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Comparison of avian survival rates derived from three methods

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Survival of adult birds varies considerably among species and estimates for most species are few and vary in their methods of calculation. Two methods presented here (Haldane 1955, Robbins 1969) calculate survival based on any season banding and the other method (Roberts 1971) is based on summer banding. Comparisons of the resulting three survival estimates for a particular species of bird are quite similar.

Downy woodpecker returns in Kansas

K. B. Kelley and A. J. Betts trapped and banded 136 Downy Woodpeckers (*Picoides pubescens*) near Baldwin City, Kansas from 1972 through 1981. Table 1 summarizes the number of birds trapped and the number of birds returning.

Calculation of avain survival

Robert's Method

Roberts' method (Roberts 1971) is based on isolating a subsample of summer resident birds from transient birds which returned at least once and analyzing the pattern of multiple returns within this subsample. The analysis is based on the distribution of returns grouped according to the year of banding. A year in which at least one return is recorded, a return-year, is considered to be an independent event. The probability of a return-year occurring is dependent only upon survival and trapping effort.

The data for the Downy Woodpeckers in Kansas are arranged for Roberts' (1971) maximum likelihood calculation in Table 2. (Any season returns are considered here.) An estimate of the sampling rate t , needed to calculate survival (S), is obtained by considering the histories of those birds known to have been alive 2 or more years after banding. The raw data indicates 25 birds were available for retrapping in a total of 48 intervening

years. Returns were recorded in only 31 of those years. Then t is equal to the number of intervening years divided by the number of those years in which returns were recorded, here equalling $31/48$ or 0.646 .

Data from Table 2 and the estimate of t can now be plugged into Roberts' (1971) equations or keyed into a microcomputer with the BASIC program available from the authors. A Fortran program presented by Roberts (1971) which calculates the maximum likelihood value of S and its standard error has been adapted into BASIC by Jon Forde for use on home computers with greater than 5K of RAM (random access memory). If you send a blank cassette or a VIC-1541 formatted disk with a self-addressed stamped mailer, Dr. Norman Sloan, Department of Forestry, Michigan Technological University, Houghton, Michigan 49931 will provide you with a copy of the program. The program is implemented for a Commodore 64, but program listings may also be obtained to be used on other microcomputers.

Table 1. Summary of banding and returns of the Downy Woodpecker in Kansas.

Year	Number Banded in Year	Number of Returns in Year	Number Banded in Year, Which Subsequently Returned
1972	18	—	6
1973	10	4	6
1974	13	8	5
1975	14	13	4
1976	16	10	3
1977	5	4	3
1978	2	4	2
1979	18	5	9
1980	28	15	6
1981	12	9	—
TOTALS	136	72	44

Haldane's method

Haldane's correction method for Lack's table (Haldane 1955) uses the dynamic approach by assuming the bird is dead when recovered. Downy Woodpecker recoveries by years after banding are presented in Table 3, and Table 4 contains this data in the form of a dynamic life table. The best estimate of S by this method is 0.544 which is similar to the estimate by Roberts of 0.569

The weakness of Haldane's method is the necessity of using a d'_x column based on percentages. This arises from the fact that the number of recoveries during a given interval is a function of the number of banded birds available in the population, which is in turn directly related to the number banded during preceding intervals (cumulative effect).

Robbins' method

Robbins' method (Robbins 1969) considers individual birds and is based on living data not recovery data. A return occurs when a bird comes back to the same point of banding after 90 days. The assembled band records are summarized by years of banding returns and presented in Table 5. Survival rates by age groups for the Downy Woodpecker resulted in a weighted mean of S of 0.542 (Table 6), amazingly consistent with the previous two methods.

Tufted Titmouse returns in Kansas

Margaret Boyd banded the Tufted Titmouse (*Parus bicolor*) in Kansas from 1955 through 1961. Survival estimates derived from the three methods were similar; 0.416 with a standard error of 0.065 by Roberts' method, 0.484 by Haldane's method, and 0.393 by Robbins' method. This close agreement in values is encouraging when such minimal amounts of data are used in survival calculations.

Summary

Three methods of estimating average annual bird survival were compared; Roberts' method, Haldane's correction method, and Robbins' method. The estimates derived from these techniques were quite similar when considering the small amounts of data used to obtain these estimates.

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Table 1. Birds cited

Birds cited	Scientific name
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Hairy Woodpecker	<i>Picoides villosus</i>
Northern Flicker	<i>Colaptes auratus</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
Cassin's Kingbird	<i>Tyrannus vociferans</i>
Western Kingbird	<i>Tyrannus verticalis</i>
Eastern Kingbird	<i>Tyrannus tyrannus</i>
Purple Martin	<i>Progne subis</i>
Blue Jay	<i>Cyanocitta cristata</i>
American Crow	<i>Corvus brachyrhynchos</i>
Bushtit	<i>Psaltiriparus minimus</i>
Carolina Wren	<i>Thryothorus ludovicianus</i>
House Wren	<i>Troglodytes aedon</i>
Winter Wren	<i>Troglodytes troglodytes</i>
Gray Catbird	<i>Dumetella carolinensis</i>
Brown Thrasher	<i>Toxostoma rufum</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
White-eyed Vireo	<i>Vireo griseus</i>
Red-eyed Vireo	<i>Vireo olivaceus</i>
Northern Parula	<i>Parula americana</i>
Yellow Warbler	<i>Denroica petechia</i>
Black-throated Blue Warbler	<i>Denroica caerulescens</i>
Black-and-white Warbler	<i>Miniotilta varia</i>
Ovenbird	<i>Seiurus aurocapillus</i>
Northern Waterthrush	<i>Seiurus noveboracensis</i>
Louisiana Waterthrush	<i>Seiurus motacilla</i>
Connecticut Warbler	<i>Oporornis agilis</i>
Mourning Warbler	<i>Oporornis philadelphia</i>
Scarlet Tanager	<i>Piranga olivacea</i>
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>
Lazuli Bunting	<i>Passerina amoena</i>
Indigo Bunting	<i>Passerina cyanea</i>
Rufous-sided Towhee	<i>Pipilo erythrophthalmus</i>
Vesper Sparrow	<i>Pooecetes gramineus</i>
Song Sparrow	<i>Melospiza melodia</i>
White-throated Sparrow	<i>Zonotrichia albicollis</i>
Dark-eyed Junco	<i>Junco hyemalis</i>
Bobolink	<i>Dolichonyx oryzivorus</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Brown-headed Cowbird	<i>Molothrus ater</i>
Northern Oriole	<i>Icterus galbula</i>
Pine Grosbeak	<i>Pinicola enucleator</i>
Red Crossbill	<i>Loxia curvirostra</i>
White-winged Crossbill	<i>Loxia leucoptera</i>
Pine Siskin	<i>Carduelis pinus</i>
American Goldfinch	<i>Carduelis tristis</i>
Evening Grosbeak	<i>Coccothraustes vespertinus</i>

Table 2. Downy Woodpecker returns arranged for survival calculation (after Roberts 1971). Variables are: J is year of banding operations, K is number of years following banding operation, R is total number of return-years recorded, D_J is total number recorded for birds banded in the Jth year of banding operations, and D_K is total number recorded in the Kth year following banding.

Year Banded	J	D _J	1	2	3	4	K	5	6	7
1972	1	10	3	3	3	1	0	0	0	0
1973	2	12	4	4	3	1	0	0	0	0
1974	3	11	5	2	1	1	1	1	1	0
1974	3	11	5	2	1	1	1	1	1	0
1975	4	7	4	1	0	0	1	1	1	0
1976	5	5	1	2	0	1	1	1	0	
1977	6	6	1	2	2	1	0			
1978	7	5	2	2	1	0				
1979	8	13	8	5	0					
1980	9	6	6	0						
D _K	R = 75	34	21	10	5	3	2	0		

Table 4. Dynamic life table illustrating Downy Woodpecker survival.

d' _x	l' _x	q' _x
27.4	77.8	35.2
21.9	50.4	43.5
14.1	28.5	49.5
6.6	14.4	45.8
4.2	7.8	53.8
3.6	3.6	100.0
77.8	182.5	Average S = 54.4

Table 3. Downy Woodpecker recoveries by years after banding.

Year Banded	Number Banded	Recoveries by Years After Banding					
		0-1	1-2	2-3	3-4	4-5	5-6
1972	18	3	3	3	1	0	0
1973	10	4	4	3	1	0	0
1974	13	5	2	1	1	1	1
1975	14	4	1	0	0	1	1
1976	16	1	2	1	1	1	0
1977	5	1	2	2	1	0	0
1978	2	2	2	1	0	0	0
1979	18	8	5	0	0	0	0
1980	28	6	0	0	0	0	0
TOTALS	124	d _x 34	21	11	5	3	2
No. banded birds available/interval		124	96	78	76	71	55
% banded birds available recovered dead (d' _x)		27.4	21.9	14.1	6.6	4.2	3.6

Table 5. Downy Woodpecker band records summarized by years of banding returns.

Banding Year	Year After Banding					
	1	2	3	4	5	6
1972	3	3	3	1	0	0
1973	4	4	3	1	0	0
1974	5	2	1	1	1	1
1975	4	1	0	0	1	1
1976	1	2	0	1	1	0
1977	1	2	2	1	0	0
1978	2	2	1	0	0	0
1979	8	5	0	0	0	0
1980	6	0	0	0	0	0
	34	21	10	5	3	2
	-6	-5	-1	-1	-1	-1
	28	16	9	4	2	1

Table 6. Survival rates by age groups for the Downy Woodpecker.

Year 1 to Year 2	16 - 28	=	57.14
Year 2 to Year 3	9 - 16	=	56.25
Year 3 to Year 4	4 - 9	=	44.44
Year 4 to Year 5	2 - 4	=	50.00
Year 5 to Year 6	1 - 2	=	50.00
Weighted Mean	32 - 59	=	54.24