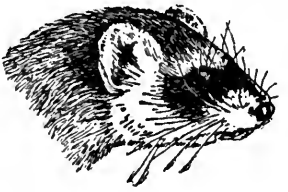
UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

ATTWATER'S PRAIRIE CHICKEN
ITS LIFE HISTORY AND MANAGEMENT

NORTH AMERICAN FAUNA 57



UNITED STATES DEPARTMENT OF THE INTERIOR
'Harold L. Ickes, Secretary

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BY

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UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1941

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 40 cents

ABSTRACT

ATTWATER'S PRAIRIE CHICKEN, a characteristic bird of the Texas coastal prairie, is closely related to the now extinct heath-hen of northeastern North America. Once abundant in an area extending from the coastal tall-grass prairies of southwestern Louisiana and Texas west and south to near Port Isabel, it has decreased in numbers as man has exploited its habitat, until now it is threatened with the same fate as that of the heath-hen.

Important factors limiting the numbers of the bird include excessive or persistent rainfall during the nesting season, heavy grazing, excessive pasture burning, agricultural operations, and overshooting. Management will usually involve protection from excessive killing, improvement of food and cover, and control of predators and of the kill by hunters. Responsibility for this rests with the landowner.

Optimum prairie chicken range apparently consists of well-drained grassland, with some weeds or shrubs, the cover varying in density from light to heavy; and with surface water available in summer; diversification within the grassland type is essential. In the absence of ample refuges for the species, probably all other favorable factors together will fail to save Attwater's prairie chicken from extinction.

This number continues the series of the North American Fauna issued by the Bureau of Biological Survey, of the United States Department of Agriculture, prior to its transfer and consolidation with the Bureau of Fisheries on June 30, 1940, to form the Fish and Wildlife Service, in the Department of the Interior.

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Allan Brooks

ATTWATER'S PRAIRIE CHICKEN

By VALGENE W. LEHMANN

Collaborator, Division of Wildlife Research, Fish and Wildlife Service[1]

INTRODUCTION

Attwater's prairie chicken (*Tympanuchus cupido attwateri* Bendire) (see frontispiece), might well be called the heath-hen of the South. It is so closely related to the now extinct heath-hen (*T. c. cupido*) of northeastern North America as to be classified in the same species. Like the heath-hen, Attwater's prairie chicken once inhabited a large area, its former range including the coastal tallgrass (*Andropogon*) prairies of southwestern Louisiana and in Texas west and south to Cameron County, near Port Isabel. In certain areas the birds were abundant. Old-timers report that the deep booming courtship calls of the males once reverberated from the prairies with such force and monotony as actually to pain sensitive eardrums. The bird, however, is no longer abundant. It has decreased in numbers as man has exploited its habitat until now it is threatened with the fate of the heath-hen—extinction.

In his "Biological Survey of Texas" Vernon Bailey (1905: 19)[2] places Attwater's prairie chicken at the head of the list of breeding birds of the Texas coastal prairie. In addition to being a characteristic bird of the region, this prairie chicken is probably the most popular species wherever found. Most people who know it have a genuine appreciation of its color and charm. Rare indeed is the person who finds no esthetic stimulus in the sight of a strutting male on the booming ground, or a brood of downy chicks on the edge of a short-grass flat. Both ranchmen and farmers highly appreciate the prairie chicken's appetite for grasshoppers, salt-marsh caterpillars (*Estigmene acraea*), and the moths of the cotton leaf worm (*Alabama argillacea*). Under proper conditions prairie chicken hunting provides a high type of sport, and the flesh of the birds, especially that of the young, is highly esteemed as food.

[1] Cooperative contribution from the Texas Cooperative Wildlife Research Unit, established by the Agricultural and Mechanical College of Texas; the Texas Game, Fish, and Oyster Commission; the American Wildlife Institute; and the Fish and Wildlife Service.

[2] Publications referred to parenthetically by date (alone or followed by colon and specific page) are listed in the Literature Cited, p. 62.

EXPLANATION OF FRONTISPIECE

Attwater's prairie chickens (*Tympanuchus cupido attwateri*) on booming ground

The real appeal of the prairie chicken, however, lies in its connection with the colorful and eventful early days in Texas. The prairie hen summons memories; it prompts old-timers to recall when the range was free of wire fences and oil derricks, and rich grasses grew waist high. Thoughtful people deplore the passing of Attwater's prairie chicken, one of the last landmarks of the prairie as it used to be. Highly appropriate was the selection of this bird as a species of major interest by the Texas Cooperative Wildlife Research unit.[3]

FORMER DISTRIBUTION OF PRAIRIE CHICKENS IN TEXAS

H. C. Oberholser, in a letter to the present writer, states that in his opinion prairie chickens once occurred at some time of year on most prairie areas in Texas. In the main it appears that the different kinds of prairie chickens in the State occupied separate ranges, and that mixing and intergradation were confined largely to marginal areas.

The principal former range of the greater prairie chicken in Texas, as indicated by the records of F. M. Bailey (1927: 130), Gross (Bent 1932: 262), Strecker (1927: 321), and old residents with whom the writer has conferred, was northeastern Texas southwest to the vicinity of Waco. Likewise, records show that the lesser prairie chicken was indigenous to northwestern Texas and the high plains region in winter to about Bandera and westward through the "hill country" to the arid plains west of the Pecos River (Bendire 1892: 355, and others). Attwater's prairie chicken, it appears, was largely confined to the better-drained prairies of western Louisiana and Southeastern Texas (fig. 1, p. 3).

According to Oberholser (1938: 190–191) the eastern limit of the range of Attwater's prairie chicken was in the vicinity of Abbeville,

[3] So many persons have assisted in the prairie chicken studies that it is impossible to list them all. General supervision of the work was by Walter P. Taylor, leader of the Texas Cooperative Wildlife Research Unit, College Station, Tex. Valuable editorial suggestions were received from W. B. Davis, professor of wild game, School of Agriculture, Agricultural and Mechanical College of Texas; and from William J. Tucker, executive secretary, Texas Game, Fish, and Oyster Commission. The bulk of examinations of crops, gizzards, and scats was done by Clarence Cottam, Clarence F. Smith, and their associates in the Section of Food Habits, Division of Wildlife Research, Fish and Wildlife Service.

In his field work in 1938 the writer was assisted by H. R. Siegler, field biologist of the Research Unit. Many Colorado County landowners cooperated; among these, M. C. Shindler, Emil Gleuck, Ed Koy, Adolf Renz, and I. V. Duncan deserve special mention. E. P. Haddon, photographer of the Texas Commission, took some of the photographs here reproduced. The assistance of the State game wardens was indispensable. Deserving of special mention are T. S. Boothe, Beaumont; J. C. Gardner, Hull; R. Z. Cowart, Rosenberg; Ed McCloskey, Victoria; C. D. Tidwell, Bay City; G. P. Ferguson, Sinton; and T. T. Waddell, Eagle Lake. Waddell's contributions to the study were outstanding; he gave most generously of his time, records, and extensive experience. To him, and to all others, the writer is deeply grateful.

Opelousas, and Bayou Teche in Louisiana. There are no authentic records of the occurrence of any species of prairie chicken in Texas south of northern Aransas County, except for one bird reported from near Brownsville by Merrill (1879: 159–160). Prairie chickens did not occur near San Antonio, Tex., in 1890, for Babbitt, in Bendire (1894: 130) wrote as follows: "The prairie hen is not found in the

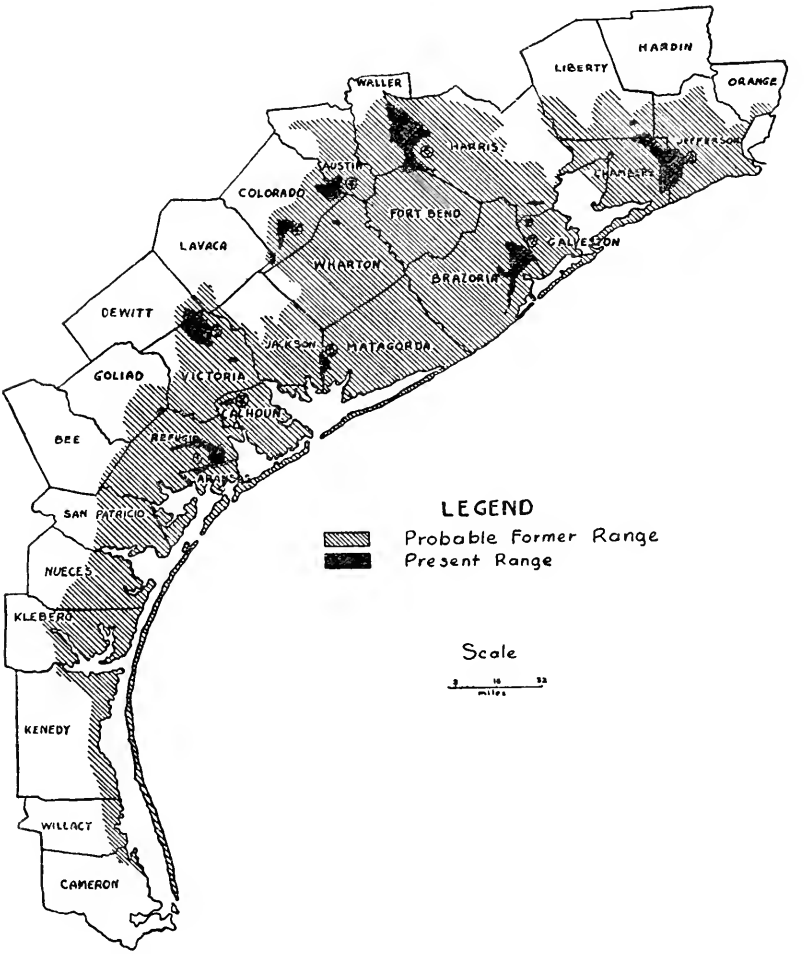


FIGURE 1.—Present distribution of Attwater's prairie chicken in Texas and probable former range in the coastal section.

immediate vicinity of San Antonio, Tex., but exists in great numbers south and southeast from here, all at an average distance of 100 miles. * * *" Simmons (1925: 82) submits the records of O. Brinkman and C. D. Oldright as evidence that Attwater's prairie chicken occurred as a breeding bird in the vicinity of Austin, Travis

County, and in Williamson County as late as 1878, but the accuracy of the data is questionable. Apparently the limit was the northern edge of the coastal prairie.

Roughly, the territory occupied by Attwater's prairie chicken was south of a line extending northeast from Refugio through Fannin, Thomaston, Provident City, Rock Island, Industry, Welcome, Bellville, Prairie View, Tom Ball, Humble, Liberty, Devers, Cheek, and Orange. All this area of approximately 8,500,000 acres in coastal Texas, however, was not occupied. Deciduous woodlands near rivers, as along the San Antonio, Guadalupe, Colorado, Brazos, and Trinity, were used only to a limited extent and only along the margins. Prairie chickens did not occupy the pine forests in Harris County and to the east or the thick mesquite-acacia brush that occurred in considerable stands in Calhoun and other western counties as much as 100 years ago. Brackish and salt-water marshes in Orange, Jefferson, and Chambers, and less widely in other counties to the west, and extensive cordgrass (*Spartina spartinae*) flats (pl. 2) in Aransas County and elsewhere in low country bordering the Gulf, probably always were little used by chickens except to a limited extent in winter. There were, however, about 6,000,000 acres of bluestem prairie that probably supported many prairie chickens in favorable years.

DIFFERENCES BETWEEN ATTWATER'S AND THE OTHER PRAIRIE CHICKENS

During the nineteenth century three kinds of prairie chickens occurred in Texas: the greater prairie chicken (*Tympanuchus cupido americanus* Reichenbach), Attwater's prairie chicken (*T. c. attwateri* Bendire), and the lesser prairie chicken (*T. pallidicinctus* Ridgway). Differences between the greater and Attwater's prairie chickens are slight; the lesser prairie chicken is somewhat better characterized.

ATTWATER'S PRAIRIE CHICKEN

Bendire (1894: 130) described Attwater's prairie chicken as—

> Smaller than *T. americanus* [greater prairie chicken], darker in color, more tawny above, usually with more pronounced chestnut on the neck; smaller and more tawny light colored spots on the wing coverts, and much more scantily feathered tarsus, the latter never feathered down to the base of toes, even in front; a broad posterior strip of bare skin being always exposed, even in winter, while in summer much of the greater part of the tarsus is naked.

In weight Attwater's prairie chicken, however, is not perceptibly lighter than the greater prairie chicken. The average of 10 males (33.11 ounces, as shown in table 1, p. 5) exceeded by 2.11 ounces the average weight of the greater prairie chicken (31 ounces), as

Dense cordgrass areas are little used by Attwater's prairie chickens except to a limited extent in winter; Aransas County, Tex., 6 miles west of Austwell, August 28, 1938. (Photo by V. W. Lehmann.)

given by Gross (1930a: 40). The average weight of six females (25.7 ounces) was only 0.6 ounce less than that of the female greater prairie chicken (26.3 ounces), according to the same authority (loc. cit.). The weight of Attwater's prairie chickens, especially that of males, varies perceptibly from season to season; three males obtained at the beginning of the courtship season were appreciably heavier (about 7.5 ounces) than those collected at other times. Darkness of color, tawniness above, and the amount of chestnut on the neck are other characters that vary greatly both seasonally and individually. Winter specimens are generally lighter in color than those collected in spring; they have comparatively little chestnut on necks and backs. The feathering on the tarsus also varies with the season; the legs of specimens collected in winter are well feathered to the base of the toes. The style of barring on the back and rump, according to F. M. Bailey (1927: 130), is the same for both subspecies, that is, the bars are single, broad, and solid black. Altogether, physical differences between Attwater's and the greater prairie chicken are minor and insufficient to allow accurate field identification. In a series of skins, however, the smaller measurements of wing, tail, bill, and total length and the differences in general ruddiness and buffiness of the underparts are characteristic and serve to separate Attwater's prairie chicken as a subspecies.

TABLE 1.—*Weights of 16 Attwater's prairie chickens*

County	Date collected	Weight [1]		County	Date collected	Weight [1]	
		Grams	Ounces			Grams	Ounces
MALES				MALES			
Colorado	Apr. 17, 1939 [2]	1,135.20	40.03	Refugio	Feb. 15, 1938	1,103.70	38.92
Do	Sept. 1, 1937 [3]	682.00	24.05	Do	do	1,125.20	39.68
Do	Sept. 4, 1937 [3]	590.07	20.81	Colorado	Mar. 18, 1938	1,120.45	39.51
Do	Oct. 23, 1937	760.20	26.81	Austin	Apr. 10, 1938 [4]	1,077.26	38.00
Do	Nov. 3, 1937	874.00	30.82	Colorado	July 26, 1938	921.34	32.50
FEMALES				FEMALES			
Colorado	Jan. 6, 1938	723.69	25.18	Refugio	Feb. 15, 1938	785.60	27.70
Do	Jan. 27, 1938	715.24	25.22	Colorado	Aug. 20, 1938	722.89	25.50
Austin	Feb. 14, 1938	726.80	25.63	Do	Aug. 23, 1938	708.72	25.00

[1] Average weights: Males, 938.94 gm. (33.11 oz.); females, 730.49 gm. (25.70 oz.).
[2] Taken from hawk.
[3] Immature bird.
[4] Taken from poacher.

LESSER PRAIRIE CHICKEN

The lesser prairie chicken is somewhat smaller than either of its relatives. Verne E. Davison, in a letter, reports that 20 mature males from Oklahoma weighed 23.50 to 31.50 ounces and averaged 27.56 ounces. Five hens weighed 23.75 to 27.50 ounces and averaged 25.55 ounces. In other words, these male lesser prairie chickens were, on the average, 3.44 ounces lighter than the male greater prairie chickens (31 ounces) weighed by Gross (1930a: 40); these female

lesser prairie chickens weighed 0.55 ounces less than the female greater prairie chickens that Gross obtained. According to Bailey (1927: 131), the general coloration of the lesser prairie chicken is paler than that of either the greater or Attwater's, and the color and arrangement of the bars on back and neck also differ. Whereas the bars are single, broad, and solid black in both the greater and Attwater's forms, they are treble, a broad brown bar enclosed by two narrow black ones, in the lesser species.

FORMER ABUNDANCE OF ATTWATER'S PRAIRIE CHICKEN

Accurate information as to the former abundance of Attwater's prairie chicken is difficult to obtain, although the data at hand record their numbers in certain areas. Many old cattlemen of the coastal prairie have told the writer that in early days the prairie chickens were relied upon to furnish fresh meat for the cattle camps. The task of killing 40 or 50 prairie chickens was menial, the cook of the outfit usually attending to it.

In the Eagle Lake area, Colorado County, not more than 35 years ago, prairie chickens were shot as clay pigeons are today. On appointed occasions parties of 10 to 20 or more men encamped in the sandhill country along the Bernard River and hunted the birds for periods varying from a few days to a week or more. At the end of each day the chickens killed, or their heads, were tallied. At the end of the encampment period the party having killed the smallest number paid the expenses of the outing. Waddell and others state that 10 or more piles of prairie chickens, each containing upwards of 100 birds, usually were left at the camp sites to rot or to be eaten by vultures. These encampments began about July 4 and continued through fall and winter.

During the summer of 1893 or 1894, in Matagorda County, near Bay City, V. L. LeTulle reports that 71 Attwater's prairie chickens were shot in 2 hours; and that in 1895, at the site of the present town of Van Vleck, he and 3 friends killed 72 birds in an afternoon, and except for poor marksmanship would have bagged many more. Near Wharton, in Wharton County, in the fall of 1894 or 1895, LeTulle found 340 piled where hunters had camped.

Mendell Burrell of the Ray Pipkin ranch (Big Hill country, Jefferson County) told the writer that as late as 1920 his domestic chickens were fed under the ranch house in winter to prevent prairie chickens from consuming the grain. In the same area it is said that flocks of from 150 to 200 Attwater's prairie chickens often alighted in the introduced chinaberry trees (*Melia azedarach umbraculifera*) around the ranch houses and fed extensively on the berries. In verification of this statement W. S. Boothe, State game warden at

Beaumont, Tex., presented the writer with a photograph, taken in 1910 on the White Ranch at Devers, showing a dozen prairie chickens in a chinaberry tree beside a house.

C. H. Brosig, who hunted Attwater's prairie chickens in the Eagle Lake area for more than 40 years, reported that the birds once were so numerous in the sandhill country bordering the Bernard River that a new covey frequently was flushed while singles from one previously discovered were being pursued. Paul Mundelius noted a similar high density in concentrations of prairie chickens in the Sealy-San Felipe section in the eastern part of Austin County in 1873–75. These conditions are seldom found on areas where the population is less than one bird to an acre, and they show the former abundance of Attwater's prairie chickens in favorable areas. Not all the coastal bluestem (*Andropogon*) prairie, about 6,000,000 acres, was equally favorable for prairie chickens even under pristine conditions; well-drained, well-populated country (one bird to an acre), as along the Bernard River, did not aggregate more than 900,000 acres, or about 15 percent of the inhabited range. A little more than half, 3,300,000 acres, or 55 percent, of the prairie country was only fairly well drained; these areas, protected for periods up to 17 years, now have a maximum population of about one bird to each 10 acres. Approximately 1,800,000 acres, or 30 percent, was poorly drained; prohibition of hunting for periods up to 15 years has not produced a population in excess of one bird to each 50 acres on certain of these large ranches. Probably, therefore, the former abundance of Attwater's prairie chicken in Texas approached, but seldom if ever attained or exceeded, 1,000,000 individuals, even in peak years.

PRESENT DISTRIBUTION AND NUMBERS

Data on the present status of Attwater's prairie chicken (table 2, p. 8) were obtained as follows:

At least 90 percent of all farms and ranches known or thought to have been occupied by the birds in 1937 were visited by the writer in company with local State game wardens. Unless the warden was thoroughly familiar with conditions on the various areas, conferences were held with landowners, managers, cowboys, guides, hunters, or other persons who were in position to know the status of prairie chickens on particular tracts. After the conferences a general reconnaissance of the areas was made by automobile or on horseback, and notes were taken on the topography, vegetation, surface water, and soil to ascertain the general suitability of the land for prairie chickens, as was done in similar studies previously made in the Eagle Lake area.

Then in the light of all available information the range of Attwater's prairie chicken was mapped in each county, and representa-

tive sample areas were selected for intensive study. The birds were then "rope counted" [4] on the sample tracts. Finally, the total population of the area was estimated from the data obtained by counting the sample plots.

TABLE 2.—*Population status of the Attwater's prairie chicken in Texas (1937)*

County	Size of tract	Census area		Territory occupied per bird		Population of whole tract
		Size	Population (rope count)	Census area	Whole tract	
	Acres	*Acres*	*Number*	*Acres*	*Acres*	*Number*
Aransas [1]		1,080	56	19.2		
Refugio		530	106	5.0		
Total or average (1) [2]	42,000	1,610	162		9.9	4,242
Calhoun [1]	6,554					[3] 25
Goliad [1]	5,000					[3] 4
Total or average (2)	11,554					
Dewitt [1]						
Victoria		230	4	57.5		
		873	14	62.3		
		218	0			
Total or average (3)	65,535	1,321	18		73.4	892
Wharton [1]	4,000					
Lavaca [1]	4,915					
Austin	18,022	4,200	32	131.2		
Colorado	49,152	14,250	315	45.2		
Total or average (4)	76,089	18,450	347		53.1	1,433
Jackson [1]						
Matagorda		736	0			
Total or average (5)	12,288	736	0			[3] 50
Harris		542	4	135.5		
		364	0			
		219	1	219.0		
		157	3	52.3		
Waller		716	0			
Fort Bend		482	0			
Total or average (6)	103,878	2,480	8		310.0	335
Brazoria		585	29	20.1		
		248	2	124.0		
		269	1	269.0		
		334	2	167.0		
Galveston [1]						
Total or average (7)	54,067	1,436	34		42.2	1,281
Jefferson		4,000	24	166.6		
Chambers		700	1	700.0		
Liberty		400	0			
Total or average (8)	91,724	5,100	25		204.0	449
Grand total or average	457,135	31,133	594		52.4	8,711

[1] Counties in which prairie chickens occur but in which counts were not made because of scarcity of birds or similarity of the areas to adjoining counties.
[2] Numbers in parentheses in total lines refer to areas correspondingly numbered in the map, fig. 1, p. 3.
[3] Estimates supplied by game wardens.

[4] For an account of the method used in rope counting see p. 49.

The known range of Attwater's prairie chicken in Texas, as of September 1937, aggregated only 457,135 acres, as compared with approximately 6,000,000 acres in former times. The range has therefore been reduced more than 93 percent during the past 100 years or so. The birds are still to be found in the counties of Aransas, Refugio, Goliad, Victoria, Calhoun, Dewitt, Jefferson, Waller, Galveston, Chambers, Liberty, Lavaca, Wharton, Colorado, Matagorda, Austin, Fort Bend, Harris, Brazoria, and possibly Jackson and Orange, although they have not been reported by reliable observers in the last two for several years. They have definitely been extirpated from Willacy and Montgomery Counties, and their distribution has become restricted throughout the State, especially in the counties of Goliad, DeWitt, Lavaca, Calhoun, Matagorda, Galveston, Fort Bend, Liberty, Jackson, and Orange, if they occur there at all. Prairie chickens had not been seen in Goliad County for at least 10 years prior to 1937, at which time four birds were reported on the W. J. O'Conner ranch.

No more than half the grassland range in any county except Refugio is occupied by prairie chickens. In the counties of Matagorda, Lavaca, Wharton, Calhoun, Liberty, Jackson, and Fort Bend even less than 10 percent of apparently satisfactory pasture is inhabited. Roughly, the available range for prairie chickens is only about 30 percent occupied and, with the exception of about 20,000 acres in southeastern Refugio County, all the occupied area has a sparse population.

The total number of prairie chickens in coastal Texas in the summer of 1937 was only about 8,700. The estimated 1937 population was probably less than 1 percent of the number believed to have occupied the coastal prairie in peak years before it was developed by white men. Approximately 4,200 chickens (or almost 50 percent of the known population of the State) inhabit two ranches in Refugio and Aransas Counties. The estimated population of 4,500 birds for the remainder of Texas is small indeed!

The consensus is that, during the past 10 years, the number of prairie chickens has decreased in all coastal counties except Refugio and Brazoria. In Refugio County there has been a rapid increase in recent years, probably largely because of excellent protection on the Salt Creek and Martin O'Conner ranches. Since 1935 the birds have spread from these onto the O'Brien, Powers, Welder, and Heard ranches near Greta, Refugio County, and probably also into Goliad County. Because of protection during a 5-year close season in Brazoria County (1932–36), R. Z. Cowart, State game warden there believes that in 1937 the number of birds had reached and possibly slightly exceeded the 1927 population level.

The prairie chicken population of the counties of Orange, Liberty, Fort Bend, Matagorda, Jackson, Lavaca, Calhoun, and Goliad, where populations of less than 100 birds per county obtain, may already be reduced to the point where recovery will be extremely difficult or even impossible. So long as any birds remain, however, every effort should be made to build up their numbers.

HABITS

COURTSHIP AND MATING

Prairie chickens do not pair for breeding, but are promiscuous. Males occupy selected courtship stations on booming grounds (see frontispiece), which are visited by the females. Copulation may take place elsewhere, however, in case of chance meetings. To attract the females, the cocks put on elaborate exhibitions, and their courtship antics are unbelievably weird. Of special interest is the manner in which the booming call is rendered.

This call of the male resembles somewhat the sound *whur-ru-rrr*, with strong accent on the second syllable. Although it generally lasts about 5 seconds, the call varies in length and tone. In mid-season the calls are characteristically deep and full-throated; later they become shorter and higher pitched, possibly because the males are then less vigorous. The sound of the booming carries for a mile or more on quiet days. It has a ventriloquial effect and often seems farther away or closer than it actually is. During the courtship season males boom regularly in early morning (sunrise until about 8 a. m.) and in late afternoon (5:30 p. m. until sunset), but calls have been heard at all hours of the day and night. Booming at night is sporadic, however, even during the peak of the courtship season in March, being most common when the moon is bright and when there is little wind.

The appearance of the male, while booming, is striking. As a preliminary to uttering the call he stretches his neck forward parallel to the ground. The erected pinnae, or neck tufts, point forward; the spread tail is held vertically or even inclined slightly over the back. The wings are extended downward and held firmly against the body and legs, the primaries almost touching the ground. The whole body appears strained and rigid. A short run forward is followed by vigorous stamping with the feet, which lasts only a few moments, but which under favorable conditions is distinctly audible for 50 feet or more. Inflation of the air sacs, which are actually but one sac with two lateral portions (pl. 3) is synchronized with the stamping. The first syllable of the booming is given before stamping ends, the male quickly jerking his head downward as he begins the call and keeping it there until the air sac is deflated.

B8188M

Male Attwater's prairie chicken, showing vocal sacs. (Photo from Texas Game, Fish, and Oyster Commission.)

The call of Attwater's prairie chicken apparently is given in the same manner as was that of the extinct heath-hen, its near relative. Gross (Bent 1932: 272) describes the booming mechanism of the heath-hen as follows:

> The sacs do not produce the notes, as was thought by some of the earlier ornithologists, but have much to do with modifying the sounds produced by the syrinx (the vocal mechanism at the juncture of the bronchial tubes). The sounds are produced by the air forced from the lungs, which vibrate specialized membranes of the syrinx under control of a complex set of muscles. The sound waves then issue through the trachea and glottis to the pharynx. In the production of such notes as the ordinary cackle the mandibles are opened and the air accompanied by the sound waves issues out of the mouth. In the tooting [booming] performance the mandibles are tightly closed, the throat patch is elevated, and the tongue is forced against the roof of the mouth (palate) by the mylohyoides muscles, which close off the exit through the internal nares. The tongue is bent in such a way that it causes the glottis at the base of the tongue to open directly in front of the esophagus. The air now coming from the respiratory system is forced to fill the modified anterior end of the esophagus, or gullet, which becomes distended like a balloon. While the air sac is filling, the sound waves produced by the syrinx beat against these tense drumlike membranes, which serve as resonators for the sounds and give them their great carrying power.

The booming call does not complete the vocabulary of male prairie chickens at courtship time. The rendition of additional calls, all distinctly henlike, is described as closely as possible on p. 12. On windy days cackling sounds, like Nos. 1, 2, and 3 in the list, carry farther than booming. The call note *pwoik* (No. 14) dominates when hens visit the courtship grounds. Observers may identify grounds where females are present by this *pwoik* call.

Males do not confine their courtship activities to vocalizing, and fights are common. Opponents usually approach each other, uttering peculiar whining notes, with necks outstretched, ear tufts erected, tails spread, wings drooped, and air sacs deflated. Then, as if possessed of the same thought, they suddenly hop off the ground, wings beating rapidly, and clash in midair. These bouts are usually discontinued after three or four flurries, and the victors seem satisfied after pursuing their opponents for short distances. Many feathers are frequently lost, but fights seldom if ever end fatally. Males sometimes engage fancied opponents, as clumps of weeds or tufts of tall grass, and at other times they joust and bluff for periods up to 30 minutes or more without striking a blow. With necks outstretched, heads held a few inches apart, and wings dangling loosely, they resemble domestic roosters fighting. At intervals males flutter into the air to heights of 3 to 5 feet, alighting nearly on the spot whence they arose. Their surplus energy apparently must be expended

in one way or another, although activity sometimes lags for brief periods.

CALL OF MALE PRAIRIE CHICKENS ON COURTSHIP GROUNDS

1. *Ca-ca'-ca-ca-ca-ca-ca-ca-caa-caa*___	All except last two notes given rapidly.
2. *Ca-ca'-caa, ca-ca'-caa*_____	Rapid.
3. *Ca-ca-ca--ca'-ca*_____	Rapid, accent on second to last syllable.
4. *Ca-ca-ca-ca-kecce*_____	All except last syllable given rapidly.
5. *Kwieee, ca-ca-ca-ca-ca-ca*_____	First syllable drawn out, remainder given rapidly.
6. *Kwerr-kwerr-pwah*_____	First two syllables drawn out.
7. *Kwier-kwier-kwier-kwier*_____	All syllables drawn out.
8. *Pwark* or *pwarrk*_____	Medium rapid. Often preceeds cackling or booming, carries as far as or farther than booming notes under certain weather conditions.
9. *Caaa-caaa-caaa-caaaa*_____	Slow and drawn out. Sounds almost exactly like protests of a domestic setting hen that is disturbed.
10. *Pwick, pwark*_____	Medium rapid.
11. *Pwick, pwick, pwick*_____	All notes drawn out with emphasis on the *ick*.
12. *Pwick, ca-ca-ca-ca-ca-caa*_____	Pause after first note, cackle given rapidly.
13. *Pwk-pwk-pwk-pwk-pwk-pwk*_____	Harsh notes executed rapidly, but in a subdued tone.
14. *Pwoik, pwoik, pwoik, pwoik*____	Executed rapidly and with much vigor. These notes predominate all other calls when a female approaches a courtship ground.
15. *Kliee, kliee, kliee; ca-ca-ca-ca*__	*Klice's* drawn out; *ca's* given rapidly. This is a prominent call in early spring.
16. *Kwoo, kwoo; kwah, kwah*_____	Rapid. Another prominent early season call.

The performers do considerable feeding when they first arrive on the courtship ground, and certain of them feed sporadically throughout their stay. At other times individuals, sometimes an entire group, sit or stand in their places and look about. Rest periods terminate abruptly, however, when a male recognizes a real or fancied challenge, or when a hen appears.

While the male is bold and noisy during the mating season, the female is demure and shy. Hens visit the courtship grounds irregularly except early in March. Even in well-populated territory a week sometimes elapses before the persistent male performers are rewarded by female company. When on or near a drumming ground, hens usually appear little interested in the spirited antics of the obviously excited males. Sometimes, however, they walk among the contestants and mate with one or several of them. Hens usually remain at the courtship areas briefly; usually they stay only a few minutes before leaving to feed elsewhere or fly to the vicinity of their nests.

In Colorado County signs of the approaching breeding season were noted early in January (1937) and late in December (1938) when certain males, probably the most vigorous, pecked at and otherwise bullied their fellows as the flocks left the roost or fed early each morning. A few weeks later, early in February (1937), and late in January (1938), males assembled early in the morning on short-grass areas that later served as courtship grounds, and fought and maneuvered for choice positions. For a week or more, calls consisted largely of miscellaneous squawks and cackles, and fights, though frequent, were of short duration. Males occasionally attempted to drum or boom, but their notes lacked midseason depth and vigor. Females, still in winter flocks, seemed indifferent to the proceedings. It was not until February 12, in 1937, and January 26, in 1938, that booming was commonly heard, and each year, after 2 to 3 weeks, flocks of females generally broke up and the courtship season was well under way. During both 1937 and 1938 courtship activity was at its peak in March, continuing through April and ending on May 20, in 1937, and on May 21, in 1938, when the last booming calls were heard.

Key areas during the courtship season are the booming grounds where males assemble each morning from daybreak until about 8 a. m. and each afternoon from 5:30 p. m. until dark and give their courtship display.

The preferred booming ground is a short-grass flat, an acre or so in extent, surrounded by an area of medium to heavy grassy cover suitable for nesting. Of several hundred sites observed during 3 years (1936–38) only one was on ground elevated enough to be termed a small knoll. The others were even with or slightly below the adjacent land surface. Stoddard (Bent 1932: 245), discussing the greater prairie chicken in Wisconsin, says that "the 'cooing' ground [courtship ground] at the sandy west end of Sauk Prairie has been used each spring for over 30 years, the birds always using the same knoll whether in rye, stubble, or grown to grass." Courtship grounds of Attwater's prairie chicken do not show the same degree of permanence. Cultivation seemingly results in immediate eviction, whether the crop is rice, corn, cotton, or something else. Likewise, the birds do not use fallow fields except where cultivated land is the only other environmental type available, or where the fallow land has aged to the extent that its surface and vegetation are nearly identical with that of nearby grassland. Even those courtship grounds that are in pastures may or may not be occupied each year for a series of years. Of 10 such grounds, on which records were obtained from 1936 through 1938, only 5, or 50 percent, were occupied each year. Their populations were fairly stable (see table 3, p. 14). Of the others, 2 were occupied in 1936 and 1937; 2 were unused except in 1936; and 1 was occupied in 1936, in part of 1937, and throughout the entire season in 1938. There was little variation in the prairie chicken

population of the pastures in which these courtship grounds were situated, but in every instance the vegetation on or near the study areas varied in density through grazing or burning. Cover changes on and near courtship areas influenced their attractiveness to the birds, possibly to the point of determining whether they would be occupied and by how many individuals.

TABLE 3.—*Occurrences in 3 years of male prairie chickens on 5 courtship grounds in Colorado County*

Name of pasture	Observations			Birds observed					
				Extremes			Averages		
	1936	1937	1938	1936	1937	1938	1936	1937	1938
Thomas	2	11	6	7- 9	6- 9	4-11	8.0	7.0	8.0
Do	2	8	6	9-11	3-10	5- 8	10.0	6.0	7.0
Do	2	14	6	5- 6	3- 9	3- 8	5.5	8.0	7.0
Duncan	2	13	11	6- 8	5-11	5-13	7.0	9.0	10.0
Everett	2	20	12	7- 7	0- 8	6-14	7.0	6.0	10.0
Total or average	10	66	42				7.5	7.2	8.4

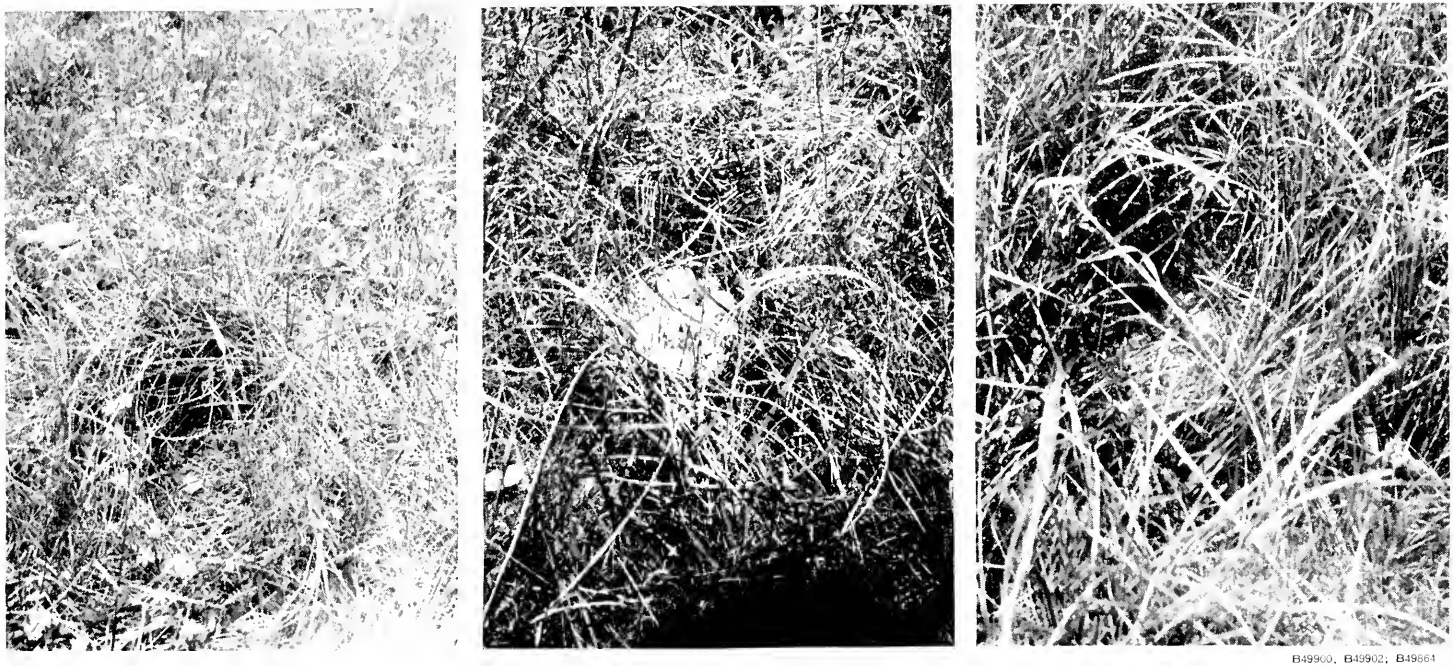
NESTING

While the males are still engaged in their courtship performances, the females quietly select and improve the nest sites and attend to laying, incubating, and hatching the eggs and rearing the young. Nests (pl. 4) are made on the ground. Of 19 examined in 1937 and 1938, 17 were in long-grass pastures, 1 in a hay meadow, and 1 in a fallow field. All were in dead grass of the previous year's growth. Fifteen (about 76 percent) were on or near well-drained mounds or ridges, and 4 were in poorly drained situations. In a choice of nest sites, cover appeared of more importance than topography and the structure of the soil. Twelve (63 percent) of the study nests were situated within 10 yards of well-marked trails, possibly because prairie chickens dislike walking through heavy matted vegetation when approaching or leaving their nests. Cattle make many trails, thereby improving nesting areas.

Study nests were found always within a radius of half a mile to a mile from occupied booming grounds. Sometimes the sites were rather distant from acceptable feeding territory, although flights of up to a mile seemed to inconvenience the birds very little.

Nests were merely shallow depressions, about 7 inches in diameter, lined with bits of dead grass, twigs, and a few feathers, presumably from the females. All were more or less roofed over because of the lapping or bending over of surrounding vegetation. Entrances faced in various directions with no preference shown. There was considerable variation in degree of concealment (pl. 5), at least according to human standards; 5 nests being excellently, 10 well, and 4 poorly, concealed. Rapid new plant growth in April and May aided ma-

Nest and eggs of Attwater's prairie chicken; Colorado County, Tex., 5½ miles north of Eagle Lake, April 1938. (Photo from Texas Game, Fish, and Oyster Commission; E. P. Haddon.)



B49900, B49902, B49864

Left, Poorly concealed nest, eggs eaten by predator (shell fragments at entrance); Winterman pasture, Colorado County, Tex., April 1937. *Middle*, Nest fairly well concealed; Sklar Marcella pasture, Colorado County, May 1937. *Right*, Well-concealed nest; Colorado County, 8 miles northeast of Eagle Lake, April 10, 1937. (Photos by V. W. Lehmann.)

terially in hiding nests; consequently, some nests that were relatively exposed when found were well hidden later. Wild indigo (*Baptisia* sp.), vetch (*Vicia ludoviciana*), phlox (*Phlox drummondii*), perennial ragweed (*Ambrosia psilostachya*), dogfennel (*Eupatorium* sp.), and panic grass (*Panicum* sp.) were green plants that aided concealment materially by mid-May. In Colorado County, favorite nesting materials were dry bluestem grass (*Andropogon scoparius*), and paspalum (*Paspalum dilatatum*).

The earliest date for a nest containing eggs was reported by Waddell near Egypt, Wharton County, February 25, 1925; the latest record is that of a nest in Colorado County in which the clutch was completed May 29, 1938. In both 1937 and 1938, however, the peak of the laying season in Colorado County was late March and early April. Hens always laid in the morning, usually from 7:30 to 9, flying to the vicinity of their nests when ready. After cautiously looking about or feeding a bit longer, hens walked to the nests and remained there for from about 20 minutes to an hour. The laying completed, they regularly walked about 20 feet from the nest, scanned the landscape, and flew away. Since incomplete clutches were unguarded except during about an hour each day, they were especially vulnerable to natural enemies.

Hens under observation normally laid an egg a day until the clutch of 8 to 15 was complete, but sometimes they failed to lay for periods of 1 to 3 days. Clutches usually contained 12 eggs, and laying was generally completed in about 2 weeks. The period of egg laying was sometimes extended, however, when nests were destroyed. Three hens, each the only resident on a small unburned plot, renested during 1937, one of them three times.

New nests, however, were placed 5 to 20 yards from old ones, and were less effectively concealed. Destructive agents had even greater opportunities to take the later nests, as they did in four out of five cases. Since booming ended by mid-May, the period for mating was short. Late broods were invariably smaller than early ones, probably because late clutches were small, their hatchability low, or their mortality heavy. A successful season depends largely on the fate of early nests, so that a primary objective of management should be to safeguard these attempts.

Twenty-nine eggs of Attwater's prairie chicken measured by Bent (1932: 264) averaged 42.3 by 31.5 millimeters in size, showing extremes of 44.9 by 32, 42.4 by 33.5, 38.8 by 28.9, and 39.8 by 28.6 millimeters. Newly laid eggs were dull cream or bluish buff in color, some of them minutely specked with red. During incubation the color of the eggs became dull and the shells shiny. Incubation began at from 1 day before until 4 days after the last egg was laid.

Except for two feeding and resting periods daily, extending from about 7 to 8 a. m. and from 5:30 to 6:30 p. m., hens incubated constantly. When incubation was advanced, morning feeding was frequently dispensed with. Two clutches pipped approximately 23 and 24 days after setting began, in each instance requiring about 48 hours longer to hatch. Of 71 eggs in 7 nests, only 3 (about 4 percent) were infertile, 66 hatching successfully. Seemingly, fertility and hatchability are high under favorable conditions.

The hatching period was evidently a time of danger. Chicks peeped incessantly and scrambled in and out of the nest. Nests emitted strong odors, apparent even to man. Females at hatching time appeared nervous and shifted their positions frequently. Unless disturbed, however, they did not leave until the last egg had hatched, after which they deserted the nests. In 1937 a nest in which all young were hatched by 11:50 a. m. on May 15 was vacated by 3 p. m. that day, and a brood that was hatching at 8:30 a. m. on June 2 was gone 24 hours later. One hen left before 2 pipped eggs were hatched and before the natal down on some of the young was dry, probably because fire ants (*Solenopsis*) had entered the nest.

GROWTH AND DEVELOPMENT OF YOUNG

When leading chicks from the nest, old birds traveled through the lightest cover or followed trails, probably because heavy matted vegetation impeded progress and increased the chance of chicks getting lost. Cow trails were favorite travel ways. Chicks ranged in front, behind, and on both sides of the hen over an area 1 to 5 yards in radius. Interruptions for sporadic feeding and for frequent brooding, which was probably more necessary for assembling than for warming the young, made progress slow. Hens with chicks less than 10 days old (pl. 6) seemed mainly concerned with watchfulness and brooding. Occasionally they caught available insects or nipped off a few green leaves or buds, but they did little continuous feeding. When danger threatened, they gave a warning call, best described as a low *kwerr*, *kwerr*, *kwerr*, and slowly skulked through the grass with head lowered and wings dangling loosely, almost touching the sod. Young birds "froze" with their bodies closely pressed to the ground. Decoy efforts of adult females were never so energetic as those of bobwhites under similar circumstances. When hens were flushed, the chicks in hiding (pl. 6) became impatient after 3 to 5 minutes, and peeped and ran about in spite of the fact that the object of suspicion remained. After the immature birds of 2 to 3 weeks of age could fly fairly well, females accompanying them did not decoy, but always flushed freely, the young doing likewise.

Chicks that were less than a week old were brooded quite often, probably in all for about 50 percent of the daylight period. Ten birds

Above, Chicks about 10 days old; Colorado County, Tex., approximately 6 miles north of Eagle Lake, May 3, 1938. *Below*, Chicks hiding; Colorado County, Tex., approximately 6½ miles north of Eagle Lake, May 3, 1938. (Photos from Texas Game, Fish, and Oyster Commission; E. P. Haddon.)

about 2 days old were brooded 42 minutes out of the 1½ hours during which they were watched on May 4, 1937. Their position during brooding was interesting. Hens squatted low with legs at an angle of about 30 degrees with the ground. Wings were drooped and feathers of the underparts were ruffled. Some chicks scrambled up and under the wings. When the brooding hens were frightened and suddenly stood erect, usually only two or three chicks were visible; the others, however, tumbled from beneath her wings a few moments later. As the chicks grew older, the time spent brooding diminished; those 2 weeks old apparently were brooded little except early in the morning, during inclement weather, and at night.

Newly hatched chicks are about the size of day-old bantams, and their coloration is nearly identical with that of young bronze turkeys. The basic, buffy yellow is streaked with gray on head and upperparts. Growth and development are rapid. Wing feathers appear almost at once; week-old chicks have primaries approximately five-eighths of an inch long. Chicks fly when 2 weeks old. Except for differences in the length of the tail and legs, they are about the size of English sparrows. When 3 weeks of age, youngsters are almost as large as starlings and can make sustained flights of 40 yards or more. At 4 or 5 weeks, young birds approximate the size of mature bobwhites, and often fly a hundred yards before alighting. When 6 or 7 weeks old, the young are about half grown and at 8 or 9 weeks they are three-fourths the size of adults. Youngsters 10 to 12 weeks old can scarcely be differentiated from the old birds in the field. Weight evidently does not increase as rapidly as size, however, for two birds approximately 3 months old were more than a pound lighter than mature individuals.

As young prairie chickens grow in size, all cannot, of course, maintain a brooding position under the sheltering body of the mother. Usually by the time they are about 3 weeks old some are forced outside; there they sleep with bodies pressed closely to that of the hen. When 4 to 5 weeks of age, two or three chicks sometimes crowd under their mother, but the remainder roost from a few inches to about 2 feet away. At 6 to 7 weeks, young birds adopt the roosting formation of adults. Flocks of Attwater's prairie chickens sleep about a foot or so apart, the individuals facing in different directions. Roosting spots vary in size from 1 to 3 square yards or more, depending on the number of birds in the group. The number of scats left at a roosting site is not an absolutely accurate index to the number of birds in a flock, because slight shifting of individuals during the night brings about the deposition of more than one pile by a bird.

Chicks about 2 weeks old take vigorous dust baths, a habit that is indulged in regularly throughout life when dry, powdery material is

available. Prairie chickens generally dust during the midday rest period that extends from about 10 a. m. to 4 p. m. Old pocket gopher mounds and cattle wallows are favorite places. Some birds use the same dust bath more than once.

BROOD SIZE

The size of the brood generally decreases with the age of the young. Of 48 broods on which accurate counts were kept (table 4, below) 6 from 1 to 3 days old contained 64 young, averaging 10.6 birds each. Three broods estimated to be 5 to 10 days old contained only 14 chicks averaging 4.6 each. Four broods 15 to 27 days old had 22 young, or an average of 5.5. Fifteen families over 4 and under 6 weeks of age aggregated 80 young and averaged 5.3. Twenty groups over 6 weeks totaled 80 young and averaged 4 each. The average size (5.3 young) of 15 families, estimated to be over 4 but under 6 weeks of age, was exactly half the average size (10.6) of 6 new broods. The average size (5.3) of 15 families over 4 but under 6 weeks old was but slightly larger than the average size (4.0) of 20 families older than 6 weeks. Therefore, it appears that juvenile mortality is heaviest during the first 4 weeks and comparatively light thereafter.

TABLE 4.—*Size of broods and number of chicks counted during May, June, and July*

County	Date	Family groups observed	Chicks per group	Chicks per average group
Colorado	May 4	1	10	10.00
Do	May 15	1	12	12.00
Do	May 18	1	12	12.00
Do	May 23	3	2, 4, 2	2.66
Do	May 28	3	7, 9, 11	9.00
Do	May 29	1	8	8.00
Do	May 31	2	4, 8	6.00
Total or average for May		12	89	7.41
Colorado	June 2	4	6, 9, 4, 2	6.33
Do	June 3	1	10	10.00
Do	June 8	2	3, 3	3.00
Do	June 10	2	4, 8	6.00
Jefferson	June 24	3	5, 4, 3	4.00
Total or average for June		12	61	5.08
Brazoria	July 1	3	5, 5, 6	5.33
Colorado	July 8	2	3, 3	3.00
Victoria	July 14	1	7	7.00
Refugio	July 17	4	10, 8, 1, 3	6.00
Do	July 19	6	10, 2, 2, 4, 5, 2	4.16
Colorado	July 26	2	10, 5	8.00
Total or average for July		18	92	5.11
Harris	Aug. 12	1	3	3.00
Colorado	Sept. 2	3	5, 3, 3	3.66
Do	Sept. 3	1	3	3.00
Do	Sept. 4	1	4	4.00
Total or average for August, September		5	18	3.60
Grand total or average		48	263	5.48

JUVENILE MORTALITY

Although much remains to be learned about juvenile mortality, its causes were fairly well established in some instances. Chicks are sometimes trapped and drowned in rice fields at the time of flooding (usually about May 10). In 1925, near Egypt, Wharton County, Waddell and others picked up hatfuls of chicks and carried them beyond the levees. In 1937 a farmer near Eagle Lake similarly rescued a brood. The number of chicks annually saved from this hazard, however, is probably insignificant in contrast to those lost. Prairie fires kill young and, as stated on page 42, burning is still common in certain areas at nesting and brooding time. Unfavorable weather, especially rains (pp. 32 to 35) and natural enemies (p. 39), account for the death of some young birds, but no small percentage of these may be chicks that are lost.

Chicks stray from the brood more often than one might suspect. During April, May, and June, 1937, no fewer than 13 strays were seen, all under 4 weeks old. Usually they occurred as singles, but sometimes in pairs and trios. How the youngsters became lost, of course, was usually unknown, but several reasons were apparent. The characteristic loose feeding formation of broods possibly contributed to straying; also, broods usually scattered widely and flew far when disturbed; and, possibly most significant of all, adults did not appear to have a highly developed rallying call that doubtless would be of assistance in reassembling youngsters.

Lost chicks evidently join other groups occasionally, as hens accompanied by young of varied sizes were several times noted in 1937. Once two chicks, about 2 and 3 weeks old, respectively, were seen with two molting males. Higher population levels might increase the frequency of adoptions.

FAMILY DISINTEGRATION

Many young Attwater's prairie chickens 6 to 8 weeks old leave the family groups and take up life on their own, but, as is true with domestic chickens, all young do not leave the hen at the same time; disintegration of the family group is gradual. Some young remain with the hen well into the fall. Unattached young, 6 weeks of age or older, as distinguished from lost chicks less than a month old, became noticeable late in June and they were frequently seen after July. Family disintegration after 6 weeks or thereabouts is normal. Young prairie chickens at that age seem as capable of foraging and resisting adverse weather as are the adults.

ANNUAL INCREASE

The actual survival of young prairie chickens (table 5, below) probably is always well below the potential yield (12 or so young from each hen) even when favorable weather conditions obtain during the critical breeding season.

TABLE 5.—*Young and adult birds observed in census after June 30, 1937*

County	Date	Area	Adults				Young		Total
			Males	Females	Sex unknown	Total	Families	Strays	
		Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Brazoria	July 1	585	2	4	2	8	5, 5, 6	1, 1, 1, 1, 1	21
Victoria	July 14	921	1	1	6	8	7	1, 2	10
Refugio	July 17	1,080	1	4	23	28	10, 8, 1, 3	2, 1, 1, 1, 1	28
Do	July 19	530	3	8	53	64	10, 2, 2, 4, 5, 1	1, 1, 2, 1, 1, 1	32
Colorado	July 26	1,450	0	2	4	6	11, 5	2, 3	21
Brazoria	July 27	851	2	0	2	4	3	1	4
Harris	Aug. 12	1,282	1	1	2	4	3	1	4
Colorado	Sept. 1	2,000	1	5	8	14	5, 3, 3	1, 2, 1, 3	18
Total		8,699	11	25	100	136	103	35	138

In a rope count on or after July 1, 1937, 138 young as compared with 136 adults (about 1:1) were enumerated on an area of more than 8,699 acres. At this time most of the counted birds were 4 weeks old or more and were beyond the age when mortality is thought to be most severe. The increase on the counted areas, then, was only about 100 percent in spite of the fact that food, cover, and weather conditions were favorable. A 100 percent increase of prairie chickens in any one year is very good, and the arguments for long open seasons and large bag limits, based on the potential annual increase (12 chicks for each hen, or about 600 percent a year), evidently are fallacious.

FLOCKING

Late in summer and early in fall, the prairie chickens displayed no marked tendency to combine into stable groups. In August and September of 1936 and 1937 well over half the birds observed in Colorado County were recorded as singles, pairs, and trios, although small groups of 4 to 6 were not uncommon. Occasional larger flocks were recorded, but these appeared to be temporary. In Colorado County, at about noon on September 1, 1937, a flock of 15 to 25 birds was noticed in a cotton field. On the following 3 days at the same hour 11, 15, and 9 birds, respectively, were present in that field; but they had come in between 9:30 and 11:30 as singles, pairs, and in small groups not exceeding 5 birds each. Between 4 p. m. and dark they left the field as they had come. Again in Colorado County, at 6 p. m. on September 3, 1937, another group of 16 birds found in a pasture came together as follows: At 5:40 p. m. a group

of 8 flushed approximately 1 mile from the spot where the large flock was later noted, and as they flew over the prairie, a pair, a single, a trio, and another pair joined the original group. All settled and fed together for a time, but the bevy disintegrated by dusk. Like instances suggest that early fall flocks of a dozen or so birds are unstable groups brought together largely by chance.

In fall, after the weather turned cool, groups of prairie chickens became the rule rather than the exception. Early November bevies generally contained 4 to 12 birds each, but large flocks became increasingly common from about December 1 to the onset of the breeding season. Late in winter (January) Guy Ferguson, State game warden, Sinton, Tex., observed flocks in Refugio and Aransas Counties that contained more than a hundred birds. Wardens Waddell in Colorado, Austin, and Wharton Counties, and McClosky in Victoria County, reported winter aggregations of about the same size. In 1936, J. O. Linney, foreman, Salt Creek (Hallahan) ranch, Refugio and Aransas Counties, noticed late winter concentrations estimated to contain 250 to 300 individuals. The writer has not observed such large winter flocks, possibly because he has not made observations in areas where the birds were sufficiently numerous. January assemblages of 25 to 35 birds were not uncommon, however, in Colorado County. Despite the fact that large flocks became more frequent from November until the breeding season, small groups of 8 or fewer birds or singles were always to be found. All packs observed in Colorado County late in November, December and January contained birds of only one sex. Late in January, residents of the coastal country eagerly listen for the first booming calls, which, besides promoting rapid disintegration of winter flocks, signal the departure of winter and the coming of spring.

SEASONAL MOVEMENTS

Spring

Comprehensive data on prairie chicken movements are lacking, but the records obtained in 1937 are of interest. Two broods that were observed two or more times daily from the time they were hatched until they were 7 and 12 days old, respectively, were, at last observation, less than half a mile from the nest sites. Another brood, estimated to be 8 days old when first discovered on June 2, was within 150 yards of the same spot at various hours during the next 6 days. A fourth brood, about 3 days old on April 29, remained within 400 yards of a certain windmill from April 29 through May 31. A 640-acre pasture that contained four broods, all under 2 weeks of age when rope counted on June 2, likewise harbored four broods 10 days later.

If this is indicative, the prairie chickens under observation spent their first several weeks of life in close proximity to the places where hatched. The daily cruising radius of a brood apparently was small, seemingly less than 300 yards in the case of birds under 4 weeks old in a favorable environment. Some 30 broods observed between May 1 and June 1 were found in light cover on or near hardpan flats and recent burns, indicating a distinct preference for those types of habitat.

Summer

An extensive movement involving both young and adult prairie chickens in Colorado County began about June 1, 1937, when many of the young were 3 to 5 weeks old, and lasted until about June 30. The sudden scarcity of the birds in places where they had been common only a few days before was striking. A 1,000-acre pasture that contained 37 individuals (16 old and 21 young) on June 2, held only 16 in all on June 10. As the prairie chickens decreased in some pastures, they increased in others. A 460-acre pasture that was unoccupied on May 1 contained 14 birds on June 8 and 23 on July 26.

This movement from the spring range was by stages. One brood that was watched closely made trips of approximately 1 mile, three-fourths mile, and 1¼ miles in 6 days from June 2 through June 8. After the first major movement, this family remained for 3 days in an area less than 500 yards in diameter; their droppings in piles formed a triangle with sides of 5, 15, and 17 yards, respectively. The movement of a combined brood of 3 hens and 16 to 25 young are recorded in figure 2, p. 23.

Leopold (1933: 291) reports that—

> All observers unanimously and independently report a strong tendency for the grown young of most species of grouse to seek the vicinity of drinking water in late summer and fall, but whether they do this out of choice or necessity is not known.

The early summer movement of young and adult Attwater's prairie chickens also was to the vicinity of surface water, but it was to water near which there also was shade. Pastures having an abundance of surface water but little or no shade-producing cover had few if any birds after mid-June. Likewise, places in which dense stands of weeds, shrubs, or tall grass were abundant, but surface water scarce, were sparsely populated. More than 95 percent of the more than 500 Attwater's prairie chickens observed from June 24 through September 4, 1937, were in heavy cover within a mile, generally within less than half a mile of surface water.

The beginning of the summer movement is synchronous with the drying up of the wild indigo (*Baptisia*, pl. 7), a plant that furnishes the principal shade on burns and heavily grazed areas from April through May. Prairie chickens require abundant shade in sum-

B50688; B49718A

Above, Wild indigo (*Baptisia*) in a closely grazed pasture; Austin County, Tex., approximately 8 miles southeast of Sealy, April 10, 1938. *Below*, Shocked grain and waste in rice fields sometimes attract prairie chickens; Colorado County, Tex., 3 miles northeast of Eagle Lake, September 5, 1936. (Photos by V. W. Lehmann.)

mer, for birds that were herded from such cover at midday panted vigorously, drooped their wings, and showed other signs of discomfort. They evidently rarely drink from surface water. In 1937, birds near water were closely observed, but only one was seen to drink during the entire summer. That was in Colorado County on June 1, 1937, when a chick about 3 weeks old drank a few times from a puddle formed by water from a leaking windmill. The soft mud bordering ponds in inhabited prairie chicken range in Brazoria, Colorado, and Austin Counties was examined thoroughly at various times, but tracks of this species were never found. Grasshoppers

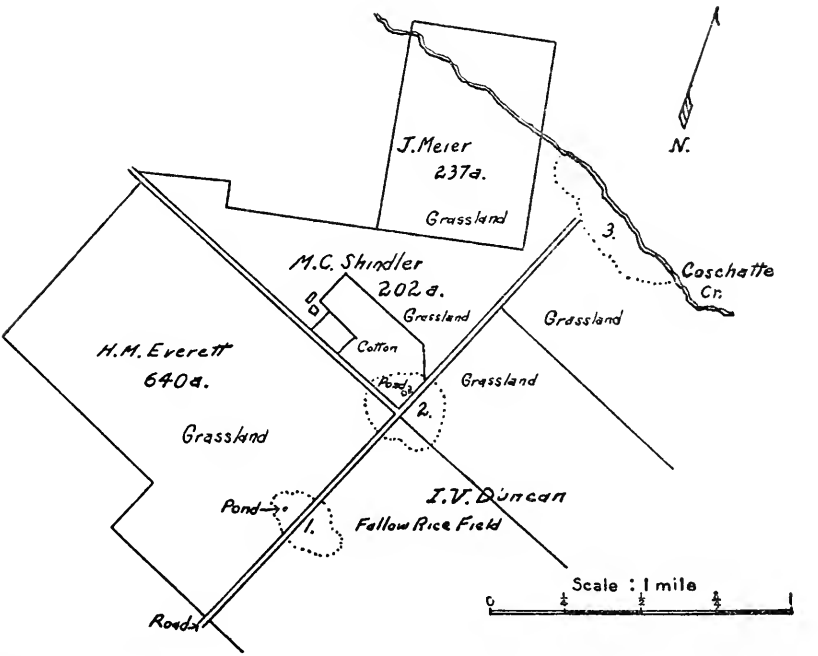


FIGURE 2.—Movements of a combined brood, May 1 to July 26, 1937, Colorado County. Birds seen in areas as follows: 1, May 1 to 28; 2, June 10 to July 10; 3, July 15 to 26.

and other favorite foods were frequently more abundant in summer in heavy cover near water, but the food factor was not thought to be of great importance at the time. The summer movements of prairie chickens to heavy cover near water are not satisfactorily explainable on the basis of cover, water, and food, but these habitat conditions must be provided where stable populations are desired.

After they found a satisfactory summer range, the prairie chickens moved little until fall, unless their summer territory was depleted or that nearby was more suitable. The population of a 460-acre pasture in Colorado County remained at nearly the same level (25

to 36 birds) from July 26 through September 3, 1937. The birds that rested in this area at noon each day, however, foraged and roosted largely in adjoining pastures, but their range was never more than 1¼ miles and usually under half a mile.

Rains in 1937 sufficiently heavy to collect in low spots caused temporary spreading of prairie chickens from previously occupied areas. As the temporary water disappeared, however, the birds again concentrated.

Fall and Winter

Populations that had been rather stable in certain pastures in Colorado County during the summer months of 1937 began shifting early in fall. About 25 birds that were summer residents of the M. Shindler cotton field from July through August were absent after September 4. Two thousand acres of regularly censused pasture where prairie chickens were common in summer contained only 9 birds when rope counted on October 22. While the birds decreased generally in the large pastures, they increased around small farms near Sealy, Austin County; Lissie, Wharton County; and Bernardo and Chesterville, Colorado County—territory 5 to 10 miles removed from the pastures in which birds had been most common during the preceding spring and summer.

Distances traveled daily were evidently great in some instances. A bird killed by a farmer at 8 a. m. on September 1, 1936, was known to have traveled at least 3 miles since dawn, because its crop was filled with rice and the nearest rice field was that distant. Two individuals, observed for 2 hours on the afternoon of October 22, 1937, traveled approximately 1¼ miles southeast of the point where first seen. When finally flushed, they flew an additional 2 miles or so in the same direction. A flock of four birds observed from 4 p. m. to 6:15 p. m. on January 4, 1938, traveled more than 1¾ miles. The movement was in a circular direction, however, for at nightfall, the birds were less than half a mile from the point where they were first observed. Cool weather, fall rains, and a seasonal abundance of food and cover, especially in the vicinity of farming communities, probably were important in promoting the general fall scattering and the long daily trips the prairie chickens made in territory that was sparsely populated at other seasons. The birds reconcentrated in large pastures, however, as fall passed into winter.

The population of the Everett pasture (640 acres), Colorado County, increased from November 3, 1937, through January 28, 1938; five censuses during that period showing 46, 58, 56 to 58, 73, and 84 birds, respectively. Excellent food and cover conditions prevailed, for the area was lightly grazed. This increase in the number of birds apparently resulted from influxes from adjoining areas. After

November 15, few fluctuations in numbers between different pastures were reported by fence riders and others. Pastures that contained the greatest numbers in November and December 1937 also harbored the largest breeding populations the following spring.

The data at hand show that late in fall, probably by about November 15, the prairie chickens move to pastures where food and cover conditions are adequate. Having found such an area, they remain until spring. Probably the best way to attract a good breeding population, therefore, is to provide suitable food and cover conditions during the preceding winter.

FOOD

Data on the food of Attwater's prairie chicken were derived mainly from analyses of 21 stomachs (crops, or gizzards, or both) and more than 200 droppings (scats). Additional information was obtained by watching feeding birds at close range through field glasses. Of the 21 stomachs, 18 were of adult prairie chickens, 2 of chicks approximately 10 days old, and 1 of a juvenile about 7 weeks old. Specimens were obtained as follows: 6 in winter (January and February), 5 in spring (April and May), 5 in summer (June through August), and 5 in fall (September through November). J. H. Gaut collected 3 stomachs near East Bernard, Wharton County, in May 1905. Over the period beginning September 1936 and ending August 1938, 2 stomachs were obtained in Austin County, 4 in Refugio County, and 12 in Colorado County. As the crops and gizzards of all birds found killed by automobiles, predators, poachers, and from other causes were saved, it was necessary to collect only 11 specimens to balance the series according to seasons.

Except during the breeding season, adult prairie chickens regularly feed twice daily, early in the morning (dawn to about 8 a. m.), and late in the afternoon (4 p. m. to dark). Occasional bits of food are picked up throughout the day, but the gullets of specimens collected about noon are usually empty or nearly so. The food capacity of prairie chickens is large. Gullets frequently contain about 20 cubic centimeters, and the gizzard about 30 cubic centimeters, of material. Since the birds ordinarily feed slowly and deliberately, apparently selecting their food with great care, it is not surprising that their diet in favorable areas is varied. Stomachs have been examined that contained 29 kinds of food and more than 1,300 items; stomachs rarely contain less than 13 kinds of food of 500 items. Mature birds evidently feed mostly on vegetation at all seasons, for the stomachs of 18 adults (table 6, p. 26) contained 88.28 percent of plant material and 11.72 percent of insects. Animal matter probably ranks higher than plants in the diet of young birds, however,

for the stomachs of 2 chicks and a juvenile (table 7, below) contained 88.5 percent of insects. The ratio of plant to animal food varies according to season (table 8, below), insects, for instance, apparently being eaten in greatest quantity in summer.

TABLE 6.—*Composition of the stomach [1] contents of 18 adult prairie chickens*

Item	Stomachs in which found	Quantity present	Item	Stomachs in which found	Quantity present
	Number	*Percent*		*Number*	*Percent*
Vegetable matter	18	88.28	Animal matter	18	11.72
Leaves and stems	12	27.11	Insects:		
Seeds and pods	16	55.67	Adults	17	10.83
Buds and flowers	5	1.30	Eggs and larvae	8	0.89
Miscellaneous [2]	6	4.20	Round worms	1	[3]
			Prairie chicken feathers	1	[3]
			Grit	11	[3]

[1] Crops or gizzards, or both.
[2] Woody pod septa, root stocks, and the like.
[3] Trace.

TABLE 7.—*Composition of the stomach contents of three young prairie chickens*

Item	Stomachs in which found	Quantity present	Item	Stomachs in which found	Quantity present
	Number	*Percent*		*Number*	*Percent*
Vegetable matter	2	11.5	Animal matter	3	88.5
Seeds or pods	2	1.5	Insects:		
Unidentified material	1	10.0	Adults	3	86.0
			Eggs or larvae	2	2.5

TABLE 8.—*Percentage of plant and animal food according to season*

Item	Spring	Summer	Fall	Winter	Whole year
Plants	94.25	71.0	85.8	95.0	86.51
Insects	5.75	29.0	14.2	5.0	13.49
Total	100.00	100.0	100.0	100.0	100.00

The data at hand indicate that Attwater's prairie chickens are preponderantly granivorous, for seeds and seed pods made up slightly more than 50 percent of all the material in the stomachs of 18 adults. Much succulent vegetation is eaten, however, including leaves, buds, flowers, and root stocks. The birds also consume insect eggs, larvae, and adults, as shown in tables 6 and 7.

Parts of some 50 kinds of plants and more than 65 species of insects were identified in the food from stomachs or scats, or by observations in the field. The names of these plants and insects together with the seasons when they are known to be eaten, are listed in tables 9 and 10, pp. 27 and 28.

TABLE 9.—*Plant foods (56) of Attwater's prairie chicken*

Plant	Parts eaten	Seasons when eaten [1]	Source of data [2]
Marsileaceae: Pepperwort (*Marsilea*)	Leaves	Wi	St.
Poaceae:			
Paspalum (*Paspalum ciliatifolium* type)	Leaves, seeds	Sp, su, au, wi	St, sc.
Bull grass (*Paspalum boscianum* ?)	Seeds	Au	St.
Paspalum (*Paspalum plicatulum*)	do	Sp, su, au	St.
Panic grass (*Panicum scribnerianum*)	do	Sp	St.
Panic grass (*Panicum spp.*)	do	Sp	St.
Crabgrass (*Digitaria*)	do	Au	St.
Sandbur (*Cenchrus*)	do	Wi	St.
Hegari (*Sorghum vulgare*)	do	Su, au	Si.
Rice (*Oryza sativa*)	do	Au, wi	Si, st.
Corn (*Zea mays*)	do	Sp	St.
Cyperaceae:			
Beakrush (*Rynchospora*)	do	Su, au, wi	St.
Sedge (*Carex*)	Seeds, leaves	Au	St.
Commelinaceae: Dayflower (*Commelina crispa*).	Leaves, seeds	Au	St.
Alliaceae: Wild onion (*Nothoscordum bivalve*)	Leaves, flowers	Wi	St.
Liliaceae: (Undetermined)	Seeds	Su, wi	St.
Leucojaceae: Stargrass (*Hypoxis*)	Leaves, seeds	Sp	St, si.
Convallariaceae: Solomons seal (*Polygonatum commutatum*).	Seeds	Su	St.
Ixiaceae: Blue-eyed-grass (*Sisyrinchium varians*).	Seeds, pods	Sp, su	St.
Polygonaceae: Dock (*Rumex* near *crispus* type)	Seeds	Wi	St.
Ranunculaceae: Buttercup (*Ranunculus near hispidus*).	Leaves, seeds, pods	Wi, sp	St.
Rosaceae: Dewberry (*Rubus*)	Seeds, fruits	Sp	St.
Malaceae: Chokeberry (*Pyrus*)	Flowers, fruits	Sp	St, si.
Mimosaceae:			
Sensitive briar (*Neptunia lutea*)	Leaves, flowers, seeds	Au, wi, sp	St, si.
Mimosa (*Mimosa*)	Leaves, seeds	Su, au, wi	St, sc.
Acacia (*Acacia*)	Seeds	Wi	St.
Cassiaceae: Partridge-pea (*Chamaecrista fasciculata*).	Seeds, flowers	Su, au	St, si.
Fabaceae:			
Wild pea (undet.)	Flowers	Sp	St.
Wild pea (*Lathyrus pusillus*)	Leaves	Wi	St.
Peanuts (*Arachis hypogaea*)	Fruits	Au	Si.
Oxalidaceae: Woodsorrel (*Oxalis*)	Leaves, seeds	Wi, sp, su	St, sc, si.
Euphorbiaceae:			
Doveweed (*Croton capitatus*)	Seeds	Au, wi	St, sc, si.
Doveweed (*C. glandulosus*)	do	Au, wi	St.
Doveweed (*C. monanthogynus*)	Seeds, leaves	Au	St, si.
Spurge (*Euphorbia*)	Seeds	Au, wi, sp	St, sc.
Spurge (*Crotonopsis linearis*)	do	Au	St.
Spurge (*Chamaesyce*)	do	Au	St.
Vitaceae: Grape (*Vitis*)	Seeds, fruits	Su	St.
Malvaceae: Mallow (*Malva*)	Seeds, pods	Sp	St.
Epilobiaceae: Gaura (*Gaura*)	Pods	Sp	St.
Ammiaceae (*Cynosciadium*)	Leaves	Wi	St.
Convolvulaceae:			
Bindweed (*Convolvulus*)	Seeds	Sp	St.
Evolvulus	Seeds, pods	Sp	St.
Polemoniaceae: Phlox (*Phlox drummondi*)	Seeds, pods, flowers	Sp, su	St, sc.
Boraginaceae: Gromwell (*Lithospermum*)	Seeds	Su	St.
Verbenaceae:			
Fog fruit (*Phyla nodiflora*)	Leaves, flowers, frult	Sp, wi, au	St, si.
Verbena (*Verbena*)	Leaves	Wi	St.
Acanthaceae: Ruellia (*Ruellia ciliosa* var. *humilis*).	Leaves, stems, seeds, buds, pods, flowers.	Au, wi	St, sc, si.
Rubiaceae:			
Buttonweed (*Diodia teres*)	Seeds	Su, au, wi	St, sc.
Buttonweed (*Diodia virginiana*)	do	Su	St.
Bedstraw (*Galium*)	Leaves, seeds	Sp, su, au	St, sc.
Ambrosiaceae:			
Marsh-elder (*Iva ciliata*)	do	Wi	St, si.
Perennial ragweed (*Ambrosia psilostachya*)	Seeds	Au, wi	St, sc.
Carduaceae:			
Thistle (*Carduus*)	do	Sp	St.
Tickweed (*Coreopsis*)	Flowers	Sp	Si.
Cichoriaceae: (*Serinea oppositifolia*)	Seeds, pods	Sp, su	St, sc.

[1] Abbreviations of seasons: Sp, spring; Su, summer; Au, autumn; and Wi, winter.
[2] Abbreviations of sources: St, stomach examination; Sc, scat examination; and Si, sight record.

TABLE 10.—*Some insect foods (68) of Attwater's prairie chicken*

Name	Form eaten	Seasons when eaten [1]	Source of data [2]
Araneida:			
Spider (Lycosidae)	Adult	Au	St.
Spider (undetermined)	do	Su, au	St.
Orthoptera:			
Grasshopper (Cyrtacanthacrinae)	do	Sp, su	St, sc.
Pigmy locust (Acrydinae)	Adult, larva	Sp, su, au	St, sc.
Grasshopper (*Syrbula*)	do	Au	St.
Grasshopper (Oedipodinae)	do	Au	St.
Western grasshopper (*Melanoplus cinereus*).	do	Su, au	St, sc.
Green grasshopper (*Chortophaga viridifasciata*).	do	Su	St.
Grasshopper (Oedipodinae)	do	Su	St, sc.
Grasshopper (*Schistocerca americona*)	do	Su	St.
Grasshopper (*Saltatoria*)	do	Su	St.
Meadow grasshopper (*Conocephalus*)	do	Sp, su, au	St.
Long-horned grasshopper (Tettigoniidae)	Adult, larva, egg	Su, au	St, sc.
Hemiptera:			
Shield bug (Pentatomidae)	Adult	Sp	St.
Bug (undetermined Hemiptera)	Adult, eggs	Sp	St.
Stinkbug (*Euschistus*)	Adult	Su	St, sc.
Homoptera:			
Leafhopper (Cicadellidae)	do	Au, wi, sp	St.
Lantern fly (Fulgoridae)	do	Sp, su, wi	St.
Soft scale (*Leucanium*)	do	Au	St, sc.
Coleoptera:			
Weevil (*Graphorhinus vadosus*)	do	Wi, sp	St.
Weevil (*Lixus*)	do	Su, wi	St.
Weevil (*Thecesternus humeralis*)	do	Wi	St.
Billbug (*Sphenophorus minimus*)	do	Sp	St.
Billbug (*Sphenophorus bartramiae*)	do	Sp, au	St, sc.
Billbug (*Sphenophorus germari*)	do	Sp, au	St, sc.
Billbug (*Sphenophorus*)	do	Su, wi	St, sc.
Weevil (*Baris*)	do	Sp, su	St.
Weevil (*Hyperodes*)	do	Sp	St.
Rice-water weevil (*Lissorhoptrus simplex*)	do	Sp	St.
Weevil (*Pachyphanes*)	do	Sp	St.
Weevil (*Anthonomus fulvus*)	do	Sp	St.
Snout beetle (Curculionidae)	do	Sp, su	St, sc.
Weevil (*Apion*)	do	Wi	St.
Scarred snout beetle (*Tanymecus lacaena*)	do	Wi	St.
Scarred snout beetle (*Eudiagogus pulcher*)	do	Au	St, sc.
Scarred snout beetle (*Compsus auricephalus*).	do	Sp	St.
Leaf beetle (*Phaedon viridis*)	do	Wi	St.
Leaf beetle (*Cryptocephalus venustus*)	do	Su, au	St, sc.
Leaf beetle (*Cryptocephalus*)	do	Su	Sc.
Leaf beetle (*Zygogramma disrupta*)	do	Su, au	St, sc.
Leaf beetle (*Oedionychis petaurista*)	do	Au	St.
Leaf beetle (*Metacroma ustum*)	do	Au	St.
Leaf beetle (*Disonycha*)	do	Sp, su, wi	St, sc.
Leaf beetle (Chrysomelidae)	do	Sp, su, au	St, sc.
Leaf beetle (*Calligrapha similis*)	do	Wi	St.
Leaf beetle (*Graphops pubescens*)	do	Wi	St.
12-spotted cucumber beetle (*Diabrotica duodecimpunctata*).	do	Wi	St.
May beetle (*Phyllophaga*)	do	Sp	St.
May beetle (Scarabaeidae)	do	Su, au	St.
Leaf chafer (*Anomala ludoviciana*)	do	Au	St.
Dung beetle (*Aphodius sp.*)	do	Sp	St.
Ground beetle (*Triplectrus*)	do	Au, wi	St.
Ground beetle (*Eumolops*)	do	Wi	St.
Ground beetle (Carabidae)	do	Sp, su, au	St, sc.
Ground beetle (*Chlaenius*)	do	Su	Sc.
Darkling beetle (Tenebrionidae)	do	Au	Sc.
Lepidoptera:			
Moths, butterflies, and skippers (3 species).	Adult, larva	Su, au	Sc.
Salt-marsh caterpillar (*Estigmene acraea*)	do	Su, au	Sc.
Diptera:			
Gall gnat (Cecidomyiidae)	Larva	Sp	St.
Robber fly (*Asilus*)	Adult	Au	St.
Hymenoptera:			
Gall fly (Cynipidae)	Adult, eggs	Sp	St.
Chalcid fly (Chalcidae)	Adult	Su	Sc.
Paper wasp (Polistes)	Adult, pupa cases	Su, wi	St.
Ant (*Odontomachus haemotodes*)	Adult	Wi	St.
Ant (*Pheidole sp*)	do	Su	St.
Fire ant (*Solenopsis sp.*)	do	Su	St.

[1] See footnote 1, table 9.
[2] See footnote 2, table 9.

Native plants are the most important source of food for the prairie chicken. Rated according to frequency of occurrence in stomachs and scats, gross bulk, and periods of availability, ruellia (*Ruellia*) appears to be by far the most important single food. It occurred in 13 of the 18 stomachs and made up almost 27 percent of all the material eaten. Stargrass (*Hypoxis*), bedstraw (*Galium*), doveweed (*Croton*), perennial ragweed (*Ambrosia psilostachya*) also were eaten freely through long seasons. Practically all the important food plants utilized by the prairie chicken grow naturally in pastures that are moderately grazed. Corn was the only cultivated grain found, and the small quantity present was probably waste. It is known, however, that prairie chickens are fond of certain crops, especially peanuts, hegari, and ripened rice. The birds frequently congregate in peanut patches, particularly after the harvest, and scratch for the waste pods. They also use conveniently situated hegari fields extensively in summer, but the good shade in such areas is probably as attractive as the grain. Prairie chickens also range into rice fields after the crop is cut and shocked, and they sometimes feed on the grain in the shock as well as on that so freely wasted on the ground (pl. 7). The rice taken from shocks usually is not objectionable, although L. D. Roberts, Eagle Lake, Tex., reports that he saw approximately 1,500 of the birds feeding in a single field of about 500 acres in the Egypt section, Wharton County, in September 1920. By scratching, the prairie chickens loosen the shocks, thus allowing moisture to seep in, and this causes some complaint. A large increase of prairie chickens might conceivably bring on control problems in certain areas. The difficulties would probably not be serious, however, because the birds could easily be frightened by shotgun fire or by other disturbances, and they quickly desert areas of potential danger.

Among insect foods of Attwater's prairie chicken, 11 grasshoppers (6 identified to genus or species) are especially prominent; 32 beetles (identified to genus or species, including 16 weevils) also are important. The vast majority (50 of 65) of the insects eaten by prairie chickens are kinds neutral (25) or harmful (25) to agriculture. Field observations, and reports of cooperators, show that prairie chickens eat in large quantities the moths of the cotton leaf worm (*Alabama argillacea*), one of the worst insect pests in the coastal area. Under ordinary conditions, the food habits of Attwater's prairie chicken, considering both insect and plant consumption, are such as to make it one of the most valuable birds of farm and range.

HABITAT REQUIREMENTS

KIND OF HABITAT BEST SUITED

The coastal prairie grassland is the real home of Attwater's prairie chicken, particularly in areas characterized by diversity of vegetation (pl. 8). Woodland, brushland, and cultivated land each furnish some food and cover at certain times and under certain conditions, but use of these types is optional with the prairie chicken, not vital. These secondary habitats are frequented mostly when food and cover are at the annual peak, as in September and October, but are little used at times of seasonal scarcity, as in December, January, February, and early in March. Wooded, cultivated, and brushy areas, individually or in combination, contribute little or nothing as courtship grounds and nesting cover. Properly managed grassland (pl. 9), however, satisfies every known requirement of Attwater's prairie chicken, and management, therefore, should be directed toward improvement of these areas.

CHARACTER AND DENSITY OF VEGETATION

Optimum food and cover conditions seemingly are approached when the prairie vegetation is varied in species, interspersion, and density. The plant life of well-populated areas includes a variety of grasses, sedges, rushes, and legumes, and tall weeds or their cover equivalent in the form of scattered clumps of myrtle or live-oak brush. The combination and density of the plants in the most favored places invariably is such as to provide cover in all degrees and well distributed.

Light cover serves (1) exclusively for the courtship performance, (2) for feeding at all seasons, and (3) for a resort when dew is heavy or after rains. Light to medium heavy cover is used (1) for roosting, especially on gentle slopes, (2) by chicks under 5 weeks old, and (3) for feeding by adults throughout the year. Cover of a medium heavy to heavy character (pl. 9) is utilized (1) extensively for nesting, (2) as a loafing cover except during the hot summer months, and (3) as feeding grounds and escape cover in emergencies. Heavy cover (pl. 9) is essential (1) for shade in summer, (2) for protection against unfavorable weather and predators at other seasons, and (3) as a source of food, especially in fall.

TOPOGRAPHY

Richness and variety in the vegetation are promoted by even slight variations in topography and soil (pl. 8). Consequently, the best natural range for Attwater's prairie chicken comprises country in which knolls, ridges, or hog wallows, are frequent. Further, knolls

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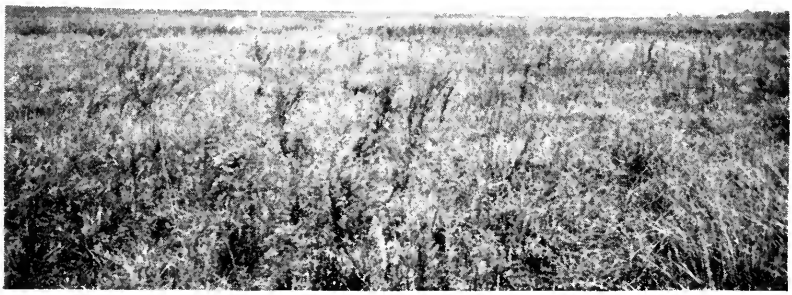
Above, Diversified cover—excellent prairie chicken range; Colorado County, Tex., approximately 7 miles northeast of Eagle Lake, September 4, 1936. *Below*, Diversity of topography and vegetation; Austin County, Tex., approximately 6 miles northeast of Bellville, June 13, 1936. (Photos by V. W. Lehmann.)



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Above, Medium-heavy to heavy cover—excellent food-cover conditions in a moderately grazed pasture; Colorado County, Tex., approximately 8 miles north of Eagle Lake, December 21, 1936. *Below*, Heavy cover, mostly myrtle brush, near stream—excellent summer range; Austin County, Tex., approximately 4 miles east of Bellville, July 14, 1936. (Photos by V. W. Lehmann.)

and ridges are least likely to be inundated in times of flood and they afford the birds better opportunity of eluding their natural enemies and man.

WATER

The balanced prairie chicken habitat should offer a generous supply of surface water throughout the year. Although Attwater's prairie chickens may not be dependent on free water for survival during normal years (see p. 23), it has been established that their favorite summer range is rather well watered. During unusually dry years such as occurred in Refugio County in 1917, surface water may be an absolute necessity. Also, through its effects on vegetation and insect life, water is necessary for the maintenance of optimum cover and food conditions. The water supply of prairie chicken areas apparently is about optimum when permanent sources are available throughout the range at intervals not greater than a mile.

Briefly, then, habitat conditions for Attwater's prairie chickens seemingly approach the ideal in grassland area when (1) the vegetation is diversified and native grasses, sedges, legumes, and small and large weeds, or their equivalent in the form of brush or dwarfed trees, are present in such stands as to provide all densities of cover; (2) knolls, ridges, and hog wallows are frequent and the soils vary from loose sand to tight clay or silt; and (3) permanent sources of surface water are available not more than a mile apart.

SEASONS OF SCARCITY

In evaluating the suitability of an area for Attwater's prairie chickens it is to be kept in mind that its productivity or carrying capacity is not determined by conditions during the best season in a good year. Rather, as Taylor (1934) states, conditions that prevail during the most critical season of the year and in the most extreme year in a series of years determine carrying capacity. In the coastal country of Texas the season of scarity, or the period when food and cover are at a minimum, normally is from December through early March. The most critical years are those of heavy rainfall in May.

LIMITING FACTORS

Factors that have contributed to the decrease of prairie chickens in Texas may be classed roughly as (1) natural, including unfavorable weather, predators, and disease; and (2) artificial, including cultivation, heavy grazing, burning, and overshooting. It might be more accurate to class limiting factors as those brought about by man, directly or indirectly. Although it is not generally appreciated, the decrease of prairie chickens in coastal Texas corresponds

with the spread of civilization. Prior to the coming of white men, the number of birds probably was well maintained, but there was a decrease as the country was developed. Attwater's prairie chicken will become extinct unless man ceases to exploit the soil, water, and other natural resources of its range.

NATURAL FACTORS

Rainfall During the Nesting Season

Prairie chickens in Texas evidently suffer greatly at times from extremes of weather. Heavy precipitation during the nesting and brooding season (March through June) appears to be an especially serious hazard, as indicated by the studies of Waddell and others in Colorado, Austin, and Wharton Counties. From 1925 through 1937 Waddell estimated the size of the annual crop of young prairie chickens on the basis of the number of birds, both young and old (1) observed on almost daily trips through their range, (2) seen by reliable resident observers, (3) bagged by hunters, and (4) counted annually on the courtship grounds in spring. From his studies he concluded that crops of young prairie chickens were (1) good in spring months when rainfall was below average, (2) fair to good when rainfall was average or only slightly above average, and (3) poor, very few young being reared, when the nesting season was abnormally wet.

Waddell's impressions as to the correlation between the amount of precipitation in spring and the size of the annual crop of chickens were tested rather thoroughly in 1936 and again in 1937. In August 1936, after a reconnaissance made with car and dog (see p. 52) over approximately 25,000 acres of territory in Colorado and Austin Counties, it was estimated that the annual increase was less than 10 percent. Rainfall there was below average in March, April, and June 1936, but it exceeded 10 inches, or approximately twice the average, in May, as shown by the records of the Weather Bureau at Columbus, situated centrally in that area. In 1937, when records of this station showed that rainfall was 2 inches or more below average in April, May, and June, rope counts made of 3,450 acres both before and after the breeding season revealed a 95-percent increase, supporting Waddell's estimate that the increase was good in a dry season.

In table 11, p. 33, Waddell's estimates of the favorableness of the years from 1925 through 1937 for prairie chicken reproduction are presented together with precipitation records of the Columbus Weather Bureau Station for March, April, May, and June in those years.

TABLE 11.—*Reproductive yield of Attwater's prairie chicken in relation to spring rainfall in inches*[1] *in the Colorado County area*[2]

Year	Estimated yield	March		April		May		June	
		Precipitation	Departure from normal	Precipitation	Departure from normal	Precipitation	Departure from normal	Precipitation	Departure from normal
1925	Good	0.33	−2.50	0.99	−2.74	2.87	−1.51	1.06	−2.12
1926	Fair	11.54	−8.71	7.86	4.13	4.10	−.28	3.37	.19
1927	Good	3.49	.66	4.00	.27	1.24	−3.14	6.43	3.25
1928	do	1.42	−1.41	3.76	.03	2.00	−2.38	8.52	5.34
1929	Poor	4.54	1.71	2.58	−1.15	16.12	11.74	.99	−2.19
1930	Fair	2.34	−.49	.48	−3.25	3.11	1.27	.89	−2.29
1931	Good	3.84	1.01	1.43	−2.30	1.98	−2.40	.90	−2.28
1932	do	3.63	.80	2.19	−1.54	.66	−3.72	3.68	.50
1933	Fair	2.36	−.47	1.43	−2.30	3.67	−.71	1.40	−1.78
1934	Good	3.91	1.08	4.28	.55	1.90	−2.48	.22	−2.96
1935	Poor	3.72	.89	4.58	.85	9.21	4.83	2.48	−.70
1936	do	1.23	−1.60	3.48	−.25	10.65	6.27	.79	−2.39
1937	Good	6.01	3.15	.52	−3.21	.47	−3.91	1.37	−1.81

[1] Records of U. S. Weather Bureau Station, Columbus, Colorado County.
[2] Colorado County, north central Wharton County, southwestern Austin County.

Waddell found good crops of young birds in the Eagle Lake area in 1925, 1927, 1928, 1931, 1932, 1934, and 1937, years when rainfall in May was 1.5 inches or more below average. Fair crops of young prairie chickens were thought to have been reared in 1926, 1930, and 1933, when rainfall in May was approximately average (0.28 below in 1926) to only slightly above (1.27 above in 1930). Poor crops were matured in 1929, 1935, and 1936, when May precipitation was appreciably above (approximately twice) the average for that month. Unusually heavy or light precipitation in March, April, or June evidently had little influence on the broods of young, for good crops were recorded in 1927, when rainfall was decidedly above average in June, and a poor crop is known to have occurred in 1936, when rainfall was below average in all months of the nesting season except May. The records at hand suggest, therefore, that the rainfall in May is a fairly satisfactory index of the suitability of the year for the reproduction of Attwater's prairie chicken under natural conditions. Good crops usually result when the rainfall in May is 1.5 inches or so below average; fair crops are probable when it is approximately average or only slightly above; and poor crops appear almost a certainty when the rainfall for that month is decidedly above average.

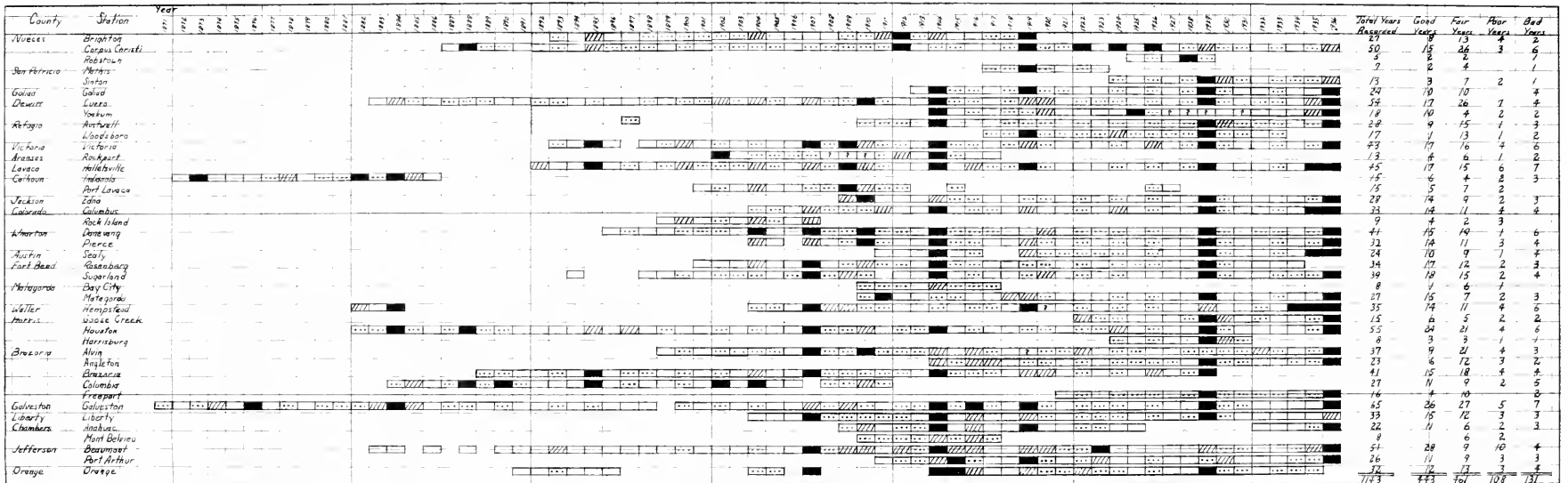
Rainfall in May is of greater significance than that in any other month, as the 1937 and 1938 nesting studies showed that most of the chicks hatch in May. Those hatched in April do not yet have a serviceable covering of feathers by May and, consequently, are almost as vulnerable to the rains as are birds hatched in that month. Nests flooded in March and April may be rebuilt, for the booming season is still in full swing, but nests flooded after May 1 are seldom re-

established because the mating season is then nearly over. May, then, is the climax, or peak month, of the breeding season, and rainfall then is of greater significance than at any other period.

The nature of rains in May may be a factor modifying the use of precipitation records for that month as indices of the number of chicks produced, as short, heavy downpours may be more serious than slow steady rains. This, however, is not known to be true. Frequently recurring light rains may be as serious as heavy ones because persistent damp conditions result in heavy juvenile mortality from chilling. Stoddard (1931: 39, 202) shows that wet spring months are favorable for hatching but not for rearing bobwhites. Percolation and drainage are slow in the heavy coastal prairie soil, and surface moisture accumulates from persistent light rains as surely as from brief heavy ones; the amount rather than the severity of the rain seems to rule.

While it is realized that annual precipitation, drainage, cover, and other environmental conditions in Colorado County are not identical with those obtaining throughout the coastal prairie chicken country, a marked similarity does, nevertheless, exist. Rainfall is moderately heavy, 39 inches annually, at Columbus, Colorado County, and it is also generous throughout the bird's range. Average annual precipitation varies from 49.35 inches at Beaumont, Jefferson County, to 33.69 inches at Austwell, Refugio County, at about the eastern and western limits, respectively, of the subspecies. Rainfall during May at Columbus (average, 4.38 inches) is heavier than in any other month. May is the wettest month in Jackson, Goliad, Lavaca, and Harris Counties as well. Heavy or persistent rains transform tremendous areas in Colorado County into veritable lakes ranging from a few inches to several feet in depth; rains produce similar results throughout the coastal region. It appears justifiable, therefore, to assume that rainfall in May is the key to prairie chicken reproduction throughout coastal Texas (fig. 3).

Of every 5 years in a given locality, apparently 2 are favorable for nesting, 2 fair to poor, and 1 bad, as determined by rainfall in May. Conditions are never uniform in the chicken country as a whole because there is variation between counties and even between parts of the same county. Records of the Weather Bureau for May 1935 show, for example, that rainfall at Galveston, Galveston County, was favorable (2.71 inches below average); at Houston, Harris County, fair (only 0.20 inch below); and that at Columbus, Colorado County, poor, being approximately twice average (4.83 inches above). During 1926 in Brazoria County conditions were good at Alvin, fair at Angleton and Freeport, and poor at Brazoria. In 1932 conditions were good at Angleton, fair at Freeport, and poor at Alvin. Though man cannot regulate rainfall to promote prairie chicken welfare



LEGEND

Rainfall 1.50 inches or more below average ..... (Good)

Rainfall 1.49 below average to 1.99 above average ..... (Fair)

Rainfall 2 inches or more above average, but less than twice average ..... (Poor)

Rainfall twice average or more ..... (Bad)

Compilations based on records of average annual May rainfall at each individual station as supplied by the Climatological Division, U. S. Weather Bureau.

Records missing or unsatisfactory ..... ?

FIGURE 3

Rainfall conditions in May in the range of Attwater's prairie chicken in Texas, in the 66 years 1871 to 1936, indicating the probable frequency of good and other reproductive years for the birds

(Facing p. 341)

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at nesting and brooding time, in many cases he can regulate pasture burning and grazing to provide adequate nesting cover in the best-drained parts of the land. Also, he can consult weather records before setting open seasons and bag limits, which should not be uniformly applied but adjusted to local conditions to preserve the birds.

Floods

Flood conditions are often produced by heavy rains in the overgrazed and overfarmed sections in the upper part of the State. Heavily burdened streams carrying flood crests from the upper country sometimes spill over their low banks and spread their silt-laden waters over thousands of acres of prairie chicken range. This occurred in the Rock Island-Garwood section (Colorado County) in June 1936, when the prairie chicken population of that section was extirpated. Floods evidently are a constant menace to birds near major streams.

Drought

Extreme drought seriously affects prairie chickens, especially during the hot summer months. G. P. Ferguson, State game warden, and fence riders on the M. O'Conner ranch, Refugio County, found many dead birds in the especially dry summer of 1917 and saw others too weak to fly. Drought reduces food supplies for both present and future use. Large cracks that form in black soil in dry weather possibly trap some young birds, according to the observations of Gross (Bent 1932: 253). Birds weakened by excessive heat, and possibly also by a shortage of food, are especially vulnerable to disease, predators, adverse weather, and other hazards.

Hurricanes

Tropical hurricanes sometimes produce flood conditions in prairie chicken country 20 miles or more from the Gulf. In 1917 a storm backed salt water over the greater part of the Pipkin ranch in the Big Hill area in Jefferson County and drowned livestock by the hundreds. That it evidently destroyed many prairie chickens as well was indicated by their exceeding scarcity for 15 years afterwards.

Hail

Heavy hail storms destroy many Attwater's prairie chickens, especially in areas where heavy protective cover is lacking. After a storm in May 1934, J. O. Linney, Guy Ferguson, and fence riders on the Salt Creek ranch, Refugio County, saw about 150 dead or crippled chickens.

Local Storms

Local storms, especially those that commonly occur in fall, kill turkeys and other domestic fowls and prairie chickens and other game birds, as reported by Marcus Shindler, Ed Koy, and other resident land-owners in the northeastern part of Colorado County.

Disease

Gross (1930a: 39), and Stoddard, Curtis, Lews, Terrel, and others (Leopold 1931: 182–183), recorded incidents strongly suggesting that disease and parasites probably were important controlling factors on the abundance of the greater prairie chicken of the Northern States. Records at hand do not show that, in the past, disease has been a factor of importance limiting the numbers of Attwater's prairie chicken in Texas. The observations, mentioned above, made by G. P. Ferguson on the M. O'Conner ranch furnished the only known evidence even faintly suggesting an outbreak of disease. In that instance, however, it is probable that mortality, if really due to disease or parasites, was an indirect result of prolonged drought. No evidence of disease or heavy parasitism was found in autopsies made on 13 prairie chickens, and no evidence of any unhealthful condition was observed among hundreds of birds in the field. Prairie chickens are doubtless susceptible, however, to ailments of domestic poultry. An outbreak of blackhead disease, probably contracted from domestic turkeys, is considered by Gross (Bent 1932: 268) as a major factor in the extermination of the heath-hen. Turkeys and other poultry, therefore, probably are unhealthful influences on a prairie chicken range.

Spread of Woody Vegetation

The encroachment of mesquite, live oak, various acacias, and other kinds of brush onto open prairie land has been an extremely important factor in reducing the range and doubtless the numbers of Attwater's prairie chickens in Refugio and other counties to the south and west. Within the memory of living men extensive prairies have been transformed into brush jungles. Specific factors that have influenced the rapid vegetational changes in the southwestern brush country are imperfectly understood. Factors probably of importance in enabling woody plants to replace the native grassland flora have been overgrazing, especially during drought years; the mechanical planting of tree seeds by cattle and horses, because livestock eat large quantities of mesquite and other beans, the seeds of which pass through the digestive tract and are distributed or planted by the droppings; the elimination of burning, previously mentioned by Bray (1901: 288–290) and Tharp (1926: 71); and the lowering of the water table. Be that as it may, hundreds of thousands of acres of what was once

tall-grass prairie are now brushland, and prairie chickens are gone from these areas.

PREDATION

NESTS

Natural enemies consume some of the eggs, young, and adults of Attwater's prairie chicken. The extent of predation on nests and the identity of other factors responsible for nest loss in the Eagle Lake area are given in tables 12 and 13.

TABLE 12.—*Fate of nests, Eagle Lake, Colorado, 1937*

Nest No.	Pasture	Date found	Date destroyed or hatched	Probable cause of destruction
1	Everett	Apr. 7	Apr. 22	Man—nest deserted after entrance was widened by a farmer.
2 [1]	do	Apr. 8	Apr. 4 [3]	Red wolf—female bird killed on nest.
3 [1]	Wintermann	Apr. 12	Apr. 7	Opossum or skunk.
4	do	do	Apr. 13	Skunk.
5	Sklar-Marcella	Apr. 13	May 17	Hatched successfully.
6 [1]	Wintermann	Apr. 21	Apr. 15	Skunk.
7 [1]	do	do	Apr. 21	Do.
8 [1]	do	do	Apr. 18	Deserted, cause unknown.
9	Duncan	Apr. 27	May 4	Hatched successfully.
10	Everett	Apr. 29	May 15	Do.
11	Willis	May 1	May 2	Man—nest deserted after farmer plowed territory nearby and revisited nest frequently.
12 [2]	Sklar-Marcella	May 11	Apr. 6	Opossum.
13	do	June 1	June 2 or June 3	Hatched successfully.

[1] Nest destroyed when found.
[2] Estimated in case of nests destroyed when found.
[3] Indicated by circumstantial evidence at the nest.

TABLE 13.—*Fate of nests, Eagle Lake, Colorado County, Tex. (1938)*

Nest No.	Pasture	Date found	Date destroyed or hatched	Probable cause of destruction [1]
14	Sen	Apr. 13	May 3	Heavy rain.
15	Thomas	Apr. 18	Apr. 23	House cat.
16	do	do	Apr. 29	Hatched successfully.
17	do	Apr. 29	May 3	Heavy rain.
18	Everett	Apr. 20	May 11	Opossum.
19	do	June 3	June 21	Hatched successfully.

[1] Indicated by circumstantial evidence at nest.

Of 19 prairie chicken nests studied in 1937 and 1938, 6 (31.5 percent) were successful, and 13 (68.4 percent) were lost. In 1937 8 of 13 nests studied were destroyed before the clutches were complete, showing that the laying period may be the one of heaviest nest loss. This might be expected, as the eggs are covered only about an hour or so each day during that time. This loss is somewhat compensated, however, by renesting (see p. 15). Opossums and skunks destroyed 6 nests—more than any other agency. Of the 6,

however, 4 were in a pasture where unregulated fire had restricted good nesting cover to 2 small unburned areas about 3 and 10 acres in size. Fur animals as well as nesting chickens were unnaturally concentrated in these unburned plots; dens containing young were 100 yards or less from each of the nests destroyed. Excessive pasture burning appeared to be the primary cause of the heavy nest loss; predation by fur animals being merely an effect, the agency of destruction that was inevitable after the burning.

Field evidence showed that a red wolf killed a female prairie chicken and destroyed her nest; a feral house cat devoured the eggs from another nest (pl. 10). It is surprising that dogs did not figure as predators on the nests and that house cats did not take an even greater number. Wandering dogs, usually in groups of three to five, were not uncommon on Colorado County prairies; L. A. Burchfield, a trapper who worked for the former Bureau of Biological Survey in Colorado County in 1937, and Waddell found that dogs did much of the damage for which the few red wolves, now largely extirpated in the area, were blamed. Heavy predation on a flock of domestic turkeys, supposedly by wolves, stopped immediately when a hound, which frequently hunted on its own initiative, was killed after having been caught in a trap set for the alleged wolves. Feral house cats on Colorado County prairies probably outnumber skunks, opossums, minks, or any other fur animals. Cotton rats and other rodents were common near several nests but took no eggs. Neither did racers, chicken snakes, king snakes, or other reptiles frequently noted after May 1 in both 1937 and 1938.

Three nests were abandoned, desertion of two of these, possibly all three, being caused by man. Nesting prairie chickens seem especially sensitive to interference, and they should not be disturbed by persons making repeated visits. Of six nests under observation in 1938, floods destroyed two, and accumulated water from heavy rains came within 1½ feet of a third (nest 16). The following excerpt from the writer's field notes of May 3, 1938, emphasizes the importance of floods:

> The prairie has been transformed into a miniature ocean dotted by tiny islands that previously had been the tops of knolls and ridges. On these islands sit wet and bedraggled prairie chickens and other birds that seem as confused and astounded as I by the sudden change in their environment. About a 5-inch depth of water covers the sites of nests 14 and 17, and former nest 15. Nest 16 has escaped by a hair's breadth, but the lining is very soggy. Problems due to hawks, skunks, and other predators seem so petty when excessive rain destroys virtually everything at a single stroke.

YOUNG

Although predators doubtless exert great pressure on the population of young prairie chickens in some areas, especially because the

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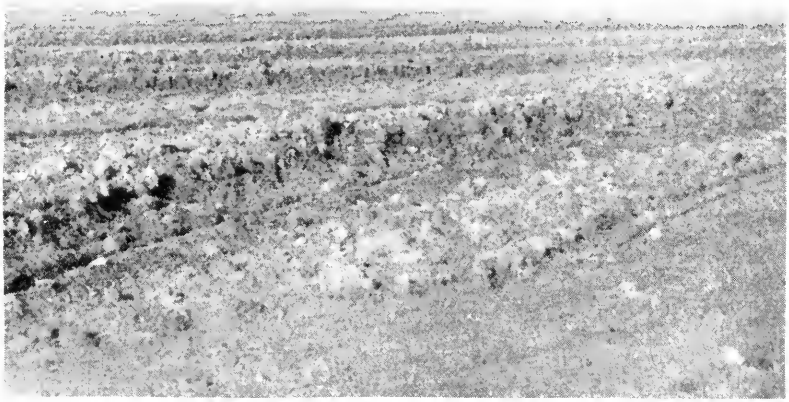
Above, Shells of eggs at prairie chicken nest destroyed by house cat; Colorado County, Tex., approximately 5 miles north of Eagle Lake, April 23, 1938. (Photo by Texas Game, Fish, and Oyster Commission; E. P. Haddon.) *Below*, Freshly killed prairie chicken recovered from a ferruginous rough-legged hawk; Colorado County, Tex., approximately 6 miles north of Eagle Lake, April 7, 1937. (Photo by V. W. Lehmann.)



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Above, Native bluestem prairie—well populated by prairie chickens; Colorado County, Tex., 6 miles northeast of Eagle Lake, December 21, 1936. *Below*, Prairie after plowing for rice—deserted by prairie chickens; Colorado County, Tex., approximately 5 miles north of Eagle Lake, March 7, 1938. (Photos by V. W. Lehmann.)

loose formation of the brood (see p. 19) and straying apparently induce mortality from this cause, definite information was difficult to obtain.

A female Krider's hawk caught a third-grown prairie chicken on May 24, 1937. From then on until June 9, when the male was collected, this hawk, assisted by her mate, hunted a section containing six broods. Most migrant raptors (roughlegs, redtails, and marsh and duck hawks) had left Colorado County prior to May 1, 1937, and April 15, 1938, before many young had hatched, and the resident species (red-shouldered, Cooper's, Sennett's white-tailed, and Krider's hawks) confined their activities largely to wooded areas. Because cover is dense in summer, and hawks are then uncommon, probably few young prairie chickens are taken in normal years.

House cats with freshly killed young prairie chickens were noted twice in 1937 and were seen stalking broods on three other occasions. Because of their numbers and predilections, house cats are thought to be exceedingly destructive.

ADULTS

Prairie chickens on the courtship grounds seemed more intent on mating than on self-preservation; consequently, losses from predation were probably heaviest at mating time. In Colorado County, during most of the 1937 and 1938 courtship seasons the abundant hawks harassed the prairie chickens persistently, sometimes with success. On April 8, 1937, 3 duck hawks, 7 marsh hawks, 2 roughlegs, 3 Krider's hawks, and 2 bald eagles kept the chicken population (about 45 birds) of the Everett pasture (640 acres) constantly moving. A freshly killed male prairie chicken (pl. 10) was taken from a ferruginous roughleg in that area on April 17. Marsh hawks, which Stoddard and others have found to be sometimes more beneficial than harmful to quail and other game, were especially annoying to courting birds, no other factor interfering with their activities to so great an extent. When a marsh hawk darted at one occupant of the booming ground, others generally cowered. The hawks pursued their intended victims for short distances, but soon returned and flushed others, or after dispersing the grouse, frequently alighted on the courtship grounds to await their return and resume the flushing tactics. On April 8, 1937, 4 marsh hawks concentrated on a single courtship ground and harassed the 6 male occupants from 5 to 7:30 p. m. Although no birds were killed, one lost many feathers when two hawks dived at it simultaneously.

By flushing prairie chickens, marsh hawks render them vulnerable to more efficient winged enemies, as duck hawks, goshawks, and the like. Waddell has seen duck hawks catch adult chickens on at least two occasions.

Mammals also take some of the birds on courtship areas. The stomach of a male house cat collected April 12, 1937, near a booming ground in the Everett pasture, Colorado County, contained the head, feet, and part of the breast of a freshly killed male prairie chicken. The remainder was found about 50 feet away.

A red wolf was suspected of killing a female prairie chicken on the nest, and either red wolves or dogs took three others in Colorado County in April 1937.

Only six instances of adult mortality were discovered that year, although intensive search for remains was made on foot and in cars over approximately 2,500 acres. In 1938, when none of the pastures were burned, no dead birds were found.

Review of Natural Factors

Natural factors limit the abundance of prairie chickens by destroying eggs, young, and adults and by reducing favorable territory. During the breeding season floods, storms, hail, drought, and excessive or persistent rains are known to be locally serious, the rains in May being most damaging. Drought has been associated with the only reported outbreak of disease that occurred in the Refugio area in 1917. The encroachment of brush on prairie land has transformed thousands of acres of what was once good prairie chicken range (pl. 11) into an unfavorable habitat. Although some predators harass the birds throughout the year, their effects are probably most serious at mating and nesting time. Natural mortality from climate and predators is severe in inferior or isolated cover.

The serious effects of natural factors are in every case either brought about or intensified by man's generally unwise treatment of natural factors. All except feral house cats and predatory dogs were operating against the prairie chickens, apparently without disastrous results, before the environment was radically modified by man. Since the unfavorable influences of natural agencies are due chiefly to man, it is encouraging to know that it is within his power and often decidedly advantageous to him so to modify his actions as to improve existing conditions and promote the welfare of the prairie chickens as well as his own.

ARTIFICIAL FACTORS

Agriculture

Much of the best prairie chicken range has been recently appropriated for agricultural uses. More than 2,000,000 acres (table 14) were cultivated in 1936. In addition, thousands of acres of sod are plowed annually, with the extension of agriculture, especially rice farming. The acreage yearly planted to rice in coastal Texas in-

creased from approximately 174,500 acres in 1922 to more than 196,500 acres in 1937.[5] This latter acreage represents only a small part of the area actually depleted: rice farming has ruined more than 84,000 acres for the birds in Colorado County (pl. 11) alone, and probably in excess of a million acres in the State as a whole. Rice is hard on the land and most areas devoted to it can be profitably cultivated during only about 1 year in 4, after which they must be left fallow for about 3 years to "sweeten." Weedy rice fields ostensibly provide satisfactory grouse range; actually, however, they lack suitable courtship grounds and safe nesting cover, and, furthermore, the levees collect water that floods nests. Prairie chickens in fallow rice land apparently are doomed even though they are hunted lightly or not at all. According to Waddell, there were 10,000 of the birds on 30,000 acres of the Egypt section, Wharton County, in 1924. Rice farming began there in 1925, and by 1937 all the 30,000 acres were either in cultivation or fallow. Hunting pressure was reduced annually after 1925, and few, if any, birds were killed after 1935. In 1938, however, less than 150 prairie chickens remained. Prairie chicken decrease was also positively correlated with the expansion of rice farming in eastern Chambers and central Matagorda Counties. As additional acres of prairie are plowed, further decreases are certain to follow.

TABLE 14.—*Harvested and other crop land (1936) in counties partially or entirely within the probable former range of Attwater's prairie chicken in Texas* [1]

County	Harvested crop land	Other crop land	Total crop land	County	Harvested crop land	Other crop land	Total crop land
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Aransas	2,484	1,772	4,256	Kenedy	204		204
Austin	105,396	11,313	116,709	Kleberg	28,639	7,211	35,850
Bee	92,247	20,685	112,932	Lavaca	158,604	10,652	169,256
Brazoria	98,045	17,787	115,832	Liberty	47,704	12,836	60,540
Calhoun	34,425	12,580	47,005	Matagorda	59,714	21,952	81,666
Cameron	130,684	32,483	163,167	Nueces	228,609	62,090	290,699
Chambers	16,772	5,727	22,499	Orange	8,245	1,334	9,579
Colorado	93,562	11,038	104,600	Refugio	40,147	16,183	56,330
DeWitt	153,307	30,843	184,150	San Patricio	165,691	35,769	201,460
Fort Bend	176,495	41,793	218,288	Victoria	100,300	17,828	118,128
Galveston	19,848	3,396	23,244	Waller	47,986	10,040	58,026
Goliad	64,374	12,711	77,085	Wharton	187,555	22,909	210,464
Harris	100,263	25,031	125,294	Willacy	60,981	10,001	70,982
Jackson	82,609	15,114	97,723				
Jefferson	44,205	12,386	56,591	Total	2,349,095	483,464	2,832,559

[1] Data from Texas Almanac and State Industrial Guide, pp. 231-236, The Dallas News, 1936.

PASTURE BURNING

Unregulated prairie fires intentionally set or of accidental origin have been, and still are, common in coastal Texas in every month of

[5] Figures supplied by David Wintermann, Relow Land Company, Eagle Lake, Tex., from data compiled by the Rice Milling Association.

the year. In Colorado and Austin Counties, for example, approximately 80 percent of the best prairie chicken country was burned over in 1936. A fire of accidental inception ran over about 3,000 acres of the 6,700 acre J. C. Anderson Estate ranch, Harris County, in May 1937. The cover on about 3,000 acres of the best prairie chicken country in Matagorda County was intentionally burned in July 1937. Pasture burning is an annual event on the Pipkin ranch, Jefferson County, fires being started during first new moon after February 15. Areas that the first fires do not cover cleanly are subsequently treated, and burning generally continues well through the nesting season. Most ranchmen, however, complete pasture burning by March.

The pastures are burned to remove old grass and encourage tender new growth more palatable to livestock. Fires usually are set when the grass is dry and the wind brisk, in order to finish the job quickly. The resulting fast, hot fires entirely denude areas except in low spots and deplete pastures of food, escape cover, and nesting sites. Prairie chickens and their natural enemies are crowded into unburned areas (pl. 12) and predation is undoubtedly intensified. During the breeding season fires destroy nests and probably many young birds as well; no fewer than nine nests with charred eggs were found by Waddell in a 640-acre pasture burned in May 1936. Plant life recovers slowly in the absence of abundant rain; consequently, fires accentuate the results of drought. Altogether, fire is one of the most important factors limiting prairie chicken numbers in pastures. When burning is carried on as outlined under Management (pp. 53 to 54), however, the evils are greatly reduced or entirely eliminated, and benefits accrue to forage and soil as well.

Overgrazing

With the possible exception of Orange and Jefferson Counties, overgrazing is severe in most of coastal Texas from late in fall through early spring. In addition to reducing cover and food for prairie chickens (pl. 12), overgrazing probably also increases the vulnerability of the birds both to natural enemies and to man. In Colorado County from 1936 through 1938, for example, it was noted that marsh hawks and other raptors harried chickens more persistently in lightly vegetated pastures than in areas where heavy grassy cover was present. Waddell observed that hunters regularly kill a higher percentage of known populations in areas where cover is light than where it is heavy. In Colorado County it has been found that the winter prairie chicken population of a pasture can be forecast with considerable accuracy by observing the extent to which the area is grazed. Large winter populations are rare in pastures where cover is short.

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Above, Excellent unburned cover at right of road; inferior burned cover at left; Colorado County, Tex., approximately 7 miles north of Eagle Lake, December 22, 1936. *Below*, Scanty cover where there has been overgrazing; the shrub is Cherokee rose (*Rosa laevigata*); Colorado County, Tex., 6 miles north of Eagle Lake, March 7, 1938. (Photos by V. W. Lehmann.)

Aside from resulting unfavorably to prairie chickens, overgrazing in the gulf coastal country has been and is resulting in (1) the spread of undesirable brush and weeds, (2) the increase of needlegrass and other largely unpalatable grasses, and (3) serious erosion. An abundance of prairie chickens cannot be maintained on overgrazed tracts; it is equally impossible to maintain forage and soil on such areas.

Oil Development

Oil development, which began with the discovery of the Spindle Top field in Jefferson County in 1901, has extended to every county in the coastal section. All the Attwater's prairie chicken area is classed as potential oil land, and almost every acre has been surveyed not once, but several times by oil crews. Veritable forests of oil derricks now stand in areas that once provided some of the finest prairie chicken range. In these areas, as in Fort Bend County, prairie chickens are almost, if not completely gone.

Drainage

Drainage canals, as in Brazoria and certain other coastal counties, have in some instances improved the territory within a mile or so of their margins by providing a permanent water supply where it was otherwise lacking during the summer months. On the other hand, drainage canals have doubtless decreased the general wildlife productivity of the counties in which they are situated by speeding up the run-off and thus lowering the water table. Until recently many prairie ponds retained water throughout the year, produced crappie, bream, and other edible fish, held safe nesting cover for black mallards and other water birds, grew an abundant supply of food for wintering waterfowl, and served as concentration points for prairie chickens during the heat of summer. Now they go dry during the slightest drought and produce virtually nothing.

Pasture Mowing

Regular mowing of grassy areas, mainly for hay or increased forage production, has promoted a nearly pure stand of grass in some of the areas treated and has reduced shade and food, and the general attractiveness of the areas for prairie chickens and certain other valuable wildlife. In Colorado County, areas that have been mowed regularly for long periods are virtually game deserts; prairie chickens use them little even at nesting time. Pasture mowing in coastal Texas appears to be extending rapidly, and further reduction in wildlife resources may be expected from this cause unless definite

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modifications are effected. Fortunately, the detrimental effects of pasture mowing to upland game birds may be mitigated, at least to some extent, by following management recommendations listed on page 56.

Mechanical Accidents

Prairie chickens sometimes fly into telephone wires, fences, and houses, or are struck by automobiles. In six instances in 1937 birds were noted as accidentally killed in the Eagle Lake section—as many as were recorded for predation. Mortality from accidents may be far more serious than is generally appreciated.

Hunting

Last, but not least, hunters certainly have contributed to prairie chicken decrease. Hunting has never been well regulated, and laws governing the taking of the birds have always been inadequate. According to the Texas Game, Fish, and Oyster Commission (Ann. Rept., 1929: 86–91) prairie chickens had no legal protection until 1883, when a 5-month closed season was declared during the breeding period. In 1885, 148 counties claimed partial or total exemption to this and other regulations, and it was not until 1903 that the legislature passed a bill designating the months of November, December, and January as the open season and setting a daily bag limit of 25. The legislation of 1903 was indeed a forward step, but there was no conservation body to enforce the measure, local officers being depended on to carry out its provisions. The Game, Fish, and Oyster Commission was not created until 1910, and for many years it was without adequate funds and personnel. As late as 1919 there were only 6 salaried wardens in Texas endeavoring to carry out, as best they might, almost wholly inadequate regulations. The law restricting the open season on prairie chickens to 4 days, September 1 to September 4, inclusive, and the bag limit to 10 a day or 10 a season, was not passed until 1929. In 1937 there were only 9 full-time wardens in all the Attwater's prairie chicken country, and they were charged with patrolling more than 8 million acres!

Development of the coastal territory, as farming, grazing, and the exploiting of oil, crowded prairie chickens into ever smaller areas, where they were more easily found and killed. The Hug-the-Coast Highway (State Highway No. 35) and various other roads increased patrol problems; the intercoastal canal in Galveston, Chambers, and Jefferson Counties made formerly remote areas easily accessible to poachers. The number of hunters increased as transportation facilities and weapons were improved. The open season in September, normally a dry period (see pp. 57 to 58), did much to

popularize hunting from automobiles. With these and other advantages, hunters evidently harvested too closely. In the Bernard River country (western Austin County and northeastern Colorado County), for example, it is known that in 1936 hunters killed 66 chickens, or 22 percent of the estimated total population (300). This was accomplished despite the fact that the gunners were closely supervised and did not hunt in the most densely populated pastures. It is probable that excessive kills have occurred in other areas for many years; the 1937 census showed that Attwater's prairie chickens were nearly or completely extirpated except on or adjoining lands where they had been hunted little, if at all, for at least 10 years. In Harris, Galveston, Waller, and possibly in parts of other counties, hunting has probably been the agency most largely responsible for prairie chicken decline.

MANAGEMENT

Leopold (1931: 3) has defined game management as the art of making land produce annual crops of wild game for recreational use. In coastal Texas, the management of prairie chickens must consist largely of the preservation of suitable grassland areas. Increased protection, habitat improvement, adequate predator control, and proper regulation of the harvest, however, will greatly encourage recovery.

PROTECTION

An act (H. B. 30) passed by the State legislature, effective September 24, 1937, forbade the killing of prairie chickens in Texas for a period of 5 years. This measure removes much of the pressure previously exerted on the birds during the regular open hunting season, for true sportsmen will observe the decree. Landowners, game wardens, and other interested individuals, however, will remember that close seasons may tend to stimulate rather than retard the operations of game bootleggers. According to the consensus of State game wardens in the coastal territory, violators are especially active (1) during the birds' spring courtship season when the conspicuous males, their instincts of self preservation dulled by the the mating urge, are easy targets for .22-caliber rifles; (2) late in July and August, when the tame young birds are of "frying" size; and (3) during the duck season, when whirring flocks of Attwater's prairie chickens evidently tempt gunners who have insufficient self control. Coastal game wardens report that, in years past, probably as many prairie chickens were illegally killed during the duck season as were taken legally during the then open season in September. The restoration of the species demands close protection for the remaining birds at all times.

Although game wardens in the prairie chicken country are sincere and energetic, the territory is too vast for adequate protection under the facilities available. Sportsmen may render valuable aid by helping conservation officers apprehend irresponsible hunters, but landowners or their resident agents must handle the job if prairie chickens are to receive anything like adequate protection. Landowners, individually or in groups, would do well to incorporate their holdings to form game-management areas, as advocated by the Extension Service, Texas Agricultural and Mechanical College and the Texas, Game, Fish, and Oyster Commission. Under that plan, increased protection is provided through appropriate posting and provision by the landowners of qualified, resident, free-service State game wardens. Also technical service is given in solving predator problems, improving wildlife food and cover, properly regulating harvests, and otherwise maintaining wildlife crops. Nonresident owners should check up on the manner in which their foremen or lessees protect wildlife during their absence. It is regrettably true that some supposedly protected ranches are in reality hunting clubs for irresponsible agents and their friends when the landowners are away. Long-time lessees who wish to manage prairie chickens or other game should insist that their contract include control over the wildlife resources of the property as well as over grazing or other values. These lessees may thus avoid embarrassment from unwelcome hunter guests directed to the area by the absentee owners.

Landowners who contemplate leasing their holdings for oil development might well follow the precedent set by a ranch owner in Refugio County. Each of his contracts carries the provision that the lease shall terminate immediately after any representative of the contracting company is caught on the property with a gun of any kind. Such a clause properly shifts the burden of supervising irresponsible oil workers from the landowner to the oil company.

Increased protection of the few remaining Attwater's prairie chickens is necessary for success in management. Protection alone, however, is largely ineffective in areas where proper food and cover conditions are lacking.

HABITAT IMPROVEMENT

At present there are few areas in Texas where excellent conditions for prairie chickens prevail, and populations fluctuate markedly (table 15). Increase or decrease in study areas was thought frequently to coincide with fluctuations in the supplies of food, cover, or surface water. In many areas marked seasonal movements may be averted and larger and more stable populations maintained by removing deficiencies in habitat.

TABLE 15.—*Fluctuations in numbers of prairie chickens, Thomas and Koy pastures, Colorado County, 1937*

Pasture	Size	Prairie chickens found							
		Feb. 22[1]	Apr. 13	May 2	June 2, 8, 10	July 26	Sept. 1	Oct. 22	Nov. 1
	Acres	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Thomas	817	31	30	28	37 16	0	17	0	1
Koy	460	0	0	0	14	23	32	0	0

[1] Count of birds at or near the courtship grounds; no allowance made for any birds that may have been missed. All other counts were by the rope method. (See p. 49.)

EVALUATING CONDITIONS

In some instances it is relatively easy to point out one or more ways in which areas are inferior. Safe nesting cover is deficient in burned pastures that are devoid of old vegetation except in low damp places. Shade is insufficient on lands kept free of tall weeds or shrubs by mowing or grazing. Winter food, or cover, or both are usually lacking in areas having few native food-cover plants, as ragweed, goatweed (*Croton*), marsh-elder, or ruellia. Sometimes, however, habitat deficiencies are obscure and general observations of an infrequent nature do not identify them. Accurate inventories are of assistance in determining (1) whether habitat improvement is needed, (2) what should be done, (3) results of work done, and (4) the surplus available for hunting. Management programs should be formulated on the basis of data obtained during inventories conducted thrice annually, in spring, summer, and winter. Inventory methods, recording and interpreting data, and management practices are discussed in the following paragraphs.

CENSUS METHODS

SPRING COUNT ON THE COURTSHIP GROUNDS

The first census method that has been tried and found useful is the spring count of birds on the courtship grounds. Necessary are an automobile, preferably of light build and high clearance, a driver who is well acquainted with the area, and someone to act as observer, note keeper, and gate opener.

A count is made on each courtship ground in the area, recording the number and sex of birds assembled there and the number and sex of birds seen between these grounds. The number of hens is recorded as a supplementary check. The number of males, increased 80 to 110 percent to allow for females that will be missed is accepted as the total population of the census area. For best results, the

spring count is made in March from daybreak to about 7:30 a. m. A population estimate based on the maximum count obtained by reworking the same area three successive mornings, or often enough to offset variations due to unfavorable weather, is likely to be sufficiently accurate. Where recounts are impracticable, the single enumeration should be made on a clear, quiet morning after a brisk norther.

Courtship grounds may be located by sight or sound of the birds assembled there, but it is preferable to "drive out" the census area in belts 150 yards or less wide. Drumming grounds should not be approached more closely than is necessary, because flushing the birds leads to inaccurate counts. As birds frequently squat, or freeze, at the approach of a car, it is desirable to wait at each occupied booming ground and refrain from counting until after vigorous courtship activity has been resumed. It is good policy to encircle a counted area completely before proceeding to a new site, for the fresh car tracks often assist in avoiding duplication.

The accuracy of spring counts on the courtship grounds was tested in the following ways: (1) A section (640 acres) was covered on 10 successive mornings; (2) a 1,000-acre pasture was searched with the aid of 15 bird dogs; (3) a 1,000-acre pasture was recounted by 5 men using 2 cars, 3 horses, and 2 dogs; (4) a section worked 3 successive days was rope counted. Spring counts have been made over approximately 150,000 acres in Colorado, Wharton, and Austin Counties. These studies show that the enumeration of birds on the courtship grounds is the most rapid and economical of all known census techniques. More than 2,000 acres a morning have often been covered in areas having populations of about 1 bird per 45 acres. There are no indications that the method affects courtship activities adversely or that it greatly endangers early nesting. Also, the spring count of males is useful in yielding data on prairie chicken abundance in comparable areas worked at nearly the same time and under nearly the same conditions.

The spring count of birds on the courtship grounds, however, is not without its defects. Its accuracy is influenced by weather and other conditions at a time convenient for counting. Opportunity is limited to a few hours a day (from about 6 to 7:30 a. m.) over a short period (in March). The spring count does not reveal the number of females present, consequently, it does not produce reliable quantitative data on sex ratio and total population. Some observers experience difficulty in distinguishing males from females, especially in the poor light of early morning. To them the analysis of sex differences, presented on p. 49, may be helpful.

B49329, B48929

Above, Rope counting of prairie chickens on Matagorda Island, Tex., October 30, 1937. *Below*, Rope counting in myrtle brush; Liberty County, Tex., approximately 8 miles southeast of Devers, June 27, 1937. (Photos by W. P. Taylor.)

FIELD BASIS FOR DIFFERENTIATION OF THE SEXES IN SPRING

Basis	*Males*	*Females*
General color	Light gray	Brownish gray.
Color of breast	Not perceptibly different from that of back.	Much lighter than that of back; appears almost white in flight.
Barring on back and breast.	Heavy, black, well defined	Light, brownish black, poorly defined.
Color of head	Orange-colored comblike structure present above each eye.	Orange-colored combs absent.
Feathers of crest	Seldom erect	Frequently erect.
Neck	Appears thick and heavy, with large, brightly colored (orange) air sac apparent on each side of neck under prominent (2.25 to 2.90 inches) neck tufts.	Appears thin and long; air sac and neck tufts rudimentary (9/16 inch long).
Size	Large, heavy (about 2¼ lb.)	Small, light (about 1½ lb.).
Action on courtship grounds.	Bold, struts, fights, and booms in open cover.	Shy, does not strut, fight, or boom.
Flocking	Usually in groups of 8 to 12 when booming, feeding, or resting at midday.	Usually alone.
Flushing	Laborious take-off; cackles when rising from ground.	Easy take-off; usually does not cackle.

THE ROPE COUNT

A second method of counting, one that has been tested with most encouraging results in the coastal prairie chicken country, is the rope count (pl. 13). Essential equipment includes two automobiles, preferably of light build and high clearance, an inch rope or a quarter-inch flexible steel cable 60 to 120 yards in length, and two strong swivels. An extra supply of water for radiators is needed in hot weather as cars heat up under the heavy going. In addition to drivers for the two cars, a third person should be taken along, if possible, to act as note keeper and general handy man.

When the census area is reached, one swivel is attached to the right end of the rear bumper of the car in which the note keeper is to ride, and the second swivel is attached to the left end of the rear bumper of the other machine. Each end of the rope or cable is then securely tied to a swivel. Care must be exercised to see that the rope or cable, in turning, will tighten its twist and not loosen or unravel. One machine takes position parallel to a fence or other definite landmark while the other goes far enough way to stretch the rope so that only a slight bend remains. After both cars are in position, they drive over parallel courses at a uniform speed of 5

to 15 miles an hour, which may be increased in light cover but which should be reduced in heavy vegetation to keep the rope, for the greater part of its length, about 5 inches above ground. Birds are tabulated as they are flushed. Those flying into uncovered territory are deducted when that area is dragged. When the end of a strip is reached, the car in which the note keeper rides turns and

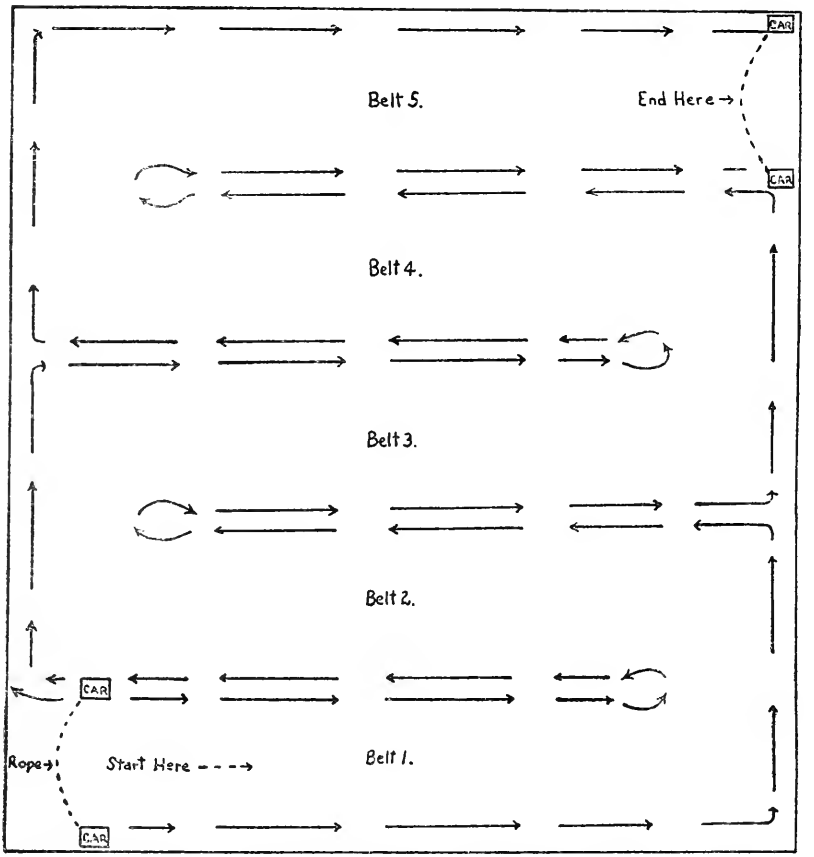

FIGURE 4.—Diagram of the rope count. Arrows show course of each car.

retraces its course while the other car makes a wide swing to the outside margin of another belt (fig. 4). This is repeated until every part of the census area has been covered.

The principle of rope counting is not new. Askins (1931: 8) reports that market hunters and others in Kansas "* * * hitched a wire between two wagons and with these driving across the prairie 300 yards apart, the gunners walked behind the wire taking the grouse as they arose until the wagon was filled." Butchers of wild-

life (they have no claim to the title of sportsmen) have used modifications of this system in coastal Texas for years.

The rope census method has been checked and rechecked for accuracy against the spring counts of birds on the drumming grounds, car counts, and counts with bird dogs. The rope count, by far the most efficient of all, has been tried over approximately 45,000 acres of grouse range, including every major prairie type in which Attwater's prairie chickens occur in Texas. Heavy myrtle brush, as in Jefferson, Liberty, and other counties east of the Brazos River, light to heavy *Paspalum-Andropogon* grassland as in Brazoria and Colorado Counties, live oak shinnery in the northern part of Victoria County, rough weedy hog wallow blackland of Refugio County, and even the extremely rough salt-grass area of the same section, have all been negotiated successfully. These tests have demonstrated clearly the practicability of the rope count under all coastal prairie conditions. Another advantage is speed; a party can easily cover 2,000 acres a day; Waddell and the writer having counted the birds on an area of this size in one morning.

Ropes last for a considerable period, one that has been dragged over 20,000 acres still being used. This method of counting is not closely limited to a short season, or to a particular part of the day, as is the spring count on the courtship grounds. The accuracy of the rope count is not dependent on special weather conditions or on other variables over which man has no control, its major advantage lying in the fact that, when properly used, it gives an accurate quantitative count in the census area. For that reason, it is most useful in prairie chicken management.

The rope count is dangerous for the layman to use during the nesting season and when young birds are small (during the latter part of March through June), for unless extreme care is taken, nests may be broken up and young birds injured, scattered, or even killed by a fast-moving, 1-inch rope. A ¼-inch rope, 50 yards long, however, has been used with success in locating nests and broods without detriment to the birds. Coffee-bean plants, yaupon bushes, trees, and old fence posts are obstacles to rope counting, but they can be avoided without great loss of time, and, with care, few breaks in the rope or cable result. Of course, cultivated fields cannot be traversed without injury to standing crops, and counting is difficult and sometimes impossible in fallow rice fields where levees are high. Inexperienced persons sometimes have trouble in keeping the proper amount of slack in the rope and in following the car tracks which are depended upon to mark the inside margin of every new belt. These minor difficulties, however, are rapidly overcome by practice.

CAR-DOG COUNT

A car-dog count is made by driving out an area in belts 40 to 150 yards wide and releasing dogs to work the area where birds are known or strongly suspected to be. Necessary equipment consists of one car and one well-trained dog, but two cars, with a man and two dogs in each, speed up the work more than 100 percent.

Since 1936 this method has been employed in working over 25,000 acres. It is economical and is highly enjoyable to dog lovers, but it is slow. The work of different dogs and that of the same dog at different times and under different conditions varies greatly. Duplications in counts or recounts are virtually unavoidable on well-populated range, and misses are frequent. As reliable data are difficult to obtain by this method, it should be used only when other census techniques are impossible.

USING THE CENSUS

Censuses produce the most dependable information when applied over an entire management area. Where this is impracticable and sampling is resorted to, care must be taken to insure that the selected area is typical with respect to vegetation, topography, water, and the like, and is sufficiently large. In a pasture consisting of 60 percent flat grassland with little or no brush and 40 percent sandhills covered with live oak shinnery it would be incorrect to sample only the sandhill territory and apply the findings to the flat grassland as well. Sampling should be divided proportionately between distinct environmental types. Sample areas should be at least a section, or 640 acres, in size, and they should preferably cover 2,000 acres. Thoroughness should never be sacrificed for extent of coverage, however, as accurate censuses made thrice annually on a well-chosen section over a period of several years will yield infinitely more usable data than will haphazard counts sporadically undertaken over more territory than can be conveniently handled.

During the spring census, investigators should list (1) males, (2) females, (3) occupied courtship grounds and the number of males at each, (4) unoccupied courtship grounds, and (5) jack rabbits, in areas where they are a common resident species, as in the country west of the Brazos River. Census sheets should show also (1) name of the pasture, (2) name of owner, (3) size of sample area, (4) exact location, (5) date of census, (6) counting method used, (7) weather, and (8) names of the investigators. Additional notes taken should describe (1) the type of country censused, whether flat grassland with few weeds, rolling country with scattered myrtle bushes, and so on; (2) grazing pressure, whether light, medium, or heavy; and (3) recent burns on high or low ground, showing the percentage of area burned, whether

burn is general or spotty, and the location of unburned cover. Careful compilation of data greatly facilities accurate interpretation.

If prairie chickens are numerous in the sample area, 1 to every 10 acres or less, cover conditions should not be changed. Instead, steps should be taken to insure that grazing and burning practices will duplicate the conditions in future years. If the birds are scarce, less than 1 to every 10 acres, and if they have not been overshot, habitat deficiencies should be sought and corrected.

SPRING

Probable habitat deficiencies limiting prairie chicken numbers in spring are scanty, poorly distributed, or overdense nesting cover and a shortage of suitable courtship grounds. Common causes of deficient cover are general burning and overgrazing that result in scarcity or complete absence over more than 60 percent of the area of old vegetation, left from previous years at an average height of at least 5 inches, and poorly distributed cover confined to a particular part of a pasture or to low, poorly drained situations. Undergrazing is the usual cause of overdense cover, the thick matted vegetation that chickens regularly avoid. Where jack rabbits (Taylor, Vorhies, and Lister, 1935) are a common resident species, they are usually either very numerous, 1 to every 10 acres or less, or entirely absent where cover is too scanty or too poorly distributed to be suitable for nesting prairie chickens. Jack rabbits are frequently scarce, 1 to every 80 acres or more, however, in cover that is overdense. A markedly unbalanced sex ratio, with more than twice as many male prairie chickens as hens, also has been noted in pastures where nesting cover was deficient.

In areas in which the cover is scarce because of general burning, conditions are improved by leaving 40 percent or more of the grassy cover unburned each year. Unburned cover should be well distributed over the pasture, the greater part being on the highest, best-drained ground, in patches of 5 to 40 acres. Favorable conditions are encouraged if burning is carried on when there is little or no wind and the vegetation is slightly damp. A quiet day following a light shower, or a still night after the dew has begun to fall, is preferable. A test fire should be set in a protected corner of the pasture. If it burns slowly, consuming only the most combustible material, and dies down in 5 to 15 minutes, a series of fires then may be set throughout the pasture. The number should be strictly regulated by the acreage to be burned and the manpower available to curb the fires in case of such unforeseen difficulties as a fresh breeze that may put fires out of control. The best insurance against trouble from that cause is a plowed fire lane, 5 to 10 feet wide, completely encircling the pasture and

dividing it into blocks of approximately 100 acres each. All pasture burning should be completed by December or early in January, well in advance of the nesting season.

Moderation in grazing is important. Cattle should not be left to graze on a tract until unpalatable bunch grasses, as smut grass, salt grass, big bluestem, and the like, are all that remain. Ideal conditions are approached when the number of animal units is strictly regulated according to the quantity and quality of the available forage. This practice avoids a condition of cover that is scanty in dry years and overdense in wet years, and, besides being favorable to prairie chickens, it conserves the soil and the range.

A shortage of courtship grounds, short-grass areas from one-half to 10 acres in extent surrounded by light to medium-heavy grassy cover, is frequently indicated by an unbalanced sex ratio with more than twice as many females as males or by a preponderant male population of 8 to 15 or more birds on each booming ground. Common causes of inadequate courtship facilities are (1) a lack of hardpan flats; (2) general burning, which denudes vegetation over a wide area and causes prairie chickens to leave; and (3) undergrazing, resulting in tall cover even on hardpan areas. These deficiencies, however, are remedied by spot burning and moderate grazing.

SUMMER

Probable deficiencies that limit the number of birds in summer are an insufficient supply of water in dry years and inadequate shade. A count made from July 1 through August 10, preferably over the same area covered in spring, reveals the number of young produced, and thus serves as a check on the success or failure of the breeding season.

The data recorded for the summer count should be the same as for the spring count and, also, investigators should note (1) the number of young, (2) the number, character, and location of water supplies, and (3) distribution of birds with respect to water and weedy cover.

A larger population of adult prairie chickens than was found in spring shows either that the spring census was inaccurate, or that other birds have moved in. In the latter event no habitat manipulation should be attempted unless the resident population plus the influx averages less than 1 bird for every 10 acres, and a larger population is desired. If the adult population has decreased since spring, however, and it is established that poaching has not occurred, the census data should be examined for information suggesting causes of the decline.

Indications of deficient water are the absence of watering places a mile or less apart, and the concentration of birds and jack rabbits in parts of the area where water is available. Indications of deficient

shade are the scarcity of prairie chickens and jack rabbits where surface water obtains. Ordinary causes of insufficient water are drainage and unusually dry seasons. Water supplies can be improved by cleaning and deepening natural ponds or constructing new ones, and allowing windmill pumps to spill over and maintain puddles nearby.

Common causes of inferior shade are heavy grazing and mowing. Shade deficiencies usually can be corrected naturally by moderate grazing and leaving unmowed plots 1 to 10 acres in extent in flats near ponds. Other methods of obtaining and maintaining tall shading cover are by (1) fencing tracts from ½ to 10 acres in size within 100 yards of water holes and leaving the fenced areas ungrazed; (2) planting tamarisk, chinaberry, black locust, elm, sycamore, cottonwood, or other adapted trees near water supplies; (3) constructing two or more brush racks 5 by 6 by 2 feet high on knolls on high ground near ponds; and (4) strip plowing near ponds as outlined on page 56.

An increase of 100 percent in the number of prairie chickens in any year is excellent. An increase of 50 percent or less may indicate either a poor breeding season or abnormally high predation. Rainfall records for May show whether breeding conditions are poor; in the event heavy rainfall is not the causative agent, predators may be responsible. In the latter instance, the number of predatory dogs and house cats should be reduced by shooting or trapping. If a thorough job is done and yet the increase is small, the aid of State or Federal wildlife technicians should be solicited.

WINTER

In winter, a grouse habitat may be deficient in food, cover, or both. This may best be determined by study of information obtained during a December or early January reconnaissance of territory that was covered in summer. Except for the data on the number of young birds and on the water supply, information recorded in winter should be the same as that in summer, and it should show whether birds are generally distributed or heavily concentrated in small areas. The rope count is the preferred method of winter census, dog counts being made only when rope counting is impracticable.

Assuming that poaching is not a factor, a winter population larger than that of the summer, shows habitat conditions on a census area already more favorable than those in pastures nearby and suggests that management be directed at maintenance, rather than at alteration of environment. A winter population smaller than that of the summer suggests food or cover deficiencies. Other indicators of such inadequacies, generally occurring together in heavily grazed areas, are a prevalence of largely unpalatable plants, as goatweed, marsh-elder, dogfennel, perennial ragweed, smutgrass (*Sporobolus poiretii*), and

cordgrass; a concentration of prairie chickens in small parts of the area; and an abundance of jack rabbits (averaging 1 to every 10 acres or less), or their complete absence. Indications that food only is lacking are a uniform growth of heavily matted grass, a sparse growth of weeds, and a scarcity of jack rabbits (averaging 1 to every 80 acres or more). Moderate grazing encourages favorable food and cover conditions.

To make up for local shortcomings, prairie chicken managers may establish (1) stockproof-fenced areas of ½ to 10 acres in as large numbers as practicable; (2) plowed strips 20 to 50 feet wide dividing sparsely inhabited parts of pastures into blocks of 50 to 200 acres; and (3) unmowed patches of cover of 2 to 10 acres or more, situated not more than 300 yards apart. Fenced areas should not be grazed, and, if possible, half of each fenced area should be planted annually to Schrock, German millet, dwarf milo, hegari (pl. 14), or red-top cane. Brush racks built in the corners of fenced areas attract quails as well as prairie chickens. In average years strip plowing may be done with satisfactory results from December through April, but February is considered most favorable. The best effects on experimental areas in Wharton County and at College Station have been obtained on strips that were plowed shortly before or after a rain and harrowed immediately after the preliminary breaking. Unmowed patches of cover should be left on knolls or ridges, in flats around ponds, or in other places where sizable stands of weeds occur.

General Recommenditions for Habitat Control

Landowners who do not undertake intensive management of prairie chickens based on counts made three times a year may adopt any or all of the following general recommendations with the assurance that some improvement will result:

Pastures should be grazed moderately by livestock.

Pasture burning should be completed before February 1; in excess of 40 percent of the pasture should be left unburned, with the remaining cover well distributed in patches of 5 to 40 acres on the best drained areas.

Mowing should not be done before July 1; unmowed patches of 2 to 5 acres or more, not more than 300 yards apart should be left on flats, knolls, or in other places where there is a good stand of weeds.

In summer windmill pumps should be allowed to form puddles.

Predatory house cats and dogs should be rigidly controlled.

The present 5-year close season (effective September 1937) should be enforced. If and when the season is reopened, not more than 35 percent of the known population should be shot when rainfall in May is normal or less. In years when rainfall in May is approximately twice normal, no birds should be killed.

Fenced plot planted to hegari; Wharton County, Tex., approximately 9 miles south of El Campo, November 1, 1937. (Photo by W. P. Taylor.)

PREDATOR CONTROL

Exhaustive studies by McAtee (1931, 1932, 1935, 1936), McAtee and Stoddard (1930), Fisher (1893)), May (1935), and others have demonstrated rather conclusively that the food of most flesh-eating birds and mammals is determined mainly by the availability of prey. Errington (1935) adds that predation is largely confined to insecure or surplus populations; in areas where there is adequate food and cover, hawks, owls, skunks, opossums, and the like feed principally on the more common rats, mice, snakes, frogs, and insects, rather than on the less numerous, swift, and elusive game birds. Flesh eaters often are neutral, and may be actually beneficial, in relation to sport and agriculture. Specific data presented on the relationships of Attwater's prairie chicken and its natural enemies (pp. 37 to 40) are by no means so comprehensive as desired. The information at hand, however, apparently justifies the following general recommendations concerning predator control on prairie chicken range:

Feral house cats and predatory dogs may well be controlled.

Hawks, owls, and fur animals should not be killed indiscriminately, their control being limited to known offenders. Inhumane pole traps should not be used. (All raptorial birds except Cooper's, sharp-shinned, and duck hawks, goshawks, and great horned owls are protected in Texas.)

Fur animals should be taken only during open seasons when furs are prime, and the harvest should be regulated to promote sustained yields.

HARVESTING THE SURPLUS

Former laws governing the shooting of Attwater's prairie chickens left much to be desired. Regulations in effect from 1925 through 1937, providing an open season from September 1 through September 4 and a bag limit of 10 birds a day or 10 a season, actually stimulated butchery and injured sport. Hunting was allowed when birds were easily found, many being concentrated near patches of heavy cover near surface water. Unwary young of the year were easily shot because they flushed near the gunner, flew straight and slowly for short distances, and ran but little after alighting. Adults performed similarly, probably because the weather was warm, the cover dense, and because they were in molt. September heat prohibited efficient work by bird dogs, so crippling losses were doubtless high. As it was also uncomfortably warm for men to walk, hunting by cars, and shooting from them, in violation of State law, became the rule in Colorado and Austin Counties and probably elsewhere in coastal Texas.

In the future, the power of making regulations might well be delegated, under proper safeguards, to the State Game, Fish, and Oyster Commission, which has the benefit of information and counsel

from its own trained game protectors and from experienced sportsmen, as well as from wildlife specialists connected with the State and Federal Governments. This power should allow for prompt modification of regulations in response to emergencies of climate, or other conditions affecting the welfare of the birds. The proper open season on Attwater's prairie chickens, assuming that the numbers of the birds can be built up to withstand the drain of shooting, cannot always be determined in advance, and regulations should be formulated in accordance with local conditions as they develop. The State legislature, meeting only at 2-year intervals, must rely on the State Game Commission for appropriate regulation of the take of game; and only under that arrangement can the people properly hold the Commission fully responsible for game protection.

If hunting is again allowed, seasons should not in any case open prior to November 15. Weather late in November is usually sufficiently cool for the comfort of men and dogs, and, normally, the prairies are too wet to allow hunting from cars. The prairie chickens, already congregating in winter packs, are widely distributed and strong flying; consequently, they are hard to find and even more difficult to hit. Probably because the young of the year are strong and more worldly wise, and because the weather is cool and the ground cover reduced, late fall birds regularly flush widely, twist crazily, fly swiftly and far, usually for a mile or more, and run after alighting. In other words the Attwater's prairie chicken in November is a game bird of the highest order; hunting it thoroughly tests the most skillful hunter and the best bird dog. That is as it should be in true sport.

RESTOCKING

At present the possibility that prairie chickens may be restored by artificial planting is remote, as wild birds are not available for trapping and moving, and artificial propagation has shown little promise. Furthermore, there is no assurance that priarie chickens, if available, would survive if moved. In Texas and Oklahoma, attempts to transplant lesser prairie chickens have been unsuccessful. Bent (1932: 263) records the failure of numerous attempts to transplant the greater prairie chicken in northern States. A number of these birds introduced in the vicinity of the Sault Sainte Marie and McMillan in northern Michigan persisted for a few years, but F. F. Tubbs, Michigan Department of Conservation, writes that they have disappeared. It is true that no intensive efforts have been made to transplant Attwater's prairie chickens in southern Texas, but there is no reason to believe that they would survive the process better than have their relatives.

Natural restocking, however, takes place rapidly and efficiently when prairie chickens are properly protected and allowed to increase. Since 1935 practically all suitable territory in Refugio County has been restocked by natural spread from the Salt Creek Ranch and the properties of Martin O'Conner. When the birds are permitted to increase elsewhere, similar results may be expected.

SUMMARY

Attwater's prairie chicken, a characteristic bird of the coastal prairie, is one of three kinds that once occurred in Texas. A few lesser prairie chickens, smaller and paler in color than Attwater's subspecies, still persist in parts of the Texas Panhandle. The greater prairie chicken, however, has been entirely extirpated from its former habitat in the central and northern parts of the State.

An intensive census made in the summer of 1937 revealed that only about 8,000 to 9,000 Attwater's prairie chickens then remained in Texas, approximately half of them being in Refugio County. The birds now inhabit only about 450,000 acres, compared with the more than 6,000,000 formerly occupied. The numbers of the coastal prairie chicken have declined 99 percent, and its range has decreasd more than 93 percent during the past century.

The mating season begins late in January or early in February, when the males assemble on short-grass areas early in the morning and late in the afternoon and boom and otherwise display the mating urge. Females are attracted to the courtship areas by this activity, and mating usually takes place there. Prairie chickens are promiscuous. The booming is at a climax in March and ends late in May.

Nests containing eggs have been found from February 25 through June 17. The peak of the laying period, however, is late in March and in April. Females build their nests in dry vegetation of the previous year preferred nesting sites being in good cover in well-drained areas and within 5 yards of an opening.

The normal rate of laying is 1 egg a day until the average clutch of 12 is completed, but intervals of 1, 2, and even 3 days are not infrequent. Subsequent attempts to nest may be made if earlier nestings are terminated while booming is still in progress. Second and third nests apparently are made in close proximity to those previously destroyed, which probably jeopardizes their chances for successful termination. The incubation period is 23 to 24 days and hatching occupies about 2 days more. The peak of the hatching season is in May. Fertility of the eggs evidently is high. Nest losses in 1937, however, were 70 percent of 13 nests studied, and those in 1938 amounted to 67 percent of 6 nests.

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In 1937, of broods on which accurate counts were obtained, 48 averaged 5.48 birds each. Mortality of young prairie chickens is highest (about 50 percent) in the first 4 weeks after hatching and comparatively low (about 12 percent) thereafter, a large share of the early mortality being in lost chicks. Other known causes of juvenile mortality include heavy or persistent rains during the brooding, drowning in rice fields, and depredations by natural enemies. Family disintegration, although gradual, begins when the chicks are 6 to 8 weeks old. It is completed after cold northers late in October and in November induce fall flocking, or segregation of the birds into flocks according to sex.

Unstable and temporary groups of 5 to 15 birds are common from September through early October, but singles, pairs, and trios predominate at that season. As fall passes into winter, flocks become larger, and in December and January groups containing 35 to 300 individuals have been observed. Singles, pairs, and trios, however, may be found throughout the year.

Young prairie chickens evidently spend their first 3 weeks within half a mile of the spot where hatched. Late in May and in June, both young and adults move to territory where cover providing good shade is found within half a mile of surface water, there to remain usually until September. When fall rains and cool weather come and the fall weeds mature, the birds scatter widely, often becoming common where scarce or entirely absent at other seasons. Concentration into areas where there is moderate-to-heavy cover and adequate food is evident by November, and populations in favorable areas fluctuate little from then through spring.

The food of adult prairie chickens is about 85 percent vegetable matter and 15 percent animal. With young birds the ratio of vegetable to animal is approximately reversed. Favorite sources of plant food are ruellia, perennial ragweed, blackberry, doveweed, and sensitive briar. Leading animal foods are grasshoppers and beetles. Greens (leaves, flowers, buds) are lowest in the diet in November and December; seeds are taken in the smallest proportions in January, February, and March. Insects are least frequently captured in November, December, and January.

Important factors limiting prairie chicken abundance include excessive or persistent rainfall during the nesting season, heavy grazing, excessive pasture burning, agricultural operations, and overshooting. Other destructive factors, not generally serious but sometimes locally disastrous, include oil development, drainage, floods, drought, hurricanes, hail, the spread of woody vegetation into prairie land, predation, pasture mowing, and possibly disease.

Available records from 1925 through 1937 show a positive correlation on unmanaged land between the production of young prairie chickens and rainfall in May. Good crops of young chickens are brought off in years when the rainfall in May is 1½ inches or more below normal. Fair broods are produced when precipitation in May is nearly, or only slightly above, normal, while poor crops are probable when rainfall in May is about twice normal. If the findings in Colorado County apply to other parts of the coastal country, 2 years in 5, on the average, are favorable to prairie chicken reproduction, 2 are fair, and 1 is poor. Conditions affecting reproduction are never the same for the entire range, for a county, or even for different parts of the same county, because of the scattered character of local rains. Attwater's prairie chicken is a highly fluctuating subspecies, its scarcity or abundance depending to a large extent on the precipitation in May.

The annual kill of these birds cannot be intelligently regulated by such general open seasons and general bag limits as have applied in Texas in the past, but should be set, when permissible at all, by regulation by the State Conservation Department on the basis of the latest detailed information obtainable.

Optimum prairie chicken range apparently consists of well-drained grassland supporting some weeds or shrubs as well as grasses, the cover varying in density from light to heavy; and with supplies of surface water available in summer. In short, diversification within the grassland type is essential.

Management usually will involve protection against excessive killing, improvement of food and cover, moderate control of predators, and wise regulation of the harvest. Responsibility for management must be assumed by the landowner. Food and cover deficiencies can best be recognized and their improvement and maintenance assured by careful counts of the birds on part, or all, of the managed area at three critical periods in March, July, and December.

To obtain and maintain favorable food and cover, the following general practices are recommended: (1) Moderate grazing of pastures; (2) completing all necessary pasture burning before February 1 and leaving unburned not less than 40 percent of the best drained ground; (3) mowing pastures after July 1 and preserving the native cover on knolls, around ponds, and in flats; (4) allowing windmill tanks to spill over in summer to increase the supply of surface water; (5) controlling the numbers of feral house cats and predatory dogs; and (6) allowing the shooting of not more than 35 percent of the *known* prairie chicken population in any year when rainfall in May is normal or below and prohibiting killing when rainfall in May is approximately twice normal or above. Hunting seasons should not open before November 15.

Under normal conditions hawks, owls, and fur animals do not appear to be serious predators on Attwater's prairie chickens, and should not be killed indiscriminately.

Persons should not request the Government to furnish prairie chickens for restocking, because there is no surplus for the purpose and no evidence that the birds can be successfully transplanted.

In the absence of ample reservations for the species all other favorable factors together cannot be counted on to save the bird from extinction. Before too late a large tract or tracts of suitable range should be established as a prairie chicken refuge by the Federal or State Government.

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