June and observation indicates that I take few or no migrant, adult towhees.

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A METHOD OF ESTIMATING ASSOCIATION OF INDIVIDUALS

BY CHARLES H. BLAKE

While it is easily observed that some birds (e.g. chickadees) travel in parties which maintain their identity, partially or wholly, for a considerable time, it is not so clear whether individuals of other species, trapped together occasionally, are, in fact, associated. Direct observation of a flock will sometimes be possible and evidence from such observation is usually conclusive. This is particularly true if the flock from which a sample is trapped is seen to fly into the trapping area as a unit.

Direct observations are not always possible and it is desirable to have some method by which the probability of association of individuals found together in the traps more than once can be estimated. It is always arguable that, if two birds are found together during a round of the traps, they did actually trap separately. The likelihood of such an event increases in proportion to the time between rounds. This must be taken into account by the observer.

Let us call the whole number of banded birds of a species present during a period of time, T; the number occurring in a flock, F; and any number of birds taken together (two or more) N. It is clear that $T \geqslant F \geqslant N$. The symbol $\geqslant$ is read "equal to or greater than." It is further evident that there are a definite number of different sets of N birds which may be drawn from F birds. This number of sets is given by the expression ${}_FC_N$, which is read: "combination of F things taken N at a time." Its numerical value is $F!/N!(F—N)!$. The symbol F! is read "factorial of F" and is obtained by multiplying together the successive whole numbers from 1 to F inclusive. We obtain N! and $(F—N)!$ by congruent operations. Comrie (1944, p. 2, 3) gives the factorials from 1 to 100, beyond which one would rarely have to go. It is more convenient to use common logarithms as given by Larsen (1948, p. 131). The procedure in this case is to subtract from log the sum of logN! and log(F—N)!. The arithmetic value of the answer will be found in any table of common logarithms. It is always possible to compute combinations by actually writing out the factorials and cancelling between numerator and denominator. If the factors remaining are not too troublesome this method may be as easy as using the tables.

Let us see how a concrete case works out. The methods used are general, although the figures are special to the instant case. For chickadees trapped by me at Lincoln, Mass. during the period 1 to 19 Oct. 1949, I recorded the following putative pairs on the number of occasions noted. In working out the frequency with which sets of two are observed, one must count in every possible pair when three or more birds are caught together. For example, a group of three birds provides three different sets of two.

The whole number of birds present, including those giving no evidence of association, is T = 20. For the sake of simplicity the calculation has only been carried out for N = 2.

TABLE OF DATA

Band Nos.	Trappings	Band Nos.	Trappings	Band Nos.	Trappings
385-397	2	399-430	1	411-385	1
" -400	2	400-397	2	" -399	1
" -403	1	" -403	2	208-402	1
393-385	3	402-408	1	" -408	1
" -397	4	" -412	1	" -412	1
" -400	2	407-393	3	209-397	3
" -403	1	" -400	3	" -400	2
" -209	3	" -209	1	" -403	2
397-403	1	408-412	1	263-985	1
385-209	2	407-411	1		

The number of pairs observed is 30; the number of observations in the sample is 52. The mean frequency of occurrence of any pair is 52/30 = 1.73.

Since ${}_{20}C_2 = 190$, it is evident, that, on a chance basis, any preassigned association of two birds will occur once in 190 observations of two birds together. It has then a probability of 1/190 = 0.0053 where certainty is 1.00. We actually find that there are, in all, but 30 different, apparent sets of two associated birds, some sets occurring more than once. In 52 observations the probability of any reassigned set occurring once is 52/190 = 0.254. What this says is, that if the birds in the pairs were associated purely by chance, our 52 observations should have yielded 52 different pairs, each occurring but once. Since a fractional occurrence of a set is impossible we find that any one actual observation shows 190/52 = 1.0/.254 = 3.7 times its chance expectation.

To assess the significance of departures from random expectation we need some mathematical criterion even if the exact value of the criterion taken rests on an intuitive statistical judgment. The frequency distribution of the number of times each set of birds was trapped seems to agree with no ordinary statistical distribution. I suggest as a preliminary criterion that we use the mean frequency (1.73) plus its square root (1.3). On this basis frequencies of 3.03 and higher would be significant in the present sample. We may round the figure to 3.0 This is $3.0/.254 = 11.8$ times the chance frequency or $11.8/3.7 = 3.2$ times the least possible frequency of random occurrence.

The seven sets which occur with significant frequency include but six birds: 48-16209, 49-4385, 49-4393, 49-4397, 49-4400, and 49-4407. We conclude that these birds form a flock which may have less firmly attached or satellite members.

Up to this point there seems little need to have introduced the exact probabilities. There are two reasons for doing so. First, if there are a large number of observations on rather few birds, some sets may occur with less than chance frequency and would be excluded from the computation of the significant level. Second, it will often, perhaps always, be necessary to know the ratio by which the occurrence of any set or group of sets exceeds random probability. In the present example the occurrence of the whole group of sets derived from the supposed flock exceeds the probability of the occurrence of all possible sets from a flock of six birds eight-fold.

We have $T = 20$ and $F = 6$ and we wish the probability of drawing a pair $(N = 2)$ of the 6 at random from the whole group of 20 birds. This is, in general, ${}_FC_N/{}_TC_N$ and, in the present case, ${}_6C_2/{}_{20}C_2 = 15/190 = 0.079$. The proportion found is that $33/52 = 0.63$ of the takings were of one of the 15 possible pairs. (13 of these 15 pairs were actually taken.) This is 8.0 times expectation. The fall from 11.8 to 8.0 times expectation results from counting in 6 pairs from the supposed flock which occurred with less than significant frequency.

Without giving the details, I find that the only set of three birds which occurred with significant frequency was 49-4385, 49-4393, 49-4397.

Two cautions are necessary. The present method can not be used to prove absence of association conclusively. Association of rarely trapped birds will be missed. Also, if the observations stretch over too long a period, changes in flock composition may obscure association which actually exists.

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SOME NOTES ON ACTIVITIES OF THE NORTHERN AND MIGRANT SHRIKES

BY OSCAR MCKINLEY BRYENS

In *The Condor,* Nov.-Dec., 1939, p. 260, Mr. Emerson A. Stoner reports on "Some 'Butcher-bird' Activities of the California Shrike *(Lanius ludovicianus gambeli),*" in which he tells of this species killing captive birds, such as caged canaries and birds in traps at his banding station. I have noted very similar happenings in my bird banding activities, with the Northern Shrike *(Lanius borealis borealis)* and the Migrant Shrike *(Lanius ludovicianus migrans).*