ILLINOIS NATURAL HISTORY SURVEY

Bulletin

Printed by Authority of the State of Illinois

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Volume 27, Article 6
August, 1961

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This paper is a contribution from the Section of Wildlife Research.

(08324—6M—10-60) 2

FOREWORD

THE present publication illustrates again the importance of continuing certain types of research over a long period of time in order to get data which allow for significant deductions to be made. Further, as the investigation reported here is in a sense pioneering work, much thought has had to go into data analysis, into weighing the importance of data, and into attempts to find the significance and relative importance of the many facts discovered. These operations have necessitated the delay of publication until it was felt that the data and conclusions could withstand the inspection of waterfowl scientists and other biologists and, more importantly, contribute significantly to our understanding of North American waterfowl.

Certainly, the analysis of the data and the developing of the philosophy of the place of sex ratios and age ratios in population mechanics was not an easy task; the data have been about as abstruse as any collected in waterfowl research.

The project was conceived by Arthur S. Hawkins in 1938, while he was employed by the Illinois Natural History Survey, and great credit for far-sightedness must go to him. It must be remembered that, at the time of the project's initiation, even good aging techniques were still to be perfected. When Mr. Hawkins entered the armed forces in 1941, Mr. Bellrose took over the study. Dr. Low contributed to the project in Illinois from 1941 to 1943 and furnished Utah data after he left Illinois.

Through the last 20 years, Mr. Bellrose has carried the brunt of the load, and in recent years Dr. Scott has contributed immeasurably to data analysis and the preparation of the study for publication, as well as arranging with the National Science Foundation for the financing of publication costs. Others, mentioned in the text, have given unselfishly of their time and talents.

Last, but by no means least, we should mention the long hours—often extending into the night—spent by James S. Ayars, Technical Editor, in working with the authors and the data. His was, as usual, a heavy and significant contribution.

It is my hope, as well as that of the authors, that this contribution will be of value in the understanding and the management of waterfowl populations over a wide area and for a long time to come.

HARLOW B. MILLS, *Chief*
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Trapping and banding ducks at the Chautauqua National Wildlife Refuge near Havana, Illinois, November, 1939.

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Determining the sex and age of ducks killed by hunters in the Illinois River valley, November, 1952.

Sex Ratios and Age Ratios in North American Ducks

FRANK C. BELLROSE, THOMAS G. SCOTT, ARTHUR S. HAWKINS, AND JESSOP B. LOW*

MANAGEMENT of waterfowl includes the intelligent manipulation of their populations. The sex classes and age classes of various species of ducks constitute measurable elements of the populations. The present study deals primarily with sex ratios and age ratios and the ways in which they relate to population productivity. Nearly three decades ago Leopold (1933:165–6) wrote: "All measurements of either game population or game productivity are enhanced in their significance and value if the sex and age as well as the number of individuals be determined."

Although observations on the age ratios of ducks have been recorded for more than a decade and on the sex ratios for more than two decades, the true relationship of these ratios to productivity has not been well understood. Much of the difficulty in understanding this relationship has stemmed from observed differences in sex and age ratios between species, regions, and seasons. Often the reported samples have favored one sex or age class so markedly as to indicate bias.

Some investigators of sex ratios in waterfowl have pointed out mathematical bias resulting from shortcomings in the techniques used and biological bias resulting from unusual responses of the birds to seasonal changes. Early in this study it was apparent that age ratio data were subject to bias resulting from the same causes. Moreover, there appeared to be additional causes for bias in the data relating to both sex and age ratios. Despite many difficulties in obtaining reliable data, progress has been made in interpreting the role of sex and age ratios in the productivity of waterfowl.

In this paper, sex ratios are expressed usually as the per cent of a population consisting of drakes, the ratio of hens to drakes, or the number of drakes per hen; age ratios as the per cent of a population consisting of juveniles (ducks that have reached the flying stage but have not completed 1 year of life), the number of juveniles per adult, or the ratio of adults to juveniles.

The statistical significance of differences among samples or among assumed ratios was determined by either making chi-square tests or referring to tables presented by Mainland, Herrera, & Sutcliffe (1956). These methods assume that the samples taken were independent observations of the characteristics being measured and that the samples were taken from homogeneous populations. It seems likely that often these assumptions were not entirely met. Therefore, the results of these tests should be viewed cautiously. In those instances in which there is a very low probability that the differences could have been due to chance, it seems very likely that the differences were real.

Technical names and all but one of the common names of ducks discussed in this paper are from the Fifth Edition of the *Check-List of North American Birds* (Anonymous 1957). Because of its wide usage among hunters and its inclusion in the Fourth Edition of the *Check-List,* the name *baldpate* was used in place of *American widgeon.* The listing of species in the tables is in accordance with the phylogenetic arrangement that was in use at the time the greater part of the study reported here was being made.

ACKNOWLEDGMENTS AND SOURCES OF DATA

The study on which this paper is based was begun in 1938. Most of the data presented here were collected by personnel of the Illinois Natural History Survey

*Frank C. Bellrose and Thomas G. Scott are members of the staff of the Illinois Natural History Survey. The other two authors were members of the staff in the initial stages of the project reported here. Arthur S. Hawkins is now Biologist, United States Fish and Wildlife Service, stationed at Minneapolis, Minnesota; Jessop B. Low is Leader, Utah Cooperative Wildlife Research Unit, Utah State University, Logan.

from inspection of trapped ducks and bagged ducks taken in Illinois from early autumn of 1939 through 1959. Other extensive data were obtained as follows: from Arthur S. Hawkins and employees of the Delta Waterfowl Research Station and the Canadian Wildlife Service, who checked the age and sex of ducks in Manitoba in 1946 and several subsequent years; from Hawkins and John J. Lynch of the U. S. Fish and Wildlife Service and Frank C. Bellrose, who checked hunters' bags in the Stuttgart, Arkansas, area at various times from 1946 through 1959; from Jessop B. Low, who obtained bag inspection data in Utah in 1943 and 1944; and from Noland F. Nelson of the Utah Department of Fish and Game, who continued this work from 1946 through 1950.

Data obtained from biologists other than the authors of this paper have been acknowledged, when possible, in connection with the table or graph presenting the data. Uncredited data from certain areas should be ascribed to the individuals listed below: John M. Anderson, data from Winous Point Gun Club, near Sandusky, Ohio; George C. Arthur, Illinois Department of Conservation, data from the Mississippi River in Illinois; Merrill C. Hammond, U. S. Fish and Wildlife Service, data from North Dakota; L. R. Jahn, Wildlife Management Institute, and Ralph Hopkins, Wisconsin Conservation Department, data from Wisconsin; Herbert J. Miller and personnel of Pittman-Robertson Project No. 45-R, Michigan Department of Conservation, data from Michigan; Charles T. Shanks, Missouri Conservation Commission, data from Missouri; Harvey W. Miller and John H. Wampole, formerly with the Nebraska Game, Forestation, and Parks Commission, data from Nebraska; T. Stuart Critcher and Yates M. Barber, North Carolina Wildlife Resources Commission, data from North Carolina; and Charles K. Rawls, Jr., Tennessee Game and Fish Commission, data from Tennessee.

Roberts Mann, David H. Thompson, and John Jedlicka of the Forest Preserve District of Cook County, along with personnel of the Illinois Natural History Survey, co-operated in the banding program at McGinnis Slough, Cook County, Illinois. Robert D. Crompton and other field assistants of the Illinois Natural History Survey conducted the banding programs at Lake Chautauqua, Mason County, Illinois.

Aelred D. Geis of the U. S. Fish and Wildlife Service and Stuart H. Mann of the Illinois Natural History Survey assisted in the statistical analysis of the sex and age ratio data and gave valuable suggestions for improving the manuscript. George H. Kelker of Utah State University read the manuscript and made helpful comments. Mrs. Frances D. Robbins, formerly with the Illinois Natural History Survey, and Ralph E. Yeatter, now and for many years a member of the Survey staff, aided in the preparation of the paper. James S. Ayars of the Natural History Survey edited the manuscript.

Appreciation is extended to all who assisted in the gathering of data and the preparation of the paper.

Publication of this paper was made possible through financial assistance from the National Science Foundation: Grant NSF-G11143.

SEX RATIOS

For several decades, waterfowl hunters and ornithologists have noted a lack of balance in the ratios of drakes to hens in the populations of various species of ducks. Some of them have called attention to the greater numbers of drakes and have expressed concern because they believed the "extra" drakes served no useful reproductive function. Others have called attention to the unequal sex ratios as possible signs of sick populations.

For example, Leopold (1933: 111) in discussing sex ratios in ducks stated:

> All of Lincoln's evidence points toward the existence of a seriously deranged sex ratio. How long it has existed, or what causes it, remains unknown. It is barely possible, of course, that it always has existed, and represents a normal condition, but this seems improbable, especially in a group of species less strongly monogamous than most other birds. The reader should note that here again we have an excess of males associated with a known decline in population, and a known trend toward adversity in recent climatic and range conditions.

Although unbalanced sex ratios among ducks were noted many years ago, little research was done on the subject until about 1940.

Determining the causes of unbalance in sex ratios among ducks is difficult because the birds have a high degree of mobility and because each of the species involved has its own population structures, migration schedules, and migration routes. Also, in some species the drakes and hens do not migrate at the same times or along the same routes. In short, the determination of sex composition in duck populations presents a difficult sampling problem complicated by differences in species, seasons, and places, and by sampling techniques that are inadequate.

Previous Sex Ratio Studies

In order to provide for an understanding of the various ways in which calculated sex ratios may vary with sampling methods or with location and season of observation, a brief review of the most important papers on waterfowl sex ratios is offered.

Over 25 years ago Lincoln (1932) asked and answered the question: "Do drakes outnumber susies?" Since that time, observers have agreed unanimously with Lincoln's answer that drakes outnumber hens in the North American duck population. There has been but little agreement, however, on the degree of unbalance or the reliability of the various methods used to obtain sex ratio data.

Lincoln (1932:3, 16) assumed that drakes and hens were taken in traps in the same proportions in which they occurred in nature but that hunters selected drakes in preference to hens. He found that drakes comprised 59.7 per cent of 40,904 ducks representing 10 species trapped and banded in North America and included in his study.

From extensive observations made during trapping and banding of ducks at Avery Island, Louisiana, during 1934–1938, McIlhenny (1940:91–3) concluded that there was a seasonal variation in sex ratios and presented data on the pintail (*Anas acuta*), blue-winged teal (*Anas discors*), ring-necked duck (*Aythya collaris*), and lesser scaup (*Aythya affinis*) which showed that, while drakes consistently outnumbered hens, the difference was less marked in autumn than in winter and spring. Of 51,884 ducks of nine species banded by McIlhenny, 67 per cent were drakes, and only 33 per cent were hens. McIlhenny (1940:87), like Lincoln, believed that hunters selected drakes in preference to hens.

In Minnesota, Erickson (1943:32–3) recorded the sex of 6,008 ducks of 15 species observed in the field during the spring migration periods of 1938, 1939, and 1940; drakes comprised 65 per cent of the populations sampled. There were significant differences between sex ratios in two periods, one early and one late in the spring. Erickson concluded from his study that "the disparity of the sex ratios obtained by trapping have been overemphasized."

On the basis of limited data, Petrides (1944:565–67) concluded that the available evidence, though inadequate, indicated "that banding traps may be less attractive to female than male ducks." He compared the sex ratios of 6,359 banded ducks—mallard (*Anas platyrhynchos*), pintail, and lesser scaup—killed by hunters, and represented by return cards in the files of the U. S. Fish and Wildlife Service, with the sex ratios of trapped ducks of the same species as recorded by Lincoln (1932:16) prior to hunting. He found that there was "negligible sex selection by hunters." Sight observations that Petrides (1944:568–70) made in and near Washington, D. C., in 1941–1943 on 25,870 ducks (most of them pintails) showed 56 per cent were drakes. After examination of the locations of banding stations, Petrides suggested that early studies of the sex ratios of banded ducks "might have been affected by faulty geographic sampling as well as by selectivity of traps."

On the West Coast, Beer (1945:118–20) found that sex ratios obtained from field observations were more reliable than those obtained from inspection of hunters' bags. He reported that the calculated sex ratios for most species of ducks remained the same throughout winter as well as early and late in the period of migration. His data, which included 10,180 ducks of 15 species, showed a drake to hen ratio of 1.18:1 (54 per cent drakes).

In eastern Washington, Yocom (1949: 226–7), after comparing sex ratios from hunters' reports (176 males to 100 females) with those from field observations in November and December (118 males to 100 females), decided that selective shooting accounted for the larger numbers of drakes among mallards reported by hunters. In 8,805 mallards observed in the field from late November to mid-March, the drake to hen ratio was 109:100.

Johnsgard & Buss (1956:384–5) took sex ratios of ducks in central Washington from February 15 to May 16, 1954. From their observations they concluded:

> Sex ratios of any single species varied at any given time as a result of at least two influences. First, sex ratios were more unbalanced on areas subject to human disturbance. Paired birds were the first to flush and the last to return to a disturbed area. . . .
> Second, sex ratios during any single period varied with the characteristics of the habitat.

After taking sex ratios of four species of ducks in the Netherlands, Lebret (1950:17) stated:

> Sex-ratio field counts of migratory duck do not reveal the sex-ratio in the species as a whole, but only differences in the migration of the sexes—provided the difficulty of different sex distribution within the sample areas had been eliminated.

Each of the methods of sampling for sex ratios—field observations, trapping, and inspection of hunters' bags—has inherent weaknesses that produce biased data. Only by determining the magnitude of bias and correcting for it when necessary can the degree of unbalance in sex ratios among waterfowl be ascertained.

Sex Criteria

The sex of a duck may be determined by one or more of the following characteristics: (1) plumage, (2) bill color, and (3) presence or absence of a penis. As a means for distinguishing sex, each characteristic has advantages and disadvantages.

In most species of ducks, differences in the plumage color between drakes and hens usually make possible the distinguishing of sexes at considerable distances in the field. However, at certain times of the year, the plumages of hens and drakes of most species are so similar as to make field separation difficult or impossible.

Drakes in eclipse plumage are so similar in appearance to hens of the same species that usually a bird in this condition must be in the hand before the sex can be ascertained. The sex of ducks in juvenile plumage also is difficult to ascertain unless the birds are in the hand; in some species no plumage differences are visible until the ducklings are several weeks old. For example, in the wood duck (*Aix sponsa*), the two white bars which extend upward behind each eye of the male and serve to distinguish the male from the female do not begin to appear until the duckling is 4 to 5 weeks of age. In the redhead (*Aythya americana*), the male first shows the distinguishing marks, delicate white vermiculations of the scapulars and interscapulars, at an age of 5 to 6 weeks (Weller 1957:19). In the canvasback (*Aythya valisineria*), the male can be separated from the female by gray vermiculations on the scapulars of the male at the age of about 4 weeks (Dzubin 1959:289).

The black duck (*Anas rubripes*) is the only common duck in the United States in which drake and hen adult plumage at all times of the year are so similar as to make difficult the distinguishing of sex. Several other ducks have plumages in which the drake and hen are very similar, but these kinds are generally uncommon and have very limited ranges in the United States. They include the black-bellied tree duck (*Dendrocygna autumnalis*), fulvous tree duck (*Dendrocygna bicolor*), Mexican duck (*Anas diazi*), and mottled duck (*Anas fulvigula*).

The bill color is of most value for distinguishing the sex in certain species when the individuals are juveniles or are adults in eclipse plumages. On the bills of most species there are fine shades of color difference that distinguish between the sexes. In certain dabbling species, the hen is characterized by dark dots, spots, or blotches at the base and sides of the upper mandible; rarely are such markings found on the bill of the drake. Species in this category are the mallard, black duck, gadwall (*Anas strepera*), green-winged teal (*Anas carolinensis*), blue-winged teal, and shoveler (*Spatula clypeata*).

The most reliable characteristic for sexing ducks in which the plumage does not readily distinguish the sexes is the presence or absence of a penis, fig. 1. The technique of examining the cloaca for the

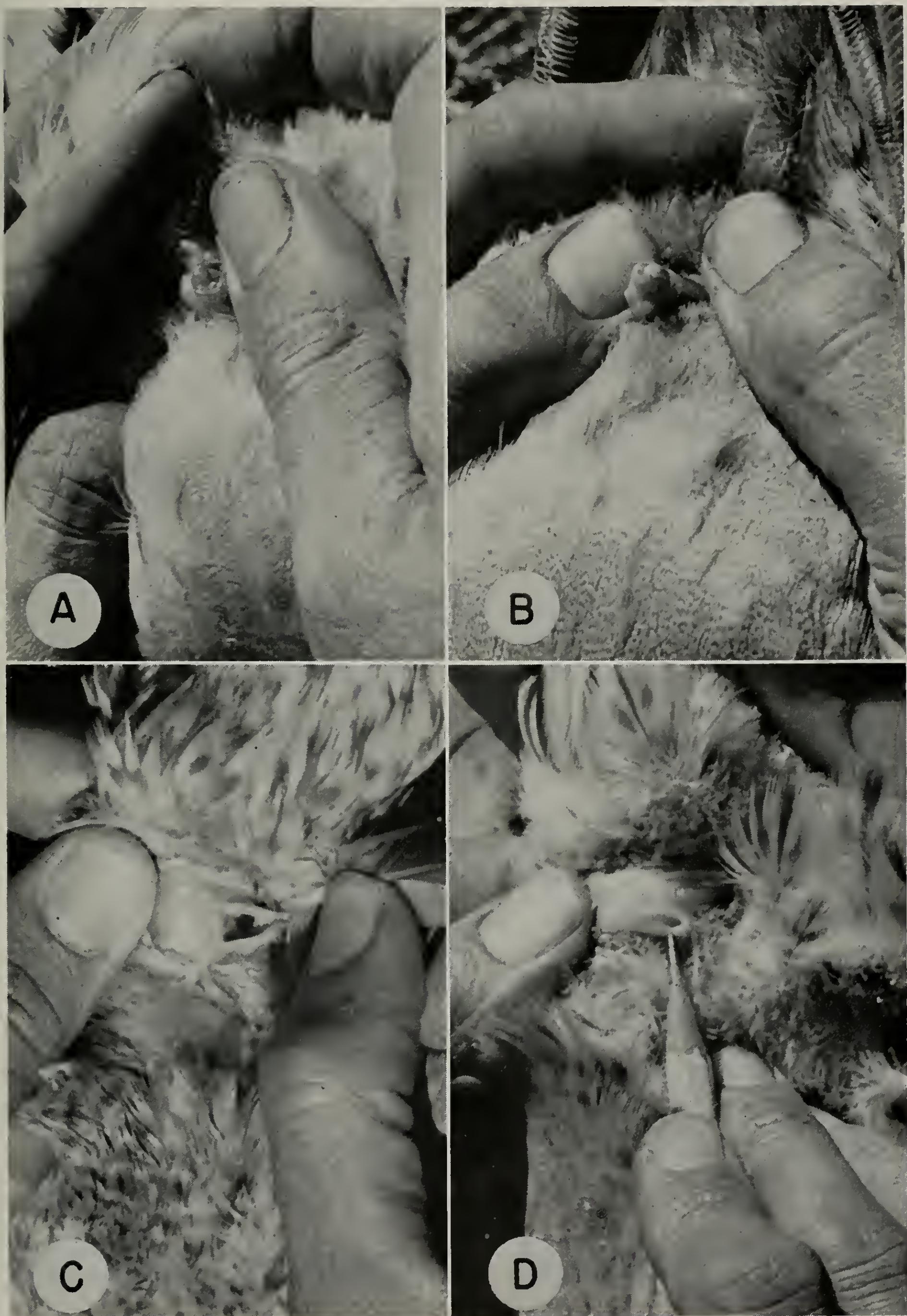

Fig. 1.—Waterfowl being sexed and aged by examination of cloaca; *A*, juvenile male mallard, with small penis; *B*, adult male mallard, with large penis; *C*, juvenile female mallard, with closed oviduct and with bursa of Fabricius disclosed by feather probe (bursa present in juvenile, both female and male, absent in adult); *D*, adult female mallard, with open oviduct (oviduct open in adult female, closed in juvenile).

occurrence of the penis has been described by Hochbaum (1942:302). Ducklings only a few days old have been successfully sexed by this method.

In the study reported here, trapped or bagged ducks that could not be readily sexed by plumage or by bill color were sexed by cloacal characters.

Sampling Populations for Sex Ratios

In the present study, several methods were used to sample waterfowl populations for sex ratios. These were (1) examination of trapped ducks, (2) inspection of ducks in hunters' bags, (3) observation of ducks in the field, and (4) examination of disease victims. In endeavoring to determine the true sex ratios existing among ducks in nature, we found that certain biases were implicit in each method. Biases in some methods were such that they could be corrected or adjusted to the extent that fairly valid ratios could be derived.

Following is a review of the four methods used in sampling duck populations for sex ratios, the advantages of these methods, and the disadvantages.

Examination of Trapped Ducks.—From the start of trapping and banding

Table 1.—Drake percentages in mallards trapped and banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, and in year-of-banding recoveries, 1939–1944 and 1947–1950. Preponderance of drakes or hens recovered is indicated by differences in percentage points: + for drakes, — for hens.

Year	Ducks Trapped and Banded			Recoveries in Year of Banding			Difference in Percentage Points
	Total Number	Number Drakes	Per Cent Drakes	Total Number	Number Drakes	Per Cent Drakes	
1939	3,474	2,574	74.1	142	114	80.3	+ 6.2
1940	5,840	4,262	73.0	442	332	75.1	+ 2.1
1941	4,834	3,200	66.2	143	100	69.9	+ 3.7
1942	6,854	4,859	70.9	512	393	76.8	+ 5.9
1943	6,445	4,655	72.2	374	284	75.9	+ 3.7
1944	3,465	2,734	78.9	222	181	81.5	+ 2.6
1947	1,786	1,481	82.9	80	65	81.3	− 1.6
1948	1,667	1,332	79.9	17	15	88.2	+ 8.3
1949	3,254	2,478	76.2	128	99	77.3	+ 1.1
1950	1,116	808	72.4	68	51	75.0	+ 2.6
All years	*38,735*	*28,383*	*73.3*	*2,128*	*1,634*	*76.8*	*+ 3.5*

Table 2.—Drake percentages in black ducks trapped and banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, and in year-of-banding recoveries, 1939–1944 and 1947–1950. Preponderance of drakes or hens recovered is indicated by differences in percentage points: + for drakes, — for hens.

Year	Ducks Trapped and Banded			Recoveries in Year of Banding			Difference in Percentage Points
	Total Number	Number Drakes	Per Cent Drakes	Total Number	Number Drakes	Per Cent Drakes	
1939	132	102	77.3	5	4	80.0	+ 2.7
1940	189	161	85.2	13	10	76.9	− 8.3
1941	549	329	59.9	7	5	71.4	+ 11.5
1942	507	348	68.6	56	42	75.0	+ 6.4
1943	417	303	72.7	28	18	64.3	− 8.4
1944	276	185	67.0	21	15	71.4	+ 4.4
1947	174	133	76.4	....	....	....	....
1948	112	87	77.7	....	....	....	....
1949	571	381	66.7	25	14	56.0	− 10.7
1950	150	110	73.3	9	5	55.6	− 17.7
All years	*3,077*	*2,139*	*69.5*	*164*	*113*	*68.9*	*− 0.6*

operations in 1939 at the Chautauqua National Wildlife Refuge, near Havana, in Mason County, Illinois, records were kept of the sex of each duck that was trapped and banded. In all of these records, the relative numbers of drakes among the mallards and black ducks were so high as to arouse suspicion that the baited, funnel-type traps being used were selective for drakes, tables 1 and 2. At McGinnis Slough, in Cook County, the relative numbers of drakes among mallards and black ducks taken in similar traps were somewhat lower, tables 3 and 4, but they were high enough to indicate that the traps tended to take disproportionate numbers of drakes.

Drakes made up about three-fourths of the mallards taken in banding traps at Lake Chautauqua in the years 1939–1944 and 1947–1950, table 1. Evidence that, among mallards, the drakes are trapped much more readily than the hens is found by comparing figures derived from trapping and banding (73.3 per cent drakes, table 1) with figures derived from inspection of hunters' bags (56.5 per cent drakes for the years 1939–1950 in table 13, or 53.8 per cent drakes after a correction factor of 1.05 has been applied to compensate for hunter preference for drakes). Mallards entered the Lake Chautauqua traps at the rate of 1.4 drakes to 1 hen. The use of data derived by one method to check on the data derived by another is discussed in the section on inspection of hunters' bags.

Further evidence that mallard drakes are trapped much more readily than the hens is found by comparing the relative numbers of birds of each sex that were retrapped in the same season at two Illinois

Table 3.—Drake percentages in mallards trapped and banded at McGinnis Slough, Cook County, Illinois, and in year-of-banding recoveries, 1941–1947. Preponderance of drakes or hens recovered is indicated by differences in percentage points: + for drakes, — for hens.

Year	Ducks Trapped and Banded			Recoveries in Year of Banding			Difference in Percentage Points
	Total Number	Number Drakes	Per Cent Drakes	Total Number	Number Drakes	Per Cent Drakes	
1941	312	195	62.5	21	14	66.7	+ 4.2
1942	1,882	1,128	59.9	143	92	64.3	+ 4.4
1943	3,009	1,922	63.9	138	78	56.5	− 7.4
1944	1.778	967	54.4	168	100	59.5	+ 5.1
1945	2,287	1,492	65.2	170	107	62.9	− 2.3
1946	1,624	860	53.0	126	61	48.4	− 4.6
1947	970	556	57.3	56	37	66.1	+ 8.8
All years	*11,862*	*7,120*	*60.0*	*822*	*489*	*59.5*	*− 0.5*

Table 4.—Drake percentages in black ducks trapped and banded at McGinnis Slough, Cook County, Illinois, and in year-of-banding recoveries, 1941–1947. Preponderance of drakes or hens recovered is indicated by differences in percentage points: + for drakes, — for hens.

Year	Ducks Trapped and Banded			Recoveries in Year of Banding			Difference in Percentage Points
	Total Number	Number Drakes	Per Cent Drakes	Total Number	Number Drakes	Per Cent Drakes	
1941	659	406	61.6	38	26	68.4	+ 6.8
1942	1,069	645	60.3	91	47	51.7	− 8.6
1943	962	595	61.9	44	24	54.6	− 7.3
1944	852	490	57.5	93	55	59.1	+ 1 6
1945	716	462	64.5	54	42	77.8	+ 13.3
1946	629	385	61.2	38	24	63.2	+ 2.0
1947	659	388	58.9	23	10	43.5	− 15.4
All years	*5,546*	*3,371*	*60.8*	*381*	*228*	*59.8*	*− 1.0*

banding stations, tables 5 and 6. Chi-square tests disclosed that the relative number of drakes retrapped was significantly greater than the relative number of hens retrapped.

Table 5.—Number of drake and hen mallards trapped and banded, and number and per cent of each group retrapped at least once in the same season, at the Chautauqua National Wildlife Refuge, near Havana, Illinois, 1940 and 1941. Sex selectivity of baited traps is indicated by the ratio of drakes to hens among retrapped ducks.

Year	Period	Number of Drakes		Per Cent of Drakes Retrapped	Number of Hens		Per Cent of Hens Retrapped	Ratio of Retrapped Hens to Retrapped Drakes
		Trapped and Banded	Retrapped		Trapped and Banded	Retrapped		
1940	Oct. 11–24	793	168	21.2	507	83	16.4	1:1.29
	Oct. 25–Nov. 7	591	111	18.8	102	3	2.9	1:6.48
	Nov. 8–21	918	86	9.4	284	11	3.9	1:2.41
	Nov. 22–Dec. 15	1,939	110	5.7	667	43	6.5	1:0.87
	Oct. 11–Dec. 15	*4,241*	*475*	*11.2*	*1,560*	*140*	*9.0*	*1:1.24**
1941	Nov. 1–7	595	36	6.1	299	8	2.7	1:2.26
	Nov. 8–21	563	97	17.2	218	19	8.7	1:1.98
	Nov. 22–Dec. 5	1,476	115	7.8	716	33	4.6	1:1.70
	Dec. 6–25	529	22	4.2	353	3	0.9	1:4.76
	Nov. 1–Dec. 25	*3,163*	*270*	*8.5*	*1,586*	*63*	*4.0*	*1:2.13†*

*Probability of difference being due to chance less than 0.02 ($X^2 = 5.95$, 1 d.f.).
†Probability of difference being due to chance less than 0.0005 ($X^2 = 33.67$, 1 d.f.).

Table 6.—Number of drake and hen mallards trapped and banded, and number and per cent of each group retrapped at least once in the same season, at Spring Lake National Wildlife Refuge, near Savanna, Illinois, 1946. Sex selectivity of baited traps is indicated by the ratio of drakes to hens among retrapped ducks.

Period	Number of Drakes		Per Cent of Drakes Retrapped	Number of Hens		Per Cent of Hens Retrapped	Ratio of Retrapped Hens to Retrapped Drakes
	Trapped and Banded	Retrapped		Trapped and Banded	Retrapped		
Oct. 17–24	173	117	67.6	121	53	43.8	1:1.54
Oct. 15–31	209	103	49.3	129	38	29.5	1:1.67
Nov. 1–7	445	171	38.4	258	75	29.1	1:1.32
Nov. 8–14	568	129	22.7	367	72	19.6	1:1.16
Nov. 15–21	189	28	14.8	108	9	8.3	1:1.78
Oct. 17–Nov. 21	*1,584*	*548*	*34.6*	*983*	*247*	*25.1*	*1:1.38**

*Probability of difference being due to chance less than 0.0005 ($X^2 = 25.39$, 1 d.f.).

Records obtained from blue-winged teals trapped and banded and later retrapped in 1944 at McGinnis Slough (Mann, Thompson, & Jedlicka 1947: 141) indicate that, at that time and place, there was no important difference between the sexes in proneness to enter traps. Hawkins found in banding blue-winged teals near the Pas, Manitoba, in 1951 that 39.0 per cent of the drakes and 31.5 per cent of the hens trapped and banded were later retrapped.

The greater tendency for mallard drakes than for hens to enter the baited, funnel-type traps at Lake Chautauqua was remarkably consistent through most of the autumn; the drake percentage in traps increased as the drake percentage in the population increased (indicated by bag checks, fig. 2).

In the mallard and the black duck, differences in behavior may contribute to differences in numbers between males and females trapped or retrapped. One difference in behavior is the greater aggressiveness of the drakes; this may occur because of differences in food demands during the fall. Studies on food consumption of penned wild mallards (Jordan 1953:122) revealed that, during the fall and winter, drakes consumed 15 per cent more food than did hens. Observations made from a blind near the traps on Lake Chautauqua showed that, when mallards were massed around the traps, the drakes were more forceful than hens in pushing their way into the traps.

Chi-square tests of data in tables 1, 2, 3, and 4 indicate that in both the mallard and the black duck the propensity of drakes to enter traps was significantly greater at Lake Chautauqua than at McGinnis Slough. The population density was much greater at Lake Chautauqua than at McGinnis Slough. Consequently, the competition for bait at trap sites was greater, the aggressiveness of drakes was

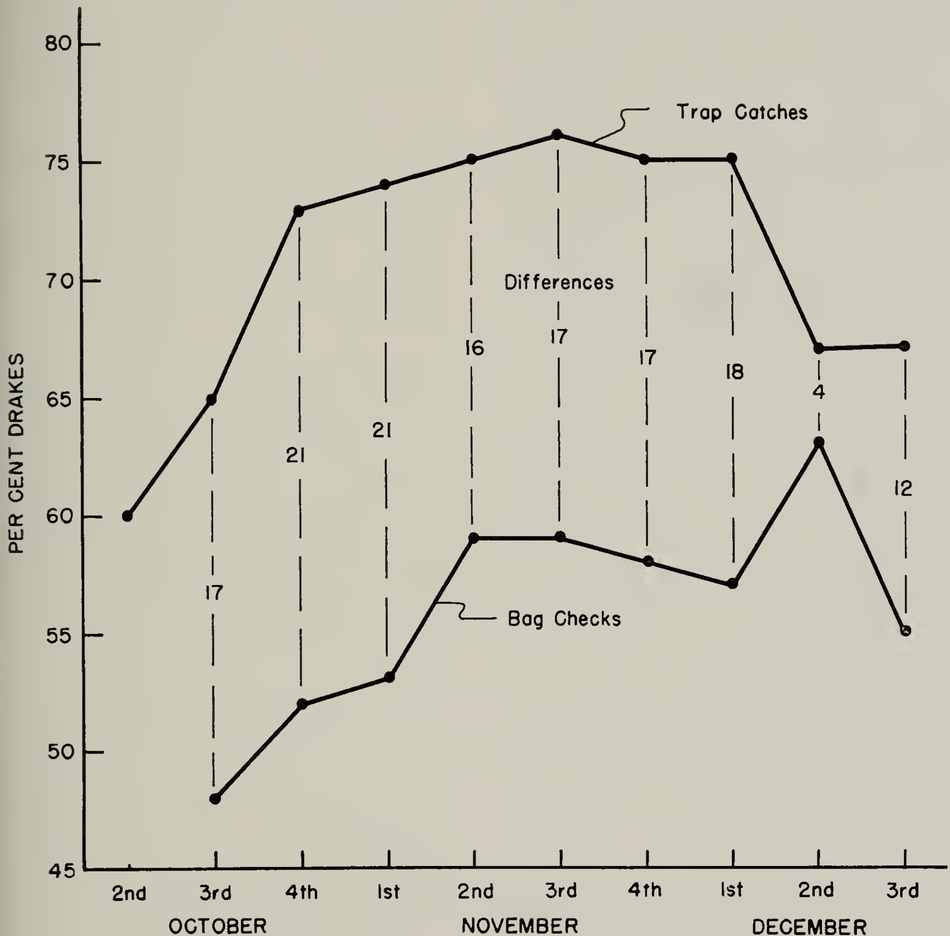

Fig. 2.—Week-to-week changes in the drake percentage of the autumn flight of mallards in Illinois, as indicated by two sampling methods: checks of mallards in hunters' bags and inspection of mallards caught in banding traps. Bag data are for the Illinois River valley, 1939–1949; trap data are for Lake Chautauqua, 1939–1944 and 1947.

greater, and the trap catch of drakes was greater at Lake Chautauqua than at McGinnis Slough.

Not all traps have been found selective for drakes. Merrill C. Hammond, biologist of the U. S. Fish and Wildlife Service, in an unpublished report prepared in 1949, stated that he captured more hens than drakes in a gate-type trap placed on shore adjacent to marsh vegetation in the Lower Souris National Wildlife Refuge in north-central North Dakota. He speculated that because of nesting activity hens were more accustomed than drakes to walking on land through tall vegetation; therefore, they would enter a trap on the shore more readily than drakes.

Supporting evidence for Hammond's speculation was obtained by Hawkins at Delta, Manitoba, in 1950. He found that in two funnel-type traps placed only a few yards apart, one in the water and the other on land, the trap in water captured 2.2 drake mallards per hen, whereas the trap on land captured only 1.5 drake mallards per hen.

Inspection of Hunters' Bags.—Inspection of ducks in hunters' bags in fall and early winter for obtaining sex ratio data was found to have some advantages. Late-molting adult drakes can be separated from hens, which they resemble during the eclipse molt, and the sexes of juveniles can be distinguished; comparisons can then be made between sex ratios of adults and those of juveniles. Available data indicate that most sex ratios derived from inspection of hunters' bags are only slightly biased, usually in favor of drakes.

Tendencies for hunters to bag proportionately more ducks of one sex than those of the other depend (1) partly upon the chronology of migration of the ducks, (2) partly upon the preferences of hunters, and (3) partly upon hunting conditions and upon skill of hunters.

Differences in chronology of migration may expose birds of one of the sexes to a greater number of hunters or make them more vulnerable to hunting than birds of the other sex.

A striking example of the relationship between the chronology of migration and shooting pressure was found in the redhead. Adult drake redheads move from their breeding grounds in southern Manitoba to more northern marshes for molting, while the hens remain on the breeding grounds, according to Milton W. Weller in an unpublished report prepared at the University of Missouri in 1954. Because bag checks showed that adult drakes comprised only a small proportion of a large kill of redheads made in southern Manitoba, Weller deduced that the southward migration of adult drake redheads involved much longer flights than the migration of adult hens. Evidence suggesting that the migration of adult drake redheads to the wintering grounds consists of long flights is given by band recoveries reported by Cartwright & Law (1952:11), who showed a much lower year-of-banding recovery rate for these birds than for juvenile males or for females.

Geis (1959:256–7) found that, among canvasbacks, adult hens and juveniles of both sexes had a higher percentage of band recoveries early in the hunting season than did adult drakes, while adult drakes had a higher percentage of band recoveries on the wintering grounds than did either adult hens or juveniles. Band recovery rates indicate that adult drakes in the canvasback, like those in the redhead, make longer flights along migration routes than do adult hens.

That hunters may prefer to shoot ducks of one sex rather than those of the other is shown by interviews with hunters and by analysis of data on duck kill. It seems logical to assume that hunters, faced with a species having a drake more brilliantly colored than the hen and given an equal opportunity at birds of each sex, would pick the more brightly colored bird, as McIlhenny (1940:87) suggested.

In Illinois, the mallard and the black duck have similar habits and behavior. On the wing, the black duck drake is identical in appearance to the hen, whereas the mallard drake, during most of the Illinois hunting season, is readily distinguishable from the hen.

That under certain circumstances hunters demonstrate a preference for drakes that are brightly colored and readily distinguishable from hens may be shown through study of the results of banding operations at Lake Chautauqua, 1939–

1944 and 1947–1950, tables 1 and 2. The drake percentage among the birds trapped can be compared with the drake percentage among the birds represented by band recoveries. Too few black ducks were banded to permit valid comparisons each year; however, when the data for the black duck were totaled for the 10 years of study, no marked hunter preference for drakes was evident in this species. In the case of the mallard, the preponderance of drakes among the banded ducks recovered indicated a consistent year-to-year tendency for hunters to select drakes to a somewhat greater extent than hens, there being only 1 year (1947) in which hunter preference for drakes was not evident.

In the period 1939–1950, the drake percentage among 2,128 mallards reported shot in the year they were banded (76.8 per cent) was shown by a chi-square test to be significantly greater than the drake percentage among 38,735 mallards that were trapped and banded (73.3 per cent), table 1. These percentage figures indicate that drakes were 1.05 times as likely to be taken by hunters as were hens. This estimate of the greater likelihood of mallard drakes being taken by hunters can be used as a correction factor to compensate for hunter preference in calculations employing other data involving the same species, the same area, the same period of years, and the same time of year. The ducks represented in table 13 were mallards shot by hunters in approximately the same area and times of year as those represented in table 1. Calculations based on data in table 13 show that for 1939–1950, the period of years covered in table 1, 56.5 per cent of the mallards checked in hunters' bags were drakes. Allowance can be made for hunter preference for drakes by applying the correction factor 1.05 to this percentage figure. The result is 53.8 per cent, which is believed to represent the average drake component of the fall populations of mallards in the Illinois River valley in the period 1939–1950.

That the degree to which hunters select drakes rather than hens may be influenced by hunting conditions and by the skill of the hunters, as well as by personal preferences of hunters, can be shown by comparison of band recovery data from mallards banded at Lake Chautauqua with similar data from mallards banded at McGinnis Slough, tables 1 and 3. Bandings at Lake Chautauqua were made in the heart of the duck hunting club area of Illinois, where ducks were comparatively numerous and where hunters, many of them experienced shots, could afford to be selective of their targets. Bandings at McGinnis Slough were in an area where competition for ducks was much keener than near Lake Chautauqua and where hunters tended to shoot at extreme ranges. Analysis of band recovery data for mallards banded at McGinnis Slough showed no hunter preference for drakes, table 3.

Even hunters who have access to the best shooting areas vary from year to year in the degree to which they choose drakes. At Stuttgart, Arkansas, in 1946, when hunting conditions were unfavorable because high water had dispersed the ducks through the swamps and when the bag limit was seven ducks, drakes comprised only 51.0 per cent of 3,350 mallards checked in hunters' bags. In the 1947 season, when hunting was much better in the Stuttgart region and the bag limit was only four, drakes comprised 59.5 per cent of the 3,317 mallards checked. Of the Stuttgart region in the hunting season of 1945–46, Hawkins, Bellrose, & Smith (1946:398) wrote: "Hunting is so good in the Grand Prairie area that the better hunters can, and a few do, deliberately select drakes." In the sample of bagged ducks they inspected, 55.8 per cent were drakes.

Field Observations. — Observations on living ducks in the field are a means of providing sex data on large samples of many species. With such data, no compensation is needed for differences in trap and hunter selectivity. It is almost impossible, however, to make a sufficient number of random counts to insure an adequate cross section of the population of a flyway or other large area. Field counts of the drakes and hens in duck populations are more readily taken in late winter and early spring than at any other time. Early in the fall the juvenile and eclipse plumages make distinguishing between the sexes difficult, and hunting activity at that time usually makes ducks

Table 7.—Drake percentages in pintails, redheads, and lesser scaups observed in the field on the Lower Souris National Wildlife Refuge, North Dakota, 1948.*

Species	Date	Number of Ducks	Per Cent Drakes
Pintail	April 22	75	56
	May 6	157	70
	May 13	204	82
	May 21	133	77
Redhead	May 6	66	53
	May 13	143	61
	May 21	137	58
Lesser scaup	April 22	243	59
	May 5 and 6	486	61
	May 13	120	68

*Unpublished data collected by Merrill C. Hammond, Biologist, U. S. Fish and Wildlife Service.

wary and difficult to approach. In winter and spring, ducks are less wary, and most of them are in their nuptial plumage; thus, in most species, the sex of each bird can be distinguished in the field with facility.

In field tests conducted in 1947 by University of Wisconsin students in game management and ornithology, the observations of several students were remarkably uniform with respect to the sex ratios they found in flocks numbering up to several hundred ducks. It seems safe to assume that field observations conducted with reasonable care can provide accurate sex ratios for flocks of ducks present in late winter and early spring.

Merrill C. Hammond of the U. S. Fish and Wildlife Service (unpublished data) found marked variations among waterfowl sex ratios observed on different sample areas or at different times, table 7. In a report, he pointed out the care necessary in making sex ratio counts in the spring on the breeding grounds (Hammond 1949: 8–9). He concluded from his observations that:

> These wide differences between certain sample areas where all [or] very nearly all of the population was counted indicate that on any given day the population on a marsh or water area is not entirely homogeneous with respects to distribution of the sexes. As Hochbaum and others have pointed out, the mated birds may frequent areas near to nesting habitats, while excess males may associate with a few females on open sloughs, channels or bays. Individual flocks and groups, even using similar habitats, for one reason or another may at times vary greatly.

A few field observations on living ducks were used in the present study to provide sex ratio data on several duck species.

Examination of Disease Victims.—At times ducks that are victims of disease offer waterfowl biologists opportunities to obtain sex ratio data. Although available information indicates that botulism and fowl cholera are not more specific for one sex than the other, it is suggested that sex ratio counts of living ducks in a disease area be made concurrently with counts of the disease victims for purposes of evaluating the relative susceptibility of drakes and hens.

Sex ratios among ducks that were victims of disease in several parts of North America were considered in the study reported here.

Sex Ratios in Different Age Classes

It is important to determine sex ratios of ducks in the different age classes as a means of discovering at what stage, or stages, of life disparity in numbers between the sexes occurs. Are there more males than females at hatching? During the first year? During adult life?

For convenience in studying sex ratios in wild birds, Mayr (1939:156–7) grouped sex ratios into three classes based upon age of birds: (1) primary sex ratio: the ratio between the sexes at fertilization; (2) secondary sex ratio: the ratio between the sexes at hatching; (3) tertiary sex ratio: the ratio between the sexes during adult life.

It is considered desirable in the present study to amend Mayr's classification to include a sex ratio for juveniles. The revised classification is as follows:

1. Primary sex ratio: the ratio between the sexes at fertilization.
2. Secondary sex ratio: the ratio between the sexes at hatching.
3. Tertiary sex ratio: the ratio between the sexes from the time of hatching to adulthood (the beginning of the first breeding season).
4. Quaternary sex ratio: the ratio between the sexes in adult life.

Primary Sex Ratios.—There is little available information on the primary sex ratio in ducks. Among wood ducks a primary sex ratio of 51 males to 49 females was determined for 574 fertile eggs by checking the sex of 85 duck embryos that died, 419 ducklings that died from paratyphoid, and 70 survivors. Hochbaum (1944:51) similarly classified embryonic and hatched ducklings of the canvasback and found 344 males and 345 females.

Secondary Sex Ratios.—The secondary sex ratios found by Sowls (1955:164) for four species of ducks are recorded in table 8. Statistical analysis of the data, which are from a study at Delta, Manitoba, revealed that at hatching the sex ratios of mallard, pintail, redhead, and canvasback ducklings did not depart significantly from a 50:50 ratio. However, in each of the four species, males exceeded females in numbers; when the data for all four species were combined, there was a slight but statistically significant preponderance of males. The findings suggest that the female embryos in these species were not as hardy as the embryos of the males. They are supported by the finding that females made up 52.7 per cent of 165 dead canvasback embryos reported by Hochbaum (1944:51). In an Illinois incubation experiment involving over 1,000 wood duck eggs, slightly more, but not significantly more, than half of the ducklings at hatching were females, table 8.

Table 8.—Male percentages found at hatching of artificially incubated eggs of four duck species at Delta,* Manitoba, and one, the wood duck, in Illinois.

Species	Number of Ducklings			Per Cent Male
	Male	Female	Total	
Wood duck..	548	564	1,112	49.3 NS
Mallard*....	394	369	763	51.6 NS
Pintail*.....	424	405	829	51.1 NS
Redhead*...	342	294	636	53.8 NS
Canvas-back*.....	315	307	622	50.6 NS

NS = Not significantly different from 50 per cent at the 0.05 probability level.
*Sowls 1955:164.

Table 9.—Drake percentages in juveniles of four species of ducks trapped in Manitoba, 1948–1950.

Species	Number of Ducks Trapped	Per Cent Drakes
Mallard............	1,720	50.2 NS
Pintail............	767	43.5*
Blue-winged teal....	4,613	47.9*
Redhead..........	757	47.3 NS
All species.........	*4,857*	*47.9**

NS = Not significantly different from 50 per cent at the 0.05 probability level.
*Significantly lower than 50 per cent at the 0.05 probability level.

Table 10.—Drake percentages in juveniles of nine species of ducks trapped in Saskatchewan, 1947–1950.*

Species	Number of Ducks Trapped	Per Cent Drakes
Mallard............	308	51.6 NS
Gadwall............	725	49.5 NS
Baldpate...........	672	56.5**
Pintail.............	273	55.3 NS
Green-winged teal...	27	44.4 NS
Blue-winged teal....	245	48.6 NS
Shoveler...........	490	50.6 NS
Canvasback........	69	56.5 NS
Lesser scaup........	87	51.7 NS
All species..........	*2,896*	*51.9*

NS = Not significantly different from 50 per cent at the 0.05 probability level.
*Unpublished data provided by John J. Lynch, U. S. Fish and Wildlife Service.
**Significantly greater than 50 per cent at the 0.01 probability level.

Table 11.—Drake percentages in juveniles of eight species of ducks trapped in Alberta, 1947–1950.*

Species	Number of Ducks Trapped	Per Cent Drakes
Mallard............	209	51.2 NS
Gadwall............	26	57.7 NS
Baldpate...........	116	50.9 NS
Pintail.............	714	54.3**
Green-winged teal...	18	50.0 NS
Blue-winged teal....	164	56.1 NS
Shoveler...........	311	50.5 NS
Lesser scaup........	43	60.5 NS
All species..........	*1,601*	*53.3*

NS = Not significantly different from 50 per cent at the 0.05 probability level.
*Unpublished data provided by Allen G. Smith, U. S. Fish and Wildlife Service.
**Significant departure from 50 per cent at the 0.05 probability level.

Tertiary Sex Ratios.—Tertiary sex ratios were derived from figures of juvenile ducks live trapped on the Canadian breeding grounds, most of them during July and August, tables 9–11. These ducks were 1 to 2 months in age. The juveniles in Manitoba were obtained by drive trapping and bait trapping, while those in Saskatchewan and Alberta were obtained by drive trapping only.

Sex ratios of ducklings in three of the four species trapped in Manitoba, table 9, showed relatively greater numbers of hens than of drakes. Statistical analysis showed that the pintails and blue-winged teals of Manitoba had highly significant excess numbers of hens. Of nine species of ducks trapped in Saskatchewan, only the baldpate (*Mareca americana*) had a significantly higher number of drakes, table 10. Of eight species of ducklings that were trapped in Alberta, table 11, seven had sex ratios that did not depart

Table 12.—Drake percentages in ducks of nine species, juvenile and adult classes, checked in hunters' bags in Manitoba, 1946–1949.

Species	Juveniles		Adults	
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes
Mallard	6,473	53.2**	1,786	49.3 NS
Gadwall	339	60.2**	137	43.1 NS
Baldpate	822	51.0 NS	147	59.2*
Pintail	1,145	51.7 NS	293	38.6**
Green-winged teal	257	57.2*	58	24.1**
Shoveler	342	50.9 NS	81	32.1**
Redhead	1,110	51.0 NS	139	51.8 NS
Canvasback	2,116	39.8**	232	49.1 NS
Lesser scaup	558	47.1 NS	302	60.3**
All species	*13,162*	*50.5*	*3,175*	*48.7*

NS = Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

Table 13.—Drake percentages in mallards, juvenile and adult classes, checked in hunters' bags in Illinois, 1939–1955 and 1959.

Year	Juveniles		Adults		Difference Between Adult (+) and Juvenile Percentages	Per Cent Drakes in Both Classes
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes		
1939	1,337	54.6**	924	65.7**	+ 11.1	59.6
1940	2,093	49.3 NS	1,471	58.5*	+ 9.2	53.1
1941	2,255	45.4**	2,226	68.7**	+ 23.3	57.0
1942	980	46.9 NS	829	67.4**	+ 20.5	56.3
1943	939	56.1**	483	67.5**	+ 11.4	60.0
1944	1,176	48.5 NS	991	68.5**	+ 20.0	57.6
1945	898	50.7 NS	1,149	67.0**	+ 16.3	59.8
1946	731	42.0**	586	61.1**	+ 19.1	50.5
1947	572	49.1 NS	242	67.8*	+ 18.7	54.5
1948	924	50.5 NS	291	60.8**	+ 10.3	53.0
1949	294	57.1*	303	67.7**	+ 10.6	63.5
1950	351	46.4 NS	230	63.5**	+ 17.1	53.2
1951	517	49.5 NS	302	60.9**	+ 11.4	53.7
1952	754	52.7 NS	453	62.0**	+ 9.3	56.2
1953	687	48.6 NS	465	64.5**	+ 15.9	55.0
1954	218	51.8 NS	240	70.8**	+ 19.0	61.8
1955	478	55.6**	268	64.5**	+ 8.9	58.8
1959	63	52.4 NS	184	66.3**	+ 13.9	62.8
All years	*15,267*	*50.4 NS*	*11,637*	*65.2***	*+ 14.8*	*57.0*

NS = Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

significantly from 50:50; the pintail had significantly more drakes.

Among 419 captive wood duck ducklings that died from paratyphoid in a hatchery at Barrington, Illinois, 51.5 per cent were females. Of 96 young wood ducks that died from other causes early in life, 48.8 per cent were females.

Information on the sex ratios of juvenile ducks 4 to 9 months old was obtained from the inspection of hunters' bags in Manitoba, Illinois, and other parts of the Mississippi Flyway.

In Manitoba during early fall, the sex ratios for a group of juvenile ducks taken by hunters were nearly balanced, table 12. Four of the nine species represented, the mallard, gadwall, green-winged teal, and canvasback, departed significantly from balanced sex ratios. The slight preponderance of males for the mallard (53.2 per cent males) was statistically significant because of the very large sample size. The gadwall and the green-winged teal had significantly more males than females, while the canvasback had significantly more females.

In Illinois, drakes made up 49.3 per cent of 12,550 juvenile mallards in hunters' bags inspected in the period 1939–1950 and 50.4 per cent of 15,267 inspected in the period 1939–1955 and 1959, table 13. Perhaps because of differences in migration schedules, considerable differences among species were evident in the calculated sex ratios for juveniles, tables 13 and 14. Highly significant deviations from a 50:50 sex ratio in the juvenile class occurred for the pintail, green-winged teal, and canvasback. The most marked deviation in the juvenile class was for the canvasback; in this species the drake segment was 39.8 per cent of 2,116 juvenile birds inspected early in the fall in Manitoba, table 12, and 64.5 per cent of 352 juvenile birds checked later in Illinois, table 14.

Table 14.—Drake percentages in ducks of nine species, juvenile and adult classes, checked in hunters' bags in Illinois, 1939–1949.

Species	Juveniles		Adults		Difference Between Adult (+) and Juvenile (−) Percentages
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes	
Black duck	371	51.7 NS	194	70.6**	+ 18.9
Gadwall	613	51.1 NS	182	58.2*	+ 7.1
Baldpate	1,128	51.5 NS	416	61.8**	+ 10.3
Pintail	2,281	58.3**	1,200	62.7**	+ 4.4
Green-winged teal	399	60.9**	160	57.5 NS	− 3.4
Shoveler	516	55.4*	110	52.7 NS	− 2.7
Ring-necked duck	717	53.8*	190	51.0 NS	− 2.8
Canvasback	352	64.5**	171	66.1**	+ 1.6
Lesser scaup	841	54.2*	441	61.0**	+ 6.8
All species	*7,218*	*55.6***	*3,064*	*61.4***	*5.8*

NS = Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

When sex ratios were calculated for juveniles from many areas in the Mississippi Flyway for 1946–1948, tables 15–17, the effect of seasonal and regional variations in the data appeared to be minimized. Deviations from a 50:50 sex ratio among juveniles were significant or highly significant statistically for only three species in 1946 and two species in 1948, tables 15 and 17. In 1947, deviations from a 50:50 ratio in juveniles were significant for one species and highly significant for four of the species listed, table 16.

The above data, obtained from trapping of ducks in the breeding season and from checking hunters' bags during the fall, indicate that the sex ratios in the tertiary or juvenile age class are close to 50:50. Local variations that exist appear to result from different seasonal movements of birds of the two sexes.

Quaternary Sex Ratios.—Populations of adult ducks normally show much larger drake segments than do those of juveniles. Exceptions are evident in the adult ducks shot by hunters in Manitoba, table 12. The data reveal for adult mallards, gadwalls, pintails, green-winged teals, shovelers, and canvasbacks in this area more hens than drakes. For pintails, green-winged teals, and shovelers, the excess of hens was highly significant. This situation came about through the movement of many adult drakes from the area prior to the opening of the hunting season. Of the species for which records are available, only baldpates, redheads, and lesser scaups showed more drakes than hens in hunters' bags in Manitoba.

Statistical analysis of data obtained from inspection of adult ducks in hunters' bags to the south, in Illinois, revealed that in most years there were significantly

Table 15.—Drake percentages in ducks of 12 species, juvenile and adult classes, checked in hunters' bags in the Mississippi Flyway, 1946.

Species	Juveniles		Adults		Difference Between Adult (+) and Juvenile (−) Percentages
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes	
Mallard	5,350	47.5**	3,593	57.1**	+ 9.6
Black duck	966	47.3 NS	215	68.3**	+ 21.0
Gadwall	474	49.7 NS	249	55.0 NS	+ 5.3
Baldpate	462	46.1 NS	119	60.5*	+ 14.4
Pintail	681	54.9*	426	65.0**	+ 10.1
Green-winged teal	360	51.6 NS	157	52.2 NS	+ 0.6
Blue-winged teal	411	46.9 NS	122	35.2**	− 11.7
Shoveler	380	49.4 NS	125	42.4 NS	− 7.0
Redhead	806	52.4 NS	204	55.3 NS	+ 2.9
Ring-necked duck	416	51.4 NS	113	55.7 NS	+ 4.3
Canvasback	1,663	45.1**	208	44.2 NS	− 0.9
Lesser scaup	510	48.6 NS	232	51.7 NS	+ 3.1
All species	*12,479*	*48.3*	*5,763*	*56.4*	*8.1*

NS = Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

Table 16.—Drake percentages in ducks of 12 species, juvenile and adult classes, checked in hunters' bags in the Mississippi Flyway, 1947.

Species	Juveniles		Adults		Difference Between Adult (+) and Juvenile (−) Percentages
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes	
Mallard	7,094	52.5**	2,604	60.8**	+ 8.3
Black duck	1,021	49.9 NS	398	55.0 NS	+ 5.1
Gadwall	647	51.3 NS	208	63.5**	+ 12.2
Baldpate	750	48.4 NS	236	60.6**	+ 12.2
Pintail	1,261	53.2*	437	53.8 NS	+ 0.6
Green-winged teal	574	62.2**	173	50.9 NS	− 11.3
Blue-winged teal	1,235	41.1**	360	31.4 NS	− 9.7
Shoveler	284	50.7 NS	56	39.3 NS	− 11.4
Redhead	396	52.8 NS	91	35.2**	− 17.6
Ring-necked duck	291	46.4 NS	85	48.2 NS	+ 1.8
Canvasback	562	38.8**	143	61.5**	+ 22.7
Lesser scaup	468	46.4 NS	310	66.1**	+ 19.7
All species	*14,583*	*50.8 NS*	*5,101*	*56.8***	*6.0*

NS = Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

more drakes than hens in the samples, tables 13 and 14. Records on 9,725 adult mallards over a period of 12 years, 1939–1950, revealed an average of 65.7 per cent drakes, with annual percentages ranging from 58.5 to 68.7 per cent; records on 11,637 adult mallards for a period of 18 years, 1939–1955 and 1959, revealed an average of 65.2 per cent drakes, with annual percentages ranging from 58.5 to 70.8, table 13. The adult class of nine other species of ducks in hunters' bags over an 11-year period, 1939–1949, contained 61.4 per cent drakes; annual percentages ranged from 70.6 per cent drakes for the black duck to 51.0 per cent drakes for the ring-necked duck, table 14.

Statistical analysis of data compiled from the inspection of adult mallards, gadwalls, baldpates, pintails, green-winged teals, shovelers, and redheads in hunters' bags in Utah over a period of 6 years, 1943–1944 and 1946–1949, table 18, revealed a highly significant greater number of drakes than hens for all species excepting the redhead.

Data from the Mississippi Flyway for 3 years, 1946–1948, tables 15–17, indi-

Table 17.—Drake percentages in ducks of 11 species, juvenile and adult classes, checked in hunters' bags in the Mississippi Flyway, 1948.

Species	Juveniles		Adults		Difference Between Adult (+) and Juvenile (−) Percentages
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes	
Mallard	7,416	52.5**	2,556	58.0**	+ 5.5
Black duck	871	47.2 NS	378	59.0**	+ 11.8
Gadwall	214	53.7 NS	31	58.0 NS	+ 4.3
Baldpate	1,068	49.5 NS	141	50.3 NS	+ 0.8
Pintail	727	51.8 NS	216	56.5 NS	+ 4.7
Green-winged teal	493	55.6*	130	49.2 NS	− 6.4
Blue-winged teal	255	47.5 NS	63	30.1**	− 17.4
Redhead	680	46.6 NS	82	51.2 NS	+ 4.6
Ring-necked duck	336	48.2 NS	66	56.0 NS	+ 7.8
Canvasback	520	48.5 NS	66	43.9 NS	− 4.6
Lesser scaup	547	49.2 NS	186	67.7**	+ 18.5
All species	*13,127*	*51.2 NS*	*3,915*	*58.1***	*6.9*

NS=Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

Table 18.—Drake percentages in ducks of seven species, juvenile and adult classes, checked in hunters' bags in Utah, 1943, 1944, and 1946–1949.

Species	Juveniles		Adults		Difference Between Adult (+) and Juvenile (−) Percentages
	Number Checked	Per Cent Drakes	Number Checked	Per Cent Drakes	
Mallard	2,027	52.3*	2,350	62.3**	+ 10.0
Gadwall	1,679	53.5**	1,955	67.7**	+ 14.2
Baldpate	2,352	52.2*	1,183	61.5**	+ 9.3
Pintail	4,230	46.8**	6,499	53.6**	+ 6.8
Green-winged teal	2,828	58.0**	4,183	72.9**	+ 14.9
Shoveler	2,480	53.7**	1,674	65.6**	+ 11.9
Redhead	734	57.3**	214	48.6 NS	− 8.7
All species	*16,330*	*52.5***	*18,058*	*62.3***	*9.9*

NS=Not a significant departure from 50 per cent at the 0.05 probability level.
*Significant departure from 50 per cent at the 0.05 probability level.
**Significant departure from 50 per cent at the 0.01 probability level.

cate that adult drakes consistently, but not in all cases significantly, outnumbered adult hens in hunters' bags for mallards, black ducks, gadwalls, baldpates, pintails, and lesser scaups. By contrast, the records show that hens were more numerous than drakes among the blue-winged teals and shovelers inspected, and year-to-year variation was evident in sex ratios among green-winged teals, redheads, ring-necked ducks, and canvasbacks. Tables 15–17 indicate the statistical significance of the departure of these sex ratios from balanced sex ratios.

Seasonal Variations in Sex Ratios

Sex ratios for many species of ducks were found to vary from week to week in any given area as the composition of the local population changed with arrival and departure of flocks containing varying numbers of drakes and hens. The seasonal changes in sex ratios were ascertained through data obtained from trapping, inspection of hunters' bags, field observation, and tallies of victims of disease.

Sex Ratios in Fall and Winter.—The sex ratios of the most important species of ducks taken by hunters during the fall hunting season in areas from the breeding grounds to the wintering grounds are indicated in table 19. Sex ratios taken in southern Manitoba for the pintail, shoveler, and canvasback suggest that large numbers of drakes make an early departure from the heavily gunned marshes of Delta and Netley. This early movement may be initially either south or north, the direction depending somewhat upon the species. Information on the early flights of drake pintails, some of which arrive at the Gulf of Mexico in August, indicates that the initial movement of these birds is south. Records of large numbers of drake canvasbacks and redheads in northern Manitoba and Saskatchewan marshes suggest that these birds probably move north from their breeding grounds before they move south.

In most species of ducks for which data are available, drakes made up a smaller proportion of the hunters' kill in Manitoba than in three states to the south, North Dakota, Illinois, and Tennessee, table 19. These data indicate that in most species more drakes than hens left Manitoba in advance of the hunting season there. A trend toward an increasing drake predominance from north to south was evident as far south as Tennessee. In all but two species for which data are available, the gadwall and shoveler, the predominance of drakes was greater in Tennessee than in Illinois. In Louisiana, a significantly greater number of hens than of drakes was evident in two species, the mallard and the pintail, and approximately balanced sex ratios were evident in four species. In all six species it was apparent that more drakes than hens were

Table 19.—Drake percentages in 12 species of ducks

Species	Manitoba, 1946–1949		North Dakota, 1949		Illinois, 1939–1950	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	8,259	52.4	2,212	57.5	22,275	56.5
Black duck	....	....	....	....	565	58.2
Gadwall	476	55.2	579	54.1	795	52.7
Baldpate	969	52.2	146	53.4	1,544	54.3
Pintail	1,438	49.0	210	53.0	3,481	59.8
Green-winged teal	315	51.1	86	53.5	559	59.9
Shoveler	423	47.3	137	51.0	626	54.9
Redhead	....	....	342	55.0	....	....
Ring-necked duck	....	....	....	....	907	53.2
Canvasback	2,348	40.7	281	56.0	931	65.3
Lesser scaup	860	51.6	136	52.2	2,012	56.2
Ruddy duck	....	....	....	....	....	....

*Sources of data for the various regions: Manitoba, Delta Waterfowl Research Station; North Dakota, Hjelle mission (personal communication); Louisiana, Richard Yancey, Louisiana Wild Life and Fisheries Commission (per- Barber, Jr., North Carolina Wildlife Resources Commission (personal communication).

north of Louisiana during a large part of the hunting season.

For all species of ducks except the shoveler, the differences in sex ratios among the various regions were statistically significant. This conclusion must be taken with some reservations because the span of years involved was not the same for each of the various areas. Some of the observed differences could be due to time as well as geographic differences.

Among adult mallards bagged in Illinois, 1939–1955, there was a steady increase in the drake segment of the fall population through the third week in November, fig. 3. The ratio between the sexes then tended to stabilize for a period, followed by an increase in the drake segment in the wintering population, usually present in Illinois after the first week in December. In Utah, sex ratios of adult mallards bagged were relatively stable throughout the autumns of several years in which bag checks were recorded, fig. 4.

Adult pintails bagged in Illinois and those bagged in Utah showed little variation in sex ratios during the fall. Adult green-winged teals and shovelers bagged in Utah showed an increase in the drake segment as the season progressed, fig. 4.

In only a few species do there appear to be differences in seasonal movement between drakes and hens of the juvenile class. In Manitoba, the canvasback had an unusually large number of hens among the juveniles bagged, table 12; in Illinois, on the other hand, this species had an unusually large number of drakes among the juveniles bagged, table 14. The drake segment of the juvenile mallard population bagged in Illinois increased through the second week of November and then tended to stabilize, fig. 3.

Sex ratios of ducks in the marshes adjacent to Great Salt Lake, Utah, have been quite variable from week to week and year to year in autumn.

The week-to-week variation in sex ratios among ducks of these marshes is understandable in view of the fact that in early summer the areas are the breeding grounds for ducks of many species, later a major molting area for transient pintails and green-winged teals, and still later one of the important migration areas for ducks in the Pacific Flyway. Chronological differences in movement of various groups of ducks—those that breed in the area, early migrants that wing-molt in the area, and large numbers of fall migrants that rest there—have resulted in ever-changing sex ratios.

Year-to-year variation in sex ratios is shown in data from the Bear River Migratory Bird Refuge at the north end of Great Salt Lake (Van Den Akker & Wilson 1951:379). In that area hens outnumbered drakes in 8 of 13 species in the period 1936–1940. However, during the hunting seasons in later years, 1943–1949,

checked in hunters' bags in seven regions in North America.*

TENNESSEE, 1951–1952		LOUISIANA, 1951		TEXAS COAST, 1947–1951		NORTH CAROLINA, 1948–1952		PROBABILITY THAT DIFFERENCES AMONG AREAS ARE DUE TO CHANCE
Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	
14,068	58.1	3,471	45.5	2,683	44.1	73	50.7	<0.0005
127	59.1	....	....	....	....	109	54.1	....
2,007	45.8	....	....	696	43.7	228	57.9	<0.0005
317	64.3	....	....	620	53.7	644	54.2	<0.02>0.01
1,084	67.1	1,204	45.9	2,688	69.5	271	70.5	<0.0005
688	63.4	1,312	49.1	1,160	54.7	96	51.0	<0.0005
174	52.3	....	....	963	48.8	201	51.7	<0.20>0.10
107	65.4	....	....	1,782	45.6	....	....	<0.0005
3,080	69.2	1,351	51.9	....	....	104	61.5	<0.0005
544	69.1	78	51.4	227	48.0	349	41.8	<0.0005
516	66.1	752	49.5	456	62.9	48	40.0	<0.0005
282	63.8	....	....	....	....	392	53.6	....

(1950:14); Illinois, authors of present paper; Tennessee, Charles K. Rawls, Jr., Tennessee Game and Fish Comsonal communication); Texas Coast, Singleton (1953:57); North Carolina, T. Stuart Critcher and Yates M.

at Ogden Bay, midway on the east side of Great Salt Lake, hens outnumbered drakes in only a few instances: in pintails 2 years and in redheads 1 year, table 20. When the statistical significance of the differences between the data for these years was investigated, the year-to-year fluctuations in sex ratios were found to be highly significant for all species except the baldpate and the shoveler. Populations that were top-heavy with drakes were observed in this same area before the hunting seasons of 1944 and 1950. Ducks that were victims of botulism in the Ogden Bay area showed that adult drakes were much more abundant than adult

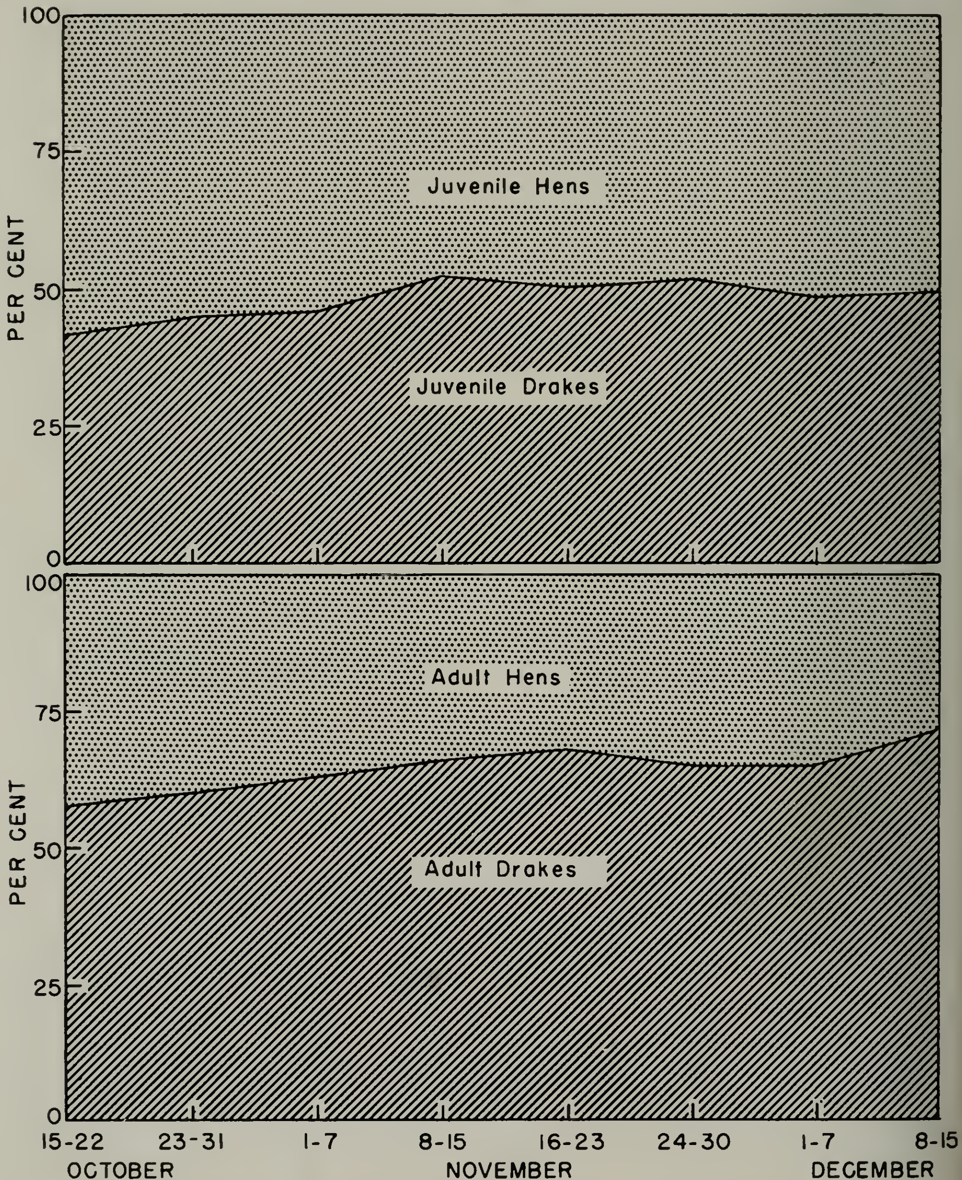

Fig. 3.—Drake-hen composition of the adult and juvenile segments of the autumn flight of mallards in Illinois, as indicated by data from checks of hunters' bags, in the autumns of 1939–1955. The drake segment of the juvenile mallard population increased through the second week in November and then became relatively stable.

Table 20.—Drake percentages in seven species of ducks checked in hunters' bags at Ogden Bay Bird Refuge, Utah, 1943–1949.*

Species	1943 Number of Ducks	1943 Per Cent Drakes	1944 Number of Ducks	1944 Per Cent Drakes	1946 Number of Ducks	1946 Per Cent Drakes	1947 Number of Ducks	1947 Per Cent Drakes	1948 Number of Ducks	1948 Per Cent Drakes	1949 Number of Ducks	1949 Per Cent Drakes	Probability That Differences Among Years Are Due to Chance
Mallard	208	61.5	318	65.4	848	59.3	2,239	58.8	1,276	54.8	1,528	56.8	<0.01>0.005
Gadwall	275	53.8	241	54.8	462	61.9	1,342	58.9	653	55.9	1,636	63.4	<0.001>0.0005
Baldpate	150	54.7	426	55.9	187	53.5	801	59.3	1,136	52.1	824	54.0	<0.10>0.05
Pintail	259	58.7	....	....	2,193	45.6	5,872	51.6	2,148	45.1	3,464	56.6	<0.0005
Green-winged teal	281	60.1	273	61.5	2,615	74.8	3,374	63.9	1,543	63.9	1,884	60.2	<0.0005
Shoveler	171	52.6	423	62.2	802	58.6	2,209	58.6	1,113	55.4	1,249	59.8	<0.10>0.05
Redhead	33	60.6	44	86.4	30	60.0	122	68.0	217	49.3	449	54.8	<0.0005

*Unpublished data for 1943–1949 supplied by Noland F. Nelson, Utah Fish and Game Department.

hens in late summer and early fall of these years, tables 21 and 22. At the Bear River Migratory Bird Refuge during the summer of 1952, drakes of several species were abnormally abundant among botulism victims, table 23.

Sex Ratios in Early Spring.—Periodic counts of ducks in late winter and

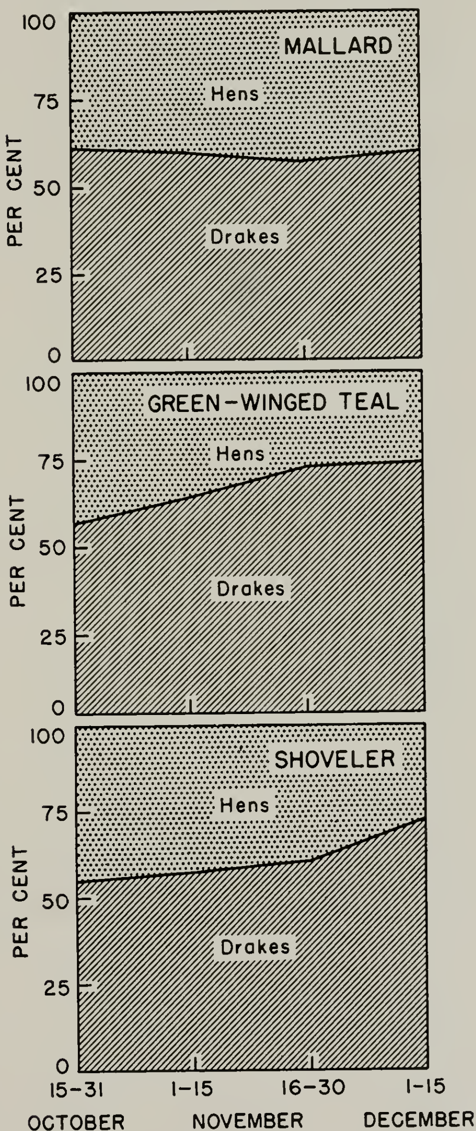

Fig. 4.—Drake-hen composition of the autumn flights of mallards, green-winged teals, and shovelers in Utah, as indicated by data from checks of hunters' bags, in the autumns of 1943, 1944, and 1946–1949.

early spring have revealed differences in the sequence of the northward migration of drakes and hens of the same species. The sequence in the migration of drakes and hens varies with the region, table 24. In the Illinois River valley, tallies of drakes and hens in late winter and spring were compiled for the years 1940–1946, fig. 5.

A preponderance of drakes was most pronounced for the mallard, pintail, canvasback, and ring-necked duck late in February. In the redhead and the lesser scaup, drakes predominated to the greatest extent in the second half of March; in the baldpate, in the second half of April.

Farther north in the Mississippi Flyway, in Minnesota, Erickson (1943:27) observed changes in the drake and hen segments of the populations during the spring migration periods of 1938–1940. Among blue-winged teals, in 2 of the 3 years, the relative number of drakes was considerably greater in the first than in the second of the two parts into which Erickson divided the migration period. Among shovelers, in each of the 3 years, the relative number of drakes was greater in the second part than in the first part of the migration period. Among lesser scaups, drakes predominated throughout the migration period in each year, but to a lesser extent in the second part than in the first. Among ring-necked ducks, the sex ratios varied little between the two parts of each migration period or among the 3 years; the average male to female ratio for the 3 years was 1.36:1 in the first part and 1.43:1 in the second part of the migration period.

Near Minneapolis, in the spring of 1950, Nelson (1950:119) observed male to female ratios of approximately 1.3:1

Table 21.—Drake percentages in seven species of ducks, juvenile and adult classes, afflicted with botulism at Ogden Bay Bird Refuge, Utah, August 1 to September 29, 1944.*

Species	Adults		Juveniles	
	Number	Per Cent Drakes	Number	Per Cent Drakes
Mallard	77	71.43	43	48.84
Gadwall	7	14.29	10	40.00
Baldpate	29	86.21	9	44.44
Pintail	502	60.56	163	45.40
Green-winged teal	292	80.14	118	62.71
Cinnamon teal	17	58.82	32	65.63
Shoveler	89	69.66	71	71.83
All species	*1,013*	*68.21*	*446*	*55.83*

*Unpublished data from Noland F. Nelson, Utah Fish and Game Department.

Table 22.—Drake percentages in six species of ducks, juvenile and adult classes, afflicted with botulism at Ogden Bay Bird Refuge, Utah, late summer, 1950.*

Species	Adults		Juveniles	
	Number	Per Cent Drakes	Number	Per Cent Drakes
Mallard	4	50.00	12	83.33
Gadwall	3	66.66	7	14.29
Baldpate	63	52.38	71	45.07
Pintail	299	70.57	91	62.89
Green-winged teal	13	38.46	9	33.33
Shoveler	34	50.00	25	48.00
All species	*416*	*64.90*	*215*	*53.85*

*Unpublished data from Noland F. Nelson, Utah Fish and Game Department.

Table 23.—Drake percentages in four species of ducks, juvenile and adult classes, afflicted with botulism at the Bear River Migratory Bird Refuge, Utah, summer, 1952.*

PERIOD	PINTAIL				GREEN-WINGED TEAL				SHOVELER				MALLARD			
	Adult		Juvenile		Adult		Juvenile		Adult		Juvenile		Adult		Juvenile	
	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes	Number	Per Cent Drakes
July																
4th week	98	76.5	84	78.6	...	...	...	...	...	...	...	...	...	...	...	...
August																
1st week	237	75.1	249	69.5	...	...	...	...	...	...	...	...	29	79.3	19	78.9
2nd week	277	76.5	283	66.1	...	...	...	...	6	83.3	11	54.5	18	88.9	20	65.0
3rd week	230	72.2	371	67.6	75	85.3	53	79.2	11	90.9	15	60.0	19	68.4	15	66.7
4th week	1,183	64.3	1,209	53.2	373	69.2	278	68.7	50	78.0	44	75.0	51	76.5	36	83.3
September																
1st week	675	54.7	536	57.4	245	59.6	186	58.1	51	56.9	36	73.3	16	50.0	13	53.8
2nd week	413	63.9	368	58.4	194	62.9	177	54.8	62	56.4	45	51.1	23	56.5	15	53.3

*Calculated from data in a report, "Sex and Age Ratio of Waterfowl Afflicted by *Clostridium botulinum*, Type C, on the Bear River Migratory Bird Refuge During Summer, 1952" by Jack P. Allen, Utah Cooperative Wildlife Research Unit, Logan.

among river ducks and approximately 2.0:1 among diving ducks.

In northwestern Iowa, Glover (1951: 486–91) recorded sex ratios for migrating waterfowl during spring in 1948 and 1949. The preponderance of drakes he observed among early arrivals of mallards and blue-winged teals declined somewhat, and thereafter the sex ratios of these species remained fairly constant. The sex ratios of gadwalls varied little during the spring. Drakes predominated in baldpate populations throughout the northward migration period, to the greatest extent toward the end of the period. The drake segment was greater than the hen segment among pintails and shovelers throughout the spring migration and showed peaks in late March, the middle of April, and early May. The drake segment among lesser scaups also exceeded the hen segment throughout the spring migration; a marked peak in drake abundance was reached during mid-April. Drakes predominated markedly among the first redhead arrivals, and again among the late departures. Among ring-necked ducks, a high peak in drake predominance occurred the first half of April; a near balance in sex ratios prevailed during the remainder of the spring migration season.

In the lower Souris National Wildlife Refuge, North Dakota, Merrill C. Hammond found marked variations in waterfowl sex ratios taken at different times during the spring, table 7. Pintail, lesser scaup, and redhead sex ratios were more heavily unbalanced in favor of drakes late in the spring than early. Changes in the sex ratios of pintails were significant at the 95 per cent level ($X^2=20.9$, 3 d.f.). The changes were not significant at the 95 per cent level for the lesser scaup ($X^2=3.1$, 2 d.f.) or the redhead ($X^2=1.2$, 2 d.f.).

In the Pacific Flyway, in western Washington, Beer (1945:119) calculated sex ratios of ducks from September through April. In December, mallard sex ratios were evenly balanced; in January, they were slightly in favor of drakes and, in February and March, slightly in favor of hens. The drake segment in the pintail population progressively declined from November through March. The sex ratio for lesser scaups was balanced in January,

Table 24.—Drake percentages in 10 species of ducks observed

Species	California, 1948–1951		Oregon, 1946–1948		Washington, 1943, 1944		North Dakota, 1939–1942, 1947–1950		Manitoba, 1939–1945	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	1,039	55.4	5,589	55.9	1,652	50.7	3,202	51.7	2,423	50.6
Baldpate	432	45.8	30	53.3	4,999	53.3	911	57.2	......	......
Pintail	......	......	4,561	57.4	622	52.2	10,173	52.7	3,250	51.9
Blue-winged teal	......	......	......	......	......	......	5,554	55.5	......	......
Shoveler	362	69.6	2,823	59.1	101	53.5	2,000	53.7	......	......
Redhead	......	......	......	......	......	......	1,805	54.8	926	58.1
Ring-necked duck	671	60.5	......	......	......	......	63	57.1	......	......
Canvasback	370	53.0	......	......	316	67.7	826	62.6	2,916	65.4
Lesser scaup	371	67.4	......	......	911	59.8	7,401	64.0	10,387	66.8
Ruddy duck	......	......	......	......	......	......	1,886	64.7	......	......

*Sources of data for the various regions: California and Oregon, Evenden (1952:393); Washington, Beer (1946:409); Minnesota, Erickson (1943:27); Illinois River Valley, authors of present paper (unpublished); Mis- (1951:487, 490) for mallard, baldpate, pintail, blue-winged teal, and shoveler, and Glover (1951:489) and Low ford (1954:78).

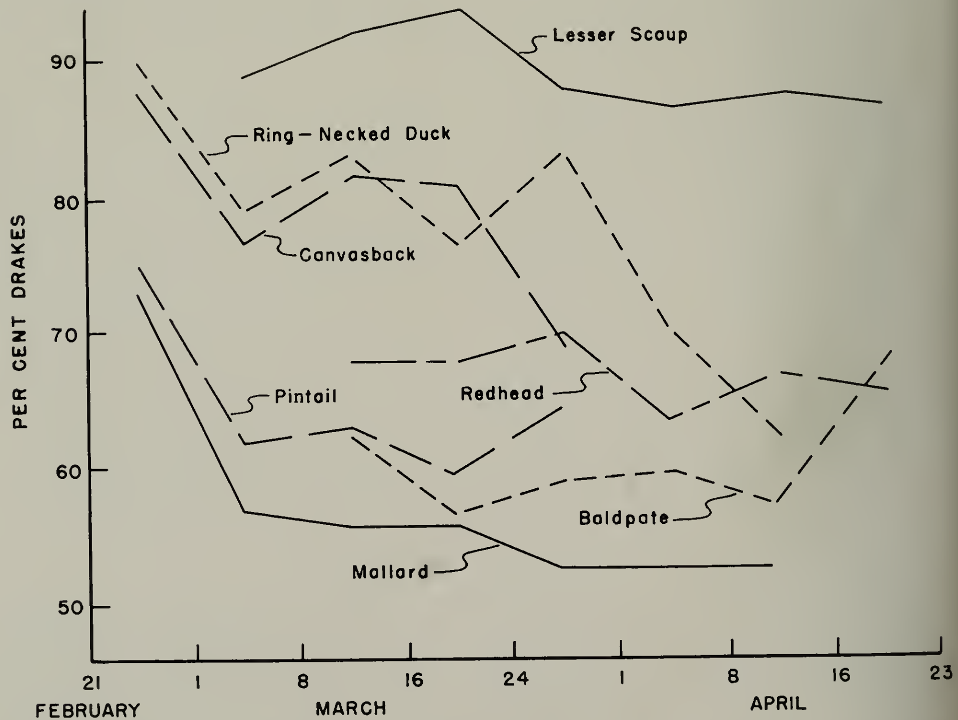

Fig. 5.—Periodic changes in the drake percentage of the flight of each of seven species of ducks during spring migration in the Illinois River valley, 1940–1946. Data were obtained from counts of living birds. A preponderance of drakes was most pronounced for the mallard, pintail, canvasback, and ring-necked duck early in the migration period. For the lesser scaup, a preponderance of drakes was most pronounced in the second half of March.

mostly during the spring months in 10 regions of North America.*

Minnesota, 1938–1940		Illinois River Valley, 1940–1947		Mississippi River Valley, Illinois, 1948–1951		Iowa, 1938–1940, 1949		Indiana, 1949–1952		All Areas	Probability That Differences Among Areas Are Due to Chance
Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Per Cent Drakes	
256	50.4	11,125	54.8	800	53.2	17,085	52.7	10,431	50.3	52.6	<0.001
126	54.8	1,238	61.6	78	53.8	1,390	56.0	1,759	55.5	54.6	<0.001
322	53.7	4,218	63.2	2,000	77.4	4,370	71.8	5,178	54.6	59.4	<0.001
447	59.7	297	64.6	......	......	3,782	59.6	1,644	56.8	59.3	<0.001
253	56.5	260	58.5	......	......	2,377	66.6	892	63.5	60.1	<0.001
210	61.0	7,880	68.1	......	......	4,385	58.6	1,275	60.7	60.2	<0.001
580	58.3	2,051	73.4	......	......	3,728	67.0	6,591	52.2	61.4	<0.001
147	64.0	6,164	79.4	3,678	75.2	2,049	65.0	2,016	65.3	66.4	<0.001
3,114	72.0	19,188	86.9	17,873	82.1	11,434	69.1	11,885	57.0	69.5	<0.001
80	48.8	460	77.4	......	......	1,976	65.8	438	53.4	62.0	<0.001

(1945:119); North Dakota, M. C. Hammond, U. S. Fish and Wildlife Service (unpublished); Manitoba, Hochbaum
sissippi River Valley, Illinois, George Arthur, Illinois Department of Conservation (unpublished); Iowa, Glover
(1941:144) combined for redhead, ring-necked duck, canvasback, lesser scaup, and ruddy duck; Indiana, Mum-

but by April there were almost two drakes to every hen. In eastern Washington, Yocom (1949:226) found among mallards relatively more drakes during December than during other months of his study; the number of hens increased proportionally in January, and in February there were more hens than drakes.

In the first 4 months of 1948, sex ratios of mallards in the Texas Panhandle were obtained from counts of ducks presumed to be victims of fowl cholera, table 25. These data revealed statistically significant ($X^2 = 16.5$, 6 d.f.) chronological differences in sex ratios at the 95 per cent level. In winter the mallard drakes and hens were about equal in number. The drake segment increased during the spring migration, and it was especially large at the end of the migration period. Inasmuch as hens were found by Singleton (1953:57) to predominate in mallard populations on the Texas coast during the hunting season, table 19, it is assumed that the progressive increase in the drake segment in the Panhandle resulted from the lingering of unmated drakes on the wintering grounds. Large numbers of mallards are paired during the fall and winter; probably some of the unmated drakes were juveniles that had lagged in testicular development while others were

Table 25.—Drake percentages in mallards and pintails found dead, presumably from fowl cholera, on the Muleshoe National Wildlife Refuge, Texas, 1948.

Period	Mallards		Pintails	
	Number	Per Cent Drakes	Number	Per Cent Drakes
Jan. 4–Feb. 16	1,212	50.2	330	64.8
Feb. 17–20	436	54.6	98	60.2
Feb. 21–March 17	3,014	56.0	769	57.0
March 18–21	831	57.3	236	54.2
March 22–31	643	56.3	328	55.8
April 1–7	162	56.8	16	43.0
April 8–25	47	63.8	8	50.0
Jan. 4–April 25	*6,345*	*55.0*	*1,785*	*57.9*

adults in which the testes had not reached recrudescence.

Among pintails presumed to have died from fowl cholera in Texas in the first 4 months of 1948, the sex ratio trend was the opposite of the trend among mallards, table 25, from a population predominantly drakes at the start of the period toward a balanced population at the end. The change in pintail sex ratios was not significant at the 95 per cent level ($X^2 = 10.4$, 6 d.f.). Drakes were found to predominate in the pintail population along the Texas coast during the hunting season, table 19. It may be concluded that the pintail drakes tend to winter farther north than the hens but that most of the pintail population winters farther to the south, in Mexico, than does the mallard population.

Sex Ratios in the Breeding Season.—Seasonal changes in sex ratios of ducks observed on the Manitoba breeding grounds in 1947 and 1949 are shown for various species in tables 26 and 27. In April, the first flights arriving on the breeding grounds showed, with minor exceptions, a closer approach to a balance between the sexes than did subsequent populations on the breeding grounds, fig. 6. Somewhere between the mid-flyway areas and the breeding areas of southern Manitoba, late migration waves predominating in hens appeared to overtake early migration waves predominating in drakes. A tendency toward balanced sex ratios

Table 26.—Drake percentages in seven species of ducks observed in four periods of the spring months along study transects on the Manitoba breeding grounds, 1947.*

Species	April 15–30		May 1–15		May 16–31		June 1–15	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	162	52.5	341	67.5	150	77.5	308	78.0
Gadwall	....	....	72	54.0	45	55.5	89	56.0
Pintail	140	55.5	248	75.0	139	73.5	197	78.0
Blue-winged teal	41	62.0	297	58.0	153	59.0	283	71.0
Shoveler	....	....	240	55.5	60	58.0	135	69.5
Canvasback	164	55.0	139	65.5	125	73.5	139	83.5
Lesser scaup	48	67.0	616	66.5	118	61.0	211	65.5

*Data supplied by Arthur S. Hawkins, an author of this paper.

Table 27.—Drake percentages in 10 species of ducks observed in four periods in the Minnedosa pothole district of Manitoba, 1949.*

Species	April 21–25		April 29–May 7		May 14–June 6		July 5–26	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	829	53.9	722	67.9	975	73.6	194	6.7
Gadwall	....	....	75	54.7	220	52.7	33	18.2
Baldpate	73	52.1	209	53.6	363	54.8	61	24.6
Pintail	213	59.2	235	74.0	274	76.6	67	4.5
Green-winged teal	52	53.8	198	53.5	164	63.4	40	27.5
Blue-winged teal	10	....	547	53.9	925	57.4	350	43.7
Shoveler	32	50.0	124	58.1	201	57.7	51	11.8
Redhead	64	51.6	114	52.6	231	55.4	34	20.6
Canvasback	190	54.2	285	56.8	334	61.1	135	0.7
Lesser scaup	163	65.0	442	60.2	459	58.8	166	48.8

*Unpublished data supplied by W. H. Kiel, University of Wisconsin.

among early arrivals on the breeding grounds evidently is observed in late March and early April on the Oka State Sanctuary in Russia, where the first mallards to arrive are paired (Teplov & Kartashev 1958:160).

The upward swing in the relative numbers of drakes among the mallards and pintails seen by observers in early May, tables 26 and 27, soon after arrival of the ducks on the breeding areas of Manitoba, may be indicative of the rate at which hens leave their mates to incubate.

By mid-July the relative number of drakes among ducks seen on potholes in southwestern Manitoba, table 27 and fig. 6, had noticeably decreased in all species—less in the lesser scaup and the blue-winged teal than in the other species. At this time, the drakes were evidently leaving the breeding areas for the lakes or marshes where they would enter the eclipse molt.

A similar sequence in sex ratios was found in 1949 by I. G. Bue, then at the University of Minnesota, in ducks seen on stock ponds in western South Dakota, fig. 7. Between the first week of May

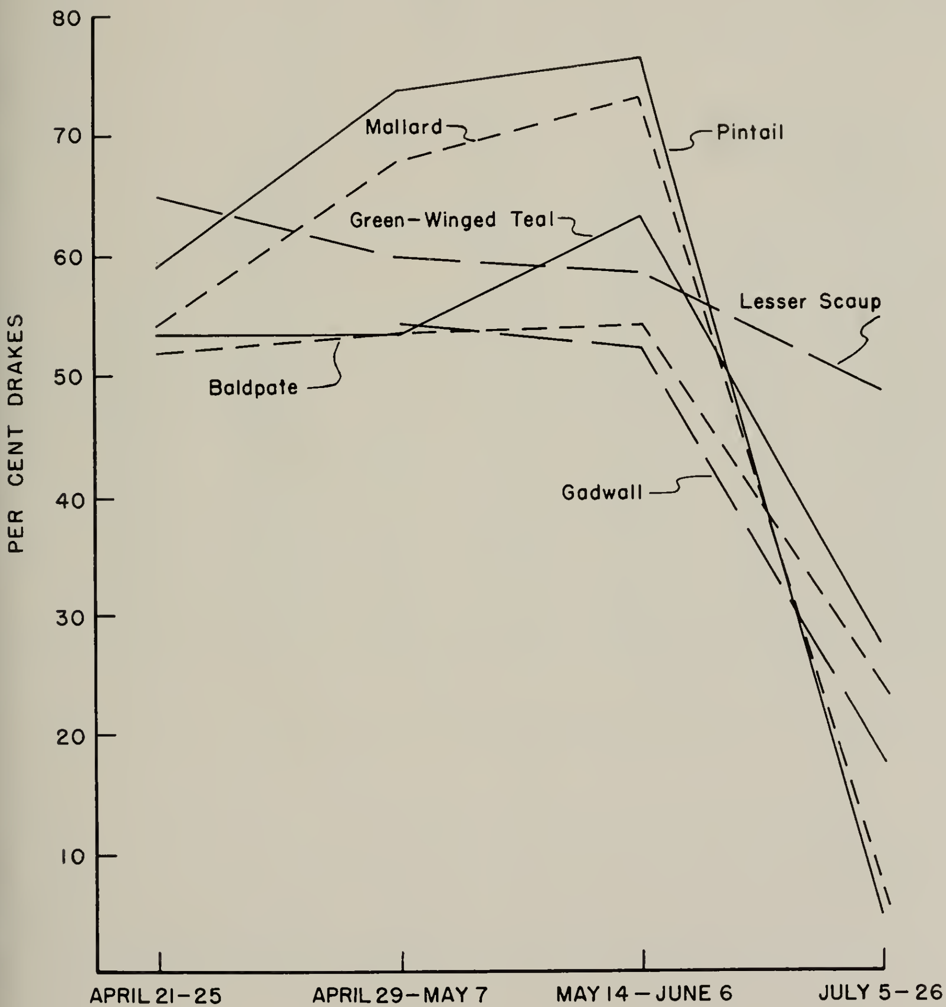

Fig. 6.—Periodic changes in the drake percentage in each of six species of ducks on a breeding grounds area near Minnedosa, Manitoba, April 21–July 26, 1949. Data were obtained from counts of living birds.

and the last, during the time pintail hens were leaving their mates to nest, the number of drakes increased from 57 to 81 per cent of the pintails observed. An abrupt decrease in the relative number of pintail drakes took place in the first half of June when many of them were departing for areas in which to molt. Mallard drakes were about 2 weeks later than pintails in their departure to molt, and blue-winged teal drakes were about 2 weeks later than the mallard drakes.

Sex ratios of ducks seen during the nesting period may provide useful information on the destruction of duck nests. When their nests are destroyed, hens return to their waiting sites, where they can be seen by observers; this behavior results in an apparent increase in the relative number of hens in the populations. Lynch (1948:26) presented evidence to show increases in the relative numbers of paired mallards and pintails seen on a study area in southern Saskatchewan late in May, 1947. These increases may have been attributable to heavy nest losses re-

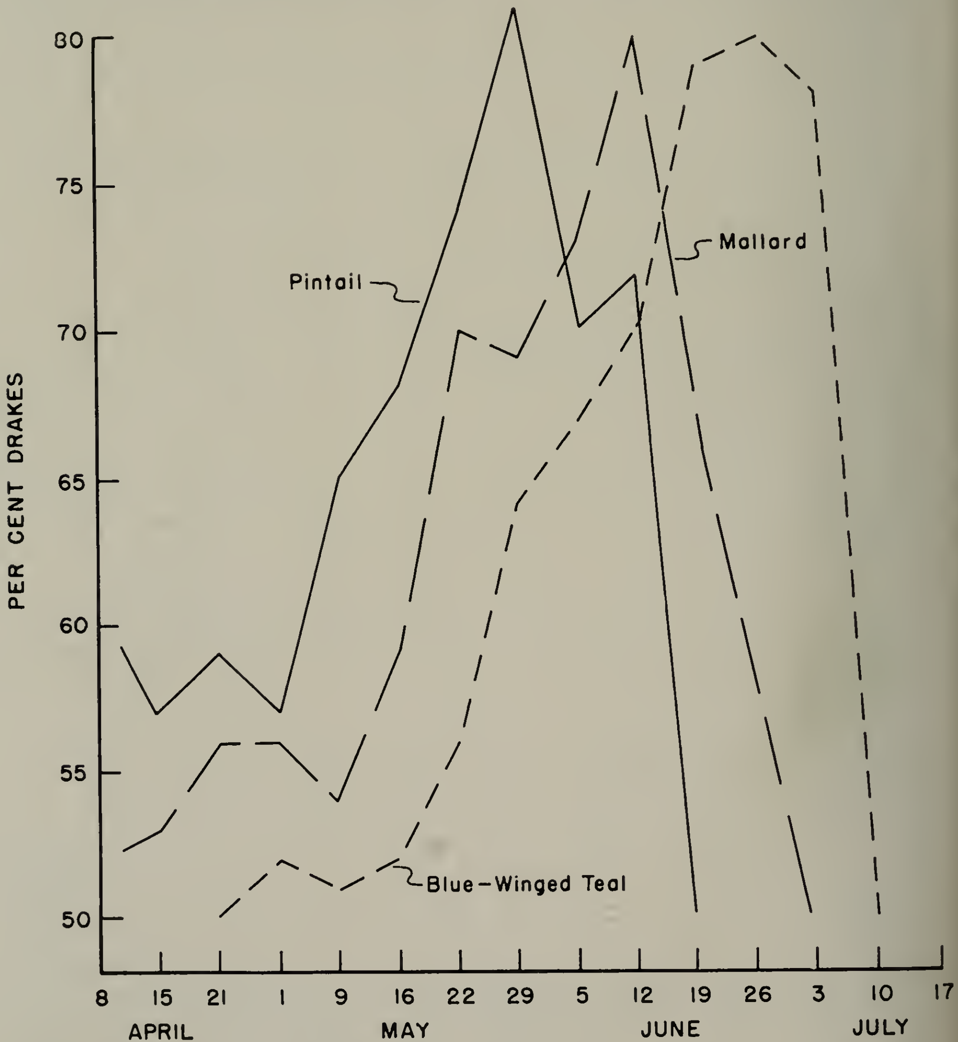

Fig. 7.—Periodic changes in the drake percentage in each of three species of ducks on stock ponds in western South Dakota, April 8–July 17, 1949. Data were obtained from counts of living birds and were provided by I. G. Bue, Commissioner, North Dakota Game and Fish Department, Bismarck, while at the University of Minnesota.

sulting from the plowing of wheat stubble in which hens were nesting.

Regional Variations in Sex Ratios

Sex ratios in ducks were found to vary with migration routes and wintering grounds, fig. 8.

The relative number of drakes among mallards reported bagged in the late 1940's in Ohio was considerably more than the relative number among mallards reported bagged in Nebraska, fig. 8; the two areas are in approximately the same latitude but in different flyways. In each area more drakes than hens were bagged. The much greater kills among juvenile drakes than among adult drakes is unexplained.

A preponderance of hens was reported for an area in British Columbia by Munro (1943:247), who found more hens (54.3 per cent hens) than drakes among 13,959 mallards trapped and banded in a period of about 12 years. More hens than drakes were reported among a few mallards in hunters' bags in eastern Wisconsin by Hopkins (1947:28), who also reported more hens than drakes among mallards that were trapped and banded in the area. The report by Hopkins is interpreted to mean that more hens than drakes of the mallard were in the area during the fall of 1946, the period covered by the report.

Drakes and hens apparently occur in various ratios in various areas of their wintering grounds. In Louisiana, table 19, inspection of hunters' bags showed that not only was the relative number of drakes low for all species but that hunters killed more hens than drakes in the mallard, pintail, green-winged teal, and lesser scaup. To the west, on the coast of

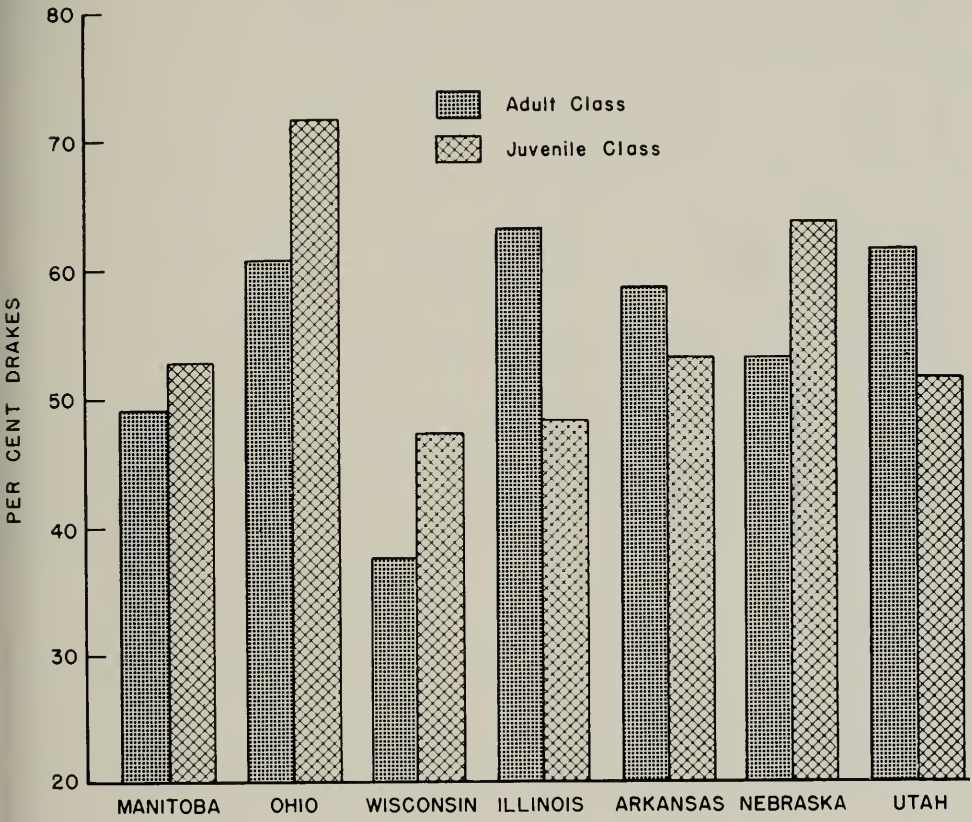

Fig. 8.—Drake percentage in juvenile and in adult mallards checked in hunters' bags in each of six states and the province of Manitoba, 1946–1948. More drakes than hens were checked in each state or province except Wisconsin.

Texas, hunters bagged more hens than drakes in the mallard, gadwall, shoveler, redhead, and canvasback. On the Texas coast, the relative number of drakes was unusually high only in the pintail and lesser scaup, species in which a large part of the population winters in Mexico.

In every duck species for which comparable figures were collected, the drake segment was larger in Tennessee, an area representing the northern part of the wintering grounds in the Mississippi Flyway, than in Louisiana, at the southern extremity of the flyway, table 19. Sex ratios obtained for the mallard, baldpate, and green-winged teal from inspection of ducks found dead in the Texas Panhandle, table 31, favored drakes to a greater extent than did sex ratios for these same species obtained from inspection of hunters' bags on the Texas coast, table 19. Drakes predominated in pintails about equally in these two Texas areas. In Texas coast mallards cited by Singleton (1953:57), the sex ratio for adults was almost evenly balanced; however, among juveniles, there were substantially more hens than drakes. Relatively greater numbers of hens than of drakes may occur in waterfowl populations to the south, in Mexico.

Although drakes greatly predominated among lesser scaups taken on the Texas coast, table 19, hens predominated among redheads and canvasbacks. Because only small numbers of redheads and canvasbacks are known to winter north of the Texas coast in the Central Flyway and because of the known preponderance of drakes in these species, it is assumed that large numbers of drakes of these species winter farther south on the Gulf Coast, in Mexico.

In the Currituck Sound area of North Carolina, where many species of ducks winter, bag checks in 1948–1952 showed the number of drakes to be relatively low for the green-winged teal, shoveler, canvasback, lesser scaup, and ruddy duck (*Oxyura jamaicensis*), table 19. Because large numbers of these ducks winter to the north of Currituck Sound, it is believed that the drakes of these species may be more numerous in those areas. The relatively large numbers of drakes among bagged pintails and gadwalls at Currituck Sound suggest that populations of these species to the south have proportionally fewer drakes.

During the spring migration, the regional variations in the sex ratios of ducks are even more pronounced than they are during the fall migration. Table 24 shows the variations in sex ratios among several species of ducks in 10 regions of North America. The mallard and the blue-winged teal showed less regional variation in sex ratios than the other species. In no region did the drake percentage for the mallard deviate more than 3.3 percentage points from the average for all regions represented. The comparable figure for the blue-winged teal was 5.3. Drakes formed more than 60 per cent of the population of eight species in Illinois, six in Iowa, and three each in California, North Dakota, and Indiana, table 24.

Illinois appears to be on a major flyway route for male ducks during the spring. In most species migrating through Illinois, the number of drakes in the spring, table 24, is relatively larger than the number of drakes in the fall, table 14. There is evidence that adult drakes of certain species, especially the divers, make longer flights during the fall migration than do the hens and the juveniles of both sexes. The probability that, in the fall, adult drakes of these species pass over Illinois, or move more quickly through the state than do the hens and juveniles, suggests one explanation for the pronounced differences between fall and spring sex ratios.

Sex ratios of ducks show less deviation from balanced sex ratios in northern areas than in other areas of the Mississippi Flyway in spring, table 24. In Minnesota, North Dakota, and Manitoba, sex ratio data were collected primarily on extensive lakes and marshes frequented by large numbers of transient ducks. Because of the location of the area, the size of the samples, and the period of years over which data were collected, the sex ratios from North Dakota appear to represent the various species in spring better than the sex ratios from other areas.

Mortality Factors Affecting Sex Ratios

As an approach to an evaluation of factors that contribute to deviations from

Table 28.—Drake percentage in each of 10 species of ducks banded by Ducks Unlimited* in the prairie provinces of Canada, 1939–1950, and the drake percentage in the year-of-banding recoveries. The difference between these two percentages for each species is a measure of hunter selectivity for that species, + for drakes, — for hens.*

Species	Ducks Banded			Year-of-Banding Recoveries			Difference Between Percentages	Probability That Percentage Difference Is Due to Chance
	Number	Number Drakes	Per Cent Drakes	Number	Number Drakes	Per Cent Drakes		
Mallard	21,021	10,405	49.5	2,131	1,131	53.1	+ 3.6	<0.001
Gadwall	1,355	602	44.4	134	68	50.8	+ 6.4	<0.20>0.10
Baldpate	1,940	991	51.1	168	86	51.2	+ 0.1	>0.99
Pintail	9,479	3,697	39.0	582	263	45.2	+ 6.2	<0.01>0.005
Green-winged teal	1,973	1,031	52.3	70	35	50.0	− 2.3	<0.70>0.60
Blue-winged teal	12,343	6,171	50.0	341	168	49.3	− 0.7	<0.80>0.75
Shoveler	686	346	50.4	41	29	70.7	+ 20.3	<0.01>0.005
Redhead	2,042	1,100	53.9	266	148	55.6	+ 1.7	<0.60>0.50
Canvasback	511	245	47.9	60	27	45.0	− 2.9	<0.60>0.50
Lesser scaup	5,134	2,615	50.9	320	159	49.7	− 1.2	<0.70>0.60

*Data calculated from Cartwright & Law (1952:10–2).

balanced sex ratios in ducks, it is desirable to examine the influence of each of the several factors responsible for mortality in these birds. The principal agents that contribute to mortality in ducks are (1) hunters, (2) disease, (3) predators, (4) agricultural operations, and (5) natural stress.

We seek to answer this question: Are hunters, disease, predators, agricultural operations, and natural stress responsible for greater loss in the ducks of one sex than in those of the other?

Hunting and Sex Ratios.—The data on hunter kill of ducks banded in Canada, 1939–1950, and recovered in the year of banding, table 28, reflect the country-wide influence of hunting on the drake-hen ratios because the banding was done on the breeding grounds during late summer and early fall at or before the beginning of the hunting season and the southward migration period.

Statistical treatment of the data showed that hunters took a highly significant greater number of drakes than of hens in the mallard, gadwall, pintail, and shoveler. Hunters took fewer, but not significantly fewer, drakes than hens in the green-winged teal, blue-winged teal, canvasback, and lesser scaup.

Data for black ducks banded at Lake Chautauqua and at McGinnis Slough and for mallards banded at McGinnis Slough, tables 2, 3, and 4, showed no significantly greater hunter kill in one sex than in the other for the period of study. Data for mallards banded at Lake Chautauqua, table 1, showed a greater hunter kill in drakes than in hens; the difference in hunter kill between the sexes was statistically significant and similar to that for mallards banded in Canada, table 28.

In most species in which hunting takes a greater toll of one sex than of the other, the male segment bears the greater loss. However, the effect of hunting on the sex ratios of the entire North American duck population is probably insignificant.

Disease and Sex Ratios.—Although numerous diseases afflict ducks, only three are known to cause large losses among these birds: (1) botulism, (2) fowl cholera, and (3) lead poisoning.

Botulism.—Botulism in ducks occurs in both Canada and the United States; it is most prevalent among the populations in the Prairie Provinces, the Northern Plains States, and the Western States. The time of botulism outbreaks usually is from midsummer to early autumn.

According to Hammond (1950:213),

> There appears to be no selectivity of sexes as far as *Clostridium* toxin is concerned and the ratio of sexes appearing in the studies is a reflection of the differential utilization. If males were attracted to areas at a time when toxin was potent and available a preponderance of males appeared in the collection.

Table 29.—Drake percentages in seven species of ducks found dead or incapacitated, presumably from botulism, at Whitewater Lake, Manitoba, in 7 weeks of 1949.*

Species	July 14–20		July 21–27		July 28–August 6		August 7–14		August 15–21		August 22–28		August 29–September 4		Entire Period	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	35	88.6	967	96.1	861	86.5	194	92.2	200	71.0	158	60.1	150	53.3	2,565	89.3
Gadwall	1	......	22	72.7	100	76.0	125	85.6	127	66.0	30	43.3	27	48.1	432	71.7
Baldpate	9	88.8	234	89.7	151	86.0	100	91.0	......	......	......	......	13	38.5	507	87.8
Pintail	7	100.0	303	88.7	273	75.4	196	78.5	140	76.4	76	63.1	217	48.8	1,212	72.4
Green-winged teal	......	......	107	90.6	23	78.2	20	80.0	24	29.2	......	......	84	58.3	258	72.5
Blue-winged teal	17	82.3	337	83.3	90	77.7	66	71.2	88	52.3	21	57.1	33	39.4	652	74.1
Shoveler	5	100.0	22	72.7	35	68.5	117	72.6	116	52.6	73	58.9	129	63.6	497	63.6

*Data obtained by F. Graham Cooch, Dominion Wildlife Service, and Arthur S. Hawkins, U. S. Fish and Wildlife Service.

Hammond (1950:212) found a ratio of 161 drakes to 100 hens among 8,395 adult ducks affected by botulism on four national wildlife refuges in North Dakota, 1937–1947. The relative number of hens increased progressively from July through September.

An inspection of ducks that presumably were victims of botulism at Whitewater Lake, Manitoba, between mid-July and early September, 1949, revealed a preponderance of drakes, table 29. There was an increase in the proportional number of hens among the victims in some species in late August; however, the hens in most species did not suffer severe losses, possibly because the disease abated in early September, before large numbers of hens arrived.

Waterfowl afflicted with botulism at the Ogden Bay Bird Refuge, Utah, in 1944 and 1950 and at the Bear River Migratory Bird Refuge, Utah, in 1952 showed a preponderance of drakes among both adults and juveniles, tables 21, 22, and 23. A comparison of the sex ratios of ducks dying from botulism in late summer of 1944, table 21, with those killed by hunters during autumn of the same year, table 20, indicated for three species proportionally greater numbers of drakes among the birds dying of the disease. The fact that, in Utah, drakes were relatively more abundant late in the summer than during the autumn may have accounted, at least in part, for relatively higher numbers of drakes among disease victims than among shot birds.

The habit of drake dabblers, while undergoing the eclipse molt, of frequenting large lakes with extensive marshes appears to expose drakes more than hens to botulism toxin. The worst known botulism areas, such as Whitewater Lake in Manitoba, Johnstone Lake in Saskatchewan, Medicine Lake in Montana, and the marshes about Great Salt Lake, Utah, are places where drakes, in much greater numbers than hens, annually gather for the wing-molt.

Fowl Cholera.—In North America, the largest losses of migratory waterfowl from fowl cholera appear to be those reported for the Panhandle of Texas by Petrides & Bryant (1951:193). Other severe losses from this disease have been reported from the south end of San Francisco Bay northward through the delta and into the lower Sacramento Valley (Rosen & Bischoff 1950:147–8).

Although Petrides & Bryant (1951: 203) found some indication that the smaller the duck the more susceptible it is to fowl cholera, the weight difference between drakes and hens in any one species is not great enough to account for a material difference in mortality rates. A small number of drake-hen ratios for mallards and pintails, living birds and victims of fowl cholera, in the Texas Panhandle in 1944–1946, table 30, suggest that the disease is not markedly selective of either sex.

Sex ratios for several hundred ducks presumably dying from fowl cholera in the Texas Panhandle in 1944–1946 and 1948 are given in tables 30 and 31. The loss of pintail drakes was proportionally greater in 1948 than in 1944–1946. The loss of mallard drakes showed approximately equal percentages in the two periods. In each period, the loss was proportionally greater among pintail drakes than among mallard drakes.

Available evidence suggests that fowl cholera is not an important cause of differences in mortality rates between the sexes. In the recorded outbreaks of this disease among ducks, drakes have predominated in the populations and have suffered losses proportionally no greater than those of hens.

Lead Poisoning.—Among migratory waterfowl, lead poisoning is more widespread geographically than either botulism or fowl cholera. It has been estimated (Bellrose 1959:282) that among all species of waterfowl in North America 2 to 3 per cent die from this disease each year.

Following experiments with penned wild mallards, Jordan & Bellrose (1951: 21) concluded that:

> The hen mortality from lead poisoning was found to be double the drake mortality, except

Table 30.—Drake percentages among pintails and mallards in the Panhandle of Texas, 1944–1946, as determined by (1) counts of ducks believed to be victims of fowl cholera and (2) visual observations of healthy ducks.*

Period	Pintail			Mallard		
	Fowl Cholera Counts		Visual Observations	Fowl Cholera Counts		Visual Observations
	Number of Ducks	Per Cent Drakes	Per Cent Drakes	Number of Ducks	Per Cent Drakes	Per Cent Drakes
March 4–16, 1944	311	70	......	187	58	......
Feb. 4–18, 1945	552	55	56	281	51	48
March 19, 1945	222	64	65	64	70	......
Feb.–March, 1946	1,008	63	71	346	56	......

*By Arthur S. Hawkins and U. S. Game Management Agents L. J. Merroka, Floyd A. Thompson, and M. H. Boone.

Table 31.—Drake percentages in four species of ducks found dead, presumably from fowl cholera, on areas in the Panhandle of Texas, winter and early spring, 1944–1946 and 1948.*

Species	1944–1946		1948	
	Number of Ducks	Per Cent Drakes	Number of Ducks	Per Cent Drakes
Mallard	878	55.8	4,348	54.4
Baldpate	......	......	860	62.6
Pintail	2,093	62.1	7,447	67.7
Green-winged teal	......	......	192	57.3

*Data for 1944–1946 from table 30. Data for 1948 from U. S. Game Management Agent L. J. Dugger.

Table 32.—Drake percentages among mallards picked up dead or incapacitated from lead poisoning in several areas of the Mississippi Flyway during late fall and winter, 1939–1955.

Place	Year	Number Checked	Per Cent Drakes
Sand Lake, South Dakota	1951	59	57.6
Heron Lake, Minnesota	1939	194	63.4
Lake Chautauqua, Illinois	1941–1955	753	62.8
Batchtown, Illinois	1953	47	68.1
Chariton County, Missouri	1949	53	64.2
Claypool Reservoir, Arkansas	1954	100	73.0
Catahoula Lake, Louisiana	1953	243	44.4

in the spring season when hens entered the breeding phase. At this season the food intake of penned wild hens increased steadily until it equaled, then exceeded, that of penned wild drakes. During this period hens proved to be less susceptible to lead poisoning than were drakes. At all other seasons hens ate less food than did drakes.

In field experiments with mallards, some of which had been dosed with lead shot and some of which had not been dosed, Bellrose (1959:276) found that:

> Because of the smaller number of experiments conducted with hens than with drakes, it is more difficult to appraise mortality from lead poisoning in the hens. However, the available data suggest that, among hens and drakes with identical ingested shot levels, hens probably suffer twice as great a mortality as drakes in the fall and a small fraction of the mortality of drakes in late winter and spring.

Actual counts of mallards picked up dead or incapacitated from lead poisoning in the Mississippi Flyway during late fall and early winter show a large preponderance of drakes, table 32. Field observations on healthy ducks in the region also show a preponderance of drakes in the wintering populations. Because most outbreaks of lead poisoning that have been reported are from the northern periphery of the wintering grounds and because drakes greatly predominate in wintering populations in those areas, undoubtedly an appreciably greater number of drakes than of hens have died from this disease.

Predators and Sex Ratios.—Investigations of predation on waterfowl are not adequate to provide a substantial basis for appraising the role of predation in selective mortality for drakes or hens. The hens, while incubating eggs for 3 or 4 weeks, and later, in caring for the flightless young for 6 to 10 weeks, may be exposed to greater predation than drakes. During the molt or flightless period, when the tendency of hens is to remain on small bodies of water, while drakes congregate on large lakes or marshes, the hens may be subjected to greater predation than drakes. Moreover, the poor physical condition resulting from the stress of egg laying and molting may also cause the hens to be more vulnerable to predation.

Kalmbach (1937:383–4), in summarizing the fate of 512 duck nests on the prairie breeding grounds in Canada, reported that eight egg-laying or incubating hens were known to have been killed by predators. Other hens may have been killed by predators without leaving evidence; 40 nests had been deserted, and 53 had been destroyed by unknown agents.

In a study that included 340 "active" duck nests in southeastern Saskatchewan during 1953, Stoudt & Buller (1954: 58–9) found seven nesting hens that had been killed by predators. During three seasons on a 1.5 square mile study area near Minnedosa, Manitoba, Alex Dzubin of the Canadian Wildlife Service (letter, March 26, 1955) found 13 hens and 6 drakes killed by predators, mowers, or muskrat traps. Because his study area was atypical in being flanked by paved highways along two boundaries, as well as by telephone and electric power wires, ducks killed by colliding with cars or by flying into wires were not included in his figures.

During a study of the fate of nests on farm land near Delta Marsh on the Portage Plains of Manitoba, 608 nests of seven species of ducks were examined (Milonski 1958:223, 225); although many nests were believed to have been lost to predation (striped skunks destroyed 7 per cent of the pintail nests and 51 per cent of the mallard nests) only five hens were known to have been killed by predators.

On Illinois study areas, raccoons destroyed 304 out of 1,579 wood duck nests and killed 103 hens in a period of 7 years. Minks killed other nesting wood duck hens, and even fox squirrels were responsible for the death of several hens. Census records indicate that during the nesting period wood duck drakes suffered negligible losses.

Agricultural Operations and Sex Ratios.—Losses resulting from mowing or combining operations on farm land are selective for nesting hens. Such losses would affect only species nesting in crops subject to mowing or combining. It seems probable that the mallard, pintail, gadwall, green-winged teal, blue-winged teal, baldpate, and shoveler would be most extensively concerned. The potential loss of nesting hens is great, because extensive areas of farm land are included in the breeding grounds. As long ago as 1948, Lynch (1948:28) pointed out that the 75,000 square miles comprising southern Saskatchewan is far from being a vast undisturbed prairie and that "three-fourths of this 'Duck-Factory' are grain-fields. The remainder is heavily grazed."

According to Forrest Lee of the Minnesota Department of Conservation (letter, January 9, 1955), the loss of blue-winged teal hens from mowing may be appreciable in Minnesota. One farmer near Hutchinson, despite the use of a flushing bar, in 1 year destroyed three hens while he was mowing an alfalfa field. A normally productive pond on his farm had no broods in that year. Interviews with a large number of farmers in the area indicated that such losses were not unusual.

Of 122 mallard and blue-winged teal nesting hens for which there was a chance of being killed (on nests destroyed directly or indirectly) in the mowing of 592 acres of hay on Horicon National Wildlife Refuge, Mayville, Wisconsin, only 5 were killed (Labisky 1957:195–7). It was believed that this low vulnerability of nesting hens resulted because "dabbling ducks generally rise swiftly and nearly vertically from the nest when flushed by the mowing machine, thus avoiding the cutting bar."

While making observations on 608 nests of seven species of ducks on farm land near the Delta Marsh in Manitoba, Milonski (1958:223) found only two hens killed in mowing operations.

The available data indicate that losses of nesting hens resulting directly from agricultural operations do not contribute importantly to imbalance in adult sex ratios.

Stress and Sex Ratios.—Little is known about stress, as defined by Selye (1956:3), in its relation to mortality in ducks. Kabat *et al.* (1956:44) found that in pheasants (*Phasianus colchicus*) the "seasonal variation in resistance to the applied stress and survival time was related to the physiological condition of the hen at particular times of the year." In July and August, pheasant hens that had completed or were about to complete their egg laying and were molting flight feathers were in their poorest physical condition of the year. Survival of pheasant hens under applied stress was shortest in June, July, and August and longest in April, immediately prior to egg laying (Kabat *et al.* 1956:12). The average survival period in July was 13 days in one year and 18 days in another, compared to 21 days in October, 27 days in December, 29 days in January, 34 days in February, 40 days in April, 22 days in May, 17 days in June, and 13 days in August.

Without doubt the greatest energy drain experienced by duck hens in the entire year occurs during late spring and summer as a result of egg laying, incubation, brooding of young, and post-nuptial molt. This sequence of activity probably places the hens in much greater jeopardy to stress than the drakes, which experience marked depletion of energy only through the period of the post-nuptial molt.

Harold C. Hanson of the Illinois Natural History Survey has determined (manuscript in preparation) that among Canada geese (*Branta canadensis*) the stress of the molt is especially severe on the female following the energy demands of egg laying and caring for the young and that this produces a differential effect on the sexes which may be the primary cause for the preponderance of males in adult populations.

Evaluation of Mortality Factors.—Information available on the principal mortality factors affecting sex ratios in the North American duck population indicates that hunters and disease take relatively more drakes than hens and that predators may take relatively more hens than drakes.

From the time of hatching to the beginning of the breeding season, only slight changes take place in the sex ratios of the yearling class of a duck population. Mortality factors that operate through most of the first year of life affect the two sexes about equally or the drakes slightly more than the hens. Available information is not sufficient to permit appraisal of the influence of predation on sex ratios. However, during the breeding season appreciable losses occur among hens; these losses, most of which appear to be attributable to predation, agricultural operations, and natural stress, may account for the predominance of drakes in the adult class.

Table 33.—Shooting losses, as measured by per cent of banded ducks recovered in year of banding, and drake percentage in the population of each of seven species of ducks.

Species	Number of Ducks Banded*	Per Cent of Banded Ducks Recovered in Year of Banding*	Drake Percentage in Population†
Dabbling Ducks			
Mallard	22,636	10.0	52.6
Baldpate	2,020	8.7	54.6
Pintail	9,951	6.1	59.4
Shoveler	749	5.9	60.1
Diving ducks			
Redhead	2,067	13.1	60.2
Canvasback	531	12.2	66.4
Lesser scaup	6,567	6.7	69.5

*Data from waterfowl bandings on Canadian breeding grounds by Ducks Unlimited (Cartwright & Law, 1952:10–1).
†Data from summary column, table 24.

Sex Ratios and Age Composition of Populations

The age composition of a duck population is reflected in its sex ratios. Because of an approximate balance between the sexes in the juvenile class and an appreciable imbalance in the adult class, the greater the proportion of old birds in any given population, the greater is apt to be the imbalance between the sexes in this population.

Influencing the age composition, and therefore to a large extent the sex ratios of the population, are (1) productivity and (2) mortality.

The more productive a species of waterfowl, the greater is apt to be the proportion of juveniles in its population at the opening of the hunting season. The greater the proportion of juveniles in a population, the more nearly balanced is its sex ratio. Some species of ducks are consistently more productive than other species. Most of the highly productive species have high shooting losses and, hence, high mortality rates.

An inverse relationship between shooting losses and the size of the drake segments is shown in table 33 for four species of dabbling ducks. The higher the shooting loss, the smaller is the imbalance between the sexes in these species.

Some species of ducks suffer excessive hunting losses in the juvenile age class. Mortality in the fall is so high in the juvenile class that birds over a year old greatly predominate in the spring populations. In these species there is a great imbalance in the sex ratios of spring populations. High vulnerability to hunting is shown in table 45 for juveniles of two species of diving ducks, the redhead and the canvasback.

Of the redhead, Hickey (1952:80) concluded that, "in the past," the kill rate for juveniles has been about 50 per cent, whereas the kill rate for adults has been 20 or 30 per cent; the annual mortality rates have been about 70 per cent for juveniles and about 55 per cent for adults. Of the canvasback, Geis (1959: 254–5) reported that the year-of-banding recovery rates (per cent of birds banded that were shot by hunters and had bands recovered within a year of the time of banding) were 22 per cent for juveniles and 14 per cent for adults; the annual rates for mortality from all causes were 77 per cent for juveniles and 35 to 50 per cent for adults. Mallard drakes banded as juveniles in Illinois had a first-year mortality rate of about 55 per cent; mallard drakes banded as adults had a first-year mortality rate of 36 per cent and an average mortality rate of about 40 per cent (Bellrose & Chase 1950:8–9).

The high mortality rate in the juvenile class of redheads and canvasbacks has resulted in relatively large numbers of old birds in the breeding populations of these species and consequently a large preponderance of drakes, table 33.

Extremely large drake segments noted in lesser scaup populations are evidently not related to high juvenile mortality resulting from hunting. The vulnerability rate of juveniles in this species, table 45, is insufficient to account for the large imbalance between the sexes, table 33. The causes of the imbalance seem to be (1) low shooting pressure on the species, table 45, (2) a low reproductive rate, table 62, and consequently (3) a relatively small number of juveniles in the population, table 53.

Variations in the age composition of waterfowl populations are largely responsible for variations in sex ratios among species of ducks. Sex ratios of various species of ducks in the spring in North Dakota, table 24, indicate that the mallard has relatively the largest number of yearlings in its breeding populations; this species is followed in order by the pintail, shoveler, redhead, blue-winged teal, ring-necked duck, baldpate, canvasback, lesser scaup, and ruddy duck.

The Question of Surplus Drakes

It seems reasonable to question the value of those drakes in excess of the number needed to provide mates for the hens in waterfowl populations. In the event such drakes do not play an essential role in species survival, an effort should be made to provide for their utilization.

While drakes outnumber hens in all species studied, drakes occur in relatively greater numbers among the diving ducks than among dabblers, table 24. Examination of available knowledge on the reproductive biology characterizing these two subfamilies reveals nothing which suggests that extra drakes may be more essential to the maintenance of populations of diving ducks than of dabblers.

The hens of diving ducks engage in less renesting activity than do the hens of dabbling ducks, and some observers feel that diving duck drakes tend to be more persistent in remaining with nesting hens than do the drakes of dabbling ducks. Species differences in this respect were observed among dabbling ducks by Sowls (1955:101), who wrote that while

> late-season or renesting courtship flights of mallards, gadwalls and pintails were common, we seldom saw them in the shovellers and blue-winged teal. I suspect that the difference occurred because of the length of time the drakes stayed with their hens after the clutches were laid. Blue-winged teal and shoveller drakes did not abandon their hens until incubation was well advanced; while mallard, pintail and gadwall drakes abandoned their hens shortly after the clutches were completed.

Robert I. Smith of the Illinois Natural History Survey (personal communication, December 9, 1960) also observed that blue-winged teal and shoveler drakes tend to remain with their hens longer than do the drakes of mallards, pintails, and gadwalls; in exceptional cases, mallard, pintail, and gadwall drakes may remain with their hens throughout and even beyond the incubation period. On the breeding grounds, drakes outnumber hens to a greater extent among pintails, blue-winged teals, and shovelers than among mallards and gadwalls, table 34. A pattern of sorts seems apparent here, but it does not afford obvious support of a need for extra drakes in reproduction.

The superficially excessive number of drakes may be significant to population dynamics among waterfowl in ways which are not directly related to the insurance of successful reproduction. At times, harassment of nesting hens by idle drakes may result in an important amount of nest desertion and possibly a reduction in productivity. Along with the severe stress of reproductive activity, harassment by drakes may contribute indirectly to mortality among hens. It is conceivable, too, that, if extra drakes are truly surplus, they may also create undesirable stress by occupying space and consuming food essential to the welfare of the productive segment of the population.

Perhaps insight into the value of extra drakes could be obtained through an experimental procedure designed to reduce the number of drakes in a subpopulation of a species having a large drake segment. Reduction of drake numbers could possibly be accomplished by deliberate hunting of drakes in places and at times when they were concentrated apart from the hens or when they could be decoyed from the hens and brought within shooting range. Teplov & Kartashev (1958:159, 161), reporting on observations made on the Oka State Sanctuary and on adjacent shooting areas in Russia, indicated that hunters are "permitted in spring to obtain the drakes of all species and also geese on passage. The most general method of obtaining waterfowl in spring is the shooting of Mallard drakes which go to a decoy duck." In Russia, the killing of female ducks is forbidden in spring. Such an experiment as that outlined above would meet the added objective of determining whether regulated hunting might be directed at what is possibly a truly expendable part of the waterfowl population.

Sex Ratios as Measures of Production

Because sex ratios reflect the age composition of a duck population, analysis of year-to-year differences in the sex ratios of a species offers a method of diagnosing the yearly changes in production. Also, because sex ratios for each species of waterfowl vary from season to season within any year, as a result of hunting and natural phenomena, the sex ratios obtained during a particular season (fall, winter, spring, or summer) should be compared with the sex ratios obtained during only corresponding seasons of other years. A

Table 34.—Drake percentages in 12 species of ducks observed in the breeding grounds region of North America, 1935–1942, 1947–1950.*

Species	Saskatchewan			Minnesota			Manitoba				North Dakota						Average
	1935	1935 1936	1937	1938	1939	1940	1939	1940	1941	1942	1940	1942	1947	1948	1949	1950	
Mallard	62.8†	60.6†	61.9†	50.0	50.0	51.1	.....	.....	.....	.....	.....	.....	53.5	50.0	51.9	51.2	51.1
Gadwall	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	51.7	53.3	52.9	53.9	52.0	52.8
Baldpate	58.3	53.3	52.9	62.5	52.6	53.3	.....	.....	.....	.....	.....	55.0	63.3	55.1	57.6	56.6	56.4
Pintail	74.3†	77.1†	58.7†	51.3	56.5	53.9	.....	.....	.....	.....	53.7	.....	58.9	.....	52.4	52.5	54.2
Green-winged teal	55.2	54.7	57.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	52.9	54.1	53.7	54.7
Blue-winged teal	59.4	57.8	53.8	63.6	57.3	55.4	.....	.....	.....	.....	.....	50.6	61.7	57.9	57.0	53.1	57.1
Shoveler	.....	.....	52.5	56.8	54.4	61.4	.....	.....	.....	.....	.....	.....	53.2	55.7	53.1	53.5	55.1
Redhead	55.0	55.4	50.8	.....	58.8	64.6	57.9	56.6	51.9	58.6	53.3	.....	55.5	55.8	55.9	52.6	55.9
Ring-necked duck	.....	.....	.....	58.5	57.6	58.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	58.3
Canvasback	60.4	55.1	57.1	66.6	74.2	50.0	69.3	66.3	65.0	64.3	66.6	.....	66.4	63.2	64.0	.....	63.5
Lesser scaup	61.1	60.9	61.0	74.4	70.6	69.4	62.0	69.0	67.7	64.3	76.0	74.0	64.3	61.2	67.2	54.3	66.1
Ruddy duck	77.4	69.5	69.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	61.6	67.3	61.6	67.4	67.8

*Sources of data for the various regions: Saskatchewan, Furniss (1935:278; 1938:22); Minnesota, Erickson (1943:27); Manitoba, Hochbaum (1944:15); North Dakota, M. C. Hammond, U. S. Fish and Wildlife Service (personal communication).

†These figures from Furniss (1935:278; 1938:22) are believed to be too high in drakes because tallies were made during nesting period; they are not included in the averages.

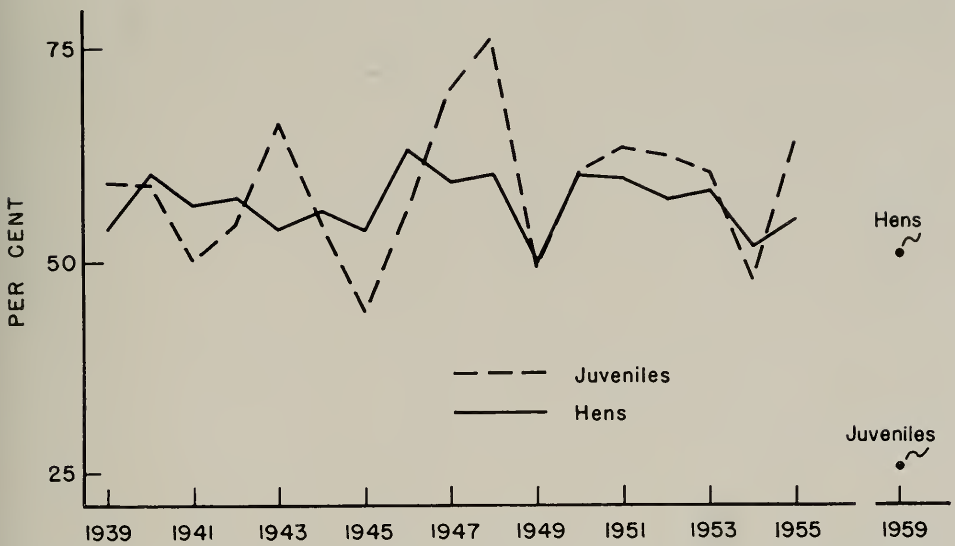

Fig. 9.—Year-to-year changes in the hen percentage and in the juvenile percentage in mallards checked in hunters' bags in the Illinois River valley, 1939–1955 and 1959. Percentages have been adjusted so that the means for juveniles and hens are equal.

comparison of the sex ratios in the summer of one year with the sex ratios in the winter of the same or another year would be biased by the disproportionate hunting losses of juveniles, which have approximately balanced sex ratios.

As a means of measuring yearly production, sex ratios have certain basic advantages over age ratios. For many species of ducks, such as the divers, age ratio data, derived from bag checks during the autumn, are difficult to obtain in adequate numbers. For the most important species, it is much easier to obtain large samples of sex ratio data from field observations than to obtain large samples of age ratio data from bag inspections. Less skill is required to determine the sex of a duck in nuptial plumage than the age of a duck in any plumage.

To test the validity of sex ratios as criteria of duck production, we have made a comparison, fig. 9, of sex ratios with age ratios, which are direct reflections of production. Both ratios were obtained from mallards killed by Illinois hunters in 1939–1955 and 1959. We have also made, for several species of ducks, comparisons of sex ratios derived from observations on the breeding grounds, table 34, with the number of juveniles per hen killed in Illinois, table 62.

As shown in fig. 9, the sex ratios (per cent hens) and the age ratios (per cent juveniles) obtained from mallards killed by Illinois hunters differed markedly in several years. The fluctuations in age ratios tended to be of greater magnitude than those in sex ratios; the peaks were higher in age ratios than in sex ratios, and the troughs were deeper. An over-all correlation of +0.59 suggests that only fair agreement exists between the sex ratios and the age ratios. We conclude that sex ratios derived from bag inspections provide a fair index to productivity but not so good an index as age ratios.

Sex ratios obtained on the breeding grounds, table 34, do not appear to provide a more reliable index to production than sex ratios calculated from bag inspections in Illinois. Data for the breeding seasons of 1935–1942 and 1947–1950 (except certain data from Furniss, table 34) show that the drake percentages for the mallard, gadwall, pintail, green-winged teal, and ring-necked duck did not, in any season for which figures are available, deviate from the average for the species by as much as 5 per cent. This lack of deviation indicated relatively stable populations; data in table 62, showing the number of juveniles per adult hen for the years 1946–1949, indicated increasing populations for all of the above-mentioned species except the gadwall.

AGE RATIOS

Two commonly used indicators of waterfowl production are brood densities (the number of broods per unit of area on the breeding grounds) and age ratios (the mathematical relationship between adults and juveniles old enough to fly).

Brood density surveys supply information of value for making preseason adjustments in hunting regulations. However, data on brood densities are not believed to constitute precise indices of production. Substantial proportions of the broods present in an area are missed by observers employing survey techniques usually considered practicable (Anderson 1953:8–10). Correction for unobserved broods may never yield to reliable standardization, for the percentage of broods not found by observers varies with many factors such as time of day, time of season, habitat, area, and waterfowl population densities.

Age ratios are believed to afford a more promising basis than brood counts for measuring waterfowl production, although they, like data on brood densities, are seldom true indices of production.

This section of the paper is written with the intention of opening the way to a more effective use of age ratios in waterfowl management. The following aspects of age ratios and their use are considered: age criteria, sampling methods for obtaining age ratios, seasonal and regional variations in age ratios, factors tending to bias age ratios, age ratios as measures of production, environment in relation to production, production in different species, and the place of age ratios in population management.

Age Criteria

In 1938, when biologists of the Delta Waterfowl Research Station at Delta, Manitoba, and of the Illinois Natural History Survey at Havana, Illinois, initiated waterfowl research programs involving the inspection of large numbers of ducks bagged by hunters, the need for finding consistently reliable external characteristics by which to separate juveniles from adults was recognized. The best external indication of age known at that time had been pointed out by Pirnie (1935:275). It was based on the appearance of the tips of tail feathers, those of adults being rounded or pointed, those of juveniles being blunt or notched. However, in the mallard, an important species in Illinois and at Delta, young birds were known to replace their juvenile feathers with adult feathers early in the fall; hence, they could not be accurately aged by this characteristic throughout the hunting season. In some species, notably those in the genus *Aythya,* the tail feather criterion was found to be more persistent than in the mallard, but, even so, it was not reliable throughout the hunting season.

During the fall of 1938, biologists at the Delta and Illinois stations searched for some characteristic by which to separate juveniles from adults in the mallard and other early-molting species. The search at Delta was concentrated on plumage, while that in Illinois was concerned with a character, pointed out by Ticehurst (1938:772–3) as being related to immaturity: striae "at the tip of the nail of both upper and lower mandibles." The Illinois group also investigated various parts of the skeleton that might exhibit differences in ossification between juveniles and adults. At that time, neither group was successful in the search for a characteristic by which to separate ducks into the two age classes.

In the following winter, Gower (1939:427) called attention to the bursa of Fabricius as a criterion of age in ducks. A short time later Hochbaum (1942:301), aided by the findings of Gower and the work of Owen (1866:244–5), learned that juvenile drakes of 5 to 10 months of age could be separated from adult drakes by the size of the penis, fig. 1. This finding, put to use in the summer and fall of 1939, provided a method of differentiating between juveniles and adults of both live and dead drakes. The new method proved faster and easier to use than the bursal method. Also, it provided for accurate separation of drakes from hens in all stages of plumage. However, the bursa was found to persist for several weeks after the transition from juvenile- to adult-type penis and therefore provided a basis for separating juveniles from adults over a longer period of time than that afforded by the penis.

Hochbaum (1942:303–4) pointed out that the oviduct, which opens into the cloaca in adult females, is sealed by a membrane in immature females, fig. 1. Wildlife technicians in Illinois have found

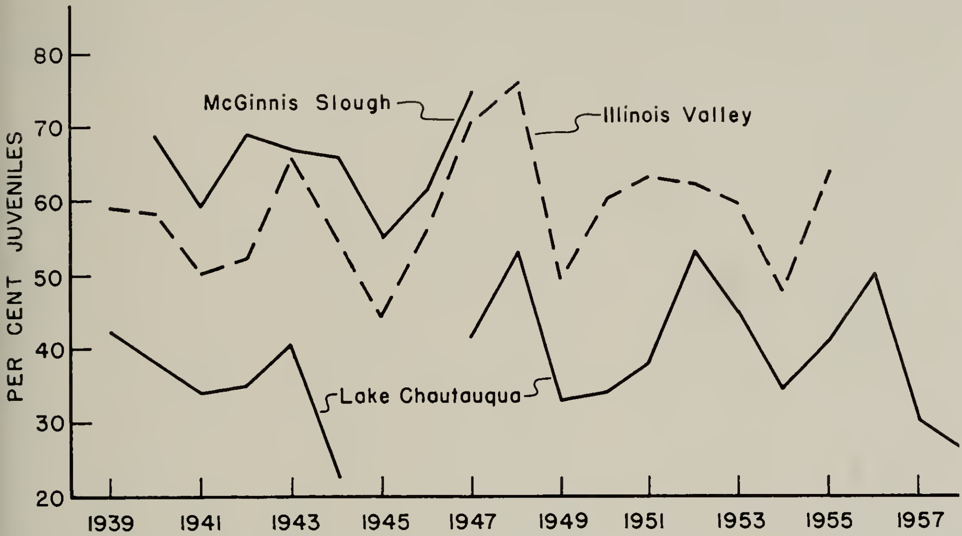

Fig. 10.—Year-to-year changes in the juvenile percentage in mallard drakes trapped at McGinnis Slough and at Lake Chautauqua and in mallards checked in hunters' bags in the Illinois River valley, 1939–1957.

that, until at least mid-January, the presence of a closed oviduct and a bursa unfailingly indicates a juvenile hen. Occasionally, a hen is found that shows an open oviduct and a small bursa; such a bird is considered adult. Most wildlife technicians have restricted their aging of hens to individuals that have been bagged by hunters. However, Hanson (1949) developed a technique that can be used for aging live females in both ducks and geese.

In 1958, after completion of most of the field work for the study reported here, Carney & Geis (1960:376–9) found that, in certain species of ducks, juveniles and adults could be identified with a high degree of accuracy on the basis of differences in the wing plumage. The technique described by these authors makes possible the extensive sampling of age ratios of ducks in all four flyways of North America. Large numbers of wings could be collected from duck hunters and shipped to a central point for interpretation by trained personnel.

Sampling for Age Ratios

Data on the age ratios of ducks may be obtained by examination of birds trapped for banding, shot by hunters, or killed by disease. It seems desirable that the relative merits of these sources of data be appraised. In the present study, all three sources of data were used for obtaining age ratios.

Examination of Trapped Ducks.—A comparison of the age ratios of mallard drakes trapped at Lake Chautauqua, table 35, and the age ratios of mallard drakes and hens taken by hunters in the Illinois River valley, table 36, discloses marked disparity in the number of juveniles per adult between the trapped ducks and the harvested ducks. The data show relatively fewer juveniles among the drakes trapped at Lake Chautauqua than among the ducks taken by hunters in the Illinois River valley, tables 35 and 36 and fig. 10. However, among drake mallards captured at McGinnis Slough in traps similar to those used at Lake Chautauqua, a higher proportion consisted of juveniles, table 37 and fig. 10, than among mallard drakes trapped at Lake Chautauqua or mallards bagged in the vicinity of that lake.

Despite marked differences in the size of samples between trapped and shot mallards, the two sampling procedures indicated similar year-to-year trends in age ratios, fig. 10. The statistical correlation in the annual changes in age ratios between mallard drakes trapped at Lake Chautauqua and mallards shot along the Illinois River was found to be significant ($r=+0.96$, 13 d.f.) at the 99 per cent level.

Mallards inspected in hunters' bags in the Illinois River valley (1939–1949) and mallard drakes taken in traps at Lake Chautauqua (1939–1944 and 1947) showed similar trends in age ratios for most of the hunting season, fig. 11. The trends tended to be parallel except in early December. The correlation between age ratios calculated weekly for the samples

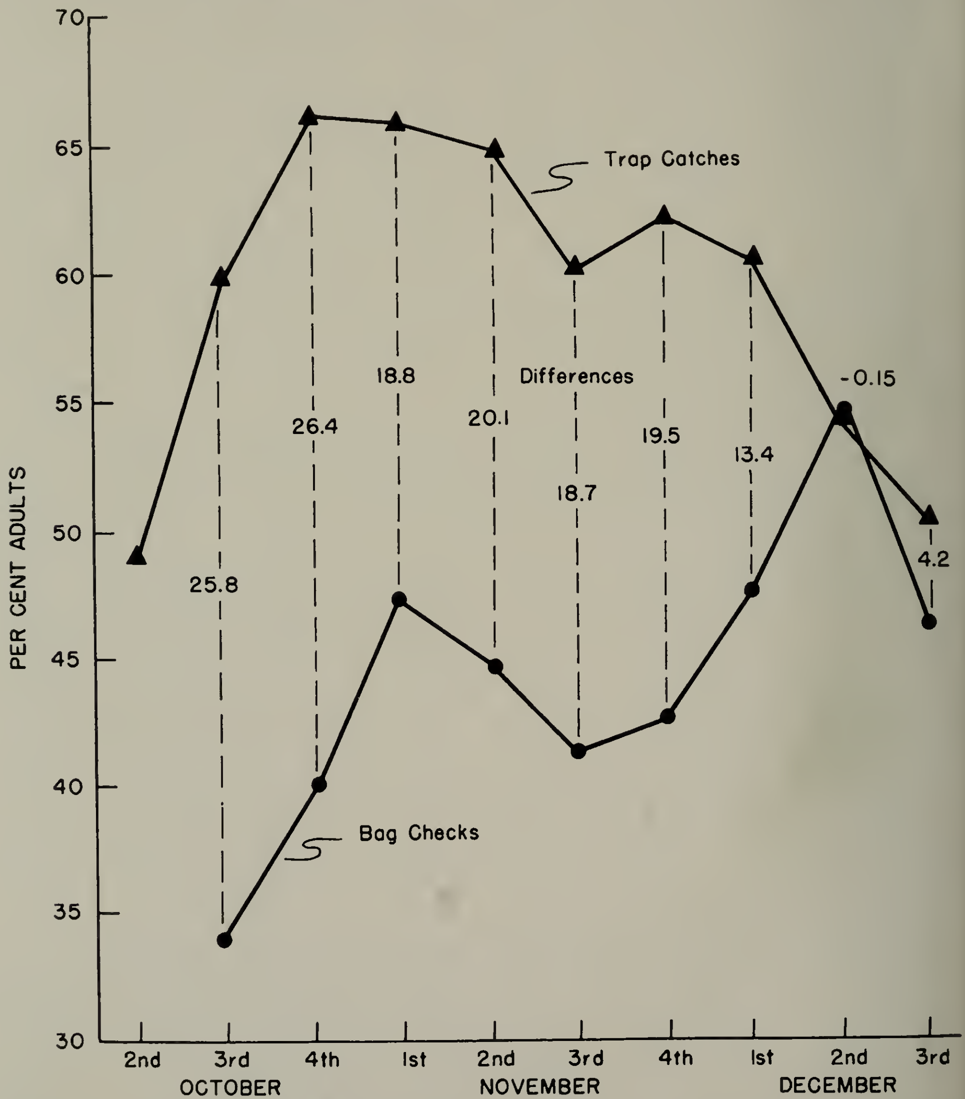

Fig. 11.—Week-to-week changes in the adult percentage of the autumn flight of mallards in Illinois, as indicated by two sampling methods: checks of mallards in hunters' bags and inspection of mallard drakes caught in banding traps. Bag data are for the Illinois River valley, 1939–1949; trap data are for Lake Chautauqua, 1939–1944 and 1947.

of trapped and shot mallards was significant ($r = +0.94$, 7 d.f.) at the 99 per cent level.

Behavior may well account for the large juvenile proportion in the mallard drakes taken in traps at McGinnis Slough, fig. 10, and the small proportion in those taken in traps at Lake Chautauqua. As discussed under sex ratios, mallard drakes were observed to be more aggressive than hens in pushing their way into the traps at Lake Chautauqua. Perhaps adults shouldered young birds aside in aggressive efforts to get at the bait. Lake Chautauqua had a much greater density of mallards and comparatively less natural food than McGin-

Table 35.—Number of juveniles per adult among mallard drakes trapped and banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, 1939–1944 and 1947–1959.

Year	Number of Drakes Trapped and Banded	Per Cent Juveniles	Juveniles Per Adult	Approximate 95 Per Cent Confidence Limits
1939	2,574	42.3	0.73	0.67–0.80
1940	4,262	37.9	0.61	0.57–0.66
1941	3,200	34.1	0.52	0.47–0.56
1942	4,859	35.3	0.55	0.51–0.58
1943	4,655	40.6	0.68	0.64–0.73
1944	2,734	22.6	0.29	0.26–0.32
1947	1,481	41.1	0.70	0.62–0.78
1948	1,332	53.1	1.13	1.01–1.27
1949	3,597*	33.1	0.50	0.45–0.54
1950	1,984*	34.1	0.52	0.47–0.57
1951	3,801*	37.7	0.61	0.56–0.65
1952	4,493	53.7	1.16	1.09–1.24
1953	1,048	44.9	0.82	0.72–0.92
1954	901	34.4	0.52	0.46–0.60
1955	998	41.1	0.70	0.61–0.79
1956	632	50.1	1.01	0.86–1.17
1957	856	29.6	0.42	0.35–0.49
1958	736	25.8	0.35	0.28–0.42
1959	93	9.7	0.11	0.04–0.18

*This figure differs from the corresponding figure in table 39 because it includes ducks banded with reward bands, which have shown a higher rate of return than standard bands (Bellrose 1955).

Table 36.—Number of juveniles per adult among mallard drakes and hens checked in hunters' bags in Illinois, principally the Illinois River valley, 1939–1955 and 1959.

Year	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult	Approximate 95 Per Cent Confidence Limits
1939	2,261	59.1	1.45	1.32–1.58
1940	3,564	58.7	1.42	1.33–1.52
1941	4,481	50.3	1.01	0.95–1.08
1942	1,809	54.2	1.18	1.07–1.30
1943	1,422	66.0	1.94	1.73–2.18
1944	2,167	54.3	1.19	1.09–1.30
1945	2,047	43.9	0.78	0.67–0.92
1946	1,317	55.5	1.25	1.11–1.40
1947	814	70.3	2.36	2.03–2.78
1948	1,215	76.0	3.18	2.78–3.63
1949	597	49.2	0.97	0.79–1.18
1950	581	60.4	1.53	1.28–1.82
1951	819	63.1	1.71	1.48–1.99
1952	1,209	62.3	1.65	1.46–1.87
1953	1,152	59.6	1.48	1.34–1.63
1954	458	47.6	0.91	0.75–1.10
1955	746	64.1	1.78	1.34–2.22
1959	247	25.5	0.34	0.30–0.38

Table 37.—Number of juveniles per adult among mallard drakes trapped and banded at McGinnis Slough, Cook County, Illinois, 1940–1947.

Year	Number of Drakes Trapped and Banded	Per Cent Juveniles	Juveniles Per Adult	Approximate 95 Per Cent Confidence Limits
1940	267	68.5	2.18	1.68–2.85
1941	195	59.5	1.47	1.11–1.98
1942	1,128	69.0	2.22	1.96–2.54
1943	1,922	67.1	2.04	1.85–2.25
1944	967	65.9	1.93	1.69–2.22
1945	1,492	54.9	1.22	1.09–1.36
1946	860	61.5	1.60	1.39–1.85
1947	556	74.3	2.89	2.40–3.55

nis Slough. This situation may have resulted in greater competition for food at Lake Chautauqua and consequently greater aggressiveness on the part of the adult mallard drakes. The greater frequency of juvenile drakes in traps at McGinnis Slough than at Lake Chautauqua may have resulted in part from greater wariness on the part of adult drakes. With an abundance of natural food at McGinnis Slough, many adults may have avoided the traps or ignored the foods they contained. Apparently, in one case (Lake Chautauqua) the traps were selective for adults while in the other (McGinnis Slough) they were selective for juveniles.

There was a significant correlation at the 99 per cent level between the age ratios of drake mallards trapped at McGinnis Slough, table 37, and the age ratios of mallards taken by hunters in the Illinois River valley, table 36 ($r = +0.93$, 6 d.f.).

Data obtained from retrapping mallard drakes previously trapped and banded at Lake Chautauqua, table 38, indicated that the banding traps there were selective, sometimes for juveniles and sometimes for adults. During the period October 4–24, juveniles re-entered the traps with greater frequency than adults ($X^2 = 31.14$, 1 d.f., significant at the 99 per cent level). In contrast, during the period October 25–December 25, adults re-entered the traps with greater frequency than juveniles ($X^2 = 12.90$, 1 d.f., significant at the same level). These retrap data showed that early in the season, when mallard numbers were low and food competition was at a minimum, banding traps were selective for juveniles, but, when mallard numbers increased and food competition became greater, the traps were selective for adults. The bulk of the mallard population arrived in Illinois after October 25, and the banding traps at Lake Chautauqua were on the whole highly selective for adults.

A correlation, significant at the 99 per cent level, was found in each year for the

Table 38.—Number of adult and of juvenile mallard drakes trapped and banded and the per cent retrapped during two periods at the Chautauqua National Wildlife Refuge, near Havana, Illinois, 1940–1943.

Period	Adults			Juveniles			Ratio of Per Cent of Adults Retrapped to Per Cent of Juveniles Retrapped
	Number		Per Cent Retrapped	Number		Per Cent Retrapped	
	Trapped and Banded	Retrapped		Trapped and Banded	Retrapped		
Oct. 4–24	1,305	297	22.8	1,026	340	28.2	1:1.24
Oct. 25–Dec. 25	9,322	991	10.6	5,265	462	8.8	1:0.83

Table 39.—Comparative vulnerability (to hunting) of adult and juvenile mallard drakes banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, 1939–1944 and 1947–1952; vulnerability measured by year-of-banding recoveries. Ducks banded with reward bands (Bellrose 1955) in 1949, 1950, and 1951 were not included in this table.

Year	Number of Drakes Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
1939	1,486	1,088	65	49	22.9	22.2	1:1.03
1940	2,647	1,615	132	200	20.1	8.1	1:2.48
1941	2,110	1,090	57	43	37.0	25.4	1:1.46
1942	3,142	1,717	216	177	14.6	9.7	1:1.51
1943	2,763	1,892	138	146	20.0	13.0	1:1.54
1944	2,117	617	125	56	16.9	11.0	1:1.54
1947	871	610	31	34	28.1	17.9	1:1.57
1948	624	708	5	11	124.8	64.4	1:1.94
1949	1,286	1,192	46	53	28.0	22.5	1:1.24
1950	449	359	24	27	18.7	13.3	1:1.41
1951	583	325	20	12	29.2	27.1	1:1.08
1952	2,082	2,411	60	151	34.7	16.0	1:2.17
All years	*20,160*	*13,624*	*919*	*959*	*21.9*	*14.2*	*1:1.54*

relative constancy between the age ratios of mallard drakes banded at McGinnis Slough and of those banded at Chautauqua ($r=+0.98$, 5 d.f.), tables 35 and 37.

In spite of trap bias, ducks taken in traps are believed to provide a rough index to yearly changes in age ratios.

Inspection of Hunters' Bags.—It became apparent early in the study that juvenile ducks were more readily taken by hunters than were adults. Tests suggested that data obtained by trapping and banding ducks could be used to correct for the greater vulnerability of the juveniles. The following equation was used for this purpose:

$$\text{Vulnerability quotient } V = \frac{\dfrac{\text{Number of adults banded during current season but before end of hunting season}}{\text{Number of year-of-banding band recoveries from adults}}}{\dfrac{\text{Number of juveniles banded during current season but before end of hunting season}}{\text{Number of year-of-banding band recoveries from juveniles}}}$$

An example of the use of the equation with banding data for 1940 in table 39 follows:

$$V = \frac{\dfrac{2,647}{132}}{\dfrac{1,615}{200}} = \frac{20.1}{8.1} = 2.48$$

Mallards were banded at one or more stations in Illinois each year from October, 1939, through 1952, and the data obtained were used for determining the yearly variations in comparative vulnerability of juvenile and adult drakes, tables 39 and 40. Adult drakes banded at McGinnis Slough, table 40, experienced relatively greater losses from hunting than did those banded at Lake Chautauqua, table 39. The number of juvenile drakes banded per juvenile recovery was about the same at both places. The data indicate that greater hunting pressure was exerted on adult drakes banded at McGinnis Slough than on those banded at Chautauqua.

Black duck drakes banded at McGinnis Slough had about the same loss of juveniles to hunting, table 41, as did mallard drakes banded there, table 40. Black duck drakes banded at Lake Chautauqua, table 42, like mallard drakes banded there, table 39, experienced a lower rate of hunting loss among adults than did black duck drakes banded at McGinnis Slough, table 41. Apparently, in mallard and black duck drakes banded at Lake Chautauqua, the relatively lower hunting losses in adults resulted from the greater protection afforded them outside the banding station area. The Chautauqua National Wildlife Refuge is about 10 times as large as

Table 40.—Comparative vulnerability (to hunting) of adult and juvenile mallard drakes banded at McGinnis Slough, Cook County, Illinois, 1942–1947; vulnerability measured by year-of-banding recoveries.

Year	Number of Drakes Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
1942	350	778	26	66	13.5	11.8	1:1.14
1943	632	1,290	21	57	30.1	22.6	1:1.33
1944	330	637	33	67	10.0	9.5	1:1.05
1945	673	819	38	69	17.7	11.9	1:1.49
1946	331	529	20	41	16.6	12.9	1:1.29
1947	143	413	8	29	17.9	14.2	1:1.26
All years	*2,459*	*4,466*	*146*	*329*	*16.8*	*13.6*	*1:1.24*

Table 41.—Comparative vulnerability (to hunting) of adult and juvenile black duck drakes banded at McGinnis Slough, Cook County, Illinois, 1940–1947; vulnerability measured by year-of-banding recoveries.

Year	Number of Drakes Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
1940	33	48	4	6	8.3	8.0	1:1.04
1941	153	253	10	16	15.3	15.8	1:0.97
1942	231	414	15	32	15.4	12.9	1:1.19
1943	259	336	8	16	32.4	21.0	1:1.54
1944	167	323	16	39	10.4	8.3	1:1.25
1945	166	296	11	31	15.1	9.6	1:1.57
1946	128	257	6	18	21.3	14.3	1:1.49
1947	117	271	1	9	....	....	....
All years	*1,254*	*2,198*	*71*	*167*	*17.7*	*13.2*	*1:1.34*

Table 42.—Comparative vulnerability (to hunting) of adult and juvenile black duck drakes banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, 1939–1944 and 1947–1950; vulnerability measured by year-of-banding recoveries.

Year	Number of Drakes Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
1939	55	47	2	2	27.5	23.5	1:1.17
1940	93	68	4	6	23.3	11.3	1:2.06
1941	181	148	1	4	181.0	37.0	....
1942	225	123	22	20	10.2	6.2	1:1.65
1943	188	115	9	9	20.9	12.8	1:1.63
1944	119	66	7	8	17.0	8.3	1:2.05
1947	70	63	....	....	....	....	....
1948	39	48	....	....	....	....	....
1949	216	165	3	11	72.0	15.0	1:4.80
1950	98	12	4	1	24.5	12.0	1:2.04
All years	*1,284*	*855*	*52*	*61*	*24.7*	*14.0*	*1:1.76*

McGinnis Slough; also, several other refuges occur within the 25- to 30-mile feeding radius of mallards congregating at Chautauqua, whereas none occurs within that distance of McGinnis Slough. It seems evident that adult mallards and black ducks at Chautauqua made good use of their acquired knowledge of protected areas.

Table 43.—Comparative vulnerability (to hunting) of adult and juvenile blue-winged teal drakes and hens banded in Illinois at McGinnis Slough, Cook County, 1942–1947, and at Moscow Bay, Mason County, 1949–1951; vulnerability measured by year-of-banding recoveries.

Year	Number of Ducks Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
1942	156	535	7	29	22.3	18.5	1:1.21
1943	131	424	2	16	65.5	26.5	1:2.47
1944	304	534	8	45	38.0	11.9	1:3.19
1945	193	444	8	23	24.1	19.3	1:1.25
1946	90	686	1	9	90.0	76.2	1:1.18
1947	65	234	1	6	65.0	39.0	1:1.67
1949	169	1,071	0	34	....	31.5	....
1950	152	505	2	22	76.0	23.0	1:3.30
1951	210	1,189	4	33	52.5	36.0	1:1.46
All years	*1,470*	*5,622*	*33*	*217*	*44.6*	*25.9*	*1:1.72*

Blue-winged teals banded at McGinnis Slough and Moscow Bay experienced greater differences between the two age groups in vulnerability to hunting, table 43, than did mallard drakes banded at Lake Chautauqua, table 39, or McGinnis Slough, table 40. Although blue-winged teals are generally considered to be less wary than mallards and black ducks, the development of wariness by juvenile blue-winged teals may be as rapid as that by juvenile mallards when the birds are subjected to hunting. Vulnerability in the blue-winged teal, as in other species, probably is related to the amount of experience that juveniles have had with hunters. Most of the juvenile blue-winged teals arrive in Illinois in advance of the open season in the northern zone and therefore are inexperienced with hunters at the time of their arrival. Most juvenile mallards and black ducks have been subjected to hunting by the time they reach Illinois.

Data collected in 1940, 1942, 1943, and 1952 showed that, as the hunting season progressed in Illinois, juvenile mallard drakes became less vulnerable, table 44, presumably as a result of increased experience with hunters. During the early part of the season, the juveniles were bagged about four times as readily as adults; late in the season they were bagged only about one and one-half times as readily. Thus, age ratios obtained from hunters' bags on major wintering grounds would be less biased by the greater vulnerability of juveniles than samples taken earlier on breeding or migration areas. The year-to-year variations in the amount of hunting experience juveniles receive before they reach Illinois may be an important factor in determining the year-to-year variations in the vulnerability of juveniles in this state, tables 39 and 40. Mallard age ratios obtained from bag checks on the breeding grounds appear to be the ratios most biased by juvenile vulnerability, and those obtained on the wintering grounds are probably the least biased, table 52.

The relative vulnerability of juveniles and adults of several duck species have been calculated from recovery of birds banded on the Canadian breeding grounds, table 45. The recovery data for the teals and the shoveler show either no greater vulnerability among juveniles than among adults or a greater vulnerability among adults. However, as recovery data for blue-winged teals banded in Illinois over a period of several years show a markedly greater vulnerability of juveniles, table

43, it is suspected that some unusual local conditions affected the Canadian bandings of these three species. Perhaps many juvenile teals and shovelers lost bands, for, until 1957, the banding office at the Patuxent Research Center, Laurel,

Table 44.—Seasonal change in comparative vulnerability (to hunting) of adult and juvenile mallard drakes banded at the Chautauqua National Wildlife Refuge, near Havana, Illinois, in 1940, 1942, 1943, and 1952.

Week	Number of Drakes Banded (Cumulative)		Number of Recoveries for Week		Number Banded Per Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
Oct. 4–10	112	90	0	0	....	....	....
Oct. 11–17	493	452	1	6	493.0	75.3	1:6.55
Oct. 18–24	1,700	1,224	8	24	212.5	51.0	1:4.17
Oct. 25–31	3,268	2,111	9	28	363.1	75.4	1:4.82
Nov. 1– 7	4,913	3,363	14	34	350.9	98.9	1:3.55
Nov. 8–14	6,360	4,561	35	55	181.7	82.9	1:2.19
Nov. 15–21	8,025	6,116	29	51	276.7	119.9	1:2.31
Nov. 22–28	9,752	7,025	48	78	203.2	90.1	1:2.26
Nov. 29–Dec. 5	10,319	7,398	73	88	141.4	84.1	1:1.68
Dec. 6–12	10,464	7,483	70	96	149.5	78.0	1:1.92
Dec. 13–19	10,629	7,626	65	51	163.5	149.5	1:1.09
Dec. 20–26	10,634	7,635	31	35	343.0	218.1	1:1.57
Dec. 27–Jan. 2	10,634	7,635	30	15	354.5	509.0	1.0.70
Jan. 3– 9	10,634	7,635	22	24	483.4	318.1	1:1.52
Jan. 10–16	10,634	7,635	5	6	2,126.8	1,272.5	1:1.67
Jan. 17–23	10,634	7,635	2	0	....	....	....
All weeks							
Total	*10,634*	*7,635*	*442*	*591*	....	....	....
Average	....	....	....	....	*24.0*	*12.9*	*1:1.86*

Table 45.—Comparative vulnerability (to hunting) of adults and juveniles, both drakes and hens, of 10 species of ducks banded by Ducks Unlimited* in the prairie provinces of Canada, 1946–1954; vulnerability measured by year-of-banding recoveries.

Species	Number of Ducks Banded		Year-of-Banding Recoveries		Number Banded Per Year-of-Banding Recovery		Ratio of Adult to Juvenile Vulnerability
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
Mallard	4,672	10,159	396	1,130	11.8	9.0	1:1.31
Gadwall	133	351	5	31	26.6	11.3	1:2.35
Baldpate	491	765	17	76	28.9	10.1	1:2.86
Pintail	5,257	3,013	155	169	33.9	17.8	1:1.90
Green-winged teal	391	1,223	12	36	32.6	34.0	1:0.96†
Blue-winged teal	1,809	2,716	42	63	43.1	43.1	1:1.00†
Shoveler	117	261	7	12	16.7	21.7	1:0.77†
Redhead	715	358	32	56	22.3	6.4	1:3.48
Canvasback	50	125	4	29	12.5	4.3	1:2.91
Lesser scaup	393	1,716	14	119	28.1	14.4	1:1.95

*Compilation by William Leitch, Chief Biologist, Ducks Unlimited; data are from bandings by field personnel qualified to separate adult and juvenile ducks.

†This ratio probably incorrect, perhaps partly as a result of loss of bands by newly banded juveniles and unusually heavy losses among juveniles between banding and opening of hunting season.

Maryland, recommended size 6 for the shoveler, although a size 5 is large enough for that species. Many banders used size 5 to mark green-winged teals, although size 4 is the proper size. Perhaps natural mortality was unusually severe in the young teals and shovelers between the time of banding and the opening of the hunting season; very few bands are recovered from ducks that are not bagged by hunters. Still another possible explanation for unexpectedly low relative vulnerability rates for juveniles on the Canadian breeding grounds has been posed by Robert I. Smith of the Illinois Natural History Survey. Smith has observed on the breeding grounds that fall flocking behavior of juveniles differs from that of adults. Prior to migration, juveniles tend to congregate, while many adults remain as single hens of male-female pairs. The nature and time of this flocking behavior, Smith believes, varies with species and with the success and duration of the nesting season. Flock size is probably inversely correlated with vulnerability, thus tending to give greater protection to the congregated juveniles than to the single adult hens or paired adults.

Band recovery data showed pronounced differences among species in the vulnerability rates of juveniles banded in Canada, table 45. Among species other than the teals and the shoveler, juveniles were least vulnerable to the gun in the mallard and most vulnerable in the redhead. Other data obtained from bandings at national wildlife refuges also disclosed wide variations in juvenile vulnerability; they showed the mallard with a comparatively low juvenile vulnerability rate, followed by the pintail, and showed the redhead with the highest vulnerability rate.

Thus, the gun vulnerability of juveniles compared to that of adults was found to vary by place, time of hunting season, year, and species.

Gun vulnerability figures for correcting age ratios obtained by checking hunters' bags in one or more flyways can best be obtained by banding adults and juveniles in southern Canada just prior to the opening of the hunting season.

When adequate data from banded ducks are available, they provide a means of testing for and, if necessary, correcting for the relatively greater vulnerability of juveniles. We believe that age ratios of ducks obtained from bag samples and corrected for the greater vulnerability of juveniles offer the best means of determining the adult-juvenile composition of duck populations. However, before these data are used to evaluate production, an appraisal of the influence of season and geography on age ratio samples is needed.

Examination of Disease Victims.—At times, age ratios have been obtained from large samples of ducks which have been victims of disease. During fowl

Table 46.—Juvenile percentages among botulism victims in five species of ducks at the Bear River Migratory Bird Refuge, Utah, during late summer, 1952.*

Period	Mallard		Pintail		Green-Winged Teal		Shoveler		Baldpate	
	Number	Per Cent Juveniles	Number	Per Cent Juveniles	Number	Per Cent Juveniles	Number	Per Cent Juveniles	Number	Per Cent Juveniles
August										
1st week	48	39.6	486	51.2	....	....	....	....	....	....
2nd week	38	52.6	560	50.5	....	....	....	....	....	....
3rd week	34	44.1	601	61.7	128	41.4	26	57.7	....	....
4th week	87	41.4	2,392	50.6	651	42.7	94	46.8	26	38.5
September										
1st week	29	44.8	1,211	44.3	431	43.6	81	38.3	65	52.3
2nd week	38	39.5	781	47.1	371	47.7	107	42.1	62	46.8

*Calculated from data in a report, "Sex and Age Ratio of Waterfowl Afflicted by *Clostridium botulinum*, Type C, on the Bear River Migratory Bird Refuge During Summer, 1952," by Jack P. Allen, Utah Cooperative Wildlife Research Unit, Logan.

cholera epizootics in wild ducks, records have been made of the species and sex affected, but little attention has been given to the ages of victims. In Utah, large numbers of waterfowl that were victims of botulism at the Ogden Bay Bird Refuge were classified as juveniles or adults by Noland F. Nelson, tables 21 and 22, and ducks lost to botulism at the Bear River Migratory Bird Refuge were similarly classified by Jack P. Allen, table 46. The degree to which botulism toxin is selective for the two age groups has not been investigated.

Epizootics resulting in extensive loss of waterfowl cannot be relied upon as dependable sources of data on age ratios because of irregular occurrence and site limitations. However, advantage should be taken of such occasions for the purpose of obtaining supplementary age data and for investigating the extent to which disease may be selective for age classes.

Seasonal Variations in Age Ratios

Because adults and juveniles, like drakes and hens, have different migration schedules, age ratios calculated for any given area have seasonal variations.

Differential migratory movements of adult and juvenile age groups often originate on the breeding grounds, where most of the adult drakes of most species leave their mates early in the nesting period to congregate on large lakes and marshes; these areas may be in the immediate breeding area or up to hundreds of miles distant. After the broods become independent, the hens leave them and molt their flight feathers but usually remain in the area where they nested (Hochbaum 1944: 119, 122). Hens that have been unsuccessful in their nesting efforts may join the drakes on the lakes or marshes, where they molt.

Certain large lakes and marshes on the breeding grounds serve ducks as gathering areas preceding southward migration. One of these areas is the Delta Marsh at the south end of Lake Manitoba, Canada. The number of juveniles per adult among mallards in hunters' bags on that marsh was checked for several weeks in 1946 and 1947, tables 47 and 48. There was a reduction in the number of juveniles per adult from the third week to the fourth week in September, 1946, followed by a gradual increase in the number of juveniles per adult until the first week in November, when a very sharp decrease took place. There was a marked decrease in the number of juveniles per adult in the period October 20–25, 1947. When the changes in these age ratios were tested statistically, it was found that in both years the changes were significant at the 99 per cent level (1946, $X^2=55.04$, 5 d.f.; 1947, $X^2=19.34$, 2 d.f.).

Table 47.—Number of juveniles per adult among mallards checked in hunters' bags on the Delta Marsh, Manitoba, in each of 6 weeks in the autumn of 1946.

Period	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult
September			
3rd week..	707	67	2.03
4th week..	146	49	0.96
October			
1st week...	329	54	1.17
2nd week..	231	61	1.57
3rd week..	196	63	1.70
November			
1st week...	33	15	0.18

Table 48.—Number of juveniles per adult among mallards checked in hunters' bags on the Delta Marsh, Manitoba, in each of three periods in the autumn of 1947.

Period	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult
Oct. 10......	121	72	2.57
Oct. 13–18...	174	71	2.45
Oct. 20–25...	163	51	1.04

A late hatch, sometimes as a result of delay in initial nesting and sometimes as a result of severe losses of early nests, may delay the appearance of juvenile mallards in Illinois, as in 1939, 1943, 1945, 1947, 1949, and 1950, fig. 12. The effect of a late hatch may be shown in the degree of retention of juvenile plumage by young during the southward migration, as was evident in juvenile mallards in Illinois in 1950 and 1953. Breeding grounds surveys indicated a delayed or extended hatch in 1950 (Hawkins 1950:42; Sowls 1950:

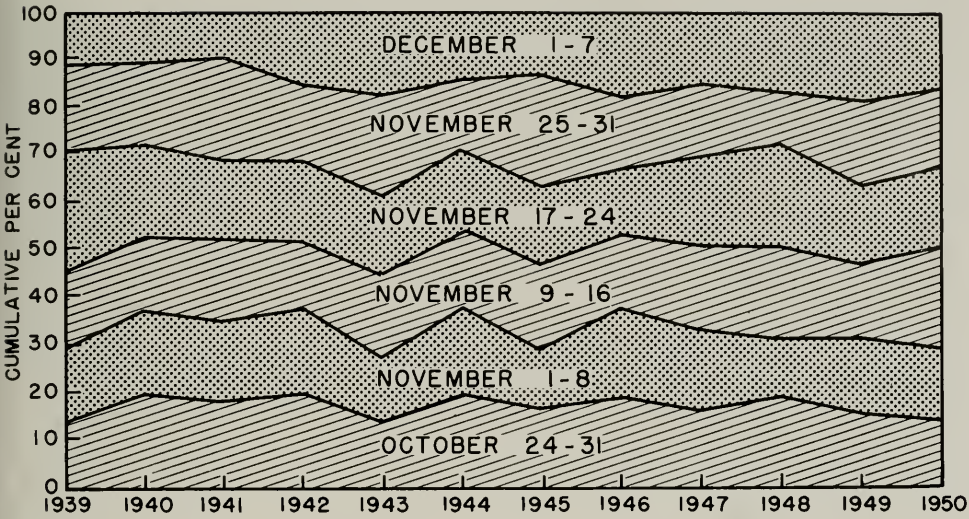

Fig. 12.—Year-to-year variations in the seasonal migration of juvenile mallards through the Illinois River valley, 1939–1950, as shown by the proportion of each year's juvenile flight that was in the valley in each of 6 weeks in autumn.

60) and in 1953 (Lynch & Gollop 1954: 47; Gollop 1954:67; Hawkins 1954:77).

That the age composition of the mallard population in Illinois varied from week to week in the fall is shown by checks of hunters' bags, table 44. In any one year, pronounced week-to-week variations in the age composition of mallards taken by hunters in Illinois suggest that there may be many migratory movements, some scarcely detectable, within a local population.

The adult-juvenile composition of the mallard flight in Illinois for the period 1939–1949 is reflected in fig. 13. Generally, juveniles made up a greater part of the mallard bag early in the season than later. The juvenile proportion in hunters' bags soon declined, as indicated by data collected during the first half of November; it recovered somewhat during the second half of November but declined again during the first 2 weeks of December. The decline in December resulted as juveniles moved farther south and large numbers of adults moved into Illinois from the north.

In 6 of 7 years, juvenile mallards in Arkansas formed a greater proportion of the hunters' bags in the second than in the first of two periods during which data were collected, table 49. The findings shown in fig. 13 and tables 49 and 50 suggest that, between the mid-flyway areas (Illinois) and the wintering grounds (Arkansas), juveniles may be more prone to leisurely migration than adults.

The daily change in age composition of the mallard bag at Stuttgart, Arkansas, for December 2–11, 1950, is given in table 50. A marked change in the relative number of juveniles in the bag occurred on December 8. A large southward flight of mallards from Illinois on December 7, as a result of zero weather and snow, contained a relatively large number of juve-

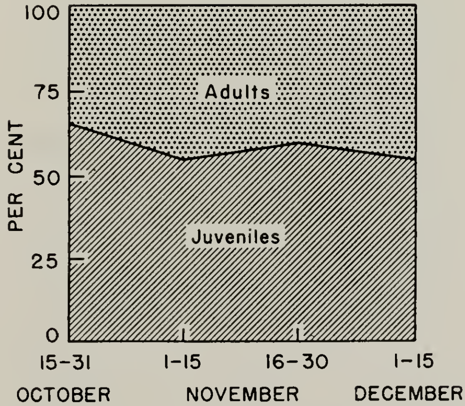

Fig. 13.—Juvenile-adult composition of the autumn flight of mallards in Illinois, as indicated by checks of hunters' bags in the autumns of 1939–1949.

Table 49.—Number of juveniles per adult among mallards checked in hunters' bags at Stuttgart, Arkansas, in 12 hunting seasons.

Hunting Season	Period of Sampling	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult	Probability That Change Resulted From Chance
1946	Nov. 23–26	1,889	55	1.22	$<0.05>0.025$
	Nov. 27–Dec. 1	1,461	52	1.08	
1947	Dec. 8–11	2,064	59	1.44	<0.005
	Dec. 12–14	1,253	67	2.03	
1948	Nov. 26–31	2,035	68	2.12	$<0.10>0.05$
	Dec. 2–4	965	71	2.45	
1949	Nov. 18–21	1,830	47	0.89	$<0.05>0.10$
	Dec. 26–27	274	51	1.04	
1950	Dec. 2–11	3,712	42	0.72	$<0.50>0.25$
	Dec. 28–29	149	46	0.85	
1951	Nov. 22–23	500	59	1.44	$<0.05>0.025$
	Dec. 1–8	2,500	64	1.78	
1952	Dec. 6–9	997	65	1.86	....
1953	Nov. 27–28	341	43	0.74	$<0.50>0.25$
	Dec. 21–22	230	48	0.92	
1954–55	Jan. 4–5	408	49	0.96	....
1955–56	Jan. 7–8	458	58	1.38	....
1958	Dec. 8–10	1,139	32	0.47	....
1959	Nov. 30–Dec. 1	1,053	23	0.29	....

nile ducks. Its impact on age ratios in Arkansas seemed apparent. When age ratios before and after the influx of the juvenile mallards from Illinois into Arkansas were statistically compared, the difference was found to be significant ($X^2=45.6$, 1 d.f.) at the 99 per cent level.

Because Utah is a breeding ground for several species of ducks, an important molting area for several species, and an important migration area for many species, it might be anticipated that age ratios in this state would show a complex relationship to migration.

Records on ducks taken in traps at Ogden Bay, Utah (Fuller & Low 1951:42), indicated that "the earlier arrivals were immature birds, adults showing up more frequently from the last of August, . . ." This evidence from trapping operations late in summer plus declining numbers of juvenile pintails during the fall in the bags of Utah hunters, fig. 14, suggest the possibility of a pronounced movement of juvenile pintails through Utah before the hunting season. According to J. B. Gollop of the Canadian Wildlife Service (personal communication), there was good evidence in Saskatchewan in 1952 that a mass exodus of juvenile pintails occurred during late August.

A tally of adult and juvenile ducks that were victims of botulism during August and the first half of September, 1952, on the Bear River Migratory Bird Refuge, table 46, also provides data on the age

Table 50.—Number of juveniles per adult among mallards checked in hunters' bags at Stuttgart, Arkansas, in each of 10 days in December, 1950.

Date	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult
Dec. 2	535	39.6	0.66
3	771	38.9	0.64
4	584	38.2	0.62
5	345	33.3	0.50
6	59	32.2	0.48
7	100	38.0	0.61
8	240	58.3	1.41
9	372	46.5	0.87
10	469	48.0	0.92
11	237	47.3	0.89
Dec. 2–11	*3,712*	*42.0*	*0.72*

ratios of ducks in a Utah area before the hunting season. These data, unlike the data from ducks trapped at Ogden Bay, do not show a large juvenile duck population prior to the hunting season. Perhaps adults are more susceptible to botulism than juveniles, or perhaps there were differences in age composition between the duck populations on these two marshes, which are about 25 miles apart. Such differences were reflected in hunters' bags checked on the two marshes, tables 55, 56, and 57. Further study of the composition of Utah duck populations seems very desirable, because of the differences in age ratios and the importance of seasonal influences on age ratios in that state.

Mallard migration in Utah in six autumns of the 1940's, fig. 14, was somewhat similar to that in Illinois, fig. 13. Juveniles were most abundant early in the season; their proportion in the bag steadily decreased to the November 16–30 period, after which it remained fairly constant. In Utah, the age pattern of migrating pintails tended to reflect that of migrating mallards, fig. 14. The green-winged teal showed a rather steady decrease in the relative number of juveniles as the season progressed, while the shoveler had a ratio of adults to juveniles that remained about the same throughout the season.

Thus, in the selection of strategic sites for collecting age data on ducks, and in the evaluation of age ratios, migration schedules of waterfowl must be considered. In some species, much of the migration occurs outside of the hunting season; in such species, age ratios calculated from data collected from hunters' bags may not be representative of the populations. Un-

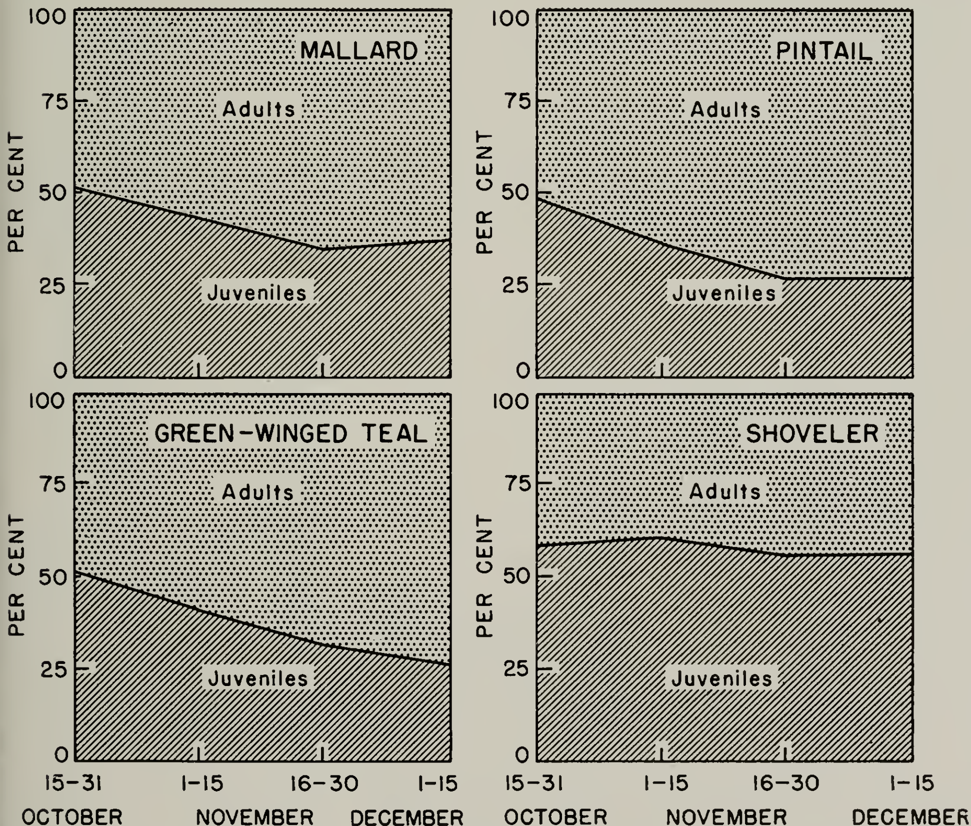

Fig. 14.—Juvenile-adult composition of the autumn flights of mallards, green-winged teals, pintails, and shovelers in Utah, as indicated by checks of hunters' bags in the autumns of 1943, 1944, and 1946–1949.

less traps are operated effectively throughout the period of migration, they, too, will provide biased data.

Age ratios obtained from mallards while on their wintering grounds undoubtedly are relatively unbiased by seasonal movements. It should not be assumed that a similar statement would be true for all species. For example, in the pintail, birds of the two sexes and ages tend to flock separately in winter, and shifting of these flocks along the Texas coast is common.

Regional Variations in Age Ratios

Regional variations in the age ratios of ducks first became apparent to the writers when data on the ducks checked in hunters' bags in Utah, Texas, and Illinois during the fall of 1943 were compared. Since that time, data which provide for further evaluation of regional differences in age ratios have become available, tables 51–57.

Mallards.—The juvenile percentage in mallards checked in hunters' bags in each of eight areas of the Mississippi Flyway is shown in fig. 15. Juveniles made up a large proportion of the ducks that were taken in Manitoba because the adult drakes tend to migrate from there early, and the juveniles are more vulnerable to shooting early in the hunting season than at any other time. It is not known why the juvenile proportion of the mallards taken by hunters in Ohio (the marshes at Sandusky Bay) was so much greater than that taken by hunters in Michigan (the Pointe Mouillee Marsh, which is less than 50 miles from Sandusky Bay).

The progressive north to south decrease in the juvenile proportion of the mallard population, as shown by checks of hunters' bags in Manitoba, the Upper Mississippi areas, the Illinois River valley areas, and the Arkansas areas, table 51 and fig. 15, reflects both a progressive decline in the juvenile population and a decline in vulnerability to hunting as a consequence of increasing wariness among juveniles.

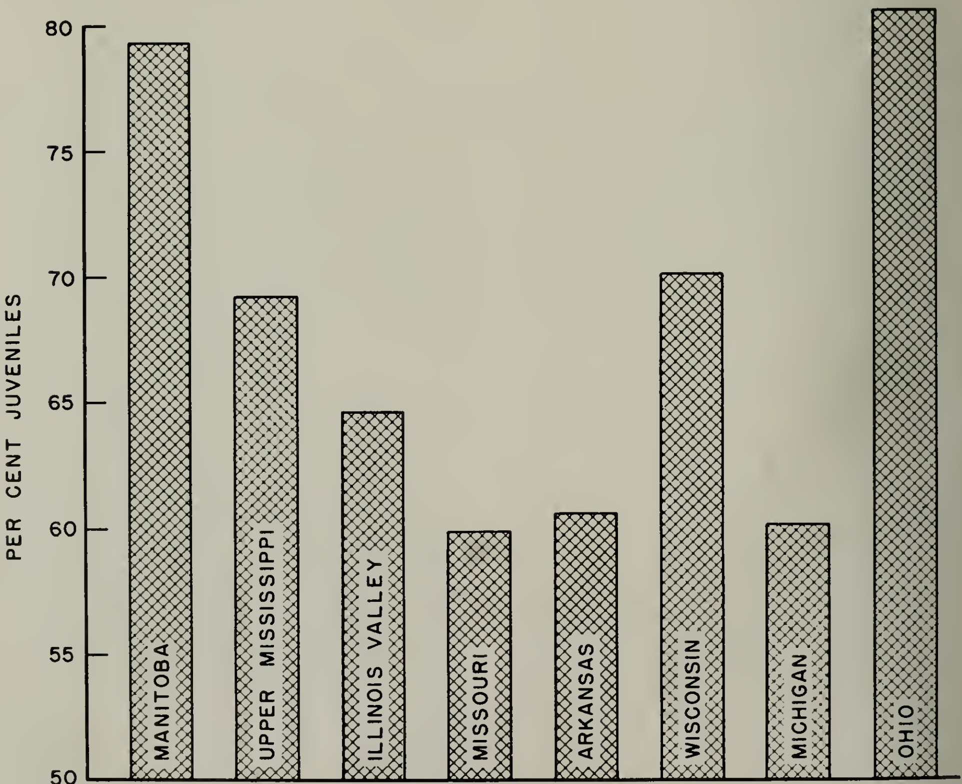

Fig. 15.—Juvenile percentage in mallards checked in hunters' bags in each of eight areas of the Mississippi Flyway, 1946–1949.

One question of concern to students of age ratios is: "Can age ratios at any one place be used to indicate yearly changes in production?" Table 51 and fig. 16 show the yearly trends in the juvenile proportion of the mallard population in a number of areas. Bag checks in Manitoba are in general agreement with those in the Mississippi River basin areas in showing increases in the juvenile component in 1947 and 1948 and a decrease in 1949. Year-to-year differences in the time of departure of adults and juveniles from the breeding grounds probably explain some of the differences between mallard age ratios taken in Manitoba and those taken in the Mississippi River basin areas.

Year-to-year changes in the juvenile proportion of the mallard populations of the Great Lakes areas—principally the

Table 51.—Number of juveniles per adult among mallards checked in hunters' bags in 13 regions of North America, 1946–1949.

Region	1946		1947		1948		1949		1946–1949	
	Number of Ducks Checked	Juveniles Per Adult	Number of Ducks Checked	Juveniles Per Adult	Number of Ducks Checked	Juveniles Per Adult	Number of Ducks Checked	Juveniles Per Adult	Number of Ducks Checked	Juveniles Per Adult
The Pas, Manitoba	......	......	1,032	14.71	......	......	1,537	8.80	2,569	10.63
Netley, Manitoba	......	......	903	4.17	1,248	5.71	893	2.92	3,044	4.29
Delta, Manitoba	1,874	1.46	496	1.70	251	5.12	......	......	2,621	1.62
Upper Mississippi River	490	1.29	653	2.72	1,192	3.00	235	0.93	2,570	2.18
Wisconsin	333	3.44	287	3.95	820	3.69	1,821	1.76	3,261	2.33
Michigan	271	2.15	212	1.08	357	1.25	242	1.82	1,082	1.50
Ohio	993	4.84	940	3.22	819	6.04	735	2.62	3,487	3.90
Indiana	......	......	......	......	369	0.86	677	1.19	1,046	1.07
Illinois River valley	1,317	1.25	814	2.36	1,215	3.18	597	0.97	3,943	1.77
Missouri	327	1.75	518	1.76	408	2.92	1,094	1.04	2,347	1.48
Arkansas	3,350	1.16	3,317	1.63	3,000	2.22	2,104	0.91	11,771	1.43
Nebraska	......	......	2,514	1.88	1,749	1.81	1,252	0.99	5,515	1.60
Utah	853	1.16	2,067	0.66	1,216	0.74	1,062	0.88	5,198	0.78

Table 52.—Number of juveniles per adult among mallards checked in hunters' bags in Manitoba, Illinois, and Arkansas, 1946–1955 and 1959.

Year	Number of Juveniles Per Adult			Difference in Numbers of Juveniles Per Adult	
	Manitoba (Delta)	Illinois (Illinois River Valley)	Arkansas (Stuttgart)	Manitoba and Illinois	Illinois and Arkansas
1946	1.46	1.25	1.16	0.21	0.09
1947	1.70	2.36	1.63	0.66*	0.73
1948	5.12	3.18	2.22	1.94	0.96
1949	....	0.97	0.91	....	0.06
1950	....	1.53	0.73	....	0.80
1951	....	1.71	1.71	....	0.00*
1952	....	1.65	1.86	....	0.21*
1953	....	1.48	0.82	....	0.66
1954	1.62	0.91	1.04	0.71	0.13*
1955	....	1.78	1.40	....	0.38
1959	0.78	0.34	0.29	0.44	0.05
Average	*2.14*†	*1.61*† *1.56*‡	*1.25*‡	*0.53*	*0.31*

*Only in 1947 did Illinois exceed Manitoba in number of juveniles per adult; only in 1951, 1952, and 1954 did Illinois fail to exceed Arkansas in number of juveniles per adult.
†For years in which data were available for both Manitoba and Illinois.
‡For years in which data were available for both Illinois and Arkansas.

Horicon Marsh in Wisconsin, the Pointe Mouillee Marsh in Michigan, the marshes at Sandusky Bay in Ohio—show little correlation with changes in the Mississippi River basin areas, fig. 16. However, the Great Lakes areas are frequented by only a small proportion of the mallard population of the Mississippi Flyway; these areas are to the east of the principal routes used by mallards migrating between their breeding and wintering areas.

There was reasonably close agreement in the year-to-year fluctuations in the number of juvenile mallards per adult in hunters' bags in the Mississippi River basin areas: the Upper Mississippi River, the Illinois River valley, and the Stuttgart, Arkansas, area, table 51 and fig. 16. There was a highly significant relationship between the age ratios of mallards bagged in the Upper Mississippi River area, Illinois River valley, Missouri, and Arkansas during the period 1946–1949, table 51, as demonstrated by a correlation coefficient of $r = +0.969$ or higher, which indicated that the probability that the correlation was due to chance was less than 0.01.

The age ratios for mallards bagged in the Illinois River valley were close to those for mallards taken in the Stuttgart, Arkansas, area in all but 2 (1950 and 1953) of 11 years (1946–1955 and 1959), table 52 and fig. 16. The lack of agreement in the age ratios from the two areas in 1950 and 1953 is believed to have been related to a delayed hatch on the breeding grounds followed by a somewhat delayed movement of juveniles to Illinois, where a high kill of these young birds occurred.

In 1950, mild weather induced large numbers of mallards to remain on the breeding grounds until November 7, when a severe cold front resulted in an unusually large exodus. The ducks moved rapidly down the flyway, and the adults passed through Illinois without stopping so long as is customary. Because of the unusually rapid movement from the breeding grounds to the heavily shot mid-flyway areas, juvenile mallards had not been much exposed to hunting by the time they arrived in Illinois and, thus, were more vulnerable to hunting than in most other years.

Fluoroscopy of live-trapped ducks in 1953, in revealing an unusually low percentage of juveniles with shot wounds, indicated that the young of that year, like those of 1950, had not been much exposed to hunting before their arrival in Illinois.

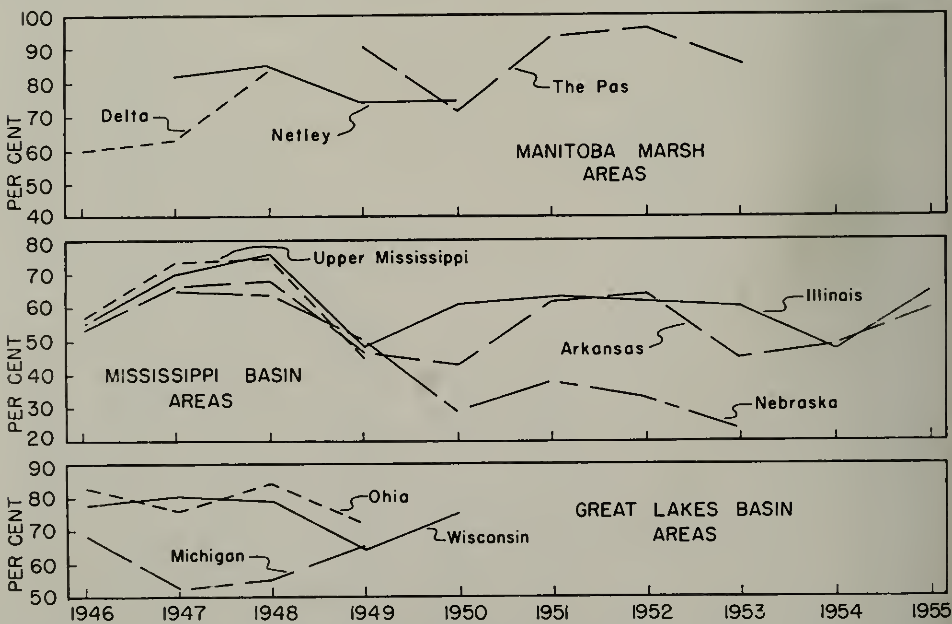

Fig. 16.—Year-to-year changes in the juvenile percentage in mallards checked in hunters' bags in each of several areas of North America, 1946–1955.

Table 53.—Number of juveniles per adult in five species of ducks checked in hunters' bags in seven regions of North America, 1948.

Region	Black Duck		Pintail		Baldpate		Redhead		Lesser Scaup	
	Number Checked	Juveniles Per Adult	Number Checked	Juveniles Per Adult	Number Checked	Juveniles Per Adult	Number Checked	Juveniles Per Adult	Number Checked	Juveniles Per Adult
Manitoba	......	......	145	4.88	337	11.37	388	24.00	275	2.59
Wisconsin	208	3.35	248	4.66	547	10.11	212	6.77	296	2.12
Michigan	374	1.08	102	0.96	191	3.00	56	2.70	117	3.76
Ohio	419	3.54	258	6.14	79	4.26	......	......	......	......
Indiana	67	1.78	......	......	......	......	......	......	......	......
Illinois River valley	58	2.82	126	2.03	......	......	......	......	......	......
Utah	......	......	2,210	0.79	1,142	2.32	206	3.76	......	......

The lack of hunting experience by juveniles before reaching Illinois in 1950 and 1953, plus the abnormally rapid flight of adults through Illinois in 1950, resulted in the unusually large differences between Illinois and Arkansas in the number of juveniles per adult in the mallard bag in those years, table 52.

With infrequent exceptions, such as those in 1950 and 1953, it appears that age ratios taken along the main stem of the Mississippi Flyway from Delta, Manitoba, to Stuttgart, Arkansas, provide an index to the yearly productivity of the mallard in the flyway.

Other Species. — Considerable regional variation in the number of juveniles per adult was found in 1948 for each of five species of ducks checked in hunters' bags in Manitoba, states of the Mississippi Flyway, and Utah, table 53. Two of the four species checked in Manitoba had more juveniles per adult in that province than in other localities.

Regional variations in age ratios among the several species and within any given species probably result in part from differences in seasonal movements among the species and between juveniles and adults. It is assumed that regional variations in age ratios derived from inspection of hunters' bags would be most pronounced in those species of ducks that depart from the breeding grounds early in the migration season. Because the hunting seasons for the various states do not coincide and because the migration schedules of adults and juveniles of a given species may differ, adults of a species may receive greater hunting pressure in one state, juveniles in another.

Table 54.—Number of juveniles per adult among mallards checked in hunters' bags in two regions of the Illinois River valley, 1939.

Region	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult
Upper	1,203	60.4	1.52
Lower	1,058	57.7	1.36

In an unpublished report for 1954, Milton W. Weller, then of the University of Missouri, pointed out the diverse movements of the two redhead age classes in Manitoba. Many adult redheads moved northward to molting areas following the breeding season, while most juveniles remained on breeding areas. The redhead bag in the molting areas showed a low juvenile percentage, whereas the bag in the breeding areas showed a high juvenile percentage. Weller speculated that differences in the migration schedules of adults and juveniles might influence bag data all along the migration routes.

The juvenile component in the population of each duck species investigated has tended to be so low in Utah, tables 53 and 55, as to warrant special attention. The marshes around Great Salt Lake have long been the scene of unusually heavy concentrations of early-migrating waterfowl. As census records showed, peaks in waterfowl populations at the Bear River Migratory Bird Refuge in 1946, 1947, and 1948 occurred before the season opened (Van Den Akker & Wilson 1951: 373). Because juveniles in hunters' bags decreased proportionately as the hunting season progressed, fig. 14, the possibility is raised that flights which are top-heavy in juveniles may leave Utah before the hunting season opens. If this assumption is substantiated in subsequent investigations, it would partially account for the abnormally large number of adults in the bags of Utah hunters.

No doubt some differences between the age ratios representing various bag inspection stations have resulted from differences in the character and size of areas sampled. In some cases, age ratio data representing a checking station may be from only a single, relatively small area, such as the Delta Marsh or Netley Marsh in Manitoba. In other cases, the data may be from many marshes representing many

Table 55.—Number of juveniles per adult in five species of ducks checked in hunters' bags in two areas adjacent to the Great Salt Lake, Utah, in 1947.

Species	Number of Ducks Checked		Juveniles Per Adult		Probability That Difference Is Due to Chance
	Ogden Bay	Farmington Bay	Ogden Bay	Farmington Bay	
Mallard	677	373	0.68	1.01	<0.005
Gadwall	398	276	2.36	0.85	<0.0005
Baldpate	422	276	3.70	1.76	<0.0005
Pintail	1,374	1,281	1.25	0.75	<0.0005
Green-winged teal	727	446	1.62	2.22	<0.025
Shoveler	419	357	2.19	3.01	<0.005

Table 56.—Number of juveniles per adult in six species of ducks checked in hunters' bags in two areas adjacent to the Great Salt Lake, Utah, in 1948.

Species	Number of Ducks Checked		Juveniles Per Adult		Probability That Difference Is Due to Chance
	Ogden Bay	Farmington Bay	Ogden Bay	Farmington Bay	
Mallard	817	247	0.88	0.77	<0.20>0.10
Gadwall	429	205	1.01	1.20	<0.40>0.30
Baldpate	1,142	320	2.30	2.44	<0.90>0.80
Pintail	2,210	761	0.78	0.64	<0.0005
Green-winged teal	1,069	395	0.88	0.78	<0.30>0.20
Shoveler	687	386	2.06	1.96	<0.80>0.70

Table 57.—Number of juveniles per adult in six species of ducks checked in hunters' bags in two areas adjacent to the Great Salt Lake, Utah, in 1949.

Species	Number of Ducks Checked		Juveniles Per Adult		Probability That Difference Is Due to Chance
	Ogden Bay	Farmington Bay	Ogden Bay	Farmington Bay	
Mallard	541	380	0.66	0.87	<0.05
Gadwall	1,153	322	0.48	0.85	<0.0005
Baldpate	296	334	3.00	0.90	<0.0005
Pintail	2,027	871	0.51	0.54	<0.50>0.40
Green-winged teal	1,212	567	0.52	0.77	<0.0005
Shoveler	555	614	1.04	1.12	<0.60>0.50

acres. For example, mallards checked at Stuttgart, Arkansas, were shot on at least 20 different swamp or reservoir tracts scattered over an area having a 25-mile radius. Most of the mallards checked in the Illinois River valley were bagged at 10 clubs distributed over a linear distance of 100 miles.

Only a slight difference in the number of juvenile mallards per adult between populations of the upper and lower sections of the Illinois River valley was found in 1939, table 54. This difference was not significant at the 90 per cent level ($X^2=1.79$, 1 d.f.).

Much greater differences in number of juveniles per adult for several species of ducks were found between populations of two marshes 25 miles apart and adjacent to the Great Salt Lake, Utah, in 1947–1949, tables 55–57. The probability that the differences were the result of chance is shown in tables 55–57. There was a statistically significant difference between age ratios in the two areas in 11 of 18 tests.

These data suggest that the age composition of migrating flocks differs and that fortuitous circumstances result in flocks especially numerous in birds of one age class or the other in a particular marsh. Where only one waterfowl area in a region has been sampled, as Winous Point in Ohio or Pointe Mouillee in Michigan, the age ratios derived may or may not reflect those for the entire region.

For species other than the mallard, regional data are not adequate to permit evaluation of the age ratios derived in any one area. For each of these species, we have compiled data from as many areas as possible in the Mississippi Flyway on the assumption that data for the total flyway represent the species better than the data from any one area and reflect year-to-year changes in the age composition of the population.

Factors Affecting Age Ratios

Age ratios can be used for appraising the productivity of ducks if the data on which they are based have been carefully evaluated as to the effect of seasonal, regional, and shooting biases. Sufficient data for calculating age ratios corrected for differences between juveniles and adults in vulnerability to hunting have been accumulated for the mallard in the Mississippi Flyway, table 58 and fig 17. Most of the data used in the table and graph

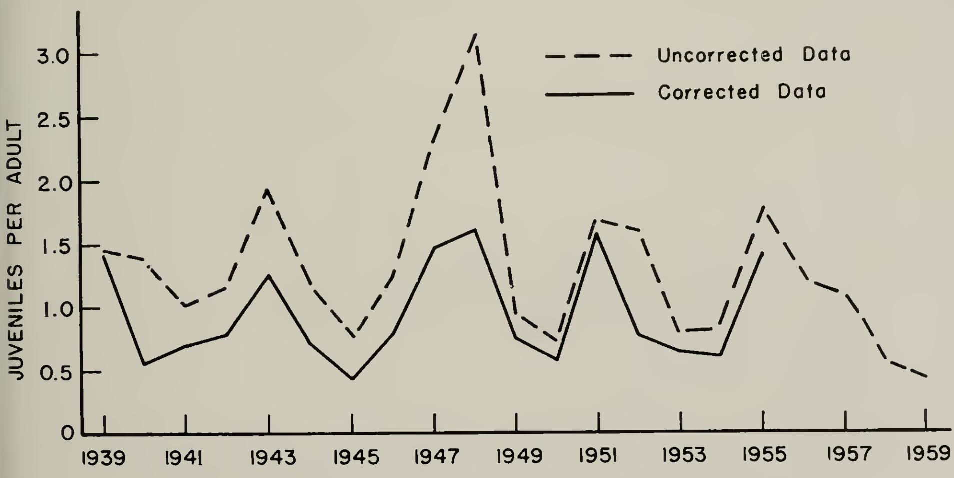

Fig. 17.—Uncorrected and corrected numbers of juvenile mallards per adult in bags of Mississippi Flyway hunters in each of several years; uncorrected numbers, 1939–1959; corrected numbers, which compensate for differences in hunting vulnerability between adults and juveniles, 1939–1955. Points on the graph for 1939–1955 are based principally on Illinois data, table 58. Points for 1956–1959 are based on data from Missouri, table 59. Because data for 1955 showed the number of juveniles per adult among Illinois mallards (1.78) to be about 10 per cent less than the number among Missouri mallards (1.99), the point for each year in the period 1956–1959 represents a figure that is 10 per cent less than the corresponding figure in table 59.

Table 58.—Number of juveniles per adult and per hen in mallard populations of the Mississippi Flyway, principally Illinois, 1939–1955; the uncorrected numbers are based upon data from inspection of hunters' bags; the corrected numbers compensate for differences between juveniles and adults in vulnerability to hunting.

Year	Number of Juveniles in Bag	Ratio of Adult to Juvenile Vulnerability to Hunting (Drakes)	Corrected Number of Juveniles in Population	Number of Adults in Bag	Uncorrected Number of Juveniles Per Adult in Bag	Corrected Number of Juveniles Per Adult in Bag	Number of Adult Hens in Bag	Corrected Number of Juveniles Per Adult Hen in Bag
1939	1,337	1:1.03	1,298	924	1.45	1.40	317	4.09
1940	2,093	1:2.48	844	1,471	1.42	0.57	610	1.39
1941	2,255	1:1.46	1,544	2,226	1.01	0.69	697	2.22
1942	980	1:1.51	653	829	1.18	0.79	270	2.42
1943	939	1:1.54	610	483	1.94	1.26	157	3.89
1944	1,176	1:1.54	764	991	1.19	0.77	312	2.45
1945	898	1:1.78*	504	1,149	0.78	0.44	379	1.33
1946	731	1:1.57*	466	586	1.25	0.80	228	2.04
1947	572	1:1.57	364	242	2.36	1.50	78	4.67
1948	924	1:1.94	476	291	3.18	1.64	114	4.18
1949	294	1:1.24	237	303	0.97	0.70	98	2.42
1950	1,627†	1:1.27†	1,281	2,234†	0.73	0.57	928	1.38
1951	517	1:1.08	479	302	1.71	1.59	118	4.06
1952	753	1:2.17	347	456	1.65	0.76	172	2.02
1953	257†	1:1.27†	202	314†	0.82	0.64	97	2.08
1954	218	1:1.55	141	240	0.91	0.59	70	2.01
1955	478	1:1.55	308	268	1.78	1.44	95	3.24
Average	....	....	....	....	*1.43*‡	*0.95*‡	....	*2.70*‡
All years	*16,049*	....	*10,518*	*13,309*	*1.21***	*0.79***	*4,740*	*2.22***

*Ratio based on data from McGinnis Slough, as explained on page 451.
†Numbers of juveniles and adults for 1950 and 1953 from Arkansas, the ducks included in table 49; numbers of juveniles and adults for other years from Illinois, the ducks included in table 36; ratio of adult to juvenile vulnerability for 1950 and 1953 explained on page 451, ratios for most other years from table 39.
‡Average of yearly figures above.
**Average based on total numbers of individuals.

were collected in Illinois, from both Illinois River and Mississippi River areas. Data from Arkansas were used for 1950 and 1953 because unusual breeding grounds and migration conditions in those years had less influence on the migration in that state than in Illinois. Data from Missouri were used for 1956–1958 because no data were available for Illinois in those years and because data from both states for 1955 permitted correction of the Missouri data. An appraisal of the effect of seasonal, regional, and hunting bias on the age ratios calculated for the mallard in the Mississippi Flyway is given below.

Seasonal Bias.—Age ratios have been determined for large numbers of population samples by inspection of ducks in hunters' bags throughout many hunting seasons in Illinois. Although the Illinois hunting seasons have varied as to opening date and length, most of each southward mallard migration has occurred during the open season (Bellrose 1944:346–50). Inasmuch as sample size was determined partly by hunter success, which in turn was determined partly by population size, the numbers of birds in the samples were approximately proportional to the numbers of birds in the populations sampled. For these reasons, we believe that in most years there was little, if any, seasonal bias in the age ratios derived from checking mallards in hunters' bags in Illinois.

Regional Bias.—Unpublished population data and records from the recovery of bands indicate that the largest segments of the mallard population in the Mississippi Flyway visit the Illinois River valley. The ducks in hunters' bags have been examined each year at numerous places throughout the valley, thereby minimizing the effect of data obtained from aberrant local concentrations of particular age groups. In 1950, an abnormal migration resulted in relatively large numbers of adult mallards passing more rapidly than usual through the Illinois River valley. In both 1950 and 1953, juvenile mallards appeared unusually vulnerable to Illinois hunters. We believe that the duck kill checked in Arkansas provided the more valid data for the Mississippi Flyway in 1950 and 1953, and we have used Arkansas data, derived from table 49, for calculating the numbers of mallard juveniles per adult for those years. For the other years included in table 52, the differences between Illinois and Arkansas in number of juveniles per adult were not so great as to warrant special treatment of the data.

Hunting Bias.—The year-to-year variations in the vulnerability figures for mallards, table 39, make it desirable to evaluate the age ratios, or number of juveniles per adult, derived from inspection of hunters' bags.

Most of the band recovery data from which the ratios of adult to juvenile vulnerability were derived, table 39, were obtained from ducks banded at the Chautauqua National Wildlife Refuge, which is in the center of the area in which bagged ducks were sampled for age. Because no ducks were banded at Chautauqua in 1945 and 1946, in those years banding data from McGinnis Slough, table 40, were used, and adjustments, based on several years of vulnerability rates, were made for differences between the two stations.

Because the Arkansas kill data for 1950 and 1953, table 49, were believed to be more valid than the Illinois data, the numbers of juveniles and adults inspected in hunters' bags in Arkansas were chosen as base figures for these years, table 58. The 1:1.27 ratio of adult to juvenile vulnerability for 1950 and 1953, table 58, was assigned rather arbitrarily. As table 44 indicates, mallard juveniles are about half as vulnerable to hunting in December as in November. Illinois data for several years showed that the difference between adult and juvenile mallard drakes in vulnerability to hunting averaged 0.54 (1:1.54 ratio, table 39). The largest part of the Illinois mallard kill was in November. In December, when the birds were in Arkansas, the difference between the adult and juvenile kill figures should have averaged about half of 0.54, or 0.27, and the ratio of adult to juvenile vulnerability should have averaged about 1:1.27.

Table 58 shows for each year in the period 1939–1955 the ratio of adult to juvenile vulnerability among banded mallard drakes and the actual (uncorrected) number of juveniles per adult checked in hunters' bags in the Mississippi Flyway, principally Illinois. It is apparent that the ratio of adult to juvenile vulnerability has no correlation with the number of juveniles per adult bagged by hunters.

Table 58 shows also for each year the number of juveniles per adult and per adult hen among mallards checked in the bags of Mississippi Flyway hunters, each number corrected for the greater vulnerability of juveniles. For the period 1939–1955, the corrected figure was 0.95 juvenile per adult and 2.7 juveniles per adult hen. These figures probably reflect the age composition of mallard populations in the Illinois River valley for the 17-year period quite well, for inaccuracies in the yearly vulnerability rates would tend to cancel each other out over the period.

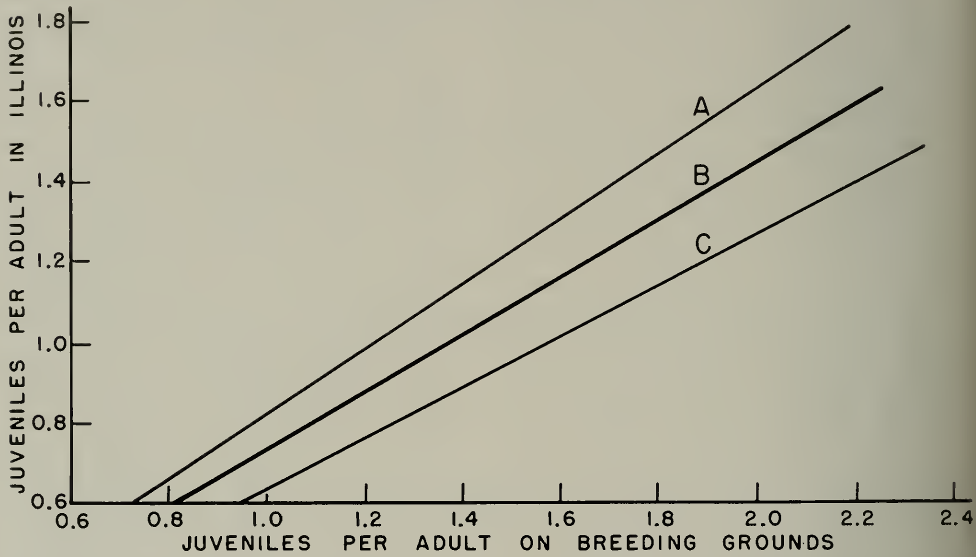

Fig. 18.—Numbers of juvenile mallards per adult on the breeding grounds just prior to the hunting season, as calculated from numbers of juveniles per adult in Illinois during the hunting season; each of the Illinois numbers on which curves *A*, *B*, and *C* are based has been adjusted to compensate for a greater shooting loss among juveniles than among adults before reaching Illinois: *A*, 2.0 juveniles per adult, *B*, 2.5 juveniles per adult, and, *C*, 3.0 juveniles per adult.

Trends in the age composition of mallard populations in the Illinois River valley reflect trends in the age composition of mallard populations on the breeding grounds prior to the hunting season. However, population figures obtained in Illinois do not represent the true age composition of the populations on the breeding grounds, because of the comparatively greater loss from hunting experienced by the juvenile segment of the population between the breeding grounds and Illinois.

Both shrinkage in the juvenile segment of mallard populations and seasonal declines in the vulnerability rates of the juveniles are indicated by the progressively smaller relative numbers of juveniles in hunters' bags as the ducks moved down the flyway from Manitoba to Illinois to Arkansas, table 52. Juvenile mallards are undoubtedly more vulnerable to hunters in Manitoba than to hunters in Illinois, and to hunters in Illinois than to hunters in Arkansas, as shown by seasonal changes in vulnerability ratios, table 44.

Shrinkage in the juvenile segment of mallard populations between the breeding grounds and Illinois is indicated not only by data in table 52 but by rather abstruse calculations employing band recoveries, mortality rates, and juvenile vulnerability rates, as discussed below.

An average annual mortality rate for adult drake mallards in the Mississippi Flyway of about 40 per cent has been derived from band recovery data for drake mallards banded as adults at Lake Chautauqua, Mason County, Illinois, 1939–1944 (Bellrose & Chase 1950:9).

It seems reasonable to assume that hunting accounts for about three-fourths of this average annual mortality and other causes for one-fourth, or an average annual mortality rate of 30 per cent from hunting and 10 per cent from other causes. An analysis of 6,000 indirect (after the year of banding) recoveries of adult drake mallards banded at Lake Chautauqua disclosed that 47.6 per cent or about one-half of the recoveries were from points north of the Illinois River valley. It seems reasonable to assume further that hunting results in approximately a 15 per cent reduction in the numbers of adult mallards before they reach the Illinois River valley from the breeding grounds.

Data in tables 44 and 47 suggest that the juveniles are 2 to 3 times as vulnerable as adults during the early fall season when in migration from Manitoba to Illinois. If we assume that juveniles are 2.5 times as vulnerable as adults, and that hunting takes a toll of 15 of each 100 adults before the flights reach Illinois, then we may say that hunting takes a toll of 2.5 times as many juveniles or 37.5 of each 100 juveniles in the same period.

Fig. 18 shows a scale for converting the age ratios of mallards occurring in wild populations in the Illinois River valley to age ratios which would be comparable for wild populations on the breeding grounds prior to the hunting season. Following is an example showing the method used to determine a point on the scale, fig. 18, representing the probable number of juveniles per adult on the Canadian breeding grounds when 0.6 juvenile per adult has been determined to exist in mallard populations in Illinois; the adults are assumed to have been subjected en route to Illinois to a shooting loss of 15 per 100 and the juveniles to a shooting loss of 37.5 per 100.

When

A = the number of adults on the breeding grounds per adult in Illinois, with a presumed 1:0.6 ratio of adults to juveniles in Illinois,

a = the number of adults to 0.6 juvenile in Illinois,

p = the per cent of the adult population remaining after a 15 per cent loss en route to Illinois,

then

$$A = \frac{a}{p} \text{ or } \frac{1}{0.85} = 1.18,$$

the number of adults on the breeding grounds to 1 adult in Illinois.

When

Y = the number of juveniles per adult on the breeding grounds, with a presumed 1:0.6 ratio of adults to juveniles in Illinois,

y = the number of juveniles to 1 adult in Illinois,

p = the per cent of the juvenile population remaining after a 37.5 per cent loss en route to Illinois,

then

$$Y = \frac{y}{p} \text{ or } \frac{0.6}{0.625} = 0.96,$$

the number of juveniles on the breeding grounds to 0.6 juvenile in Illinois.

Thus, when there is a ratio of 0.6 juvenile per adult in Illinois, the adults have been subjected to a 15 per cent loss en route to Illinois, and the juveniles have been subjected to a shooting loss 2.5 times as great as that of adults, the ratio on the breeding grounds is 0.96 young to 1.18 adult, or 0.81 juvenile to 1 adult.

An average of 0.95 juvenile per adult was calculated for mallard populations in the Mississippi Flyway, principally Illinois, over a 17-year period, 1939–1955, table 58. This average takes into account differences in vulnerability between adults and juveniles. If juveniles suffered a loss of 37.5 per cent en route, the calculated average number of juveniles on the breeding grounds just prior to migration per 0.95 juvenile arriving in Illinois was 1.52 (0.95÷0.625). If adults suffered a loss of 15 per cent en route, the calculated average number of adults on the breeding grounds just prior to migration per adult arriving in Illinois was 1.18 (1.0÷0.85). For the 17-year period, the calculated average number of juveniles per adult on the breeding grounds just prior to migration was 1.29 (1.52÷1.18).

If the average number of juveniles per adult in Illinois (0.95) is to the number of juveniles per hen in Illinois (2.7), table 58, as the number of juveniles per adult on the breeding grounds (1.29) is

Table 59.—Number of juveniles per adult among mallards shot at the Duck Creek Wildlife Area, Puxico, Missouri, 1955–1959.*

Year	Number of Ducks Checked	Per Cent Juveniles	Juveniles Per Adult	Approximate 95 Per Cent Confidence Limits
1955	5,581	66.6	1.99	1.79–2.19
1956	2,368	58.5	1.41	1.37–1.45
1957	478	54.8	1.21	0.87–1.55
1958	581	37.7	0.60	0.47–0.73
1959	2,064	32.6	0.48	0.42–0.54

*Data supplied by George Brakhage of the Missouri Conservation Commission.

to the number of juveniles per hen on the breeding grounds (X), the number of young per hen on the breeding grounds can be calculated by solving for X in the following equation:

$$0.95:2.7::1.29:X$$
$$X=3.7$$

Bag data for the Mississippi Flyway, principally Illinois, uncorrected for the greater vulnerability of juveniles to hunters, showed an average of 1.43 juveniles per adult over the period 1939–1955, table 58. This average is greater than the calculated average number of juvenile mallards per adult on the breeding grounds just prior to the hunting seasons (1.29). A higher figure for Illinois than for the breeding grounds may have resulted because the disproportionate loss of juveniles before the mallard populations reached Illinois was more than compensated for by the disproportionate vulnerability of juveniles in Illinois.

Age Ratios as Measures of Production

Many wildlife technicians have assumed that increases in the number of juvenile ducks per adult in hunters' bags reflect increases in production of young during the breeding season immediately preceding, that age ratios can be used as indices of production, and that curves plotted from age ratios may be regarded as production curves.

Year-to-year changes in the age ratios of mallards in the Mississippi Flyway are shown in tables 52, 58, and 59 and fig. 17 for 21 years, 1939–1959. The production curve plotted from the corrected age data follows a pattern somewhat similar to that plotted from the uncorrected age data, fig. 17. However, because errors of varying magnitude are probably present in the yearly vulnerability factors used in correcting age data, it has been deemed advisable to use uncorrected age data rather than the corrected data as the better indices of year-to-year changes in productivity.

The data (uncorrected) on which the broken line in fig. 17 is based indicate that lows occurred in the production of young mallards in 1941, 1945, 1950, 1953, and 1959; highs occurred in 1939, 1943, 1948, 1951, and 1955. This somewhat rhythmic production trend may be an inherent characteristic of waterfowl populations and may prove to be density dependent in origin.

Significant data for the Mississippi Flyway are lacking on yearly changes in production of species other than the mallard. However, John E. Chattin of the U. S. Fish and Wildlife Service has made available age ratios of pintails trapped at seven banding stations in California, Oregon, and Nevada from 1949 through 1959.

The relatively large number of juveniles among the pintails trapped, particularly in 1951 and 1952, fig. 19, suggests bias in the samples, possibly the result of juveniles entering the traps more readily than adults. Nevertheless, the variations in trap selectivity from year to year are probably not great enough to produce large errors in the indices of production. It is believed that the age ratios obtained from pintails trapped in the Pacific Flyway probably provide a fairly reliable picture of the production trend of the species. A comparison of mallard age ratios in the Mississippi Flyway with pintail age ratios in the Pacific Flyway for 11 years, 1949–1959, fig. 19, reveals for most years an unexpectedly close agreement between the production trends of the two species.

The extent of agreement in production trends between the two species is especially remarkable when differences in distribution and habits of the species are considered. The pintails of the Pacific Flyway breed largely in the western part of the northern plains, whereas the mallards of the Mississippi Flyway breed largely in the eastern part of the northern plains. Moreover, mallards are more prone to nest in the Aspen Parklands and the northern mixed Coniferous Forest than are pintails, which are for the most part confined to the grasslands.

Factors responsible for the yearly fluctuations in mallard production appear to have fairly consistent simultaneous effects on pintail production. Discovery of this fact justifies the use of Mississippi Flyway mallard age ratios as criteria for evaluating the accuracy of breeding ground surveys and the effect of environmental conditions on over-all duck production.

Because breeding grounds surveys have been used in the past to provide most of the waterfowl production information on which annual hunting regulations have been based, and will undoubtedly be used for a similar purpose in the future, an appraisal should be made of the validity of these surveys.

Breeding grounds surveys are affected by the vastness of the breeding grounds, shifts in waterfowl populations with changing water conditions, and difficulty in finding and counting broods. Age ratios obtained from ducks bagged on and south of the breeding grounds provide a means for evaluating the validity of waterfowl breeding grounds surveys and in themselves serve as measures of production.

We have attempted to appraise the validity of breeding grounds surveys by comparing the results of surveys on the plains of Manitoba and Saskatchewan with the mallard age ratios obtained through inspection of hunters' bags in the Mississippi Flyway, principally Illinois. Banding of ducks on the breeding grounds has demonstrated that most of the Mississippi Flyway ducks breed in Manitoba and Saskatchewan.

The first comprehensive breeding grounds surveys were made by the U. S. Fish and Wildlife Service in 1947. In that year, although the nesting population was reported "fair" for Saskatchewan as a whole, brood production was not correspondingly high (Lynch 1948:33). In the same year, the duck crop in the pothole country of Manitoba was considered good, but the production in other types of nesting area was "moderate to very poor"

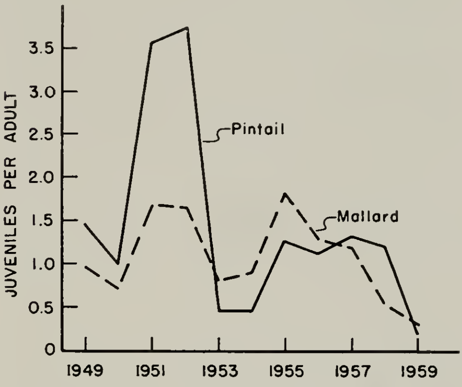

Fig. 19.—Year-to-year changes in the numbers of juveniles per adult in two species, the data derived by two methods in two areas: pintails trapped in the Pacific Flyway and mallards checked in hunters' bags in the Mississippi Flyway, 1949–1959.

(Hawkins 1948:52). Yet, in 1947, mallard age ratios from the Mississippi Flyway showed a pronounced increase in juveniles over the number in 1946, fig. 17. A year later, 1948, "good production" was reported, and "moderate improvement in the waterfowl output for Manitoba" was forecast, by Hawkins & Cooch (1948:97); a small increase in the duck population of Saskatchewan was recorded by Soper (1948:63). Mallard age ratios obtained in the Mississippi Flyway in 1948 showed a further increase in the number of juveniles per adult to a new peak, fig. 17.

In 1949, mallard age ratios from the Mississippi Flyway indicated that a sharp drop had occurred in the relative number of young, fig. 17. From the breeding grounds, Hawkins (1949:64) reported that, in Manitoba, nest success was well below that of 1948. Lynch (1949:52) reported a reduced nesting population in Saskatchewan as a whole, but a successful hatch in the Aspen Parklands, where mallards from the drought-stricken southwestern part of the province had moved to join the ducks that normally nest in the Parklands.

In 1950, Mississippi Flyway age ratios disclosed a further drop in the number of young mallards per adult, fig. 17. On the breeding grounds, Hawkins (1950:45) concluded "that Manitoba produced considerably fewer ducks in 1950 than in 1949." In Saskatchewan, Colls (1950:40) reported "evidence of a lack of, or an unsuccessful attempt at, first nesting among mallards and pintails," and added that by the end of July there appeared to be no important attempts at second nesting by these two species.

In 1951, mallard age ratios derived from bagged ducks in the flyway indicated a marked increase in the production of young, fig. 17. Hawkins, Gollop, & Wellein (1951:49), reporting on other species as well as the mallard in Manitoba, wrote, "the juvenile crop probably doubled the previous year's." Colls & Lynch (1951:40), after observing the success of the first nesting attempt in Saskatchewan, wrote that "a more than usually successful waterfowl-rearing season" was anticipated for the area.

In 1952, the flyway age ratios indicated a decline in the number of young mallards per adult. From one Canadian province, Hawkins & Wellein (1952:64) reported: "Manitoba's contribution to the fall flight of 1952 should be about one-fifth less than in 1951." From Saskatchewan, Gollop, Lynch, & Hyska (1952:37), following a survey in July, 1952, reported a potential production "almost twice that of last year."

A decrease in the production of young in 1953 was reflected by age ratios for mallards bagged in the Mississippi Flyway and by field observations in the area. Moderate decreases were reported in Manitoba by Hawkins (1954:76) and in Saskatchewan by Lynch & Gollop (1954:49).

Age ratios for mallards bagged in the Mississippi Flyway showed little change from 1953 to 1954, fig. 17. For 1954 on the breeding grounds, predictions made after a summer census were that the fall flight of ducks from southern Manitoba would be "about the same as last year," but that a "noticeable" reduction would occur in size of flights from northern Manitoba and from both northern and southern Saskatchewan (Crissey 1954:59, 62, 37).

In 1952, John J. Lynch of the U. S. Fish and Wildlife Service developed mathematical formulas for forecasting waterfowl production in Saskatchewan (Gollop, Lynch, & Hyska 1952:37 and charts 1 and 2). From the formulas he

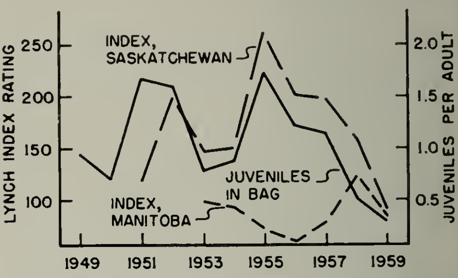

Fig. 20.—Relationship between age ratios of mallards in autumn and the hatch on the breeding grounds in the previous spring, as indicated by number of juvenile mallards per adult in hunters' bags in the Mississippi Flyway, principally Illinois, 1949–1959, and forecast indices of duck production in Canada (Lynch forecast indices, Gollop, Lynch, & Hyska 1952:37), the indices derived from breeding grounds surveys in Manitoba, 1953–1959, and Saskatchewan, 1951–1959.

derived forecast indices, one as of June 1 and another as of August 1. The August index was based upon July data: number of broods per square mile, number (per square mile) of late-nesting pairs and single drakes and hens which supposedly represented late-nesting pairs, number of ponds per square mile, number of ducklings per class III (almost completely feathered) brood, and number of class II (partially feathered) and class III broods per square mile. An index rating of 100 was deemed satisfactory; an index rating of 300 was deemed perfect. Later, some minor modifications were made in the formulas.

A mimeographed report, "Waterfowl Breeding Ground Survey Report, 1958," compiled by Arthur S. Hawkins for the U. S. Fish and Wildlife Service, provides a comparison of late season forecast indices for Saskatchewan, 1951–1958, and for Manitoba, 1953–1958. A similar re-

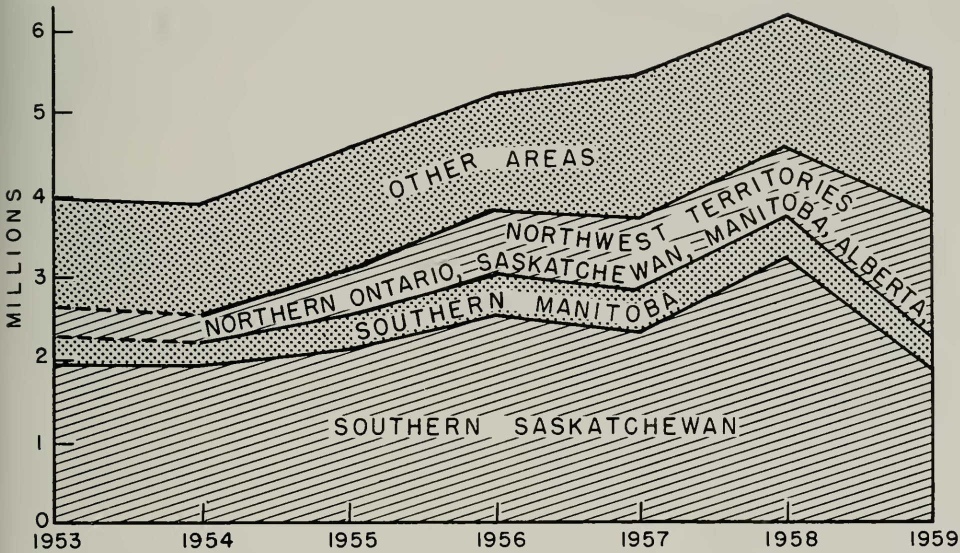

Fig. 21.—Estimated numbers of mallards in various parts of the Canadian breeding grounds in May, 1953–1959.

port compiled by Hawkins in 1959 provides data on breeding grounds forecasts for that year. The production forecast indices for Saskatchewan and Manitoba may be compared with the number of juvenile mallards per adult as checked in the bags of Mississippi Flyway hunters, fig. 20.

For the period 1952–1959, the population curve plotted from the forecast indices of waterfowl production in Saskatchewan was similar to the curve plotted from the Mississippi Flyway age ratios for mallards, fig. 20. However, for the years 1955 through 1958, and especially for 1958, the forecast indices showed considerably higher production than was shown by the age ratios, fig. 20.

Manitoba forecast indices showed very little correlation with mallard age ratios from the Mississippi Flyway, fig. 20. For example, in 1957 and 1958, Manitoba forecast indices pointed to an increasing production of young; yet the mallard age ratios from the Mississippi Flyway pointed to a decreasing production of young. That there is only slight correlation may be ascribed to Manitoba's relatively small contribution of mallards to Illinois and adjoining states. Aerial surveys made on the breeding grounds in May indicate that about six times as many mallards nest in the plains and parklands of southern Saskatchewan as in the plains and parklands of southern Manitoba, fig. 21; the Saskatchewan contribution to the Mississippi Flyway kill is larger than that of Manitoba, even though much larger numbers of Saskatchewan mallards than of Manitoba mallards are killed in the Central and Pacific flyways (Cartwright 1956:14–5, 17–8, 20–1).

For 8 years, beginning with 1952, Saskatchewan breeding grounds indices showed production trends similar to those derived from mallards shot by hunters in the Mississippi Flyway, fig. 20. Information on breeding grounds success of ducks in Saskatchewan in 1951 was somewhat contradictory. The report by Colls & Lynch (1951:40) indicated "a more than usually successful waterfowl-rearing season." The forecast index for 1951, although above 100 and therefore "satisfactory," indicated a production that was low compared to that of most other years of the period 1949–1959. We are inclined to believe that some mechanical error was made in calculating the 1951 forecast index for Saskatchewan.

During the period 1949–1954, duck production as determined from breeding grounds surveys in Manitoba showed a fairly close relationship to production as determined from age ratios of mallards shot in the Mississippi Flyway, principally Illinois. However, production as determined by the forecast index in Manitoba showed no positive correlation with production as indicated by age ratios of ducks shot in the Mississippi Flyway; diametrically opposite production trends were indicated for 1954, 1955, 1957, and 1958, fig. 20. The mallard flight reaching Illinois from Manitoba, compared to that from Saskatchewan, may have been so small as to have had little influence on age ratio figures obtained from mallards inspected in hunters' bags in the Mississippi Flyway.

One item apparently responsible for bias in the forecast index, especially in Manitoba, has been the production factor associated with late-nesting ducks. This factor was included in the index formula to measure the anticipated brood production represented by pairs, lone hens, and lone drakes (believed to be mates of incubating hens) found on the last survey flights, usually conducted in mid-July. The production from ducks that are actually breeders may be lower than anticipated, and many ducks that are classed as breeders may be through breeding. Charles D. Evans of the U. S. Fish and Wildlife Service and Ralph Hancox of the Manitoba Game Branch recognized the latter possibility in Manitoba in 1958 (unpublished report), when they found abnormally high numbers of molters and premolters on breeding areas. In spite of diligent effort to classify breeders and nonbreeders correctly, Evans and Hancox believed that they included many nonbreeders in their late-nesting index.

It is apparent from age ratio data from the Mississippi Flyway that in those years in which there was a major population shift from the Canadian Grasslands north to the lakes and marshes of the Aspen Parklands and Mixed Coniferous Forest production of young declined more than had been anticipated.

No doubt some of the differences between production data based on age ratios obtained from bagged ducks in the Mississippi Flyway and similar data based on breeding grounds surveys stem from differences in production between the Grasslands, the Parklands, and the Coniferous Forest region. Because of difficulty of access, difficulty in making observations, and a low density of breeding ducks, only cursory duck surveys have been made in the Coniferous Forest region. Hence, the production of mallards from this region is largely unknown but may be larger than suspected. Although the population density of mallards there may be low, this region is so vast that it may well contain a sizable breeding population.

Other differences between production data from the Mississippi Flyway and data from the breeding grounds surveys may result because the Mississippi Flyway data include only mallards, whereas data from breeding grounds surveys include all species of ducks. Mallards usually make up over half of the breeding population, but diving ducks and late-nesting species, such as the baldpate and the gadwall, which may show yearly production trends different from those of the mallard, may influence the production data from the breeding grounds.

Production and Environment

It is difficult to evaluate the effect of environment on waterfowl production because of the vastness of the breeding grounds and the variations in water and weather conditions. Seldom, if ever, are water or weather conditions similar over the entire breeding range. Moreover, an area that is favorable for waterfowl in one year may be unfavorable the next. Nevertheless, a general review of water and weather conditions in Manitoba and Saskatchewan, the principal breeding range of the mallard of the Mississippi Flyway, has been made for the years 1939–1946 from *The Duckological,* a news sheet published at irregular intervals by Ducks Unlimited (Canada), with headquarters at Winnipeg, and for the years 1947–1959 from published and unpublished reports of breeding grounds surveys by the U. S. Fish and Wildlife Service and the Canadian Wildlife Service. In the following paragraphs the water and weather conditions on the breeding grounds for each of the 21 years in the period 1939–1959 are summarized in relation to mallard production as indicated by the number (uncorrected) of juveniles per adult inspected in hunters' bags in the Mississippi Flyway

—Illinois and Arkansas, table 58, and Missouri, table 59.

Water conditions on the Canadian plains in the spring of 1939 were much improved over those of 1938. Conditions for breeding ducks were good in Saskatchewan and poor in Manitoba. Most water areas persisted until broods were on the wing. These conditions resulted in a production per breeding mallard (uncorrected number of juveniles per adult) which was about equal to the average of such production data for 17 years, 1939–1955, table 58.

In 1940, spring water conditions in Manitoba were the worst in the history of that province and in Saskatchewan were poor as far west as the central part. Water conditions were good in western Saskatchewan. Good rains in June improved many water areas. Mallard production in this year, as in 1939, was close to the average for the 17-year period, table 58.

In the spring of 1941, water conditions, although greatly improved over conditions in 1940, were considered fair in Manitoba and ranged from poor to good in Saskatchewan. Water areas rapidly dried up when such summer rains as fell failed to maintain them. Heavy losses among ducklings occurred as a result of drought. A drop in the number of young per adult bagged in the Mississippi Flyway revealed a sizable decline in mallard production, table 58.

In the spring of 1942, water conditions were fair to good in Manitoba; they were bad, fair, or good, depending on the locality, in that part of Saskatchewan where most of the ducks are produced. Heavy spring rains prevailed over most of the plains, and these continued into the summer. The number of young per adult in the Mississippi Flyway, table 58, indicated a moderate increase in mallard production.

Spring water conditions in 1943 throughout the Canadian plains were the best in many years, being rated fair over northern Saskatchewan and northern Manitoba and good to excellent almost everywhere in the southern parts of these provinces. In that year, age ratios in the Mississippi Flyway, table 58, indicated a pronounced increase in mallard production.

In 1944, there was "lots of water" in northern Saskatchewan and Manitoba, but in the southern parts of these provinces, where most of the ducks are produced, water levels were largely "dangerously low" to fair. A larger than usual proportion of the breeding waterfowl population moved through the Grasslands northward into the Aspen Parklands and Mixed Coniferous Forest. Rains in June removed danger of heavy loss of ducklings through drought. Mallard production declined markedly to a point below average, table 58.

In 1945, spring water conditions were good in Manitoba and all of Saskatchewan but the southwestern part, where few Mississippi Flyway mallards breed. Water conditions in Manitoba remained good for ducks, but southern prairies of Saskatchewan dried up. Subnormal temperatures occurred through much of April and May, and, in the northern portions of Manitoba and Saskatchewan, ice was still present on marshes and lakes on May 24. Age ratios of ducks bagged on the flyway indicated that mallard production had declined to the lowest point since the study started in 1939, table 58.

In 1946, water conditions were excellent in Manitoba and through a belt 100 miles wide in eastern Saskatchewan. June rains improved water conditions in Alberta and Saskatchewan. May was excessively cold, and heavy frosts occurred. Age ratios from the Mississippi Flyway indicated that mallard production rose considerably but remained below the 17-year average, table 58.

More detailed information on breeding grounds conditions became available in 1947, when extensive surveys were inaugurated by the U. S. Fish and Wildlife Service. Salient facts from these surveys have been condensed in tables 60 and 61 and are shown graphically in figs. 22 and 23. These tables and figures, as well as tables 58 and 59, should be referred to in connection with the following paragraphs on duck production and breeding grounds conditions.

In 1947, a year in which fair to good water conditions prevailed and slight to moderate water loss occurred during the breeding season in Manitoba and Saskatchewan, the number of juveniles per adult

Table 60.—Environmental conditions on breeding grounds in southern Manitoba, 1947–1953, and mallard production as indicated by number of juveniles per adult checked in hunters' bags in the Mississippi Flyway.

Year	Water Conditions	Breeding Population of All Ducks Per Square Mile	Water Loss	Spring Temperature	Farming Activities	Number of Mallard Juveniles Per Adult*	Authority for Environmental Conditions and Breeding Population
1947......	Fair	11.8	Slight	Subnormal	Average	2.36	Hawkins (1948, 1950)
1948......	Good	13.4	Slight	Subnormal	Favorable	3.18	Hawkins & Cooch (1948), Hawkins (1950)
1949......	Good	32.2	Moderate	Above normal	Adverse	0.97	Hawkins (1949, 1950)
1950......	Excellent	37.5	Slight	Extremely subnormal	Favorable	0.73	Hawkins (1950)
1951......	Fair	41.0†	High	Normal	Adverse	1.71	Hawkins, Gollop, & Wellein (1951), Hawkins (1954)
1952......	Poor	28.3†	High	Above normal	Adverse	1.65	Hawkins & Wellein (1952), Hawkins (1954)
1953......	Fair to good	28.1†	None	Extremely subnormal	Favorable	0.82	Williams (1953), Hawkins (1954)

*Data from table 58.
†Calculated from data in table IV, Hawkins 1954:79, for area of 135.75 square miles ("No. per Sq. Mi." in table IV should undoubtedly be "Number of Square Miles"); figures for 1951 and 1952, with data from one additional transect included, are shown in table I, Hawkins & Wellein 1952:64.

Table 61.—Environmental conditions on breeding grounds in southern Saskatchewan, 1947–1953, and mallard production as indicated by number of juveniles per adult checked in hunters' bags in the Mississippi Flyway.

Year	Water Conditions	Breeding Population of All Ducks Per Square Mile	Water Loss	Spring Temperature	Farming Activities	Number of Mallard Juveniles Per Adult*	Authority for Environmental Conditions and Breeding Population
1947......	Good	....	Moderate	Subnormal	Adverse	2.36	Lynch (1948), Smith (1948)
1948......	Good	17.3	Moderate-high	Subnormal	?	3.18	Soper (1948), Colls & Lynch (1951)
1949......	Poor	10.7	Slight	Above normal	Very adverse	0.97	Lynch (1949), Colls & Lynch (1951)
1950......	Excellent	16.3	Slight	Extremely subnormal	Favorable	0.73	Colls (1950), Colls & Lynch (1951)
1951......	Good	15.8	Slight	Normal	?	1.71	Colls & Lynch (1951)
1952......	Good	38.5	Slight	Normal	?	1.65	Gollop, Lynch, & Hyska (1952)
1953......	Excellent	40.2	Slight	Subnormal	Favorable	0.82	Williams (1953), Lynch & Gollop (1954)

*Data from table 58.

in the bags of Illinois hunters revealed a spectacular rise in production by the mallard; the rise occurred even though spring temperatures were below normal. The spectacular increase in production continued in 1948, as water conditions in Canada improved. In 1949, water conditions in Saskatchewan were poor, and mallard production dropped drastically.

In 1950, water conditions were excellent in both Manitoba and Saskatchewan. May of 1950, however, was unusually cold and wet. Mallard production, as indicated by age ratios of ducks bagged in the Mississippi Flyway, declined. In 1951, water conditions were good through the breeding season in Saskatchewan and fair in Manitoba; a major water loss occurred in Manitoba. In that year, mallard production increased considerably. The two provinces differed materially in water conditions in 1952. In Manitoba, rapid disappearance of water areas began in April and continued through the summer; by August waterfowl conditions were the worst known since breeding grounds observations were started. In Saskatchewan, water conditions were favorable throughout the breeding season. Mallard production in 1952 declined very little, if at all, age ratios of bagged ducks indicated. In 1953, water conditions were excellent in Saskatchewan and fair to good in Manitoba. There was no water loss during the season in Manitoba and only a slight loss in Saskatchewan. Despite these favorable water conditions, age ratios of bagged ducks revealed a decline in the production of mallards in 1953.

Although small water areas in Saskatchewan and Manitoba were almost at maximum numbers in 1954, age ratios indicated only a slight increase in mallard production, fig. 22. In 1955, with a further increase in number of ponds in Saskatchewan, but with a sizable decrease in the number in Manitoba, mallard production increased materially.

Ponds were down in number in Saskatchewan in 1956, but they increased in number in Manitoba, fig. 22. In that year, age ratios of bagged ducks indicated a

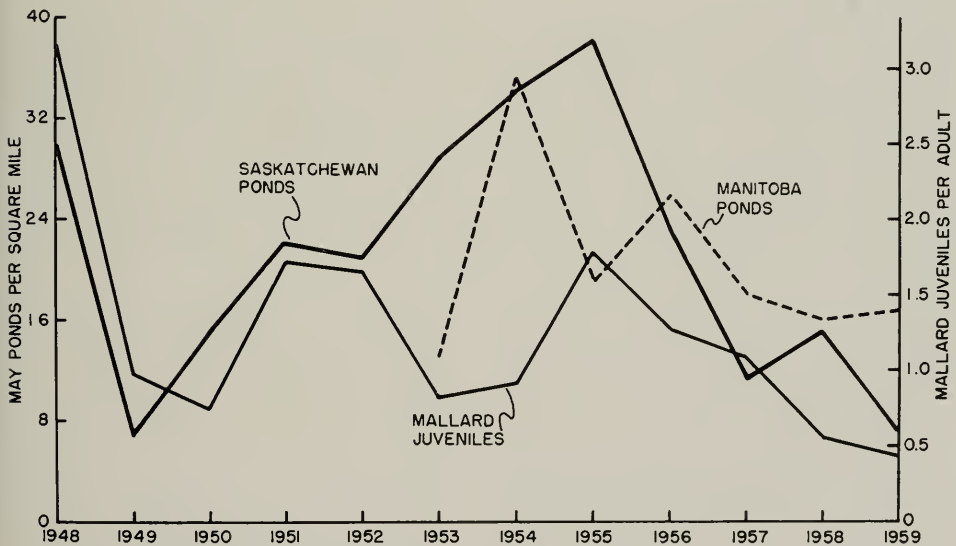

Fig. 22.—Relationship between water conditions on the Canadian breeding grounds and mallard production, as indicated by the number of ponds per square mile in southern Saskatchewan and southern Manitoba in May of certain years, and by the number of juveniles per adult checked in hunters' bags in the Mississippi Flyway. Points on the graph representing number of juveniles per adult for 1948–1955 are based principally on data from Illinois, table 58; points for 1956–1959 are based on data from Missouri, table 59. Because data for 1955 showed the number of juveniles per adult among Illinois mallards to be about 10 per cent less than the number among Missouri mallards, each point on the graph for the years 1956–1959 represents a figure that is 10 per cent less than the corresponding figure in table 59. Data for the breeding grounds are from the U. S. Fish and Wildlife Service and the Canadian Wildlife Service.

drop in mallard production. In 1957, ponds were down in number in both provinces, and mallard production declined. In the following year, 1958, water areas continued down in number in Manitoba but increased in Saskatchewan; mallard production showed a further decline.

In 1959, water conditions in Manitoba remained about the same as the year before, but the number of ponds in Saskatchewan declined sharply. For the fourth consecutive year mallard production declined; the number of juveniles per adult in the Mississippi Flyway, as represented by data from Missouri, was at a 21-year low, tables 58 and 59.

No completely objective correlation can be made between waterfowl production and conditions on the breeding grounds. Much of the information from the breeding grounds is not of an objective nature; it is not subject to convenient or exact measurement, and the effects of the many environmental variables are not well understood.

In Saskatchewan, mallard production (as determined by the number of juveniles per adult among birds bagged in Illinois) and water abundance (as measured by the number of ponds per square mile in May) followed similar trends in most years of the period 1948–1959, fig. 22. Mallard production and water abundance followed divergent trends in 1950, 1953, and 1958. In 1954, mallard production showed no decisive trend, while water abundance rose markedly. In Manitoba, mallard production tended to parallel water abundance in the years 1956–1959 but not in the 3 years previous.

In 1945, 1950, and 1953, when water conditions on the breeding grounds were fair to excellent and mallard production was down, temperatures below normal and other unseasonable weather conditions, including blizzards, occurred as late as mid-May, disrupting the nesting activities of the mallard, pintail, and other early nesters. In 1947, when water conditions were fair to good, and subnormal temperatures were experienced early in the nesting period, mallard age ratios indicated substantially better than average production.

Concerning weather and water conditions in Manitoba in 1950, Hawkins (1950:42) reported as follows:

> If abundant water were the only requirement of nesting waterfowl, ducks nesting in Manitoba would have had a "banner" year;

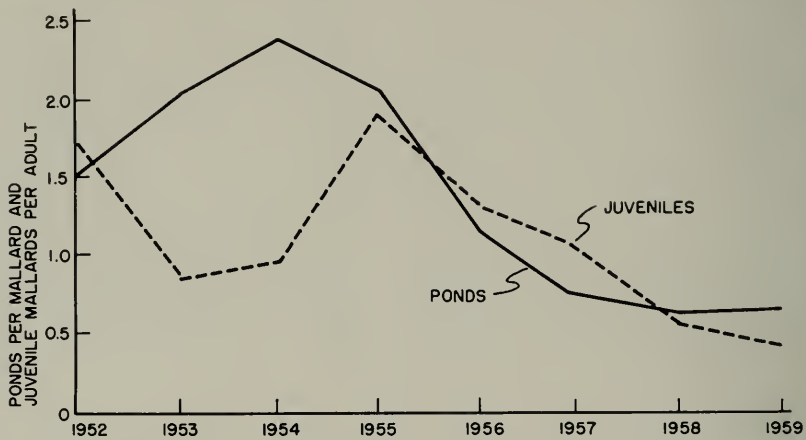

Fig. 23.—Relationship between the density of the adult mallard population on the Canadian breeding grounds in spring and the production of young, 1952–1959, as indicated by the number of ponds per mallard in southern Manitoba and southern Saskatchewan in May and by the number of juveniles per adult checked in hunters' bags in the Mississippi Flyway the autumn following. Data for the breeding grounds in 1952 represent Saskatchewan only. Points on the graph representing number of juveniles per adult for 1952–1955 are based principally on data from Illinois, table 58; points for 1956–1959 are based on data from Missouri, table 59, as explained in the legend for fig. 22. Data for the breeding grounds are from the U. S. Fish and Wildlife Service and the Canadian Wildlife Service.

they did not, however, in spite of the greatest spread of surface water in many years.

. . . .

Sub-normal temperatures continued throughout the nesting and brooding season. May was particularly cold and wet, possibly a factor in the poor hatch. From July 12 to 15, when many broods were only a few days old, temperatures dipped almost to the freezing point, perhaps another factor affecting success.

Colls (1950:36–7) reported that unseasonably cold weather prevailed all over Saskatchewan for most of the summer and that the more northerly lake country remained ice-bound in some cases as late as the end of May; however, he stated "that weather and water conditions over southern Saskatchewan were exceptionally favourable for the 1950 waterfowl population."

Hawkins (1954:75) reported that on April 15, 1953, the worst spring blizzard in many years combined with several days of freezing temperatures to adversely affect waterfowl production in Manitoba. Another record-breaking blizzard occurred on May 11, and smaller snowstorms on April 24 and May 14 resulted in snowdrifts which could have buried large numbers of nests. Indeed, a few nests that had been buried were found after the snow disappeared. Furthermore, temperatures accompanying the blizzards were sufficiently low to freeze unprotected eggs.

In Saskatchewan, Lynch & Gollop (1954:45) reported that May, 1953, was very cold, with much snow prior to the middle of the month. Stoudt & Buller (1954:55) reported that the weather was "wet, cold and miserable for the most part" during the nesting and brooding season, but concluded: "We have always heard of the dire effects of wet, cold weather on newly hatched ducklings but such ill effects were *not* noted during the 1953 brooding season."

A late breakup of ice occurred in Manitoba lakes in 1954 (Evans 1955:72), with freezing temperatures and snow extending into early May. May and early June were generally cool and wet.

Saskatchewan experienced a record-breaking cold wave in late April and early May of 1954 that substantially delayed nesting by mallards and pintails (Gollop & Lynch 1955:46–7). As late as mid-May, many lakes were still frozen over.

As a result of adverse weather in the spring of 1954, Stoudt & Stinnett (1955:60) found an extremely high nest loss among mallards as well as other ducks on a small study area in southeastern Saskatchewan. They attributed the loss in the first nesting effort of mallards to a blizzard and zero temperature on May 1. Most of May and June was characterized by cold, very wet weather, retarding the development of good nesting cover. The paucity of nest cover and the lack of stable food for predators resulted in greatly increased predation upon duck nests. Flooding destroyed many nests missed by predators.

Decreased production by the mallard on the plains of Canada in years of very plentiful water and of cold weather, snow, and heavy rains at nesting time suggests that cold and excessively wet springs may be as unfavorable to duck production as dry and warm springs.

It is quite evident that water and weather conditions on the breeding grounds during the nesting and rearing period were major factors contributing to the gross changes in mallard production in 1939–1959. Yet there was another factor in mallard production, population density, that seems to have operated in most years within the broad limits of the environment, and, indeed, that may well have been the dominant regulating factor in production in those few years in which there was a poor correlation between environment and age ratios. In 2 years having similar water conditions but breeding populations of different sizes, the number of juveniles produced per breeder may be lower in the year with the larger population than in the year with the smaller.

Several years ago, an inverse relationship between population density and production of young was reported for the muskrat by Errington (1943:877), who stated: "the data indicate that rates of increase tend to vary with particular habitats and inversely with the density of the breeding stock."

That an inverse relationship between population density and production could be detected in upland game was noted by several writers (Baskett 1947:25–7;

Bump *et al.* 1947:540; Errington 1945: 13).

Production in the mallard and possibly other duck species may bear, within certain undetermined limits, an inverse relationship to population densities, or a direct relationship to number of ponds per duck. (Increased density in a duck population on the breeding grounds may be brought about by a decrease in the number of water areas as well as by an increase in the number of ducks.)

With the exception of 1953 and 1954, years in which cold temperatures and snow reduced production of the mallard, there was a good correlation between number of ponds per breeding mallard and production of young on the Canadian breeding grounds. As the number of ponds per breeding mallard decreased from 2.0 to 0.6 in the Grasslands and Aspen Parklands of Manitoba and Saskatchewan, production declined from 1.78 juveniles to 0.54 juvenile per adult, fig. 23.

A change in the density of the mallard population on the breeding grounds may affect production in two ways: (1) alter the rate of nest destruction and desertion; (2) alter the relative number of ducks that can be accommodated by prime breeding habitat.

Sowls (1955:74) found that most mallards nest within 100 yards of pond, slough, or lake margins rather than at greater distances from water. The area of nest concentration adjacent to a body of water has been called the nesting zone. As ponds and other small water areas decline in number, greater concentrations of mallard nests occur in the nesting zones of the bodies of water that remain. It is probable that, as nest density increases, the rate of nest loss rises. Although data on the relationship between nest density and nest loss are lacking for waterfowl, Stokes (1954:36) found that in pheasants nest abandonment increased with breeding density.

Unpublished field studies by Alex Dzubin (letter March 5, 1960) of the Canadian Wildlife Service suggest that space requirement also may be related to mallard production. Dzubin believes that, through interactions involving both aggressive and sexual behavior, pairs of mallards space themselves over the breeding grounds. Adequate spacing is most evident in the Aspen Parklands region, with its abundance of water areas; it is less evident in the Grasslands region, which may have a scarcity of water areas. Space behavior of ducks around waiting areas tends to place a limit on the number of pairs any one area can accommodate.

The role of space in regulating the size of breeding populations of waterfowl is apparent in an analysis made by Schroeder (1959:4–5) of water areas and numbers of breeding ducks in North Dakota. Schroeder found that the numbers of breeding ducks and water areas tended to fluctuate up and down together. For example, in 1950, water areas numbered 11.4 and breeding ducks 24.6 per square mile, whereas, in 1959, water areas had declined to 2.1 per square mile and ducks to 8.4 per square mile.

Evans & Black (1956:52) found a direct relationship between water areas and breeding ducks on an 11.25-square-mile prairie pothole area in South Dakota. Their study showed that as the number of potholes with water on May 10 increased and then decreased from 1950 through 1953 so did the number of breeding pairs of ducks.

Stoudt (1959:103) reported a direct relationship "up to a certain point" between numbers of breeding ducks and numbers of water areas on a study area 40 miles long and one-eighth mile wide near Redvers, in southeastern Saskatchewan. He did not find this direct relationship in "extremely wet years and extremely dry years."

From 1953 through 1958, there were only small variations in the number of water areas each year on May 1 in a Lousana, Alberta, study area, but the number of breeding pairs of mallards on this small area rose from 103 to 338 during that period (Smith 1959:3, 8). The number of ponds on May 1 decreased from 198 in 1958 to 131 in 1959 and the number of breeding pairs from 338 to 241.

The smaller a study area, the less likely it is to show direct relationships between the numbers of breeding pairs and the numbers of water areas. Local variations in mortality rates, homing, and population saturation levels that grossly affect the data for small areas may have no appreciable effect upon the data for extensive areas, because the many local variations in the extensive areas tend to cancel each other.

Because the space behavior of ducks limits the number of breeding pairs that a given waterfowl habitat can accommodate, when an increase occurs in the breeding population of an area that has reached the limit of its carrying capacity, or when a decrease occurs in the number of ponds on the area, some of the ducks associated with the area must do one of two things: (1) move to other areas not occupied to the saturation level or (2) fail to reproduce.

The areas to which the ducks move may be of poorer quality for the production of young than the areas occupied to the saturation level. Biologists have long been aware of the tendency of bird populations to make maximum use of the best available habitat before occupying less favorable habitat. On a Saskatchewan study area, Stoudt (1952:55) found that breeding pairs of ducks tended to make maximum use of the small water areas (1 acre or less) and shift to less favorable habitat when the prime areas were occupied to the limit of their carrying capacity.

Under conditions associated with population or habitat changes, ducks may move from a region of basically good habitat to a region of inferior habitat. In 1959, there was an increase in the number of mallards found during May in the marshes of the Coniferous Forest in northern Alberta and other northern parts of Canada and a decrease in the number found in southern Saskatchewan. The Coniferous Forest lacks the quality habitat for nesting mallards supplied primarily by the Grasslands and secondarily by the Aspen Parklands.

Biologists have noted that under severe crowding many ducks do not breed and that some ducks that make attempts at nesting do not make further attempts if the first attempts fail. Arthur S. Hawkins and Gerald Paspichal in an unpublished report of the U. S. Fish and Wildlife Service on the 1959 breeding season in the pothole country of western Manitoba noted that many ducks in that area were individuals that had been displaced from other areas. They found indications that some ducks did not attempt to nest and that others did not make the usual renesting attempts after having lost nests. Stoudt (1959:104) observed that many pairs of ducks in southeastern Saskatchewan in 1959, a year of very low water levels, "did not seem to nest at all."

Fig. 17 may be interpreted as showing that when the Grasslands and Aspen Parklands have reached the limit of their carrying capacity as a result of population increases and/or habitat deterioration, the production of juveniles per adult mallard declines for 2 to 4 years, until the breeding population has declined to a point where population density is no longer a limiting factor. Then, when a decrease in population or an increase in water areas results in more space per breeding pair, the production of young per breeder increases for 1 to 3 years, until population density again becomes a limiting factor.

The highs and lows in a breeding population of mallards may lag 1 or 2 years behind the highs and lows in the production of young per breeder. The first year a high breeding population produces a smaller number of young per breeder, the over-all population will probably continue to increase because of the large number of breeders still present to produce young. The over-all population may continue to increase even into the second year of lower production. When the breeding population is at a low point, the over-all population will probably continue to decline for a year after an increase in production, as the increased number of young per breeder may fail to result in as many young as are needed to replace the ducks lost through hunting and natural mortality the previous year.

The foregoing analysis of the effect of environment on production of mallards and other ducks points up the importance of water areas that are available to breeding pairs. Also, it points to abnormally low temperatures and associated weather conditions in April and May as factors of major importance in production. Abnormally low temperature conditions do not occur on the breeding grounds as frequently as abnormally low water conditions. Within the framework of acceptable nesting environment, and within certain undetermined population limits,

Table 62.—Number of juveniles per adult hen (the number corrected for the greater vulnerability of juveniles to hunting) in each of 12 species of ducks checked in hunters' bags in the Mississippi Flyway, principally Illinois, 1946–1949.

Species	Number of Adult Hens	Number of Juveniles	Number of Juveniles Per Adult Hen	Juvenile Vulnerability Factor*	Corrected Number of Juveniles Per Adult Hen
Mallard	3,631	19,860	5.47	1.3	4.2
Black duck	402	2,858	7.11	1.8	4.0
Gadwall	201	1,335	6.64	2.4	2.8
Baldpate	210	2,280	10.86	2.9	3.7
Pintail	445	2,669	6.00	1.9	3.2
Green-winged teal	226	1,427	6.31	1.7	3.7
Blue-winged teal	370	1,901	5.14	1.7	3.0
Shoveler	119	836	7.03	1.7	4.1
Redhead	190	1,882	9.91	3.5	2.8
Ring-necked duck	123	1,043	8.48	2.0	4.2
Canvasback	208	2,745	13.20	2.9	4.6
Lesser scaup	297	1,525	5.14	2.0	2.6

*Correcting factors for most species are from tables 42, 43, and 45, ratio of adult to juvenile vulnerability. The correcting factor for the green-winged teal and the shoveler is assumed to be the same as that for the blue-winged teal, and the correcting factor for the ring-necked duck the same as that for the lesser scaup.

production of mallards, and possibly all species of waterfowl, seems to be inversely related to population density.

Production in Different Species

Age ratios of ducks checked in hunters' bags in the Mississippi Flyway for the period 1946–1949 provide indices of production for the various species, table 62. At least a partial correction for the greater vulnerability of juveniles than of adults has been made by using banding data from Illinois for the black duck and blue-winged teal, tables 42 and 43, and banding data from Canada for the mallard, gadwall, baldpate, pintail, redhead, canvasback, and lesser scaup, table 45. It has been assumed that the ratio of adult to juvenile vulnerability in the green-winged teal and shoveler is similar to that in the blue-winged teal and that the ratio of adult to juvenile vulnerability in the ring-necked duck is similar to that in the lesser scaup. Even though the calculations representing the "corrected number of juveniles per adult hen," table 62, were derived from arbitrarily selected vulnerability ratios, it is believed that they are so close to the actual juveniles-per-hen figures that some useful generalizations can be made.

The differences among the species are not so great in the "corrected number of juveniles per adult hen" as in the actual number of juveniles per adult hen in hunters' bags, table 62. The vulnerability differential between adults and juveniles offers an explanation for the excessively high ratios of 10 to 13 juveniles per adult hen that have been found in checks of hunters' bags.

Several species of ducks appear to have about equally high production rates, table 62: mallard, black duck, shoveler, ring-necked duck, and canvasback. The baldpate and green-winged teal seem to be intermediate in production. The gadwall, pintail, blue-winged teal, redhead, and lesser scaup appear to be species with comparatively low production rates.

The fact of survival in a duck species indicates that the species is adapted to maintain its place in the total duck population. The production of each species must compensate for the losses suffered through mortality, or the species declines. With possibly a few exceptions, notably the redhead and the wood duck, no duck species has been known to undergo more than a temporary major decline in population status in recent times.

Age Ratios in Population Management

One aim of waterfowl management is the establishment of hunting regulations that will permit the greatest possible harvest of birds without undue depletion of populations. Age ratios obtained through inspection of ducks in hunters' bags offer valuable assistance in determining the well-being of populations and in evaluating the extent to which production may be expected to replace annual losses.

An average annual production of 2.7 young of flying age per adult hen has been estimated for mallards of the Mississippi Flyway in the period 1939–1955, table 58. Although this average figure and other production figures shown in table 58 are for the mallard only, they are of value in making over-all hunting regulations because mallards comprise about half of the duck population.

Major year-to-year changes in production of the mallard, changes that probably are present in other species also, require flexibility in regulations governing the duck kill.

Production data from age ratios need to be supplemented by information from the breeding grounds in the northern part of the Mississippi Flyway. More information is needed on the effect of different combinations of regulations on mortality in the mallard and other species of ducks. Bellrose & Chase (1950:22) found evidence that natural losses plus hunting losses occurring under the regulations in force in the years 1939–1947 resulted in an annual mortality rate of about 48 per cent in male mallards; the annual mortality rate of the entire population was somewhat higher.

The extent to which increased production in ducks can compensate for increased mortality is at present pure speculation. The ability of animals to compensate for annual variations in mortality rates by flexibility in production is widely recognized. More than 80 years ago, Forbes (1880:9) wrote: "The fact of survival is . . . usually sufficient evidence of a fairly complete adjustment of the rate of reproduction to the drains upon the species." A few years ago, Allen (1943:113–4) cited the resilience of the fox squirrel in compensating for severe losses in number. Bump *et al.* (1947:539–40) reported for the ruffed grouse (*Bonasa umbellus*) in New York "a distinct tendency for greater relative increases to be associated with lower breeding populations." Diem (1959:304–5), in reporting on duck production in an Alberta study area, stated that some years "having low breeding populations have witnessed bumper crops of young."

The probability that ducks have some degree of elasticity in their capacity to reproduce is shown by differences in production among various species. It is shown further by differences in production between the ducks of different flyways. Although age ratios for Nebraska mallards have tended to follow the same general trend from year to year as those in Illinois, they have consistently reflected lower numbers of juveniles per adult, fig. 16. There is good evidence from banding and from the percentage of birds carrying shot wounds that shooting pressure is lighter in the Central Flyway (and, therefore, that the mallard undoubtedly has a lower mortality rate in that flyway) than in the Mississippi Flyway. Perhaps the apparently lower reproduction rate of mallards in the Central Flyway is the result of the lower mortality rate there.

More data are needed on production and mortality rates in various species of ducks in each of the four flyways. By comparing production and mortality rates in various species of ducks in each of the four flyways, it would be possible to learn a great deal more than is now known about an apparent inverse relationship between mortality and production and the operation of other population mechanisms of waterfowl.

Waterfowl population research requires a more concerted effort to appraise production and to relate this to habitat conditions. We recommend that state and federal biologists, working through the four flyway councils, make detailed and uniform appraisals of conditions on the breeding grounds and that, by use of age ratios obtained from bagged ducks, they determine yearly production for the important species.

The most feasible approach to the problem of obtaining data on age ratios appears to entail the establishment of stations where large samples of particular species could be obtained. Some samples should be taken where there is evidence that a cross section of the migrating population can be obtained or where the wintering populations exhibit a minimum of regional bias. In some areas, a station might be established at which the age ratios for only one species of duck are taken. For example, in the Mississippi Flyway, the best station for sampling the mallard might be Stuttgart, Arkansas; the best for the gadwall, Mobile Delta, Alabama; the best for the pintail and the green-winged teal, the coastal marshes of Louisiana; the best for the ring-necked duck, Reelfoot Lake, Tennessee; the best for the redhead and the canvasback, Lake St. Clair and the Detroit River, Michigan.

SUMMARY

1. The present study is an evaluation of sex and age ratios in North American duck populations and the ways in which, in waterfowl management, these ratios can be used to measure productivity. (Page 391.)

2. Determination of sex composition in duck populations presented a difficult sampling problem complicated by differences in species, seasons, and places, and by inadequate sampling techniques. (Page 393.)

3. In the study reported here, most trapped or bagged ducks that could not be readily sexed by plumage differences were sexed by cloacal characters. (Page 396.)

4. Four methods of sampling waterfowl populations for sex ratios were used: (1) examination of trapped ducks, (2) inspection of ducks taken by hunters, (3) observation of ducks in the field, and (4) examination of disease victims. Biases evident in each method were recognized, and corrections were made whenever possible. (Page 396.)

5. Baited, funnel-type traps tended to take disproportionate numbers of drakes, while gate-type traps placed on shore tended to catch a predominant number of hens. (Pages 397, 400.)

6. Inspection of ducks in hunters' bags made possible the separation of drakes and hens in molting adults and in juveniles. (Page 400.)

7. Most sex ratios derived from inspection of hunters' bags showed little bias, usually in favor of drakes. (Page 400.)

8. Banding records indicated that mallard drakes were 1.05 times as likely to be shot by hunters as were hens, the differential probably a result of hunter preference for drakes. (Page 401.)

9. A few field observations on living ducks in spring were used to provide sex data on samples of several species; however, because it is almost impossible to make a sufficient number of random observations to insure an adequate sampling of the population of a flyway or other large area, field observations were not more extensively used. (Pages 401–2.)

10. The validity of sex ratios obtained from examination of ducks that were victims of disease was found to need further study. (Page 402.)

11. Analysis of available data showed no significant departure from an evenly balanced sex ratio in ducks at fertilization or at hatching. (Pages 402–3.)

12. Data obtained from examining juvenile ducks trapped during the breeding season or taken by hunters during the fall indicated that the ratio between the sexes from the time of hatching to adulthood was close to 50:50; local variations appeared to result from differences in seasonal movements. (Pages 403–5.)

13. Although sex ratios of adults usually favored drakes, there were numerous exceptions. (Pages 405–6.)

14. Sex ratios of many species of ducks varied from week to week in any given area as the composition of the local population changed with the arrival and departure of flocks containing varying numbers of drakes and hens. (Page 408.)

15. In most species of ducks for which data were available, drakes made up a smaller proportion of the hunters' kill in Manitoba than in three states to the south (North Dakota, Illinois, and Tennessee), indicating that more drakes than hens left Manitoba in advance of the hunting season. Among adult mallards bagged in Illinois, there was a steady increase in the drake segment through the third week in November, followed by a period of stabilized sex ratios, and then further increase in the drake segment of the wintering population, usually present in Illinois after the first week in December. In Utah, sex ratios of adult mallards bagged by hunters were relatively stable throughout fall. In only a few species did there appear to be differences in seasonal movements between

drakes and hens in the juvenile class. (Pages 408–9.)

16. Periodic counts of ducks in late winter and early spring revealed differences in the sequence of northward migration of drakes and hens of the same species. (Pages 411–16.)

17. The first spring flights arriving in Manitoba showed, with minor exceptions, a closer approach to a balance between sexes than did subsequent populations. (Pages 416–9.)

18. Sex ratios in ducks were found to vary with migration routes and various areas of their wintering grounds. (Pages 419–20.)

19. Information collected on the principal mortality factors affecting the North American duck population indicates that hunters and disease take relatively more drakes than hens. This information is not sufficient to permit appraisal of the influence of predation on sex ratios; however, appreciable losses among hens during the breeding season, most of these losses apparently attributable to predation, agricultural operations, and stress, may account for the predominance of drakes in the adult class. (Page 426.)

20. Data showed that, the more productive a species of waterfowl, the greater is apt to be the proportion of juveniles in its population at the opening of the hunting season; the greater the proportion of juveniles in a population, the more nearly balanced is its sex ratio. (Page 426.)

21. Drakes occurred in relatively greater numbers among diving ducks than among dabblers; however, examination of the available knowledge on the reproductive biology characterizing these two subfamilies revealed nothing which suggests that extra drakes may be more important to the maintenance of populations of diving ducks than of dabblers. (Page 427.)

22. The study suggested that the value of extra drakes needs investigation through an experimental procedure designed to reduce the number of drakes in a subpopulation of a species having a large drake segment. (Page 428.)

23. Sex ratios that were derived from inspection of mallards in hunters' bags in Illinois provide a fair index to production but not so good an index as age ratios; sex ratios obtained from observations on the breeding grounds in Canada do not appear to provide a more reliable index to production than sex ratios calculated from bag inspections in Illinois. (Page 429.)

24. Age ratios alone, this study assumed, are seldom true indices of waterfowl production, but they offer a promising basis for measuring it. (Page 430.)

25. In this study, age ratios were obtained by examination of ducks trapped for banding, shot by hunters, or killed by disease. (Page 431.)

26. Although most traps were selective for adults, ducks taken in traps were found to provide a rough index to yearly changes in age ratios. (Pages 431–5.)

27. Juveniles were found to be more vulnerable to hunting than adults; the vulnerability differential varied with place, time of hunting season, year, and species. (Pages 435–9.)

28. Age ratios obtained from bagged ducks and corrected for the greater vulnerability of juveniles offered the best means of determining the adult-juvenile composition of duck populations. (Page 439.)

29. Age ratios derived from waterfowl lost to severe outbreaks of disease were considered unreliable because of the irregular occurrence and site limitations of such outbreaks. (Pages 439–40.)

30. Because juveniles and adults do not follow identical migration schedules or routes, age ratios showed seasonal and regional variations. (Pages 440–9.)

31. Age ratios were found to be useful for appraising the production of ducks if the data on which they are based have been carefully evaluated as to the effect of seasonal, regional, and shooting biases. (Page 449.)

32. A production curve (page 449) that was plotted from corrected age data for mallards in hunters' bags in the Mississippi Flyway for 17 years, 1939–1955, follows a pattern somewhat similar to that plotted from uncorrected data and shows a somewhat rhythmic production trend that may be inherently characteristic of waterfowl populations and prove to be density dependent in origin. (Page 454.)

33. A comparison of mallard age ratios in the Mississippi Flyway with pintail age ratios in the Pacific Flyway for 11 years, 1949–1959, revealed for most years an unexpectedly close agreement between pro-

duction trends of the two species involved. (Pages 454–5.)

34. For the period 1952–1959, the population curve plotted from forecast indices of waterfowl production in Saskatchewan was similar to the curve plotted from the Mississippi Flyway age ratios for mallards. Manitoba forecast indices showed very little correlation with mallard age ratios from the Mississippi Flyway, possibly because, as aerial surveys indicated, about six times as many mallards nest in the plains and parklands of Saskatchewan as in the plains and parklands of Manitoba, and because the Saskatchewan contribution to the Mississippi Flyway kill of mallards is larger than that of Manitoba. (Page 457.)

35. An attempt was made to correlate water conditions on the breeding grounds with mallard production. In Sasketchewan, mallard production (as determined by the number of juveniles per adult among birds bagged in Illinois) and water abundance (as measured by the number of ponds per square mile in May) followed similar trends in most years of the period 1948–1959. In Manitoba, mallard production tended to parallel water abundance in the years 1956–1959 but not in the 3 years previous. (Page 462.)

36. Decreased production by the mallard on the plains of Canada in years of very plentiful water and of cold weather, snow, and heavy rains at nesting time suggests that cold, excessively wet springs may be as unfavorable to duck production as dry, warm springs. (Page 463.)

37. Population density, as well as water and weather conditions on the breeding grounds, seems to have contributed to gross changes in mallard production in 1939–1959; it may well have been the dominant factor regulating production during those years in which there was poor correlation between age ratios and conditions on the breeding grounds. (Page 463.)

38. Age ratios of ducks checked in hunters' bags in the Mississippi Flyway for the period 1946–1949 provided indices of production for the various species. Several species appear to have had about equally high production rates: mallard, black duck, shoveler, ring-necked duck, and canvasback. The baldpate and green-winged teal seem to have been intermediate in production. The gadwall, pintail, blue-winged teal, redhead, and lesser scaup appear to have had production rates lower than those of the other species. (Page 466.)

39. Age ratios obtained through inspection of ducks in hunters' bags were found to be of value in establishing hunting regulations, for they provide a basis for evaluating the well-being of the population and the extent to which production may be expected to replace annual losses. (Pages 466–7.)

40. Further progress in waterfowl population management, the study concluded, requires a more concerted effort to obtain age ratio data by design and to relate these data to conditions on the breeding grounds. (Page 467.)

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Of necessity, variation occurs in some of the terms. For example, *peach* in the index may refer to either the fruit or the tree.

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