June 9	0900-1035	T	10
1978	May 9	1100-1220	S	3
	May 9	1335-1650	S	7
	June 8	1000-1200	S	5
	June 8	1330-1535	S	5

Total census times:

1977	Observer S	500 min
	Observer T	190 min
1978	Observer S	520 min

In practice it was found convenient to leave a full five minutes between counts for travel between points even though only two or three minutes walking was usually involved so that the subsequent series of five-minute periods were easier to time; thus, ten five-minute counts took 95 minutes, and ten twenty-minute counts 245 minutes, to perform.

At the end of the season the IPA lists from the various points were calculated as described by Blondel et al. using the scoring of 1 for singing males, pairs and family parties, and 0.5 for single birds seen or heard. The higher of the two counts for each species was taken as the IPA value for that season. Separate IPAs were worked out for five, ten, fifteen and twenty-minute count periods.

The belt transect method used was based on the procedure described by Järvinen and Väisänen (1977) but with modifications to suit both the longer breeding season and the shape and size of the Aston Rowant plot.

The method involved recording birds within 25 metres of a transect line, that is, inside a 50 metre wide "main belt". Birds seen or heard beyond this distance, or only seen in flight, are also recorded in a "supplementary belt". Together the two belts are termed the "survey belt". Since the area of the main belt is known, densities can be calculated simply from the main belt data, but after calculation of species-specific correction coefficients, it is possible to obtain more reliable estimates of density from the survey belt. The belt chosen was a loop, as far as possible representative of the habitats of the plot and keeping away from the plot-boundaries; the choice of route was however constrained by the availability of cleared paths. The route together with the 50 metre main belt is shown in Figure 5.1.

The route was not ideal in that part of the main belt lay outside the CBC census plot, and also in that it was possible that birds singing in the centre of the plot could be recorded in the supplementary belt from opposite sides of the transect loop. The route was 1.61 km in length, but the area of main belt lying within the census plot was only 7.45 hectares.

A fairly slow walk was employed, averaging less than 1.4 km per hour, and all birds not behind the observer were recorded. Common Birds Census abbreviations for species and activities were used. Registrations were made on a 1:2500 scale map of the census plot on which the route and main belt had previously been drawn. Visit dates and times for the belt transects are shown in Table 5.2.

Two transects were made each season, as a modification of the Finnish method in response to the longer British breeding season. All transect visits were made around noon. The transects were started at the most convenient point on the route, which varied between visits.

At the end of the season, main belt and supplementary belt registrations were counted for each species; each registration was treated as evidence of a pair except that two conspecifics found more or less together and family parties (adults plus juveniles) were treated as one pair. The sum of the main belt and supplementary belt totals for each species was also tabulated as the survey belt total. In each case the results from the early season and late season transects were compared and the higher of the two totals was taken as the number of pairs detected that season.

Table 5.2 Dates and duration of belt transect census work at Aston Rowant[a]

Year	Date	Time (BST)	Duration (min)
1977	May 4	1125-1250	85
	June 3	1145-1255	70
1978	May 9	1225-1330	65
	June 8	1200-1305	65

[a] All census work was done by observer S.

Results

Rate of accumulation of IPA registrations

For each set of twenty-minute IPA counts, the numbers of IPA registrations recorded in each five-minute period were counted for each pair. No weightings depending on the quality of the registrations were applied. In Table 5.3, the mean percentages of the total registrations after twenty minutes are given for each length of count, together with the ranges of values recorded at the different points.

The percentages of total registrations detected in the shorter time periods were quite similar for each of the four counts. However, the overall trend in means and standard deviation of these percentages (also Table 5.3) and the overall ranges of 25-64% for five minutes, 48-79% for ten minutes and 75-96% for fifteen minutes show that the shorter counts were progressively more variable with respect to the final totals.

On average, more than 13% of the registrations were obtained in the fourth five-minute period. It is clear that prolonged counts would have yielded more registrations. In closed scrub habitats where most birds are detected by song or calls, the number of registrations can be expected to reach saturation rapidly, as the observer begins to lose track of which birds were heard previously; in more open sites, however, saturation should be slower, as in most cases distant birds and birds seen flying over will continue to be treated as new.

Table 5.3 Proportion of IPA registrations acquired in relation to census duration.

Count	Percentage[a] of total observations made in first 5 mins	10 mins	15 mins	Total number of observations[b]
Early 1977	48 (42-61)	71 (61-78)	88 (81-94)	382
Early 1978	45 (25-64)	66 (56-77)	85 (75-93)	226
Late 1977	49 (37-59)	68 (48-79)	87 (77-96)	306
Late 1978	46 (35-63)	68 (52-79)	85 (77-92)	269
overall mean and s.d.	47.4 ± 8.6	68.4 ± 7.7	86.8 ± 5.0	100.0

[a] Figures in brackets are ranges of counts over different census points

[b] From 20 minutes counting

In Table 5.4, the ten points at which twenty-minute counts were made are classified according to habitat. The period after the initial five minutes was on average more important, and the final total of registrations higher, in the field edge sites where visibility was particularly good. However, the differences between the habitat groups were not statistically significant.

The 1978 data were also tested for diurnal effects, to investigate whether the time of day affected either the initial rate at which registrations were made or the final number of registrations. No comparable 1977 data were available since the counts were not individually timed. The proportion of the total registrations which were made in the first five minutes were unrelated to time of day (within the range 1000 - 1650 hrs BST), both for the early and for the late set of counts. However, the total number of registrations detected after twenty minutes was correlated with the time of day, both for the early season counts ($r = -0.616$, $P < 0.05$) and the late season counts ($r = -0.853$, $P < 0.001$). The data are plotted in Figure 5.2 and reveal a pattern of decrease in numbers of birds registered with time of day between 1000 and 1400, followed by a shallow increase between 1400 and 1600. The early and late counts for each point are joined by a straight line; note that the points were covered in more or less the same order for the late counts as the early counts, and that in nine cases the (generally higher) late season count was performed at an earlier time of day than the early season count. Thus the counting procedure was not well designed to detect diurnal effects. However, the data strongly suggest that time of day is important if IPA counts are to be compared between

Table 5.4 Accumulation of IPA registrations[a] in relation to the local habitat at the census point

Habitat	Census points	Total registrations[b] Mean ± S.D.	Percentage in first 5 min
Field edge	2	36.1 ± 10.1	45.1 ± 10.5
Closed scrub	3	28.3 ± 6.9	46.9 ± 8.4
Open scrub	5	27.7 ± 7.7	48.7 ± 8.2

[a] Data from 1977 and 1978 combined

[b] After 20 min census

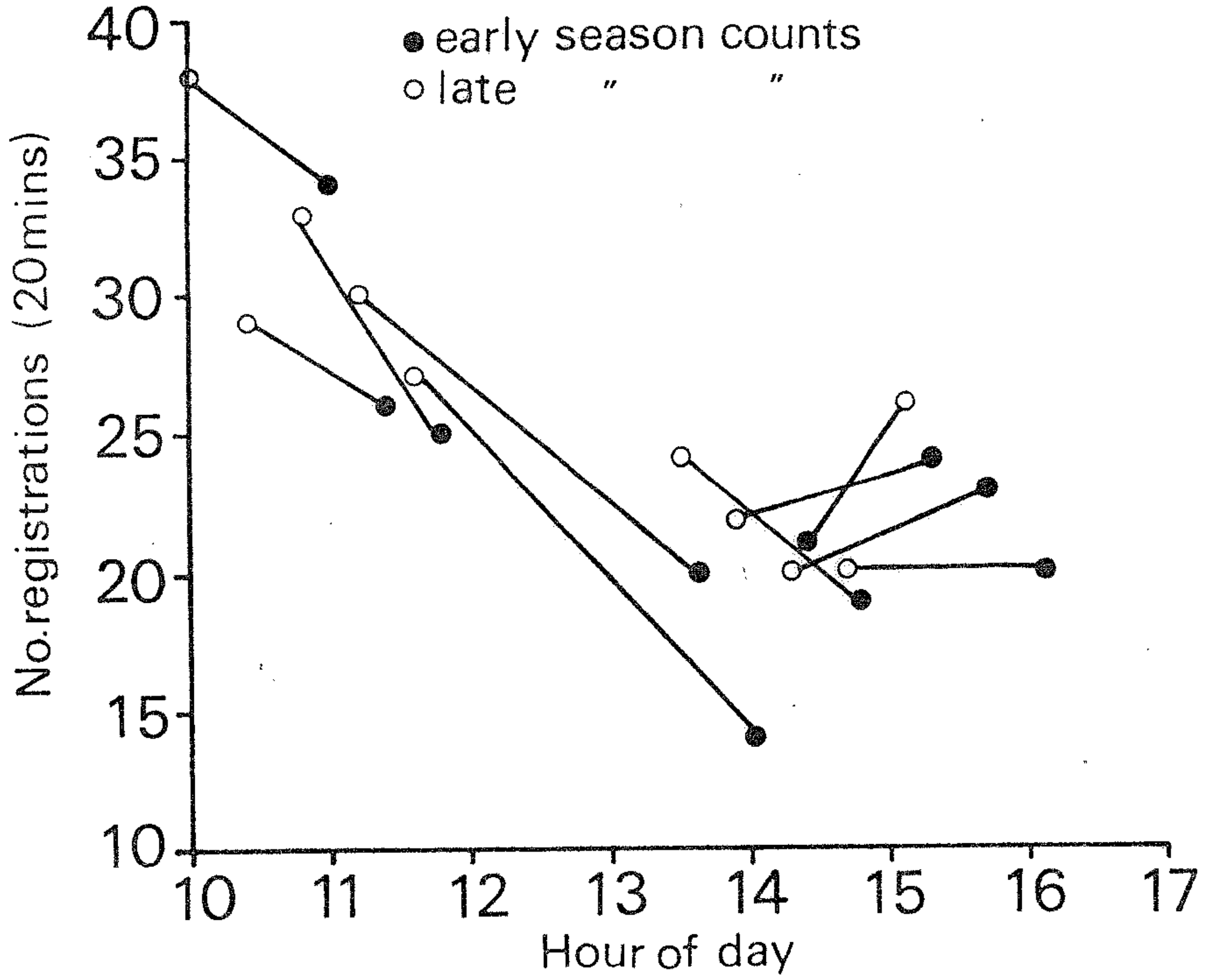

Figure 5:2 Number of IPA registrations at different listening points in relation to time of day (BST). Early and late season counts at the same points are joined by solid lines.

years. Table 5.1 shows that all the 1977 counts were performed before 1240, while in 1978 the counts were generally later and continued until 1650. It would not be surprising therefore if the 1978 IPAs were less efficient than those in 1977. French workers routinely confine their fieldwork to the three to four hours following sunrise to avoid the problems otherwise introduced by such diurnal effects (Ferry, *pers.comm.*).

It was conceivable that the rate of accumulation of registrations might vary with the population level of the species concerned. To test this the relative proportions of the final (20 minutes) total reached after only five and after ten minutes at each point were calculated and regressed under angular transformation on the 20 minute totals. In no case were significant relationships found.

IPA values and CBC cluster totals

The IPA values for each length of count for 1977 and 1978 are given in Tables 5.5 and 5.6 respectively, together with, for comparison, the mean number of territories detected by the four ten-visit mapping censusses.

Kendall's coefficient of concordance (Siegel 1956) was used to assess the similarity of ranking between each set of IPA values and the four sets of ten-visit mapping census results relevant to that year. This method enabled the inclusion of rankings for absences recorded on particular IPA or mapping census results and for species recorded but failing to yield clusters in mapping censusses. Thus 66 species were ranked in 1977 and 59 in 1978. The coefficients of concordance are given in Table 5.7.

Table 5.5 Comparison of CBC cluster totals with IPA scores over various census durations[a]

Observer-	Mapped territories[b] A,B,C,D	20 minute IPA[c] S	15 minute IPA[c] S	10 minute IPA[c] S	5 minute IPA[c] S	5 minute IPA[c] T
Sparrowhawk	0.25	0	0	0	0	0
Kestrel	1	0.15	0.15	0.1	0.05	0
Grey Partridge	1.25	0	0	0	0	0
Pheasant	2.5	0.3	0.3	0.3	0.2	0
Lapwing	1	0	0	0	0	0
Stock Dove	0.5	0	0	0	0	0
Wood Pigeon	6.25	1.9	1.65	1.2	0.7	0.7
Collared Dove	2.25	0.6	0.6	0.3	0.3	0
Turtle Dove	1	0.1	0.1	0.1	0.1	0
Tawny Owl	0.5	0	0	0	0	0
Swift	0	0.25	0.25	0	0	0
Great Spotted Woodpecker	0.25	0	0	0	0	0
Skylark	1	1.75	1.55	1.05	0.7	0
Swallow	0	0.15	0.15	0.1	0	0
House Martin	0	0.05	0.05	0.05	0	0
Tree Pipit	1.5	0.4	0.4	0.3	0.2	0.2
Meadow Pipit	0.25	0.05	0.05	0	0	0
Yellow Wagtail	0	0.1	0.1	0	0	0
Pied Wagtail	0.25	0.05	0	0	0	0
Wren	19.5	2.35	2.15	1.8	1.55	0.95
Dunnock	20.5	2.45	1.95	1.5	1.0	0.5
Robin	27.25	2.7	2.5	2.2	1.85	1.3

Table 5.5 cont...

Observer -	Mapped territories^{b} A,B,C,D	20 minute IPA^{c} S	15 minute IPA^{c} S	10 minute IPA^{c} S	5 minute IPA^{c} S	5 minute IPA^{c} T
Blackbird	23.5	3.35	3.25	2.5	1.95	1.55
Song Thrush	11	1.1	1.1	0.9	0.65	0.4
Mistle Thrush	3.75	0.35	0.3	0.15	0.15	0.3
Lesser Whitethroat	2.25	0.4	0.4	0.4	0.4	0.1
Whitethroat	2.25	0.3	0.3	0.3	0.2	0
Garden Warbler	2	0.4	0.3	0.3	0.3	0
Blackcap	5	0.8	0.8	0.8	0.5	1.05
Chiffchaff	1	0	0	0	0	0
Willow Warbler	27	3.25	3.05	2.65	2.3	2.05
Goldcrest	12.5	1.7	1.6	1.5	1.35	0.7
Spotted Flycatcher	2	0.1	0.05	0	0	0
Long-tailed Tit	3.75	0.25	0.15	0.15	0.15	0
Marsh Tit	2.5	0.15	0.1	0.1	0.1	0.15
Coal Tit	4.75	0,4	0.35	0.15	0.05	0
Blue Tit	14.75	2.0	1.8	1.65	1.0	0.95
Great Tit	10.25	1.75	1.55	1.1	0.75	0.25
Nuthatch	0	0.05	0.05	0.05	0	0
Treecreeper	0	0.1	0.1	0.1	0.1	0
Jay	0	0.05	0.05	0.05	0.05	0
Magpie	2.75	0.35	0.35	0.25	0.2	0.2
Jackdaw	0.25	0	0	0	0	0
Carrion Crow	1.25	0.15	0.15	0.1	0.05	0.05
Starling	1.5	0.55	0.55	0.45	0.15	0
Tree Sparrow		0.1	0.1	0.1	0.1	0

Table 5.5 cont...

Observer - A,B,C,D,	Mapped territories[b]	20 minute IPA[c] S	15 minute IPA[c] S	10 minute IPA[c] S	5 minute IPA[c] S	5 minute IPA[c] T
Chaffinch	24	3.0	2.95	2.7	2.15	1.05
Greenfinch	3.25	1.2	0.8	0.6	0.6	0.2
Goldfinch	2.75	0.35	0.35	0.35	0.1	0
Linnet	3	0.75	0.45	0.4	0.25	0.3
Redpoll	0.75	0.2	0.1	0	0	0
Bullfinch	9	1.15	1.1	0.95	0.8	0.3
Yellowhammer	7	1.0	0.9	0.9	0.7	0

Notes

[a] 1977 data

[b] Territory numbers are the mean values for the four CBC observers

[c] IPA's are the mean values for ten points (see text)

Table 5.6 Comparison of CBC cluster totals with IPA scores over various census durations 1978 data. Conventions as in Table 5.5

Observer - A,B,C,D	Mapped territories	20 minute IPA S	15 minute IPA S	10 minute IPA S	5 minute IPA S
Sparrowhawk	0.75	0	0	0	0
Kestrel	1	0.2	0.15	0.05	0.05
Hobby	0	0.1	0.1	0	0
Red-legged Partridge	0.25	0	0	0	0
Grey Partridge	0.75	0	0	0	0
Pheasant	1.25	0.5	0.3	0.1	0
Stock Dove	0.25	0.1	0.1	0.1	0
Wood Pigeon	9.5	1.6	1.4	1.0	0.4
Collared Dove	2.5	0.25	0.25	0.25	0.15
Turtle Dove	0.5	0.05	0.05	0.05	0
Cuckoo	0.25	0	0	0	0
Tawny Owl	0.5	0	0	0	0
Swift	0	0.1	0.1	0.1	0
Green Woodpecker	1.25	0.2	0.2	0.2	0
Great Spotted Woodpecker	0	0.15	0.15	0.15	0
Skylark	0.5	1.1	1.0	0.6	0.3
Swallow	0	0.45	0.35	0.2	0.15
Tree Pipit	0	0.1	0.1	0.1	0
Meadow Pipit	0.75	0	0	0	0
Wren	24.75	1.6	1.4	1.15	0.95
Dunnock	17.5	1.3	1.1	0.9	0.55
Robin	23	1.35	1.25	1.05	0.7

Table 5.6 cont...

Observer -	Mapped territories A,B,C,D	20 Minute IPA S	15 minute IPA S	10 minute IPA S	5 minute IPA S
Blackbird	22	2.45	2.35	2.2	1.45
Song Thrush	8.25	1.75	1.6	1.15	0.9
Mistle Thrush	4.25	0.35	0.35	0.3	0.25
Lesser Whitethroat	2	0.7	0.5	0.4	0.4
Whitethroat	0	0.05	0.05	0.05	0
Garden Warbler	0.25	0.1	0	0	0
Blackcap	8.25	1.2	1.1	0.7	0.3
Chiffchaff	1	0.2	0.2	0.2	0.2
Willow Warbler	24.5	2.6	2.5	2.25	2.15
Goldcrest	6.75	0.5	0.4	0.3	0.1
Spotted Flycatcher	1.25	0.05	0	0	0
Long-tailed Tit	2.25	0.05	0.05	0.05	0
Marsh Tit	0.5	0	0	0	0
Coal Tit	6.5	0.45	0.25	0.2	0
Blue Tit	13.5	1.3	1.2	1.05	1.05
Great Tit	8.75	0.8	0.75	0.6	0.4
Nuthatch	0.25	0	0	0	0
Jay	0.5	0.1	0.1	0.05	0
Magpie	2.75	0.1	0.1	0.1	0.1
Jackdaw	0	0.2	0.2	0.1	0
Carrion Crow	1	0	0	0	0
Starling	0.25	0.55	0.4	0.35	0.2
House Sparrow	0	0.05	0.05	0.05	0.05

Table 5.6 cont...

Observer -	Mapped territories A,B,C,D.	20 minute IPA S	15 minute IPA S	10 minute IPA S	5 minute IPA S
Chaffinch	26.5	2.55	2.2	1.95	1.7
Greenfinch	5.5	1.6	1.45	1.25	1.1
Goldfinch	2.25	0.7	0.55	0.55	0.45
Linnet	2	0.05	0.05	0.05	0.05
Redpoll	0.25	0	0	0	0
Bullfinch	6.25	0.35	0.35	0.2	0.1
Yellowhammer	8.25	0.55	0.55	0.5	0.4

Table 5.7 Kendall coefficients of concordance [a,b] between CBC census results (4 observers) and IPA counts.

IPA counts duration:		5 min	10 min	15 min	20 min
Year	1977	0.852	0.860	0.866	0.865
	1978	0.808	0.825	0.821	0.824

Note: [a] All coefficients were highly significant, $P < 0.001$

[b] Corrections for tied rankings were made as described by Siegel (1956)

All concordance coefficients were highly significant when tested using X^2 ($P < 0.001$). Thus, IPA counts in both years gave very similar results as to the ranking of dominance in the bird community to those obtained from ten-visit mapping censusses. In both years the concordance was lowest when the five-minute IPA counts were considered, suggesting that the longer time-periods may give better results in this respect. However, this suggestion may be an artefact of the study design used here. A more relevant comparison would be between the results obtained from the same fieldwork time distributed into a larger number of counting periods of short duration. Dawson and Bull (1975) found no difference in precision between the use of five-minute and ten-minute counting periods, the improvements due to the extra five minutes at each location being compensated by the greater number of sample points possible with shorter counts at each point.

Although the rankings were concordant between the IPA and mapping results, the ten-visit mapping censusses performed consistently better in the detection of species. Of the species discovered by ten-visit censusses to be territorial, between 81% and 90% in 1977 and 59% and 91% in 1978 were detected by IPA counts of various lengths (Table 5.8). These percentages take no account of possible errors in the mapping method results which are not an absolute standard of bird densities present.

For individual species, there were a number of consistent differences in rankings between IPA and the mapping censusses, reflecting the differences in sensitivity between the two methods. Swifts and hirundines ranked consistently higher on IPA counts than on mapping censusses; these species

Table 5.8 Percentage of territorial species (as detected by the mapping census observers) which were also detected by IPA counts.

		Observer			
Year	IPA duration (min)	A	B	C	D
1977	5	83	81	87	85
	10	83	81	87	85
	15	90	85	89	87
	20	90	88	89	87
1978	5	72	59	74	71
	10	88	77	84	82
	15	88	77	84	82
	20	91	80	87	85

never merited more than a record of their presence on mapping censusses, no matter how many were seen, since they were clearly not territorial on the site. Skylarks also ranked higher on IPA counts since from most points it was possible to hear birds singing above the arable fields beyond the western boundary of the plot. On mapping censusses birds are not recorded unless within the plot or just outside the boundaries, but the instructions for IPA censusses (Anon. 1977) set no limit beyond which birds should be be recorded.

Conspicuous birds liable to be seen flying over (Woodpigeon, Starling) ranked higher on IPA than on mapping censusses, while small and inconspicuous species (Goldcrest, Long-tailed Tit, Marsh Tit, Coal Tit) tended to rank lower on IPA. Mapping methodology allows the observer to investigate the small sounds which often lead to the discovery of birds such as Goldcrest and Coal Tit, while the IPA observer must remain stationary and record only the birds he can positively identify from the counting point.

IPA values from different observers

The results of five-minute IPA counts from the two observers in 1977 are given in Table 5.5. There was poor numerical agreement between the two sets of figures, with 36 species recorded by observer S against 21 species for observer T. However, both sets of IPAs were strongly correlated with the numbers of territories mapped (see Table 5.9) and they were also highly correlated with each other ($r = 0.887$, $P < 0.001$). Thus, while it would not be possible to derive direct estimates of percentage change between years if the observer had changed,

Table 5.9 Regression analyses for IPA counts of 5 min duration against the results of individual observers, using standard 10 visit CBC surveys.

IPA Observer		CBC Observer A	B	C	D
S	r	0.939	0.915	0.918	0.931
	d.f.	42	43	40	41
	slope	0.074	0.083	0.067	0.067
	intcpt	0.024	0.020	0.116	0.047
T	r	0.868	0.850	0.866	0.848
	d.f.	39	40	36	38
	slope	0.054	0.061	0.049	0.048
	intcpt	-0.044	-0.052	0.018	-0.024

Note: All correlation coefficients are highly significant, $P < 0.001$

the results of either observer could be taken as a valid measure of the bird community present.

Population changes assessed by IPA and by mapping

It has been demonstrated elsewhere (Section 4) that the four mapping census observers were consistent in their estimates of the 1977-78 percentage changes in numbers for 21 of the more abundant species. For these 21 species, regressions of the mapping estimates of change (as derived from combining the territory totals from the four observers) on the four estimates of change from the different lengths of IPA count were made (Table 5.10).

The results show generally poor correlation between mean CBC results and the IPA values; only the changes detected by the ten-minute counts were significantly correlated with those obtained from mapping.

Figure 5.3 shows the scatter of points for the ten-minute IPA percentage changes plotted against mapping. Only four of the IPA changes - those for Goldcrest, Bullfinch, Robin and Greenfinch - were individually statistically significant.

For almost all the species plotted, there was a smaller positive or a larger negative change from the ten-minute IPA counts than from mapping so that the trend line has a negative intercept. This was true also for the other lengths of IPA count (although the correlations were not significant). It is clear that for these 21 species the IPAs in 1978 were less efficient, when compared to the number of territories mapped, than those in 1977.

Table 5.10 Correlation coefficients between IPA counts of various durations and the standard CBC results[a].

IPA duration	Correlation coefficient[b]
5	0.241
10	0.476*
15	0.408
20	0.389

Notes: [a] Obtained as average of 4 independent CBC surveys

[b] Under angular transformation

* $P \leqslant 0.05$

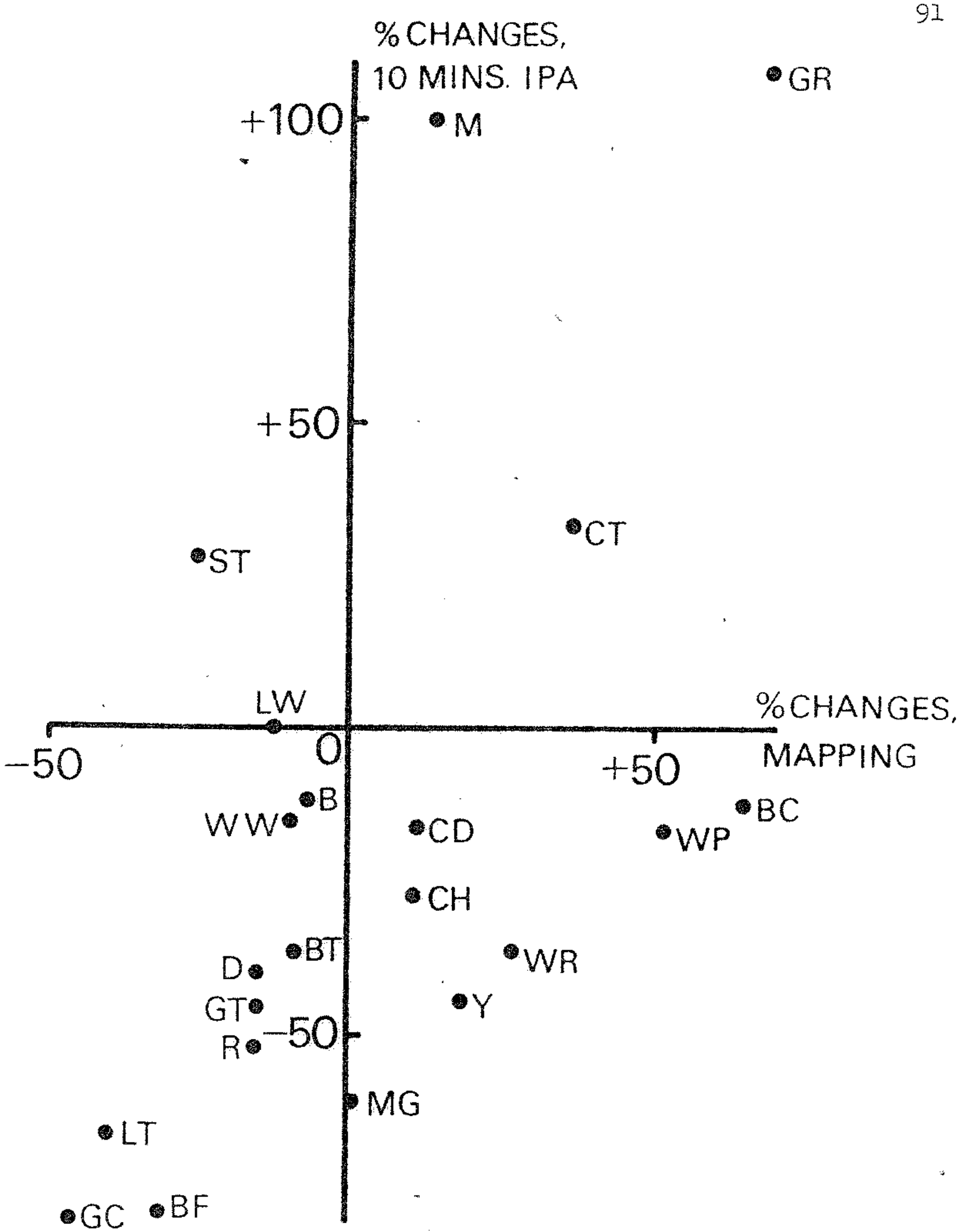

Figure 5:3 IPA estimates of 1977-78 population changes for 21 species at Aston Rowant in relation to the estimates made from CBC data. For species codes see Appendix 1.

The major outliers in Figure 5.3 are the several species for which a large increase was recorded on the IPA counts. Of these, the Mistle Thrush and Coal Tit figures were based on only three IPA observations in 1977, but sample sizes of 18 for Song Thrush and 12 for Greenfinch were more satisfactory. Song Thrush was the only species consistently outlying in the distribution when each of the four lengths of IPA were compared with mapping. It is not clear why the efficiency of IPAs in recording Song Thrushes should have been higher in 1978 than in 1977, when the general trend in efficiency was the opposite, but the differences in the timing of the IPA visits with respect to time of day and to the stage of the Song Thrush breeding cycle are likely to have been responsible. Slagsvold (1973a) found two distinct seasonal peaks in the song activity of Song Thrush in south-east Norway corresponding to stages of the breeding cycle. Song Thrush registration frequency was sharply seasonal at Aston Rowant (Section 8) and thus likely to have been affected by the timing of the IPA counts, combined with diurnal differences in song frequency.

For species other than the 21 already discussed small samples gave rise to poor estimates of percentage change. A simple non-parametric test was devised instead. Each IPA change was classified as either +, - or zero. The changes estimated from the different lengths of IPA count were treated separately with each compared in turn with the results from mapping. A single estimate of change from mapping was obtained by taking the four estimates, cancelling any pairs of + and -, and expressing the result in terms of numbers of excess plus and minus estimates. Thus if all observers agreed as to the sign of the change, the result was either four excess minuses or four excess pluses, while three observers recording a decrease and the fourth an increase was classed as two excess minuses and so on.

Contingency tables were drawn up using these summaries of the mapping results and the +, - and zero estimates from IPA. Because of the small entries in many of the cells of the contingency tables, it was necessary to combine adjacent categories until the expected values were above the minimum requirements for the X^2 tests. No significant associations were found, but the tendency for minus estimates on IPA to be associated with two or more excess minuses from mapping, and plus estimates to be associated with less than two excess minuses, almost reached significance ($0.05 < P < 0.1$) for the ten, fifteen and twenty-minute IPA counts when tested as a 2 x 3 contingency table. The full table for the ten-minute IPAs giving rise to the highest value of X^2 (5.68, 2 degrees of freedom) is reproduced as Table 5.11.

This Table, in common with that for the other lengths of IPA count, suggests that more species were recorded as plus, and fewer as minus, by IPA counts than by mapping. Thus for these forty-six species, IPA counts were more efficient overall in 1978, relative to the mapping method, than they were in 1977. This result is in contrast to that obtained for the twenty-one major species on the site, where regression of mapping against IPA percentage changes gave a negative intercept (Figure 5.3).

Table 5.11 Contingency table for the directions of population changes 1977-78, as detected by 10 minute IPA counts and by CBC mapping. See text for details.

		-4	-3	-2	-1	0	1	2	3	4
IPA results	+			1	5	2				1
	0	1	2	5	6	4	1	3		
	-	4	2	3	2	3	1			

Note: Table entries show the number of species concerned

Comparison of belt transect results with mapping

The results from the belt transect counts are given in Table 5.12. In each case individual birds seen or heard and pairs or family groups obviously together were scored as one territory. The higher of the two counts for each species was taken as the value for that species and year. Both "main belt" and "survey belt" totals are given in the table of results: the survey belt totals are the sum of the main belt and supplementary belt observations (Järvinen and Väisänen 1975).

Table 5.13 shows that between 89% and 93% of the territorial species detected by ten-visit mapping censusses in 1977 were found in the belt transect survey belt. The belt transects were less effective in this respect in 1978 than in 1977, and only 80% to 88% of the territorial species were recorded. Totals of 42 species in 1977 and 35 in 1978 were detected in the survey belt.

The numbers of birds detected in the supplementary belt, and hence the survey belt, are highly dependent on the conspicuousness of the species concerned. It is thus not possible to use survey belt data in the estimation of densities, unless the percentage of survey belt observations likely to be recorded from the main belt is already known for each species from previous studies in the same or similar habitat.

Densities derived from the belt transect main belt data are shown in Table 5.14 for the ten commonest territorial species, together with the densities recorded by each of the four ten-visit mapping censusses.

Table 5.12 Birds detected by belt transects 1977 and 1978

	1977		1978	
	Main Belt	Survey Belt	Main Belt	Survey Belt
Kestrel	0	2	1	2
Red-legged Partridge	0	1	0	0
Grey Partridge	0	0	1	1
Pheasant	0	1	0	2
Stock Dove	0	1	0	0
Wood Pigeon	2	9	3	3
Collared Dove	0	1	0	1
Turtle Dove	1	1	0	1
Swift	0	0	0	1
Skylark	0	6	0	0
Swallow	0	0	0	1
Tree Pipit	1	1	0	0
Meadow Pipit	0	1	0	1
Yellow Wagtail	0	1	0	0
Pied Wagtail	0	1	0	0
Wren	4	9	1	5
Dunnock	4	7	4	7
Robin	6	12	7	11
Ring Ousel	1	1	0	0
Blackbird	5	13	3	14
Song Thrush	3	7	1	4
Mistle Thrush	2	4	2	2
Lesser Whitethroat	1	1	1	2
Whitethroat	2	3	0	0
Garden Warbler	1	2	0	0
Blackcap	0	2	0	2
Chiffchaff	0	1	0	1
Willow Warbler	9	21	6	14
Goldcrest	3	3	3	3
Spotted Flycatcher	1	2	0	1

Table 5.12 cont...

	1977		1978	
	Main Belt	Survey Belt	Main Belt	Survey Belt
Long-tailed Tit	1	2	0	1
Marsh Tit	1	2	0	0
Coal Tit	2	2	0	2
Blue Tit	7	11	7	8
Great Tit	2	5	2	5
Nuthatch	0	0	1	1
Magpie	0	1	0	1
Carrion Crow	0	1	0	0
Starling	0	3	0	1
House Sparrow	0	0	0	1
Chaffinch	4	20	7	14
Greenfinch	0	3	3	6
Goldfinch	0	2	0	1
Linnet	0	5	1	1
Bullfinch	5	8	2	3
Yellowhammer	2	3	0	3

Table 5.13 Belt transect species lists in 1977 and 1978 as percentages of the species lists of individual CBC observers in those years.

CBC Observer	1977	1978
A	93	88
B	90	80
C	89	84
D	90	82

Table 5.14 Densities (territories per ha.) for ten common species estimated from belt transect data and from mapping censuses.

		Transect densities[a]	CBC observer			
			A	B	C	D
Wren	1977	5.4	6.6	4.9	8.4	7.3
	1978	1.3	7.0	7.0	11.5	9.1
Dunnock	1977	5.4	6.6	7.3	8.0	6.6
	1978	5.4	6.3	4.9	6.6	6.6
Robin	1977	8.1	10.5	7.0	9.4	11.1
	1978	9.4	5.9	7.0	9.1	10.1
Blackbird	1977	6.7	8.7	7.7	5.9	10.5
	1978	4.0	6.6	7.7	6.6	9.8
Song Thrush	1977	4.0	3.5	3.1	4.2	4.5
	1978	1.3	2.4	2.8	3.1	3.1
Willow Warbler	1977	12.1	8.7	8.0	12.5	8.4
	1978	8.1	7.3	8.0	10.1	8.7
Goldcrest	1977	4.0	4.9	3.5	4.5	4.5
	1978	4.0	2.1	2.1	2.1	3.1
Blue Tit	1977	9.4	4.9	6.3	2.8	6.6
	1978	9.4	4.5	6.3	3.5	4.5
Great Tit	1977	2.7	4.5	3.5	2.4	3.8
	1978	2.7	3.1	2.1	2.8	4.2
Chaffinch	1977	5.4	8.4	8.0	7.7	9.4
	1978	9.4	7.3	8.7	8.0	12.9

Notes:

[a] Belt transect densities were calculated as main belt observations divided by the area of main belt (7.45 hectares)

[b] Mapping densities were calculated as the number of clusters (including edge clusters) divided by the area of the plot.

For the belt transect data, poor estimation by the observer of the distance of birds from the transect line is likely to be a major source of error (Järvinen and Väisänen 1975), since the observer was inexperienced in belt transect fieldwork. The figures from mapping are uncorrected for edge effect and so are higher in some cases than the true mapping densities.

Table 5.15 shows how the belt transect densities were correlated with those from mapping. Only one of the eight correlations for individual seasons achieved significance, but when 1977 and 1978 were combined the results were correlated for three of the four CBC observers. In addition, CBC totals for 1977 averaged across the four observers (Table 5.5) were well-correlated with the main belt results for the 42 species detected in that year ($r = 0.884$, $P < 0.001$) but rather poorly with the survey belt totals ($r = 0.357$, $P < 0.05$). This suggests that the main belt is a good assessor of the CBC densities but that the survey belt results, increased by the addition of supplementary belt observations to those of the main belt, contribute little improvement over this.

Blue Tit was consistently over-estimated by the belt transects with respect to the four CBC observers, while in individual years, Wren, Dunnock, Blackbird, Song Thrush and Chaffinch were under-estimated and Goldcrest over-estimated. These discrepancies probably relate to seasonal deviations from the normal species conspicuousness at the time of the belt transects. But is is also possible to argue that such "over-estimates" are due to inadequacies in the estimation of the densities of these species when using the CBC method. That is, the CBC results may under-estimate the real density of Blue Tits and other species mentioned here.

Table 5.15 Values for the correlation coefficient, r, for the comparison of densities between belt transect and mapping method. (Data from Table 5.14).

Mapping observer	1977	1978	1977/78
A	0.544	0.424	0.492*
B	0.676*	0.588	0.625**
C	0.598	0.237	0.399
D	0.558	0.460	0.494*

The relationship between the percentage changes derived from the belt transects and those from mapping was also investigated using these ten species (Figure 5.4). Mapping results were combined for the four observers, as for Table 5.10, and angular transformation applied before performing the regression. No significant correlations were found, however, neither for the main belt nor for the survey belt percentage changes.

Discussion

As the present study is concerned with evaluating the IPA and belt transect methods for the assessment of bird populations in Britain, the discussion treats the census results obtained here with the CBC method as a standard for comparison. As noted already, however, the mapping method does not necessarily provide an absolute density standard and discrepancies discussed below may in some instances originate in shortcomings of the mapping approach. It would, however, be tedious to reiterate this caution at every point below.

In both 1977 and 1978 at Aston Rowant, the results from IPA counts were concordant with those from the mapping censuss (Table 5.7). Thus the IPA method gave a good assessment of th ranking of the bird community in each year. The extent to which this result is dependent on the density and distribution of the counting points was not investigated, but it would be expected that, given a similar array of counting points, the bird community of an unknown area of similar habitat to Aston Rowant could be adequately measured by using the IPA method alone.

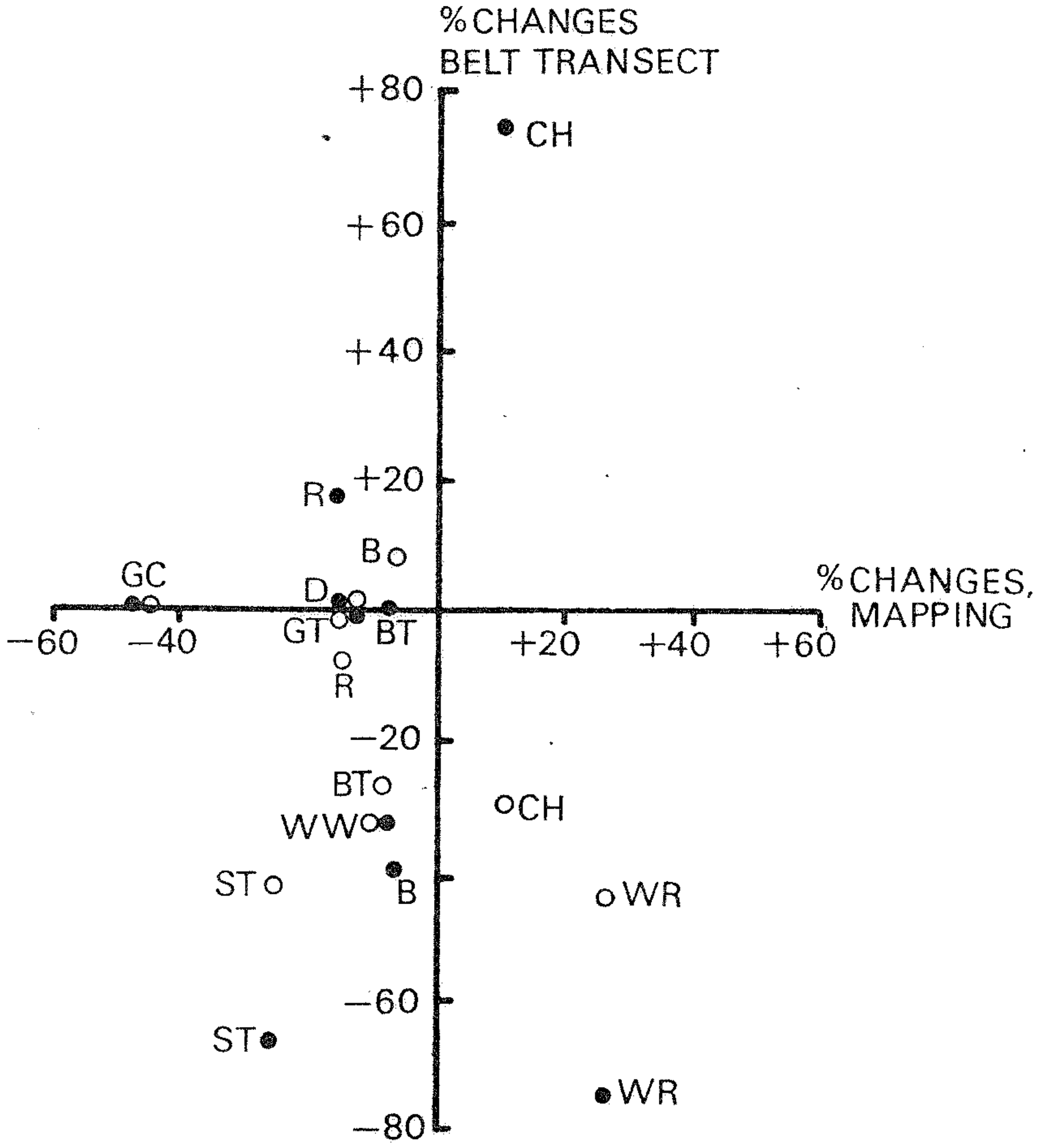

Figure 5:4 Population changes estimated from belt transects at Aston Rowant in 1977-78 and the corresponding estimates from CBC work. For species codes see Appendix 1. Closed and open symbols indicate main belt and survey belt (see text) respectively.

A number of cases of difference between IPA and mapping results for individual species have already been discussed. The IPA method is likely to over-record conspicuous and aerial species and under-record inconspicuous species with respect to the mapping method, at least in the habitat investigated. Up to 41% of territorial species, as assessed by a ten-visit mapping census, were missed during short-duration IPA counts, and in no case were more than 91% of the territorial species found (Table 5.8). Thus the species lists from IPA are relatively incomplete. This effect would presumably be less pronounced in the case of a census conducted in more open habitats and less if a larger number of count points were used. Ferry (1976) found that at least 15-30 points were needed to approach complete enumeration of the species present in a homogeneous habitat.

The results from the present study suggest that IPAs may be more observer-specific than the CBC method. Since the IPA method is based mainly on audible records, and uncertain records cannot be verified during counting, very high standards of observer competence and vigilance are demanded. This is in contrast to the mapping method for which species lists were relatively complete, though with significant differences between observers (Section 3). (However, the completeness or otherwise of species lists may simply be a function of total field time and therefore biassed in favour of the CBC procedure). It may be possible, however, to train a group of observers to the point where no differences in their abilities are detectable.

The percentage changes between 1977 and 1978 detected by the IPA method were rather poorly correlated with those found by the ten-visit mapping censusses. Only the ten-minute

IPA data were significantly correlated with the mapping results for the twenty-one major species (Table 5.10), while for the remaining forty-six species it was not possible to demonstrate any associations between the IPA and mapping results. Scatter diagrams (e.g. Figure 5.3) showed that, for most of the major species, the efficiency of the IPA counts was rather lower compared to mapping in 1978 than it had been in 1977, although the reverse was true for Song Thrush and for most of the minor species.

A possible underlying cause of these differences in efficiency is the difference in mean time of day for the IPA counts between 1977 and 1978 (see Table 5.1). There is evidence from the present data that the time of day is related to the number of registrations made at a point (Figure 5.2) and the number of registrations is in turn related to the final IPA estimates, although the method of taking the higher of the two counts during the season may in some circumstances provide a limited buffer against time of day affecting the IPA. It may, therefore, have been possible to improve the detection of population changes by ensuring stricter comparability in the diurnal times of the counts between 1977 and 1978. Stricter comparability of seasonal timing may also have been desirable.

A further possible cause is that the detectability of each major species was dependent on the population level. Walankiewicz (1977) studied five woodland plots by mapping and by IPA in the same year, and found that for most species there was an inverse relationship between detectability by IPA and population density as measured by mapping. If this effect were operating in the present data, the 1978 IPAs would have appeared more efficient than in 1977, rather than less so, since most of the major species declined. However, one of the species studied by Walankiewicz (Wood Warbler) was more easily detected at the higher population levels, probably as a result of reciprocal stimulation by singing males, and this may be the pattern shown by the birds at Aston Rowant.

The twenty-minute IPA results in 1977 were achieved with the expenditure of 8.3 hours' effort and four return journeys, and those for 1978 with 8.7 hours' effort and two return journeys. These figures compare with ten return journeys and an average of 33 hours' effort for the mapping censusses. Thus although the information given by the IPA method is more limited in scope and more sensitive to observer efficiency than is that from a ten-visit mapping census, the saving in observer effort is considerable. This difference would in fact be increased still further if other forms of point counts known to be more efficient than the IPA method were used (Dawson *pers. comm.*).

The time required for IPAs may be further reduced if shorter counting periods are used, although because of the time needed for travel between points, the saving in total time is not proportional to the reduction in counting period. Alternatively, time saved by reducing the counting period can be spent in increasing the number of points; no evidence was obtained, however, to suggest that increasing the number of points would lead to an improvement in the absolute accuracy of the census, though doing so necessarily increases the precision of estimate. In addition, additional points distributed through a heterogeneous habitat are more likely to increase the proportion of species actually detected.

Table 5.16 sets out the relative merits of the four time-periods compared at Aston Rowant. For each parameter the periods are ranked from one (high) to four.

On the criteria given in Table 5.16, ten minutes was the optimum length of count. Five-minute IPAs were consistently poor by comparison with the longer periods, and twenty-minute counts were not worth the extra expenditure of time, except that more complete species lists were produced in both years. That the twenty-minute results did not give an improvement in the results as compared to mapping, suggests that biases rather than additional useful data are being added during the final five minutes. One possible source of bias, that the final total of registrations at each point is related to the proportion of the total recorded in the first five or first ten minutes, has already been discussed; other possible biases might have emerged from a larger body of data.

The conclusions drawn from Table 5.16 about the optimum length of count are only known to apply for the bird species, species densities and habitat found at Aston Rowant, and may not be applicable elsewhere.

The belt transect counts at Aston Rowant were performed in approximately a quarter of the time taken for the IPA counts (Tables 5.1 and 5.2) and produced only one estimate of numbers for each census visit, rather than the ten for the IPA points. The method was good at detecting the territorial species on the plot (Table 5.13); in 1977 the transects were better than the twenty-minute IPA counts in this respect, but in 1978 fell between the results for the fifteen- and twenty-minute counts (Table 5.8).

Table 5.16 Comparative rankings of IPA durations of 5, 10, 15 and 20 min on various criteria (see text). Rank 1 for most efficient, rank 4 for least efficient[a].

	5	10	15	20
Percentage of territorial species detected, 1977 and 1978	4	3	2	1
Concordance with 1977 CBC results	4	3	1	2
Concordance with 1978 CBC results	4	1	3	2
Correlation of 1977-78 changes with CBC assessments	4	1	2	3
Effort per point	1	2	3	4

Notes: [a] Data from Tables 5.7, 5.8 and 5.10

For the ten commonest species, main belt densities were poorly correlated with densities obtained from the mapping censusses (Table 5.5) and no correlations between percentage changes from belt transects and from mapping were found to be significant. However, because of the necessarily unrepresentative choice of habitats within the main belt and the absence of any replication for the early and late counts, this cannot be considered a powerful test of the belt transect method; the few significant correlations found therefore, suggest that further investigation would be worthwhile. Against this are certain risks with the belt transect approach if used by a large number of volunteer workers, the most important probably being the risk that individual amateur participants will not fully appreciate the significance of delimiting the main belt. Errors in assessing the position of the 25 m cut-off are quite significant in relation to the final density estimates obtained. Another imponderable is the extent to which CBC participants in farmland and woodland are motivated by the resulting identification of clusters approximating the territories of individual birds, particularly given that they may collect the information at their own pace. Hence the final assessment of which census techniques are viable for use in national schemes dependent on volunteer labour, must depend not just on the technical merits of the census method considered but on the subjective judgement of the attractiveness of the fieldwork and its results by the participants.

SECTION 6

ASSESSMENT OF ABSOLUTE POPULATION SIZES

The CBC scheme was devised as a population monitoring exercise. For this purpose it needs only to reflect the proportional changes in populations from year to year. In particular, absolute assessments of the population sizes on census plots are not required. For any single CBC plot we may write the number of clusters found as I and its relationship to the absolute population size P as

$$I = XP$$

where X is a constant reflecting the effectiveness of the CBC fieldwork in detecting the territorial pairs present. Svensson (1979) refers to this coefficient as the <u>absolute census efficiency</u>. This efficiency will depend on a number of variables (Enemar 1959), amongst them the field ability of the observer, the amount of time and effort he puts into each census visit, the number of visits made, the nature of the habitat on the census plot, the ease or difficulty of registering individuals of each species and, possibly, the absolute density of the breeding birds on the plot. Provided these factors are already constant from year to year we may write the ratio of population in any two years a and b as

$$\frac{P(a)}{P(b)} = \frac{(I(a)/X)}{(I(b)/X)} = \frac{I(a)}{I(b)}$$

That is, the changes in population size between years are exactly reflected in the changes in the CBC index between years, independently of the absolute efficiency of the census. This depends upon the constancy of the census effectivity and its contributing factors between years and any change in these factors would invalidate the fundamental assumptions of the CBC approach. Census efficiency X varies between observers (Section 3) but, as we have seen in Section 4, the pairing of census plots (and therefore of observers) across years removes the effects of this variation: the assessments of population change made by the different observers were then mutually consistent despite their individually very different census efficiencies. Consequently combining the independent estimates of population change obtained by observers throughout the country provides a valid estimate of national population change, subject to the plots surveyed being representative and remaining so over time. Bailey (1967) reviews the requirements of the national CBC scheme in these respects.

It would be useful to be able to compare population density assessments made on different census plots (as, for example, in different habitats) with each other. However, since each observer has an individual efficiency the CBC clusters could not immediately be used for this purpose; there exists a residual uncertainty about the cluster density which precludes their use as absolute population measures. With very large numbers of observers censussing a given habitat type, such uncertainties can be treated as statistical "noise" about the mean for each habitat but they nevertheless reduce the precision with which for example, differences in bird densities between habitats could be established. Although in principle census efficiency on the part of individual CBC participants may vary within wide limits, it is probable that reasonably experienced ornithologists will have fairly similar values of X. Enemar <u>et al</u>. (1978) found little difference in census efficiency among a group of experienced Swedish ornithologists and concluded that any one person could substitute for any other without significant loss of accuracy or precision. However, the value of this coefficient for British census plots is currently unknown. Milner and Hornby (1977) therefore recommended an investigation of the possibility of establishing the efficiency with which the CBC results estimated the true population densities on the Aston Rowant census plot.

Theoretical considerations

The rationale for the study of census efficiency suggested by Milner and Hornby (1977) was that with a very large number of census visits to a single plot it should be possible to establish with precision the true number of breeding pairs of each species present on the census plot. These values could then be compared with the standard CBC results to obtain species-specific census efficiencies within the Aston Rowant habitat. Although these values would not be valid for other habitats, they would at least provide a first approximation of the efficiency of the CBC work.

We may develop a theoretical base for this rationale as follows. On any single visit we estimate that the probability of detecting a member of the breeding pair actually present on the census plot is P and the corresponding probability of failing to register that territory on the visit is Q. Then we may use the binomial theory to estimate the probabilities of detecting the territory on 0, 1, 2 etc. visits according to the terms in the expansion.

$$(P + Q)^n + P^n + \binom{n}{1} P^{n-1}Q + \binom{n}{2} P^{n-2}Q^2 + \binom{n}{3} P^{n-3}Q^3 + \ldots\ldots$$

where the terms

$$\binom{n}{k} = \frac{n!}{k!\ (n-k)!} \qquad \text{(Equation A)}$$

as in the standard binomial theory.

According to the standard CBC rules for the analysis of clusters generated with the mapping method (Appendix 2) a cluster is acceptable only if it contains three or more registrations (assuming at least 8 census visits to the plot). Consequently the probability of identifying the cluster successfully will be given by the binomial expansion above, less the terms in Q^n, Q^{n-1}, Q^{n-2}, these being the three terms describing respectively failure to find the bird on all visits, all but one visit, and all but two visits.

Examination of equation A shows that the probability of establishing a cluster is sensitive to the number of visits (n) paid to the site and is also sensitive to the probability of detecting the pair on a single visit. Figure 6.1 shows the consequential probability of failing to achieve the minimum of three registrations needed to establish a cluster as a function of the efficiency of detection of the birds during a single visit (P), and does so for various numbers of census visits. The Figure shows that, for all species for which there is a 60 per cent chance of detecting the pair in a single visit, the probability of missing the bird over a series of 8 visits is only 5 per cent. On the other hand, for a species for which the probability of detecting the pair in a single visit is 0.35 the chances of failing to detect the pair in the course of 8 visits is in excess of 42 per cent and a total of 16 visits is required to bring the probability of missing the pair over

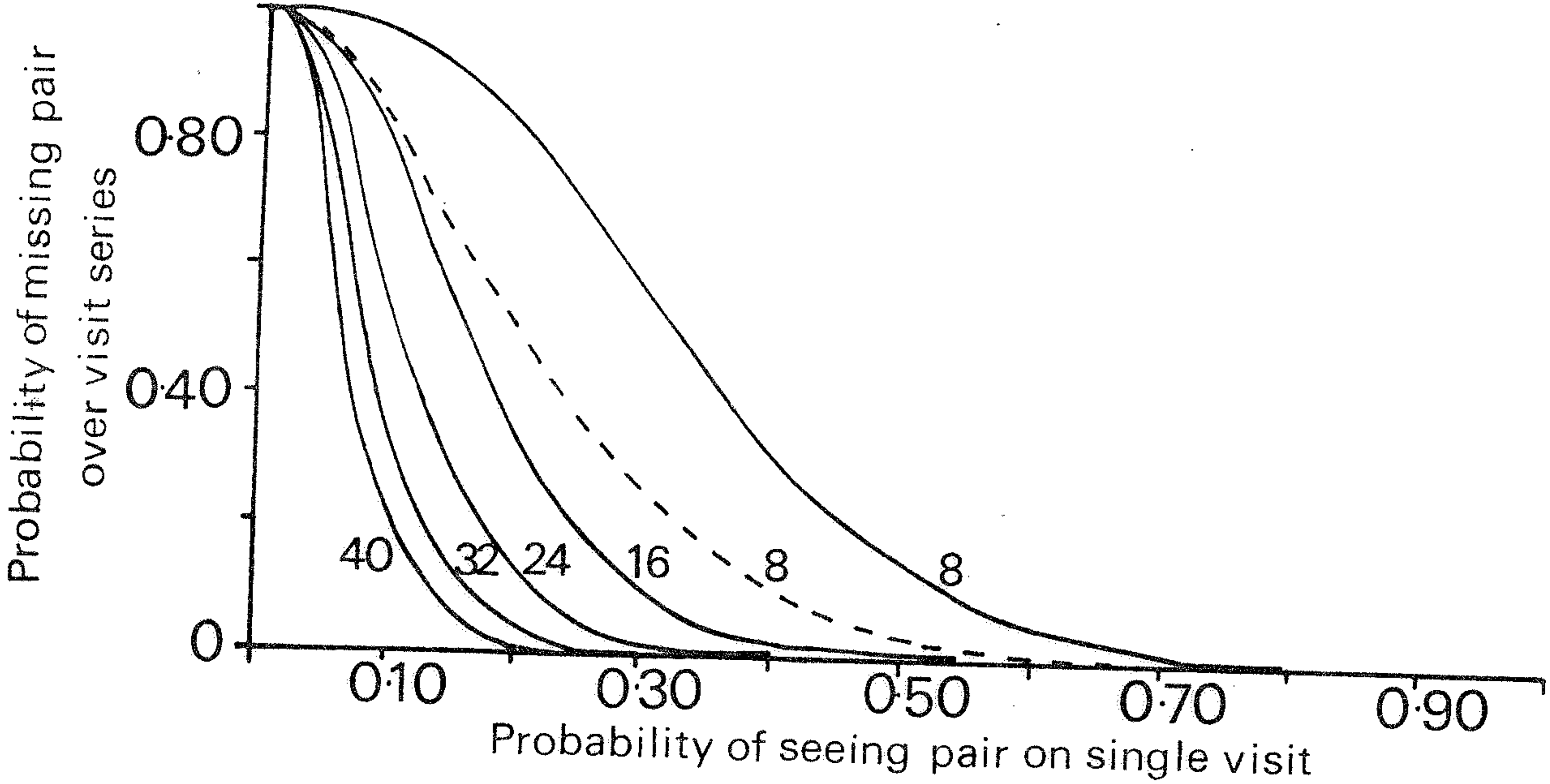

Figure 6:1 Probability of failing to detect a territorial pair during the census period in relation to the number of census visits made and the probability of detecting the pair in the course of a single visit.

the visit series to below 5 per cent. Similarly, with even lower visit efficiencies (in the sense of Svensson 1979)) still higher numbers of visits are required to reduce the probability of missing the pair over the visit series to any required level. Thus, for a standard requirement of three registrations per cluster the difficulties in detecting the species concerned in the course of a visit must be compensated for by the larger number of visits. Further, it is worth noting that changing the acceptance level (the number of registrations required to form a cluster) could equally alter these probabilities. Figure 6.1 shows that whilst a species with a probability of 0.35 of detection during a single visit has a 43 per cent chance of being missed altogether during 8 visits with an acceptance level of three registrations, it has a less than 17 per cent chance of being missed if the acceptance level is reduced to two registrations per cluster. However, as we shall see below, a reduction in the acceptance level quickly increases the chance of generating spurious clusters as a result of the presence of transient (non-resident) birds on the census plot, thus generating an error in the opposite direction. There exists, therefore, a trade-off between acceptance level, the chance of failing to register a pair genuinely present, and the number of visits to be made to the census plot.

The data of Figure 6.1 may be re-cast to express directly the proportion of territories detected in the course of a visit sequence in relation to the number of visits in that sequence. Normal CBC work involves 8-12 census visits. Figure 6.2 shows that species with a visit efficiency of 0.6 or

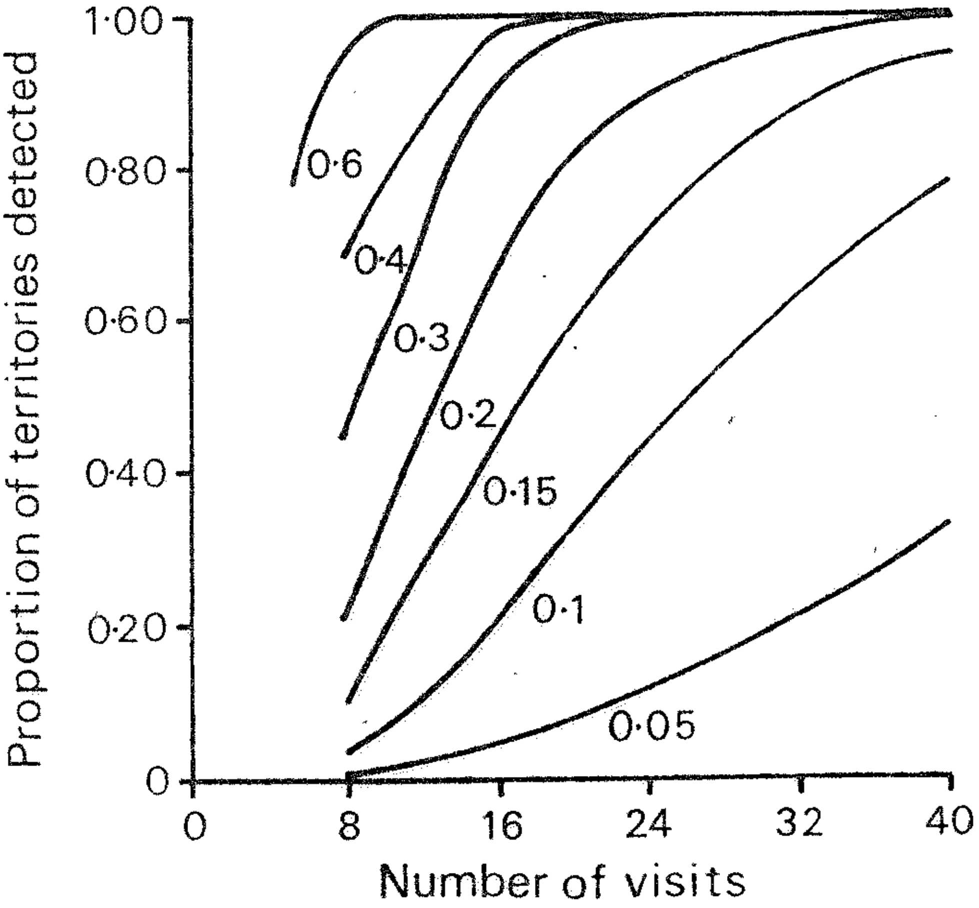

Figure 6:2 The proportion of territories detected in relation to the number of census visits made to the plot, for various probabilities of detecting the pair in a single visit.

more (i.e. six chances in ten of being detected in any single visit) will have 95 per cent or more of their territories detected in the course of normal CBC work. A species with a visit efficiency of 0.4 will see between 70-80% of its territories detected during such fieldwork. For still lower visit efficiencies, however, the proportion of territories detected at the standard acceptance level of three registrations per cluster deteriorates. However, by increasing the number of visits to the census plot the proportion of territories actually detected can be increased: for visit efficiencies of 0.4 some 15 visits are sufficient to detect 95 per cent of the territories actually present, for visit efficiencies of 0.3 some 18 visits are required. Within the scope of the 40 visits paid to Aston Rowant, therefore, one might anticipate detection of at least 95 per cent of the territories of all species with visit efficiencies of 0.15 or higher (Figure 6.2) i.e. all but the most difficult of the CBC species. This, then, was the rationale behind the attempted analysis of the absolute efficiency of the CBC approach.

In practice not all birds present on a census plot are resident individuals. A proportion of the birds sighted on any census plot will be "transients" - birds visiting the site for a relatively short period of time, either whilst in passage during migration to a site further north or as a non-territorial bird perhaps seeking a vacancy in which it can establish a territory. Such birds generate registrations which do not belong to a true territory but cannot be distinguished as such as the basis of the mapping method.

A further source of "stray" or "spurious" registrations arises from multiple registrations of the same individual in the course of a single census visit: such registrations appear twice on the visit map and are not immediately identifiable as referring to the same individual bird. The CBO Guiding Principles (Appendix 2) set standards for the number of registrations from a single visit which may be included within a single cluster, thereby providing a measure of standardisation of the treatment of such registrations. Nevertheless, such registrations appear on maps and therefore are potentially liable to be assigned to a non-existent cluster.

We may develop a theoretical treatment of the effects of these spurious registrations by recourse to the binomial theorem. Let R be the proportion of all registrations which are real and S the corresponding proportion of spurious registrations. Then for a total of n visits we have the binomial expansion:

$$(R + S)^n = R^n + \binom{n}{1} R^{n-1} S + \binom{n}{2} R^{n-2} S^2 + \binom{n}{3} R^{n-3} S^3 + \ldots$$

where terms of order three or higher with R or R^2 present indicate spurious clusters of three or more registrations. Figure 6.3 shows that use of the standard acceptance level of three registrations per cluster within the Aston Rowant study would result in a 10 per cent increase in the number of spurious clusters by 23 visits, a 20 per cent increase in spurious clusters by 31 visits and a 32 per cent increase in spurious clusters by 40 visits, these figures being for a probability of 0.05 that any single registration is spurious i.e. that one registration in 20 is due to a transient rather than a resident bird. These figures are sensitive to the relative frequency of transient (and multiple) registrations: Figure 6.4 shows that the probability of spurious territory establishment by 40 visits drops from 32 per cent when 5 per cent of the birds are

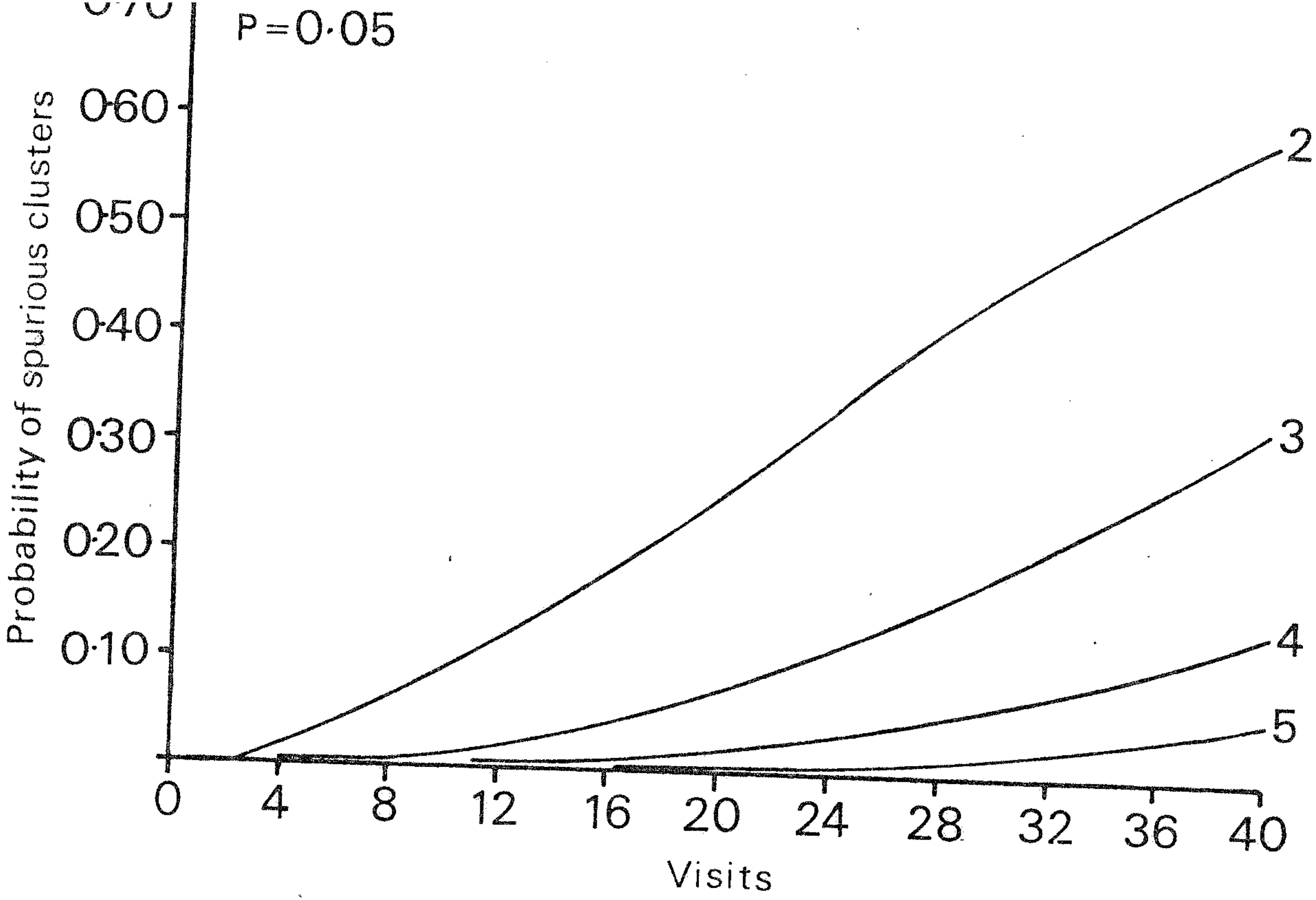

Figure 6:3 The probability of generating spurious clusters in relation to the number of census visits to the plot, for minimum requirements of 2,3,4 and 5 registrations per cluster. Computations for an 0.05 probability that any single registration is spurious (due to transient birds or multiple sightings of the same bird).

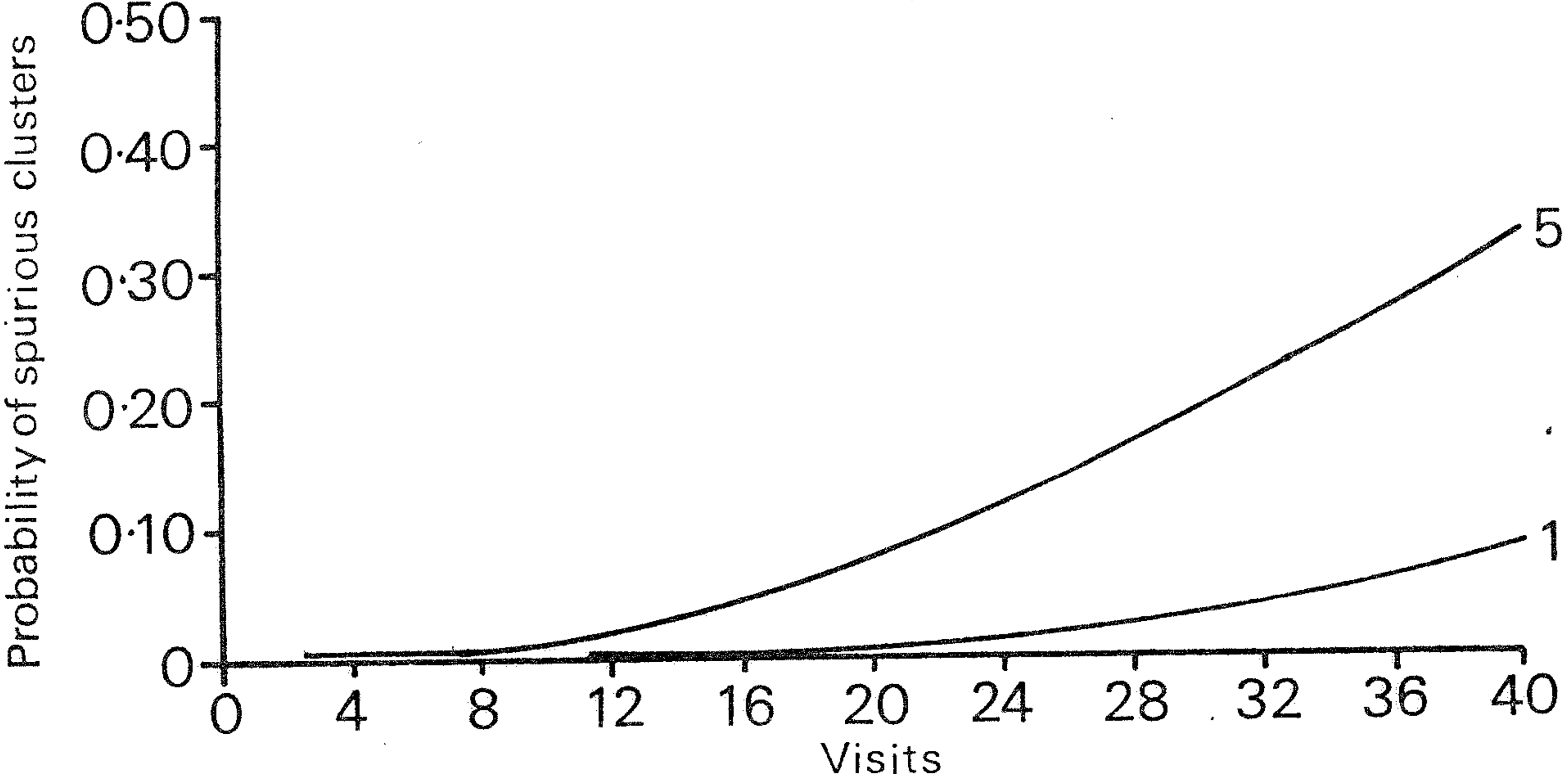

Figure 6:4 The probability of generating spurious clusters in relation to the number of census visits to the plot when 1 and 5 per cent of the birds on the plot are transients.

transients to only 7.5 per cent when one per cent of the birds is transient. It is worth noting that the "leading line" effect of the Chilterns makes Beacon Hill especially prominent in its frequency of migrant birds. The frequency of transient registrations is thus likely to be relatively high as compared to other CBC plots. Examination of Figure 6.3 shows that substantial reductions in the probability of spurious clustering can be achieved by increasing the acceptance level for cluster establishment. Thus, with an acceptance level of four registrations the theoretical chances of spurious clustering are reduced from (at 40 visits) 32 per cent to less than 14 per cent. On the other hand, increasing the acceptance level has the effect of reducing the proportion of real territories actually recorded: Figure 6.1 showed this effect for a change of acceptance level of from two registrations per cluster to three registrations per cluster for eight census visits. Svensson (1979) has recently discussed this effect in some detail and concluded that alteration of the acceptance level was a poor procedure for many species. On this basis, therefore, reduction in the frequency of spurious clusters on Aston Rowant by increase in the acceptance level used in the analysis was considered undesirable. The theoretical conclusion is that with a significant number of migrants passing through the Aston Rowant census plot during the fieldwork for the present study there could be a systematic increase in the frequency of spurious clusters as the number of visits considered in analysis is increased. With a 5 per cent incidence of transients this effect would certainly be significant (more than 32 per cent of the clusters being spurious on 40 visits) but, in the absence of colour-marking of individual birds, it is not possible to establish the true frequency of transient birds.

These theoretical arguments indicate that we can expect a proportion of the clusters identified with large numbers of visits to Aston Rowant to be spurious and thus to alter the shape of the cluster total versus number of visit curves expected. Thus the data may not display curves precisely of the form shown in Figure 6.2 but will have some deviation imposed by the presence of spurious clustering. In addition, in practice analysts are unlikely to draw clusters based on only three registrations when dealing with maps with as many as 40 visits present. Such maps are outside the scope of their normal training and some registrations will inevitably be drawn into existing clusters. The extent of these deviations will depend upon the relative importance of the frequency of resident birds and of the presence of transient or multiply-registered individuals and, as such, has to be assessed empirically from the field data. Finally, we may note that the ideas above are based exclusively on a binomial model with probability of detecting birds constant across territories and across date. Both constancies can be relaxed in other models based on the Poissonian binomial distribution and on the Lexian distribution (Aitken 1945) but in the light of the empirical evidence (below) that the results obtained were limited by factors already considered in the simple model, there seemed little point in introducing the additional complexity of these distributions.

Materials and methods

In 1977 a total of 45 visits were made to the plot (Table 2.1). Of these, the first four were made by a single observer and were also rather early in the season (prior to 10 April). These visits were therefore omitted from consideration in the present analysis. The basic design of the analysis thereafter was to take visits systematically throughout the census period in such a way as to balance out any seasonal effects in bird activity and to keep an approximate balance of contributions by different individuals. It was desired to base the analysis on a range of total visits from five to forty-one visits, in steps of four. Clearly, to obtain a forty-one visit map all the available information had to be utilised. Maps based on smaller numbers of visits thus re-used some of the information used in the total forty-one visit maps. Since this re-use was unavoddable, the selection of particular visits for inclusion on maps derived from any particular total visits was done cumulatively with visit total, to minimise the amount of map preparation needed. Thus, for a map appropriate to a 5 visit census the data from visits 5, 15, 25, 35 and 45 were combined to provide a systematic apread throughout the season; a map appropriate to a 9 visit census was then constructed by adding to this first map data from visits10, 20, 30 and 40; for a 13 visit map, data from visits 7, 17, 27 and 37 were added to that already on the 9 visit map; and so on. Table 6.1 sets out the full schedule used.

These multi-visit maps were compiled by a staff member not involved in analysis. Since the previous studies

Table 6.1 Schedule of visits used in generating multi-visit maps. Details of the date, duration, observer etc. of each visit were presented in Table 2.1 Each line is cumulative to the preceding line.

Number of census visits	Reference numbers[a] of visits used
5	5, 15, 25, 35, 45
9	10, 20, 30, 40
13	7, 17, 27, 37
17	12, 22, 32, 42
21	11, 21, 31, 41
25	13, 23, 33, 43
29	6, 16, 26, 36
33	8, 18, 28, 38
37	9, 19, 29, 39
41	14, 24, 34, 44

[a] Numbers are those listed in Table 2.1

(Section 3) showed that analysts did not differ significantly in their findings, the species were shared between the two available analysts. The 10 multi-visit maps for each species were arranged in random sequence for each of the two analysts, who then processed the maps in this sequence. This minimised the risk of analysts memorising the results of their earlier analysis for a particular species and unconsciously adjusting their analytical procedure accordingly. It was, of course, necessary that the analysts knew the species concerned and the number and dates of visits made to the site, to enable them to apply the standard CBC analysis rules.

Results

Table 6.2 tabulates the CBC cluster totals for each species in visit sequences of various lengths. Since the work of cluster analysis was shared by two analysts the totals (of species) to clusters established by each of the two on different numbers of visits are also listed. Pairing the totals from each analyst at each visit total gave a highly significant correlation ($r = 0.993$, $P < 0.001$) showing that both analysts had responded to the extra information provided by the additional visits in identical manner. The identity of the analysts was, therefore, disregarded for all subsequent analyses.

By combining the cluster totals from all species (both analysts) within each visit-total category, Figure 6.5 was constructed. This shows how the total number of clusters varied with the number of visits made to this census plot.

Table 6.2 Number of clusters established in relation to number of census visits made. P indicates species registered but inadequate data for a cluster.

Species	Number of visits									
	5	9	13	17	21	25	29	33	37	41
Kestrel	1	1	2	1	2	2	2	2	2	2
Partridge	2	2	2	2	3	3	3	3	3	3
Pheasant	1	3	3	4	4	5	5	5	5	5
Stock Dove	P	1	1	1	1	2	2	2	2	2
Collared Dove	1	3	4	3	4	4	4	4	4	6
Wood Pigeon	4	5	6	8	9	9	12	12	12	14
Turtle Dove	1	1	1	1	1	2	2	2	2	2
Carrion Crow	1	1	2	2	2	2	2	2	3	3
Magpie	2	2	3	3	3	4	4	4	5	4
Great Tit	6	7	11	15	18	17	18	19	22	22
Blue Tit	9	12	14	19	21	20	23	24	27	28
Coal Tit	8	2	5	6	8	8	10	10	11	9
Marsh Tit	2	3	3	4	4	4	4	4	6	6
Long-tailed Tit	2	2	5	5	5	5	5	6	6	6
Wren	11	20	27	23	27	29	33	33	33	33
Mistle Thrush	2	3	3	4	3	3	3	4	4	3
Song Thrush	4	8	9	14	13	13	14	14	16	16
Blackbird	9	17	21	23	25	25	30	33	32	33
Robin	18	23	35	36	38	35	43	39	42	47
Blackcap	5	5	4	5	6	10	8	10	9	10
Garden Warbler	1	2	2	3	3	4	4	4	4	4
Whitethroat	P	1	1	4	5	5	5	5	5	5
Lesser Whitethroat	1	1	2	2	2	3	3	3	3	3
Willow Warbler	17	26	26	29	34	38	38	39	40	43
Goldcrest	5	9	12	15	19	16	19	23	22	21
Spotted Flycatcher	1	2	2	2	2	2	4	4	4	4
Dunnock	12	13	23	25	26	30	34	33	32	39
Tree Pipit	1	2	3	3	3	3	3	3	3	3
Starling	P	1	2	2	2	2	3	4	4	4
Greenfinch	2	3	4	5	4	6	6	6	6	5
Goldfinch	P	1	2	4	4	4	5	4	5	5
Linnet	3	5	6	6	6	8	8	7	8	7
Bullfinch	8	10	11	13	15	15	14	15	18	18
Chaffinch	14	20	24	28	28	30	30	36	35	37
Yellowhammer	4	6	6	9	9	9	9	10	11	11

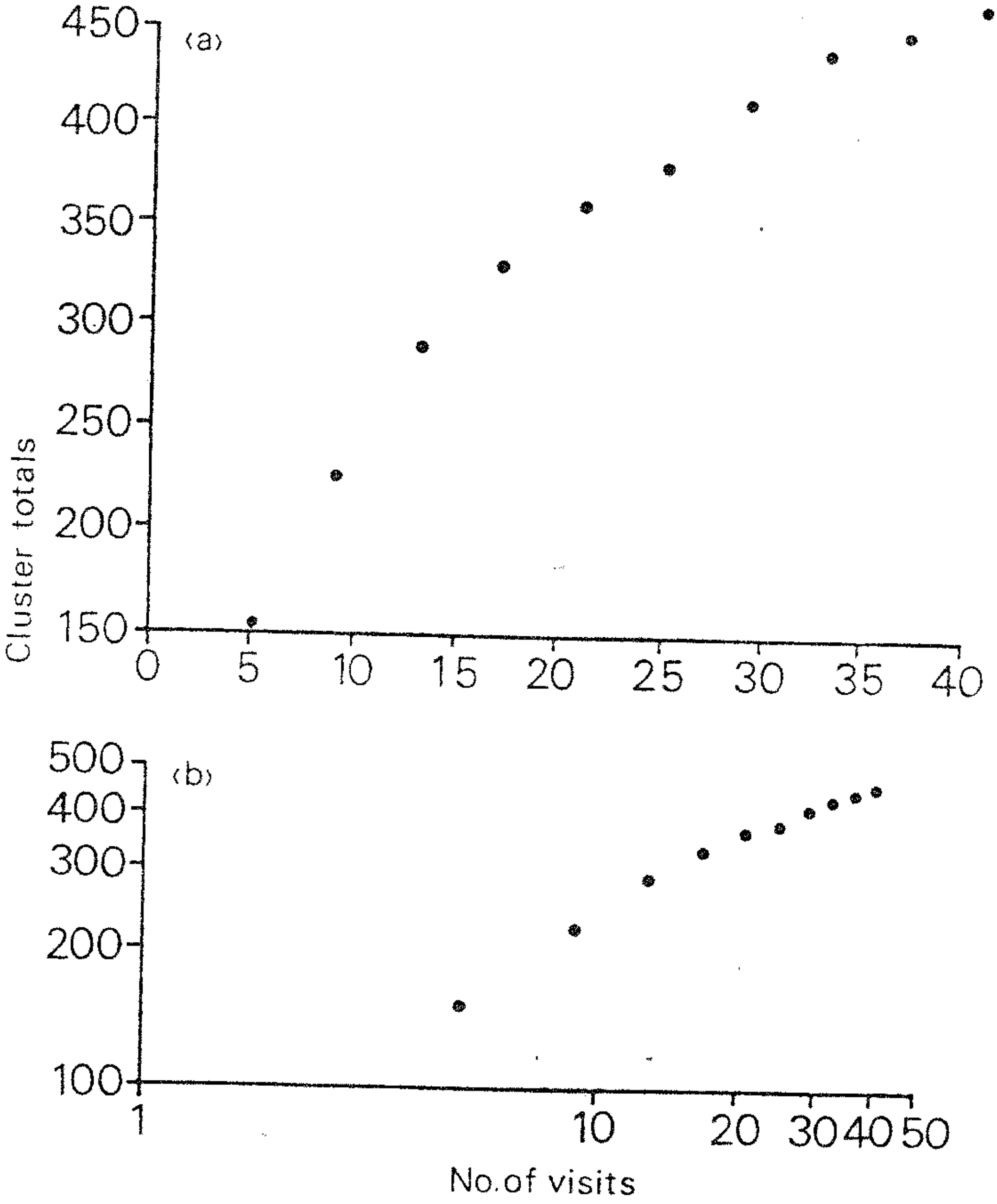

Figure 6:5 Cluster totals (all species) in relation to number of census visits to Aston Rowant, plotted on linear (above) and logarithmic (below) scales.

Below about 13 visits the relationship is almost exactly linear ($r = 0.9994$) but above this the increase in cluster total with further visits begins to level off. However, even with a total of 41 visits this process had not reached a clear asymptote. Thus, the results show many of the characteristics of a standard species-area curve (e.g. May 1976, Preston 1962). Figure 6.5b therefore shows a double logarithmic plot of the same information. The logarithmic transformations go a long way towards linearising the relationship ($r = 0.9894$, $P < 0.001$) but there remains obvious curvilinearity: over 5-13 visit totals the cluster total increases with visit number with an exponent of about 0.68 but this exponent gradually decreases with more visits. It follows that processes other than those analogous to a species-effort curve are involved.

Figure 6.6 presents the relationship between cluster totals for individual species and the number of visits made. The figures can be broadly categorised into three classes: (a) *plateau species* e.g. Whitethroat - in which the cluster total increases with visit number to a definite plateau and remains there thereafter; (b) *staircase species* e.g. Marsh Tit and Carrion Crow - in which the cluster totals increase in a stepwise fashion with increase in visit number, remaining at an intermediate plateau value in between; (c) *asymptotic species* e.g. Great Tit and Willow Warbler - in which the cluster total gradually levels off with increasing visits, though the graph cannot be said to have definitively plateaued even with a total of 41 visits. These categories are not completely exclusive. Where the steps in the "staircase" of class (b) are small the pattern begins to merge with that of

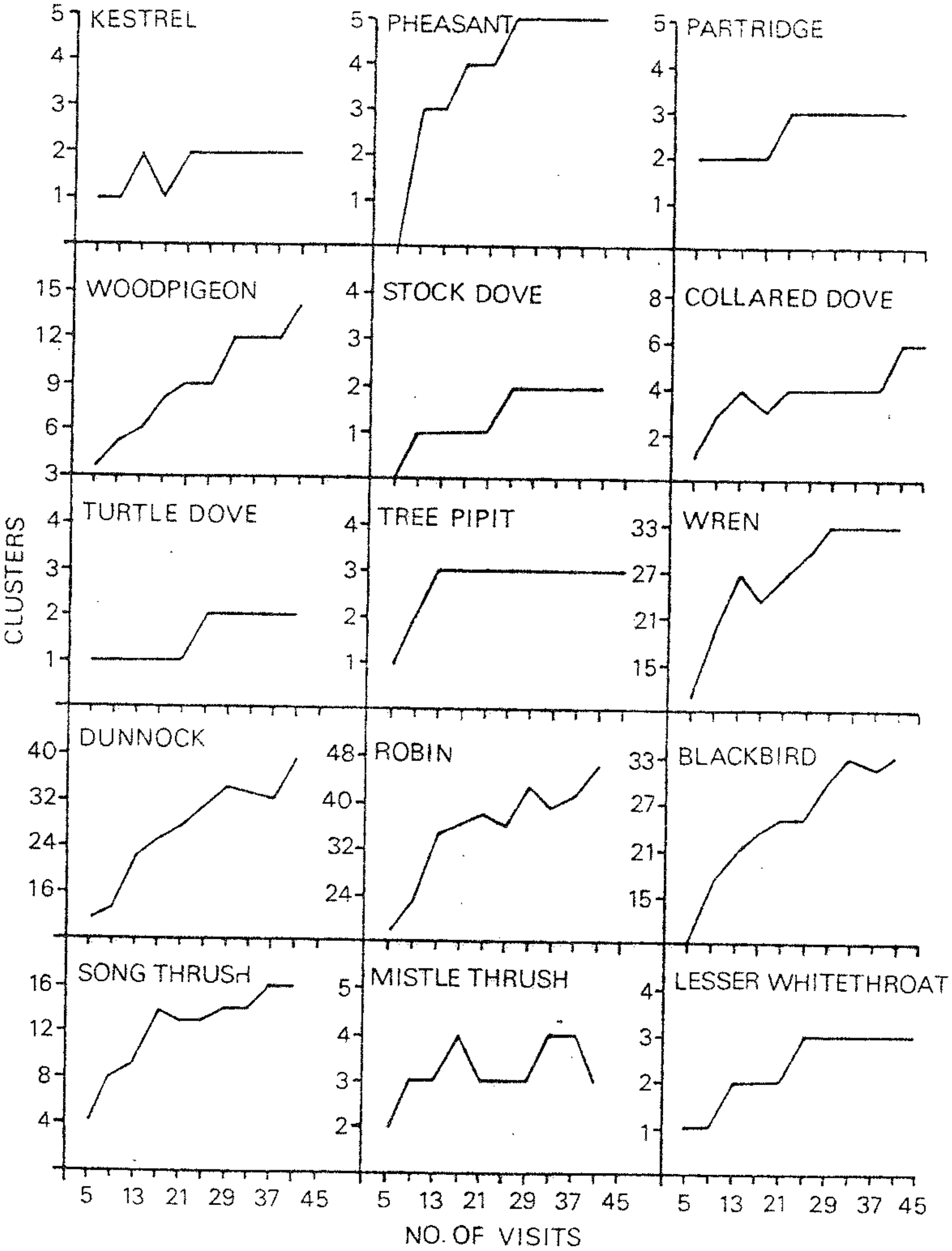

Figure 6:6 Cluster totals for individual species in relation to number of census visits to Aston Rowant.

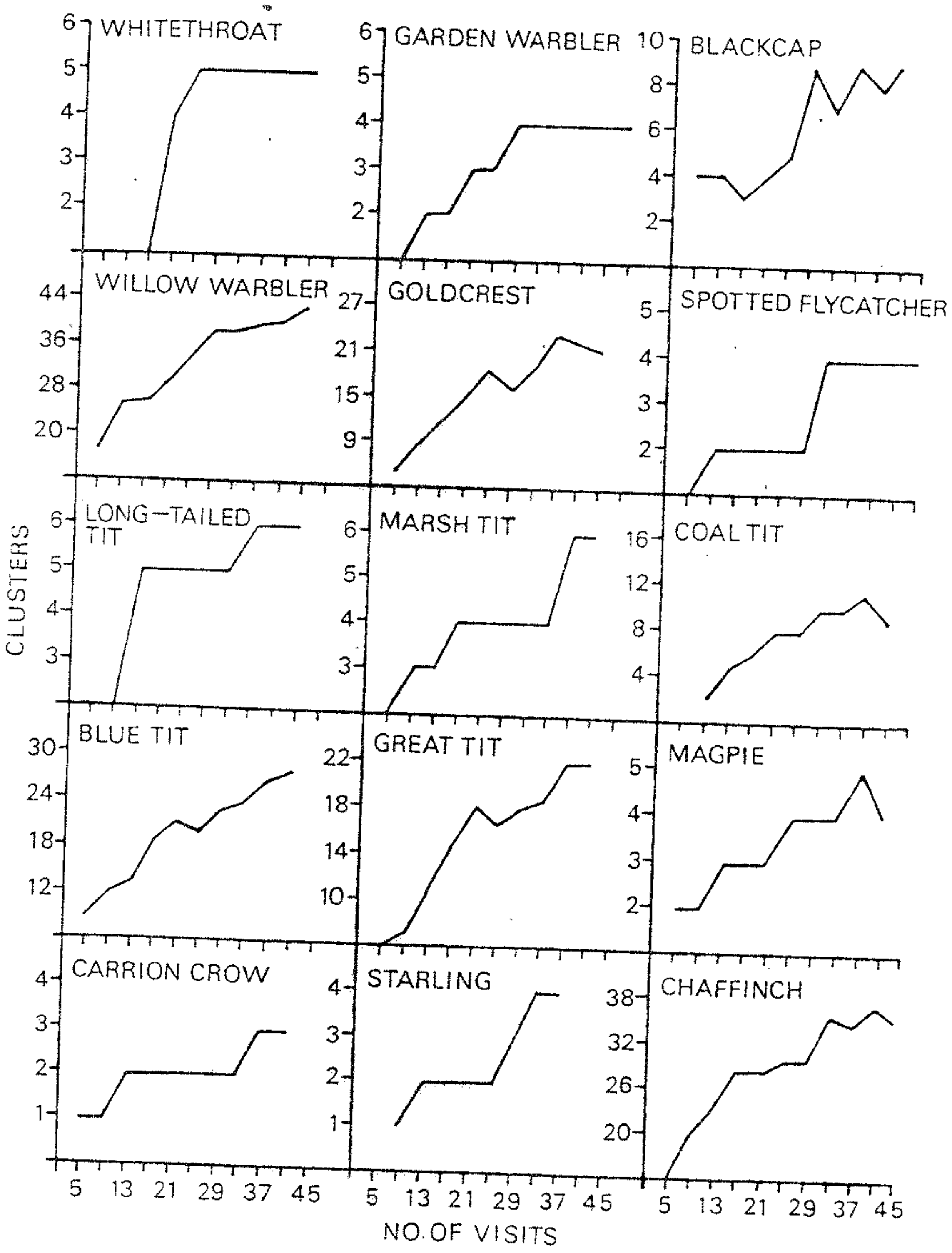

Figure 6:6 (continued)

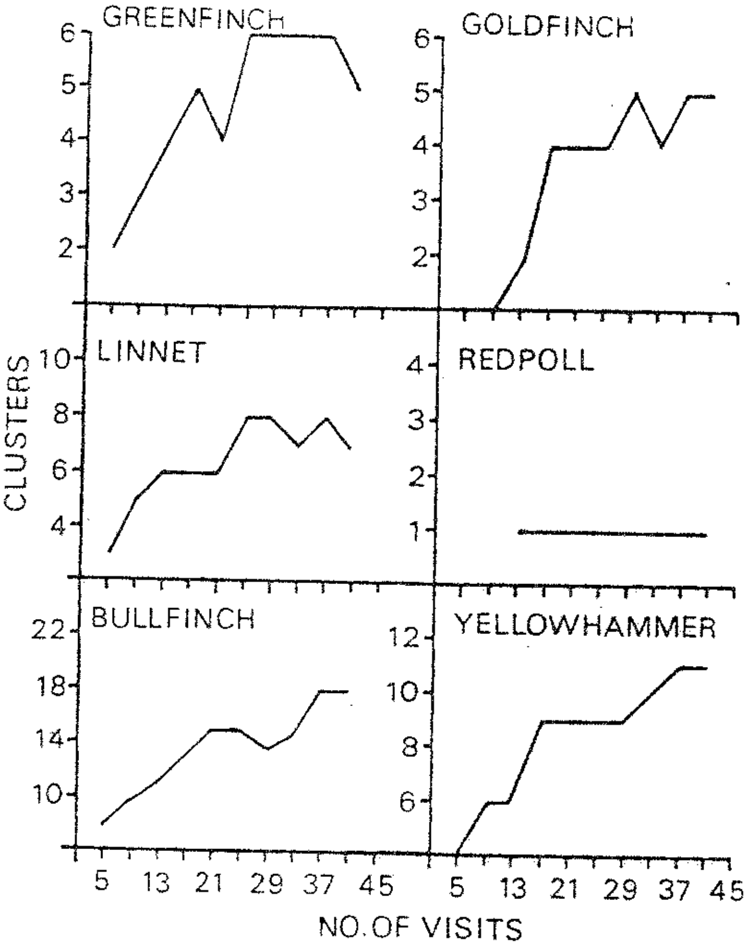

Figure 6:6 (continued)

the plateau species (type a) as with the Pheasant. Similarly a species with an asymptotic pattern may show inflections corresponding to an incipient step on the "staircase", as in the Blackbird data. The Blue Tit should probably be classified as asymptotic, though the trend towards this is very slight.

As a first approximation, asymptotic species can probably be regarded as a rather more rounded version of a plateau species. That is, given enough visits they would attain a similar plateau to that apparent with the Whitethroat.

To the extent that these curves (of all three types) represent an increase in the number of clusters over the same range of visit totals followed by some form of levelling off, they are of the form obtained theoretically in Figure 6.2. We can, therefore, consider the plateau values obtainable from Figure 6.2 as being, to some approximation, an estimate of the number of breeding territories on the plot and can compare these with the results obtained from standard CBC censusses. As there were four such standard censusses (Section 3) the four estimates were averaged before comparison with the plateau estimates of breeding territories. This comparison is presented in Figure 6.7 and shows that there is a very high correlation ($r = 0.9865$, $P < 0.0001$) between the two. That is, the CBC clusters constitute a highly efficient predictor of the plateau estimate of breeding territories even though the CBC data are based on only 10 visits. Thus, if the plateau values are true estimates of the real number of territories of each species present at Aston Rowant the CBC clusters are highly correlated with them.

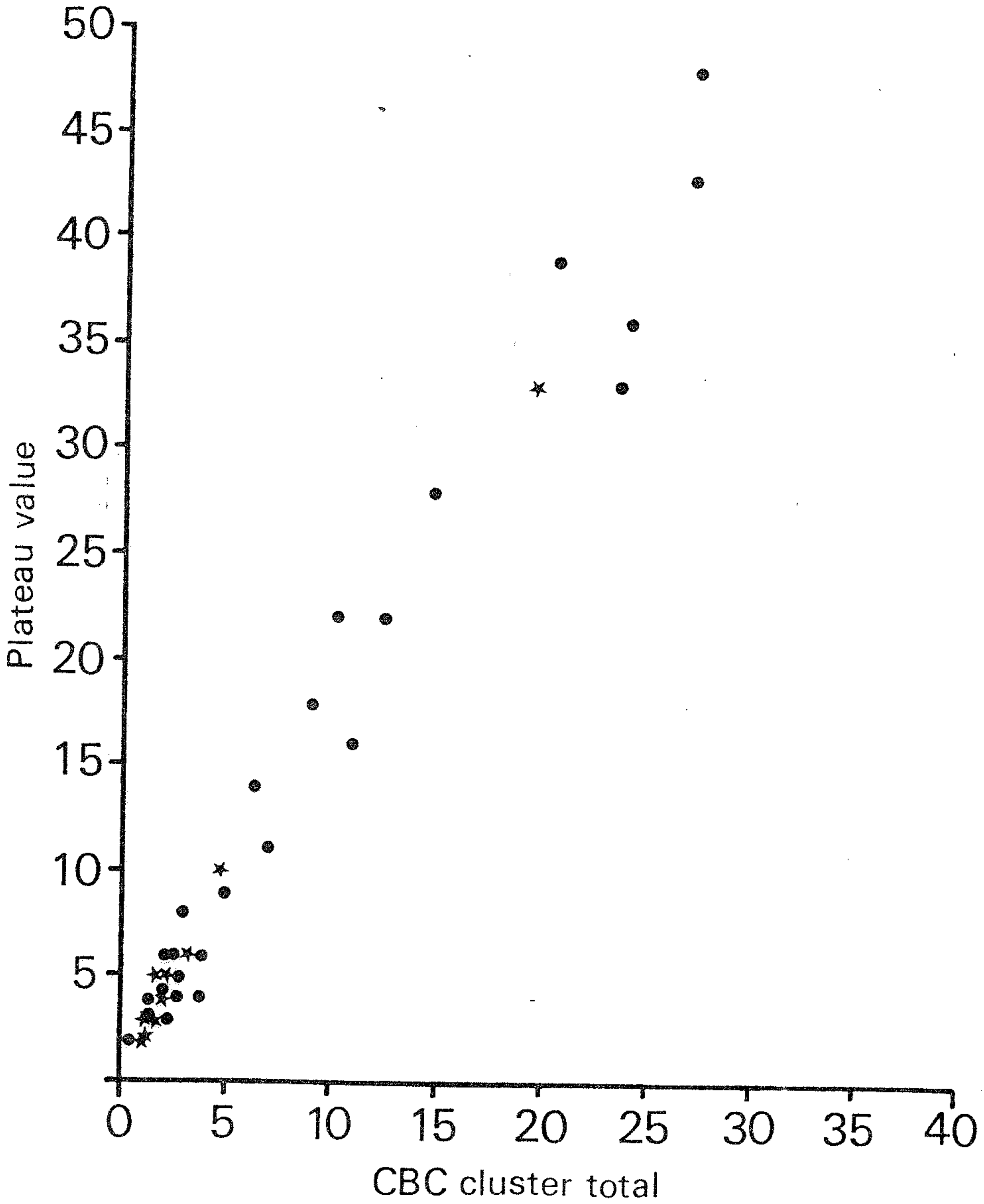

Figure 6:7 Relationship between the number of clusters established at the final plateau level (see text) and the number established by ten-visit CBC censuses (averages of four observers' results). Each point represents the data for a single species. Species with step function curves (see text) are indicated by stars. The correlation for all 35 species is $r = 0.986$ ($P < 0.001$).

Table 6.3 presents the results of an initial literature survey of comparable studies of the relationship of the mapping method clusters to independent population censusses of the same plot. They show that in general the mapping method cluster totals are highly correlated with population censusses made by other methods. Only the studies by Nilsson (1977) deviate from these patterns and his surveys were made with the express intention of evaluating variants of the mapping method, the two correlations cited being based on time-restricted census periods and on non-standard versions of the IBCC procedures. As shown in Section 7, time-restricted sampling does not give as precise an estimate of population changes as does the CBC method conducted over the full breeding season, a factor which must contribute to Nilsson's anomalous results. In the light of this the data in Table 6.3 suggest that the high correlation between plateau estimates of breeding territories and CBC cluster totals shown in Figure 6.7 are typical of the mapping method as a whole. This has the important implication that the estimates of territory totals on the census plot obtained after 40 visits are already well-predicted by the data obtained by 10 visits, whilst the literature data indicate that the mapping method is equally well correlated with the results obtained from the much more labour-intensive nest counts, capture-recapture techniques or intensive surveys and banding studies.

The plateau estimates of breeding territory totals cannot be treated as definitive estimates of the breeding population at Aston Rowant without first considering the possibility of spurious clustering arising from the effects described in Figure 6.3. In the absence of knowledge of the relative

Table 6.3 Correlation between the results of CBC-type mapping censusses and independent assessments of the true breeding population.

		Number of species censussed	Relationship of mapping results to independent population census			Basis of population estimate
			Correlation	Regression slope	Intercept	
a)	Enemar, *et al.* (1973)	13	0.908	1.031	-0.598	Nest count
b)	"	13	0.944	0.924	+0.026	Nest count
c)	Mannes and Alpers (1975)	6	0.937	0.697	-0.201	Nest box count
d)	Nilsson (1977)	5	0.692	--	--	Intensive survey
e)	Nilsson (1977)	5	0.778	--	--	Intensive survey
f)	Stamm *et al.* (1960)	12	0.974	1.24	-8.24	Capture - recapture
g)	Osborne (unpublished)	21				Intensive
h)	Boddy (unpublished) (1977 data)	31	0.805	0.336[a]	0.299	Mist-netting
i)	Boddy (unpublished) (1978 data)	30	0.829	0.350[a]	-0.128	Mist-netting

Notes [a] Refers to dependence on adult individuals netted, whilst CBC results imply pairs.

frequency of occurrence of migrants on the census plot it is impossible to make a quantitative correction. However, it is possible to make an indirect assessment of the validity of these plateaux values as estimates of the breeding population. Consideration of the trend in Figure 6.7 shows a slope of approximately 1.76 plateau clusters per CBC cluster. This suggests that CBC fieldwork was estimating an average 57 per cent (= 100/1.76) of the territories really present. This figure of 57 per cent could be an under-estimate if the plateau values were themselves under-estimating the breeding territories (but this is unlikely on the basis of Figure 6.2). That is, there is a slight chance that the value of 57 per cent is an under-estimate of census efficiency (X) as a result of spurious clusters inflating the plateau estimates of the real breeding territories (Figure 6.3). Examination of Figure 6.2 shows that detection of 57 per cent of the breeding territories would already be achieved for species with visit efficiencies of as low as 0.3 for a census sequence of 10 visits. Such a visit efficiency, whilst conceivable, seems unduly low by comparison with the 60 per cent and above recorded by Enemar (1959, 1962) and the range of values discussed by Svensson (1977). This discrepancy has suggested a need to examine more closely the validity of the curves by Figure 6.6 and outcomes of the processes modelled within Figure 6.2. Two hypotheses are possible to account for such a low apparent visit efficiency. Either the fieldwork conducted on Aston Rowant was considerably below the efficiency of the Swedish work cited and the model of Figure 6.2 was indeed correct, or spurious clusters had inflated the population estimate in accordance with the processes underlying Figure 6.4. We can test between these two hypotheses by testing predictions which can be derived from each of them.

In Figure 6.2 we can see that species with low detectabilities take progressively longer to reach plateau value. Application of this prediction to the empirical data of Figure 6.6 would mean that these species taking longer to reach a plateau were species which were relatively less easily detected in the field. One test, therefore, of this hypothesis is to enquire whether the speed of reaching the plateau is correlated with some independently derived measure of detectability.

Table 6.4 summarises the basic information used for such a test. To construct this Table each of the species plots in Figure 6.6 was examined subjectively and the size of the plateau and the minimum number of visits required to come onto the plateau were established. For most species at least one plateau was evident, although in a few cases its position or the number of visits required to reach it was somewhat uncertain (for asymptotic species) and these plateaux are, of course, only crude approximations. For other species distinct plateaux were present so that two values were obtained. In such cases the first one attained is described as an "intermediate" plateau and the second one as "final" plateau. There are, of course, obvious uncertainties in evaluating the positions of plateaux for species which show only inflections in the plot and other workers surveying the same series of plots might reach different values for particular species. Nevertheless, there is a sufficient number of species involved in these diagrams to allow for an overall statistical analysis.

Table 6.4 Relationships between number of visits required to yield a plateau in number of clusters identified at analysis and the number of clusters at plateau. For some species an intermediate plateau was identified: such values are also tabulated here.

Species	Plateau type [a]	Visits required	Plateau value, clusters
Kestrel	(S)	17	2
Partridge	S	21	3
Pheasant	S	25	5
Stock Dove	I	9	1
	F	25	2
Collared Dove	I	17	4
	F	41	6
Wood Pigeon	I	29	12
	F	37	14
Turtle Dove	S	25	2
Carrion Crow	I	13	1
	F	37	3
Magpie	I	13	3
	F	25	4
Great Tit	I	21	18
	F	37	22
Blue Tit	-	41	28
Coal Tit	S	29	10
Marsh Tit	I	17	4
	F	37	6
Long-tailed Tit	I	13	5
	F	33	6

Table 6.4 cont...

Species	Plateau type [a]	Visits required	Plateau value, clusters
Wren	S	29	33
Mistle Thrush	I	9	3
	F	33	4
Song Thrush	I	17	13
	F	37	16
Blackbird	I	21	25
	F	33	33
Robin	(I)	13	35
	(F)	41	48
Blackcap	(I)	5	5
	F	25	9
Garden Warbler	S	25	4
Whitethroat	S	21	5
Lesser Whitethroat	I	13	2
	F	25	3
Willow Warbler	(I)	29	38
	F	41	43
Goldcrest	(I)	21	17
	F	33	22
Spotted Flycatcher	I	9	2
	F	29	4
Dunnock	I	29	34
	F	41	39
Tree Pipit	S	13	3
Starling	I	13	2
	F	33	4

Table 6.4 cont......

Species	Plateau type[a]	Visits required	Plateau value clusters
Greenfinch	S	25	6
Goldfinch	I	17	4
	F	29	5
Linnet	I	13	6
	(F)	25	8
Bullfinch	I	21	15
	F	37	18
Chaffinch	(I)	21	29
	F	33	36
Yellowhammer	I	17	9
	F	37	11

Notes: [a] Notation used is: S, sole plateau; I, intermediate plateau; F, final plateau; ( ), the presence or positions of the plateau is particularly uncertain. See Figure 6.6 for examples. In several cases a "plateau" containing only two adjacent points has been ignored.

The first measure of species detectability was obtained by recourse to Enemar's (1959) listing of census effectivities for 10 common species on his census plot, a plot which bore some resemblance in its description to that at Aston Rowant. Table 6.5 presents these effectivity measures in relation to the number of visits required to reach a plateau value for that species in Figure 6.6. The correlation coefficient between the two variables was -0.463 (not significant Thus, although those species taking longer to attain their plateau values at Aston Rowant were less easily detected in Enemar's study (as predicted), the relationship was not statistically significant. However, since it is possible that conditions on Enemar's plot were significantly different from those at Aston Rowant this failure is not necessarily of great import. Ideally, the effectivities calculated for Aston Rowant would be used in such an analysis but in the present context this would entail circularity of argument.

A similar test was carried out by estimating species detectabilities on a different basis. Four experienced CBC workers, all of them professional ornithologists, were asked to assign the species listed in Table 6.4 to one of five conspicuousness categories, ranging from 5 for most conspicuous and easily detected species on a CBC plot to 1 for the least easily detected. Although these estimates were subjective they were made in each case on the basis of several years of CBC experience. Moreover, the estimates of conspicuousness made for each species by the different ornithologists were significantly in agreement (Kendall's coefficient of concordance = 0.662, $P < 0.001$). These conspicuousness categories were, therefore, averaged across the four observers to yield an

Table 6.5 Relationship between number of visits required for cluster plateau (see text) and census effectivity as measured by Enemar (1959), for ten species present in Enemar's and the present study.

	Effectivity[a]	Visits required to reach plateau[b]
Chaffinch	69	33
Willow Warbler	73	41
Garden Warbler	73	25
Whitethroat	64	21
Blackbird	50	33
Robin	45	41
Blackcap	58	25
Dunnock	37	41
Great Tit	60	37
Blue Tit	51	41

[a] From Enemar (1959 p. 32) (Note that Joensen (1965) says his results very similar to Enemar's).

[b] From Table 6.4

average score for each species. The data are presented in Table 6.6. Figure 6.8 shows the visits required to reach plateau values by each species in relation to the detectability index calculated in Table 6.6. For the 35 species the correlation between the two variables was $r = 0.302$ ($P = 0.078$). That is, the species conspicuousness values were not significantly related to the time taken to reach plateau values and such correlation as existed was of opposite sign to that expected on the basis of the model of Figure 6.2. This second analysis thus contradicts the idea that the speed of plateauing of the empirical data were correlated with species effectivity, as should have been the case were census efficiency the determining factor.

The alternative hypothesis is that the shape of the curves is significantly influenced by the occurrence of spurious clusters in accordance with the processes of Figures 6.3 and 6.4. To test this hypothesis two further analyses were conducted.

The first of the two analyses conducted was based on intraspecific differences. For each species with both an intermediate and a final plateau value the difference in the sizes of these plateaux was calculated and divided by the number of extra visits involved in moving from the start of the intermediate plateau to the start of the final plateau, thus giving a rate of change of plateau value, in units of cluster per extra visit (Table 6.7). This rate of change measure was plotted against the number of clusters in the final plateau in Figure 6.9. The figure shows that the increase rate in clusters per visit rose systematically with

Table 6.6. Conspicuousness scores assigned to species censussed at Aston Rowant by four experienced CBC fieldworkers.

Species	Assessor I	J	K	L	Average
Kestrel	2	3	3	4	3.00
Partridge	2	3	3	1	2.25
Pheasant	3	2	4	3	3.00
Stock Dove	3	2	2	2	2.25
Collared Dove	5	3	3	4	3.75
Wood Pigeon	4	3	2	4	3.25
Turtle Dove	2	3	3	3	2.75
Carrion Crow	5	4	3	5	4.25
Magpie	5	3	5	5	4.50
Great Tit	5	3	4	4	4.00
Blue Tit	4	2	4	4	3.50
Coal Tit	3	2	3	3	2.75
Marsh Tit	1	1	2	2	1.50
Long-tailed Tit	3	1	3	4	2.75
Wren	5	5	4	5	4.75
Mistle Thrush	4	2	2	4	3.00
Song Thrush	3	3	1	3	2.50
Blackbird	4	4	4	4	4.00
Robin	5	4	5	5	4.75
Blackcap	3	4	3	4	3.50
Garden Warbler	3	4	3	4	3.50
Whitethroat	4	4	2	4	3.50
Lesser Whitethroat	3	3	2	2	2.50
Willow Warbler	5	5	5	5	5.00
Goldcrest	3	1	2	3	2.25
Spotted Flycatcher	1	1	4	3	2.25
Dunnock	4	3	2	4	3.25
Tree Pipit	3	3	5	3	3.50
Starling	4	2	1	5	3.00
Greenfinch	3	3	3	4	3.25

Table 6.6 cont....

	Assessor				
Species	I	J	K	L	Average
Goldfinch	3	2	3	4	3.00
Linnet	4	2	2	4	3.00
Bullfinch	3	2	3	2	2.50
Chaffinch	5	4	4	4	4.25
Yellowhammer	5	5	4	4	4.50

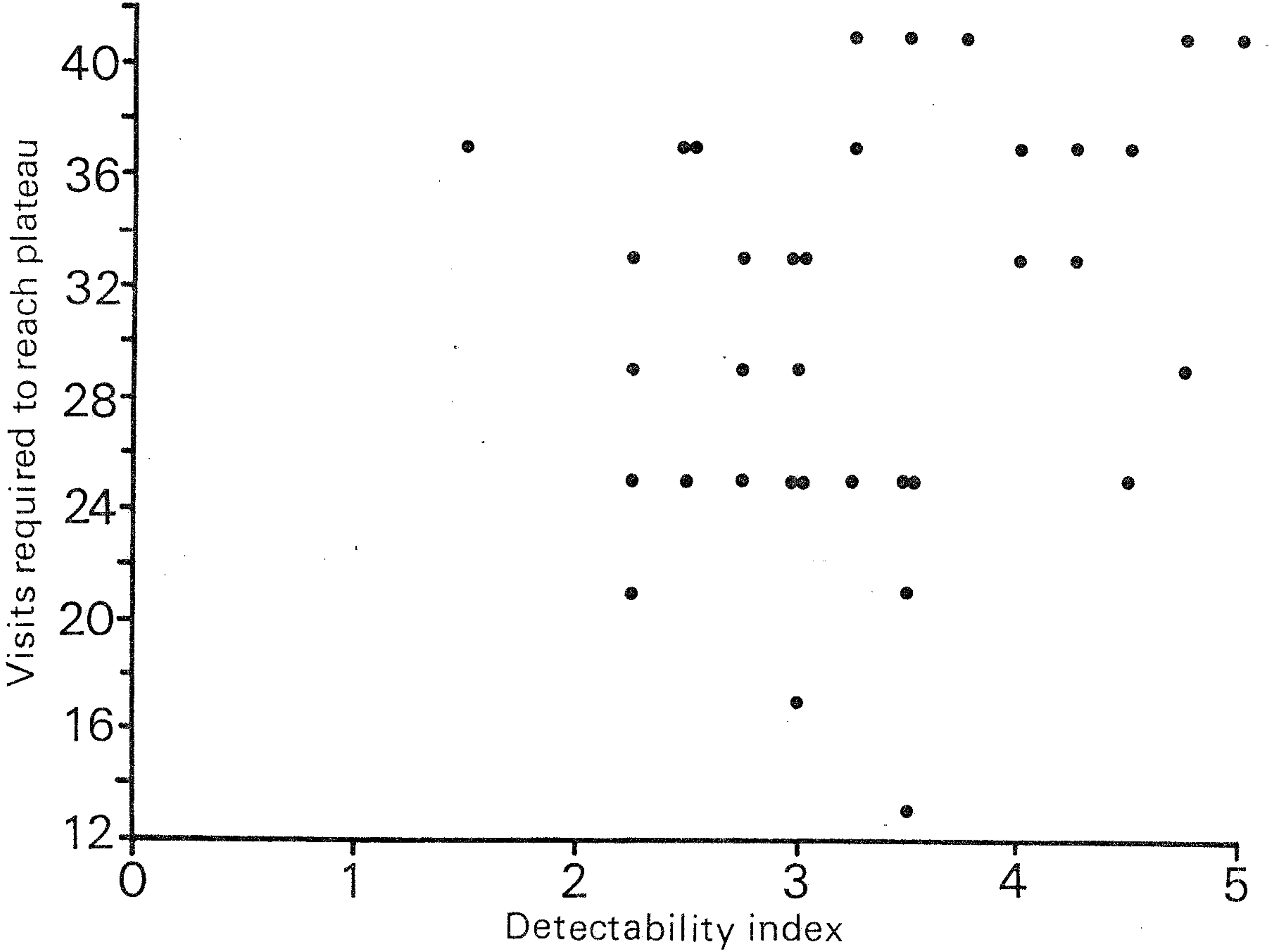

Figure 6:8 Number of visits required for a species to yield a constant ("plateau") number of clusters at Aston Rowant, in relation to an index of subjective ease of detection of the species in the field.

Table 6.7 Intraspecific change in plateau value with extra visits in relation to final plateau value.

Species	Final plateau clusters	Rate of change of plateau, clusters per extra visit
Stock Dove	2	0.062
Collared Dove	6	0.083
Wood Pigeon	14	0.250
Carrion Crow	3	0.083
Magpie	4	0.083
Great Tit	22	0.250
Marsh Tit	6	0.100
Long-tailed Tit	6	0.050
Mistle Thrush	4	0.042
Song Thrush	16	0.150
Blackbird	33	0.667
Robin	48	0.464
Blackcap	9	0.200
Lesser Whitethroat	3	0.083
Willow Warbler	43	0.417
Goldcrest	22	0.417
Spotted Flycatcher	4	0.100
Dunnock	39	0.417
Starling	4	0.100
Goldfinch	5	0.045
Linnet	8	0.167
Bullfinch	18	0.188
Chaffinch	36	0.583
Yellowhammer	11	0.100

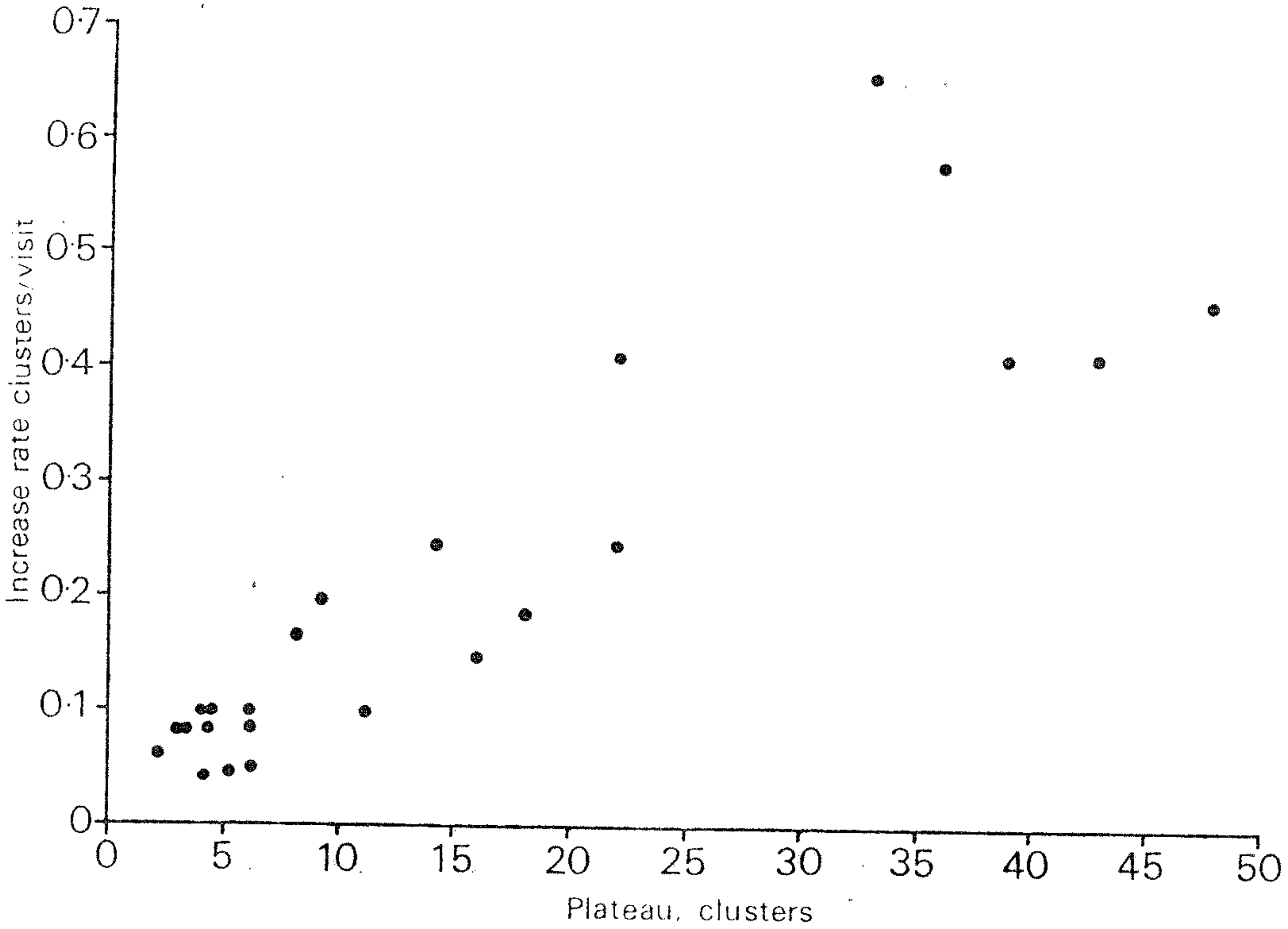

Figure 6:9 Rates of increase in cluster totals estimated as extra visits were added between the first and second plateaux in relation to the final plateau for the species. See text for rationale.

the number of clusters in the final plateau. That is, a species for which many clusters were eventually established was also a species in which each extra visit made resulted in a pronounced tendency to add further clusters to the estimate, whilst for a species with rather few clusters present the estimate of territories on the plot was systematically less sensitive to the number of visits made. This is not a self-evident outcome, for the numbers of visits at which intermediate and final plateaux are reached are variable between species, as also is the relative size of the two plateau values. Reference back to Figure 6.4 shows that the rate of increase in the probability of spurious clustering at a given frequency of transients was approximately linear for the larger visit totals, indicating systematically larger numbers of clusters per visit were added as visit totals increased. Such a process could be expected to lead to a positive correlation between clusters per visit and final cluster values, such as was found in Figure 6.9. It should be noted that this effect is intraspecific, so that one is measuring in Figure 6.9 the tendency to evaluate for a single species additional clusters with additional visits and this species would have had a constant territorial density throughout the visit total sequence.

Figure 6.10 shows the corresponding analysis for interspecific variation, again using data from Table 6.4. In this Figure the number of clusters present at the plateau is plotted against the number of visits required to reach the final plateau for each species. Calculation of a regression of plateau level on number of visits yielded an exponential

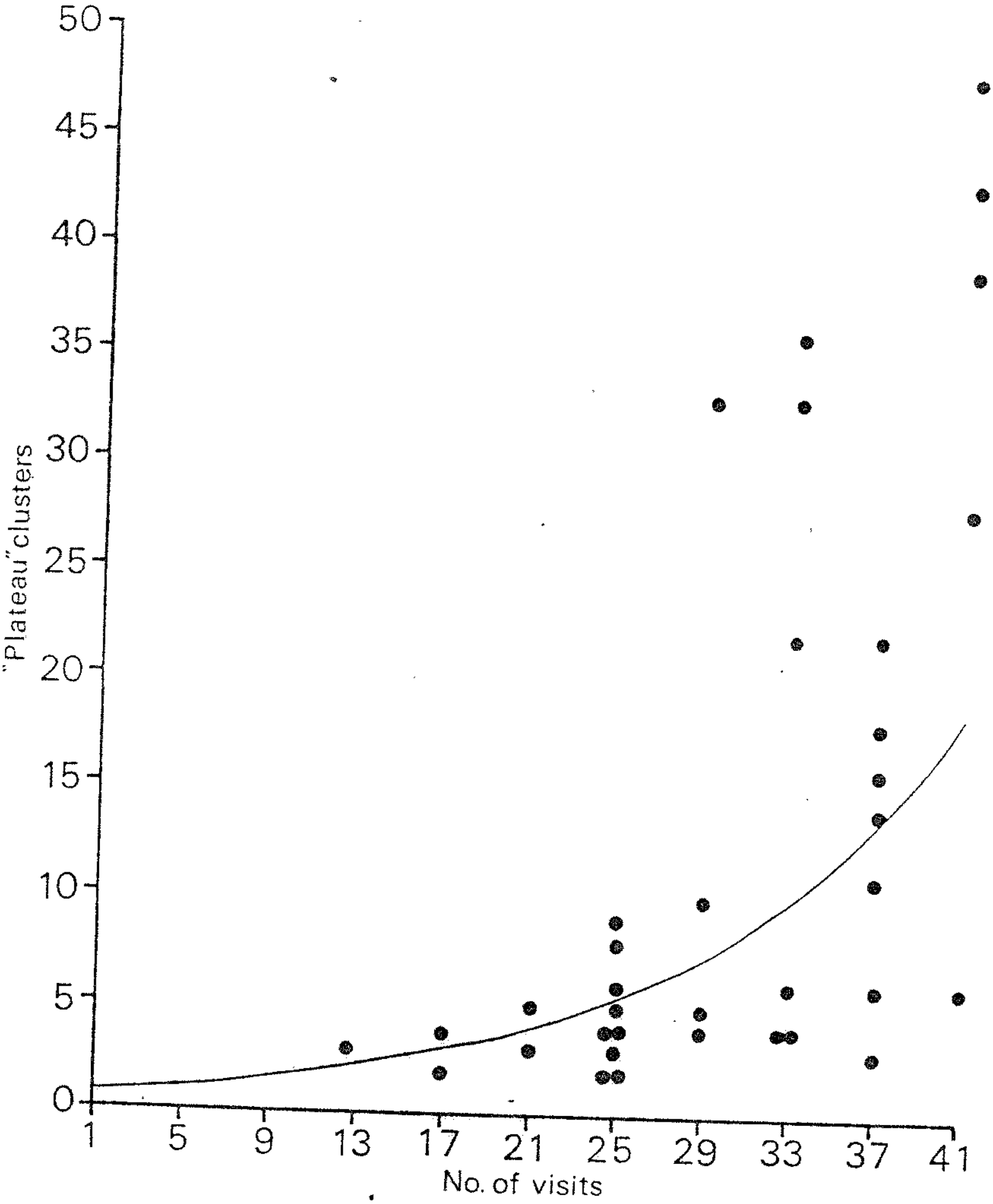

Figure 6:10 Final plateau estimate of clusters for each species at Aston Rowant in relation to the number of visits required to reach that plateau. The line shows the best fit for an exponential relationship: $\ln(T) = 0.07\,V - 0.242$

fit to the data:

$$\ln(T) = 0.07V - 0.242 \qquad r = 0.608,\ P < 0.01$$

where T is the number of clusters present at the plateau, V is the number of visits needed to reach that plateau, and In denotes natural logarithm. On an interspecific basis, therefore, the number of clusters finally present in a plateau increases exponentially with the number of visits required to detect the existence of that plateau in the first instance. This is a result one might expect on the basis of spurious clustering, for the greater variation in real densities present in the interspecific analysis provides greater scope for the analyst (to assign multiple registrations to different clusters and for using transient registrations) than would be present in the intraspecific studies (for which it has already been suggested a change in plateau value can arise only through the greater spatial range of registrations generated by large number of visits).

It must be noted, however, that in Figure 6.10 the fitting of an exponential curve is not strictly correct since both the number of clusters in the plateau and the number of visits required to identify that plateau are variables subject to experimental error. One could therefore interchange the two axes and treat the number of visits required to establish a plateau as a variable dependent on the number of clusters in the plateau. Whilst this would clearly alter the precise equation of the curve there can be little doubt on the basis of the data points in Figure 6.10 that the relationship is indeed curvilinear, so that the conclusion from the analysis would remain intact.

Finally, the analysis of Figure 6.10 which was based on the relationship between final plateau cluster totals and the number of visits required to reach it can be performed also in respect of the intermediate plateaux. The validity of such analysis would turn on the accuracy with which the intermediate plateaux mirrored the real number of territories on the census plot. Regressing the plateau cluster total on number of visits required for plateau in the same way as with the data of Figure 6.10 yielded the regression

$$\text{In}(T) = 0.202 + 0.088V \qquad r = 0.580,\ P < 0.01$$

with notation as before. The results are thus qualitatively the same as before, with an exponential relationship between the two variables, but with the intermediate plateau the relationship is even steeper at high visit numbers. Consequently, if the intermediate plateau values are a better approximation of the real territorial densities of birds in Aston Rowant the statistical artefact suggested as generated by a breakdown in CBC rules and spurious clustering is even more severe than estimated on the basis of Figure 6.4.

These results are thus in accordance with the predictions which arise from the spurious clustering idea and are not in accordance with the species effectivity hypothesis. They therefore suggest that the build-ups of cluster totals with increasing number of visits shown in Figure 6.6 were significantly influenced by the high frequency of migrants recorded on the Aston Rowant census plot or by the tendency of CBC analysts to avoid accepting excessive numbers of multiple registrations (registrations from the same visit within a single cluster) as visit totals increased. We can examine this suggestion somewhat further by comparing the results of the present study with those of Bilcke and Joiris (1979) for the nine species occurring in common in the two studies (Table 6.8). Bilcke and Joiris examined the effect of increasing the visits made to a total of 46 visits on the cluster totals they obtained for various species: Table 6.8 tabulates the number of visits they estimated were required for detection of 90 per cent of the final population assessment of these species. The Table compares these values against the number of visits required for the Aston Rowant data to reach their initial plateau: the correlation between the two groups is $r = 0.676$ ($P = 0.044$). Thus the two studies tended to show very similar patterns of response interspecifically to the build-up of visit information. This suggests that the Aston Rowant results were not atypical of such situations and that the importance of the spurious clusters suggested by the analysis just completed is similar to that found in general use of the mapping method on large numbers of visits.

Discussion

Inspection of the plots for individual species (Figure 6.6) shows that in the region of 9-12 visits (the number of visits made by most CBC observers) there is a relatively linear relationship between the number of clusters established by the CBC analysts and the number of visits made. On pooling all territories, increasing the number of visits made from nine to ten led to an average increase of 16.2 extra clusters, which on a total of 224 clusters obtained from

Table 6.8 Comparison of number of visits to first plateau for nine species at Aston Rowant with the number of visits required to detect 90 per cent of the population of these species in a Belgian forest (Bilcke and Joiris 1979).

Species	Visits for plateau[a]	Visits for 90 per cent detection[b]
Great Tit	21	6
Blue Tit	41	13
Coal Tit	29	6
Marsh Tit	17	8
Wren	29	4
Song Thrush	17	4
Blackbird	21	6
Robin	13	4
Chaffinch	21	3

[a] At Aston Rowant. Intermediate plateau used when two plateaux present

[b] From Bilcke and Joiris (1979)

nine visits represents a 7.3 per cent error. With a larger number of visits the error is proportionately smaller; increasing from 13-14 visits generates an extra 10.3 clusters which on the total of 289 clusters represents a 3.5 per cent error. These accuracy errors are comparable with the precision of the individual CBC indices and thus would be significant were there to be a systematic change in the number of visits made by CBC workers throughout the country between years. In practice, however, some observers tend to decrease their visits in a particular year whilst others increase the visits they make in the year, so that the average pattern is unlikely to change significantly from year to year. Moreover, where observer effort has altered by more than two or three visits, or where there are large changes in the time spent in the field, results for the year concerned are excluded from the index calculations as a matter of routine CBC practice. Within these limits another consideration is that the calculations above were based on the results for all territories pooled (Figure 6.5) whilst in practice the results differed from species to species (Figure 6.6). The errors are likely to be most severe for species such as Blackbird and Blue Tit (Figure 6.6) but these are the species which occur in practically all census plots and are thus least likely to vary in average number of visits per plot from year to year. Conversely, the less common species were less sensitive to the effects of extra visits so that even the proportionately larger impact of a single observer making more or fewer visits in a particular year will be abated by this reduced sensitivity. The important overall conclusion from these analyses is that the annual variation between observers as to the number of visits they pay to the census plots is unlikely to have any significant impact on the CBC indices calculated from the data.

Figure 6.7 showed that final plateauvalues for the 35 species studied on Aston Rowant were very highly correlated with the cluster totals obtained from standard CBC methods. Since it is likely that surplus (multiple) registrations would be generated more frequently in more abundant species than in less abundant species, it seems reasonable to expect the plateau values, although inflated, to be reasonably in proportion to the real density of the species at Aston Rowant. On this basis the CBC data from the site would also be correlated with the true population, in line with the literature studies cited in Table 6.3. It is not, however, possible to calibrate the CBC results precisely, as was the original intention of this phase of the study, since the analyses conducted pointed to significant inflation of the plateau values over the true densities. Consequently the average species effectivity of 0.30 is artificially low and the CBC workers in the present study will have achieved better absolute census efficiencies than this, i.e. their X-coefficient will be considerably above the 0.30 suggested by Figure 6.7. Their absolute census efficiencies are thus likely to have been in line with those reported in previous studies e.g. Enemar 1959, Joensen 1965.

Finally, a word needs to be said on the subject of "real densities". Much of the discussion above focussed on the extent to which some true breeding density for each species could be assessed. Evidence is now available to suggest that the number of breeding pairs using a census plot may vary through the breeding season and that the total number of pairs which breed on a plot may even exceed the number present at any one time. Parr (1979), for example, found that individual breeding territories of Golden Plovers were held by different (colour-marked) pairs in the early and in the late parts of the breeding season. Similarly, Tomialojc (1980) found that predation losses in dense populations of Woodpigeons generated a quite rapid reduction in the number of pairs nesting on the census plot and therefore in the number available to be censussed as the breeding season progressed. Such studies of population turnover show that the true carrying capacity of the plot may be quite different from that censussed (even perfectly) at any one time. For population monitoring these problems are less important (unless the extent of turnover varies from year to year) but they limit severely the extent to which a real census efficiency can be defined in principle, let alone measured in practice. The difficulty is probably least with summer migrants and other species with rather compressed breeding seasons and greatest with prolonged seasons, and probably few species approach the degree of turnover shown by Golden Plovers (Parr 1979). Nevertheless there is need for caution in pursuing the goal of species-specific census effectivities in too absolute a sense.

SECTION 7

THE EFFECTS OF CENSUS DATE ON THE RESULTS OF INTENSIVE CBC SURVEYS

In addition to meeting their basic aim of monitoring annual changes in population levels of farmland and woodland birds (Bailey 1967, Williamson 1970, Batten and Williamson 1974) the CBC studies undertaken throughout Britain by BTO members have provided extensive information on the relative abundance of the bird species present in different habitats and have proved useful for broad comparisons of the bird communities therein (Benson and Williamson 1972, Gordon 1972, Morgan 1975). When such information is derived from the general body of CBC results in the BTO's files these comparisons are subject to a number of limitations of the CBC method. The most important of these are that the absolute census efficiency of different census workers show significant differences between observers (Enemar 1962 and Section 3) and that the census efficiencies for the various species on the census plots differ substantially both between species and between census plots (Colquhoun 1940, Walankiewicz 1977, Svensson 1979): they also differ but to a smaller extent with the weather prevailing during the census visits (Section 8) and, due to edge effects, with the area of the plot (Cousins 1977, Marchant 1981). Nevertheless, these sources of error are generally small enough to ignore for the purposes of the broad comparisons desired between habitats (Williamson 1974b,c).

An important use of the CBC method which has not yet been fully validated is as a tool for the intensive study of the bird communities of unusual habitats that can be visited only for a short time. This use of the mapping method of bird censussing was developed particularly by Williamson (e.g. 1964, 1969, 1971a): thus in a series of visits to the island of Rhum in the Hebrides, Williamson (1971a, 1975) obtained valuable information on the successional changes in bird life there as the newly planted woodland policies developed in age and structure. When this type of expedition is conducted in standard manner with respect to timing and so on from year to year, the longitudinal comparisons attempted by Williamson are valid provided phenological events are constant between years. There remains the question, though, as to how useful or otherwise such information is for comparison with material derived from the general body of CBC data and from censusses conducted in other habitats at slightly different times of the year (Batten 1976, Wilson 1977, Williamson 1969) since the seasonal spread of localised census work can influence its results (Cyr 1977). Such a question is also pertinent to the use of the CBC mapping method in assessing the use of pesticides in agricultural practice (e.g. Edwards 1977) and in evaluating forest bird census results conducted in monitoring the side-effects of aerial spraying against defoliating caterpillars.

The present Section reports an investigation of the effects of the timing of such intensive survey work by comparison with the standard CBC censussing of the same plot.

Materials and methods

As part of the present investigation of Common Birds Census methods and assumptions, the census plot on Beacon Hill within the National Nature Reserve at Aston Rowant, Buckinghamshire, was visited for CBC census work a total of 40 times (plus some preparatory visits) in each of the years 1977 and 1978. Four observers were involved, each independently visiting the census plot ten times in each year, but in each of the two years the sequence of 40 census visits could be used to compare the results which would have been obtained from short-time intensive surveys akin to the expeditions of Williamson (1971a, 1974b) with those of standard CBC work; sub-sets of visits within different time periods were extracted to mimic an expedition to the census plot and thus to examine the relative efficiency of intensive surveys conducted at different times of year.

The evaluation of expedition methodology was conducted both with the 1977 and the 1978 data. Table 7.1 shows the visit dates used in defining individual 'expedition' periods in each year. Within each year a total of six expedition periods were used each involving ten visits within a period of 2-3 weeks. Since six expeditions of ten visits apiece required a total of 60 visits, whilst the Aston Rowant exercise involved a maximum of 45 visits in any one year, the census information from certain visits had to be used twice in each of the adjacent expedition periods; such visits are indicated by date overlaps in Table 7.1. Since each of the four observers visited the census plot throughout the season no one observer dominated the results from any particular period, so that analysis of the species maps from each period varied in response to seasonal factors rather than to observer bias.

The species maps from the expedition period visits were collated independently of the analyst, and subsequently

Table 7.1 Visit dates used in defining 'expedition' periods in 1977 and 1978, and totals of clusters (all species) established within each period.

	Sequence	Expedition period Start	Finish	Visits used	Cluster total
1977	1	15 April	30 April	7-16	256
	2	27 April	19 May	14-23	261
	3	7 May	26 May	20-29	230
	4	19 May	3 June	24-33	222
	5	31 May	23 June	30-39	237
	6	16 June	4 July	35-44	206
1978	1	8 April	4 May	1-10	213
	2	27 April	17 May	8-17	236
	3	9 May	25 May	13-22	244
	4	17 May	31 May	17-26	260
	5	29 May	19 June	24-33	230
	6	15 June	12 July	31-40	205

analysed in random species and expedition period sequence by two workers. Investigations reported elsewhere (Section 3) established that there were no differences in analyses conducted by different analysts, thus enabling the results to be pooled without reference to the identity of the analyst concerned.

The analysis of each species map was conducted on the basis that any three registrations for the species were adequate evidence for a territory, in accordance with the standard CBC methodology, but the method deviated from the standard procedure in not requiring a ten-day interval between registrations. This rule is employed in the standard analyses to ensure exclusion of transient birds and, as such, is clearly inappropriate to a census conducted on a short timescale as in an expedition.

Results

Table 7.1 shows that there were minor differences between years in the pattern of territory totals established in the different periods. In 1977 the cluster totals decreased slightly but not significantly with date (Kendall's tau = -0.60, $P < 0.10$) whilst in 1978 the totals peaked in period 4 (late May). There was thus no evidence for systematic seasonal variation in the total number of territories found. Comparison of the expedition period averages for the two years gave very similar results: in 1977 the mean and standard deviation between periods were respectively 245.3 ± 19.0 and in 1978 they were respectively 231.3 ± 18.4. Variation between periods was thus similar in the two years. Overall, there was no evidence of major changes in census efficiency through the season, apart from perhaps a slight decline in late June (present in both 1977 and 1978).

Certain species differed markedly from this general pattern, showing pronounced seasonal patterns. Table 7.2 presents the data on individual species totals within the six census periods of each year, together with the average species total for the year derived from the work of the four independent observers employing standard CBC methodology. Figure 7.1 presents the same results graphically for the species studied. In several cases the results for 1977 and 1978 showed somewhat different patterns, so that no firm conclusions about seasonal variation in census efficiency with that species could be reached. For other species, however, a clear pattern was present. The most prevalent trend was for the cluster estimates to peak in the later census periods, as with the Woodpigeon, Turtle Dove, Goldcrest and most of the smaller migratory passerines. The trend is not surprising in the case of the latter group, since they will in general be late arriving onto the census plots and therefore be more numerous later in the season. Another group of species showed a marked seasonal decline, or a decline in the latter part of the same season; these include Pheasant, Great Tit, Blue Tit, Coal Tit, Blackbird, Robin and probably Dunnock and Chaffinch. Interpretation of trends in the other species is rather more difficult, either because the total number of clusters in any one year was small or because the patterns observed were markedly different in the two years, e.g. Linnet and Bullfinch. Variation in pattern between the two years could be interpreted,

Table 7.2 Species cluster totals established within each 'expedition' period in 1977 and 1978. (P = present but no cluster established)

Species	Year	Expedition period[a]						CBC
		1	2	3	4	5	6	total[b]
Sparrowhawk	1978	P	1	1	1	0	P	0.75
Kestrel	1977	1	1	1	1	2	2	1.00
	1978	1	1	1	1	P	1	1.00
Pheasant	1977	6	2	1	1	2	1	2.50
	1978	3	2	1	1	P	P	1.25
Stock Dove	1978	P	P	P	2	1	1	0.25
Woodpigeon	1977	6	1	3	6	9	5	6.25
	1978	5	2	4	11	14	10	9.50
Turtle Dove	1977	P	P	1	1	2	1	1.00
Collared Dove	1977	3	4	3	3	3	2	2.25
	1978	3	3	2	2	2	2	2.50
Green Woodpecker	1978	2	1	P	1	1	1	1.25
Carrion Crow	1978	2	2	1	1	1	1	1.00
Magpie	1977	2	1	2	2	2	2	2.75
	1978	1	2	2	2	2	3	2.75
Jay	1978	1	1	1	1	P	1	0.50
Great Tit	1977	14	11	8	6	5	2	10.25
	1978	10	10	10	9	5	6	8.75
Blue Tit	1977	18	18	10	10	9	11	14.75
	1978	14	16	16	16	9	9	13.50
Coal Tit	1977	8	6	6	5	3	2	4.75
	1978	6	6	9	5	5	4	6.50
Marsh Tit	1977	4	3	1	1	2	2	2.50
	1978	8	8	0	8	1	2	0.50
Long-tailed Tit	1977	3	4	4	3	3	1	3.75
	1978	3	1	1	3	2	3	2.25
Wren	1977	21	19	17	14	19	22	19.50
	1978	28	30	22	24	22	19	24.75
Mistle Thrush	1977	3	2	2	3	3	3	3.75
	1978	5	4	5	4	2	P	4.25
Song Thrush	1977	7	10	10	7	9	8	11.00
	1978	6	7	7	10	7	6	8.25

Table 7.2 cont...

Species	Year	Expedition period[a]						CBC total[b]
		1	2	3	4	5	6	
Blackbird	1977	24	23	23	22	20	18	23.50
	1978	15	18	19	26	22	20	22.00
Robin	1977	33	32	22	19	18	14	27.25
	1978	24	24	24	19	16	15	23.00
Blackcap	1977	1	5	6	7	4	4	5.00
	1978	2	5	9	9	7	6	8.25
Garden Warbler	1977	0	P	1	2	2	1	2.00
	1978	0	1	1	2	1	P	0.25
Whitethroat	1977	0	1	1	1	2	3	2.25
Lesser Whitethroat	1977	1	2	2	2	3	3	2.25
	1978	0	3	4	3	2	2	2.00
Willow Warbler	1977	24	34	23	27	27	22	27.00
	1978	20	24	25	27	25	20	24.50
Chiffchaff	1977	P	P	1	1	P	P	1.00
	1978	1	1	1	1	1	1	1.00
Goldcrest	1977	7	11	12	15	18	15	12.50
	1978	4	7	10	8	10	6	6.75
Spotted Flycatcher	1977	0	0	1	3	4	2	2.00
	1978	0	P	1	2	2	2	1.25
Dunnock	1977	20	22	21	18	21	19	20.50
	1978	21	19	21	17	15	14	17.50
Tree Pipit	1977	2	3	1	P	1	2	1.50
Starling	1977	1	2	3	2	P	P	1.50
Greenfinch	1977	3	2	2	3	3	4	3.25
	1978	2	4	3	3	7	10	5.50
Goldfinch	1977	2	3	2	1	4	4	2.75
	1978	1	4	2	3	3	1	2.25
Linnet	1977	3	5	5	3	3	3	3.00
	1978	2	2	1	2	3	3	2.00
Bullfinch	1977	9	9	10	7	9	7	9.00
	1978	4	4	5	7	6	6	6.25
Chaffinch	1977	23	20	21	22	20	14	24.00
	1978	22	25	28	30	28	23	26.50
Yellowhammer	1977	7	6	4	4	6	9	7.00
	1978	5	6	7	7	8	8	8.25

Notes: [a] See Table 7.2 for date of each period

[b] Mean of estimates by four independent observers using normal CBC methods

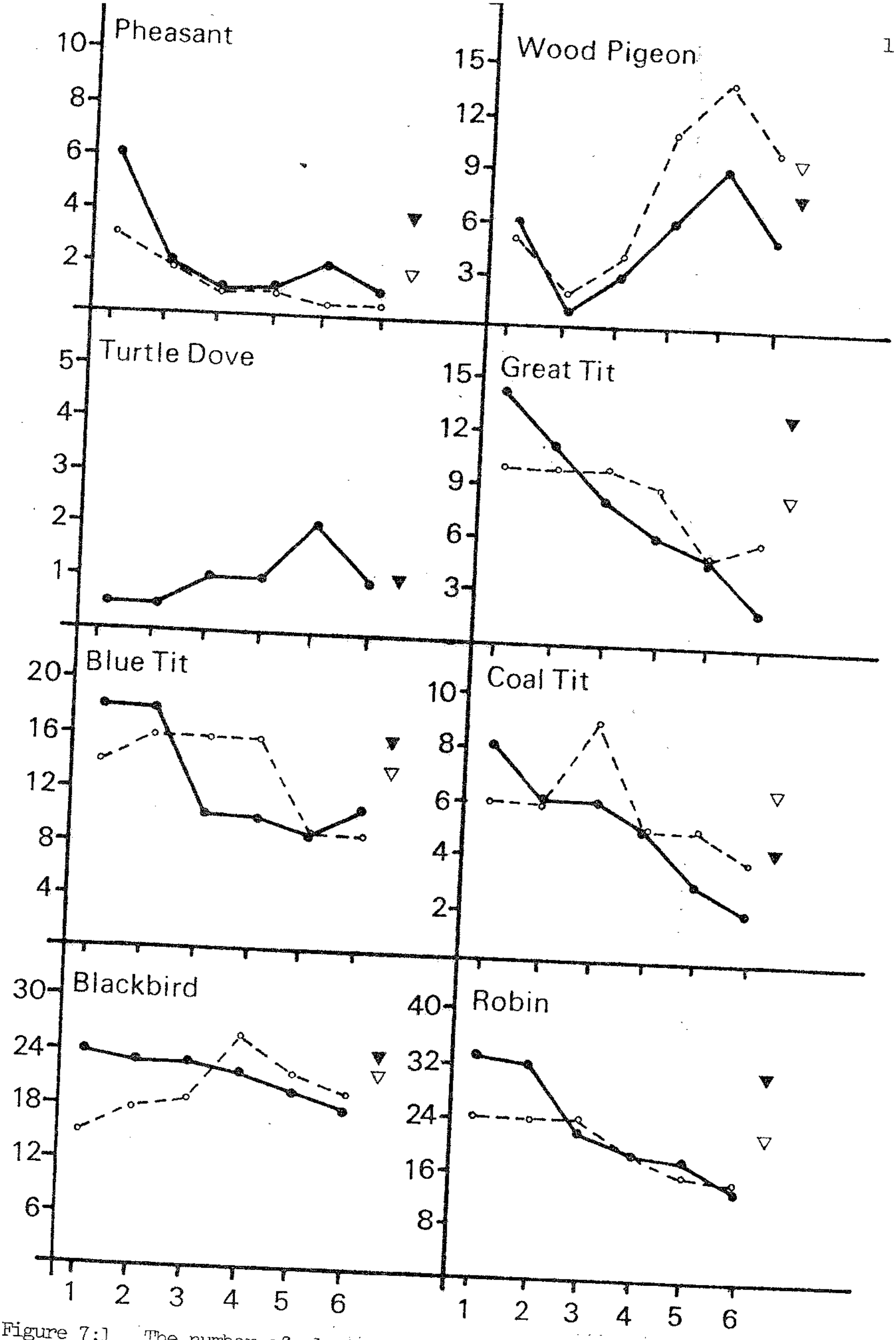

Figure 7:1 The number of clusters established from registrations made during a given period of intensive census visits in relation to date in 1977 (dots) and 1978 (open circles). Dates of period 1-6 are shown in Table 7.1. Cases with birds present but without a cluster being established are treated as half a cluster. Where data are shown for only one year, no clusters were established within any single expedition period in that year.

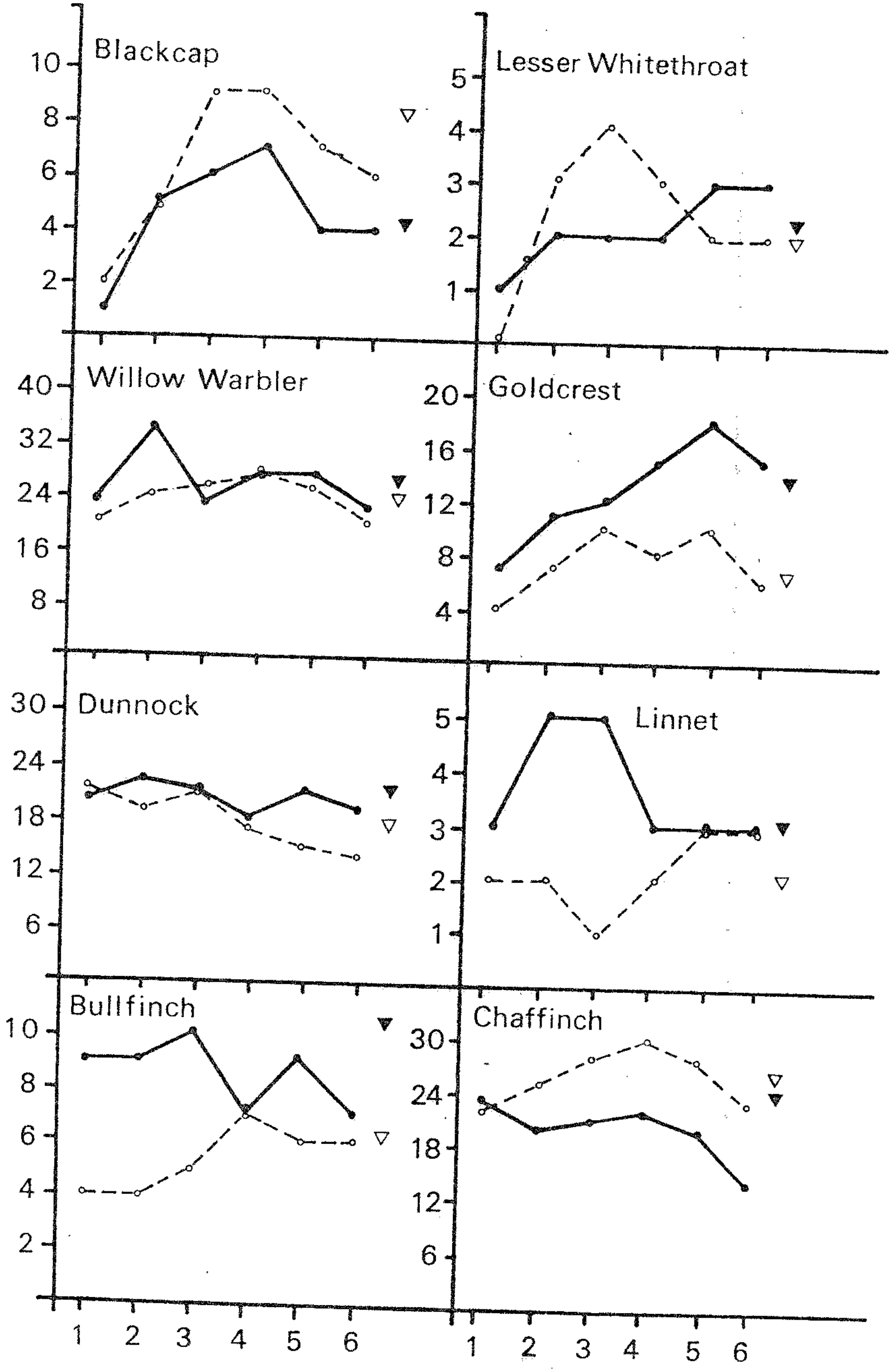

Figure 7:1 (continued)

Symbols at right-hand edge of each diagram indicate level of population established by normal CBC work for that year (solid symbol 1977, open symbol 1978), estimated from four independent CBC censuses in each case.

however, as evidence for the absence of any systematic and biologically based seasonal variation which needs to be taken into account in assessing census efficiency. On this basis, the results of Figure 7.1 tend to suggest that for many species there is no major seasonal variation in census efficiency but that for certain species a very early or a very late census period will lead to biased estimates of the numbers of breeding birds on the plot.

An important question in relation to the objectives of census expeditions of unusual habitats or census plots is whether or not these biases influence significantly the estimates made of the composition and structure of the breeding communities on these plots. This question was examined here by comparing the structure of the cluster totals from each expedition period with the structure derived from the standard CBC analyses (averaged across four observers). For each expedition period the correlation coefficients for species totals were calculated between the expedition period total and the corresponding four normal CBC totals (Table 7.3). Were there no differences between the expedition totals and the CBC totals, perfect correlation would result; the extent to which each correlation departs from unity reflects the presence of confounding factors in the expedition methodology as against the CBC method. The results (Table 7.3) show excellent correlations between the expedition results and the CBC results for all periods. A correlation coefficient of 0.948 or above indicates less than 10 per cent discrepancy between the expedition and the normal CBC results and this was achieved in 1977 in census periods 1, 2 and 3, and in all but the first two periods in 1978. The conclusion must therefore be that the expedition approach provided a satisfactory estimate

Table 7.3 Correlations between cluster totals for each species in each 'expedition' period and the cluster totals for the species obtained by the normal season-wide CBC method (average[b] of four independent observers' estimates); all values significant at $P<0.001$.

Expedition period		Year	
Sequence	Date[a]	1977	1978
1	April	0.948	0.919
2	Early May	0.951	0.937
3	Mid-May	0.956	0.960
4	Late May	0.944	0.955
5	Early June	0.926	0.948
6	Late June	0.892	0.951

Notes:

[a] See Table 7.1 for exact dates

[b] The census totals obtained independently by the four CBC observers were each correlated with the expedition results for the period concerned and the resulting correlation coefficients averaged after z-transformation (Snedecor and Cochran 1967 p.187) to obtain the best single estimate of the agreement between expedition and CBC censuses.

of the community spectra that would be obtained employing standard CBC methods throughout the breeding season, though best when the expedition is conducted in mid-season. At Aston Rowant this meant mid-May but because breeding seasons vary slightly with latitude even within Britain, a June census might be adequate for a plot in Scotland.

The analysis of Table 7.3 used the normal CBC results as a reference standard and showed that each of the expedition results was closely correlated with that standard. Such findings imply that the separate expedition period results were consistent amongst themselves when tested in this parametric fashion. A separate direct measure of the extent of agreement between the six estimates obtained from the expedition approach can be made by calculating Kendall's coefficient of concordance (Siegel 1956), a non-parametric measure of the consistency of ranking of the species abundance obtained in each census. With the 1977 data the coefficient of concordance calculated was 0.864 ($X^2 = 165.8$, $P < 0.001$), showing a statistically significant agreement between the six expedition periods in their description of the community of Aston Rowant, despite the different seasonal timings of the expeditions. With perfect agreement between them a coefficient of unity would have been obtained. Similar calculations with the 1978 data provided a coefficient value of 0.890 ($X^2 = 176.2$, $P < 0.001$). In each year, therefore, excellent agreement was obtained between the results from different expeditions as to the relative abundance of the species recorded on the census plot.

Expedition-censussing has hitherto been used only for describing community spectra in particular habitats or on particular plots, but the general consistency of the expedition-type results with those derived from the more temporally extended CBC method raises the question whether or not the time-restricted approach might be viable for routine CBC censussing. Although the Aston Rowant experiment was not designed for the purpose, it is possible to get an initial assessment of the viability of this approach by analysing the data of Table 7.2. Table 7.4 presents the population changes occurring between 1977 and 1978 as assessed in the different expedition periods and compares them with the change in CBC levels for the two years. The final line of the Table shows that the changes estimated from single expedition periods are indeed correlated (across species) with those estimated from the formal CBC approach and in all cases significantly so. Nevertheless, the magnitude of the correlation coefficients are relatively low: the highest coefficient - that for period 5 - corresponds to 67 per cent of the variance in the two changes occurring in common, whilst the lowest coefficient - that for period 6 - corresponds to only 25 per cent of the variations in estimates being in common. Part of the discrepancies must lie with differences in the period used in the two years, there certainly being differences in the calendar dates of the corresponding periods in the two years (Table 7.1) and probably with even bigger changes in the timing of breeding seasons between the two years. Nevertheless, the overall conclusion to be drawn from Table 7.4 is that expedition-type censussing is not a viable alternative to an extended census season over the normal breeding seasons of the several species concerned, when annual monitoring of population levels in a habitat or community is the object of the exercise. However, since the changes detected by expedition period analyses were correlated significantly with the changes detected by the normal CBC approach (Table 7.4) the

Table 7.4 Changes in cluster totals between corresponding expedition periods in 1977 and 1978 in relation to change in CBC method results (mean of four observers) for the same census plot.

Species	Expedition period						Mean change in CBC totals
	1	2	3	4	5	6	
Kestrel	0	0	0	0	-2	-1	0.00
Pheasent	-3	0	0	0	-2	-1	1.25
Woodpigeon	-1	1	1	5	5	5	3.25
Collared Dove	0	-1	-1	-1	-1	0	0.25
Magpie	-1	1	0	0	0	1	0.00
Great Tit	-4	-1	2	3	0	4	-1.50
Blue Tit	-4	-2	6	6	0	-2	-1.25
Coal Tit	-2	0	3	0	2	2	1.75
Marsh Tit	-4	-3	-1	-1	-1	0	-2.00
Long-tailed Tit	0	-3	-3	0	-1	2	-1.50
Wren	7	11	5	10	3	-3	5.25
Mistle Thrush	2	2	3	1	-1	-3	0.50
Song Thrush	-1	-3	-3	3	-2	-2	-2.75
Blackbird	-9	-5	-4	4	2	2	-1.50
Robin	-9	-8	2	0	-2	1	-4.25
Blackcap	1	0	3	2	3	2	3.25
Garden Warbler	0	1	0	0	-1	-1	-1.75
Lesser Whitethroat	-1	1	2	1	-1	-1	-0.25
Willow Warbler	-4	-10	2	0	-2	-2	-2.50
Chiffchaff	1	1	0	0	1	1	0.00
Goldcrest	-3	-4	-2	-7	-8	-9	-5.75
Spotted Flycatcher	0	0	0	-1	-2	-1	-0.75
Dunnock	1	-3	0	-1	-6	-5	-3.00
Greenfinch	-1	2	1	0	4	6	2.25
Linnet	-1	-3	-4	-1	0	0	-1.00
Bullfinch	-5	-5	-5	0	-3	-1	-2.75
Chaffinch	-1	5	7	8	8	9	2.50
Yellowhammer	-2	0	3	3	2	-1	1.25
Correlation with change in CBC method totals	0.590**	0.784**	0.533*	0.638**	0.821**	0.504*	

Note: Only species territorial in at least one census period each year are considered.

* $P < 0.01$; ** $P < 0.001$.

long-term monitoring of gross population changes, such as those in the woodland policies on Rhum studied by Batten and Pomeroy (1969) and by Williamson (1975), is a realistic objective for expeditions to attempt.

Discussion

The results obtained here confirm the viability of expeditions as a means of assessing the bird communities of census plots and habitats not routinely covered by the Common Birds Census scheme. Table 7.3 showed clearly that results gathered within any of the expedition periods considered here gave information on bird community structure comparable to that obtained from an extended CBC season in the same site. Only results gathered very early or very late suggested any inadequacies and these were slight. Moreover, the results from the different periods are concordant amongst themselves to a high degree, thus indicating that census work based on expeditions conducted at any time through the main period of territorial establishment in May or early June provides a feasible method of studying otherwise unvisited habitats. (We note though that these dates might differ with latitude). The analyses thus confirmed the validity of studies such as those of Williamson (1971a, 1974b) and Batten (1976) as a means of broadening the CBC information on the bird communities of different habitats.

On the other hand, the findings of Table 7.4 show that it would be unwise to attempt to use such expedition-derived information to detect small changes in population levels between years, in the way that the normal CBC results do for sites surveyed throughout the breeding season. It probably remains valid to suggest that gross population changes such as those associated with successional change or drastic management of the habitat, can in fact be adequately monitored by expedition work. It might be desirable to have further investigations of the type attempted in Table 7.4 to establish the significance of the variation in correlation coefficient size apparent in the present analysis. The present results suggest that some expedition periods are better than others in terms of predicting the population change that would have been obtained from normal CBC methods but there is no systematic trend apparent in the present results to provide guidance as to the best time of year for such studies, contrary to Swedish experience with point counts (Svensson 1977). One might speculate on the possibility of the highest correlations obtained - those for periods 2 and 5 (Table 7.4) - corresponding to seasonal peaks of activity by double-brooded species, but this is not supported by consideration of the seasonal distribution of registrations (see Figure 8.3 for examples).

Finally, it is worth noting that these results indicate that the criticism of standard census periods advanced by Slagsvold (1973b) is not applicable to the CBC as conducted in England. Slagsvold found that census results for the Song Thrush in his Norwegian study varied considerably as his census period dates were more constant than the timing of the well-marked seasonal peak in song activity; he suggested that census dates should be chosen each year on the basis of the general phenology peak in registration frequency (see Table 7.2 and Figure 8.3) but the census results nevertheless remained broadly independent of the timing of the intensive survey work. Thus, the seasonalit experienced by Slagsvold (1975) in Norway presumably reflects the sharper onset of the breeding season there and is not detected within the more prolonged season experienced by birds in Britain. These conclusions are most valid in relation to the use of the CBC scheme for monitoring a whole range of species, in farmland or in woodland. They are less valid in respect of monitoring population trends in a single species, to which the whole of a census programme might be directed. With such objectives seasonal restriction of census effort could be advantageous but such a programme would be inconsistent with the CBC objectives in Britain.

SECTION 8

THE INFLUENCE OF WEATHER CONDITIONS ON THE DETECTION OF BIRDS DURING COMMON BIRDS CENSUS FIELDWORK

In his classic paper establishing the mapping method of censussing bird populations, Enemar (1959) suggested that weather conditions during the census would be of particular importance to census effectivity, through its effect on the intensity of bird song. Enemar noted that this would be particularly important for the mapping of singing territorial males, and standardised his census visits to those conducted in clear sunny weather, noting that low temperatures (in particular) were depressive of bird song. Armstrong (1963) subsequently reviewed the relationship of bird song to weather and noted that low temperatures and mist were especially significant in retarding song output. In principle, therefore, census visits conducted under these conditions should be relatively poor in providing registrations of birds, a point which might require modification of the standard treatment of visit maps within the BTO Common Birds Census programme.

In practice the CBC is not based exclusively on contacts with singing males, but includes all registrations evidential of a territory. Sightings thus play a larger part in the determination of the eventual total of clusters than did the essentially aural location method of Enemar (loc.cit.). Thus it is not clear what the overall effect of changing weather in the course of the census season might be. Moreover, because the CBC scheme depends on the voluntary efforts of BTO members it is not possible to omit altogether censusses conducted under less than ideal weather conditions (the practice adopted by Enemar) without falling below the minimum number of visit maps for analysis; the vagaries of British weather in any event preclude raising the threshold number of visits asked of participants without reaching an unacceptably high level. This section therefore presents the results of a systematic investigation of the effects of the weather prevailing at the time of censussing on the total registrations obtained in the visits.

Materials and methods

For the present study the 40 visit maps showing the positions of all registrations were examined on completion of the census work and the total numbers of registrations for each of 27 species established for each visit. These totals made no distinctions as to type of registration obtained. When the registrations from the ten visits of each observer were plotted onto species maps, statistically significant differences in the resulting totals of clusters were present (Section 3). These differences between observers were reflected in the frequencies of registrations obtained by each but as the trends apparent in the four observers' results were mutually consistent no attempt was made to correct the data for observer identity.

The data on the weather prevailing on each census visit were obtained from the meteorological station at RAF Benson, 11 km WSW from Aston Rowant. Temperature data, however, were corrected to local conditions on the census plot, by reference to irregularly (approximately weekly) gathered data collected at Aston Rowant. Observations made simultaneously at the two sites were plotted against each other and the resulting graph used to correct Benson temperature to local values where these were not directly measured at Aston Rowant. The mean temperature for the period 0600-0900 hrs BST or 0900-1200 hrs BST were used as appropriate to the observer concerned. Rainfall was recorded at Benson station for the 24-hour period beginning 0900 GMT but was attributed to the calendar date of the period 0900-2359 hrs. Cloud cover was recorded in eighths of the sky covered at all levels; for coding purposes values such as 1-2 eighths were entered as 1.5 eighths. Windspeed was measured in knots. Wind direction was given initial consideration as a variable of possible significance but showed no visible correlation with bird registrations and was not analysed further.

All species with evidence towards two or more territories on the census plot were included in the analysis. A full list of the birds present on the site in 1978 is provided in Table 3.1, and totalled 59 species, of which 27 are studied here. The sample provided a diverse range of species, including birds characteristic of quite different habitats but present because of the heterogeneity of the census plot.

Data collected on registration frequencies were treated statistically almost exclusively by correlation analysis. In these the raw frequency counts were used without transformation. In some cases non-linear relationships were present and are noted expressly below. Non-parametric statistical tests used followed Siegel (1968).

Results

Seasonality of weather

The census work at Aston Rowant in 1978 spanned the period 8 April through 12 July and consequently experienced a seasonal improvement of weather (Figure 8.1). Ambient temperatures in particular increased through the months of April and May, from 0-5°C in early April to 10-15°C (occasionally higher) by the start of June (Figure 8.1). Temperature changed little through June and early July. The correlation between temperature and date over the whole period was 0.609 ($P < 0.01$).

Average wind strengths decreased slightly but not significantly over the census period ($r = -0.191$, n.s.) with May and early June perhaps slightly calmer than either April or late June and July (Figure 8.1). Only ten of the census visits were made on days with appreciable rainfall, and such rain as fell was not noticeably seasonal (Figure 8.1). Cloud cover during the censusses varied erratically, except that those of late May and June were conducted in generally sunny conditions.

Seasonality of bird registrations

Since the April censusses at Aston Rowant were conducted in cool weather and those in June in warm weather, seasonal activity by the species censussed is confounded with the effects of temperature. Figure 8.2 shows the seasonal distributions of registrations of all species and reveals a systematic trend towards seeing and hearing more birds in the

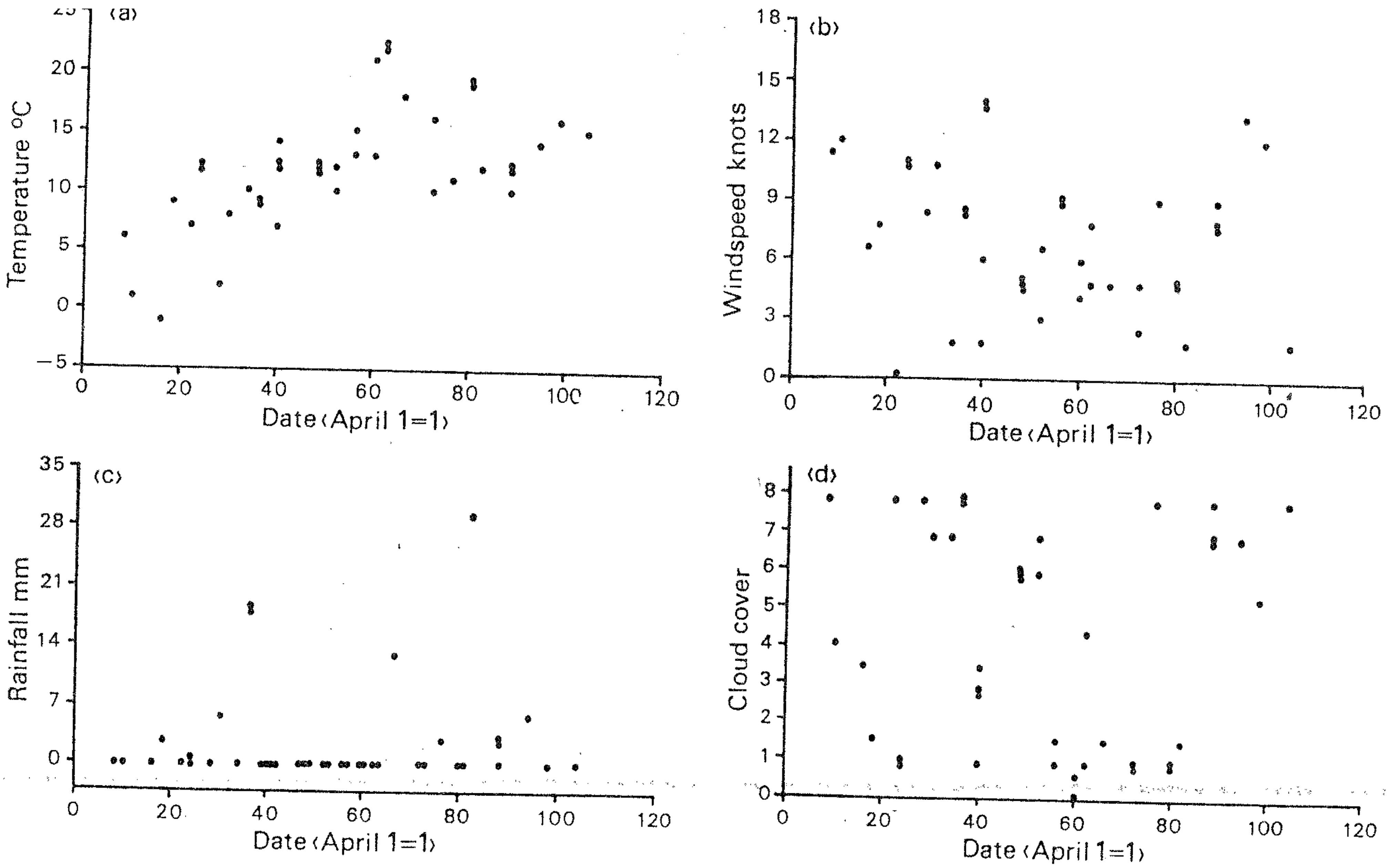

Figure 8:1 Weather conditions during CBC visits to Aston Rowant in 1978: (a) temperature; (b) windspeed; (c) rainfall; (d) cloud cover.

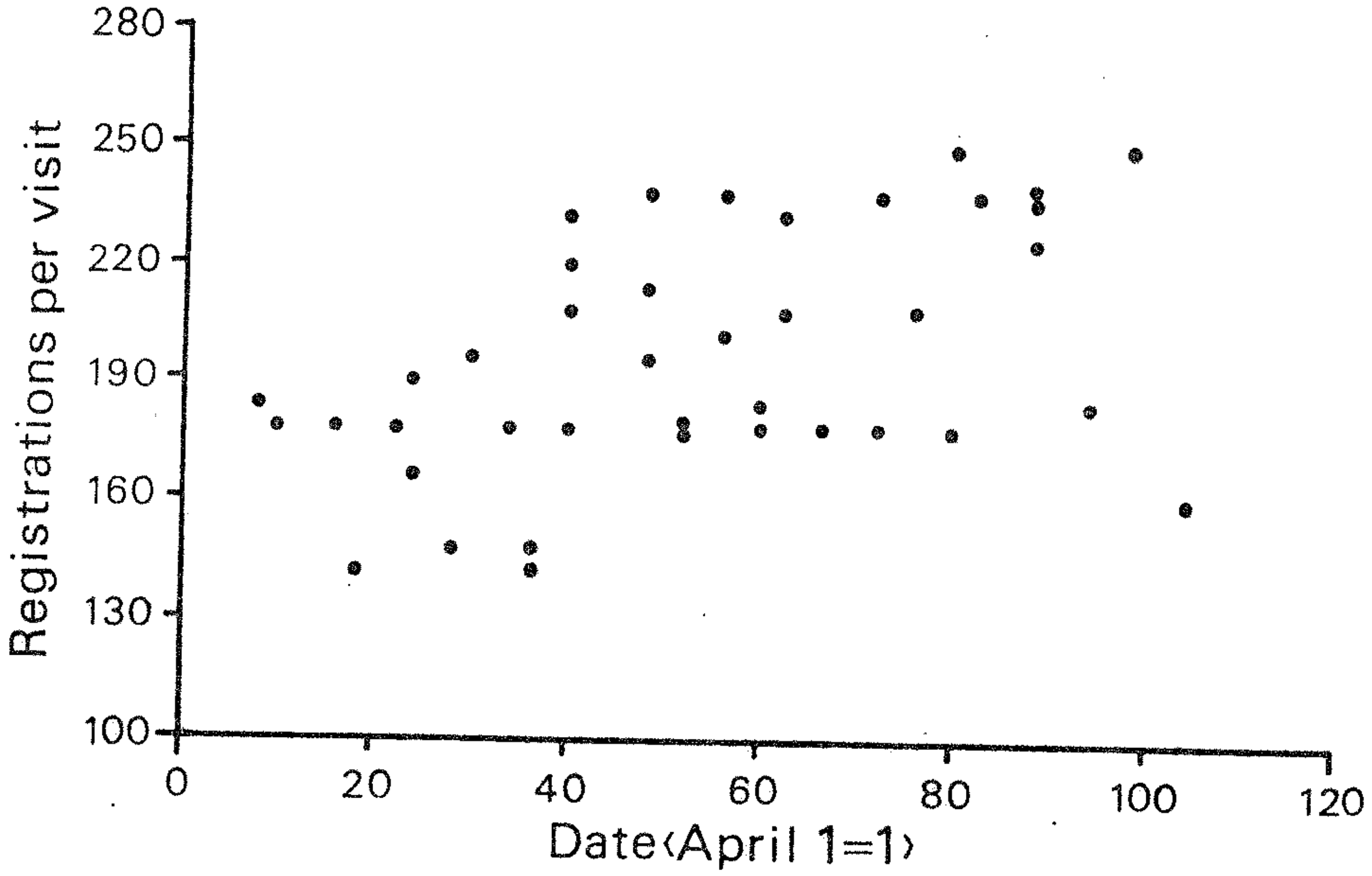

Figure 8:2 Registration totals (all species combined) obtained on each census visit in relation to visit date.

later censusses ($r = 0.478$, $P < 0.01$). There is, therefore, a bias towards obtaining a statistical correlation between registration frequency and temperature measured across census visits, irrespective of the day-to-day sensitivity of census efficiency to the prevailing temperature. Moreover, this bias will vary between species: an early breeding bird such as the Mistle Thrush will have largely ceased its breeding activities by the last of the census visits and will thus yield fewest registrations on the warmest days, whilst the late-breeding Woodpigeon, for example, will have the opposite bias. The seasonal increase in total (non-specific) registrations shown in Figure 8.2 indicates either that most species were more frequently registered later in the season or that those birds numerically most abundant on the Aston Rowant site were registered most frequently in the later visits. It is therefore necessary to consider each species individually.

Table 8.1 summarizes the seasonal trends for each species in the form of correlations between the registrations obtained for each one on a visit and the date of that visit. In general these correlations provide a fair representation of the seasonal changes for each species, positive values indicating the bird was seen more frequently later in the season and negative values indicating early sightings were more prominent. But reservations are necessary for some of the results. Only one pair of Marsh Tits was encountered on the plot until late June and July, when several additional birds appeared. These presumably originated in the spread of juveniles or adults from territories elsewhere and account entirely for the positive correlation in Table 8.1. In the cases of Garden Warbler and Chiffchaff, registration totals for individual visits exceeded

Table 8.1. Correlations between registration frequency (number of registrations of the species obtained on a census visit) and date of visit (1 April = 1) for 27 species.

Woodpigeon	0.450**
Collared Dove	-0.291
Magpie	0.507**
Great Tit	-0.497**
Blue Tit	-0.470**
Coal Tit	-0.273
Marsh Tit	0.476**
Long-tailed Tit	-0.055
Wren	-0.355*
Mistle Thrush	0.658**
Song Thrush	-0.026
Blackbird	0.145
Robin	-0.378**
Blackcap	0.388*
Garden Warbler	-0.045
Lesser Whitethroat	0.197
Chiffchaff	-0.195
Willow Warbler	0.232
Goldcrest	0.228
Spotted Flycatcher	0.293
Dunnock	-0.266
Greenfinch	0.580**
Goldfinch	-0.085
Linnet	-0.084
Bullfinch	0.394*
Chaffinch	-0.073
Yellowhammer	0.209

* $P < 0.05$ ** $P < 0.01$

two birds only once (when three Chiffchaffs were seen on 22 April). For these species, then, the data were rather inadequate for realistic assessment of trends in census efficiency. For all other species linear correlation was adequate to some degree of approximation. The most frequent error arose where particular species either peaked in registration frequency very early and declined thereafter, as with the Wren (Figure 8.3), or rose through the early part of the season to a late peak e.g. Goldcrest (Figure 8.3). For these species the correlations presented under-estimate the true strength of seasonal change. (Polynomial regression is in principle possible in these cases but the resulting plethora of coefficients would have complicated later analysis more than achieving a better statistical fit warranted). The other birds affected in this way were Mistle Thrush, Willow Warbler, Dunnock and Song Thrush, the last-named having negligible correlation with date because of a pronounced mid-season peak in detection frequency (Figure 8.3). In the case of Woodpigeon (Figure 8.3) the seasonal increase was more of a step function than a trend: no more than six birds were detected on any visit prior to 26 May but double figure totals were regular thereafter. The only other species requiring special comment is the Blackcap for which registrations rose to a late May peak, decreased through most of June but then rose once more in late June and July (Figure 8.3). As these later registrations included much singing they presumably indicate the onset of a second nesting cycle.

Examination of Table 8.1, with these caveats, shows that the 27 species divided almost equally between seasonal increases (12) and seasonal decreases (15), nor was there any

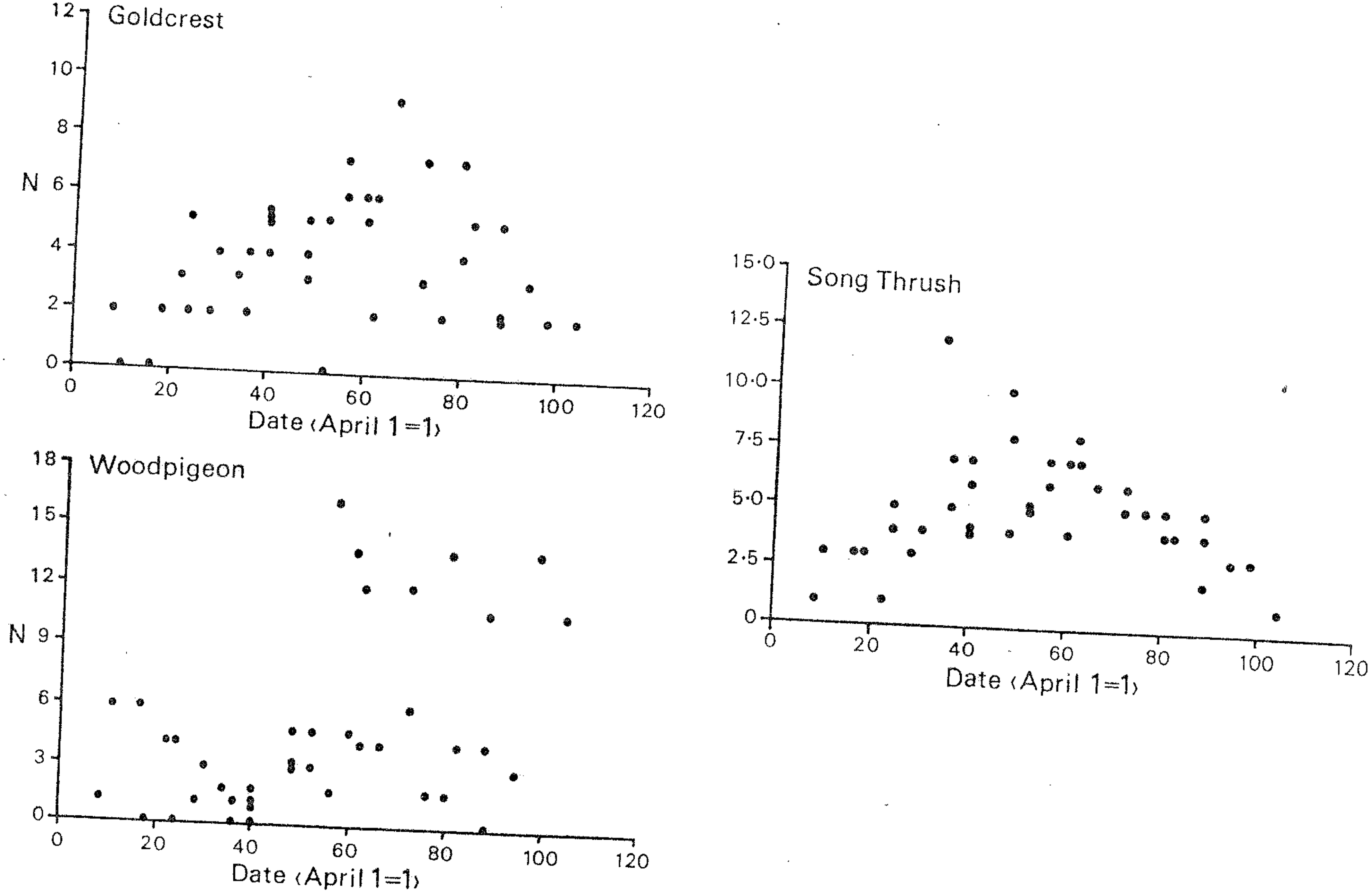

Figure 8:3 Seasonal distribution of registrations of various species on Aston Rowant census plot:
(a) Goldcrest; (b) Woodpigeon; (c) Song Thrush; (d) Wren; (e) Blackcap.

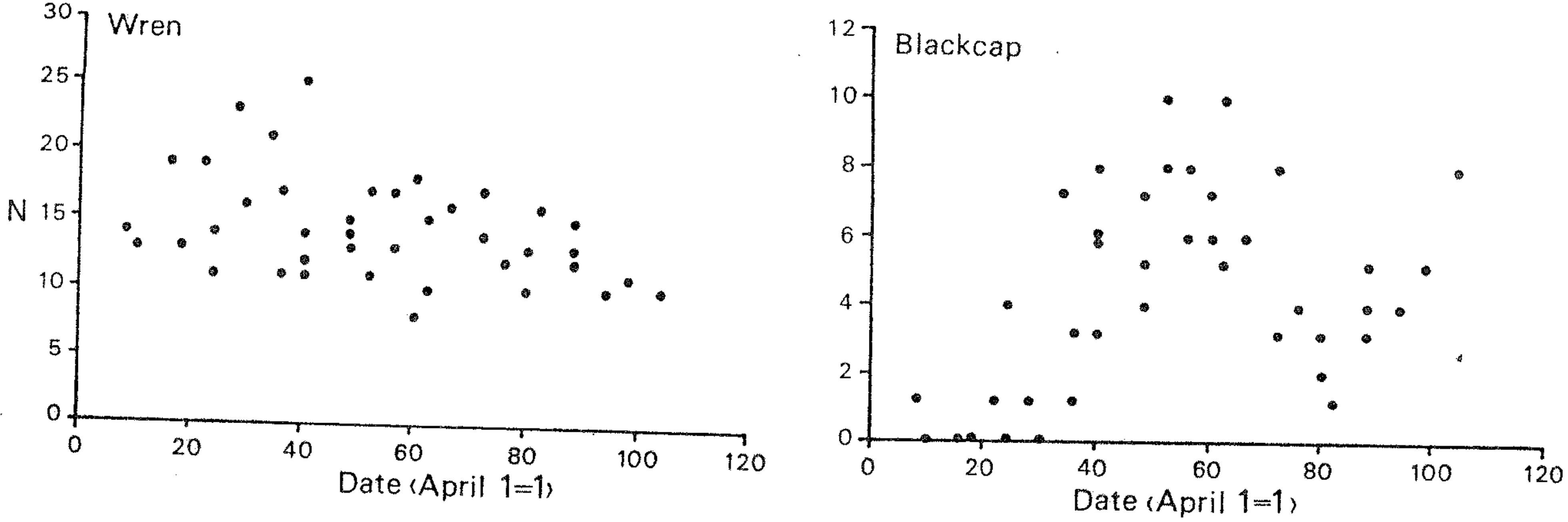

Figure 8:3 (continued)

differential amongst the individually significant trends (six increases, five decreases). The trend for all registrations to increase as the season progresses must therefore reflect either the most numerous species being active later or a change in detection efficiencies as the season progresses. The Table identifies as significantly early breeders (insofar as this is reflected in registrations in CBC work) the five species Great Tit, Blue Tit, Wren, Mistle Thrush and Robin. One may also note, though, that three other species which one would expect to find amongst the earliest breeders - Collared Dove, Coal Tit and Dunnock - account for the next largest of the negative correlations. The Table identifies as particularly late breeders (again, as reflected in CBC registration totals) the five species Woodpigeon, Magpie, Blackcap, Greenfinch and Bullfinch. (The inadequacy of the data for Marsh Tit, the sixth bird with significant positive correlation here, was noted earlier). The seasonality of registrations for these ten species indicates that any temperature dependencies they show in the following section need particular care in interpretation.

Bird registrations and weather conditions

A broad overview of the effects of weather conditions on the detection of each species was obtained by calculating the correlations between the visit registration totals for the species and each of the four weather variables: temperature, rainfall, windspeed and cloud cover (Table 8.2). Temperature was clearly the most frequent correlate of bird registration, 14 of the 27 species' correlations reaching statistical significance. Four species were affected by wind strength and two

Table 8.2 Correlations between detection frequency for a species with each of four environmental variables.

Species	Temperature[a]	Rainfall	Windspeed	Cloud cover	Date-corrected temperature[a,b]
Woodpigeon	0.318*	-0.195	-0.250	-0.229	0.062
Collared Dove	-0.349*	-0.006	0.054	0.201	-0.226
Magpie	0.316*	-0.243	0.114	0.132	0.011
Great Tit	-0.356*	-0.109	0.316*	0.273	-0.077
Blue Tit	-0.189	-0.111	0.355*	0.098	0.139
Coal Tit	-0.067	-0.341*	-0.263	-0.241	0.130
Marsh Tit	0.068	-0.055	0.115	0.293	-0.318
Long-tailed Tit	-0.061	-0.199	0.200	0.057	-0.035
Wren	-0.479**	0.030	-0.329*	0.048	-0.354*
Mistle Thrush	-0.390*	-0.069	0.149	0.071	0.018
Song Thrush	0.241	-0.007	-0.226	-0.184	0.324*
Blackbird	0.352*	0.000	-0.160	-0.233	0.336*
Robin	-0.274	-0.208	0.135	0.128	-).060
Blackcap	0.460**	-0.287	-0.307	-0.153	0.306
Garden Warbler	0.291	-0.018	-0.021	-0.445**	0.402*
Lesser Whitethroat	0.309	0.096	-0.052	-0.099	0.243
Willow Warbler	0.487**(0.152)	-0.021	-0.174	-0.224	0.448**
Chiffchaff	0.033	-0.116	-0.367*	-0.249	0.195 (0.261)
Goldcrest	0.462**	0.100	-0.243	-0.461**	0.418**
Spotted Flycatcher	0.472**(0.388)	-0.186	-0.014	-0.199	0.387*
Dunnock	-0.211	-0.337*	-0.001	0.154	-0.064 (0.394)
Greenfinch	0.370*	-0.031	0.083	-0.101	0.026
Goldfinch	0.011	0.180	-0.007	0.031	0.079
Linnet	-0.285	-0.133	-0.088	-0.039	-0.296
Bullfinch	0.464**	-0.140	-0.053	-0.013	0.307
Chaffinch	0.231	-0.168	0.040	-0.218	0.348*
Yellowhammer	0.317*	-0.297	-0.173	-0.132	0.244

* $P<0.05$ ** $P<0.01$

[a] Figures in brackets are values computed omitting early visits on which the migrant concerned had not yet been recorded on the census plot.

[b] Values are partial correlations between registration frequency and temperature, with date of visit as the controlled variable.

each of rainfall and cloud cover respectively. Overall, two-thirds (18 of 27) of the species considered were significantly affected by at least one environmental factor.

Temperature

Table 8.3 shows that most, although not all, of the species considered were registered more frequently on warm than cold days. No less than 17 of the 27 showed this trend, ten of them significantly so. However, if there were no particular sensitivity by birds in general to the ambient temperature during census visits one would expect half the species to give positive correlations with temperature, and half negative, and the results here do not deviate significantly from this ($X^2 = 1.33$ and $X^2 = 1.78$, n.s. for all 27 species and for the 14 individually significant ones respectively). In addition, the total (all species) registrations obtained on each visit were not quite significantly linked to temperature ($r = 0.305$, $0.05 < P < 0.10$).

The simple temperature correlations of Table 8.2 make no allowance for the biassed seasonal distribution of registrations already discussed (Table 8.1). The final column of Table 8.2 therefore presents partial correlations between registrations and temperature, with date held constant. Despite the shortcomings (already discussed) of the linear correlation coefficients of Table 8.1 as estimators of seasonal trends for some species, they proved very effective in removing negative correlations between detection frequency and temperature. Correction for the seasonal increase in temperature shows that the apparent positive links with temperature for six species (Woodpigeon, Magpie, Blackcap, Greenfinch, Bullfinch and

Table 8.3 Summary of species detection probabilities in relation to weather factors (Data in Table 8.2)

Weather factor	Sample	Number of species with weather correlation Negative	Number of species with weather correlation Positive	χ^2
Temperature	All species	10	17	1.33
	Significant[a] species	4	10	1.78
Windspeed	All species	17	10	1.33
	Significant[a] species	2	2	0.00
Rainfall	All species	22	5	9.48**
	Significant[a] species	2	0	0.50
Cloud cover	All species	16	11	0.59
	Significant[a] species	2	0	0.50

[a] Species with statistically significant correlation of registration frequency with the weather variable concerned.

** = $P < 0.01$

Yellowhammer) were due largely to these being seasonally active in the warmer months. Similarly, the apparent depressive effects of warm temperatures on the detection of Collared Dove, Great Tit and Mistle Thrush were due to their breeding in the earlier part of the census season. Nevertheless, five species retained a temperature dependence in their detection rates (Figure 8.4): Wren, Blackbird, Goldcrest, Willow Warbler and Spotted Flycatcher. Of these the Wren was the only one to show reduced registration rates on warm days. Three others - Song Thrush, Chaffinch and Garden Warbler - showed positive links between detection rate and temperature, once the influence of date was removed. As noted earlier, the Garden Warbler registrations were generally rather sparse so the correlation is not entirely satisfactory.

Using the seasonally corrected temperature correlations, 19 of the 27 species are revealed as more frequently seen or heard on warm days and analysis of the sizes of the correlations shows the effect is significant (Wilcoxon Signed Ranks Test: $Z = 2.26$, $P = 0.024$). On the other hand, correction of the (weak) temperature dependence of the pooled (all species) registrations for the link with date (shown as Figure 8.2) completely removes any suggestion of significant correlation ($r = 0.020$, n.s.). Presumably the depression of Wren registrations (which typically accounted for 6.7 per cent of all registrations on a visit and for up to 15 per cent on occasion) on warm days contributed at least in part to obscuring any trend in total registrations.

Finally, referring back to Table 8.1, we note that only fo Robin and Blackcap there showed significant correlation with date which subsequently vanished in partial correlations holding

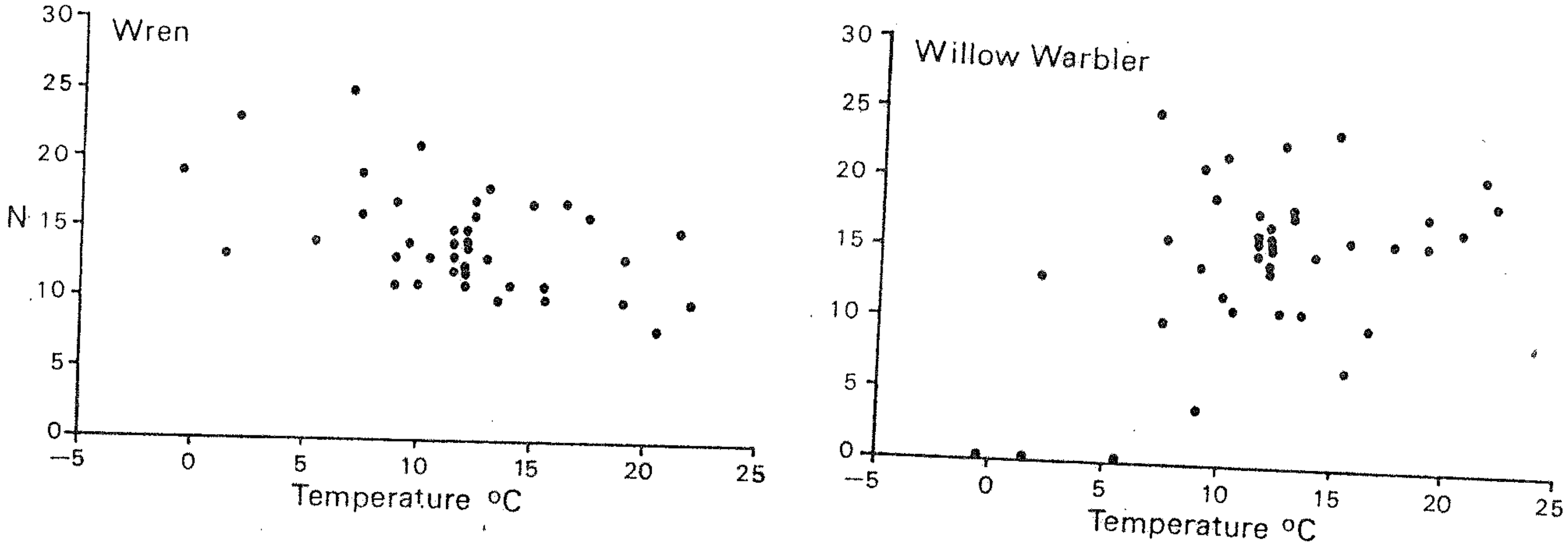

Figure 8:4 (continued)

temperature constant. The remaining species with seasonal trends all had significant seasonality independently of temperature.

Wind strength

Table 8.2 shows that only four species - Great Tit, Blue Tit, Wren and Chiffchaff - were correlated in detection frequency with wind speed, the first two positively, the second two negatively. As noted earlier, few Chiffchaffs were recorded at any one time on the census plot. The data for the other three species are presented in Figure 8.5. There are no obvious reasons why these trends exist. Wind-speed showed little directional trend but it may be significant that the period of calm weather in May already noted coincided approximately with the seasonal peak in Wren registrations shown in Figure 8.3. Similarly, both Great Tit and Blue Tit are territorially most active in the earliest part of the census period when winds are rather stronger than in May, and decreased through May. This suggests that these three species showed correlations with wind strength due entirely to co-incidence of their seasonal activity with the wind pattern on Aston Rowant in 1978. Examination of Table 8.3 provides no evidence for wind strength having a generally depressive or stimulatory effect on the registration of species in general, though it might be noted that the range of wind strength experienced at Aston Rowant during the 1978 census work was not particularly large.

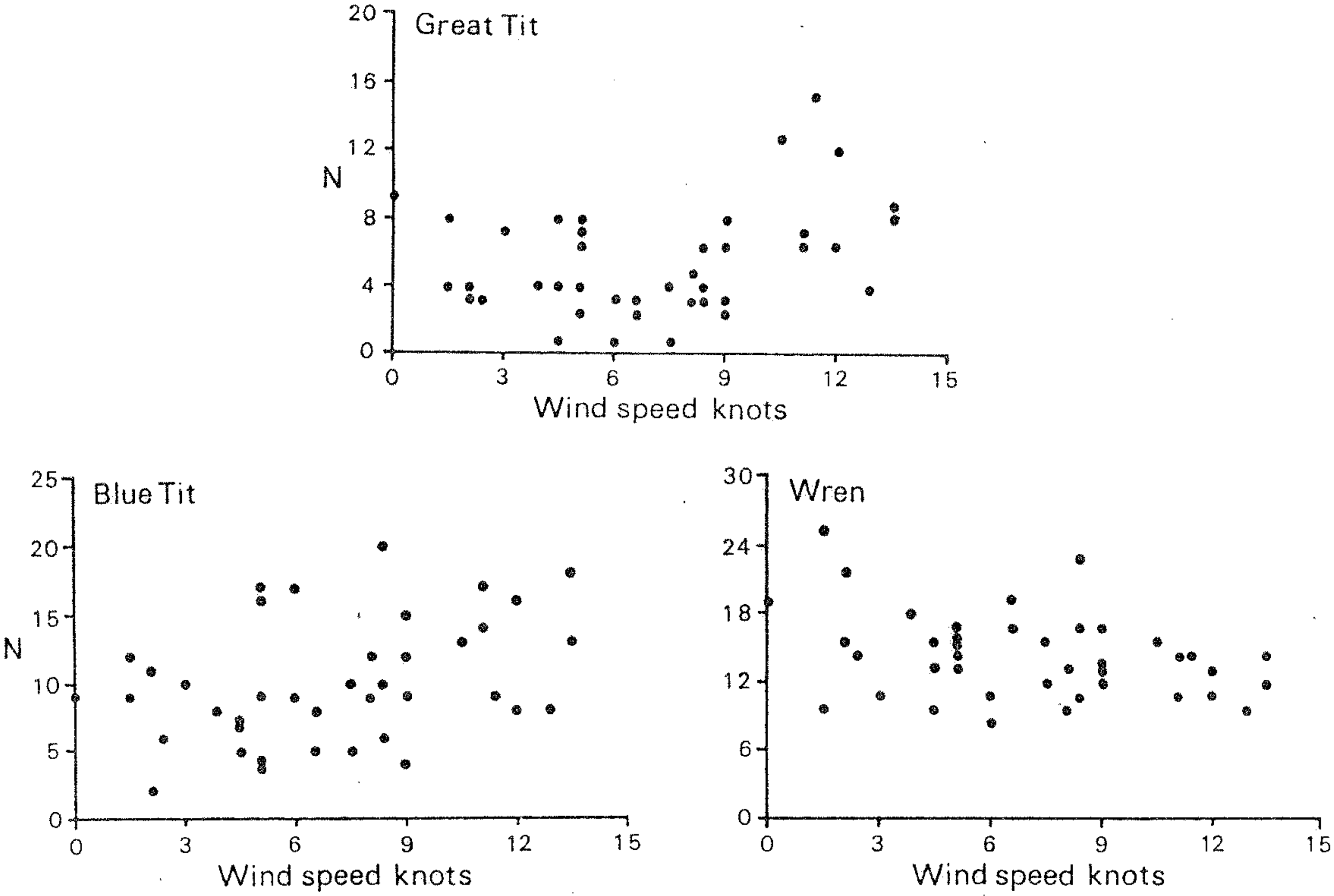

Figure 8:5 Dependence of registration frequency on wind strength in (a) Great Tit; (b) Blue Tit; (c) Wren.

Rainfall

Only two species showed significant sensitivity to rainfall (Table 8.2). Dunnocks showed a systematic decrease in registrations with increased rain (Figure 8.6), despite there being generally rather few wet days during the 1978 fieldwork (Figure 8.1). This is undoubtedly due to observer efficiency with this species, the bird being readily overlooked even in ideal conditions (Williamson 1971b). The Coal Tit results were less clear-cut (Figure 8.6) but as song registrations fell off even more sharply with rainfall (unpublished data) they presumably reflect the species' behaviour in wet weather.

The overall effects of rain in reducing registrations of birds were not confined to Dunnock and Coal Tit. Table 8.3 shows that negative correlations between detection rates and rainfall were significantly more frequent than expected by chance ($X^2 = 9.48$, $P < 0.01$). That is, although only two species showed marked depression of their registration frequencies on wet days, most species were less likely to have high totals on such days. These lower frequencies could be due either to reduced singing by the birds but constant observer efficiency or to reduced observer efficiency and constant song output (and both effects can occur together). Overall, the registrations of all species obtained on a census visit depended only weakly on rainfall ($r = 0.131$, n.s.) so the effects, although demonstrable, are not a serious problem for censussing, at least within the limited range of rainfall experienced during the Aston Rowant fieldwork. Moreover, it is unlikely that observers actually attempt to detect birds whilst rain is actively falling, so that in practice the effects described here constitute a broader time-scale of response to rain by the birds.

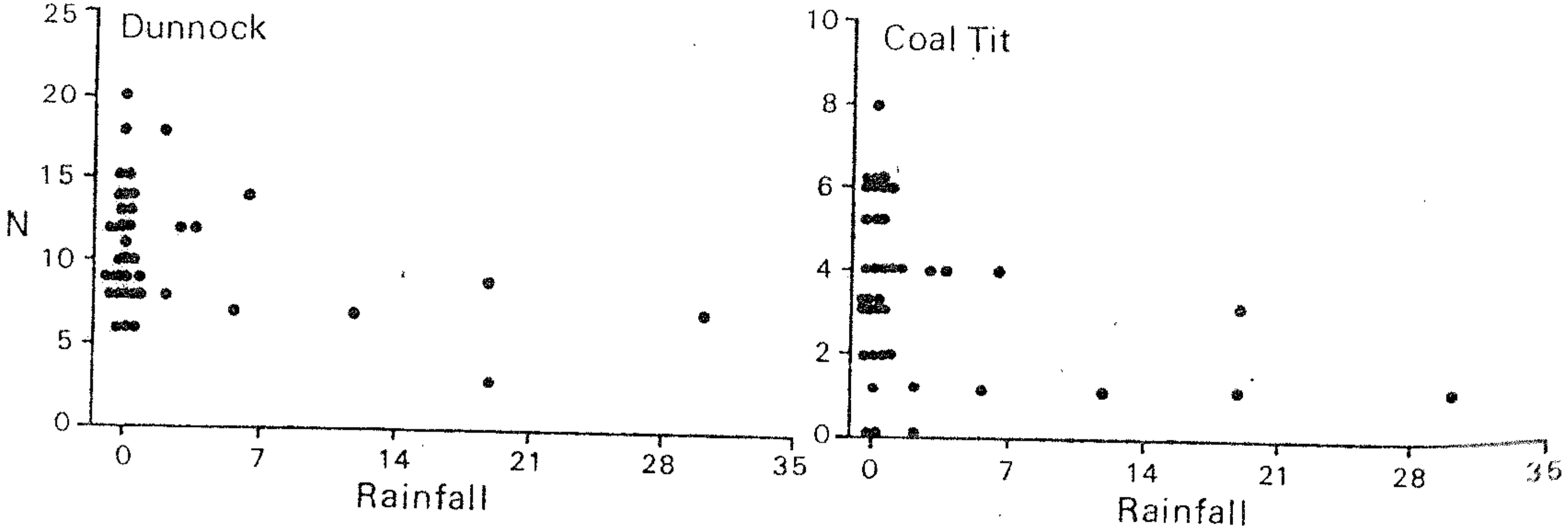

Figure 8:6 Registration frequencies in relation to rainfall for Dunnock and Coal Tit.

Cloud cover

Only Goldcrest and Garden Warbler registrations were significantly correlated with cloud cover (Table 8.2) and within the Table as a whole there was no overall trend towards correlations of one sign or the other (Table 8.3). The registration totals (all species combined) for each visit were likewise independent of cloud and sunshine ($r = -0.162$, n.s.). There was little seasonality in cloud cover at Aston Rowant during the 1978 fieldwork (Figure 8.1) but it is noticeable that a period of generally clear skies in the last week in May and first week in June coincided with the seasonal peak in Goldcrest registrations (Figure 8.3). The scarcity of Garden Warbler registrations has already been noted and the correlation of Table 8.2 is due largely to a transient bird recorded on visits on 26 and 29 May during the fine spell just noted. Thus there is little evidence that cloud cover seriously influenced the detection of birds during censussing.

Multiple factors

For three species - Great Tit, Wren and Goldcrest - the registrations obtained on each visit were correlated with two (rather than with one) weather factors. For all three species temperature was involved, but for Great Tit and Wren wind strength was the second variable whilst for Goldcrest it was cloud cover (Table 8.2). To test for independent effects of the two variables in each pair, partial correlations were calculated to control their joint variation. For all three species temperature remained significant ($r_p = -0.332$, $P < 0.05$ for Great Tit; $r_p = 0.561$, $P < 0.01$ for Wren; $r_p = -0.340$, $P < 0.05$ for

Goldcrest). For Great Tit, however, windspeed was not independently significant ($r_p = 0.288$, n.s.), thus confirming a suggestion made above. Wren detection, on the other hand, was depressed by wind strength even at constant temperatures ($r_p = -0.456$, $P < 0.01$). For Goldcrest cloud cover continued significant even with temperature controlled ($r_p = 0.342$, $P < 0.05$). The findings for these last two species, of course, do not preclude the coincidence of seasonal song peaks with periods of calm nor of sunshine respectively, suggested earlier in explanation.

Discussion

Slagsvold (1973a, 1977) has documented the effects of date and spring weather on the output of song by passerines on his Norwegian census plots. He found a consistency of seasonal pattern, with song output rising steeply in April and declining slowly into June when his census work ended. Because June song was more frequent than in April a weak positive correlation resulted, as at Aston Rowant. Slagsvold also found that amongst 36 species in Norwegian forest there existed a close relationship between the onset of egg-laying for first broods and the dates of song maxima, though in migrants, maxima were sometimes several days ahead of egg-laying, apparently because of territorial disputes between newly arrived males. These findings were thus similar to those found here, with different species peaking in song output in relation to their specific breeding cycle.

In Norway, the dates of song maxima were also closely correlated with temperature during the preceding days, particularly for those species with early song maxima. Much the same result emerged from the present study, where several of the early breeding species had negative correlations with ambient temperature because of the close cross-correlation between temperature and date (Table 8.2). Slagsvold (1973a) also found the frequencies of Song Thrush registrations on each visit were well-correlated with diurnal mean temperature, though this effect was superimposed on well-marked seasonal peaks associated with increased territorial display by birds before egg-laying, with decreased activity during incubation. At Aston Rowant the same patterns held, with markedly seasonal Song Thrush registrations (Figure 8.3) obscuring a significant temperature effect on correction for census date (Table 8.2). Tinbergen (1939) found that captive Song Thrushes began singing in mid-winter in response to an artificial rise in temperature, and laying by this species at Oxford (Myres 1955) was correlated with ambient temperature. Such results suggest the temperature correlations are biologically founded rather than the result of observer bias.

Table 8.2 showed that ambient temperature was the most important weather variable, a conclusion also reached by Slagsvold (1977). Cox (1944) noted that bird song in England was largely independent of changes in sky and atmosphere in spring and summer, though snowfall in March in one year depressed song output. Armstrong (1963) has more thoroughly reviewed the influences of weather conditions on bird song and concludes that temperature is of dominant importance, though spells of sustained wind, rain or snow have each a different retarding effect.

The seasonal and temperature cross-correlations noted for species such as the Great Tit may be biologically rather than statistically founded. Perrins (1970) has noted that the timing of breeding by Great Tits is correlated with the temperatures prevailing in the weeks before egg-laying, apparently because the maintenance requirements of the female compete for a limited food supply with the development of egg follicles. An increase in ambient temperature reduces female energy costs and allows breeding to proceed, with consequential reduction in frequency of registrations. Thus, although the decline is seasonal and not dependent on temperature in the partial correlation analyses (Table 8.2) it does in fact ultimately depend on temperature. Dunn (1976) has shown that titmice species breeding in Wytham Wood lay in order of body size, the smallest doing so earliest, presumably because their absolute energy costs are smaller and allow them to devote energy to egg formation sooner. One might therefore expect to find the larger early breeding species to be more tightly coupled, in their activity, to temperature and this appears to be the case at Aston Rowant (Figure 8.7). For this analysis it is the seasonal temperature coefficients (i.e. uncorrected for date) that must be used and the analysis is confined to 'early' species (defined as those for which daily total registrations at the commencement of census work were already more than half the maximum recorded over the season). The correlation between temperature sensitivity and log body weight is significant ($r = 0.861$, $P < 0.02$), indicating that 74 per cent of the variation between species is associated with body size. For a direct comparison with Dunn's (1976) work the coefficient for Marsh Tit (though based on very few data) was included with the other three species and gave a correlation of 0.968 ($P < 0.01$). These body weight dependencies suggest that the seasonal decline in registration frequency in these early breeders is the consequence of the timing of laying being itself temperature-sensitive in accordance with the model of Perrins (1970).

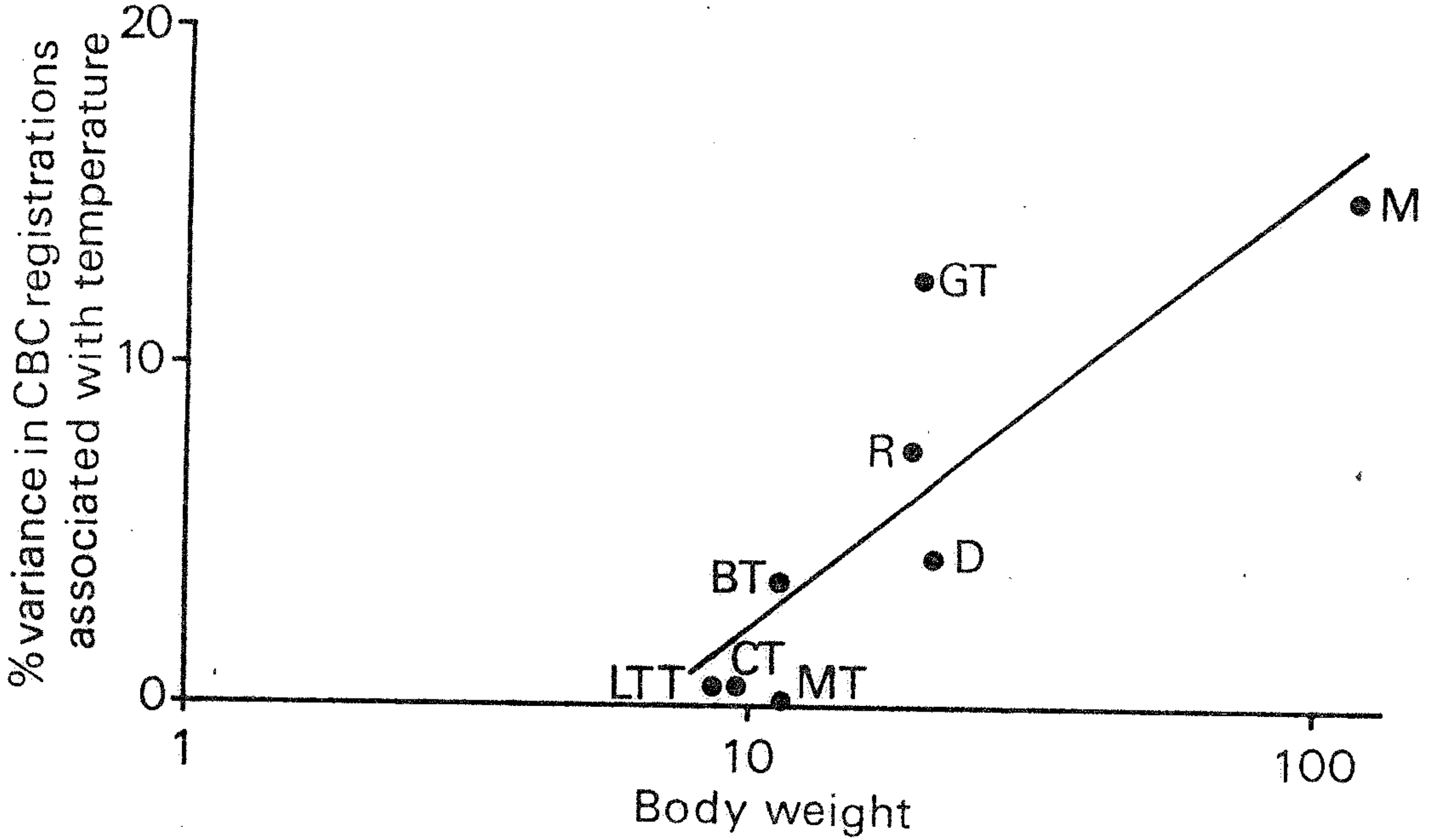

Figure 8:7 Temperature sensitivity of early breeding species in relation to body weight. Sensitivity measured as percentage of variation in registration totals associated with temperature during the census. Correlation squares for Table 8.2, body weights from various sources. For all eight species the regression obtained was

$$y = 0.059 \ln (\text{Body weight g}) - 0.113$$

with $r = 0.862$ ($P < 0.01$). For species codes see Appendix 1.

The importance of rainfall as a determinant of registration frequency (Table 8.3) has received little attention in the literature, perhaps because breeding season studies are generally conducted in fine weather and meet rain, if at all, only in association with lowered temperature. It is possible that the results obtained in the present study originate in reduced observer efficiency on wet days, as suggested for the Dunnock above. Problems faced by observers on wet days include their vision being obscured by rain on binoculars (and spectacles, in some cases), the difficulties of keeping visit maps dry, and coping with the additional noise and movement of water dripping onto foliage. Observer concentration may also suffer whilst moving across unpleasantly wet terrain. Several of these effects persist even after the cessation of rainfall and could account for the rainfall effects detected, even if the observers at Aston Rowant avoided the rainy periods of a wet day. Armstrong (1963) notes, though, that rainfall may have an indirect effect on birds: Wrens, for example, build when rain has made nesting material particularly pliable and they sing less whilst so engaged. In the present study, all registrations (and not just song) were less frequent on wet and windy days and were so throughout the census period and not only whilst building (but the possibility of indirect effects remains open). Thus, birds with young may need to brood more closely in rainy conditions, thereby reducing their general activity on the census plot. Such an effect might underlie the negative correlation of Wren detections with temperature which persisted after correction for date. Whitehouse and Armstrong (1953) found that time spent off the nest during incubation increased with temperature, so precluding explanation of the registrations decline on this basis. But low temperatures require greater foraging intensity by small birds, so that Wrens might be searching for food more actively in cool conditions and thus be seen more.

Windy conditions have varying effects on the output of bird song (Armstrong 1963), though Scheer (1952) found a slight but systematic trend towards reduced song. In the present study, 17 of the 27 species showed this trend (Tables 8.2, 8.3). From a bird's point of view, wind is likely to be adverse in effect either by waving the branches of trees about (making it awkward to use them) or by increasing the background noise with increased rustling and the like. It may be significant that of the seven species with large negative correlations (above 0.200 in magnitude), five - Woodpigeon, Coal Tit, Song Thrush, Blackcap and Chiffchaff - are predominantly treetop singers. Possibly the Goldcrest is in this category also. Only the Wren is anomalous in this respect and, as previously noted, its correlation with wind conditions is largely through coincidence of its seasonal peak in registrations with a period of calm weather in May. The effect of wind in increasing environmental noise would also make it difficult for Coal Tit, Chiffchaff and Goldcrest to be detected easily by observers, each of them being a relatively quiet and inconspicuous species. However, of the other three species of this type - Marsh Tit, Long-tailed Tit and Willow Warbler - only the last-named had a negative correlation of any size, so it is difficult to be conclusive about the effects of wind noise on detectability overall.

The results obtained in the present study indicate that seasonality, temperature and rainfall are the most important correlates of the registration totals obtained on a census visit, with the effects of the first two well-correlated for early breeding species in particular. Because different species had different seasonality, ranging from the very early peak for Mistle Thrush through mid-season timing for Song Thrush to late breeding by Woodpigeon (Figure 8.3) total registration efficiency varied little over the census periods as a whole, though the results for individual species did differ with date (Table 8.1). This finding agrees with the conclusions of Järvinen et al.(1977) using line transects on Finnish census plots. The results also bear out the argument of Slagsvold (1973b,c) that census efficiency for individual species can be affected by the timing of the census period. However, with the extended census period normally used by CBC participants in Britain this effect will be reduced and any residual impact on the census estimate removed from the CBC index by the pairing of results from each observer across years (Section 4). In this way annual variations in the phenology of breeding seasons, as discussed by Slagsvold (1975, 1976), can have, at most, a second order effect on the CBC index. Some residual effects on the bird community composition estimates are undoubtedly present but the analysis of CBC maps prepared on the basis of a restricted census period (such as employed by Williamson (1969) in CBC expeditions to little-studied habitats in Britain) show that only June censusses are noticeably poor for Aston Rowant; censusses at other periods within the breeding season were well correlated with those of the extended census periods (Section 7). Also, it should be pointed out that even though temperature was shown to have significant effect on the census detection rates for individual species, the correlations over the whole fieldwork period were rather small (Table 8.2), in the worst case (Willow Warbler) accounting for 20 per cent of the variation. Rainfall had even less effect on census efficiencies (Table 8.2). It is thus unlikely that serious errors would be introduced into the CBC results by the normal pattern of weather variation in British census work; CBC participants do not, as a rule, conduct censusses in very cold or very wet conditions! Only census expeditions, constrained to operate within the chosen period, are likely to experience significant weather effects in their results and this requires merely suitable caution in the interpretation of such data when collected in adverse weather.

Finally, one must note that whilst much of the consideration of the underlying causes of the correlations and trends reported here have been discussed in terms of weather influence on song it is possible, as Armstrong (1963) noted of the Wren, for weather to affect other bird activities. CBC workers in Britain report all evidence pertaining to territorial and breeding presence by the target species so that non-song registrations were included in the registration totals analysed here. Relevant work on the influence of weather factors on the non-song component of these totals is negligible at present and requires further study.

SECTION 9

SUMMARY

1) This Report presents the results of a field validation of Common Birds Census assumptions requested by Milner and Hornby (1977) in respect of four areas: (a) the consistency of observer effectiveness from year to year (Milner and Hornby Recommendation 9.4) (b) the effectiveness of the use of professional analysts trained in the interpretation of the international mapping method of bird censussing as a means of securing desirable standardisation (Milner and Hornby Recommendation 9.7) (c) the relationship of a point count method of censussing to that of the Common Birds Census scheme (Milner and Hornby Recommendation 9.13) and (d) assessment of the absolute level of observer census effectivity, the effects of using an extended censussing season by comparison with those of a more compressed season, and the effects of weather conditions on census efficiency (Milner and Hornby Recommendation 9.16).

2) The Report is based upon fieldwork conducted on the Aston Rowant National Nature Reserve in 1977 and 1978, involving four independent ten-visit CBC censusses by observers of a wide range of census experience (0-11 years), plus some preparatory visits, and independent assessment of point counts and belt transect methods by two other observers.

3) CBC observers did not differ significantly with respect to the species lists recorded in each year (Table 3.1).

4) CBC observers differed very significantly as to the total number of territories recorded by each on the census plot in 1977 (Table 3.5).

5) CBC observers differed significantly as to the totals of each species recorded by individual observers in 1978 in the case of 24 of the 26 species tested (Table 3.4, Table 3.6), apparently because more experienced observers spent longer in the field on each census visit.

6) Previous experience of census work on the plot was apparently unimportant as a factor.

7) The range of variation in total territories recorded by individual observers was only 15 per cent (Table 3.5) whilst for individual species the coefficients of variation were in the range 11-109 per cent (Table 3.7). The median value was 52 per cent. Variation between CBC observers in census efficiency was effectively eliminated by the procedure of pairing observers across years: no significant heterogeneity was found amongst the four observers' estimates for population changes in each of 21 species with adequate densities at Aston Rowant in 1977 and 1978 (Table 4.3) and for a further 45 less common species on the plot the variation observed was close to random (Table 4.4).

8) Three analysts achieved significant standardisation as to the interpretation of CBC returns: they agreed closely as to species rankings derived from four observers (Table 3.3, Table 4.1), as to the total territories (of all species) registered by each observer on the census plot (Table 3.5), and as to the species totals for each observer for 24 of the 26 species tested (Table 3.6). Median variation due to analysts was only 6 per cent (Table 3.8).

9) Comparison of point counts made at ten stations within the census plot at two times of year showed that between counts lasting 5, 10, 15 and 20 minutes respectively, the shorter period results were more variable between sites (Table 5.3).

10) The accumulated registrations in point counts increased more rapidly and over longer periods in open sites than in more closed habitats (Table 5.4) and for conspicuous species than for inconspicuous species (Table 5.5).

11) Substantial disagreement existed between the results of point counts obtained by two independent observers (Table 5.9).

12) Point counts showed significant agreement with normal CBC censusses as to the relative abundance of species present (Table 5.5, Table 5.6) but nevertheless detected only 59-91 per cent of the species detected by the CBC work (Table 5.7, Table 5.8). Aerial feeders (Swifts, hirundines) and conspicuous species (Skylark, Woodpigeon, Starling) were over-emphasised by the point count method whilst inconspicuous species (Goldcrest, Long-tailed Tit, Marsh Tit, Coal Tit) were under-represented.

13) Population changes estimated from the point count methods were not significantly correlated with the Common Birds Census-derived estimates except in the case of ten-minute point counts, for which 23 per cent of the variance was in common (Table 5.10, Figure 5.3). These poor correlations were probably associated with a greater sensitivity of the point count method to time of day effects (Figure 5.2). The changes estimated from point count censussing were negatively biased by comparison with the Common Birds Census results (Figure 5.3).

14) Belt transect censussing detected 80-93 per cent of the species found in the Common Birds Census work (Table 5.14, Table 3.2).

15) Belt transect results for ten common species were correlated with those of the Common Birds Census results for three of the four CBC observers, but only when the results of both years were pooled (Table 5.15). Main belt results were more strongly correlated with the CBC results than were the full survey belt results.

16) Population changes estimated from belt transect work were not correlated with the corresponding changes estimated from the Common Birds Census technique (Table 5.16).

17) An attempt was made to estimate the absolute census effectivity of the CBC method by using the number of territories established with large numbers of visits (up to 41) as an estimator of the true number of breeding pairs. A binomial model was used to estimate the likely effects of multiple registrations of the same bird in the course of a census visit and of the presence of transient birds on the census plot (Figures 6.1 - 6.4).

18) The number of clusters established (all species pooled) increased with number of visits up to 41 visits (maximum used) but did not level off (Figure 6.5). Cluster totals for individual species also increased with visit total but for some species reached a plateau, for others showed a system of multiple plateaux, and for others again a pattern of asymptotic increase (Figure 6.6).

19) The extent to which curves for individual species levelled off with visit total was not correlated with species-specific conspicuousness (Figure 6.8).

20) Subjective estimates of the approximate value at which the clusters-visits total curves levelled off were correlated with the cluster totals for ten-visit CBC surveys (Figure 6.7), but both intraspecific analysis (Figure 6.9) and interspecific analysis (Figure 6.10) suggested that these estimates were inflated by the presence of spurious clusters due to increased frequency of multiple sightings of the same birds during a visit. The internationally agreed guide-lines for analysis of mapping returns provide for adjustment of the acceptance level with visit total within range 8-12 visits but such adjustments are inadequate to cope with the much higher probabilities of spurious clustering obtaining with up to 41 visits.

21) Absolute visit efficiency was estimated at an average of at least 57 per cent (Figure 6.7) but this efficiency is under-estimated in direct proportion to the over-inflation of the breeding pair totals by the presence of spurious clusters.

22) At normal frequencies of CBC visits per census the increase in cluster total with extra visits was at most 5-7 per cent per visit (Figure 6.6). These rates of increase were density-dependent across species. Since the most common species are statistically least likely to be subjected to a net change of visit total between years, the practical effects of the relationship on the national CBC data are negligible.

23) The effects of using a compressed census period were compared against the normal extended season results by extracting runs of ten visits from the 45 visits available, to give analogues of intensive surveys conducted at six different times through the season. Very early and very late census periods give biased results for certain species (Table 7.2, Figure 7.1).

24) Community structure estimated from each intensive survey was well correlated with that obtained from normal CBC work (Table 7.3).

25) Year-on-year changes estimated from corresponding intensive census periods had significant but low correlations with the population changes estimated from normal season-wide CBC census work, to the point where intensive survey would not be suitable for monitoring population change, despite its suitability for assessing community structure.

26) Data gathered from all four CBC observers were analysed in relation to the weather prevailing at the time of the census work. Bird registrations increased seasonally (Figure 8.2), giving rise to many secondary correlations with seasonally increasing temperatures (Table 8.1).

27) Amongst the early breeding species the sensitivity of registration frequency to temperature was dependent on species body size (Figure 8.7).

28) Although few species showed statistically significant responses to temperature and rain, the majority of species were most frequently detected on warm days and on dry days (Table 8.2, Table 8.3).

29) Individual species less frequently detected on windy days were those with weak voices or that sing from treetops.

30) Only Wren and Goldcrest were significantly affected by more than one weather factor, the former by temperature and wind strength, the latter by temperature and cloud cover.

31) Overall, weather influences detected were too weak to bias CBC results, though they confirmed the inadequacy of results gathered on very cold or very wet days.

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APPENDIX 1

BRITISH TRUST FOR ORNITHOLOGY
Beech Grove, Tring, Hertfordshire HP23 5NR

POPULATIONS SECTION

* * * * * * * *

GUIDING PRINCIPLES FOR THE ANALYSIS OF COMMON BIRDS CENSUS RETURNS

Introduction

The aim of the mapping method is to assess the number of territories of each species by plotting registrations of birds encountered , particularly singing males, and any other activities considered to be of a territorial nature - such as fighting, carrying nest material etc. - on outline maps during successive visits to the census plot throughout the breeding season. Recording such contacts on the 'visit' or 'discovery' maps employs the nationally agreed abbreviations for the species concerned, and the internationally accepted code of symbols for the various events (see References).

Such registrations are subsequently transferred to new outline maps, one for each species, the contacts now becoming A,B,C etc., according to the chronological succession of the visit maps (see figures). The approximate bounds of individual territories are indicated by drawing rings round groups of registrations deemed to represent the activities of distinct 'pairs'. The boundaries of these 'paper territories' do not necessarily represent the exact confines of each individual territory, and this 'clustering' is merely an expedient forassessing the number, distribution and relationship to habitat of territory-holding males on the data available.

Nor can it be claimed that the resulting assessment is a precise representation of the number of pairs occupying the census plot. With a well conducted and carefully analysed census of 9 or 10 visits to farmland, and 12 or more visits to woodland, the mapping method undoubtedly provides a closer approximation to reality than can be obtained in any other way. Since there are limitations with the data, absolutely fixed and rigid rules cannot be defined for the analysis, and at a number of points a subjective approach to interpretation of the data is unavoidable. The decisions, however, are not arbitrary, since the analyser draws on his accumulated experience of census work in a wide spectrum of habitats, and his field knowledge of bird behaviour.

In order to reduce this subjective element to the minimum, and to establish consistency in the manner of analysis, some guiding principles were formulated by members of the Populations Section team for delineating 'paper territories', and an outline of these is given below. By applying them impartially to all areas, it is felt that the gaps which might otherwise exist if an individual approach were used are reduced, and the best possible agreement among the analysers is achieved.

A. TERRITORIAL SPECIES

A basic assumption is made that all species other than those considered in section B are potentially holders of a well defined area from which others of the same species (though they may visit) are excluded from settling. In its simplest form a species map will therefore comprise a number of groups or clusters of visit-letters signifying song or other activity in which the same visit letter is not repeated in an identical way in the same cluster. (This is to say, if the same visit letter is repeated in the same cluster, it must represent different activities e.g. B and B food.)

In practice, however, this ideal condition is rarely satisfied. Among the reasons for this are (a) intrusion of the territory by an unmated, wandering male may occur (b) a migrant male may sing whilst still on passage, or (c) the observer may unwittingly make a 'double registration' (see paragraph 4). In these cases the analysis may have to be modified according to one or other of the rules set out below.

Clusters

1. Where non-overlapping registrations group themselves into well defined clusters, they are accepted as belonging to discrete territories, provided they fulfil the criteria stated below. Examples are given in the figures. For exceptions see paragraph 4.

2. Where two males are noted as singing at the same time (symbols joined by a dotted line) they should be assigned to different territories, provided they are supported by other registrations. A lack of supporting registrations would indicate the type of intrusion noted at 4(a) and (b) and in such cases the unsupportedregistration would be discarded. An example is given in figure 4. For exceptions, see paragraph 4.

Diffuse Registrations

3. Particularly with common species (and possibly also in others), where the registrations do not readily fall into groups, but are more evenly spread over the species map, a start may be made by looking for a nucleus of successive observations (e.g. B,C.D) and building outwards from this apparent focus of territorial activity. A natural aggregation of this kind should not be split to make parts of two territories. An example, showing the 'right' and 'wrong' treatment, is given in figure 1. Where a nucleus of successive registrations does not exist, it may still be possible to work outwards from an interrupted series which nevertheless looks realistic (e.g. A,D,E). In the absence of any such guide it is often useful to start from some point where the habitat is typical of the species in question. Unless it fulfils this criterion, one should not start from some quite arbitrary point, such as a corner of the map. Where habitat is of little practical assistance (as with a farm hedgerow species), the intersection of two or more hedges may afford a useful starting point.

Double Registrations

4. Within apparently good clusters, double or repeat registrations are not infrequently found. Such registrations might belong to the same individual, or to different birds (see 2 above). They may be joined together on the visit map (and copied to the species map) by an unbroken line, indicating actual movement by the same individual; or by an unbroken line with a query, indicating that although movement of the same individual was suspected, this could not be proved. In the first instance there is no difficulty in interpretation, the joined symbols clearly belonging to the same territorial grouping; in the second case, a decision as to whether two separate territories are involved will depend upon each

of the symbols having the support of an adequate number of other registrations. For an example see figure 3.

There is also a danger that the same individual may give two or more identical registrations in different positions, on the same visit; the extent to which this happens varies with different species. With small secretive birds such as the Wren, and woodland canopy songsters such as Blackcap and Chiffchaff, unobserved changes of position are not unusual. Experience shows that it is much less usual in birds with relatively small territories such as Robin, Chaffinch and Willow Warbler.

In obvious natural groupings one double registration may be allowed for any territory, particularly if the species is a summer visitor, when confusion is possible because of a passage migrant or wandering unmated male. For some species (e.g. Wren, Blackcap, Garden Warbler, Lesser Whitethroat, Chiffchaff) it is often advisable to consider the possibility of two double registrations; but the analyser must seriously consider the possibility of a second territory if there are more than two. The analyser will have to bear in mind the following considerations:-

(i) the frequency of visits to the census plot (see para 5).

(ii) the fact that separation on the basis of there being two registrations might create two unnaturally small and unusually crowded territories quite unrealistic for the species in that kind of habitat. An example is given in figure 4.

Minimum requirements

5. The minimum requirements for a CBC territory cluster are two registrations when 6 - 8 visits have been made to the plot, and three registrations in the event of 9 or more visits. Each registration (or the first and last of three) should be separated by a period of 10 days. Thus, two Robin (or any other) records in less than 10 days in mid-April would not qualify as an established territory, whereas one made in mid-April and one made in mid-May would be acceptable (assuming 6 - 8 visits).

Song registrations have the highest valency, but field-work has shown that there are species which sing rarely or intermittently, and it is permissible to use other criteria provided these have territorial implications.

In deciding what minima to apply, the analyser must take into account the total number of visits to the plot, or to different parts of it if the cover has been uneven. He must also determine the number of effective visits in the case of individual species; thus, visits on which a given species could not have been present anyway (e.g. migrants such as Whitethroat or Spotted Flycatcher at end of March or early April) must be disregarded. The rule followed in the case of summer visitors is to count the number of visits from the first on which that particular species was actually present on the census plot. As so few census visits are made late in the evening two records for a crepuscular species (e.g. Woodcock, Nightjar, owls) occurring 10 days apart are sufficient evidence of a territory, even if 9 or more visits are made.

Non-overlapping registrations

9. In common species (e.g. Blackbird, Dunnock) it often happens that where the number of visits is small (6-7) two apparently 'natural' groupings are situated sufficiently close together, without any overlapping registrations, to leave some doubt in the analyser's mind as to whether to accept one 'large' territory, or two 'normal' ones. His decision must have regard to the type of habitat, the spatial distribution of registrations in relation to normal territory size (paragraph 6), and the distribution of the records in time (paragraphs 5, 10).

Shifts of Territory

10. With territorial birds it is not possible to be sure of shifts of territory due to early nest failure and subsequent re-nesting in a different position. Cases of this kind must occur, but the only provision that can be made to avoid inflating the final count is to allocate neighbouring territories to the one pair if the occupation is at different, non-overlapping periods as shown by the visit-letters. An example is given in figure 2, where (A) would be regarded as a shift of territory, and (B) would be counted as two because of the overlap on visit F.

Family Parties

11. A record of "fam" (= family party) is not acceptable as the basis for a territory unless it has the support of at least one (6-8 visits) or two (9 or more visits) other registrations, since family parties may move a considerable distance and my originate outside the census plot.

Nests

12. A nest containing eggs or young is acceptable as the basis for a territory even if it is not backed up by other registrations. An empty nest, even if apparently used in that season, has no such standing, as the pair may have moved to a new site (see paragraph 10). Nests are not necessarily near the middle of the 'paper territory' indicated by the male's song-posts, but they may nevertheless serve as useful pointers to the delineation of clusters where the registrations are diffuse.

B. NON-TERRITORIAL SPECIES

With semi-colonial species (e.g. Linnet and some other finches, occasionally Lapwing) rings can be drawn round obvious groups of registrations and the number of pairs within each ring is taken as being the largest number of pairs substantiated on any two separate visits. If one visit should contribute a greater number than on all others it is best ignored, since it might represent a concentration for feeding purposes (see paragraph 8). A larger number noted on a late season visit might, however, represent a family party, in this context representative of one pair (but see paragraph 11).

Difficulties sometimes arise in these species if the registrations are diffuse and no clear groupings emerge; in such cases the likelihood is that the plot is a feeding rather than breeding area - as often happens with Swifts, Swallows and other hirundines. In these and some other colonial species (e.g. Jackdaw, Starling) the most satisfactory figure is gained by an actual nest-count, or, failing this, a count of the number of pairs regularly seen at a colony.

Kenneth Williamson
Roger Bailey
Leo. A. Batten

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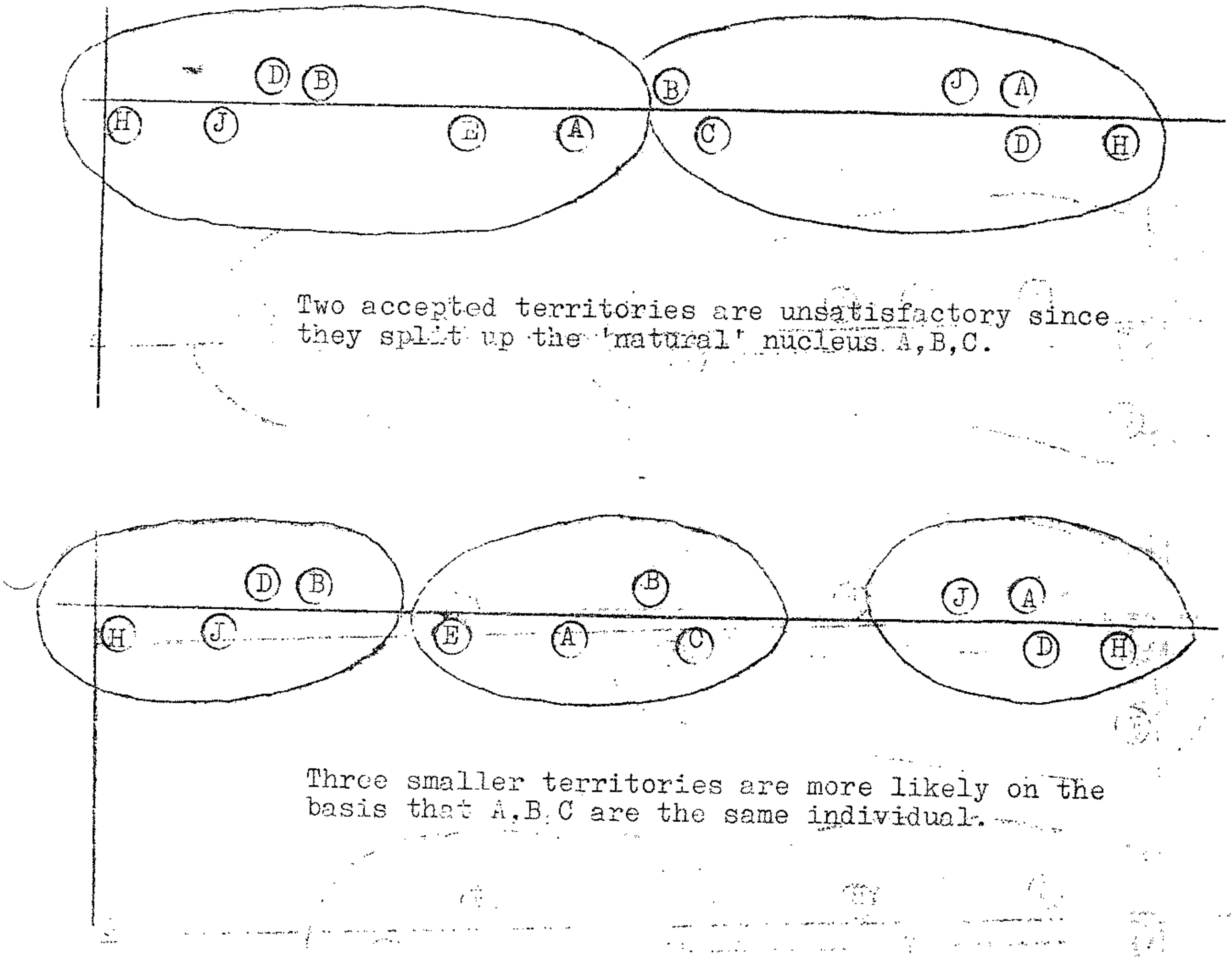
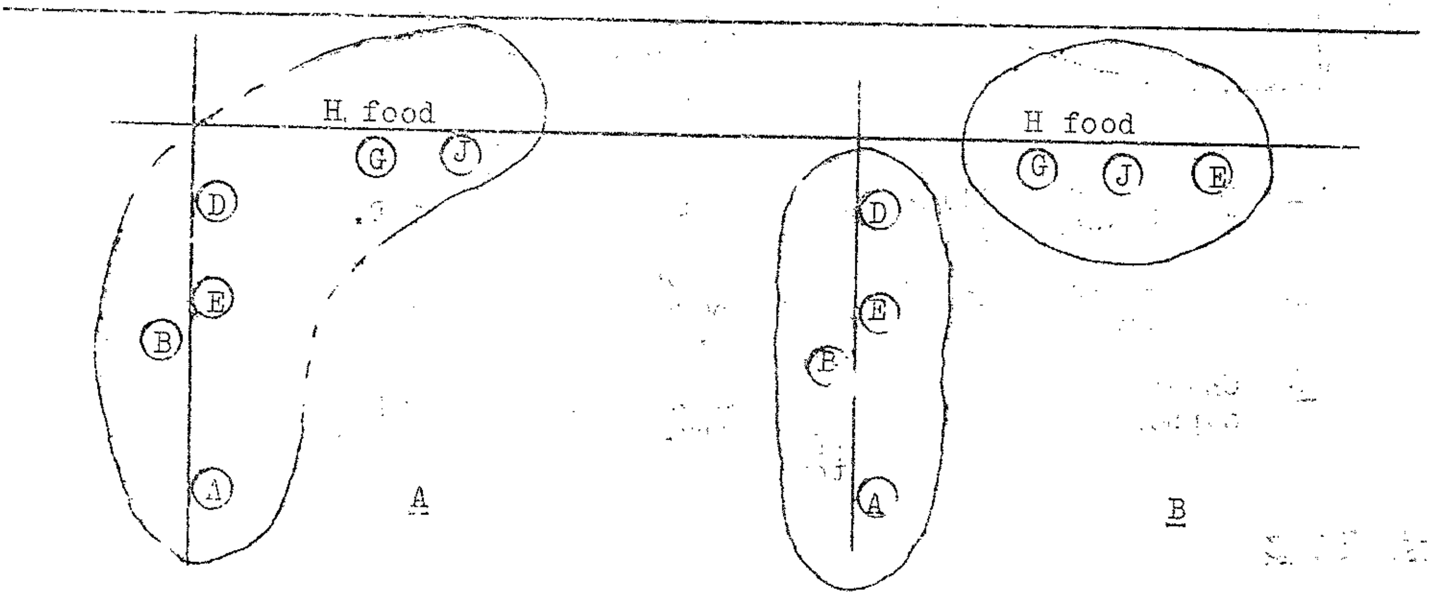
SPECIES MAP - DUNNOCK *Prunella modularis* (9 visits)



Two accepted territories are unsatisfactory since they split up the 'natural' nucleus A,B,C.

Three smaller territories are more likely on the basis that A,B,C are the same individual.

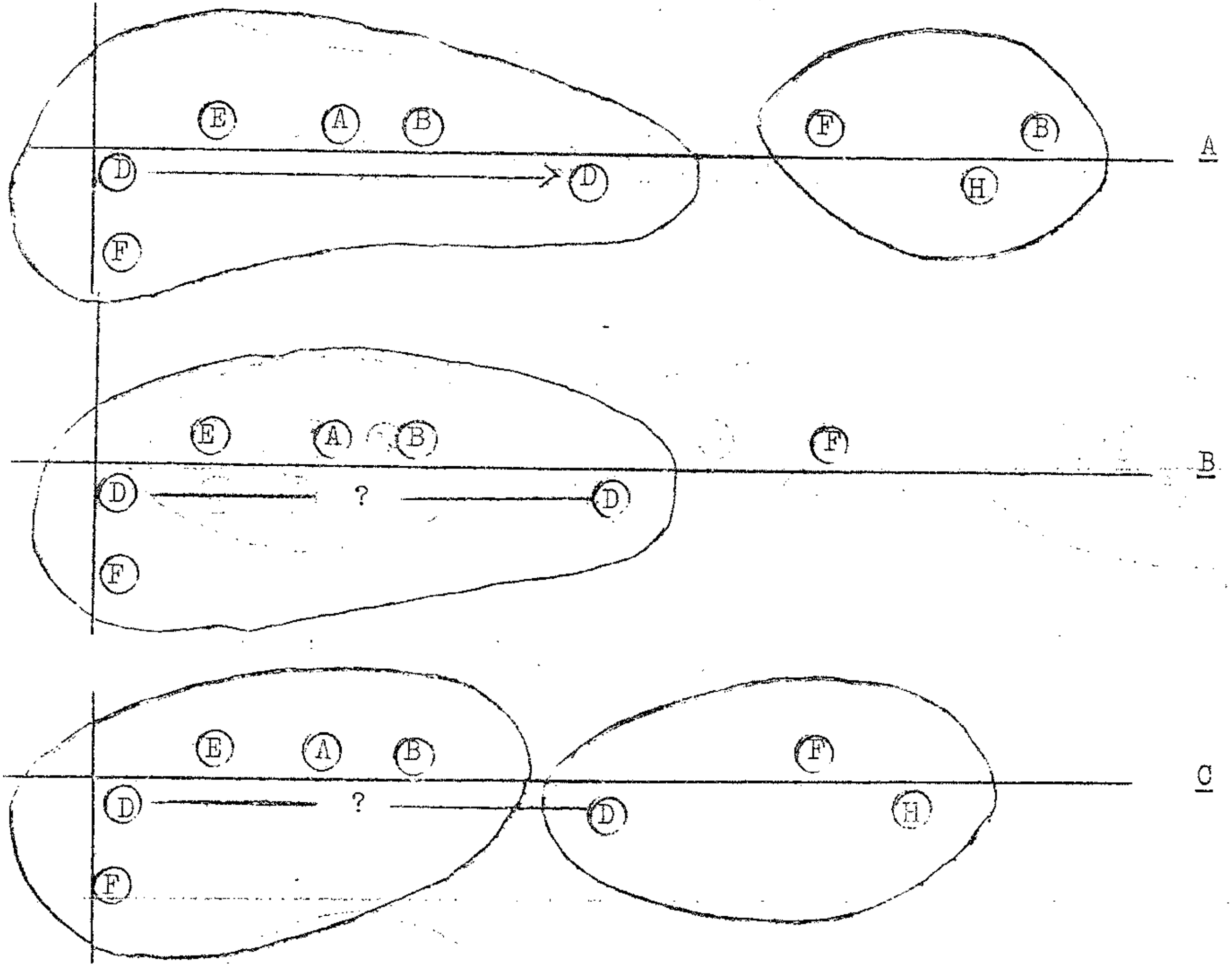
FIGURE 1



A. Shift of territory to new site (? after nest failure).
B. Two distinct territories involved, with overlap on visit E.

FIGURE 2

SPECIES MAP - DUNNOCK *Prunella modularis* (9 visits)



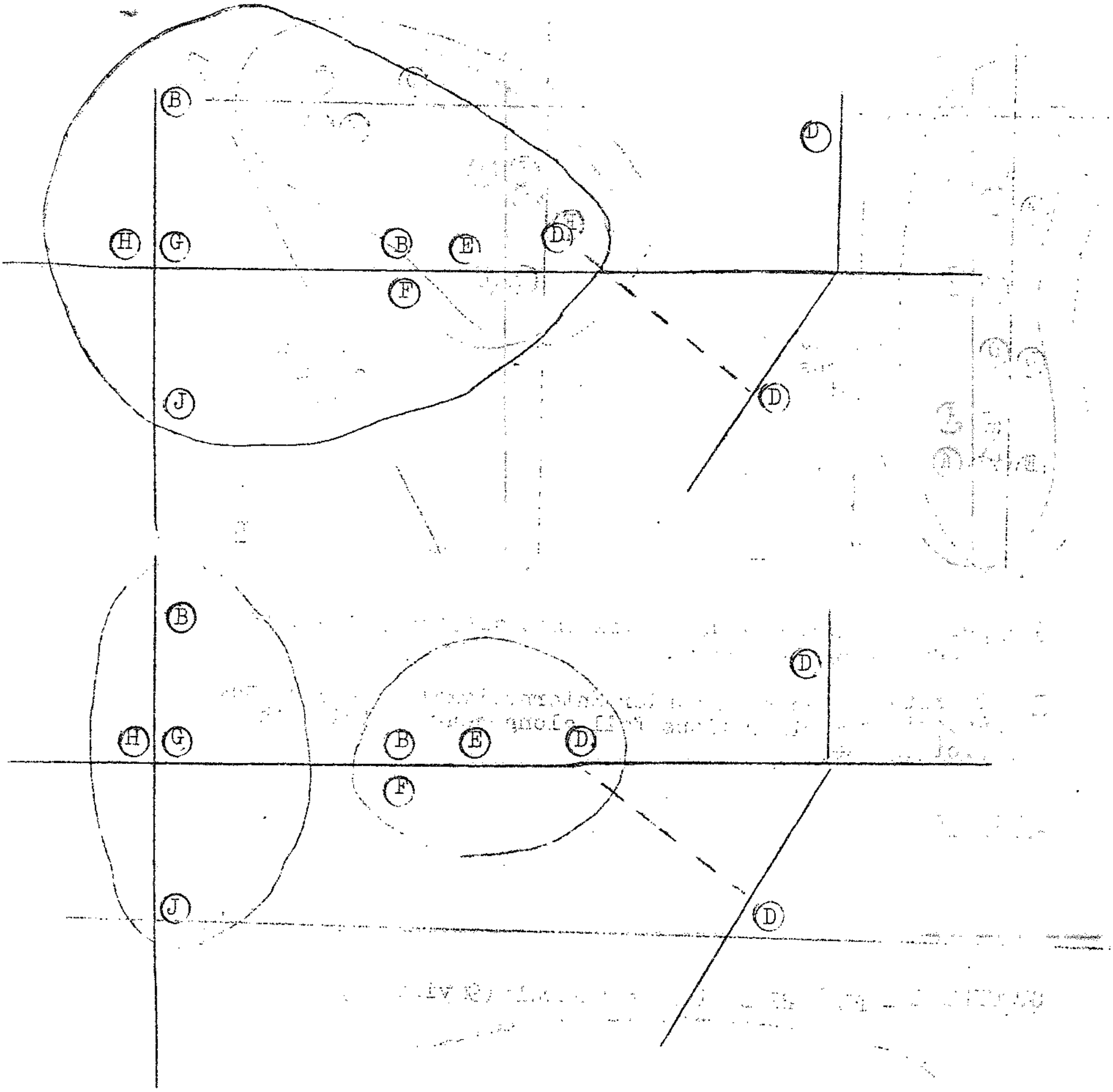
A Change of position clearly recorded on visit D. Two territories.

B Change of position suspected on visit D. No support for second territory.

C Change of position suspected on visit D. Full support for a second territory.

FIGURE 3

SPECIES MAP - CHIFFCHAFF Phylloscopus collybita (9 visits)



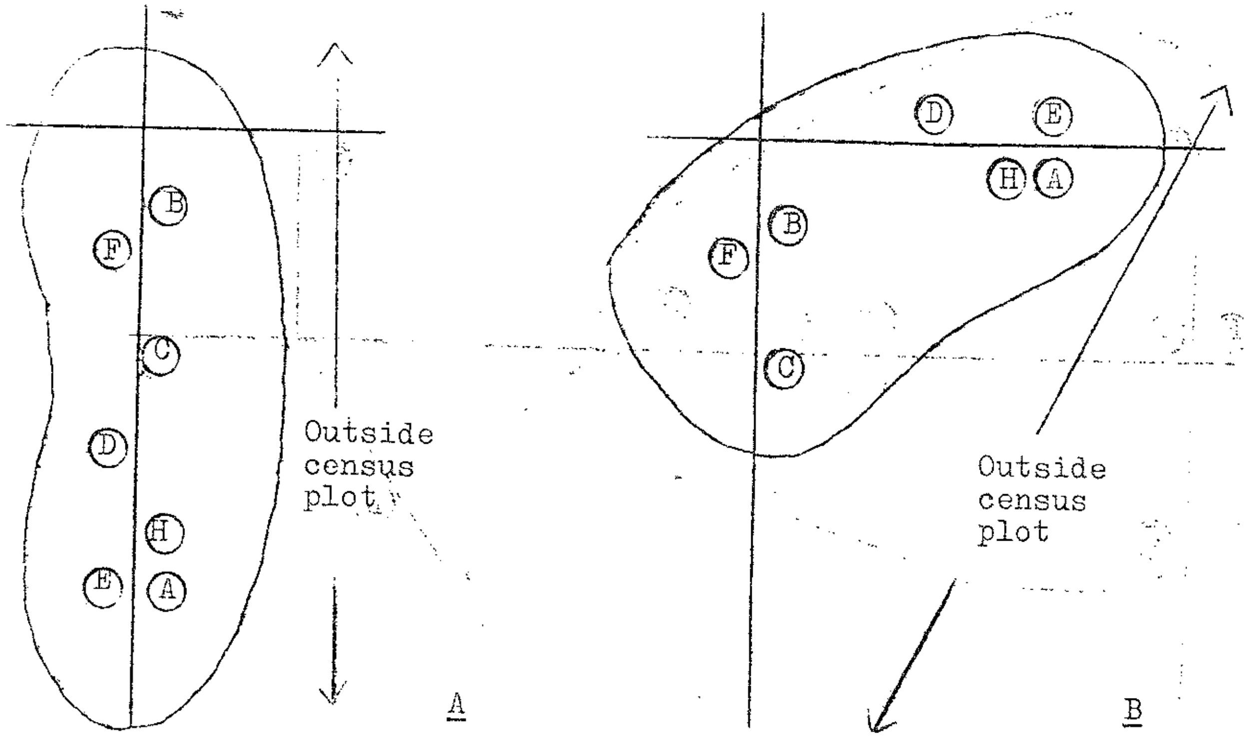
A Double registration on visit B - almost certainly same bird.

B Unsatisfactory interpretation as it opts for two unnaturally small territories, unusually close together, for this species.

NOTE: Passing migrant singing on visit D

FIGURE 4

SPECIES MAP - ROBIN Erithacus rubecula (9 visits)

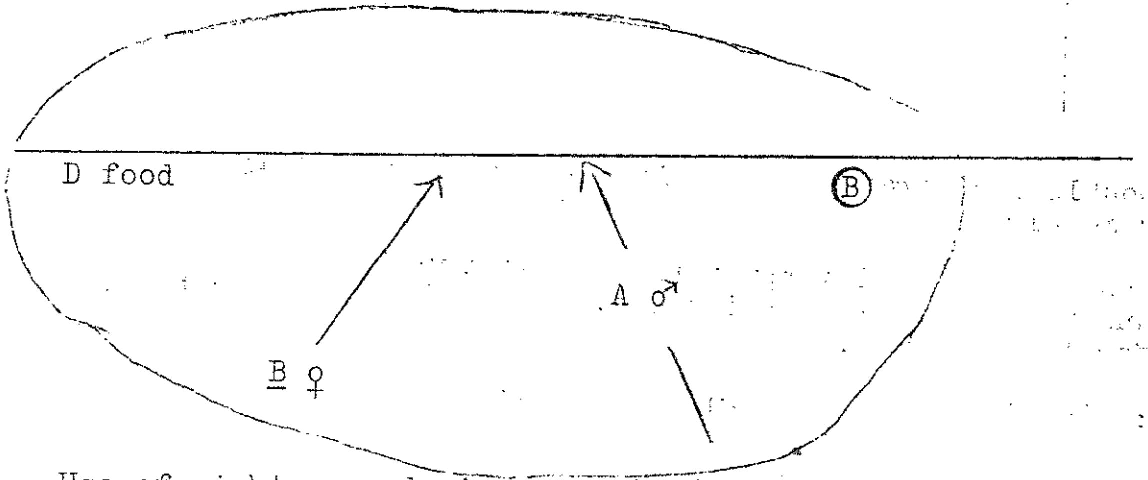


A Territory counted on the basis that all song posts are along the boundary hedge.

B Territory not counted (under International Rules) as the majority of registrations fall along hedge outside the plot boundary.

FIGURE 5

SPECIES MAP - BLACKBIRD Turdus merula (9 visits)



Use of sight-records in support of territory

FIGURE 6

BRITISH TRUST FOR ORNITHOLOGY
Beech Grove, Tring, Herts

COMMON BIRDS CENSUS INSTRUCTIONS

INTRODUCTION

The primary aim of the Common Birds Census is to investigate the status and number of common birds by means of breeding season censuses on a nation-wide scatter of sample plots. The comparison between successive years' results enables us to maintain an 'annual index' of fluctuations in population levels and to discover if there are any definite trends in numbers of different species.

The Census was started in 1961 at the request of the Nature Conservancy Council, with the original appeal being made for censuses in the agricultural environment, since it is on farmland plots that the growing use of toxic chemicals as weed-killers and pesticides, together with the destruction of hedgerows and other features of habitat, have created widespread hazard to bird populations. However, for nation-wide representative census work cannot be limited to farmland, so woodland, moorland, wetlands and parkland are included in our list of habitats.

It is important that, once established, a census plot is CONTINUED over a number of years.

This work is invaluable to conservation and we are constantly in need of new areas. The work is exacting but it is informative and pleasurable. We appeal urgently to anyone who can help with this enquiry to do so, and thus enable us to learn more about the numbers of our common birds and the factors influencing them.

Results of our work regularly appear in the BTO's Journal Bird Study which is free to members of the Trust.

THE CENSUS METHOD

A mapping technique introduced in 1964 has simplified both the field-work and subsequent analysis, but considerable time could be saved for research at headquarters if more observers would help in the routine preparation for analysis by:-

a) adopting the species symbols and other conventions supplied with these instructions, using them meticulously in preparing maps
b) preparing accurately plotted species maps from the data on their visit sheets.

UNIFORMITY IN METHOD OF PLOTTING IS MOST IMPORTANT, AND WE WOULD PARTICULARLY ASK OBSERVERS TO FOLLOW THESE INSTRUCTIONS CLOSELY AND TO CONSULT THE TRUST'S STAFF IF IN ANY DOUBT. It is astonishing how confusing and time-wasting even small departures from the normal can be.

All species should be included in the census except gulls, heron, rook and late individuals of winter-visiting species, unless nesting or holding territory. Territories for House Sparrow, Woodpigeon, Swift, the hirundines and Starling will normally be assessed on the basis of nests found.

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Records of nests found and revisited at least once will be welcomed by the Trust's Nest Records Scheme, and observers are asked to enter the details on Nest Record Cards issued by the Trust.

It is emphasised that CONTINUITY OF RECORD is an important aim of the census work and this should be borne in mind when selecting one's area.

PLEASE REMEMBER THAT THE PERMISSION OF THE LAND-OWNER OR FARMER SHOULD BE OBTAINED BEFORE BEGINNING THE CENSUS.

SELECTION OF CENSUS PLOT

a) Farmland: The plot chosen should be typical of the local countryside and should preferably be part of a larger area of similar type. While large stands of timber, lakes and tracts of marsh should be excluded, it must be borne in mind that copses, gardens, small orchards and scrub-grown fields are characteristic of much agricultural countryside and should be treated as an integral part of the environment. However, it is important that farmland census plots should not contain more than 10% of woodland and scrub (other than field hedgerows).

It is essential to choose well-defined boundaries, such as main roads, streams, canals, railway lines etc. On no account should an 'imaginary' boundary line be drawn through the middle of a field, as this creates considerable difficulties in the analysis.

b) Woodland: Any type of woodland (including orchard) is of interest, whether with or without clearings and secondary growth, but where possible woods of a specific type should be chosen, e.g. oak, beech, hornbeam etc. Here it is not usually possible to select such well-defined boundaries, though small streams, rides and path-ways may serve. If the area chosen is part of a larger tract of similar kind, birds recorded in the boundary zone should be marked on the maps whether inside or just outside the boundary. A more detailed note on how a woodland census may be tackled is given in Appendix A.

c) Other habitats: Censuses carried out in other habitats such as moorland, commons, suburban gardens or parks, sewage farms, developing gravel and sand pits etc. are of interest, particularly to relate bird populations with habitat change.

d) Nature Reserves: A number of nature reserves administered by such bodies as the Nature Conservancy, The Royal Society for the Protection of Birds, and the Society for the Promotion of Nature Reserves, and County Naturalists' Trusts are being censused, and we would welcome additional areas of this kind, since information arising from census work will be of great value in planning reserve management. Equally the inclusion in census plots of S.S.S.I.'s (Sites of Special Scientific Interest) or other areas of conservation interest is of value.

SIZE OF PLOT AND NUMBER OF VISITS

Generally speaking, accuracy in census work is a function of the size of the plot, the spacing of visits, and the time spent per unit area. The following guide is based on the assumption that the observer will be working alone; if the census work can be shared by a team, then careful planning of visits can increase efficiency, and cover of a sample plot larger than the one indicated may be possible.

It is better to tackle a smaller plot throughly than attempt a larger one and risk inadequate cover. Accuracy is likely to be greater for larger areas, provided a balance can be struck between size of area and the time available for each visit, since the margin

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of error due to 'edge effect' is lessoned. It is most important not to 'rush' the observations, and one's progress should be fairly slow and thorough so as to give the maximum opportunity for registering the birds.

a) Farmland: Experience has shown that 200 acres is the amount of fairly open farmland that most observers can cover adequately with a season's total of 10 full visits. If the fields are small and bounded by thick hedgerows, or there are a number of small copses and similar scrub, about 150 acres should be manageable on the same basis. Farmland areas should not be less than 150 acres.

It is very desirable that there should be a mimimum of 10 visits with not less than 3 each in April, and May but if no more than 7 or 8 complete visits can be achieved observers are asked to make short supplementary visits to boost the number of registrations. An indication of the extent of cover and of time spent in the field should be made for each partial or complete visit; this can be done effectively by using biros of different colours if one map in used for two or three partial visits.

b) Commons and moors: such areas are frequently more uniform than farmland and do not have such a high bird density, so that censuses of wider extent are possible. Lack of topographical features, however, may make accurate mapping more difficult and some system of marking posts may be necessary, as described in Appendix A.

c) Woodland: The bird density in woodland is high compared with farmland and more time in relation to unit area is necessary to ensure efficient fieldwork. Employing 15 visits, about 50 acres is a suitable plot size in fairly open woodland/scrub, but only 25 acres should be attempted if there is a lot of secondary growth and no clearings, or in more open woodland if only 10-12 visits are possible.

d). Orchards and parks: These should be treated in the same way as open woodland.

e) Suburban gardens: Bird density is highest in suburban areas with mature gardens, but accurate mapping is usually easier since each bird has an 'address', and large-scale maps are often available at the local surveyor's office. On the basis of, say 15 visits, 30-40 acres should be possible.

SPREAD OF COUNTS

This is essentially a breeding bird census and counts should be made at regular intervals between the first fine spell after mid-March (south and midlands) or the beginning of April (north of England and Scotland) and the end of June. Special attention should be paid to each species during the peak of its song period; this may be different from one area to another, depending on geographical location.

It is important that the visits should be made in favourable weather, when bird song is not depressed by wind or heavy rain. Singing and territorial behaviour are generally most conspicuous in the early morning, and some species also sing well in the evening. A slow rate of progress with frequent pauses during the course of the survey especially when working in woodland - greatly increases the census efficiency.

FIELD RECORDING

An immediate aim of our work is that the final analysis should give as accurate a picture as possible of the number and distribution of territories within the census area. This is best done by means of

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Field Recording continued...

the mapping technique described below. We are confident that this enhances the accuracy of the counting and at the same time eases the work for recorder, analyser and research student alike; and there is no doubt that it enables the observer to derive greater pleasure and knowledge from his efforts.

The technique is substantially the same as that initiated in Sweden by Anders Enemar (*Var Fagelvarld*, 1959) and now adopted as standard practice by the International Bird Census Committee for all habitats (see *Bird Study* 1969, pp 248-255). The basic unit of the census is the territorial singing male, but any evidence of territory holding, such as nest-finds, newly fledged young, alarm call, adults carrying nest material or food for young, distraction display (injury feigning) should be noted, as indicated below.

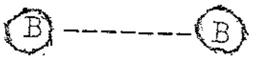
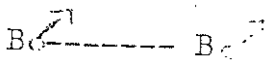
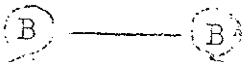
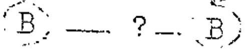
A separate blank map should be used for each visit to the census plot, unless the plot is sub-divided, when one map may suffice for two or three visits if a different coloured biro is used each time (but please use easily distinguishable colours). Successive complete visits or combinations of partial visits should be marked 'A', 'B', 'C' *et seq*. the date of the visit must be recorded and a brief note of the weather, and the starting and finishing times of each visit be recorded on the map. It is essential to distinguish between partial visits by adding a suffix to the letter, e.g. 'B1','B2', 'B3', *et seq*. In addition the extent of cover for all visits should be outlined in the same colour used for registrations.

The blank maps can be foled over a piece of hardboard and secured by strong elastic bands or bulldog clips. Always carry a pencil - biros will not work in the rain! Brief supplementary visits to check outstanding problems may not require a separate blank map, but the extent of cover should clearly be outlined, and visits denoted by a suffix as described above.

The bird should be registered by the accepted symbols (see the appended list of birds). Please use the following conventions for different kinds of registrations (the examples given are for Blackbird).

Ⓑ	Singing male
B̲	Alarm call
B material	Seen with nest material in beak
B food	Seen with food in beak
BB	Two males fighting (movement of either on breaking up can be shown by an arrow)
B*	Nest
B♂ or B♀ B or B juv	Sight-record, with indication of sex or age if appropriate.

It will be found most helpful at the analysis stage if the visit maps carry an indication of which registrations, in close proximity to one another, are definitely of different birds, or belong either definitely (or even doubtfully) to the same bird. The following conventions must be used:

	Different birds heard in song at the same time
	Different bird in view at same time
	Singing bird seen to take up new position
	Thought to be the same bird in a changed position but not certain

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Field recording continued....

OBSERVATIONS OF CONTEMPORANEOUS ACTIVITIES, ESPECIALLY THOSE INDICATIVE OF TERRITORIAL COMPETITION (the dotted line) ARE MOST USEFUL.

It is also helpful if nests in close proximity known to be in use at the same time (hence to belong to different pairs) are joined by a dashed line on the map.

B*-----B*

In the case of colonial or semi-colonial birds such as Starling, martins, Swallow, Swift, Reed Warbler, Linnet (see figure), Greenfinch, Goldfinch and Tree Sparrow, use the accepted symbol and number seen at each visit, enclosed in brackets, e.g. LI(8). When the species sheets are plotted each 'colony' is encircled and an estimate made of the number of pairs present, e.g. x 4. Individual pairs for most of these species may not be colonial and can be treated in the same manner as other species which exhibit well-defined territories.

In the case of Skylark and the pipits it is often useful to mark the points of ascent (arrow point upwards from circling bird) or descent (arrow point downwards) if observed; also any considerable movement during song-flight is worth plotting (as shown for Blackbird above).

Starlings are best censused by counting occupied nests at a time when the nestlings are noisy. Search of the farm buildings is the only satisfactory way of arriving at figures for Swallow and House Martin.

Remember that actual proof of nesting is not necessary to qualify for inclusion in the census; a pair may be nesting outside the boundary yet hold part of their territory within the census area; or the whole census area may represent but a part of the total territory (e.g. Kestrel, Cuckoo, Kingfisher).

COMPILING SPECIES SHEETS

When no further visits are intended, the full complement of visit maps should be arranged in chronological order and the data transferred to 'species maps' for which the balance of the outline blanks can be used. Many observers have found it advantageous to make up their species maps as they go along, incorporating registrations after a visit has been completed.

On each species map the position of individuals Skylarks, Blackbirds, Willow Warblers etc. will be identified by the appropriate visit letter 'A', 'B', 'C' etc or where partial visits have been carried out 'A1', 'A2', 'A3' etc. Conventions indicating 'song' 'alarm call' and so on, should agree with the records on the visit sheets. PLEASE BE SURE TO COPY EACH CONVENTION EXACTLY, both the kind and its position; attention to this point will obviate a great deal of checking and even re-plotting. If time does not permit an attempt to delimit the territories it is still important that the observer draws up his own species sheets, even if this means delaying the submission of the returns until the end of the year or even later in the winter.

•In the case of farmland, it should be possible to get more than one species on one map, thus economising on materials. When this is done, a differently coloured biro must be used for each different species. Please use easily distinguishable colours. A field species such as Skylark, Partridge or Moorhen will often 'double' conveniently with one of the hedgerow species. It is desirable, however, to have separate sheets for the really common birds, which in most cases will be Blackbird, Dunnock and perhaps Skylark, Robin, Chaffinch and Wren. Please ask for more maps rather than overcrowd the ones you have left at the end of the season.

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Species sheets continued...

Individual nests should be registered once only on the species map and should be given a serial number to correspond either with a special number written at the right-hand side of the 'species' panel on the nest record card, or (if nest record cards are not kept) with the same number on a separate list giving details of nest histories. This information is required because of the need to distinguish where possible, first and second, or even third nesting attempts of the same pair. Care should be taken to determine whether a nest is of the current year or from a previous year, in which case it should be ignored.

Experience during previous years has shown that it is easy to overlook some registrations on visit sheets when transferring them to species sheets and it is therefore EXTREMELY IMPORTANT TO CANCEL EACH SYMBOL on the visit maps immediately one has transferred it to the species sheet. Failure to cancel the symbols doubles the work to be carried out on the census by the BTO Staff. Cancellation can be done by ticking or lightly stroking through the symbol so that it remains legible in case a final check is necessary. When all species maps have been drawn up, a final check on the visit sheets should be made to make absolutely sure that no symbols have been missed.

ANALYSIS

It is most helpful if the preliminary analysis is done by the observer, so that it need only be checked by the Populations Section, who have now developed a standard method of delimiting territories which is based on considerable field experience as well as the study of many different returns. A separate set of instructions can be sent to persons wishing to attempt their own analysis. The growth of the scheme has been such that we would welcome assistance of this kind; but if the observer cannot undertake this side of the analysis it will be done at headquarters. In such a case, the earlier in the autumn that the species and visit maps can be sent to headquarters the better.

When complete each species map may show discrete groupings of letters indicating the positions held by the territorial males on the different visits. Generally speaking, a cluster of symbols in which there is no duplication will indicate a particular male's territory - or, to be more exact, that part of a territory which is most closely defended. In practice, some 'double' registrations may occur, either because a bird has changed position unseen during the period of observation, or because of some temporarily visiting male (which has perhaps not established a territory of its own), or because of a migrant singing whilst on passage. Generally, however, there are unlikely to be more than two duplications of this type in any one territory.

In drawing the outlines of presumed territories, PLEASE USE A SOFT PENCIL, not a biro or pen, as staff may wish to make some adjustment to conform with the established method of analysis.

HOW TO OBTAIN MAPS

The 25" O.S. map appropriate to the census plot will be used as a basis. So that we can order the correct maps, a tracing of the selected plot from a 6", 2½" or 1" map (O.S.) giving map number, grid references, towns, main roads (with road numbers), names of farms, local landmarks etc. should be sent to the Populations Section. If known, it is also helpful to have the 25" map sheet number(s). The maps will be ordered and paid for by the BTO and will be sent to the observer if necessary.

How to obtain maps continued...

Alternatively, many large libraries (e.g. County Libraries) and County Planning Offices, hold 25" maps for their district or county and it is of great assistance if an observer who has access to these can let us have a tracing or photocopy of his proposed plot. The area can also be up-dated at this point. This type of assistance is always greatly appreciated and apart from helping us economise, it allows us to arrange for you to receive blank maps more promptly than is sometimes possible (this is particularly important when an observer does not decide to do a census until late in the winter, mid February or March.)

Finalising the plot and its boundary lines will be left to the judgement of the observer, and he or she should return the map(s) to the Populations Section as soon as this is done. Where possible however, it is helpful if the boundaries are finalised on the small scale tracing sent in when applying for large scale maps. It may be necessary to up-date the 25" maps (e.g. because of loss of hedgerows and filling in of pools, new buildings etc), and if this is necessary before the first seasons work, it is helpful if the observer can inform us that alterations will need to be made before blanks are duplicated.

A number of outline maps of the census plot will then be sent to the observer for use in the survey as described above.

FORWARDING AND FILING OF RETURNS

All the visit maps and species sheets should be sent to the Populations Section, so that a careful check can be made and the results transferred to our permanent records.

The final species sheets will be traced and kept in a carefully indexed vertical plan filing system, so that any given tracing can be laid over the appropriate habitat map and the main characteristics of the bird's territories in relation to vegetation and land-use can be seen at a glance. It cannot be too strongly emphasised that the intrinsic value of this permanent record of the census worker's time and effort depends to a great extent on the detailed accuracy of the key habitat maps.

The original materials, or any part of them, will be returned to the observer later if so desired, in which case a request should be made when forwarding the results.

The address to which returns and correspondence should be sent is:- Populations Section, British Trust for Ornithology, Beech Grove, Tring, Herts. (Tel: Tring 3461/2).

COMPILING A HABITAT MAP

Since in future years much of the research will be concerned with habitat tolerance, a detailed description of each census plot is desirable. Most of the information can be supplied in an observer's first season so that in later years only changes (e.g. loss of hedgerow, cropping changes, improved drainage etc) need be recorded. It is essential that these changes should not be overlooked, and one of the outline maps should be used to record each season's details. The main key Habitat Map should be drawn up in accordance with the specifications given below. A standard method of recording these details is important if valid comparisons are to be made. Information can be recorded as the census work proceeds, and the Habitat Map completed in mid-June.

a) Geographical Features: Any comparison that might be made regarding climatic and topographical factors will be done on a national scale, but an indication of altitude and exposure should be given and contours are useful and can be copied from the 6" or 2½" O.S. maps.

.../

Habitat Map continued...

b) Soil: Soil features will also be viewed very broadly but any notes which you can give on its nature and drainage properties will be very useful.

c) Vegetation: The type of vegetation is of prime importance to the birds in providing nest-sites and determining availability of food. Information is required to show broadly the botanical character of each census area as a guide to how typical it is of the locality in which it is situated.

Characteristically plant communities exhibit a layered construction, with the upper tiers dominating the lower. In this country there are commonly four tiers:-

1) Primary - Tree layer (above 15ft)
2) Seondary - Shrub Layer (between 4-15 ft)
3) Field Layer - Herbaceous vegetation and low shrubs, generally less than 3ft and not more than 6ft
4) Ground Layer - Mosses, lichens etc.

d) Woodland/and Copses: Shade green and marked 'CLOSED' or 'OPEN' according to spacing of trees. (Closed means that tops of adjacent trees touch or almost touch when in full leaf.) Record the species of each teir one above the other. Qualify field-layer with 'DENSE' (almost continuous cover of thistles, willow-herb or other tall plants) 'MEDIUM' (short grass interspersed with patches of taller vegetation), or 'SPARSE' (short grass and low-flowering plants). Give dominant species where possible as shown below.

CLOSED OAK
HAZEL
DENSE

Treat orchards in the same way but give field-layer as for crops.

e) Scrub: Shade green where scrub occurs. Indicate height by using 'HIGH' (over 15ft), 'MEDIUM' (4-15ft), 'LOW' (up to 4ft). Write 'SCRUB' and name of species; if mixed give in order of abundance. Treat young plantations in the same way e.g. LOW SCRUB, HAWTHORN, BRAMBLES.

f) Boundary Vegetation: Give an indication of width by using fine or broad green lines accordingly. For remnant hedges use broken lines. Trees - large trees (more than 26ft) mark with encircled crosses (X); small trees (15-26ft) marked with open crosses X, write name of species above the boundary line.

g) Shrubs: Shade green, give names of species below boundary line. Give height and order of abundance as for scrub, e.g.

———(X)——————X——————XXX————X (X)———
MEDIUM HAWTHORN BRAMBLES

In cases where there is considerable mixing of boundary trees it may be necessary to give a more general description, e.g. MIXED OAK, ELM, ASH.

h) Field Vegetation: i) Natural - areas covered by a thick field-layer of such plants as willow-herb, nettled, heather, bracken, coarse-grasses, rushes or reeds. Stipple green and mark. (notes and lists of other species of flowering plants found in the area would be a useful addition).

ii) Crops - mark fields with crops present during the main part of the breeding season. Distinguish between leys and permanent pasture. Gives notes on farm livestock.

.../

Habitat Map continued.....

iii) No crop - state whether stubbled, bare fallow or newly turned soil.

i) Water: shade all water blue. If flowing indicate direction with blue arrows.

The above scheme outlines the minimum requirements. Observers with a particular interest in the ecology of their own area are invited to give as full a description as they like. Many have already submitted information which will be of great value in the future when we shall examine more closely the individual relationships of birds to their environment and one another.

Anyone who finds difficulty in describing the habitat is welcome to ask the advice of the Trust, or may find it useful to ask a friend, who has a special interest in the subject, to cover this aspect for him. Information on soil and land use is more easily obtained from the farmer.

Photographs of the area, particularly to illustrate the nature of hedges and other features of the habitat, are welcome. The positions from which are taken and the part of the plot they embrace can be indicated on one of the blank maps. It is important that the type of habitat immediately surrounding the census plot is indicated on the habitat map, particularly in the case of woodland.

Use of Farm Chemicals: census work on the present scale is providing information useful to those who are studying the adverse effects of some farm chemicals on our birds. It is therefore important that information on spraying and the use of seed-dressings, weed-killers etc should be obtained from the farmer if he is willing to give it. Very often labels of 'Directions for Use' are left lying in the fields or hedgerows and information on this aspect can be gained from these if copies are sent with the returns.

February 1977

APPENDIX A

Surveying Woodland Plots

Census work in woodland is much more difficult than on farmland because the bird density is higher and the habitat much more uniform. Moreover, visibility is often restricted by the canopy or the shrub layer so that the registration of individual males is often imprecise. In the case of scarcer species with wide-ranging territories this imprecision may not much matter, but with the commoner species it can be an important source of confusion and error. It is, of course, these commoner species which are the most important for the construction of an 'annual index'.

The inherent disadvantages of working in woodland can be largely overcome by establishing a 'grid'. The census worker is then always aware of his exact position in the area and can plot the singing males and other bird-activities with much greater accuracy. The grid enables one to follow and record exactly the movements of individual singing males and also record at what points males of the same species are 'singing against' each other, - classes of registration which are extremely valuable to the delineation of territories at the analysis stage.

The grid is simple. A base-line is established along afairly straight ride or pathway forming one boundary of the plot with points A,B,C,D, and so on at intervals of 50-metres. The trees at or close to these points are given zero marks - $\underset{0}{A}$, $\underset{0}{B}$, $\underset{0}{C}$, etc. Lines are then set up at right-angles to these points, and further marks are set up on trees at 50-metre intervals along each line, thus $\underset{50}{A}$, $\underset{100}{A}$, $\underset{150}{A}$, and so on.

If the grid is to serve for repeat censuses over a succession of years, the stems of the trees can be marked at the appropriate intervals with white paint, at or slightly above eye-level; if however, there are objections to permanent marking, white card with letters and figures about 9" high in waterproof crayon can be tied round the stems. It is useful to hang a few white or coloured streamers from the lower brances to render the marked trees more prominent. If adjacent marks, either parallel with the baseline or at right-angles to it, are obscured by intervening secondary growth, then streamers hung from the branches of intervening trees can be used to indicate the line.

A compass should be used to set up the lines at right-angles to the baseline. If a 50-metre tape is not available, the equivalent measurement in yards is 54.7. It is better to have the grid in units of 50-metres as the plot area is then easy to determine in hectares. This is the standard used in expressing bird-densities in all continental census work, and will be adopted also in Britain.

The permission of the land-owner must be sought, of course, before setting up a grid, and it is best to select census plots in areas of restricted public access, to avoid interference with the markers. It is recommended that anyone who would like to attempt a woodland census of the kind mentioned should contact the District Officer of the Forestry Commission, who will usually be able to offer helpful advice and co-operation.

.../

Coloured Fluerescent Plastic Tape can be obtained from:-

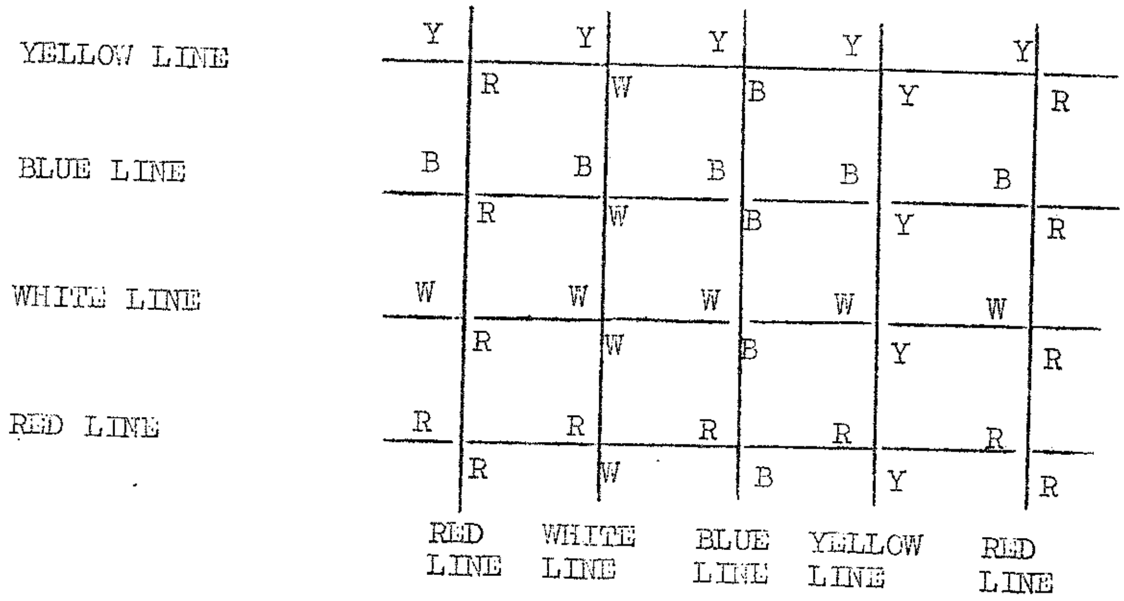
Auto Wrappers (Sales) Ltd., Tape and Bonding Clinic,
110/112 Hammersmith Road, London W6 7JS. Tel: 01-748 8863

Orange is the best colour, one inch wide will do, two inch is ideal.

OPEN COUNTRY SURVEYS

Large areas of relatively open moor, heath, salt-marsh etc. where the terrain is uniform and the majority of birds are Skylarks, pipits and other field species, require a grid. Since visibility is generally unobstructed by trees and/or secondary growth, markers can be set at 100-metre intervals.

A colour-code using combinations based on, say, red, white, blue and yellow can be used to identify the points where the grid-lines intersect, as shown below:-



The lines parallel with the baseline should be regarded as 'dominent' and their colour shown uppermost.

As a temporary expedient, heavy guage galvanised wire cut out to 4ft lengths and twisted into a ring at the top to fly coloured plastic tapes or linen streamers can be used. But only in areas from which grazing animals are excluded. Otherwise bamboo poles painted with the appropriate colours are preferable. Using this method the plot takes longer to prepare for census work, but the immense gain in precision more than justifies the extra labour.

It is no use attempted grid surveys of this kind in any area to which the general public has free access.

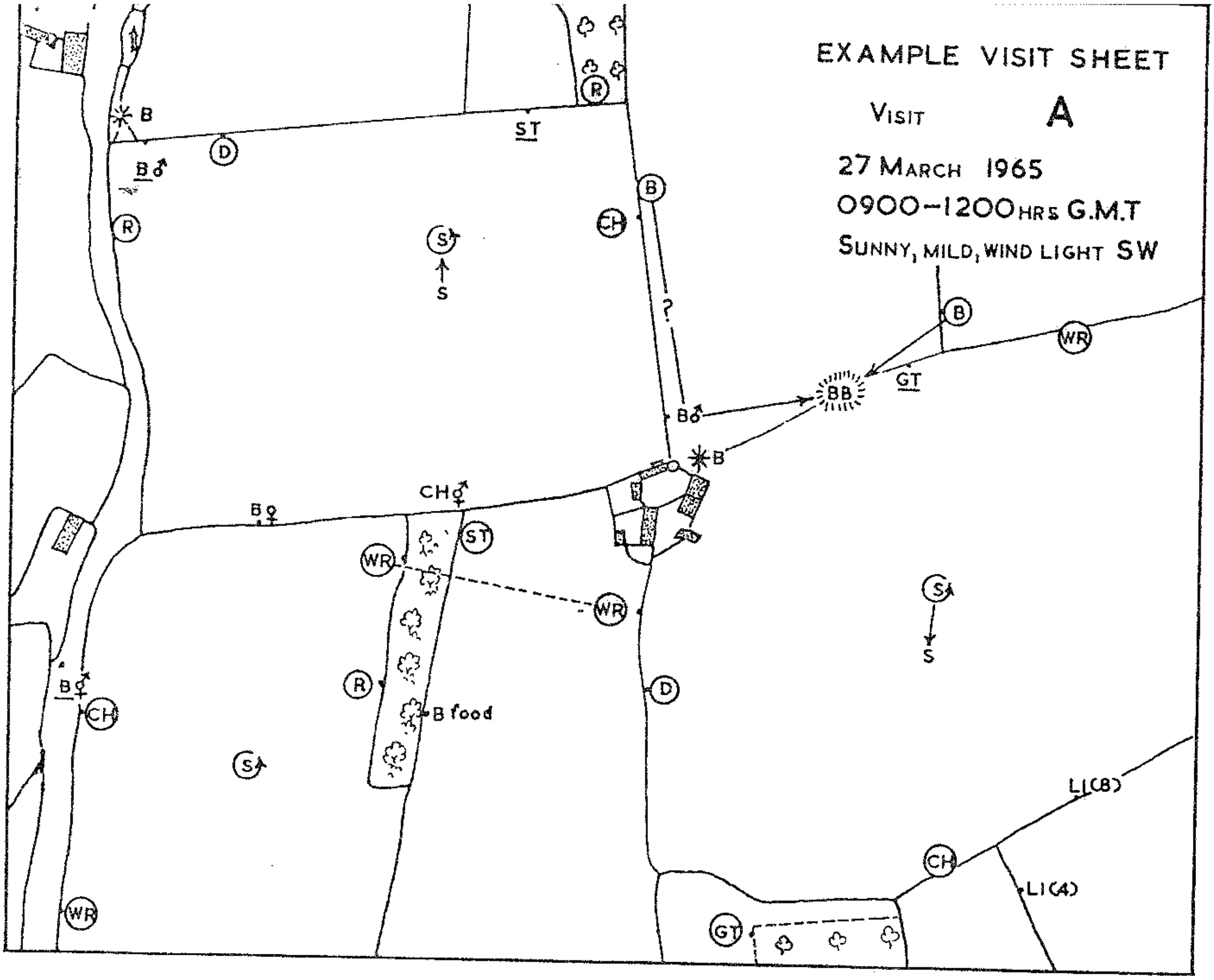
APPENDIX B

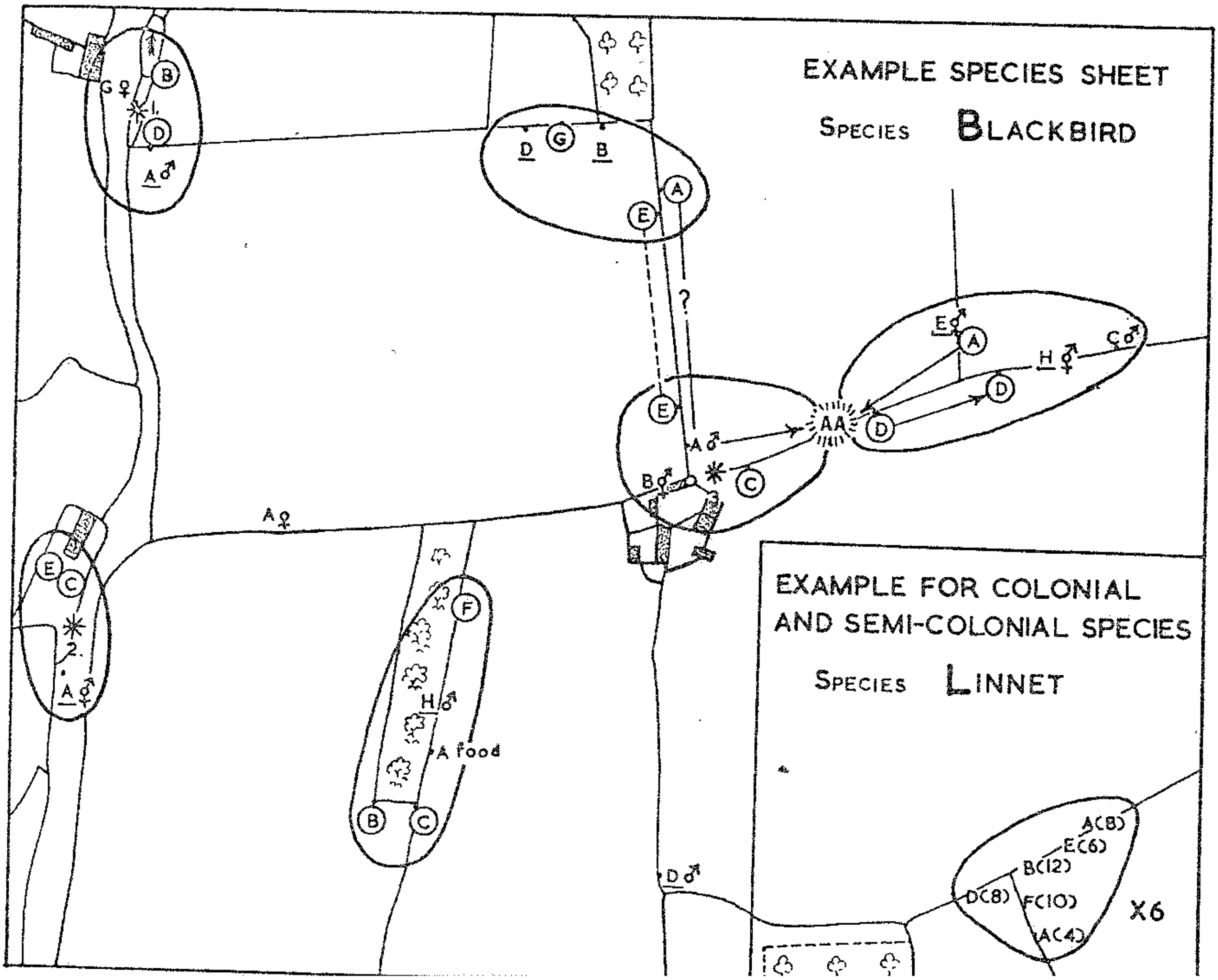
GG	Great Crested Grebe
LG	Little Grebe
H	Heron
MA	Mallard
T	Teal
GY	Gargancy
WN	Wigeon
PT	Pintail
SV	Shoveler
TU	Tufted Duck
PO	Pochard
E	Eider
RM	Red Breasted Merganser
GD	Goosander
SU	Shelduck
CG	Canada Goose
MS	Mute Swan
BZ	Buzzard
SH	Sparrowhawk
HH	Hen Harrier
ML	Merlin
K	Kestrel
RG	Red Grouse
RL	Red-legged Partridge
P	Partridge
Q	Quail
PH	Pheasant
WA	Water Rail
MH	Moorhen
CO	Coot
OC	Oystercatcher
L	Lapwing
RP	Ringed Plover
LP	Little Ringed Plover
GP	Golden Plover
SN	Snipe
JS	Jack Snipe
WK	Woodcock
CU	Curlew
CS	Common Sandpiper
RK	Redshank
GK	Greenshank
DN	Dunlin
RU	Ruff
GB	Great Black-backed Gull
LB	Lesser Black-backed Gull
HG	Herring Gull
CM	Common Gull
BH	Black-headed Gull
CN	Common Tern
FP	Feral Pigeon
SD	Stock Dove
WP	Woodpigeon
TD	Turtle Dove
CD	Collared Dove
CK	Cuckoo
BO	Barn Owl
LO	Little Owl
TO	Tawny Owl
LE	Long-eared Owl
SE	Short-eared Owl
NJ	Nightjar
SI	Swift
KF	Kingfisher
G	Green Woddpecker
GS	Great Spotted Woodpecker
LS	Lesser Spotted Woodpecker
WL	Woodlark
S	Skylark
SL	Swallow
HM	House Martin
SM	Sand Martin
RN	Raven
C	Carrion Crow
RO	Rook
JD	Jackdaw
MG	Magpie
J	Jay
GT	Great Tit
BT	Blue Tit
CT	Coal Tit
MT	Marsh Tit
WT	Willow Tit
LT	Long-tailed Tit
NH	Nuthatch
TC	Treecreeper
WR	Wren
DI	Dipper
M	Mistle Thrush
FF	Fieldfare
ST	Song Thrush
RE	Redwing
RZ	Ring Ousel
B	Blackbird
W	Wheatear
SC	Stonechat
WC	Whinchat
RT	Redstart
N	Nightingale
R	Robin
GH	Grasshopper Warbler
RW	Reed Warbler
MW	Marsh Warbler
SW	Sedge Warbler
BC	Blackcap
GW	Garden Warbler
WH	Whitethroat
LW	Lesser Whitethroat
WW	Willow Warbler
CC	Chiffchaff
WO	Wood Warbler
GC	Goldcrest
FC	Firecrest
SF	Spotted Flycatcher
PF	Pied Flycatcher
D	Hedge Sparrow/Dunnock
MP	Meadow Pipit
TP	Tree Pipit
RC	Rock Pipit
PW	Pied Wagtail
GL	Grey Wagtail
YW	Yellow Wagtail

(Cont'd)

WX	Waxwing
SG	Starling
HF	Hawfinch
GR	Greenfinch
GO	Goldfinch
SK	Siskin
LI	Linnet
TW	Twite
LR	Redpoll
BF	Bullfinch
CR	Crossbill
CH	Chaffinch
BL	Brambling
Y	Yellowhammer
CL	Cirl Bunting
CB	Corn Bunting
RB	Reed Bunting
HS	House Sparrow
TS	Tree Sparrow

For other species please write in full or use a different abbreviation from those listed above.


EXAMPLE VISIT SHEET
VISIT A
27 MARCH 1965
0900–1200 HRS G.M.T
SUNNY, MILD, WIND LIGHT SW
B
B♂
D
R
ST
S
?
B♂
BB
GT
WR
B
CH♂
B♀
WR
R
B food
D
L1(8)
L1(4)
GT


EXAMPLE SPECIES SHEET
SPECIES BLACKBIRD
G♀
A♂
D
G
B
A
E
?
E♂
C♂
H♂
AA
A♂
B♂
A♀
A♂
H♂
A food
D♂
EXAMPLE FOR COLONIAL AND SEMI-COLONIAL SPECIES
SPECIES LINNET
A(8)
E(6)
B(12)
D(8)
F(10)
A(4)
X6

APPENDIX 3

SPECIES MONITORED BY THE COMMON BIRDS CENSUS

Census plots are characterised as a) farmland, b) woodland and c) special according to their habitat type. Separate indices are calculated for farmland and woodland wherever species totals within this habitat alone are adequate as to sample size (+ in appropriate column). For other species and for residual plots of adequate sample all data are pooled to give a Scarce Species Index.

Species	Farmland Index	Woodland Index	Scarce Species Index
Mallard	+	–	–
Sparrowhawk	–	–	+
Kestrel	–	–	+
Red-legged Partridge	+	–	–
Grey Partridge	+	–	–
Pheasant	+	–	+
Moorhen	+	–	–
Lapwing	+	–	–
Stock Dove	–	–	+
Collared Dove	–	–	+
Turtle Dove	+	–	+
Cuckoo	+	+	–
Little Owl	–	–	+
Tawny Owl	–	–	+
Green Woodpecker	–	+	–
Great Spotted Woodpecker	–	+	–
Skylark	+	–	–
Swallow	+	–	–
Tree Pipit	–	–	+
Meadow Pipit	–	–	+
Yellow Wagtail	–	–	+
Pied Wagtail	+	–	–
Wren	+	+	–
Dunnock	+	+	–
Robin	+	+	–
Redstart	–	–	+

Appendix 3 cont....

Species	Farmland Index	Woodland Index	Scarce Species Index
Blackbird	+	+	–
Song Thrush	+	+	–
Mistle Thrush	+	+	–
Sedge Warbler	+	–	+
Lesser Whitethroat	+	–	–
Whitethroat	+	+	–
Garden Warbler	+	+	–
Blackcap	+	+	–
Chiffchaff	+	+	–
Willow Warbler	+	+	–
Goldcrest	–	+	+
Spotted Flycatcher	+	+	–
Long-tailed Tit	+	+	–
Marsh Tit	–	+	–
Coal Tit	–	+	+
Blue Tit	+	+	–
Great Tit	+	+	–
Nuthatch	–	+	–
Treecreeper	+	+	–
Jay	–	+	+
Magpie	+	+	–
Jackdaw	+	–	–
Carrion Crow	+	+	–
Starling	+	+	–
Tree Sparrow	+	–	–
Chaffinch	+	+	–
Greenfinch	+	+	–
Goldfinch	+	–	+
Linnet	+	+	–
Redpoll	–	–	+
Bullfinch	+	+	–
Yellowhammer	+	+	–
Reed Bunting	+	–	–
Corn Bunting	+	–	–

APPENDIX 4

SCIENTIFIC NAMES OF SPECIES MENTIONED IN THE TEXT

Mallard	Anas platyrhynchos
Sparrowhawk	Accipiter nisus
Kestrel	Falco tinnunculus
Hobby	Falco subbuteo
Red-legged Partridge	Alectoris rufa
Grey Partridge	Perdix perdix
Pheasant	Phasianus colchicus
Moorhen	Gallinula chloropus
Lapwing	Vanellus vanellus
Stock Dove	Columba oenas
Woodpigeon	Columba palumbus
Collared Dove	Streptopelia decaocto
Turtle Dove	Streptopelia turtur
Cuckoo	Cuculus canorus
Little Owl	Athene noctua
Tawny Owl	Strix aluco
Swift	Apus apus
Green Woodpecker	Picus viridis
Great Spotted Woodpecker	Dendrocopos major
Skylark	Alauda arvensis
Swallow	Hirundo rustica
House Martin	Delichon urbica
Tree Pipit	Anthus trivialis
Meadow Pipit	Anthus pratensis
Yellow Wagtail	Motacilla flava
Pied Wagtail	Motacilla alba
Wren	Troglodytes troglodytes
Dunnock	Prunella modularis
Robin	Erithacus rubecula
Nightingale	Luscinia megarhynchos
Redstart	Phoenicurus phoenicurus
Wheatear	Oenanthe oenanthe
Ring Ousel	Turdus torquatus
Blackbird	Turdus merula
Song Thrush	Turdus philomelos
Mistle Thrush	Turdus viscivorus

Appendix 4 cont....

Sedge Warbler	*Acrocephalus schoenobaenus*
Reed Warbler	*Acrocephalus scirpaceus*
Lesser Whitethroat	*Sylvia curruca*
Whitethroat	*Sylvia communis*
Garden Warbler	*Sylvia borin*
Blackcap	*Sylvia atricapilla*
Wood Warbler	*Phylloscopus sibilatrix*
Chiffchaff	*Phylloscopus collybita*
Willow Warbler	*Phylloscopus trochilus*
Goldcrest	*Regulus regulus*
Spotted Flycatcher	*Muscicapa striata*
Long-tailed Tit	*Aegithalos caudatus*
Marsh Tit	*Parus palustris*
Willow Tit	*Parus montanus*
Coal Tit	*Parus ater*
Blue Tit	*Parus caeruleus*
Great Tit	*Parus major*
Nuthatch	*Sitta europaea*
Treecreeper	*Certhia familiaris*
Jay	*Garrulus glandarius*
Magpie	*Pica pica*
Jackdaw	*Corvus monedula*
Carrion Crow	*Corvus corone*
Starling	*Sturnus vulgaris*
House Sparrow	*Passer domesticus*
Tree Sparrow	*Passer montanus*
Chaffinch	*Fringilla coelebs*
Greenfinch	*Carduelis chloris*
Goldfinch	*Carduelis carduelis*
Linnet	*Carduelis cannabina*
Redpoll	*Carduelis flammea*
Bullfinch	*Pyrrhula pyrrhula*
Yellowhammer	*Emberiza citrinella*
Reed Bunting	*Emberiza schoeniclus*
Corn Bunting	*Miliaria calandra*

APPENDIX 5

ANOVA tables for observer-analyst effects

Results of two-way analysis of variance in respect of observer and analyst differences in cluster totals for individual species (summarized as Table 3.6 in main text).

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

a) ANOVA tables for Pheasant

Data table

Analyst	Observer A	B	C	D	Mean
W	3	4	1	3	2.75
X	3	3	1	2	2.25
Y	3	4	1	3	2.75
Mean	3.00	3.67	1.00	2.67	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.6667	0.333	3.00
Observers	3	11.5833	3.861	34.75***
Residuals	6	0.6667	0.111	

b) ANOVA tables for Wood Pigeon

Data table

Analyst	Observer A	B	C	D	Mean
W	8	4	3	12	6.75
X	5	4	4	11	6.00
Y	5	4	5	11	6.25
Mean	6.00	4.00	4.00	11.33	

ANOVA table

Source of variance	Degree of freedom	Sum of squares	Mean square	F
Analyst	2	1.667	0.583	0.47
Observers	3	108.0000	36.000	28.80***
Residuals	6	7.5000	1.250	

c) ANOVA tables for Collared Dove

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	2	3	3	2	2.50
X	2	2	2	3	2.25
Y	2	4	3	2	2.75
Mean	2.00	3.00	2.67	2.33	

ANOVA table

Source of Variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	0.5000	0.250	0.53
Observers	3	1.6667	0.556	1.18
Residuals	6	2.8333	0.472	

d) ANOVA tables for Magpie

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	3	3	1	3	2.50
X	4	2	2	3	2.75
Y	4	2	2	3	2.75
Mean	3.667	2.333	1.667	3.000	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	0.1667	0.083	0.27
Observers	3	6.6667	2.222	7.27*
Residuals	6	1.8333	0.306	

g) ANOVA tables for Coal Tit

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	6	4	2	6	4.50
X	6	5	2	6	4.75
Y	6	5	2	6	4.75
Mean	6.00	4.67	2.00	6.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.1667	0.083	1.00
Observers	3	32.0000	10.667	128.00***
Residuals	6	0.5000	0.083	

h) ANOVA tables for Marsh Tit

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	2	3	1	4	2.50
X	2	3	2	3	2.50
Y	2	3	2	4	2.75
Mean	2.00	3.00	1.67	3.67	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean squares	F
Analysts	2	0.1667	0.083	0.43
Observers	3	7.5833	2.528	13.00**
Residuals	6	1.1667	0.194	

e) ANOVA table for Great Tit

Data table

Analyst	Observer A	B	C	D	Mean
W	15	12	7	14	12.00
X	16	12	7	11	11.50
Y	13	10	8	12	10.75
Mean	14.67	11.33	7.33	12.33	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	3.1667	1.583	1.00
Observers	3	84.2500	28.083	17.74**
Residuals	6	9.5000	1.583	

f) ANOVA tables for Blue Tit

Data table

Analyst	Observer A	B	C	D	Mean
W	17	20	8	20	16.25
X	14	18	8	18	14.50
Y	15	19	8	19	15.25
Mean	15.33	19.00	8.00	19.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	6.1667	3.083	7.39*
Observers	3	242.0000	80.667	193.60***
Residuals	6	2.5000	0.417	

k) ANOVA tables for Mistle Thrush

Data table

Analyst	Observer A	B	C	D	Mean
W	6	5	3	6	5.00
X	4	3	3	4	3.50
Y	4	4	2	6	4.00
Mean	4.67	4.00	2.67	5.33	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	4.6667	2.333	4.20
Observers	3	11.6667	3.889	7.00**
Residuals	6	3.3333	0.556	

l) ANOVA tables for Song Thrush

Data table

Analyst	Observer A	B	C	D	Mean
W	10	9	12	11	10.50
X	10	9	13	11	10.75
Y	9	9	13	12	10.75
Mean	9.67	9.00	12.67	11.33	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.1667	0.083	0.27
Observers	3	24.6667	8.222	26.91***
Residuals	6	1.8333	0.306	

i) ANOVA tables for Long-tailed Tit

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	5	5	2	6	4.50
X	5	4	2	4	3.75
Y	5	4	2	4	3.75
Mean	5.00	4.33	2.00	4.67	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	1.5000	0.750	2.45
Observers	3	16.6667	5.556	18.18**
Residuals	6	1.8333	0.306	

j) ANOVA tables for Wren

Date table

	Observer				
Analyst	A	B	C	D	Mean
W	18	13	24	18	18.25
X	19	14	28	21	20.50
Y	18	13	24	21	19.00
Mean	18.33	13.33	25.33	20.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	10.5000	5.250	4.20
Observers	3	220.2500	73.417	58.73***
Residuals	6	7.5000	1.250	

m) ANOVA tables for Blackbird

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	25	21	16	28	22.50
X	25	22	17	29	23.25
Y	26	21	17	30	23.50
Mean	25.33	21.33	16.67	29.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	2.1667	1.083	3.54
Observers	3	252.9167	84.306	275.91***
Residuals	6	1.8333	0.306	

n) ANOVA tables for Robin

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	28	21	27	31	26.75
X	27	21	27	32	26.75
Y	30	20	27	34	27.75
Mean	28.33	20.67	27.00	32.33	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	2.6667	1.333	1.09
Observers	3	210,9167	70.306	57.52***
Residuals	6	7.333	1.222	

o) ANOVA tables for Blackcap

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	7	5	7	2	5.25
X	7	4	8	2	5.25
Y	6	4	7	2	4.75
Mean	6.67	4.33	7.33	2.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.6667	0.333	1.50
Observers	3	52.9167	17.639	79.38***
Residuals	6	1.333	0.222	

p) ANOVA tables for Whitethroat

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	3	1	1	3	2.00
X	3	2	1	3	2.25
Y	3	2	1	3	2.25
Mean	3.00	1.67	1.00	3.00	

ANOVA table

Source of variance	Degree of freedom	Sum of squares	Mean Square	F
Analysts	2	0.1667	0.083	1.00
Observers	3	9.0000	3.0000	36.00***
Residuals	6	0.5000	0.083	

q) ANOVA tables for Willow Warbler

Data table

Analyst	Observer A	B	C	D	Mean
W	25	22	30	25	25.50
X	26	22	36	24	27.00
Y	25	23	33	26	26.75
Mean	25.33	22.33	33.00	25.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	5.1667	2.583	0.96
Observers	3	189.5833	63.194	23.45***
Residuals	6	16.1667	2.694	

r) ANOVA tables for Goldcrest

Data table

Analyst	Observer A	B	C	D	Mean
W	15	12	14	16	14.25
X	13	10	13	13	12.25
Y	14	10	12	16	13.00
Mean	14.00	10.67	13.00	15.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	8.1667	4.083	5.44*
Observers	3	31.0000	10.333	13.78**
Residuals	6	4.5000	0.750	

s) ANOVA tables for Dunnock

Data table

Analyst	Observer A	B	C	D	Mean
W	19	19	23	21	20.50
X	18	20	23	19	20.00
Y	19	21	23	21	21.00
Mean	18.67	20.00	23.00	20.33	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	2.0000	1.0000	1.80
Observers	3	29.6667	9.8889	17.80**
Residuals	6	3.3333	0.5556	

t) ANOVA tables for Tree Pipit

Data table

Analyst	Observer A	B	C	D	Mean
W	3	2	1	2	2.00
X	2	1	1	2	1.50
Y	3	2	1	2	2.00
Mean	3	2	1	2	2.00

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.6667	0.333	3.00
Observers	3	4.3333	1.4444	13.00**
Residuals	6	0.6667	0.111	

u) ANOVA tables for Greenfinch

Data table

Analyst	Observer A	B	C	D	Mean
W	5	5	1	3	3.50
X	4	4	2	3	3.25
Y	3	5	2	3	3.25
Mean	4.00	4.67	1.67	3.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analyst	2	0.1667	0.083	0.16
Observers	3	15.3337	5.111	9.68*
Residuals	6	3.1667	0.528	

v) ANOVA tables for Goldfinch

Data table

Analyst	Observer A	B	C	D	Mean
W	5	4	1	2	3.00
X	4	2	1	2	2.25
Y	4	4	1	2	1.75
Mean	4.33	3.33	1.00	2.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	1.1667	0.583	1.62
Observers	3	19.3333	6.444	17.85**
Residuals	6	2.1667	0.361	

w) ANOVA tables for Linnet

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	2	4	4	1	2.75
X	3	4	3	2	3.00
Y	2	5	4	2	3.25
Mean	2.33	4.33	3.67	1.67	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.5000	0.250	0.69
Observers	3	13.3333	4.444	12.31**
Residuals	6	2.1667	0.361	

x) ANOVA tables for Bullfinch

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	11	11	11	11	11.00
X	9	10	12	9	10.00
Y	8	11	9	10	9.50
Mean	9.33	10.67	10.67	10.00	

ANOVA TABLE

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	4.6667	2.333	1.91
Observers	3	3.6667	1.222	1.00
Residuals	6	7.3333	1.222	

y) ANOVA tables for Chaffinch

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	24	23	21	26	23.50
X	23	24	22	27	24.00
Y	24	23	20	28	23.75
Mean	23.67	23.33	21.00	27.00	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	0.5000	0.250	0.31
Observers	3	54.9167	18.306	22.72**
Residuals	6	4.8333	0.806	

z) ANOVA tables for Yellowhammer

Data table

	Observer				
Analyst	A	B	C	D	Mean
W	6	5	6	9	6.5
X	6	6	5	7	6.0
Y	6	7	6	10	7.25
Mean	6.00	6.00	5.67	8.67	

ANOVA table

Source of variance	Degrees of freedom	Sum of squares	Mean square	F
Analysts	2	3.1667	1.583	2.28
Observers	3	17.5833	5.861	8.44*
Residuals	6	4.1667	0.695	

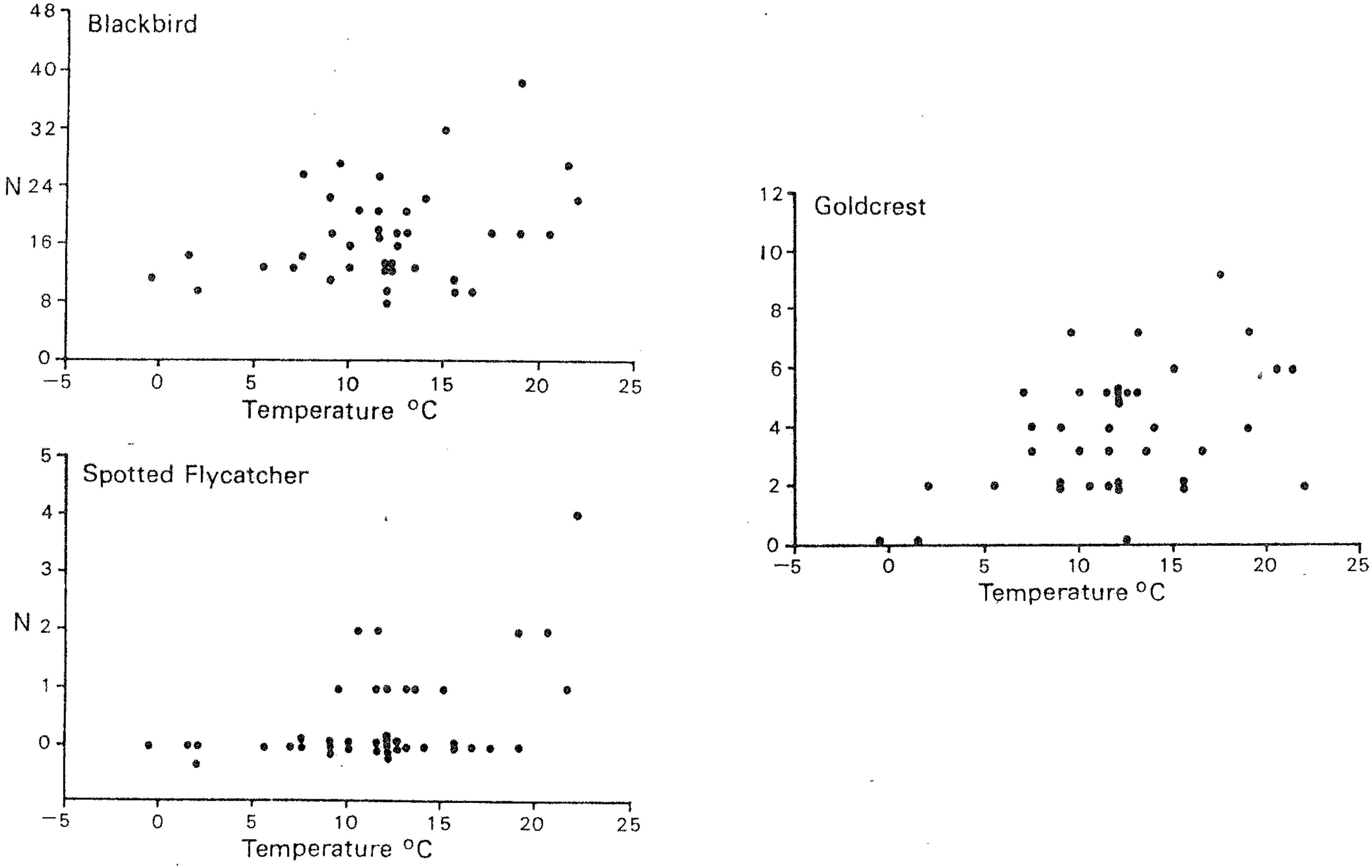


Figure 8:4 Temperature sensitivity of registration totals for various species:(a) Blackbird; (b) Spotted Flycatcher; (c) Goldcrest; (d) Wren; (e) Willow Warbler.