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REFERENCES

BENT, ARTHUR CLEVELAND. 1946. Life Histories of N. A. Jays, Crows, and Titmice. Smithsonian Inst., Washington, D. C.

BRACKBILL, HERVEY. 1949. Courtship Feeding by the Carolina Chickadee and Tufted Titmouse. *Auk*, **66**: 290-292.

BUTLER, A. W. 1897. Birds of Indiana, Dept. of Geology and Natural Resources, Indianapolis.

GILLESPIE, MABEL. 1930. Behavior and Local Distribution of Tufted Titmice in Winter and Spring. *Bird-Banding*, **1**: 113-127.

HINDE, R. A. 1952. The Behavior of the Great Tit (Parus Major) and Some Other Related Species. 201 pp. E. J. Brill, Leiden.

MIDDLETON, RAYMOND J. 1949. Tufted Titmouse Nesting Seven Years. *Bird-Banding*, **20**: 15-16.

NICE, MARGARET M. 1931. Birds of Oklahoma. Univ. of Norman Press, Norman.

ODUM, EUGENE P. 1941. Annual Cycle of the Black-capped Chickadee. *Auk*, **58**: 314-333.

——— 1942. *Auk*, **59**: 499-531.

OWEN, HELEN AND PAUL. 1956. Tufted Titmice Burying Sunflower Seeds. *Ky. Warbler*, **32**: 62.

PRICE, JOHN B. 1936. The Family Relations of the Plain Titmouse. *Condor*, **38**: 23-28.

SIBLEY, CHARLES G. 1955. Behavioral Mimicry in the Titmice (Paridae) and Certain Other Birds. *Wilson Bull.*, **67**: 128-132.

VAN TYNE, JOSSELYN. 1948. Home Range and Duration of Family Ties in the Tufted Titmouse. *Wilson Bull.*, **60**: 121.

WAYNE, ARTHUR T. 1910. Birds of South Carolina. Daggett Prtg. Co., Charleston.

WIGHT, E. MEL. 1934. Attracting Birds at Chattanooga. *Migrant*, **5**: 46.

WILLIAMS, ARTHUR B. 1950. Birds of the Cleveland Region.

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CHANGES IN SEX RATIO OCCURRING WITH AGE IN YOUNG CALIFORNIA QUAIL IN CENTRAL OTAGO, NEW ZEALAND

BY G. R. WILLIAMS

Studies on population dynamics of California quail in various parts of New Zealand (where they were introduced in 1862—Williams 1952) have been proceeding for some years now. One aspect of the work that will be of interest because of a number of recent articles (Hickey 1955, Campbell and Lee 1956, Rosene and Fitch 1956, Wallmo 1956) is that of changes in the sex ratio of this species that occur with advancing age.

First of all, it is well known that the sexes can be distinguished at an age of six to seven weeks; secondly, I have found—as will appear elsewhere—that young birds may be aged with fair accuracy (to within about three to four days either way from the true date of hatching) up to an age of about 22 weeks by means of the progress of the primary wing molt

(though the molt, or rather the growth of the 8th primary, is not absolutely complete until 25 weeks). Such a method has already been described for bobwhite quail by Petrides and Nestler (1943, 1952), and Thomson and Kabat (1950), for the scaled quail by Wallmo (1956), and recently, for the California quail in California by Genelly (1955). Thirdly, birds one year of age or more may, of course, be readily distinguished from immatures by their possession of unmottled upper primary coverts.

Incidentally, it seems timely to suggest a clear and systematic way of referring to the different age components in the population of the various species of quail and, perhaps, other game birds for that matter. Thus: *Chicks*—those that have not yet begun to undergo the first primary wing molt, *juveniles*—those in which the first primary wing molt is in progress, *immatures*—those that have completed this molt, and *adults*—those that have undergone a general post-nuptial molt. In the case of the species of quail already mentioned, the *approximate* ages in each group will be respectively—0-4 weeks, 4-25 weeks, 25 weeks to 12 months and 12 months or more. In these same species—and most others—primaries IX and X are usually retained during the first year.

This paper is confined almost entirely to a discussion of sex ratio changes in a quail population that has been sampled by trapping and banding only. Another method of sampling is by shooting, but this will be discussed more fully elsewhere.

All birds trapped and banded are sexed, aged (accurately if they are juveniles), and weighed, the last, among other things, being a useful check on the ageing. To reduce errors in what follows, no sexings in birds of less than six weeks have been accepted for it is felt that the state of the molt in these categories may be such as to cause appreciable errors in the sexings of males, resulting in their being classed as females. At present there are not sufficient numbers in some of the weekly age groups to allow reliable comparisons to be made between them individually; therefore, a certain amount of "lumping" has had to be done, as may be seen from the table. Furthermore, to reduce any bias that may arise because of the development of a "trap habit" only birds trapped *once* have been used in the calculations. In a two-year study the following distributions were obtained:

	1955			1956			1955 & 1956		
AGE GROUP	♂	♀	% ♂	♂	♀	% ♂	♂	♀	% ♂
6- 9 weeks	5	6	45.4	9	30	23.1	14	36	28.0
10-13 weeks	18	35	33.0	44	75	37.0	62	110	36.1
14-17 weeks	45	36	55.5	58	51	53.2	103	87	54.0
18+ weeks	7	5	58.3	17	13	56.7	24	18	57.2
Adults	91	49	65.1	101	58	63.6	192	107	64.0

(Ages among the juveniles are taken to the nearest week)

With one minor exception, clear and approximately parallel trends occur for each year, and although the samples within each particular group are not always as large as one would like, the fact that similar trends *are* nevertheless obtained is reassuring as far as their general reliability is concerned. An X^2 test, using the juveniles only, shows that there is an association between the sex ratio and the age, significant

at about the 0.001% level. However, future work may show that the figures so far obtained may need some adjustment; the earlier part of the trend seems remarkably steep. But, even if the first age group (wherein sexing errors are most likely to arise) is eliminated from our consideration, a clear trend is still apparent. It should, perhaps, be mentioned here that in the 18+ weeks group the time of trapping (approximately 10 to 18 weeks after the peak hatching period in early December) ensures that very few birds are older than about 25 weeks.

For this particular area (mainly the Poison Creek Field Experimental Station in Central Otago, South Island), it is unfortunate that there are insufficient figures from trapping and banding operations to allow of the inclusion of another age group (i.e. *immatures*) between the 18+ week class and the adults, for it would be comforting to find a figure intermediate in value between 57.2% and 64.0% for it. However, information *is* available for a late-immature group but it has been obtained from the results of trapping over a much wider area in Central Otago for a number of years. The percentage of males calculated from these data (the mean age of the birds being 6-7 months) is found to be 48.6 (118/244) but this is not significantly different by X^2 test from the 1955-1956 figures for the 18+ week group. Nor are either of these percentages significantly different from that found for the same late-immature age group by calculation from *shooting diary* returns from Central Otago over the last 8 years (51.2%: 2014/3933). Since, at the 95% level, the confidence limits for the 18+ week group at Poison Creek lie between 41% and 71% males, the suggestion made earlier that the Poison Creek figures at present available may exaggerate the real trend is not inconsistent with the results of the statistical analysis so far. Furthermore, because the figures for the 18+ week group are not significantly different from those obtained for birds in the late-immature group some three months later, it appears that the major difference between the sexes in mortality among young birds has disappeared by then.

Admittedly the following explanations may be offered to account for the trend just described: (i) it results from a difference in the tendency of each sex to enter the traps; or (ii) it is merely a measure of the certainty of correctly identifying the sexes as the birds grow older. Let us take each of these in turn for discussion:

Any argument that maintains that there is a sex difference in "trapability" must postulate a gradual reversal of its expression—males becoming less wary as they grow older and females more so. It must also account for the fact that both shooting and trapping yield the same late-immature and adult sex ratios. That two different methods of sampling are biased in the same direction to the same degree is no doubt possible but rather unlikely. The simplest hypothesis seems the best: both shooting and trapping can give a reliable sample of the population as a whole—a point of view reached intuitively by Emlen (1940), for the California quail in California, and by Stoddard (1931) for the bobwhite. Besides, the method of trapping is such that a sex difference in "trapability," should it exist at all, seems likely to exert very little influence: there is no evidence that parties predominantly

of one sex are formed at the ages with which we are mainly concerned, and the traps themselves are essentially shallow rectangular wire nets four feet or more square which, when set, have only one side in contact with the ground and so may be readily approached from three sides. There are no narrow entrances. To reduce wariness food is laid about the traps and they are left propped up for three or more days before the automatic tripping device is set. (In many cases when statistical analysis has shown there to be a trap bias of some kind—see, for example, the elegant analysis by Leslie, Chitty & Chitty, 1953—the traps used have a restricted entrance.)

As for incorrectly identifying the sexes, the only group in which this might be an appreciable source of error is that including birds 6-9 weeks of age. However, even with this group disregarded, the trend among the young birds is still quite clear (and significant at the 0.001% level). Sexing errors in the one direction (males wrongly classified as females) of about 25% and 15% respectively would be needed in the first two age groups in the table to upset the trend which is apparent there. There is no evidence, so far, that errors of such magnitude are being made; in fact, an examination of the records available at present of birds within these groups that have been retrapped or shot indicate that any such error is less than 5%.

Measurements of apparent differences in mortality rates between the sexes in young birds such as I have described in this paper seem to have been made only rarely on wild populations of other birds, no doubt because of the general difficulty in accurately ageing and sexing the juveniles of most bird species. What is usually reported is no more than a comparison of the sex ratios between birds of the year *as a whole* and adults (c.f. for species of quail: Stoddard 1931, Emlen 1940, Leopold 1945, Lehmann 1946, Hickey 1955, and Campbell & Lee 1956). If figures for *all* birds trapped in Central Otago over a number of years are compared in this way we get a result similar to those given by the authors just cited, but our analysis of one segment of the juvenile and immature group has shown that there seems to be an age/sex structure within it that had not previously been suspected. Earlier explanations of the cause of the discrepancy between the two groups as a whole had suggested that an approximately equal sex ratio at hatching is upset once breeding age is reached, and females begin to suffer greater stresses and risks than males. It now appears, in California quail at least, that an imbalance between the sexes may appear long before the birds reach breeding age and even before the population is subjected to the mortality exerted by shooting. The risks and stresses attendant upon breeding activity may then accentuate this imbalance. In other species of quail the odd occasion when a sex ratio among the young birds *as a whole* favoured females was regarded as anomalous and due to improper sampling (c.f. Campbell & Lee 1956), but whether or not females will predominate in such a group may depend upon the time of year at which the population was sampled; for example, in our table only 203 of the 454 juveniles are males, that is, 44.7%.

A rather interesting fact emerges if a comparison is made between the *adult* sex ratios given for California quail and bobwhite quail in Table No. 8 in Hickey (1955), those given for Gambel's and scaled quail in Campbell & Lee (1956) and California quail in this paper: The value of X^2 in a 2x9 contingency table is 11.148 which indicates that the ratios are not significantly different from each other. Thus, in these quail the *adult* sex ratio seems remarkably insensitive to variation in species or locality, and has a value of approximately 62:38 in favour of males. A similar result emerges when an analysis is made of the sex ratios among *immature* birds using Hickey's table for California quail and bobwhite and the figures given in this paper for late-immatures from Central Otago obtained by trapping and by shooting over a number of years. Campbell & Lee's figures for Gambel's and scaled quail were not included as their "young-adults" include birds up to about 18 months old. In a contingency table the value for X^2 was found to be 5.81 which is not significant for 7 degrees of freedom, and the value of the ratio is approximately 51:49 also in favour of males.

If the trend that has been demonstrated is real and of fairly general application, it poses some rather interesting questions: For example, what is the true sex ratio in California quail at hatching? If it is unity at fertilization, is there a greater mortality among males *in ovo* or does it occur between hatching and an age of about six weeks, to be followed by a period in which males have a better survival rate, comparatively, than females for a time until an equilibrium is reached some time late in what is usually called the "postjuvenile" moult? The last seems the most likely explanation, but there is no way of being sure at present. Of course, the preponderance of females in the earliest age groups may, in reality, prove to be far smaller than the available figures suggest. *In proof:* Results for 1957 have just been analysed. When added to those already given for 1955 plus 1956 the result is to decrease the steepness in the trend among the juveniles by increasing the proportion of females in the 6-9 week group and slightly decreasing that of males in the 18+ week group. But the picture is essentially unchanged: an excess of males becomes obvious from the 14-17 week group onwards and mortality rates in both sexes are then approximately equal until adulthood is attained. Work on this project is to be continued and should confirm the figures we have, or allow a more accurate approximation to the truth to be made. However, the present findings seem of sufficient importance to justify their publication at this stage so that other workers might be prompted to look for a similar phenomenon elsewhere. Lack (1954) reviews some markedly unequal sex ratios claimed to occur among the young birds of a few species—in particular, some of the *Icteridae* and the sparrow hawk *(Accipiter nisus)*—but he makes the point that equality is usual in young birds as a group. But, as we have just seen and reflection will show, this does not mean that a trend may not be occurring *within* such a group. Nevertheless, because there are relatively few species in which it is possible to age and sex birds from an early stage, such a trend would be hard to detect unless it were uniform throughout, and the sexual differences in mortality of a reasonable magnitude.

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LITERATURE

CAMPBELL, H. & L. LEE. 1956. Notes on the sex ratio of Gambel's and scaled quail in New Mexico. *Jour. Wildl. Mgmt.*, **20**: 93-94.

EMLEN, J., JR. 1940. Sex and age ratios in survival of the California quail. *Jour. Wildl. Mgmt.*, **4**: 92-99.

GENELLY, R. E. 1955. Annual cycle in a population of California quail. *Condor*, **57**: 263-285.

HICKEY, J. J. 1955. Some American population research on gallinaceous birds. *in* Recent studies in avian biology, A. Wolfson, ed. Univ. of Illinois Press, Urbana.

LACK, D. 1954. The natural regulation of animal numbers. Oxford Univ. Press.

LEHMANN, V. W. 1946. Bobwhite quail reproduction in southwestern Texas. *Jour. Wildl. Mgmt.*, **10**: 111-123.

LEOPOLD, A. S. 1945. Sex and age ratios among bobwhite quail in southern Missouri. *Jour. Wildl. Mgmt.*, **9**: 30-34.

LESLIE, P. H., D. CHITTY & H. CHITTY. 1953. The estimation of population parameters from data obtained by means of the capture-recapture method. *Biometrika*, **40**: 137-169.

PETRIDES, G. A. & R. B. NESTLER. 1943. Age determination in juvenal bobwhite quail. *Amer. Midl. Nat.*, **30**: 774-872.

——— 1952. Further notes on age determination in juvenile bobwhite quails. *Jour. Wildl. Mgmt.*, **16**: 109-110.

ROSENE, W., JR. & F. W. FITCH. 1956. A comparative test of the investigator as a variable in aging quail. *Jour. Wildl. Mgmt.*, **20**: 205-206.

STODDARD, H. L. 1931. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons, New York.

THOMSON, D. R. & C. KABAT. 1950. The wing molt of the bobwhite. *Wilson Bull.*, **62**: 20-31.

WALLMO, O. C. 1956. Determination of sex and age of scaled quail. *Jour. Wildl. Mgmt.*, **20**: 154-158.

WILLIAMS, G. R. 1952. The California quail in New Zealand. *Jour. Wildl. Mgmt.*, **16**: 460-485.

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DISPERSAL FROM A BANDING STATION: STARLINGS AND ROBINS

BY JOHN T. NICHOLS

STARLINGS

Bird-banders realize that a proportion of the birds at their feeding-and-banding station carry their bands, but that the proportion falls off abruptly a short distance away, and not far away a banded bird is rarely seen. I have computed a theoretical ratio between the proportion of banded Starlings where banded, and an estimated 650 yards away, where I take the railroad train from Garden City, Long Island,