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A PRELIMINARY QUANTITATIVE STUDY OF BIRDS NEAR BICKER, PARTS OF HOLLAND.

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1. Introduction.

Although the importance of careful observation and recording of all aspects of bird behaviour cannot be under-rated, there are many relationships between birds and their environment, and among the species themselves, which can be determined only by quantitative studies, involving the analysis of numerical results. Comparatively little work has been done in this field, however, and there is great scope for any naturalist with arithmetical or mathematical ability. Quite useful results can be derived from numerical data by simple arithmetic processes, such as taking averages, but there is always a danger of misleading and even wrong conclusions unless tests are made to determine their reliability or significance by the use of statistical methods. These methods are all based on the determination of probabilities, and although often complicated in their theoretical background, are very simple to apply in practice. Many of the most useful processes, with their application to bird studies, are described in a paper (1) by the author published by the London Natural History Society, of which there is a copy in the Library of the Lincolnshire Naturalists' Union. There are also text-books available.(2)

The author is working on a programme of research in bird ecology which involves the numerical comparison of bird populations in different habitats and the determination of the effect of various environmental factors. As part of this programme, observations are being made in the arable-farming district around Bicker, and it is thought that a survey of the results of the preliminary work will prove of interest and may be stimulating to local ornithologists, who may be able to provide some useful constructive criticism.

2. Method.

The basic data is obtained by making sample counts in the habitat chosen. A suitable route through the area is selected, and the observer walks slowly along this, recording the birds seen. A restriction on the counting is generally needed in respect of distance of the bird from the route. Large birds can be seen at great distances in open country, but small birds are seen only when they are much closer. To count *all* birds seen would not, therefore, give a fair sample of the bird population ; no bird should be counted which is so far away that smaller birds in between could not be seen. This rule restricts recording to perhaps 200 yards in open country, and to about 30-50 yards in woodland. For many purposes, *all* birds seen within this restricted distance must be counted, whether identified or not ;* this is most important when the relationships of the numbers of birds and numbers of species is being studied (see Section 5). Sometimes it is difficult to decide whether the unidentified bird is of a species already recorded or not, and it may be necessary to make an "intelligent guess" ; this is much better than simply ignoring the bird, because errors will tend to cancel out when the average of a number of counts is taken—but when difficult cases are ignored, the error is always the same way, and will not tend to cancel out.

Two routes were chosen for the sample counts near Bicker, as follows :—

(*a*) Starting from the entrance to Rabbit Hill Farm along Mill Road to Bank House (at Hoffleet Stow), then along the Roman Bank to Paradise Farm. This is all along the public road, passing five houses, two farmyards, some tall elms, a very small spinney of perhaps 200 square yards, and the large garden of Bank House. For the rest, the route is through cultivated fields, with hedgerows (mainly kept low) and a little waste land beside the road. The main crops are the usual ones—grain, potatoes, sugar beet, with mangolds, cabbages, etc., as subsidiaries. The route is about three-quarters of a mile long, covering approximately two sides of an equilateral triangle, and the walking time for each count is 20-25 minutes.

(*b*) Starting in the fields beside Rabbit Hill Farm, along the edges of the fields in the general direction of the third side of the triangle mentioned above. The route includes no houses, gardens or farmyards ; there are two short lengths of hedgerow and a considerable length of drain which is mainly kept well cleared of vegetation. The length of route is perhaps half-a-mile, and the walking time for each count is about 25-30 minutes.

It will be seen that the second route, referred to as " Fields" for brevity, is a far less complex habitat than the first, or " Road " route. The effect of this difference will be seen later to be marked but not very large.

*Naturally, when lists of *named* species are drawn up (*e.g.* as in Table I) only positive identifications should be included.

The data on which this paper is based comprises counts as follows :—

Road: 6 counts in June 1946, 3 in August 1946, 2 in December 1946, 2 in March 1947 and 3 in May 1947.

Fields: 1 in June 1946, 3 in August 1946 and 2 in May 1947.

This is a total of 22 counts in all.

The details of each count are not recorded here, as they would occupy so much space, and are not really important, being merely a means to an end. The following paragraphs set out the results in a compact form.

3. Relative Abundance of Species.

The number of winter counts is too small to justify averaging, but the average number of birds seen of each species during the summer is shown in Table 1 with separate lists for " Road " and " Fields". These lists should give the relative abundance of the various species with some accuracy, especially in the case of those which are fairly stationary ; but with species such as Starling, Jackdaw, Magpie, Cuckoo, etc., which move over wide areas, a large factor of chance is introduced unless the number of counts is very large, say 100 or more. The main difference between " Road " and " Fields " results are :—

(*a*) House-sparrow : High abundance on " Road " due to farmyards and houses.

(*b*) Skylark : Greater frequency in " Fields" to be expected.

(*c*) Partridge : ditto.

(*d*) Jackdaw : High position for " Fields " due to a chance flock on one occasion.

(*e*) Yellow-Bunting : Greater frequency on " Road " due to greater proportion of hedgerows.

(*f*) Blackbird : ditto.

Lists such as these will prove invaluable in assessing changes in the bird population in future times, due, for example, to changing land-use, etc. Of course, the fact that they are based on sample counts and not on a complete census must not be overlooked. Certain factors, such as the different conspicuousness of different species, are not allowed for ; but it is thought that these have a relatively small effect in open country.

Additional species recorded in the summer, but not on regular counts were Blue Tit, Pied Wagtail, Green Woodpecker, Tawny Owl and Little Owl.

TABLE I.

SPECIES IN ORDER OF FREQUENCY, SUMMER (MAY-AUGUST).

ROAD		FIELDS	
Species	*Average No. per Count*	*Species*	*Average No. per Count*
House Sparrow	22.3	Woodpigeon	6.0
Yellow Bunting	4.75	Skylark	5.0
Woodpigeon	4.35	House Sparrow	4.8
Starling	4.0*	Jackdaw	3.5†
Crow—Rook	3.0	Partridge	3.3
Blackbird	2.85	Yellow Bunting	3.2
Skylark	2.1	Starling	2.7*
Whitethroat	1.25	Rook—Crow	2.5
Mistle-Thrush	0.9	Blackbird	1.0
Chaffinch	0.85	Black-headed Gull	1.0
Partridge	0.75	Magpie	0.8
Swallow	0.7	Corn Bunting	0.8
Hedge-Sparrow	0.7	Swift	0.5
Stock-Dove	0.6	Stock-Dove	0.5
Wren	0.5	Hedge-Sparrow	0.3
Jackdaw	0.4	Wren	0.3
Magpie	0.25	Chaffinch	0.2
House-Martin	0.25	Whitethroat	0.2
Cuckoo	0.25	Cuckoo	0,2
Kestrel	0.25		
Corn-Bunting	0.15	(20 species)	
Meadow Pipit	0.15		
Great Tit	0.15		
Lapwing	0.15		
Herring Gull	0.15		
Robin	0.08		
Swift	0.08		
(28 species)			

*High position of Starling due to flock in both cases : 35 on 8-8-46 on " Road" and 16 on 9-8-46 on " Fields."

†High position of Jackdaw here due to flock of 15 on 30-5-47.

Additional species recorded on the winter counts were Jay, Song-Thrush, Lesser Spotted Woodpecker and Turtle-Dove (one bird of each), and three species of gulls were seen : Black-headed, Herring and Lesser Black-headed. No doubt more extensive observation will add considerably to this list, comprising 39 species in all.

4. Effect of Weather.

The nine counts made along the road in the summer of 1946 provide just about enough information to examine the effect of the weather. Table 2 shows the relevant data. The weather variations are only normal ones ; and only short-term effects are being considered.

If the weather is arbitrarily classified as " Fine" or " Poor" as shown, we can determine the average number of birds and species seen for each class of weather. The results are shown in Table 3. It will be seen that the differences in averages are small. However, such differences might still indicate a definite effect of weather if the numbers from which the averages are determined vary very little among themselves. Thus a statistical test of significance is required.

TABLE 2.

EFFECT OF WEATHER, SUMMER 1946.

Date	Time (Dbl. S.T.)	No. of Birds	No. of Species	WEATHER				
				Temp.	Sun	Rain	Wind	Poor or Fine
7-6	5-30 p.m.	45	13	H	S	F	S	F
7-6	6- 0 p.m.	53	13	H	S	F	S	F
8-6	11- 0 a.m.	41	13	W	D	W	—	P
8-6	11-30 a.m.	53	12	W	D	W	—	P
11-6	11- 0 a.m.	41	10	C	O	F	W	F
11-6	11-30 a.m.	59	13	C	O	F	W	F
6-8	11- 0 a.m.	49	11	H	S	F	W	F
6-8	11-30 a.m.	57	10	W	D	F	W	P
8-8	11- 0 a.m.	84	10	C	D	F	W	P

Temperature : H=hot ; W=warm ; C=cool.
Sun : S=sunny ; O=overcast ; D=dull.
Rain : F=fine ; W= very wet.
Wind : W=windy ; S=still.

TABLE 3.

ANALYSIS OF TABLE 2.

Weather.	Average No. of Birds.	Average No. of Species.
Poor	59	11.3
Fine	50	12.0
Whether differences are significant or not	Not	Not

Such a test gives the result that the difference in the average number of birds could be expected to occur once in five times by pure chance, and that the difference in the average number of species would occur once in four times by pure chance. Thus we must say that the differences are "not significant," and that any effect of weather which may be suggested by the figures of Table 3 is both very small and very unreliable.

The same results have been obtained by the author in cases where much more data was available and for different habitats ([3] [4]) and the general agreement makes the conclusion very convincing.

Of course, long spells of severe weather such as occurred near the beginning of 1947 do have a marked effect on the bird population, but this is quite a different case from the one considered above.

5. The Diversity of the Bird Population.

Ornithologists have not, in the past, shown very much interest in the relationships between the number of species and the number of birds in a given habitat. But by the use of a suitable technique, such relationships may prove very useful.

A theoretical study of the relationships between species and individuals in any natural population was published by R. A. Fisher in 1943 ([5]) and practical applications to entomology and other branches of natural history have been given by C. B. Williams ([6]). The application to birds has been discussed briefly by the present author ([1]). Insufficient data is yet available to show just how useful this technique will prove in bird study.

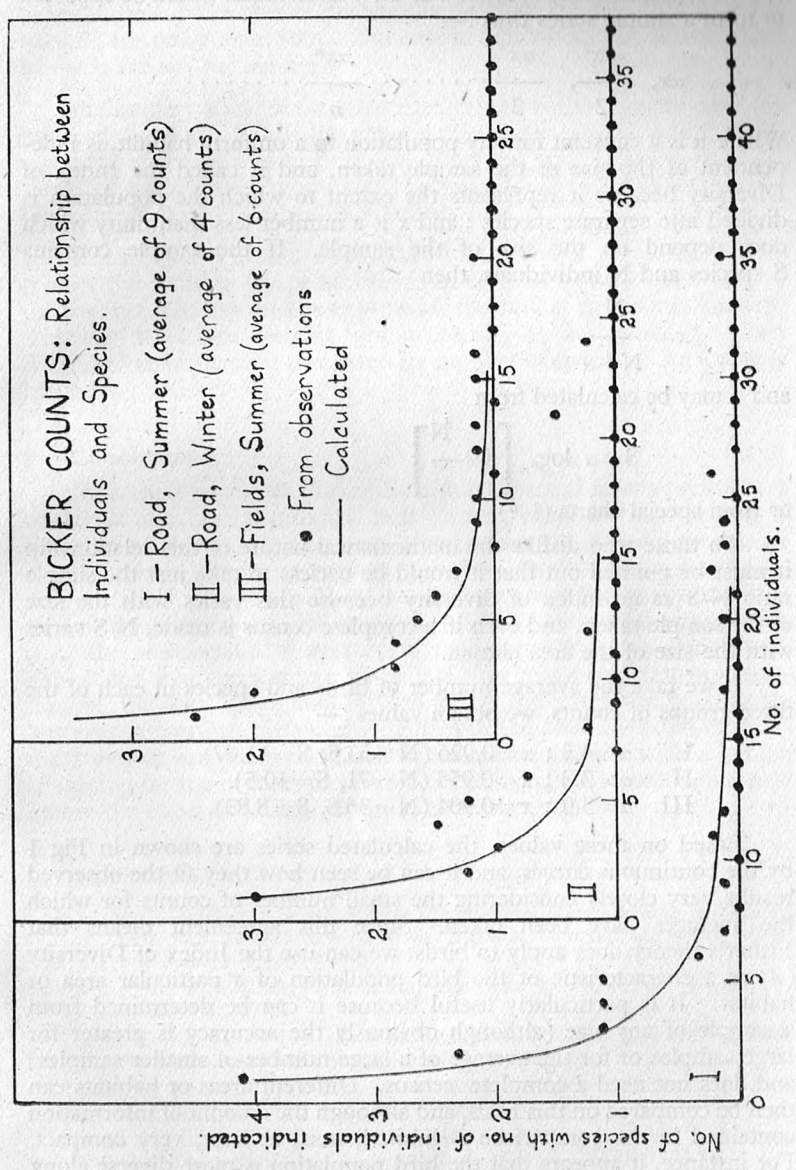
It is interesting to consider in the Bicker bird counts, what is the average number of species per count, represented by one bird only, how many by two, etc. In Fig. 1 are shown the results of an analysis of this relationship for three sets of counts :—

I—The nine counts on the Road during Summer 1946.

II—Four counts on the Road during Winter 1946-7.

III—The six counts in the Fields during the Summers of 1946 and 1947.

In each case the results are averaged thus : For each set of counts the total number of records of species being represented by only one bird in a count is divided by the number of counts, then the process is repeated for species represented by two birds, and so on. Thus Fig. 1 shows the average distribution of species and numbers. It will be seen that there are more species represented by only one bird than by two, more by two than by three, and so on, although there are naturally irregularities in the relationship due to averaging over only a small number of counts.



For a distribution such as this, Fisher showed that the number of species represented by 1, 2, 3 . . n . . . individuals would be expected to form a simple series thus :—

$$\alpha x, \quad \frac{\alpha x^2}{2}, \quad \frac{\alpha x^3}{3} \cdots\cdots\cdots \frac{\alpha x^n}{n} \cdots\cdots\cdots$$

Where α is a constant for any population in a uniform habitat, is independent of the size of the sample taken, and is called the Index of Diversity because it represents the extent to which the population is divided into separate species ; and x is a number less than unity which does depend on the size of the sample. If the sample contains S species and N individuals, then

$$x = \frac{N}{N+\alpha}$$

and α may be calculated from

$$S = \alpha \log_e \left[1 + \frac{N}{\alpha}\right]$$

or from special charts ([1], [6]).

To those who dislike the mathematical nature of this relationship it must be pointed out that it would be useless to take just the simple ratio N/S as an index of diversity because this varies with the size of the sample taken, and even if a complete census is made, N/S varies with the size of the area chosen.

If we take the average number of birds and species in each of the three groups of counts, we obtain values :—

I. $\alpha = 4.3$; $x = 0.926$ (N = 53.5, S = 11.67).
II. $\alpha = 3.3$; $x = 0.955$ (N = 71, S = 10.5).
III. $\alpha = 3.9$; $x = 0.904$ (N = 36.8, S = 8.83).

Based on these values, the calculated series are shown in Fig 1 by the continuous curves, and it can be seen how they fit the observed results very closely considering the small number of counts for which the averages have been taken. Since this agreement means that Fisher's theory does apply to birds, we can use the Index of Diversity (d) as a characteristic of the bird population of a particular area or habitat. It is particularly useful because it can be determined from a sample of any size (although obviously the accuracy is greater for large samples or for the average of a large number of smaller samples) and does not need a complete census. Different areas or habitats can then be compared on this basis, and although the amount of information contained in the comparison is limited, it is, at least, very compact. For instance, it appears that the bird population is more diverse along the road than in the fields, which seems reasonable since the habitat is more varied ; and the diversity is greater in summer than in winter.

Strictly, since the index of diversity is obtained from average results of quite a small number of counts, a statistical test should be applied to see if these differences of diversity in different habitats or at different seasons are really significant. But this is difficult to do, and will not be discussed any further here.

Preliminary work so far completed by the author suggests that the index of diversity of birds in common inland habitats varies from about seven for mixed habitats such as woodland and grass or heath, to below three for such simple habitats as beechwoods. It is evident that the diversity of arable farmland is relatively low.

A particularly useful application of the index of diversity is to correct the number of species found in a habitat of a certain area to the number which would be expected if the habitat were some standard size, say 100 acres (simple proportionality is not correct). Then different habitats can be compared for number of species. An example has been published ([1]).

6. Conclusions.

This short paper has shown the results obtained from a preliminary survey of the bird population near Bicker, based on sample counts along fixed routes. It has been shown that the relative abundance of the various species appears to vary with small changes in what is really a fairly uniform habitat, but ordinary weather variations have no definite effect on the bird numbers. The diversity of the population (*i.e.*, the relationship of species to total numbers) also varies with habitat and with the season. Thus it is clear that a complete investigation of the bird population (discounting the rarer species, which, however interesting, are unimportant from the practical point of view) must aim at sampling the small variations in habitat with a proper weighting for the proportion of each, must include all seasons, but may ignore the effect of all but exceptional weather variations.

7. References.

1. D. G. Tucker, " Some Simple Quantitative Relationships in Ecology with particular reference to Birds," *London Naturalist* for 1946 (No. 26, published 1947), p. 42-55.
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