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AVIAN DENSITY AND PRODUCTIVITY STUDIES AND ANALYSIS ON THE PAWNEE SITE IN 1972

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TABLE OF CONTENTS

ABSTRACT

The accuracy of several avian census methods was investigated on 10 8.1-ha plots and along a 39.4-km roadside count. Methods employed included spot-mapping, flushing, total counts, ratios, and roadside and Emlen strip count precedures. Systematic nest searches were considered to be the absolute base. Live-trapping, banding, and color-marking also were employed to obtain another index of breeding densities.

A total of 422 nests of 22 species were found during the 1972 breeding season. Nesting success varied from 40.0% for the Western Meadowlark and Mountain Plover to 58.8% for the Chestnut-collared Longspur among ground nesters while all aboveground nesters had higher nesting success except for the Brewer's Sparrow and Cliff Swallow.

Growth date for Brewer's Sparrow and Loggerhead Shrike nestlings were gathered to compare with those for the previous year. Nesting phenology and nest site selectivity information was also compiled. A total of 679 nonraptorial birds of 17 species were banded.

INTRODUCTION

Avian population studies at the Pawnee Site were expanded in 1972 to include several new approaches to the problem of accurately determining the biomass on a given area. Replicates of the area's most characteristic census plot were established to provide increased precision in estimating various population parameters. Intensive searches for nests were conducted on eight plots to show the relationship between census results and breeding populations. New census techniques were tried, and detailed field tests were made of factors affecting the accuracy of the primary census method, the spot-mapping of singing males. New statistical analyses were employed in an effort to make the roadside census a measure of density rather than merely a means of showing relative abundance, seasons of occupancy and migration. Productivity studies continued with sample size reaching an all-time high of 422 nests of 22 species. Banding operations resulted in the marking of 679 birds (non-raptors) of 17 species, including 108 individually color-marked.

DENSITY DETERMINATIONS

From mid-March to the end of July, weekly counts were made on six 8.1-ha (20-acre) plots established in the six different grazing treatment pastures (see Table 1 for plot descriptions). Data were recorded on a separate map of the plot for each count. Plot 1, located in the heavily summer-grazed pasture, was considered to be the most typical of the Pawnee National Grassland. For this reason, four replicate plots were established to provide additional information concerning it, especially increased precision of estimating the mean number of breeding birds. These replicates, called 1A through 1D, and Plot 1 were counted weekly beginning on May 4 until the end of July. The sequence in which the plots were counted was randomly chosen each week to

Table 1. Characterization of the six original 8.1-ha avian plots on the Pawnee Site.*

Plot	Season of Grazing	Intensity of Grazing	Vegetation
1	Summer	Heavy	Shortgrass, pricklypear, little litter
2	Summer	Light	Short-midgrass, pricklypear, litter
3	Winter	Heavy	Short-midgrass†, saltbush, locoweed, little litter
4	Summer	Moderate	Short-midgrass, few forbs, moderate litter
5	Winter	Moderate	Short-midgrass, saltbush, locoweed, litter
6	Winter	Light	Short-midgrass, saltbush, heavy litter

* Adapted from Giezentanner 1970.

† Underlining indicates dominance.

eliminate any time biases. Fig. 1 shows the location and orientation of these new plots.

The weekly counts were used in two ways to estimate the breeding populations in 1972. One was a simple ratio technique based on the average number of all individuals seen on a plot over a 13-week period. Data from 1970, when extensive use was made of the flushing method of territorial mapping (Wiens 1969), were the base for the calculations. For example, the weekly average during the nesting season in 1970 for Plot 1 for Horned Larks (*Eremophila alpestris*) was 14.6, while 4.5 males were known to have territories on it. In 1972 this same average was 12.4, so 14.6/4.5 = 12.4/X or 3.8 territorial males on this plot.

The other method employed for the first time in 1972 was the spot-mapping of singing males. This is the system recommended for worldwide use by the International Bird Census Committee (Svensson 1970). It requires a series of visits to the area during the breeding season with subsequent recording of the location of each singing male noted, known as a registration, on a map of the plot. Other indications of territoriality, e.g., aggressive interactions or food carrying, are also recorded. At the end of the season a composite map with all registrations is compiled for each species. In theory, registrations should then produce a cluster of points where a territory is located. Stray points not in clusters are assumed to represent transients or territorial birds away from their territories. In either case, they are considered surplus and are not used in further calculations. The results for McCown's Longspur (*Rhynchophanes mccownii*) on Plot 1 are shown in Fig. 2.

Unfortunately, the mapping method does not work well for some of the dominant breeding birds on the prairie, especially the Horned Lark. Singing by Horned Larks virtually ceases shortly after sunrise, so a census taken

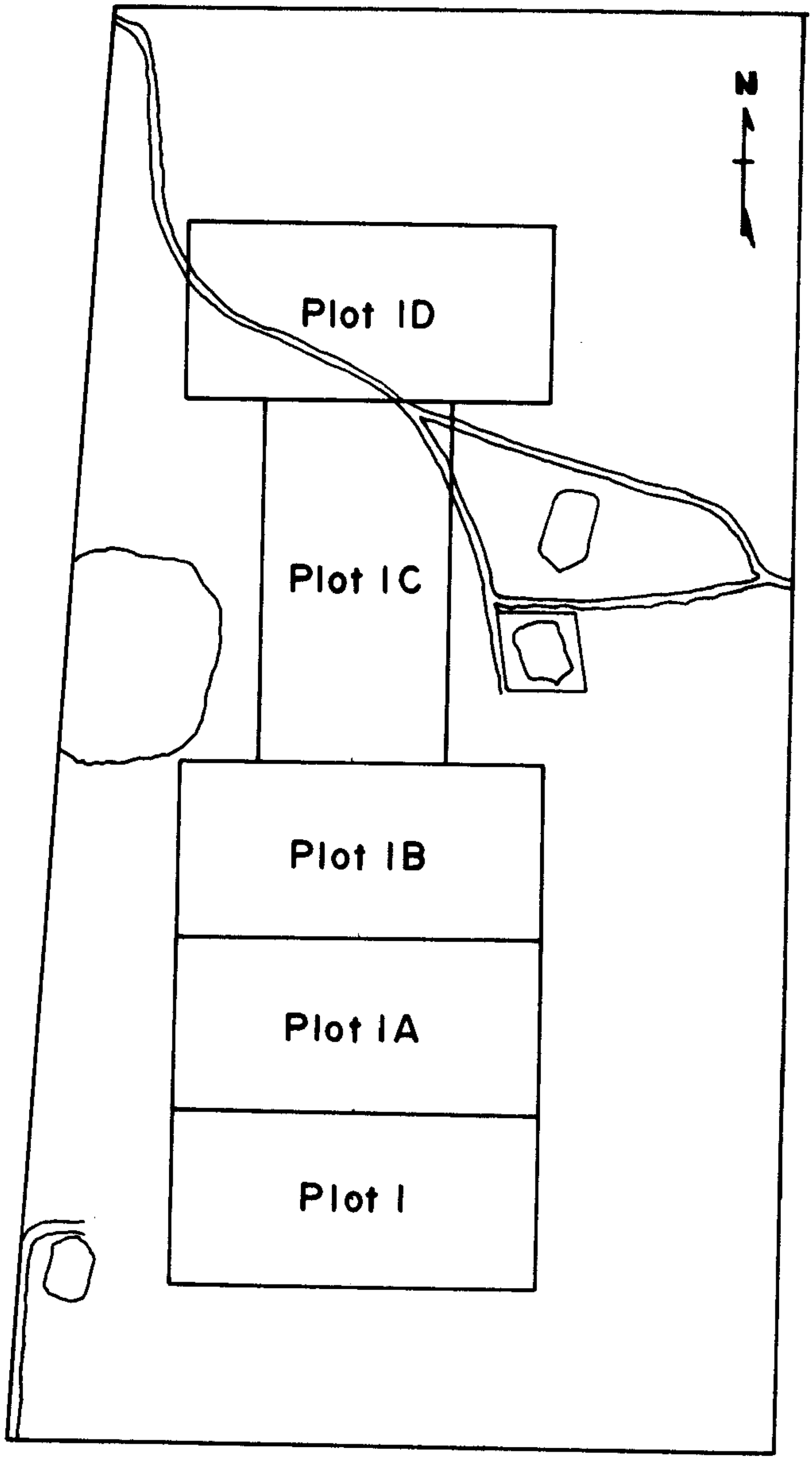

Fig. 1. Location and orientation of newly established replicate plots in 23E.

PLOT COUNTS

Section: Plot 1 23 E

Species: McCown's Longspur (males only)

Key: Plain number = Registration
Subscripted number = Observation
Hachures = Territory boundaries

1--May 3
2--May 11
3--May 15
4--May 22
5--May 29
6--June 5
7--June 12
8--June 19
9--June 26
10--July 5
11--July 10

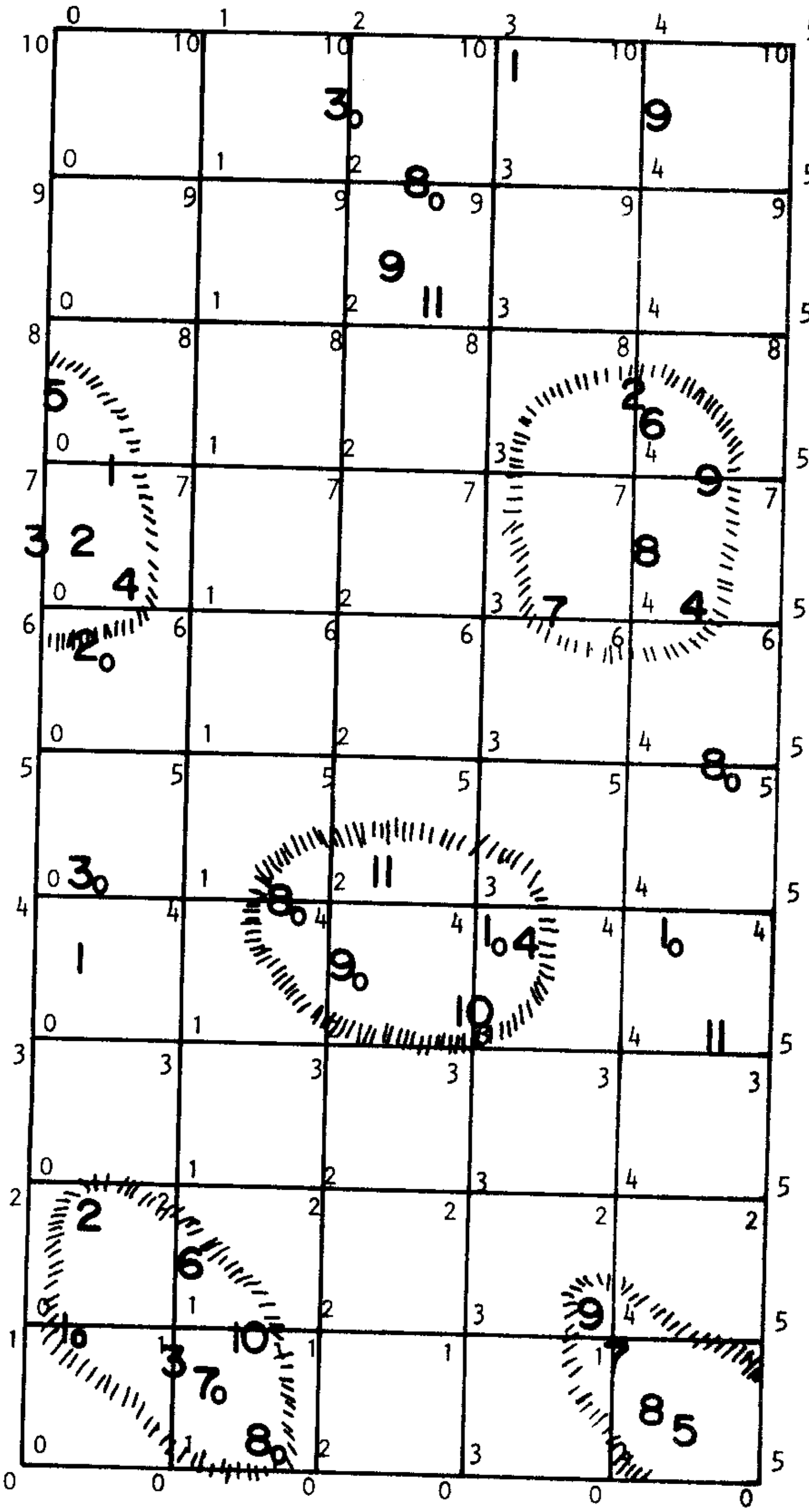

Fig. 2. Example of a composite map based on the weekly censuses of Plot 1, 23E.

anytime later and based solely on singing males would grossly underestimate the true population. Brewer's Sparrows (*Spizella breweri*), too, can easily be underestimated due to their inconspicuousness in the shrubby areas they inhabit. Finally, even conspicuous aerial singers like the Lark Bunting (*Calamospiza melanocorys*) and McCown's Longspur display less and less as the morning advances, especially on clear warm days. For these reasons and because of the aforementioned ratio method, all birds seen or heard on a plot were recorded. Attempts were made to identify sex and age of all birds sighted to assist in delineating territories. For this study, territories determined by the mapping method were based primarily on registrations but also observations or the mere presence of a bird. While this increased the chances of random sightings being combined into a territorial cluster, it seemed to be the best scheme available. An example of the increased subjectivity this system introduced into the drawing of territorial boundaries can be seen in Fig. 3.

In an effort to show the exact relationship between census results and actual breeding populations, intensive systematic nest searches were conducted on several plots. Plot 1 was searched three times, Plot 1B, 1D, and 2 once each and Plots 3, 4, 5 and 6 once each for Brewer's Sparrow only. Also random searches and routine census work resulted in finding of additional nests. All together, 92 nests of six species were found on the 10 plots.

Estimation of the 1972 breeding population was achieved by combining the results of the nest searching and spot-mapping (Tables 2, 3 and 4). A comparison of these results and those of the ratio technique is also shown. Table 5 indicates the stimated total population, which includes both the stationary breeding population and the non-stationary, non-breeding, or floating population, for each plot and each species. Comparison of trends in 1972 to previous years for the total population on the original six plots for each species is shown in Fig. 4 and 5.

PLOT COUNTS

Section: Plot 1 23 E

Species: Horned Lark (both sexes)

Key: Plain number = Registration
Subscripted number = Observation
Hachures = Territory boundaries

1--May 4
2--May 12
3--May 17
4--May 24
5--May 30
6--June 8
7--June 16
8--June 24
9--June 27
10--July 6
11--July 11

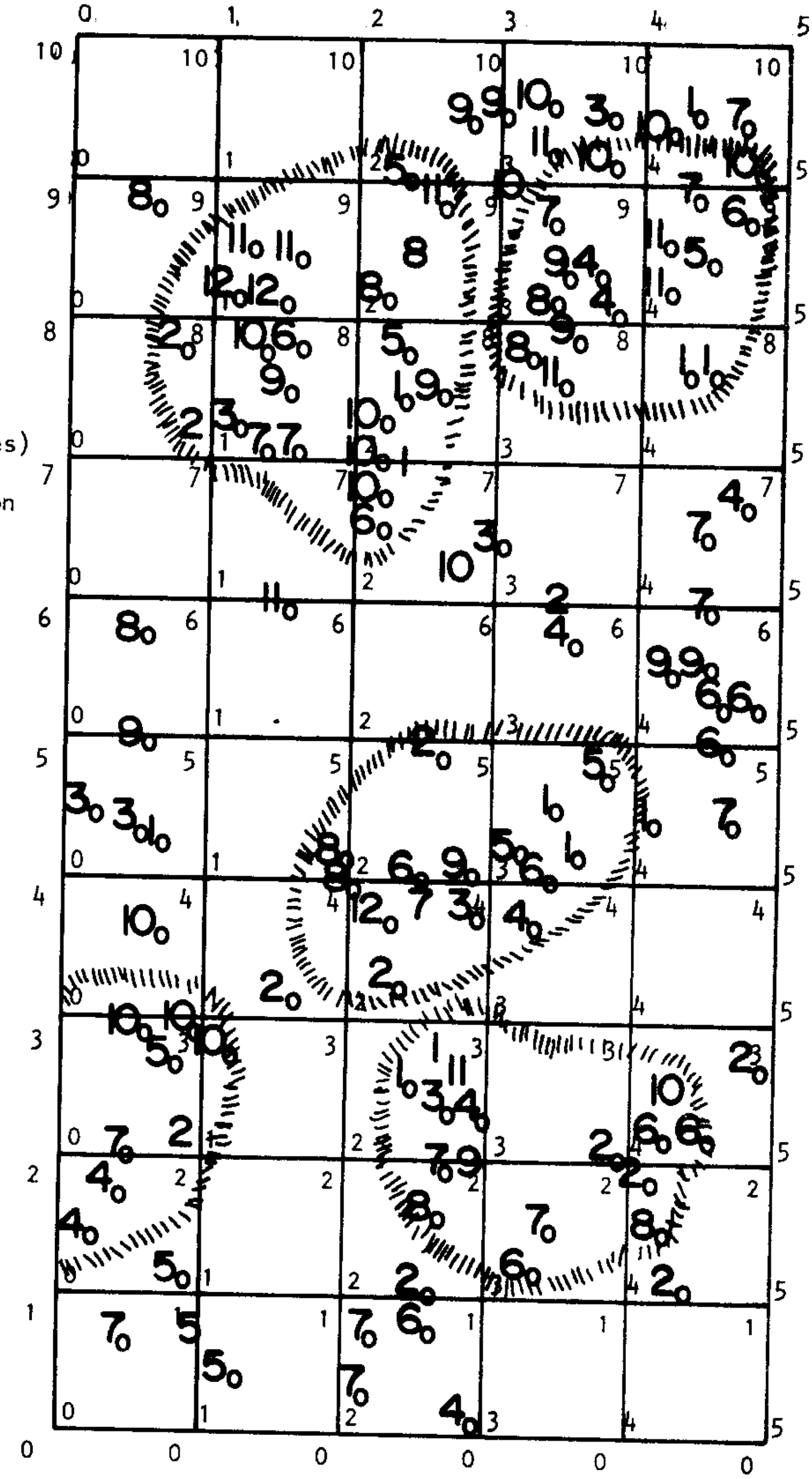

Fig. 3. One example out of several possibilities of a composite map for the Horned Lark based on the weekly censuses of Plot 1, 23 E.

Table 2. Pairs of breeding birds on the six original plots in 1972 as estimated by four different methods* (densities in pairs/100 ha in parenthesis).

Species	Plot 1				Plot 2				Plot 3			
	M	N	M + N	R	M	N	M + N	R	M	N	M + N	R
Horned Lark	4.5 (55.6)	5.0† (61.8)	5.0 (61.8)	3.8 (46.9)	2.0 (24.7)	0.5	2.5 (30.9)	2.5 (30.9)	2.5 (30.9)	0.0	2.5 (30.9)	3.0 (37.1)
Lark Bunting	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	0.0 (0.0)	5.0 (61.8)	8.0† (98.9)	8.5 (105.0)	2.9 (35.8)	4.0 (49.4)		4.0 (49.4)	2.2 (27.2)
McCown's Longspur	4.0 (49.4)	3.5† (43.2)	4.0 (49.4)	2.2 (27.2)	4.5 (55.6)	1.5	4.5 (55.6)	3.8 (46.9)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)
Western Meadowlark	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	0.0 (0.0)	1.0 (12.4)	0.0	1.0 (12.4)	1.0 (12.4)	1.0 (12.4)	0.0	1.0 (12.4)	0.9 (11.1)
Brewer's Sparrow	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.5 (30.9)	3.0† (37.1)	3.0 (37.1)	6.9 (85.2)
Mountain Plover	0.5 (6.2)	0.5	0.5 (6.2)	0.3 (3.7)	0.0 (0.0)	0.5	0.5 (6.2)	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)
Mourning Dove	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	1.0 (12.4)	1.0	1.0 (12.4)	0.0 (0.0)
TOTAL	9.0 (111.2)	9.0	9.5 (111.7)	6.3 (77.8)	12.5 (154.5)	10.5	17.0 (210.0)	10.2 (126.0)	11.0 (135.9)	4.0	11.5 (142.0)	13.0 (160.6)

Table 2. Continued.

Species	Plot 1				Plot 2				Plot 3			
	M	N	M + N	R	M	N	M + N	R	M	N	M + N	R
Horned Lark	3.0 (37.1)	0.0	3.0 (37.1)	2.4 (29.6)	4.0 (49.4)	1.0	5.0 (61.8)	4.0 (49.4)	3.5 (43.2)	0.0	3.5 (43.2)	2.8 (34.6)
Lark Bunting	4.0 (49.4)	0.5	4.5 (55.6)	2.6 (32.1)	2.0 (24.7)	1.0	3.0 (37.1)	1.7 (21.0)	5.0 (61.8)	0.0	5.0 (61.8)	3.3 (40.8)
McCown's Longspur	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.5 (6.2)	0.0	0.5 (6.2)	0.7 (8.7)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)
Western Meadowlark	0.0 (0.0)	0.0	0.0 (0.0)	1.0 (12.4)	1.0 (12.4)	0.0	1.0 (12.4)	0.8 (9.9)	1.0 (12.4)	0.0	1.0 (12.4)	1.0 (12.4)
Brewer's Sparrow	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	0.8 (9.9)	1.0 (12.4)	3.0† (37.1)	3.0 (37.1)	2.2 (27.2)	3.0 (37.1)	6.5† (80.3)	6.5 (80.3)	2.2 (27.2)
Mountain Plover	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Mourning Dove	1.0 (12.4)	1.0	1.0 (12.4)	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)
TOTAL	8.0 (98.9)	1.5	8.5 (105.0)	6.8 (84.0)	8.5 (105.0)	5.0	12.5 (154.4)	9.4 (116.1)	12.5 (154.4)	6.5	16.0 (197.6)	9.3 (114.9)

* M = Mapping method. N = Nest searching. M + N = Mapping nest searching combined. R = Ratio method.

† Thorough nest search(es).

Table 3. Pairs of breeding birds on the replicate plots in 1972 as estimated by four different methods* (densities in pairs/100 ha in parenthesis).

Species	Plot 1A				Plot 1B				Plot 1C				Plot 1D			
	M	N	M + N	R	M	N	M + N	R	M	N	M + N	R	M	N	M + N	R
Horned Lark	4.5 (55.6)	1.0	4.5 (55.6)	3.4 (42.0)	3.5 (43.2)	3.5† (43.2)	3.5 (43.2)	2.9 (35.8)	4.5 (55.6)	0.5	5.0 (61.8)	3.1 (38.3)	5.5 (67.9)	3.5† (43.2)	6.0 (74.1)	3.0 (37.1)
McCown's Longspur	4.0 (49.4)	1.5	4.0 (49.4)	2.1 (25.9)	3.5 (43.2)	3.5† (43.2)	5.0 (61.8)	2.3 (28.4)	2.0 (24.7)	2.5	2.5 (30.9)	1.7 (21.0)	3.0 (37.1)	2.5† (30.9)	3.0 (37.1)	1.5 (18.5)
Mountain Plover	0.0 (0.0)	0.0	0.0 (0.0)	0.2 (2.5)	0.5 (6.2)	0.5	0.5 (6.2)	0.4 (4.9)	0.0 (0.0)	0.0	0.0 (0.0)	0.2 (2.5)	0.0 (0.0)	0.5	0.5 (6.2)	0.5 (6.2)
Mourning Dove	0.0 (0.0)	0.0	0.0 (0.0)	NR§	0.0 (0.0)	0.0	0.0 (0.0)	NR	0.0 (0.0)	0.0	0.0 (0.0)	NR	1.0 (12.4)	1.5	1.5 (18.5)	NR
Western Meadowlark	1.0 (12.4)	0.0† (0.0)	1.0 (12.4)	NR	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	NR	0.0 (0.0)	0.0	0.0 (0.0)	NR	0.0 (0.0)	0.0† (0.0)	0.0 (0.0)	NR
TOTAL	9.5 (117.3)	2.5	9.5 (117.3)	5.7	7.5 (92.6)	7.5	9.0 (111.2)	5.6	6.5 (80.3)	3.0	7.5 (92.6)	5.0	9.5 (117.3)	8.0	11.0 (135.9)	5.0

* M = Mapping method. N = Nest searching. M + N = Mapping nest searching combined. R = Ratio method.

† Thorough nest search(es).

§ NR = No comparative ratio available.

Table 4. Comparison of estimates of pairs of breeding birds in 1972 based on the original six census plots and on all plots (densities in pairs/100 ha in parentheses) as determined by the combination of mapping and nest searching results.

Species	Density on Original Six Plots		Density on All Plots	
	Total	Average	Total	Average
Horned Lark	21.5	3.5 (43.2)	40.5	4.1 (50.6)
Lark Bunting	25.0	4.1 (50.6)	25.0	2.5 (30.9)
McCown's Longspur	9.0	1.5 (18.5)	23.5	2.4 (29.6)
Western Meadowlark	4.0	0.7 (8.7)	5.0	0.5 (6.2)
Brewer's Sparrow	12.5	2.1 (25.9)	12.5	1.3 (16.1)
Mountain Plover	1.0	0.2 (2.5)	2.0	0.2 (2.5)
Mourning Dove	2.0	0.3 (3.7)	3.5	0.4 (4.9)
TOTAL	75.0	12.4 (154.4)	112.0	11.4 (138.3)

Table 5. Average total birds on all plots in 1972 (densities in birds/100 ha in parenthesis).

Species	Plot Number										All Plots Averages
	1	1A	1B	1C	1D	2	3	4	5	6	
Horned Lark	12.4 (153.1)	10.9 (134.6)	9.3 (114.9)	10.2 (126.0)	9.7 (119.8)	5.0 (61.8)	6.3 (77.8)	8.5 (105.0)	8.2 (101.3)	8.2 (101.3)	8.8 (108.7)
Lark Bunting	0.5 (6.2)	1.0 (12.4)	1.0 (12.4)	0.5 (6.2)	1.1 (13.6)	4.1 (50.6)	6.4 (79.0)	4.3 (53.1)	3.7 (45.6)	5.4 (66.7)	2.8 (34.6)
McCown's Longspur	6.6 (81.5)	6.2 (76.6)	6.9 (85.2)	5.2 (64.2)	4.4 (54.3)	8.1 (100.0)	0.2 (2.5)	0.8 (9.9)	1.2 (14.8)	0.2 (2.5)	4.0 (49.4)
Western Meadowlark	0.2 (2.5)	0.5 (6.2)	0.5 (6.2)	0.5 (6.2)	0.3 (3.7)	1.2 (14.8)	1.0 (12.4)	0.6 (7.4)	0.9 (11.1)	0.8 (9.9)	0.7 (8.7)
Brewer's Sparrow	0.0 (0.0)	0.2 (2.5)	0.1 (1.2)	0.0 (0.0)	0.0 (0.0)	2.6 (32.1)	11.0 (135.9)	1.1 (13.6)	2.1 (25.9)	2.9 (35.8)	2.0 (24.7)
Mountain Plover	0.8 (9.9)	0.7 (8.7)	1.1 (13.6)	0.6 (7.4)	1.3 (16.1)	0.1 (1.2)	0.1 (1.2)	0.1 (1.2)	0.1 (1.2)	0.0 (0.0)	0.5 (6.2)
Mourning Dove	0.1 (1.2)	0.1 (1.2)	0.4 (4.9)	0.5 (6.2)	0.5 (6.2)	1.2 (14.8)	1.4 (17.3)	0.6 (7.4)	0.0 (0.0)	0.0 (0.0)	0.5 (6.2)
Others	0.0 (0.0)	0.3 (3.7)	0.0 (0.0)	0.3 (3.7)	0.0 (0.0)	0.0 (0.0)	1.0 (12.4)	0.3 (3.7)	0.2 (2.5)	0.8 (9.9)	0.3 (3.7)
TOTAL	20.6 (254.4)	19.9 (245.8)	19.3 (238.4)	17.8 (219.8)	17.3 (213.7)	22.3 (275.4)	27.4 (338.4)	16.3 (201.3)	16.4 (202.5)	18.3 (226.0)	19.6 (242.1)

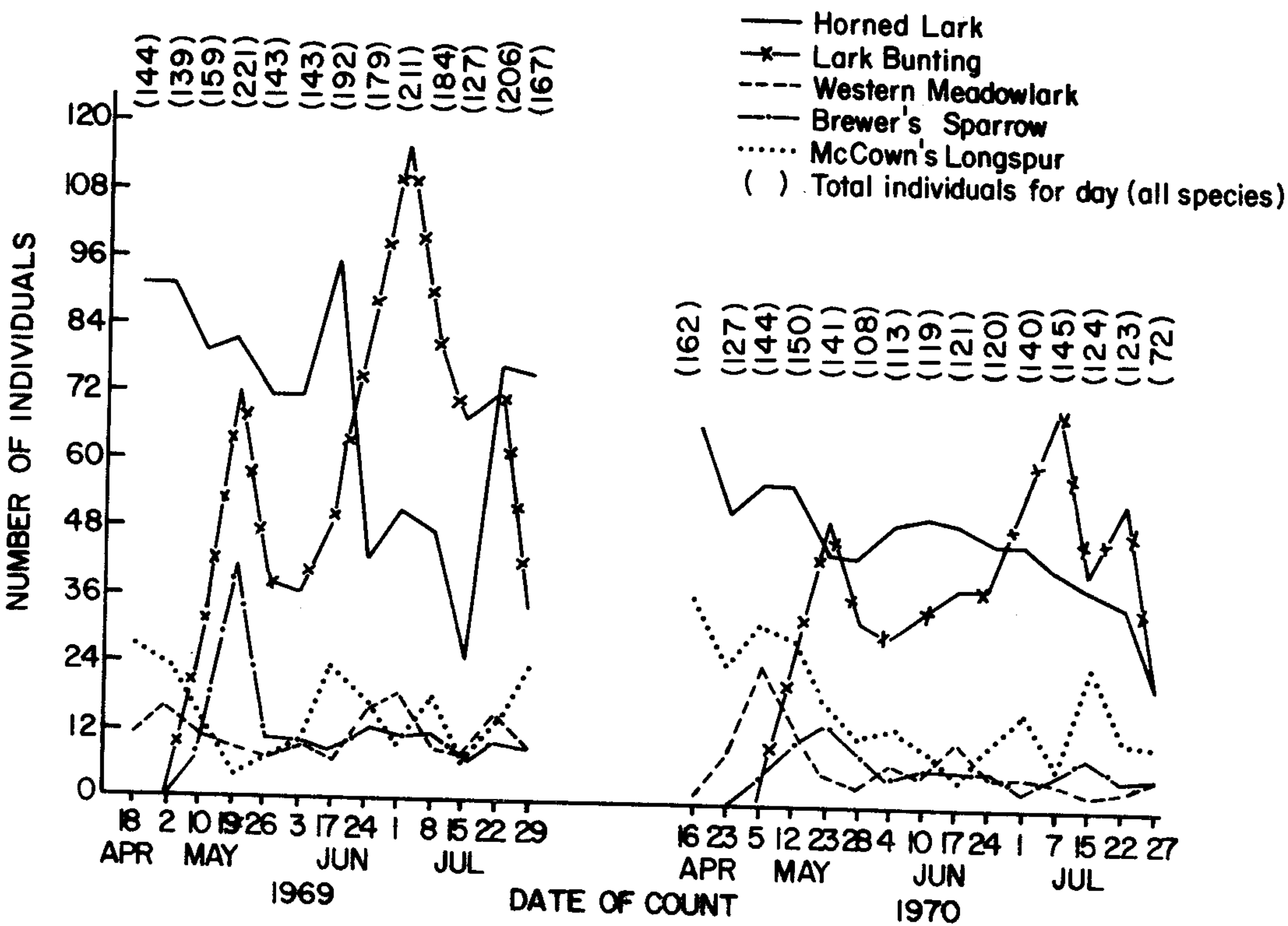

Fig. 4. Trends of total birds seen on the original six census plots, 1969 and 1970.

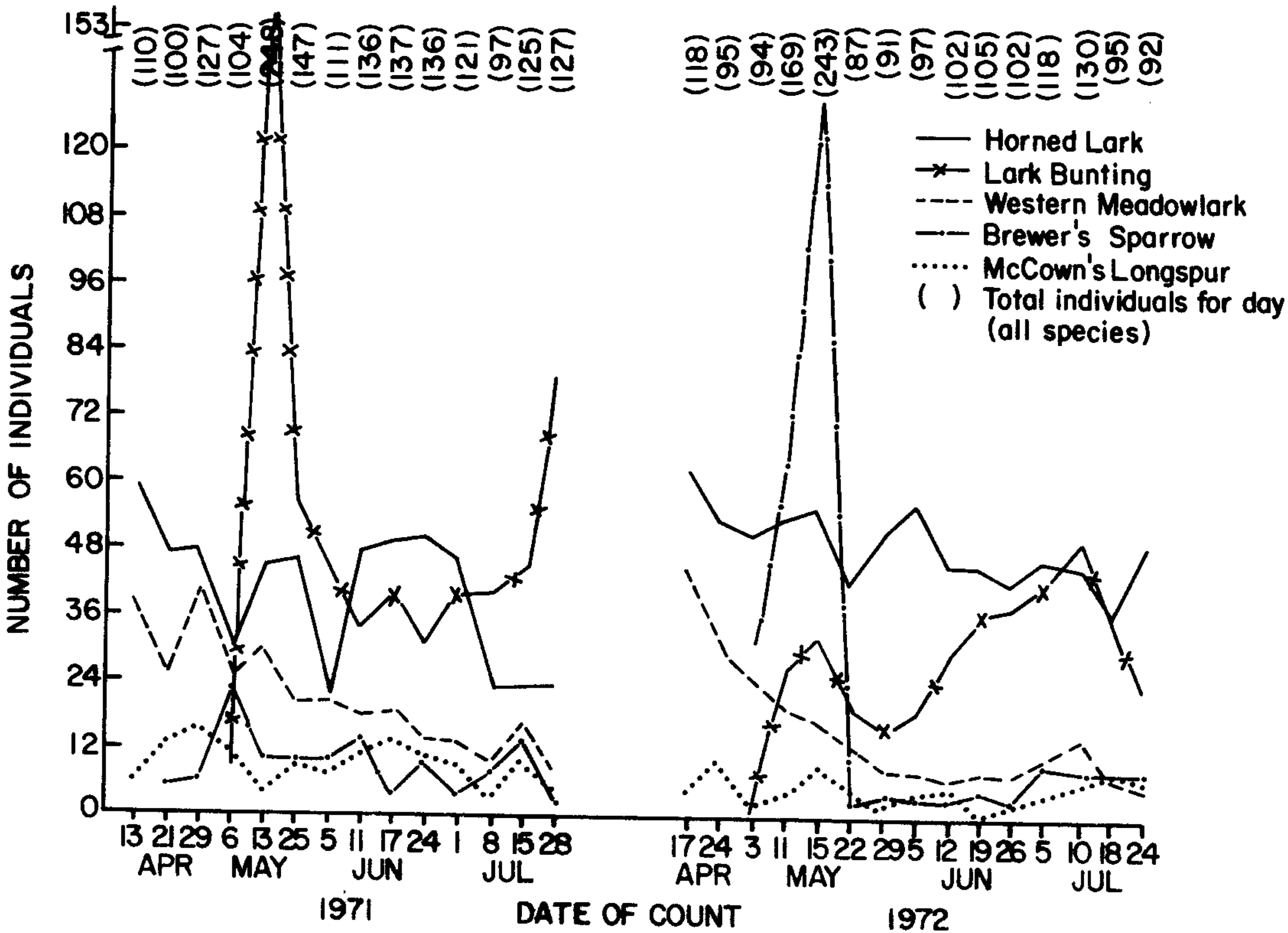

Fig 5. Trends of total birds seen on the original six census plots, 1971 and 1972.

Tables 3 and 4 show a wide discrepancy between results of the different methods. With few exceptions, the ratio technique had the lowest estimate for all species. The most notable difference was for Lark Buntings. The ratio method estimated a total of 12.7 territories for all plots combined, only half of the 25.0 calculated from mapping and nest search results. The mapping method alone was about 30% more efficient as it estimated 20.0 territories. The ratio technique was inaccurate for Brewer's Sparrows, also. While the overall total of this method was close to nest search results, Plot 3 was greatly over estimated and Plot 6 was greatly underestimated (Table 2). Nest searches for this species were considered quite accurate because of its aboveground nesting habit. However, the mapping method was not a much better indicator of the true stationary population for the Brewer's. Agreement among the techniques was generally better for Horned Larks, McCown's Longspurs and Western Meadowlarks (*Sturnella neglecta*) than for the other species.

The best comparison between the methods is one based on those plots that were thoroughly searched for nests. These included Plots 1, 1B and 1D for Horned Larks and McCown's Longspur, Plot 2 for Lark Buntings and Plots 3, 4, 5 and 6 for Brewer's Sparrows. Using the number of nests as the base, the mapping method gave estimates 112%, 110% and 63% as large in estimating the true stationary population for Horned Larks, McCown's Longspurs, and Lark Buntings, respectively. The ratio method was less efficient for these three species, giving estimates of 81%, 63% and 36%, respectively, of the numbers of nests. The ratio technique estimated 90% of the Brewer's stationary population while the mapping method accounted for only 52% of it. As implied previously, any accuracy by the ratio method for Brewer's was accidental, for it was due to cancelling of large errors. The greater accuracy of the mapping method for this species was confirmed by a simple regression analysis which resulted in a sample correlation coefficient of 0.69 for the mapping method and -0.50 for the ratio method.

The mapping method calculated a stationary population greater than that indicated by nest searches for both the Horned Lark and McCown's Longspur. This overestimation was probably due to both overlooking nests during searches and the presence of stationary but non-breeding birds. An attempt will be made in the 1973 field season to record the occurrence and ascertain the percentage of these non-breeding stationary individuals.

As in 1970 and 1971, Plot 2 had the highest breeding population, primarily due to Lark Buntings (Table 2). McCown's also had their greatest abundance in this plot. Horned Larks were most abundant in Plot 1D as were Brewer's in Plot 6. Meadowlarks avoided the heavily and moderately summer-grazed pastures but were evenly distributed in the other four plots. Mountain Plovers (*Eupoda montana*) favored the plots in 23E although for the first year a nest was found on one of the other plots.

One-way analysis of variance was applied to total numbers seen of the above species on plots used for nesting by that species. McCown's, Brewer's, Meadowlarks and Mountain Plovers all showed no significant difference at the standard 0.05 level. Lark Bunting populations on Plots 2 through 6 were statistically different at the same level, as were Horned Larks on Plots 1 through 1D. Numbers of the latter on Plots 1 through 6 were significantly different at the 0.01 level. Significance implied that some plots used for nesting were utilized less than others. Non-significance implied that if a plot was suitable at all for breeding, it was used to the same degree as any other suitable plot.

The estimated total stationary population for all plots combined, based on the mapping method and nest searches, was 112 pairs, or 138.3 pairs/100 ha. When based on the six treatment plots as in years past, the estimated density was 154.4 pairs/100 ha. Since the replicates were purposely established in the pasture considered most representative of the Pawnee as a whole, breeding densities for the individual species were calculated from the 10 plot mean. Horned Larks had the highest density, 50.0 pairs/100 ha (74.1 pairs/100 ha), followed by Lark Buntings--30.9 (105.0), McCown's Longspurs--29.0 (55.6), Brewer's Sparrows--15.4 (80.3), Western Meadowlarks--4.9 (12.4), Mourning Doves (*Zenaidurea macroura*)--4.3 (18.5) and Mountain Plovers--2.1 (6.2). The figures in parentheses were the maximum density achieved, calculated from the optimum plot for that species.

While the above estimates were believed to be the most accurate, they were unfortunately not comparable to previous years because of the change in interpretation of the data. To be comparable, estimates of this year's densities from the ratio technique must be used. An alternative would have been to recompute previous estimates based on a ratio of total birds to breeding birds as determined by the mapping method. However, this would have involved the same unproven assumption as the ratio technique, which was that the relationship between breeding and non-breeding birds in a population is constant over a period of years. Still it is useful to compare years, and the ratio method will serve this purpose in the following discussion.

The total population declined slightly from about 120 pairs/100 ha in 1970 and 1971 to 113.2 pairs/100 ha in 1972. Lark Buntings (26.1 pairs/100 ha), Meadowlarks (9.7), Mountain Plovers (0.6) and Mourning Doves (0.0) were all at a five-year low. Conversely, Brewer's (24.9) were at their greatest density ever. McCown's (13.8) were down from 1970 and 1971, but Horned Larks (38.1) increased over the same period. Efforts are being made to relate these fluctuations to abiotic factors such as temperature and precipitation but are not complete at this time.

Establishment of the four replicate plots in 23E yielded increased precision in estimating populations of species that nested in that pasture. The replicates also permitted for the first time an assessment of the variance of their populations. The mean of the total numbers of Horned Larks ranged from 12.4 in Plot 1 to 9.3 in Plot 1B. As mentioned previously, this difference was statistically significant, indicating habitat selection even within this rather uniform pasture. The overall mean in 23E for the Horned Larks was 10.5 individuals, and the estimated variance was 5.23. Plot 1B had the highest average number of McCown's, 6.9, while Plot 1D had the fewest, 4.4. Overall mean and variance were 5.8 and 4.25, respectively. Mountain Plover numbers were quite small in all plots, ranging from 1.3 in 1D to 0.7 in 1A. Plovers averaged 0.9 on all plots in 23E with a variance of 1.34. Numbers of Mourning Doves were even less and averaged only 0.3 per plot. Their estimated variance was 0.55.

Density Indices

As part of the banding program, 124 Sherman small mammal traps were set in a two-chain grid on and around Plot 1 and part of Plot 1A. The area encompassed by the grid, including a one-chain wide buffer strip, was 20.2 ha. Horned Larks accounted for over 70% of all birds captured and were the only species caught in large enough numbers to allow estimations of population size from recapture rates. A total of 47 captures, including 24 recaptures, were made during the 10 trap days. Although numbers involved were small, it was still possible to compute the size of the population using the Schnabel (1938) procedure. The final estimate was 22.2 birds on the grid, or 110.0 birds/100 ha.

Another index of population size can be obtained by viewing the last day's catch as input for the Petersen (1896) estimation technique. Ideally, all marking should have taken place at one time, but so few birds were caught each day that this was impossible. The result, which is based on the ratio of total catch to recaptures, was 28.4 birds, or 140 birds/100 ha.

The average of all Horned Larks seen on Plots 1 and 1A was 11.75 birds, or 144.1 birds/100 ha. Considering the small sample size and inherent problems of indices, their results were comparable with this direct count. The direct estimate of total population was naturally higher than the estimated stationary population for these two plots, 117.2 birds/ha. The difference between the total and stationary populations, 27.9 birds/100 ha, is an estimate of the average floating population of Horned Larks on these plots.

ACCURACY OF THE MAPPING METHOD

Composite mapping of the location of territorial singing males has become the most widespread method of censusing passerines in the breeding season. First introduced by Williams (1936) in Ohio, it is now the recommended technique of the International Bird Census Committee (Svensson 1970). It is currently used for national censuses in many countries, including the Common Birds Census of Great Britain (Batten 1971), as well as the *American Birds* annual breeding census in this country. As with any census method, though, it is not without its shortcomings. Critical evaluations by Enemar (1959) and Hogstad (1967) among others have shown various factors are capable of influencing the results. The following discussion attempts to illustrate the reason for and the degree of these influences on the accuracy of censusing breeding passerines on the shortgrass prairie.

Strip Width

The normal procedure for censusing one of the 8.1-ha, 200 m x 400 m plots involved traversing the length of the plot twice while continuously recording the positions of all birds seen. The paths of travel were equidistant from the sides and the center, so the width of the strip surveyed on each traverse was 100 m, or 50 m on each side of the observer. To determine the effect of increasing or decreasing this width, four counts of Plot 1 and two counts of Plot 1B were made. Each count consisted of censusing a plot in one morning using three different width strips--80 m, 100 m, and 200 m. An effort was made to keep all other factors, especially speed of traverse, constant.

Some general conclusions are apparent from Table 6. As was expected, the greater the transect width, the fewer the birds observed. For the two primary species and the total, the number recorded in the 200-m strip was, with one exception, less than the number seen in one of the narrower strips. Table 7 portrays the comparison of the three widths based only on sightings of territorial male McCown's Longspurs. Out of 18 trials, seven birds were not recorded on all three width strips for that count. Of these seven incomplete sightings, five were cases of the bird being recorded on the 80-m and 100-m strips, but not on the 200-m.

The widest census strip clearly caused unnecessary omissions, even for conspicuous aerial singers. Since no territorial birds were missed whether the strip was 80 m or 100 m, other factors must have caused the differences noted in Table 6. Use of an 80-m strip required three traverses and thus increased the chance of a bird passing over the plot and being recorded. Similarly, having only one traverse explained some, but not all, of the reduced observations with the 200-m strip. Probably a more important reason for the increased sightings with the 80-m strip was duplication.

Table 6. Effects of varying the width of the census strip on sightings of primary breeding species in 23 E.

Plot	Date	Strip Width (m)	Horned Lark	McCown's Longspur	Other Species	Total
1	May 25	80	18	3	2	23
		100	14	4	1	19
		200	7	4	1	12
1	June 10	80	17	6	1	24
		100	11	6	5	21
		200	7	3	2	12
1	June 17	80	9	6	1	16
		100	12	5	0	17
		200	6	3	1	10
1	June 29	80	17	10	1	28
		100	11	11	1	23
		200	12	7	0	19
1B	May 25	80	7	3	0	10
		100	14	6	2	22
		200	7	1	3	11
1B	June 30	80	8	2	0	10
		100	5	8	0	13
		200	9	3	0	12

Table 7. Effects of varying the width of the census strip on sightings of territorial male McCown's Longspurs.

Plot	Date	Location of Bird in Plot	80-m Strip	100-m Strip	200-m Strip
1	May 25	7/0	A*	A	A
		6/3	A	A	--
		3/2	A	B†	A
1	June 10	7/3	A	A	A
		2/5	B	A	--
		4/3	A	A	A
1	June 17	7/3	A	A	A
		2/2	B	A	A
		1/5	--	--	A
1	June 29	6/4	A	A	A
		4/4	A	A	A
		1/4	A	A	A
		3/2	A	A	--
1B	May 25	1/2	--	--	A
1B	June 30	4/5	B	A	--
		5/2	A	A	B
		7/2	A	A	B
		9/1	A	A	--

* A = Registration

† B = Observation

Obviously, the smaller the strip, the easier it was for a bird to be recorded in adjoining strips. Considering the layout of the plot and the species involved, a 100-m strip appeared optimal.

Speed of Traverse

To test speed of traverse effects, four counts of Plot 1 and one of Plot 1B were conducted. Each count involved two censuses, one at the standard speed of about 30 m/min and one twice that speed. Again, other factors were held constant.

At least within the range tested, speed of traverse had very little effect on the registering of territorial birds (Table 8). Out of 13 sightings of territorial male longspurs, 11 birds were seen at both speeds for that plot. While the relationship was not so precise, the tendency toward similarity was still evident when all longspurs were considered, probably because territorial birds comprise most of the sightings (Table 9). However, Table 9 also revealed a consistently lower number of Horned Larks, and thus total birds, observed when the speed was doubled. Non-displaying birds made up almost all of the Horned Lark sightings. These non-displayers were naturally less conspicuous and thus easier to overlook as speed of traverse increased. Apparently either speed was adequate for determining territories, but the slower one allowed a more accurate assessment of the floating population which is necessary for total biomass calculations.

Time of Day

It is well known among professional and amateur ornithologists alike that non-nocturnal singing birds show a peak singing intensity shortly after dawn (e.g., see Winterbottom 1972). To illustrate this phenomenon on the Pawnee, censuses were made throughout the day on June 3 from 0500

Table 8. Effects of varying speed of traverse on registrations of McCown's Longspur.

Plot	Date	Location of Bird in Plot	Speed of Traverse 30 m/min	60 m/min
1	June 2	2/1	A*	A
		7/2	A	A
		7/4	A	A
1	June 10	7/4	A	A
1	June 11	7/4	A	A
		6/4	A	A
		5/1	A	A
1	June 27	6/3	A	A
		5/1	A	A
		8/5	--	A
1B	June 11	1/4	A	A
		3/0	A	--
		4/4	A	A

* Registration

Table 9. Effects of varying the speed of traverse on sightings of the primary breeding species in 23E.

Plot	Date	Traverse Speed (m/min)	Horned Lark	McCown's Longspur	Other Species	Total
1	June 2	30	14	3	2	19
		60	13	4	1	18
1	June 10	30	13	4	0	17
		60	8	4	0	12
1	June 11	30	10	4	1	15
		60	6	5	0	11
1	June 27	30	12	4	3	19
		60	7	6	1	14
1B	June 11	30	6	6	6	18
		60	3	3	2	8

until 1800. Plots 1 and 1B were counted once every two hours for a total of 14 surveys. Several additional attempts to repeat the procedure had to be cancelled because of adverse weather conditions.

Combined results of all censuses generally paralleled the expected pattern although species differences became apparent (Fig. 6). Both singing and calling were greatest in the first period which included counts beginning 30 min before and ending 30 min after sunrise. Horned Larks and McCown's Longspurs accounted for all 34 registrations. The first period accounted for 11 or 32.4%, of all registrations, including 53.3% of all Horned Lark registrations. In contrast, only three out of 19, or 15.8%, of all longspur registrations were recorded in the first period. Thus, longspurs started singing later in the morning than Horned Larks but continued longer. The early peak of singing was then attributable only to the larks. Observations peaked in the second period and were higher in the morning than in the afternoon.

The results indicated the optimal time for conducting a census. Territorialism in Horned Larks was best assessed very early in the morning, while McCown's Longspurs displayed well throughout the morning. Although not documented, field work suggested the interval between song flights for the longspur increased after early morning. Also, mornings were much better for estimating the floating population.

Observer Variation

Observer variation and bias are factors common to any experiment involving humans. In a long-term study such as this it is important to know if any serious deficiencies exist among observers. To discover if different observers obtain markedly different results from the same area, three project ornithologists simultaneously censused a total of six plots in two mornings.

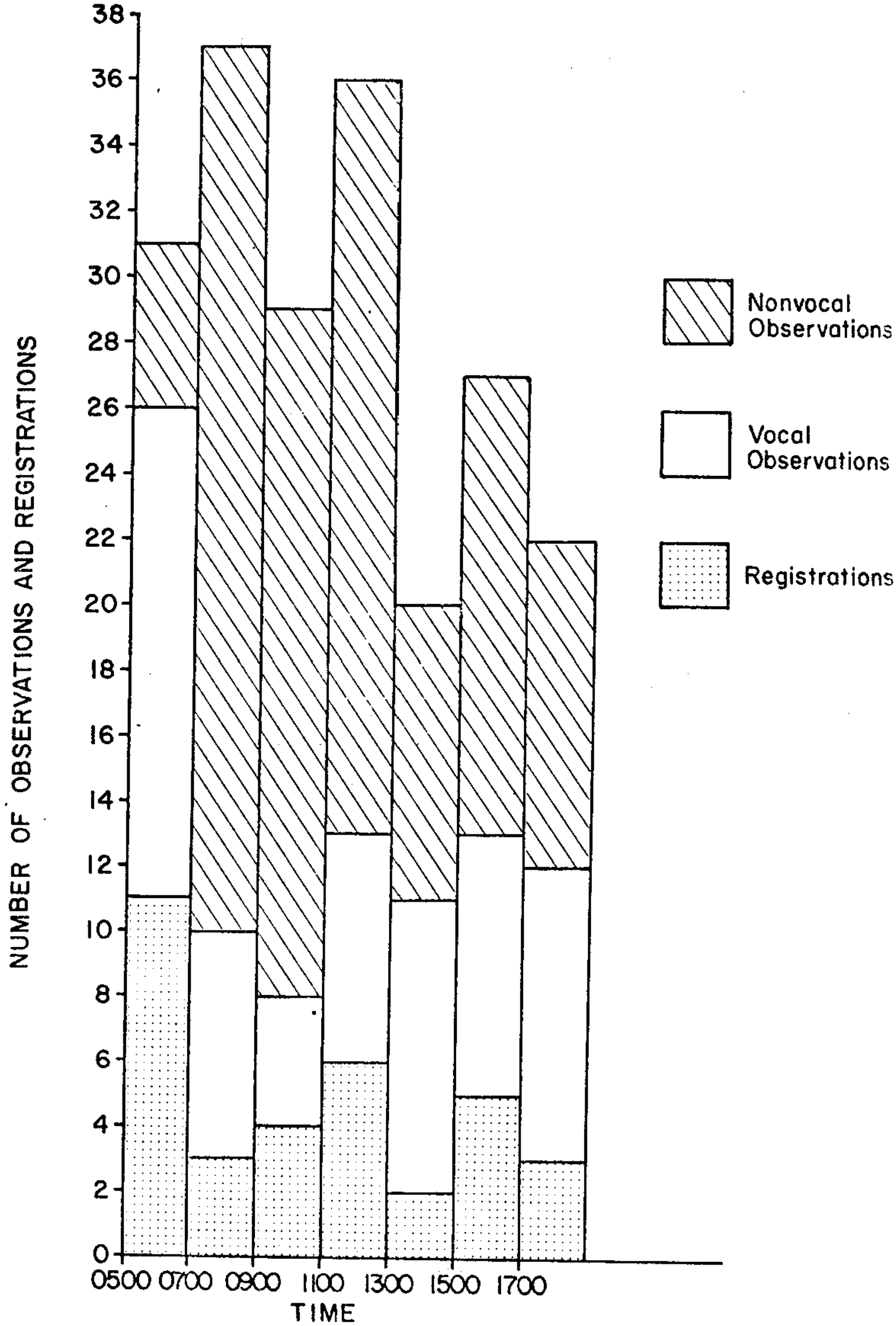

Fig. 6. Trends in singing and calling for nesting species in 23E on June 3, 1972. Each column represents Plots 1 and 1A combined.

The routes of travel and traverse speed were equal with the observers spaced about 300 m behind each other. Overall totals by species are given in Table 10.

While no distinct trends were evident, some personal leanings appeared. Observer C, the last to census the plot in each case, usually recorded the most birds. Observer A, the first to survey the plot, noted fewer longspurs, while Observer B saw fewer Horned Larks. However, Table 10 includes observations as well as registrations, so it was strongly affected by birds entering and leaving the plot during the census. Table 11 avoided most of this problem by considering only territorial birds. Of the 26 longspurs, 14 were recorded by all three observers. Seven of the remaining 12 involved birds known not to be present on the plot during the entire census or those with territories extending beyond the plot boundaries. It was possible that some of the other five cases may have involved birds that left the plot unknown to the observers. In any case, agreement among the observers was about 74%, signifying adequate coverage by each. Enemar (1962) in a similar experiment involving six ornithologists surveying a wooded area found the agreement was an almost identical 75%.

Weather

Nineteen counts were made of plots in 23E during inclement weather to illustrate the problems of censusing under these conditions. Ten counts were made on overcast mornings, five on raining or snowing mornings and one each on a foggy and a windy morning. Results of two counts will not be discussed as no comparative, fair morning census could be taken within a few days of the poor weather count.

Table 10. Comparison of total sightings recorded by three observers in simultaneous surveys.

Plot	Date	Observer	Horned Lark	McCown's Longspur	Other Species	Total
1	June 16	A	15	4	0	19
		B	12	4	2	18
		C	16	5	3	24
1A	June 16	A	9	4	6	19
		B	17	8	1	26
		C	15	8	3	26
1B	June 16	A	10	6	2	18
		B	7	12	2	21
		C	11	7	4	22
1	July 6	A	17	4	1	22
		B	8	7	2	17
		C	9	7	2	18
1A	July 6	A	12	10	0	22
		B	9	5	2	16
		C	11	6	1	18
1B	July 6	A	7	4	1	12
		B	5	7	2	14
		C	8	2	1	11

Table 11. Comparison of sightlings of territorial male McCown's Longspurs as recorded by three observers in simultaneous surveys.

Plot	Date	Location of Bird in Plot	Observer A	Observer B	Observer C
1	June 16	9/3	A*	--	--
1A	June 16	2/1	A	B†	B
		7/3	A	B	B
		10/3	A	B	--
		WMLξ	A	B	A
1B	June 16	3/2	A	A	A
		3/5	A	B	A
		1/3	A	B	A
		2/4	--	B	A
1	July 6	7/0	A	A	A
		4/2	A	A	A
		1/4	A	A	B
		0/0	A	A	A
		2/2	B	A	A
		4/4	§	A	A
		WML	A	B	A
1A	July 6	5/4	A	§	§
		1/4	A	§	§
		6/0	A	B	§
		10/1	B	§	A
		7/3	B	A	B
1B	July 6	8/2	A	A	B
		4/4	A	A	--
		9/1	§	A	§
		2/3	--	A	A
		3/5	§	A	§

* A = Registration

† B = Observation

ξ WML = Western Meadowlark

§ Bird known to be absent from plot or having a territory extending beyond plot boundaries.

The comparison of the inclement weather censuses with the nearest fair weather census can be found in Table 12. Precipitation, especially snow, caused the greatest discrepancy in survey results. The snows of April 14 and 26 drove all passerines (but not Mountain Plovers) from the plots, thus requiring reestablishment of territories after the storm. The lone Horned Lark recorded on April 14 merely flew over the plot but did not land. In general, numbers of Horned Larks observed appeared more easily depressed than those of McCown's Longspurs, except perhaps during windy conditions. Only half as many larks were seen on overcast mornings as compared to fair mornings, while the similar number was almost 60% for the longspur. Figures were 36% and 71%, respectively, for rainy mornings.

Registrations as well as observations decreased during poor weather. Only on 10 out of the 22 trials of Table 13 was a particular longspur recorded as a registration on both the fair and inclement weather censuses. Similar registrations occurred 53% of the time on overcast days but only 33% on windy days and 25% on rainy days.

For both emphasized species, fair weather mornings permit a much more accurate estimation of the breeding and the floating population.

Species Effectivity

The main premise of the preceding discussions is that when one surveys an area under favorable conditions territorial birds will make their presence known by singing. However, several factors can lead to chance omissions of birds which are in fact territorial. For example, they may simply not be on the study area at the time of the survey or may remain outside their territory and be dismissed as a surplus registration. Lengthy pauses in singing of some individuals can also lead to oversights. Enemar (1959) points out that birds with territories further from the path of traverse

Table 12. Comparison of censuses made during inclement weather conditions with the nearest fair weather census.

Date of Inclement Weather Census	Date of Fair Weather Census	Plot Censused	Type of Inclement Weather	Horned Lark			McCown's Longspur			Other Species			Total		
				I*	F†	Pξ	I	F	P	I	F	P	I	F	P
April 14	April 17	1	Snowing	1	13	7.7	0	10	0.0	0	2	0.0	1	25	4.0
April 19	April 17	1	Heavy fog	12	13	92.3	3	10	30.0	5	2	100.0+	20	25	80.0
April 26	April 24	1	Snowing	0	10	0.0	0	10	0.0	0	1	0.0	0	21	0.0
May 1	May 1	1	Windy	6	8	75.0	4	13	30.8	0	0	--	10	21	47.6
May 8	May 11	1	Overcast	3	11	27.3	9	9	100.0	2	0	100.0+	14	20	70.0
May 8	May 12	1A	Overcast	11	12	91.7	5	14	35.7	0	5	0.0	16	31	51.6
May 10	May 11	1	Overcast	4	11	36.3	5	9	55.6	0	0	--	9	20	45.0
May 10	May 12	1A	Overcast	4	10	40.0	1	10	10.0	0	3	0.0	5	23	21.7
June 6	June 8	1	Overcast	7	8	87.5	4	6	66.7	0	4	0.0	11	18	61.1
June 6	June 8	1B	Overcast	6	7	85.7	3	3	100.0	1	5	20.0	10	15	66.7
June 19	June 20	1	Overcast	5	11	45.4	5	7	71.4	2	1	100.0+	12	19	63.2
June 19	June 16	1B	Overcast	1	10	10.0	7	6	100.0+	0	2	0.0	8	18	44.0
June 23	June 24	1	Overcast	5	11	45.5	5	6	83.3	1	4	25.0	11	21	52.4
June 23	June 24	1B	Overcast	5	11	45.5	2	2	100.0	1	2	50.0	8	15	53.3
June 30	June 27	1	Heavy rain	2	12	16.7	2	4	50.0	0	3	0.0	4	19	21.1
July 3	July 5	1	Misting	8	14	57.1	4	6	66.7	0	2	0.0	12	22	54.5
July 3	July 6	1B	Misting	2	7	28.6	4	4	100.0	1	1	100.0	7	12	58.3

* I = Inclement weather count

† F = Fair weather count

ξ P = Percent I/F

Table 13. Comparison of inclement and fair weather censuses based on sightings of territorial male McCown's Longspurs.

Date of Inclement Weather Census	Date of Fair Weather Census	Types of Inclement Weather	Location of Bird in Plot	Fair Weather Census	Inclement Weather Census
May 1	May 1	Windy	7/1	A*	--
			4/2	A	A
			3/2	A	--
May 8	May 11	Overcast	8/4	A	B†
			7/1	A	A
			2/1	A	--
May 10	May 11	Overcast	8/4	A	--
			7/1	A	A
			2/1	A	A
			9/2	--	A
June 6	June 8	Overcast	8/4	A	A
			5/5	A	--
			5/3	A	--
			1/3	A	B
June 19	June 20	Overcast	1/4	A	A
			7/4	A	A
June 23	June 24	Overcast	1/4	A	A
			7/4	A	A
June 30	June 27	Heavy rain	1/4	A	--
			7/4	A	A
July 3	July 5	Misting	1/1	A	--
			4/3	A	--

*A = Registration

†B = Observation

are less likely to be recorded, as passing through a territory induces the holder to more readily proclaim his presence. Then, too, males are known to sing more frequently and defend their territory more aggressively early in the nesting cycle. Perhaps most importantly, different species inherently have different singing intensities.

Colquhoun (1940) employed "coefficients of relative conspicuousness to compensate for the differences in the ease of recording different species. Later Enemar (1959) introduced the term "species effectivity" which he defined as the "the percentage of the stationary population (of one species) which will be registered on the average at each standard survey." The reciprocal of species effectivity is the "measuring error," or the average percentage overlooked on each survey. The level of effectivity is of extreme importance in determining the degree of confidence with which the observer can view his results. For instance, densities based solely upon registrations for the Horned Lark, which has a very low effectivity, cannot be a very accurate figure.

Calculation of species effectivity is based upon the potential number of registrations that can be expected for that species. For example, if an area encompassing four territories is surveyed 10 times, the potential registration is 40. However, the potential is rarely realized, even for one individvidual. If only 20 registrations were actually recorded on the 10 censuses, the species effectivity would be 50%. Following this procedure, an analysis was made of the effectivity of the breeding species on the plots. Results are given in Table 14.

The first question concerning the results is why were Horned Larks, Brewer's Sparrows, Mountain Plovers, and Mourning Doves, all of which nested in at least one of the plots, omitted. Problems associated with censusing

Table 14. Species effectivity for some common birds on the Pawnee Site, 1972.

Species	No. of Stationary Males	No. of Trials	No. of Registrations	Species Effectivity (%)
McCown's Longspur	22	331	146	44
Lark Bunting	20	152	84	55
Western Meadowlark	5	35	18	51

the former two, including time of day and habitat, have already been mentioned. Their resulting effectivity, about 10% to 15% for both, is not considered the optimum that could be achieved. Lack of song and territory size in relation to plot size (about 2:1) invalidate any estimation of plover effectivity as does absence of territorial advertisement in Mourning Doves.

Lark Buntings has the highest effectivity of the three species adequately measured, 55%. The overall figures for the Western Meadowlark and McCown's Longspur were 51% and 44%, respectively. Variation among individuals for all three was quite high, for example, ranging from 30% to 100% among Lark Buntings. On the average survey about one out of every two territories went unnoticed for these species. This was a dramatic illustration of the need for multiple surveys. These effectivity figures were at the low end of the 50% to 70% range Enemar (1959) found for some common forest birds. Additional years' data are necessary to determine if this low effectivity as measured is the true picture for the prairie avifauna.

If each survey is 50% effective, then each additional survey only increases the probability of registering a new individual by 0.5. Therefore, it would take at least five surveys at this level of effectivity to be 96% confident of counting all territorial males. Obviously, several more surveys are needed to produce the clusters of registrations necessary to delineate territories.

ROADSIDE CENSUS

Since July 1968, periodic counts have been made on a 50-stop, 39.4-km (50-mile) avian roadside census route on the Pawnee National Grassland. The procedure employed was that of the North American Breeding Bird Survey as described by its originators, C. S. Robbins and W. T. Van Velzen (1967). Basically, it involved recording all birds heard and all birds seen within a 0.40-km (0.25-mile) radius of a designated stop. Stops were located 0.8 km (0.5 mile) apart along the predetermined route. Counts of route in the Breeding Bird Survey begin promptly at one-half hour before sunrise and are made only annually. However, counts of the Pawnee route, which is not an official part of the Survey, were begun at sunrise and made weekly during the breeding season (April 1 to August 1) and monthly during the remainder of the year.

The primary objective of the Breeding Bird Survey "is to measure changes in bird populations on a regional or continental basis" (Robbins and Van Velzen 1967). This is accomplished by developing indices of relative abundance for each species for comparison with other species and other areas or years. In addition, the technique also yields data on seasons of occupancy and migration timing and numbers when several counts are made during the season. However, useful the roadside survey is in detecting large-scale fluctuations in bird populations, it is not in itself an accurate measure of density. If correction factors could be found to convert the roadside indices into actual densities, the roadside survey would be much preferred to plot counts because of the additional information the former yields.

With this goal in mind, data from the 1972 breeding season were submitted to the Colorado State University Computer Center for analysis by one of the statistical library programs, STAT38R, Stepwise Multiple Regression. In this program independent variables were entered into the desired regression equation in an ordered fashion with the variable that made the greatest reduction in the error sum of squares, and thus had the highest partial correlation, entered first. Any variable could be forced into the equation regardless of whether or not it was significant, if certain default operations were deleted. This permitted assessment of the relative influence that nonsignificant variables exerted on the dependent variable.

The problem, then, was to develop equations capable of accurately predicting breeding densities of the emphasized species from data collected on a series roadside counts made during that breeding season. However, accurate densities necessary for comparison were available only for species which nested on the 8.1-ha census plots in sufficient numbers. These included the Horned Lark, Lark Bunting, McCown's Longspur, Western Meadowlark and Brewer's Sparrow. Total numbers of these species seen during the weekly censuses of the six original census plots constituted the dependent variables. There were seven independent variables: corresponding totals for each species from the weekly roadside counts and temperatures, wind velocities, and cloud covers (based on Weather Bureau code numbers) at the start and end of each weekly plot count (all plots were counted in one morning). To check if the roadside was also being influenced by these weather factors, the procedure was reversed. The roadside counts were then taken to be the dependent variables with the independent ones being the plot counts and the temperatures, wind velocities, and cloud covers at the start and end of each weekly roadside survey. Results of the first analysis with the plot counts as the dependent variables can be seen in Table 15, while the results of the reversed analysis are in Table 16.

The most readily apparent result of the first test was the surprisingly low correlation between the plot and roadside censuses of a given species. For the five species, only the Lark Bunting censuses showed a significant ($p = 0.006$) correlation. Numbers of McCown's Longspurs seen during plot counts were significantly ($p < 0.050$) correlated with the starting temperature and starting cloud cover of these counts. Brewer's Sparrow numbers also showed some relationship ($p = 0.087$) with the starting cloud cover and a

Table 15. Results of test one with the plot counts as the dependent variables and the roadside counts and weather factors associated with the plot counts as the independent variables (df = 1,15).

Species	Step No.	Independent Variable Entered†	R^2	Increase in R^2	Partial F-Valueξ
Horned Lark	1	Start T	0.16310	0.16310	2.73
	2	End W	0.25059	0.08749	1.52
	3	End T	0.29884	0.04825	0.83
	4	End C	0.41863	0.11979	2.27
	5	Start W	0.47806	0.05944	1.14
	6	Start C	0.53332	0.05525	1.07
	7	HL Road	0.53847	0.00515	0.09
Lark Bunting	1	LB Road	0.42441	0.42441	***10.32
	2	Start T	0.53425	0.10984	* 3.07
	3	End C	0.60019	0.06954	1.98
	4	End T	0.65690	0.05671	1.82
	5	Start W	0.68237	0.02546	0.80
	6	End W	0.68524	0.00287	0.08
	7	Start C	0.68610	0.00086	0.02
McCown's Longspur	1	Start T	0.33201	0.33201	** 6.96
	2	Start C	0.56133	0.22932	** 6.80
	3	MC Road	0.64089	0.07955	2.66
	4	End T	0.71095	0.07006	2.67
	5	End C	0.76162	0.05068	2.13
	6	End W	0.80104	0.03942	1.78
	7	Start W	0.80464	0.00359	0.15
Western Meadowlark	1	ML Road	0.02439	0.02439	0.35
	2	End W	0.06095	0.03656	0.51
	3	Start T	0.09604	0.03509	0.47
	4	Start C	0.17343	0.07739	1.03
	5	End C	0.17612	0.00270	0.03
	6	Start W	0.17693	0.00081	0.01
	7	End T	0.17743	0.00050	0.01
Brewer's Sparrow	1	Start W	0.36290	0.36290	** 7.98
	2	Start C	0.49656	0.13366	* 3.45
	3	BS Road	0.50889	0.01233	0.30
	4	End W	0.51538	0.00648	0.15
	5	Start T	0.52236	0.00699	0.15
	6	End T	0.58483	0.06246	1.35
	7	End C	0.59133	0.00650	

† = Temperature
W = Wind velocity
C = Cloud cover

ξ Preceding numbers:
*** = Significant at 0.01 level
** = Significant at 0.05 level
* = Significant at 0.10 level

Table 16. Results of test two with the roadside counts as the dependent variables and the plot counts and weather factors associated with the roadside counts as the independent variables (df = 1,15).

Species	Step No.	Independent Variable Entered†	R^2	Increase in R^2	Partial F-Valueξ
Horned Lark	1	Start T	0.13139	0.13139	2.12
	2	Start C	0.25655	0.12516	2.19
	3	HL Plot	0.43667	0.18007	* 3.84
	4	End T	0.52625	0.08963	2.08
	5	End W	0.55053	0.02428	0.54
	6	End C	0.57390	0.02338	0.49
	7	Start W	0.58247	0.00857	0.16
Lark	1	LB Plot	0.42441	0.42441	***10.32
	2	Start C	0.53893	0.11452	* 3.23
	3	Start T	0.54798	0.00905	0.24
	4	End T	0.56062	0.01264	0.32
	5	End W	0.57225	0.01163	0.27
	6	Start W	0.58042	0.00816	0.18
	7	End C	0.58401	0.00359	0.07
McCown's Longspur	1	MC Plot	0.31956	0.31956	** 6.58
	2	Start W	0.37750	0.05794	1.21
	3	Start T	0.53201	0.15450	** 3.96
	4	Start C	0.56564	0.03364	0.85
	5	End T	0.58709	0.02144	0.52
	6	End W	0.59318	0.00609	0.14
	7	End C	0.59370	0.00052	0.01
Western Meadowlark	1	End T	0.16836	0.16836	2.83
	2	ML Plot	0.19112	0.02276	0.37
	3	Start T	0.20785	0.01673	0.25
	4	End C	0.21891	0.01106	0.16
	5	Start C	0.23200	0.01309	0.17
	6	End W	0.23902	0.00702	0.08
	7	Start W	0.24263	0.00361	0.04
Brewer's Sparrow	1	Start T	0.20356	0.20356	* 3.58
	2	Start W	0.29304	0.08948	1.65
	3	Start C	0.33325	0.04021	0.72
	4	End T	0.49692	0.16367	* 3.58
	5	End C	0.58059	0.08367	2.00
	6	End W	0.59866	0.01807	0.41
	7	BS Plot	0.60064	0.00198	0.04

† T = Temperature
W = Wind velocity
C = Cloud cover

ξ *** = Significant at 0.01 level
** = Signigicant at 0.05 level
* = Significant at 0.10 level

significant ($p = 0.014$) correlation with the starting wind velocity. Numbers of Horned Larks and Meadowlarks had no correlation ($p > 0.130$) to any of the independent variables of the first test.

Reasons for the lack of correlation among variables was not easily discernible. The occasional scarcity of Meadowlarks during plot counts, e.g., only one seen on six plots on June 19, probably contributed to the very low percentage of its variation that was accounted for by regression. This may have been partially true for Brewer's Sparrows, also. However, this was certainly not true of the other three species. Also, it was expected that wind velocities would exert a greater effect on aerial singers, such as Lark Buntings or McCown's Longspurs, than on nonaerial singers like the Brewer's Sparrow. However, the opposite was true. Lack of significance in this case was probably caused by the cessation of either census when wind velocities became extreme (usually 14 mph or more). Apparently, unknown or unmeasured factors, possibly concerning the observer or the phenology of the breeding season, determined the relationship between the two counts.

As part of the phenological aspect of the problem, it was known that Lark Buntings and Brewer's Sparrows do not arrive on the Pawnee until after the breeding season for the area as a whole had already begun. Both of these species tended to remain in large flocks near the roads for at least a week after their arrival before dispersing into their individual territories in the pastures. Therefore, it was suspected that counts made during this period prior to territorial establishment were strongly influenced by chance encounters with flocks and thus subject to unnecessarily large fluctuations when compared to later counts. For this reason, two data points collected during this time were omitted for both of the above species, and test one was rerun.

The resulting values of the rerun (Table 17) were quite different in each case. The simple r-squared value for the Lark Bunting counts more than doubled from 0.42441 to 0.96658, indicating the roadside count alone was a fairly accurate predictor of the plot counts during the 1972 breeding season of this species. However, the contribution of the counts toward the multiple r-squared value increased little for the Brewer's Sparrow, althouh some weather variable's contributions did show a substantial increase. For both species, a considerable change occurred in the order in which the variable were entered into the regression equation. Thus the decision to delete data points during migration for the reason stated appeared valid for the Lark Bunting, but only partially so, if at all, for the Brewer's Sparrow.

In summary, data gathered during the roadside counts were not capable of predicting the numbers of birds seen during plot counts within a reasonable degree of accuracy. This was true even when six weather variables were employed in an attempt to increase the predictability. The one exception was for Lark Buntings where two significant ($p < 0.010$) variables accounted for 97.9% of the variation in plot count numbers after deletion of data points gathered during migration. The final conclusion is that any estimation of breeding density must still be based on plot counts.

PRODUCTIVITY

A total of 422 nest of 22 species were found during the 1972 breeding season. The eight emphasized species (Mourning Dove, Horned Lark, Loggerhead Shrike, Western Meadowlark, Lark Bunting, Brewer's Sparrow, McCown's Longspur, and Chestnut-collared Longspur) accounted for 318 of these nesting attempts. Nest were checked at least weekly after the initial visit to determine clutch size and number of young hatching and fledging or causes of failure.

Table 17. Results of rerun of test one after deletion of two data points for the Lark Bunting and Brewer's Sparrow that were collected during migration. Plot counts are the dependent variables and roadside counts and weather factors associated with the plot counts are the independent variables (df = 1,13).

Species	Step No.	Independent Variable Entered†	R^2	Increase in R^2	Partial F-Valueξ
Lark Bunting	1	LB Road	0.96658	0.96658	***404.97
	2	Start W	0.97200	0.00541	2.51
	3	End C	0.98409	0.01209	*** 9.12
	4	Start T	0.98490	0.00081	0.59
	5	Start C	0.98586	0.00096	0.68
	6	End T	0.98595	0.00009	0.06
	7	End W	0.98598	0.00003	0.02
Brewer's Sparrow	1	End W	0.27878	0.27878	** 5.41
	2	Start C	0.41706	0.13828	3.08
	3	Start T	0.44607	0.02901	0.63
	4	BS Road	0.53969	0.09361	2.24
	5	End T	0.63555	0.09586	2.63
	6	Start W	0.70443	0.06889	2.10
	7	End C	0.72299	0.01856	0.54

† T = Temperature
W = Wind velocity
C = Cloud cover

ξ *** = Significant at 0.01 level
** = Significant at 0.05 level

Type of supporting vegetation and nest height were recorded for aboveground nesters, and vegetation adjacent to the nest was recorded for ground nesters. Table 18 indicates the nesting, hatching, and fledging success for all species studied. However, the following discussion will be limited to species represented by more than five nests.

Ground nesting species included the Horned Lark, McCown's Longspur, Mountain Plover, Lark Bunting, Western Meadowlark and Chestnut-collared Longspur (*Calcarius ornatus*). The first three preferred heavily grazed pastures while the last three were found primarily in moderate to lightly grazed ones. Brewer's Sparrows nested only in fourwing saltbush on the study area. Loggerhead Shrikes (*Lanius ludovicianus*) nested in saltbush and a variety of trees, while Black-billed Magpies (*Pica pica*) and Western Kingbirds (*Tyrannus verticalis*) nested only in tress in 1972. Say's Phoebe (*Sayornis saya*), Barn Swallow (*Hirundo rustica*), and Cliff Swallow (*Petrochelidon pyrrhonota*) nests were found only in man-made structures, especially abandoned houses and wooden bridges, although phoebes were thought to have nested on cliffs and erosional remnants in nearby areas. The most adaptable nester was the Mourning Dove which nested on the ground in heavily or lightly grazed pastures, in small or very large trees, under bridges and in barns. Aboveground dove nests were four times more plentiful in the sample than ground nests, but this reflected ease of finding rather than true proportions.

Nesting success, or the percent of total nests observed successfully fledging at least one young, varied from 40.0% for the Meadowlark and the Mountain Plover to 58.8% for the Chestnut-collared Longspur among ground nesters. All aboveground nesters had a higher nesting success except the Brewer's Sparrow and the Cliff Swallow.

This better success was no doubt due to the added protection of an aboveground nest which guarded against mammalian predation. Obviously

Table 18. Summary of nesting data for the Pawnee Site, 1972.

Species	Total Nests Observed*	Complete Nests*	Successful Nests*	Percent Success*	Eggs Laid	Eggs Hatched	Percent Hatched*	Young Fledged	Percent Fledged*
Mallard	1	1	0	0.0	7	0	0.0	0	0.0
Mountain Plover	10	10	4	40.0	29	10	34.5	10	34.5
Killdeer	1	1	1	100.0	4	3	75.0	3	75.0
Mourning Dove	99	97	54	54.6	202	127	62.9	101	50.0
Rock Dove	2	2	1	50.0	3	2	66.7	2	66.7
Common Nighthawk	3	3	2	66.7	6	3	50.0	3	50.0
Western Kingbird	12	11	7	63.6	47	30	63.8	24	51.1
Say's Phoebe	20	19	17	85.0	93	66	71.0	58	62.4
Horned Lark	49	46	22	46.8	122	67	54.9	46	38.7
Barn Swallow	29	26	18	66.7	118	72	61.0	58	65.4
Cliff Swallow	7	6	3	50.0	27	23	85.2	9	47.4
Black-billed Magpie	12	6	10	83.3	36	32	88.9	13	36.1
Mockingbird	2	2	2	100.0	7	7	100.0	6	85.2
Robin	1	1	0	0.0	4	0	0.0	0	0.0
Loggerhead Shrike	22	21	18	81.8	138	119	86.2	98	71.0
Starling	1	1	1	100.0	4	4	100.0	4	100.0
House Sparrow	3	2	2	66.7	6	4	66.7	4	66.7
Western Meadowlark	15	14	6	40.0	63	30	47.6	19	30.2
Lark Bunting	59	49	31	55.4	198	134	69.1	81	43.3
Brewer's Sparrow	17	15	7	41.2	49	31	63.3	22	44.9
McCown's Longspur	39	38	21	53.9	114	71	62.3	48	42.1
Chestnut-collared Longspur	18	16	10	58.8	56	28	50.0	23	41.1
TOTAL	422	377	231						

* See text for definition.

Brewer's nests, which were exclusively in shrubs and averaged only 27.6 cm high, enjoyed no such advantage. Too few Cliff Swallow nests were followed to adequately estimate their success. Say's Phoebes had the highest nesting success, 85%, as 17 out 20 attempts succeeded. Mourning Doves had 36.8% and 58.8% success for ground and aboveground nests, respectively, for a combined total of 54.6%.

Predation was the greatest cause of nest failure, accounting for 115 out of 169 losses, or 68.1% (Table 19). This number included 80.4% of all ground nest failures and 49.3% of all aboveground failures. It also included nest predation by the Western Meadowlark, two cases of egg destruction and one of killing a nestling. To our knowledge, the Meadowlark has never before been reported to destroy nests.

Desertion of eggs or young was the second most important cause of nest failures, amounting to 19.5% of all losses. Only in the Barn Swallow did desertion cause more failures than predation. Desertion was generally lower among ground nesters. Destruction of nests by weather was responsible for 12.4% of all unsuccessful attempts. However, it is believed direct losses due to weather occurred only in the Mourning Dove and Cliff Swallow. In the latter species, collapse of nests accounted for all failures.

Certain biases were present in the determinations of the various percentages. Many of the Meadowlark nest were found in ditches with tall grass. These ditch nests probably represent a greater proportion in the sample than in the population, as they were easier to find. Since ditches are common routes of travel for many small mammals, predation was undoubtedly greater on these nests. This could have had a significant influence on the result because of the small sample size for this species. Percentages were probably

Table 19. Causes and proportions of nest failures on the Pawnee Site, 1972.*

Species	Number of Nest Failures	Percent Predation	Percent Weather Destruction	Percent Desertion
Mountain Plover	6	50.0	--	50.0
Mourning Dove	45	46.7	40.0	13.3
Western Kingbird	4	75.0	--	25.0
Say's Phoebe	3	100.0	--	--
Horned Lark	25	84.0	--	16.0
Barn Swallow	8	37.5	--	62.5
Cliff Swallow	3	--	100.0	--
Black-billed Magpie	2	50.0	--	50.0
Loggerhead Shrike	4	100.0	--	--
Western Meadowlark	9	55.6	--	44.4
Lark Bunting	25	88.0	--	12.0
Brewer's Sparrow	10	70.0	--	30.0
McCown's Longspur	18	83.3	--	16.7
Chestnut-collared Longspur	7	100.0	--	--
TOTAL	169	68.1	12.4	19.5

* Only for species represented by five or more total nests observed.

in error for the Mountain Plover, also. The precocial nature of its young made any assessment of nesting success quite difficult.

As stated earlier, nesting success was based upon total nests observed, not just complete nests. This procedure tends to slightly overestimate the true percentage as successful nests have a greater probability of being included in the sample simply because they are in existence longer than unsuccessful ones. This is not necessarily true, however, of nest failures because of abandonment. It is hoped the increased number of nests of the emphasized species over previous years and the similarity of the number of total nests observed and complete nests overcome any overestimation. Should the reader wish, corrections are available for estimating the number of unfound failures to compensate for nests found after incubation had begun (Woolfenden and Rohwer 1969).

One further bias concerns the percentages of nest failures. It was noted that weather caused losses in only two species. However, weather was probably the prime factor leading to desertion of some Horned Lark and Mountain Plover nests. These cases, though, were included in the desertion figures, since abandonment was the proximate reason for the failures.

Hatching and fledging success, the total number of eggs laid which hatched and fledged, were again generally higher in the aboveground nesters. However, some exceptions occurred. Lark Buntings hatched 69.1% of their eggs, higher than four species of aboveground nesters. Magpies fledged only 36.1%, despite having the highest hatching success, 89%. Overall, ground nesters fledged about 35% to 45%, while aboveground nesters were more variable. Shrikes were the most successful at fledging young in 1972, achieving 71%.

Reproductive rates (Table 20) provide additional comparisons between species and are necessary for calculations of biomass. These rates include

Table 20. Reproductive rates of birds of the Pawnee Site, 1972.*

Species	Number of Nests	Clutch Size			Hatched per Nest	Hatched per Successful Nest	Fledged per Nest	Fledged per Successful Nest
		Mean	Mode	Range				
Mountain Plover	10	2.90	3	2-3	1.00	2.50	1.00	2.50
Mourning Dove	97	2.04	2	1-4	1.28	1.90	1.02	1.87
Western Kingbird	11	4.27	4	3-5	2.73	3.75	2.18	3.43
Say's Phoebe	19	5.17	5	4-6	3.67	3.88	3.22	3.63
Horned Lark	46	2.65	3	2-4	1.49	2.39	1.05	2.19
Barn Swallow	26	4.54	5	3-5	2.77	3.60	2.32	3.41
Cliff Swallow	6	3.86	4	3-5	3.29	3.83	1.50	3.00
Black-billed Magpie	6	6.00	6	5-7	5.33	5.33	2.17	2.60
Loggerhead Shrike	21	6.57	7	6-7	5.67	6.26	4.67	5.76
Western Meadowlark	15	4.20	4,5	3-6	2.14	5.00	1.36	
Lark Bunting	49	3.81	4	3-5	2.68	3.44	1.72	3.00
Brewer's Sparrow	15	3.06	3	2-4	1.94	3.10	1.38	3.14
McCown's Longspur	38	3.00	3	2-4	1.87	2.54	1.26	2.40
Chestnut-collared Longspur	16	3.15	3	3-4	1.75	2.80	1.44	2.56

* Only for species represented by five or more nests observed.

clutch size (mean, mode, and range) and number hatched and fledged per nest and per successful nest.

Mean clutch size of ground nesters ranged from 2.90 in the Mountain Plover to 4.20 in the Meadowlark. Shrikes had the largest average clutch, 6.57, and doves had the smallest, 2.04, of any aboveground nester. This latter value was surprising as doves are usually believed to be determinate layers with a two-egg clutch. All dove clutches in excess of two (four nests with three and two with four) were in aboveground situations.

Fewer young were hatched or fledged per nest in ground nesting species, mainly reflecting their smaller clutches. All nidicolous species naturally showed a decrease between number hatched and number fledged. The species with the highest hatching percentage, the Black-billed Magpie, had the greatest loss between hatching and fledging, losing an average 3.16 young per nest.

GROWTH RATES

Preliminary results of nestling growth studies conducted during the 1970 field season were presented by Strong and Ryder (1971). Follow-up work was completed and reported by Strong (1971). Endeavors in this regard were limited to two species during the 1972 field season for different reasons. Brewer's Sparrow growth results for previous years were considered incomplete owing to small sample size, and investigations on it were thus continued. Data gathering persisted on Loggerhead Shrikes even though the number of young weighed in earlier years was adequate as the authors are attempting outside publication on this species.

Young shrikes averaged 4.06 g during their first day (Table 21). They grew rapidly until their 12th day, gaining 3.11 g per day over this period and achieving 89% of their fledging weight. From day 12 to day 17 of the nestling

Table 21. Growth of Loggerhead Shrike nestlings on the Pawnee, 1969-1972.

Age (days)	Number Weighed	Mean Weight (g)	Percent of Asymptote	Standard Error	Minimum (g)	Maximum (g)	Daily Gain (g)
0	18	4.06	9.4	0.1114	3.2	4.9	--
1	39	5.92	13.7	0.1672	4.0	8.6	1.86
2	44	8.69	20.2	0.2231	4.9	11.7	2.77
3	29	11.05	25.7	0.3120	8.3	14.8	2.36
4	37	14.45	33.6	0.4258	10.3	19.5	3.40
5	39	18.19	42.3	0.3306	14.2	23.9	3.74
6	26	21.10	49.1	0.5618	16.1	27.8	2.91
7	36	25.76	59.9	0.4052	16.7	30.1	4.66
8	36	29.89	69.5	0.3888	24.3	35.5	4.13
9	20	33.95	79.0	0.7652	25.8	39.7	4.06
10	25	35.65	82.9	0.8720	23.6	43.5	1.70
11	33	38.29	89.1	0.8328	27.8	46.6	2.64
12	42	39.23	91.2	0.5041	31.3	44.8	0.94
13	46	39.84	92.7	0.5157	33.1	46.7	0.61
14	22	42.50	98.8	0.7111	36.9	48.1	2.66
15	6	42.53	98.9	0.6048	41.2	45.4	0.03
16	5	43.22	100.5	2.0660	36.1	48.6	0.69
17	7	42.07	97.8	0.8869	38.1	46.0	-1.15
18	8	43.55	101.3	0.5255	41.0	46.3	1.48
TOTAL	518						

period, growth was slow and showed some fluctuation. Individuals occasionally lost weight during this time. Birds averaged 42.07 g on their 17th day when most broods fledged.

The asymptote of Table 21 was estimated and adjusted by use of Ricklefs' (1967) technique of fitting growth curves. This procedure transforms the growth curve into a straight line, permitting graphical measurement of the slope. The slope is then directly proportional to the growth rate constant, K. Using this method, K for the loggerhead was found to be 0.387.

Providing similar equations are used to fit the growth curves (there are three possibilities), both intra- and interspecific comparisons can be made directly from the K values. For curves fit by different equations, other growth indices are available. The time required to achieve from 10% to 90% of the asymptote, t_{10-90}, is sometimes used. For this study t_{10-90} was 11.3 days. Similarly, the time needed to attain 50% of the asymptote, t_{50}, was 5.8 days. Both t_{10-90} and t_{50} have an inverse relationship with the K value, for obviously as the rate of growth increases, the time required to reach a certain level of growth decreases.

Obtaining accurate measurements on the growth of Brewer's Sparrows is still hampered by lack of sufficient data, but preliminary estimates have been calculated. Brewer's weighed 1.38 g at hatching and gained an average of 0.95 g until fledging on day ten (Table 22). Unlike the shrike growth curve, that for the Brewer's Sparrow showed little leveling at its upper reaches and no fluctuation or weight loss.

Similar computations of growth rate indices for the Brewer's Sparrow were made as for the shrike. The t_{50} value for the sparrow as 3.6 days. The K value for the Brewer's Sparrow was found to be 0.520. This indicates a growth about one and two-thirds times as fast as that of the loggerhead.

Table 22. Growth of Brewer's Sparrow nestlings on the Pawnee, 1970 and 1972.

Age (days)	Number Weighed	Mean Weight (g)	Percent of Asymptote	Standard Error	Minimum (g)	Maximum (g)	Daily Gain (g)
0	10	1.38	13.9	0.0714	1.00	1.65	--
1	7	2.17	21.9	0.1263	1.76	2.53	
2	11	3.44	34.7	0.0906	2.70	3.90	1.27
3	5	4.62	46.7	0.0407	4.51	4.75	1.18
4	5	5.97	60.3	0.1241	5.66	6.35	1.35
5	5	6.60	66.7	0.1182	6.40	7.11	0.63
6	4	7.24	73.1	0.0640	7.11	7.45	0.64
7	4	8.53	86.2	0.1302	7.10	9.32	1.29
8	3	9.08	91.7	0.3536	8.60	9.94	0.55
9	3	9.90	100.0	0.0468	9.80	10.00	0.82
10	1	9.90	100.0	--	--	--	0.00
TOTAL	58						

It is, however, quite near the figures of 0.552, 0.542, 0.511, and 0.480 that Strong (1971) calculated for the Meadowlark, Horned Lark, and McCown's and Chestnut-collared Longspur, respectively. The rapid growth of the Brewer's when compared to other aboveground nesters may be partially explained by the high level of predation it experiences. It should be remembered that the low level of nesting success in Brewer's Sparrow, which was caused mostly by predation, was more similar to ground nesting species than to aboveground nesting species. Apparently, then, Brewer's Sparrow growth more closely resembled that of ground nesters than that of other aboveground nesters because of similar stresses.

NESTING PHENOLOGY

Studies of nesting phenology, based upon the number of nests initiated per week, were continued in 1972. Nests for the eight emphasized species were backdated using standard incubation and rates of laying periods to determine the date of laying of the first egg. These dates were then grouped weekly to construct graphs that could be used to estimate the number of nesting attempts for each species and compared to previous years. Discussion of 1970 and 1971 results was presented by Strong (1971).

As in past years, Horned Larks were the earliest nesters; they began laying in late April (Fig. 7). Two definite peaks were found in their nest initiation curve. However, both peaks occurred later than in previous years. This may have been due to a late April snowstorm that, at least in 23E, drove all Horned Larks from their already established territories and thus delayed the breeding season. The nesting season apparently lasted 2 weeks longer than in any other year, but this was probably a reflection of the researcher's effort rather than the bird's.

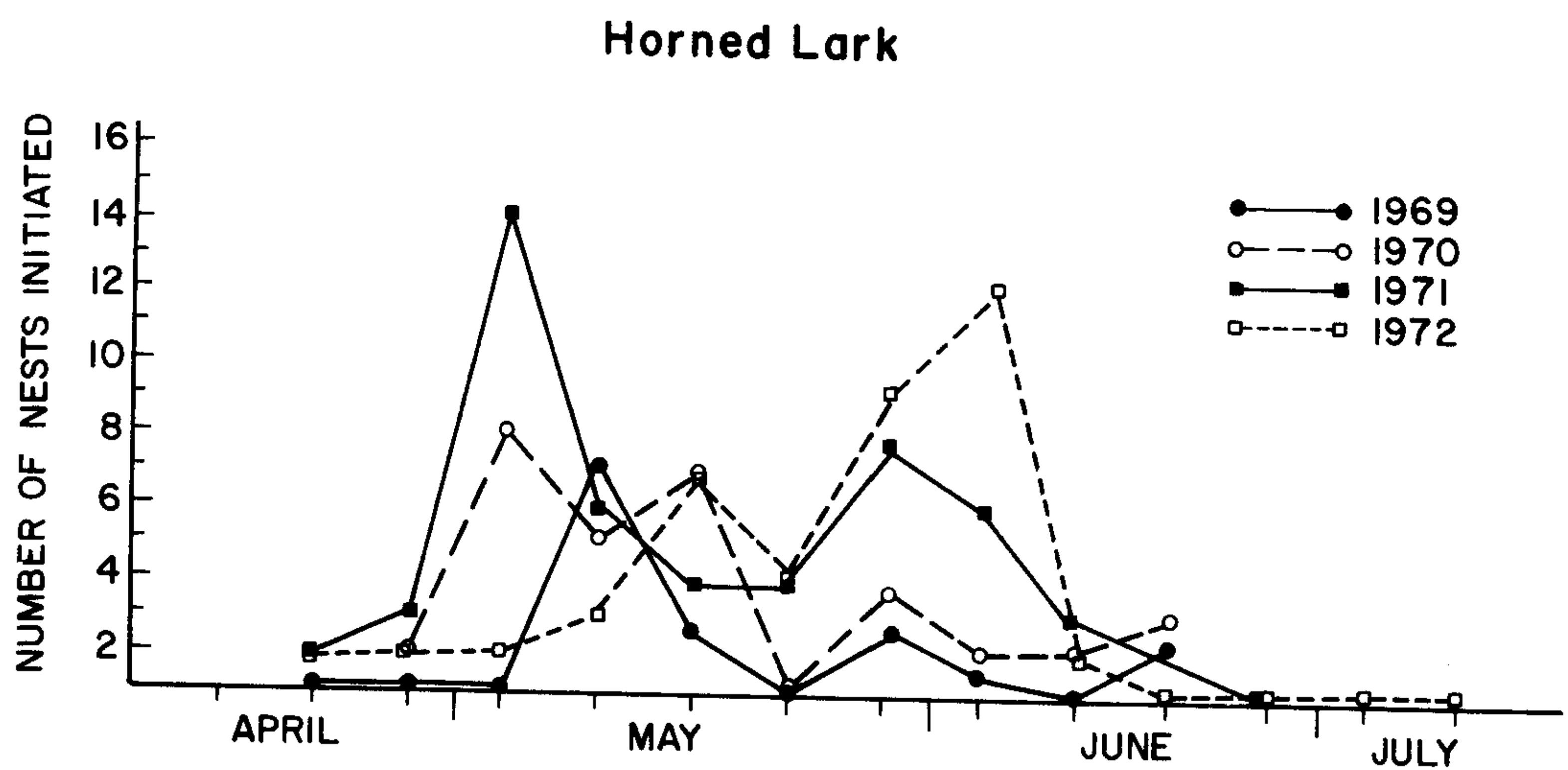

Fig. 7. Nesting phenology of Horned Larks on the Pawnee Site, 1969-1972.

The occurrence of two peaks was an indication that two broods were attempted per season. Maher (1970) believed this was also a possibility at the Matador Site in Saskatchewan. Another fact pointing toward double-broodness was the high percentage of nests that were located in close proximity to another nest.

McCown's Longspurs began nesting in the second week in May and continued until the second week in July (Fig. 8). Again, two peaks were evident in the nest initiation curve and were later than in previous years. However, in 1971 there was only one peak, while in 1970 at least two and possibly three occurred. It appeared that McCown's was also double-brooded, but the evidence was inconclusive. Felske (1971) thought two broods per season were probable at the Matador Site.

Western Meadowlarks began nesting very early in May and continued until early June (Fig. 9). The 1971 nesting season began 1 week later and lasted 1 week longer, while the 1970 nesting started 3 weeks later and lasted 2 weeks longer. Since Horned Lark and McCown's Longspur nesting seasons were later than in previous years, it appeared the same factors do not exert the same influences on different species. It is possible the polygamous breeding habits of the Meadowlark confounded this method of analysis and made it invalid. However, the possibility of double-broodedness for this species cannot be ruled out. The raising of two broods per season for the Meadowlark was reported by Bent (1958).

The first Lark Bunting nest was found in the second week in May and last in late July (Fig. 10). One definite peak and perhaps a smaller second one were noted in 1972. The timing of both was in close agreement with previous years. As evidenced by this study, Lark Buntings may have attempted

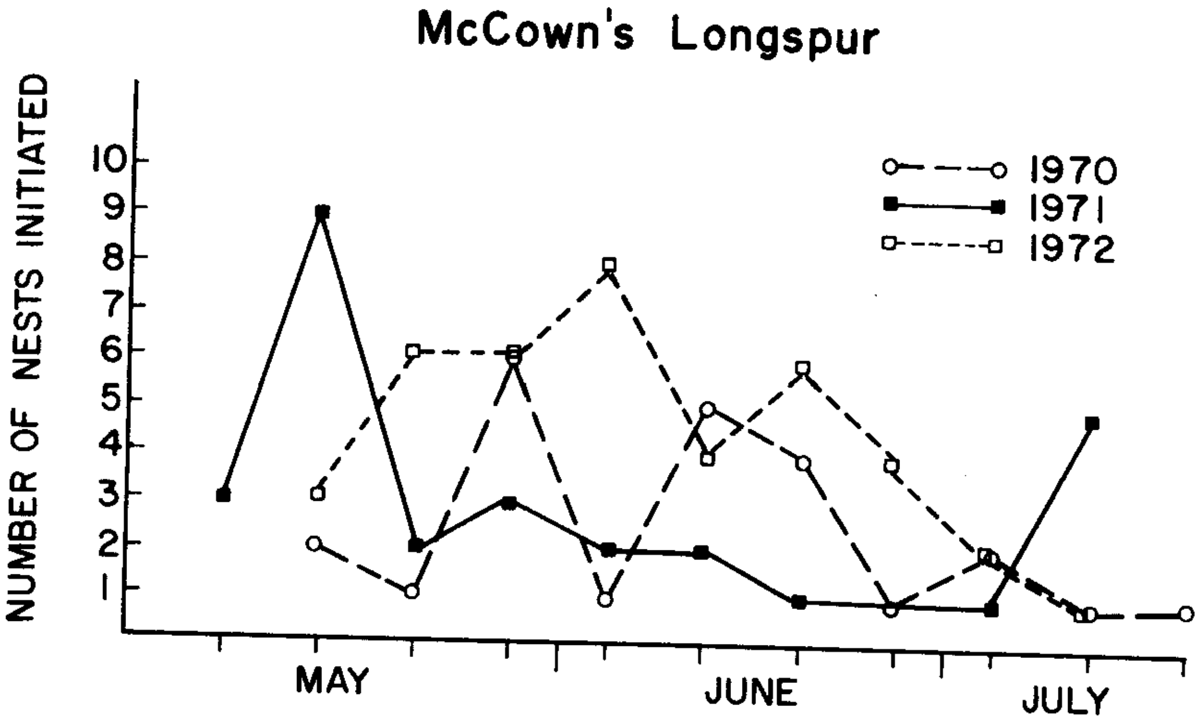

Fig. 8. Nesting phenology of McCown's Longspurs on the Pawnee Site, 1970-1972.

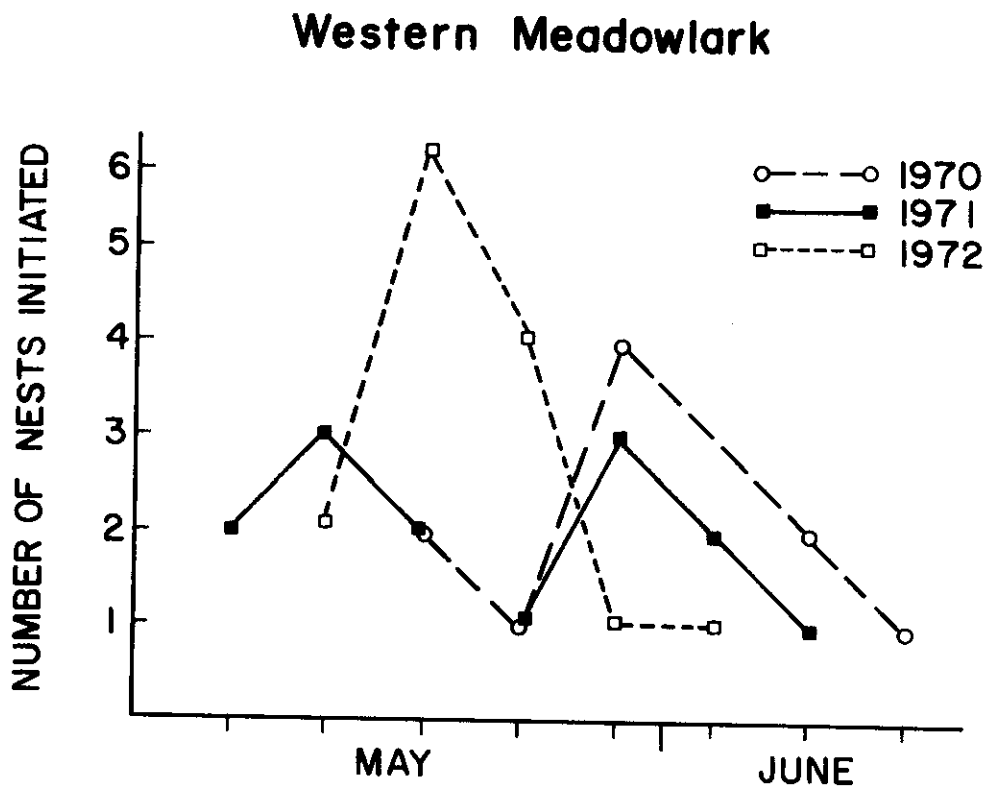

Fig. 9. Nesting phenology of Western Meadowlarks on the Pawnee Site, 1970-1972.

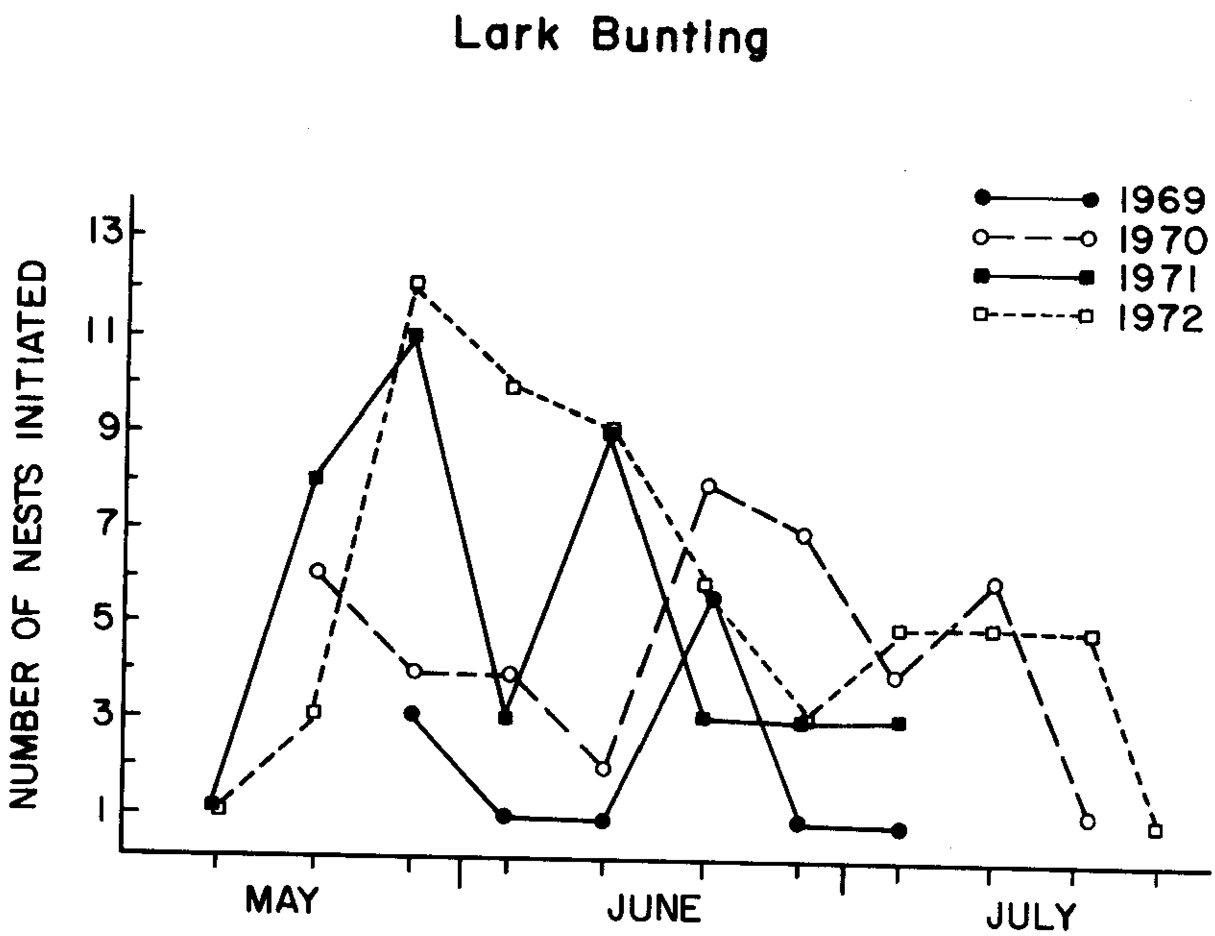

Fig. 10. Nesting phenology of Lark Buntings on the Pawnee Site, 1969-1972.

two broods per season. However, Creighton (personal communication), who has intensively studied this species for several years at the Pawnee Site, does not believe second broods are attempted.

Brewer's Sparrows nested from late May until late July 1972 (Fig. 11). The ending date was 2 weeks later than in previous years, but again this was probably just a reflection of nest searching effort. Small sample size and gaps in the curves made any conclusions about peaks of nesting activity difficult. It is possible, though, that some second broods were attempted.

The 1972 nesting season of the Loggerhead Shrike was very similar to 1970 and 1971, indicating a well-defined breeding season (Fig. 12). Nesting lasted from early May to mid-June. It was believed that the extension of the season into June in 1972 and 1970 was primarily due to renesting efforts. The occurrence of one definite peak in 3 out of the 4 years indicated the shrikes were single-brooded. However, Miller (1931) reported second broods to be common throughout most of their range.

Mourning Doves again had the longest nesting season, lasting from early May to early August when nest searching was discontinued (Fig. 13). The ending dates in 1970 and 1971 were not comparable as they indicated not the end of the nesting season, but the end of the nest searching. Several peaks were shown for each year, illustrating the multi-broodness which is well documented for this species.

For the first time, a sufficient number of Chestnut-collared Longspur nests were located to permit a determination of its nest initiation curve (Fig. 14). The first nest was found in the third week in May and the last in the fourth week in June. Only one peak of nesting attempts was evident. This was somewhat surprising in view of the two peaks shown by

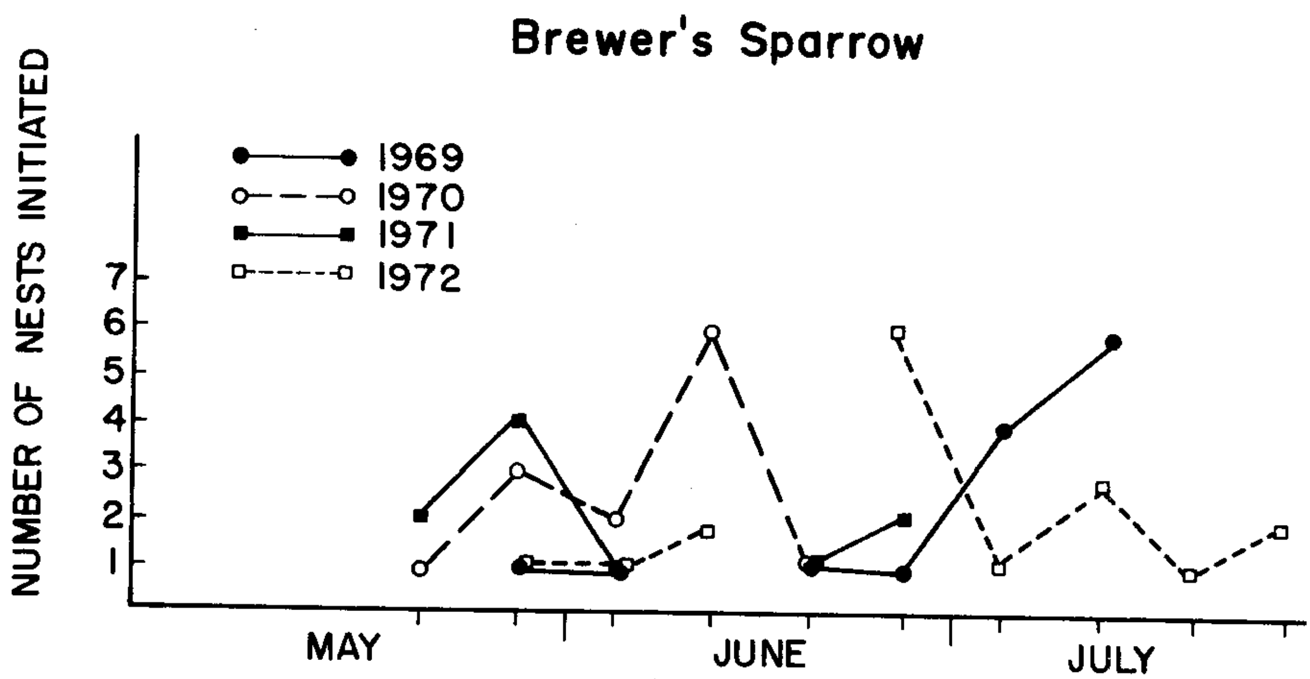

Fig. 11. Nesting phenology of Brewer's Sparrows on the Pawnee Site, 1969-1972.

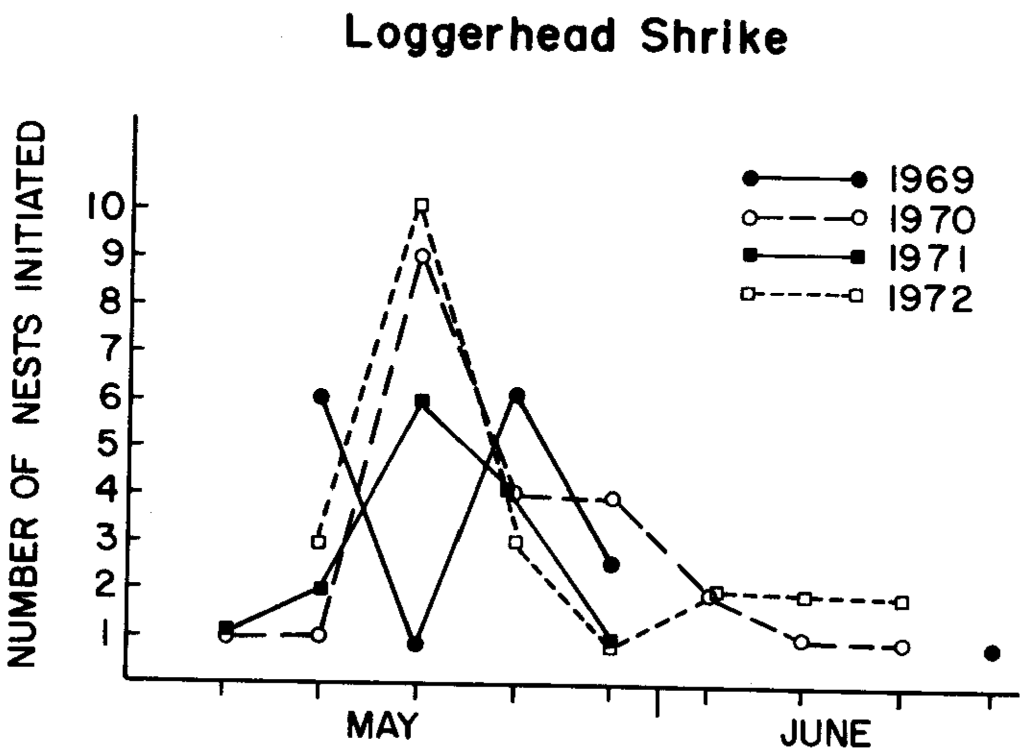

Fig. 12. Nesting phenology of Loggerhead Shrikes on the Pawnee Site, 1969-1972.

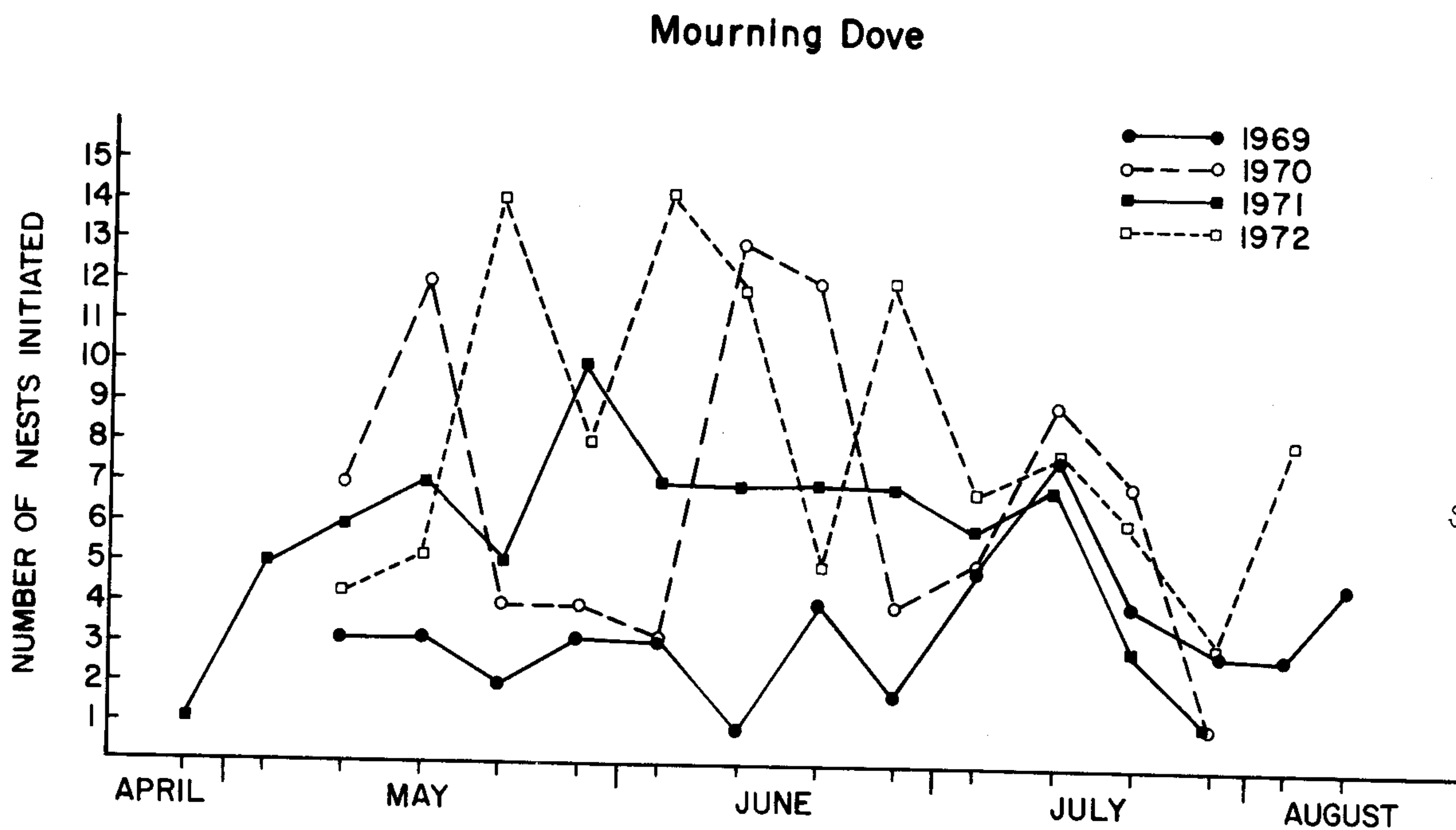

Fig. 13. Nesting phenology of Mourning Doves on the Pawnee Site, 1969-1972.

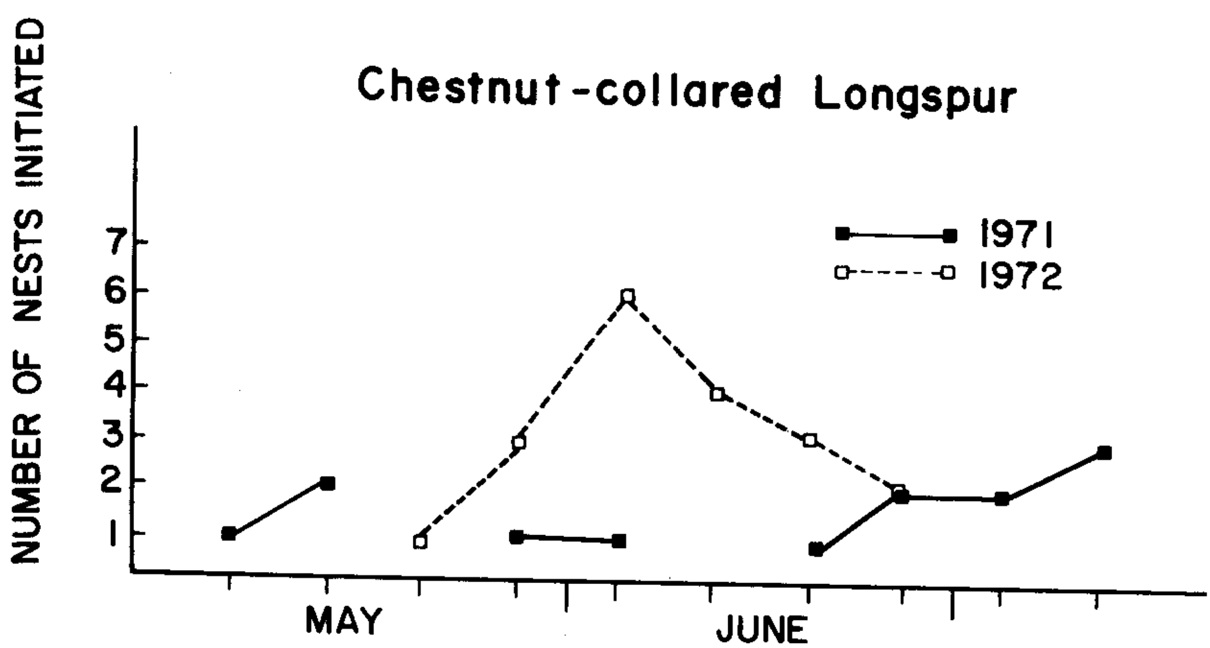

Fig. 14. Nesting phenology of Chestnut-collared Longspurs on the Pawnee Site, 1971-1972.

other similar-sized ground nesters in the area. Additional years' data are needed to document or refute this fact.

NEST SITE SELECTIVITY

It has been previously mentioned that differences occurred among the breeding and total populations of the five plots in the heavily summer-grazed pasture, 23E. Since this pasture appeared to have fairly uniform vegetation throughout, it was thought variations in slope might explain some of the differences in bird numbers. To test this, an analysis was conducted as follows.

The boundaries of all plots in 23E were located and drawn on a large-scale (1'' = 40') topographic (contour interval = 2') map of the pasture. The 5 x 10 grid system of each plot was also drawn in, so each 8.1-ha plot was broken down into fifty 0.162-ha squares. The number of contour lines in each square of Plots 1, 1B, and 1D, which were thoroughly searched for nests, was counted, and the number of squares containing a certain number of lines was totaled. Next, sites of all Horned Lark and McCown's Longspur nests found on these plots were located, and the number of contour lines in squares containing nests was again counted and the squares totaled. These totals permitted determination of expected and observed number of nests for a given number of contour lines per square, thus allowing use of a chi-square goodness-of-fit test. Results of this test can be seen in Table 23.

According to this analysis, both species showed no selection for or against various degrees of slope at standard significance levels. This was contrary to the general impression the observers received from their field work, which indicated a definite preference by the birds for flatter areas, especially by McCown's for ridgetops. The probability level was

Table 23. Effects of the degree of slope on nest site selection of Horned Larks and McCown's Longspurs in 23E.

	No. of Contour Lines per Square							Total	Chi-square
	0	1	2	3	4	5	6		
No. of Squares	4	25	41	21	21	19	19	150	
No. of Expected Horned Larks Nests	0.66	4.16	6.84	3.50	3.50	3.17	3.17	25	4.77 p = 0.58
No. of Observed Horned Lark Nests	2	4	6	5	2	2	4	25	
No. of Expected McCown's Longspur Nests	0.48	3.00	4.92	2.52	2.52	2.28	2.28	18	6.77 p = 0.36
No. of Observed McCown's Longspur Nests	0	6	5	3	1	3	0	18	

only 0.58 for the Horned Lark, but was slightly higher for the McCown's at 0.36, perhaps illustrating a greater selectivity by the latter species. About 83% of the chi-square value for the McCown's was contributed by avoidance of squares with six or more contour lines and preference for those with only one line. This analysis will be expanded next year to include more areas of greater slope to verify or refute the discrepancy between field and calculated observations.

BANDING

Banding operations at the Pawnee Site in 1972 resulted in the marking of 679 nonraptorial birds of 17 species (Table 24). The majority of the birds marked were young-of-the year, and most of these were banded while still in the nest. Adults were captured primarily in Sherman small mammal traps used exclusively for this purpose or those used in the small mammal population studies. All Horned Lark and McCown's Longspur adults caught in 23E and all Lark Bunting adults caught in 23E or 23W were individually color-banded to facilitate future studies. All young of these species captured in these pastures were also color-banded but not individually so. Also, broods of Loggerhead Shrikes from nest near the study area were color-marked so each brood was distinct. All together, 108 adults were individually color-banded, and 119 young-of-the-year were color-banded. Additional banding of hawks, eagles, and owls will be reported at a later date by Olendorff.

Table 24. Nonraptorial birds banded at the Pawnee Site in 1972.*

Common Name	Scientific Name	Number Banded
Horned Lark	*Eremophila alpestris*	144
Loggerhead Shrike	*Lanius ludovicianus*	103
Lark Bunting	*Calamospiza melanocorys*	70
Say's Phoebe	*Sayornis saya*	63
Mourning Dove	*Zenaidura macroura*	49
McCown's Longspur	*Rhynchophanes mccownii*	49
Barn Swallow	*Hirundo rustica*	39
Black-billed Magpie	*Pica pica*	37
Mountain Plover	*Eupoda montana*	29
Brewer's Sparrow	*Spizella breweri*	21
Cliff Swallow	*Petrochelidon pyrrhonota*	18
Western Kingbird	*Tyrannus verticalis*	17
Chestnut-collared Longspur	*Calcarius ornatus*	14
Western Meadowlark	*Sturnella neglecta*	10
Mockingbird	*Mimus polyglottos*	8
Killdeer	*Charadrius vociferus*	5
Common Nighthawk	*Chordeiles minor*	3
TOTAL		679

* Includes 27 birds banded by Phillip D. Creighton.

LITERATURE CITED

Batten, L. A. 1971. Bird population changes for the years 1969-1970. Bird Study 18(4):213-217.

Bent, A. C. 1958. Western Meadowlark, p.84-98. *In* Life histories of North American blackbirds, orioles, tanagers, and allies. U.S. Nat. Mus. Bull. 211. 549 p.

Colquhoun, M. K. 1940. Visual and auditory conspicuousness in a woodland bird community: A quantitative analysis. Proc. Zool. Soc. Lond., Ser. A 110:129-148.

Enemar, A. 1959. On the determination of the size and composition of a passerine bird population during the breeding season--A methodological study. Var Fagelvarld Suppl. 2:1-105.

Enemar, A. 1962. A comparison between the bird census results of different ornithologists. Var Fagelvarld 21(2):109-120.

Felske, B. E. 1971. The population dynamics and productivity of McCown's Longspur at Matador, Saskatchewan. M.S. Thesis. Univ. Saskatchewan, Saskatoon. 133 p.

Giezentanner, J. B. 1970. Avian distribution and population fluctuations on the shortgrass prairie of north central Colorado. US/IBP Grassland Biome Tech. Rep. No. 62. Colordo State Univ., Fort Collins. 113 p.

Hogstad, O. 1967. Factors influencing the efficiency of the mapping method in determining breeding bird populations in in conifer forests. Nytt Mag. Sool. 14:125-141.

Miller, A. H. 1931. Systematic revision and natural history of the American shrikes (Laniidae). Univ. Calif. Publ. Zool. 38(2):1-242.

Petersen, C. G. J. 1896. The yearly immigration of young plaice into the Limfjord from the German Sea. Rep. Danish Biol. Sta. 1895 6:1-77.

Ricklefs, R. E. 1967. A graphical method of fitting equations to growth curves. Ecology 48(6):978-983.

Robbins, C. S., and W. T. Van Velzen. 1967. The breeding bird survey, 1966. U.S. Dep. Interior, Spec. Sci. Rep. Wildlife No. 124. 107 p.

Schnabel, Z. E. 1938. Estimation of the total fish population of a lake. Amer. Math. Monthly 45(6):348-352.

Strong, M. A. 1971. Avian productivity on the shortgrass prairie of northcentral Colorado. M.S. Thesis. Colorado State Univ., Fort Collins. 70 p.

Strong, M. A., and R. A. Ryder. 1971. Avian productivity on the Pawnee Site in northcentral Colorado. US/IBP Grassland Biome Tech Rep. No. 82. Colorado State Univ., Fort Collins. 54 p.

Svensson, S. [ed.]. 1970. Bird census work and environmental monitoring. Bull. Ecol. Res. Comm. No. 9. 52 p.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. 8:1-93.

Williams, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6(3):317-408.

Winterbottom, J. M. 1972. Results of the garden bird counts organized by the Percy Fitzpatrick Institute of African Ornithology. Ostrich 43(2):125-129.

Woolfenden, G. E., and S. A. Rohwer. 1969. Breeding birds in a Florida suburb. Bull. Fla. State Mus. 13(1):1-83.

APPENDIX I

FIELD DATA

Avian Nesting Data

Avian nesting data collected at the Pawnee Site were recorded on form NREL-26. These data are stored on Grassland Biome data set A2U209B. A sample data form and an example of the data are attached.

IBP

GRASSLAND BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

FIELD DATA SHEET--AVIAN NESTING A2U209

Data Type	Site	Gen/Spp	Nest No.	TWP	Range	Sec	Ht (cm)	Habitat	Code
1-2	3-4	5-8	9-12	13-15	16-18	19-20	21-24	25-69	70

Data Type	Site	Initials	Date			Time	Eggs	Young	Age	Adult	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Number	Weight	Length	Primary	Code
			Day	Month	Year																						
1-2	3-4	5-7	8-9	10-11	12-13	14-17	18-19	20-21	22-23	24-25	26	27-30	31-33	34-36	37	38-41	42-44	45-47	48	49-52	53-55	56-58	59	60-63	64-66	67-69	70
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Site
01 ALE
02 Bison
03 Bridger
04 Cottonwood
05 Dickinson
06 Hays
07 Hopland
08 Jornada
09 Osage
10 Pantex
11 Pawnee

Number
E EGG
1,2,...,N Bird No.

Code
C Comment follows
S Nest summary card follows

Adult
01 Building
02 Incubating
03 Brooding
04 Near nest, alarme
05 Not seen
06 Other

Outcome
01 Fledged, young seen leaving nest
02 Fledged, adults excited near
03 Fledged, adults with young near
04 Fledged, nest empty, in tact
05 Failure, nest deserted
06 Failure, weather
07 Failure, predator
08 Failure, other
09 Unknown

Data Type	Site	Initials	Date			Time	Outcome	Eggs Laid	Incubation Period	Eggs Hatched	Fledging Period	Young Fledged	Comments	Code
			Day	Month	Year									
1-2	3-4	5-7	8-9	10-11	12-13	14-17	18-19	20-21	22-23	24-25	26-27	28-25	30-69	70
26														

+++ EXAMPLE OF DATA +++

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2611DKP25057217000600  02
2611DKP29057217150600  02
2611DKP05067216550501  02
2611DKP130672162500050803
2611DKP180672083000051304                                              S
2611DKP22067211500000004
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2611DKP22067211150206  05  05
2611LALU001308N62W210122ELM TREE  IN TALL GRASS
2611DKP25057217300700  06
2611DKP29057217300700  02
2611DKP05067218000700  06
2611DKP13067217150007  04
2611DKP18067207200007  04
2611DKP22067210450007  04
2611DKP29067211300000004
2611DKP29067211300307  07  07
2611LALU001409N66W200168ELM TREE  IN PLOWED FIELD
2611DKP26057205400600  02
2611DKP31057215000105  04
2611DKP07067216000006  04126.7        227.7       328.8       428.8
26                        528.5        630.3
2611DKP10067209450006  04
2611DKP16067213450006  04
2611DKP21067215000060004
2611DKP21067215000306  06  05
2611LALU001510N66W060157ELM TREE  IN WHEAT FIELD
2611DKP26057208400700  02
2611DKP29057205400700  02
2611DKP03067219150700  02
2611DKP10067205250205010З
2611DKP18067215450007090 4
2611DKP23067205150000000 5
2611DKP23067205150707  070000
2611LALU001611N65W310081SHORT GRASS AND 4-WING SALTBUSH
2611DKP01067211400000001
2611DKP05067214000100  05
2611DKP07067206450200  04
2611DKP09067211150500  02
2611DKP13067212500600  02
2611DKP16067210450600  02
2611DKP18067214450600  02
2611DKP20067208550600  02
2611DKP21067206400600  02
2611DKP24067206400600  04
2611DKP26067211350105010314.39        23.98       34.91       44.43
26                        54.48
2611DKP27067211000006020315.84        25.34       37.16       46.06
26                        56.03        64.22
2611DKP28067213500006030318.88        28.90       311.2       49.80
26                        59.72        66.64
2611DKP29067209000006040311 1.0        211.9       313.9       412.7
26                        512.7        68.64
2611DKP30067211250006050311 4.7        215.6       319.5       417.6
26                        518.0        612.6
2611LALU001611N65W310081SHORT GRASS AND 4-WING SALTBUSH
2611DKP05077211050006100313 4.6        236.8       339.7       436.9
26                        537.8        633.2
2611DKP06077209500006110413 6.3        237.3       343.5       439.8
26                        539.5        636.1
2611DKP10077210450006150414 0.2        243.1       345.6       444.7
26                        545.6        641.1
2611DKP11077210150000000 4
2611DKP11077210150206  06  06
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