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Nesting Chronology of South Dakota Ducks

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NESTING CHRONOLOGY OF SOUTH DAKOTA DUCKS

BY

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This thesis is approved as a creditable and independant investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor Date

Head, Department of Wildlife and Fisheries Sciences Date

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Abstract

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Duck broods were censused on 476 randomly selected plots in South Dakota during July of the years 1973 through 1976. Broods were also censused on wetlands located off the study plots both in July and August of these years, except in 1976 when no August counts were made. Hatching and nest initiation dates were determined by back dating from brood age-classes. Early nesting species were mallards (*Anas platyrhynchos*) and pintails (*A. acuta*). Northern shovelers (*A. clypeata*), redheads (*Aythya americana*), and canvasbacks (*A. valisineria*) were intermediate nesters while blue-winged teal (*Anas discors*), gadwalls (*A. strepera*), and American wigeons (*A. americana*) were late nesters. Mallards and pintails initiated nests over the longest periods of time.

Variables associated with wetland habitat, temperature, and physiography were examined by multiple regression to see if these factors influenced nest initiation dates. Results of the analyses were inconclusive. There is probably not enough variation in most of these aspects across South Dakota to allow statistical perception of potential relationships with nest initiation dates. I suggest that this type of analysis be applied to data collected over a much broader and more diverse area, the entire prairie pothole region.

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INTRODUCTION

Eastern South Dakota lies within the prairie pothole region and is an area of high duck production. Abundant livestock dams in the western half contribute substantially to the state's duck production (Bue et al. 1952, Ruwaldt et al. 1979). Consequently, South Dakota offers excellent opportunities for nesting and brood research.

Projects involving waterfowl nesting or broods must be timed to coincide with the appearance of pairs, nests, or broods of the species being investigated. In order to determine when research efforts should be conducted, it is necessary to have a calendar of reproductive activities. One objective of this project was to determine nesting chronology of blue-winged teal (*Anas discors*), mallards (*A. platyrhynchos*), gadwalls (*A. strepera*), pintails (*A. acuta*), northern shovelers (*A. clypeata*), American wigeons (*A. americana*), redheads (*Aythya americana*), and canvasbacks (*A. valisineria*). In addition, environmental factors potentially affecting nesting chronology were evaluated. This project was part of a four year study with the broad objective of assessing the importance of wetlands to duck production and non-game bird populations in South Dakota.

STUDY AREA

General

South Dakota occupies 199,552 km^2. Most of the state lies between 43° and 46° north latitude. The southeast tip extends to 42° 30' north latitude. Agriculture is the main industry with pasture and small grains dominating land use in the east and rangeland and wheat in the west (Westin et al. 1967).

Physiography

Two broad land forms, the Central Lowland and the Missouri Plateau, form most of South Dakota (Fenneman 1938). Eight major physical strata, (Fig. 1), further subdivide the state (Flint 1955). The Central Lowland occupies the eastern third of the state and contains the 3 easternmost strata. Four of the remaining strata occur on the Missouri Plateau in the west part of the state. The Black Hills constitute the eighth and westernmost stratum. This stratum was dropped from the study due to low wetland density and few breeding pairs. The 8 strata differ in topography, parent soil, vegetation, and climate. Strata are described in detail by Flint (1955) and Ruwaldt et al. (1979).

The Missouri River divides the state into 2 nearly equal halves. Topography in the east is primarily of glacial origin and that in the west of erosional origin (Flint 1955). Major drainage east of the Missouri River is from north to south and major drainage west of the river is from west to east. Most of eastern South Dakota is underlain by Cretaceous period shale (Fenneman 1938). The surface topography loosely conforms to the bedrock surface which is covered by varying

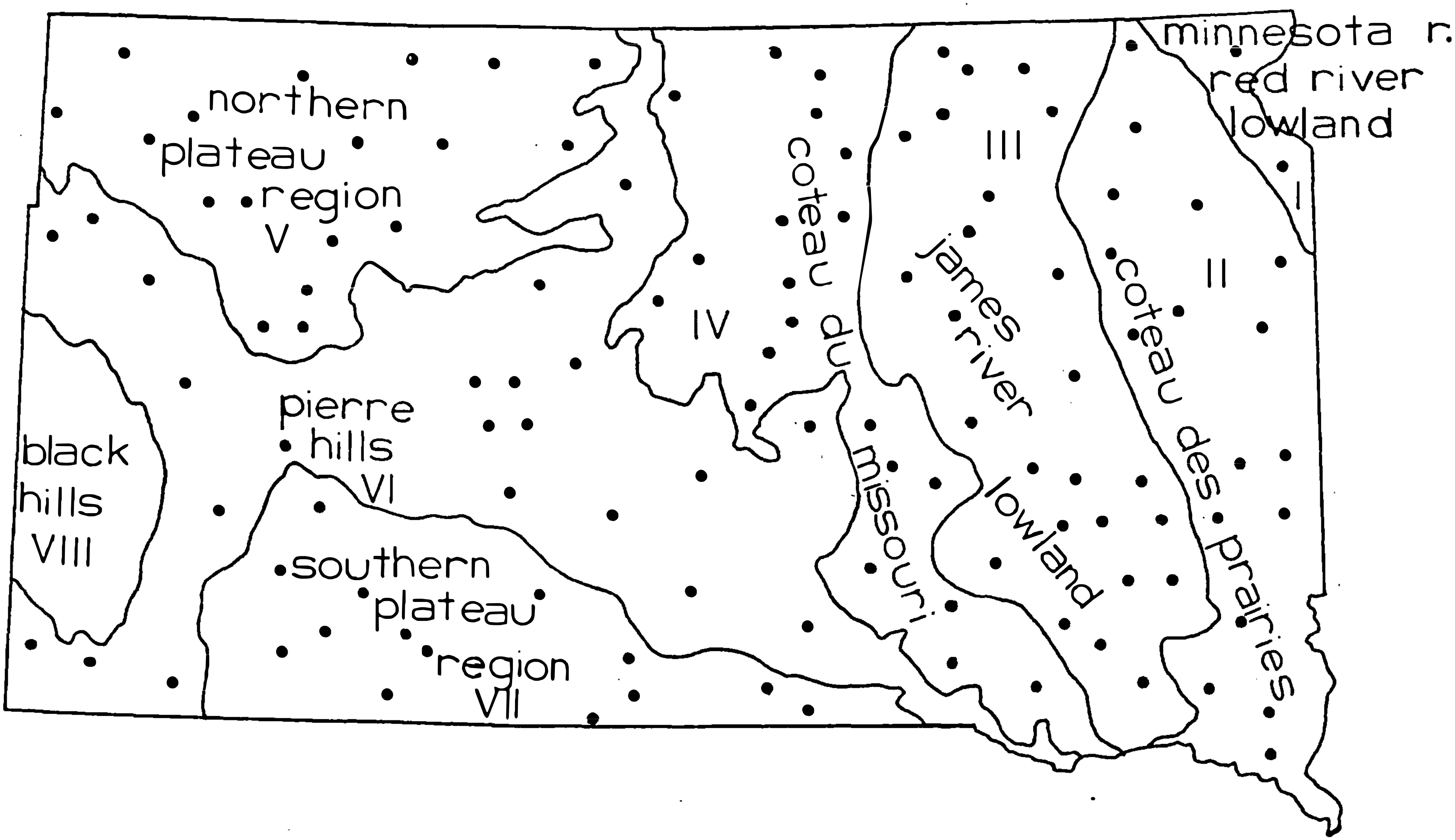

Figure 1. Locations of physiographic strata and sample plots within South Dakota.

thicknesses of glacial till.

Wetland basins in South Dakota are estimated to number 430,000 with an area of 584,700 ha (Ruwaldt et al. 1979). Natural ponds and lakes constitute 68% of the total number and 75% of the area. Dugouts constitute 12% of the number and 1% of the area. Stock ponds (excluding dugouts) comprise 21% of the number and 14% of the area. Intermittent streams comprise 4% of the area while permanent streams comprise 6% of the area. Other wetlands including man-made lakes, roadside ditches, and miscellaneous basins (quarries, sewage lagoons, borrow pits, etc.) do not contribute much to the total area and are not included in these figures. Ninety-two percent of the natural ponds and lakes occur east of the Missouri River and 87% of the stock ponds are west of the river. Natural wetlands are particularly abundant in the coteau regions of the east where glaciation has left many water holding depressions. Mature drainage patterns west of the Missouri River provide sites where many stock ponds have been constructed.

Climate

South Dakota has a continental type climate with cold winters and warm to hot summers (Spuhler et al. 1971). Extreme temperatures range from -29 C during winter to 38 C in the summer. The mean annual temperature ranges from 9 C in the south to 7 C in the north. The mean date of last frost is 5 May in the southeast to 20 May in the northwest. The average date of first frost is 5 October in the southeast to 15 September in the northeast.

Daily temperatures averaged across South Dakota were relatively comparable during periods of nest initiations in the four years of this study, although some exceptions are noted (Fig. 2). Above normal temperatures occurred in late March and early April as well as early June of 1976. Below normal temperatures were noted in late March of 1974 and early April of 1975. Temperatures at individual weather stations throughout the state varied considerably. Average monthly temperatures during nest initiation periods are summarized in Table 1.

Subhumid conditions prevail in the east and shift to semi-arrid conditions in the Missouri Coteau and west of the Missouri River. Mean annual precipitation ranges from 33.0 cm in the northwest to 63.5 cm in the southeast (Spuhler et al. 1971). Most of the precipitation falls during the growing season which lasts 120 days in the northwest to 150 days in the southeast. Mean annual evaporation ranges from 81 cm in the northwest to 112 cm in the southeast. Snowfall varies from 64 to 114 cm.

Eisenlohr (1969) determined that direct precipitation on wetlands provides the primary source of water to natural wetlands in the Missouri Coteau of North Dakota. Wetlands in the coteau regions of South Dakota are similar to those in North Dakota. Snowmelt contribution varies depending on the rapidity of the melt and whether or not the ground is frozen.

Annual precipitation varied markedly among the 4 years of this study (Table 2). Above average precipitation occurred late in 1972 and spring precipitation in 1973 was above normal. Water conditions were consequently very good during the 1973 breeding season. The total number of broods observed on sample plots was highest in 1973. State wide precipitation was above normal during late winter and spring months of 1975. Wetland

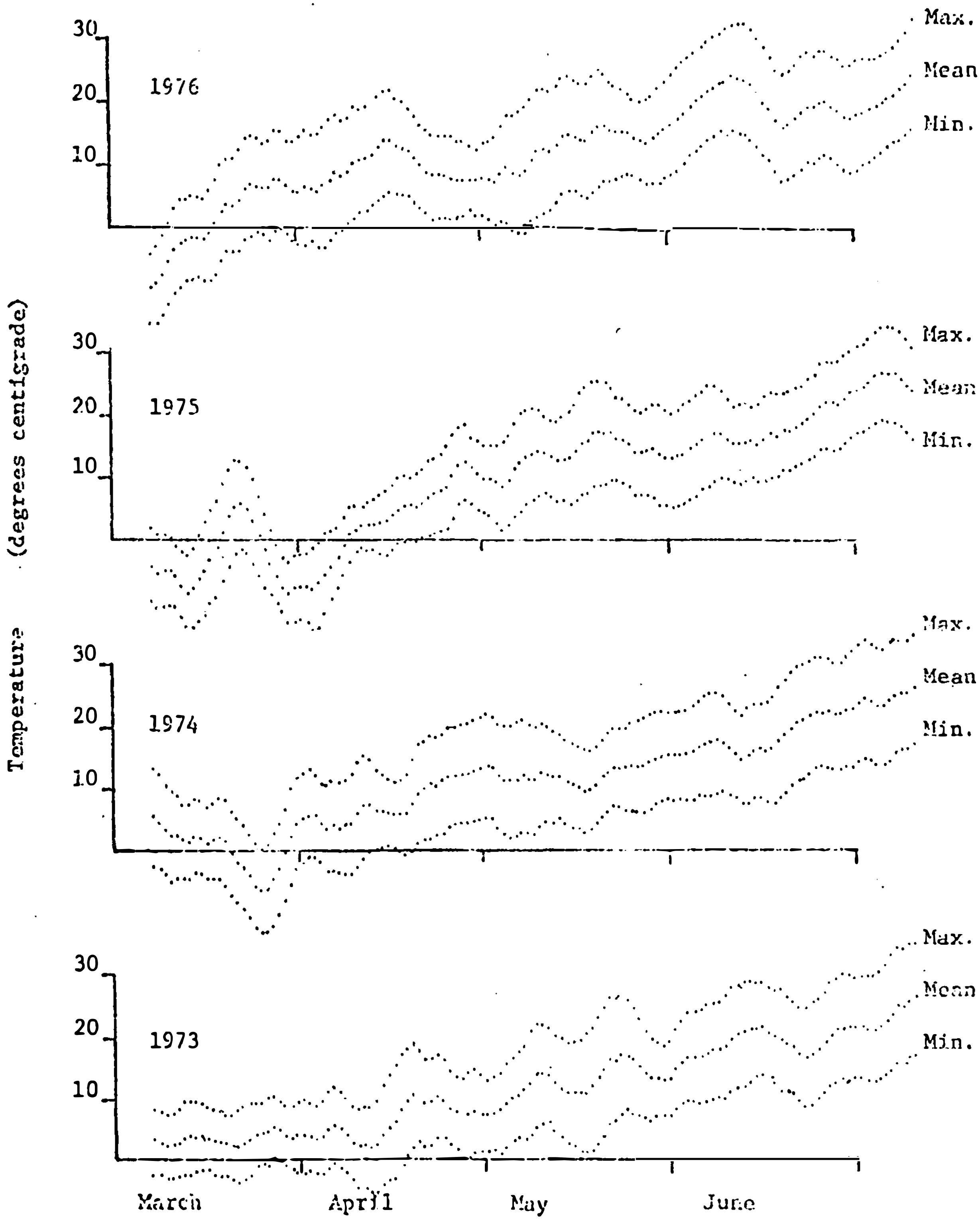

Figure 2. Seven day floating point temperature curves - averaged over entire state.

Table 1. Summary of average monthly temperatures (Centigrade).[a,b]

Year	March	April	May	June
1973	3.8 (+4.3)	7.0 (-0.7)	13.5 (-0.6)	19.8 (+0.4)
1974	1.7 (+2.2)	8.6 (+0.9)	13.0 (-1.1)	19.4 (+0.0)
1975	-3.3 (-2.8)	4.7 (-3.0)	14.2 (+0.1)	18.8 (-0.6)
1976	0.4 (+0.9)	9.8 (+2.1)	14.0 (-0.1)	20.6 (+1.2)
Normal	-0.5	7.7	14.1	19.4

[a]Source: U. S. Dept. Commerce, National Oceanic and Atmospheric Administration. South Dakota Annual Summaries. National Climatic Center, Federal Bldg., Asheville, N. C.

[b]Parentheses indicate departures from normal temperatures.

Table 2. Average monthly precipitation (cm).[a,b]

	1972	1973	1974	1975	1976
January	0.71 (-0.41)	1.07 (-0.05)	0.25 (-0.87)	2.46 (+1.34)	1.42 (+0.30)
February	0.76 (-0.61)	0.76 (-0.61)	0.81 (-0.56)	0.74 (-0.63)	1.52 (+0.15)
March	1.55 (-1.17)	6.17 (+3.45)	1.96 (-0.76)	5.38 (+2.66)	1.73 (+0.99)
April	4.78 (-0.25)	4.72 (-0.31)	5.44 (+0.41)	6.58 (+1.55)	4.98 (-0.05)
May	12.40 (+5.31)	7.39 (+0.30)	7.67 (+0.58)	5.36 (-1.73)	4.04 (-3.05)
June	5.97 (-3.00)	3.94 (-5.03)	3.96 (-5.01)	10.87 (+1.90)	7.44 (-1.53)
July	8.56 (+2.97)	4.78 (-0.81)	4.78 (-1.02)	2.97 (-2.62)	3.86 (-1.73)
August	2.87 (-2.18)	3.71 (-1.34)	4.34 (-0.71)	5.56 (+0.50)	2.77 (-2.28)
September	0.99 (-2.92)	8.10 (+4.19)	1.19 (-2.72)	2.44 (-1.47)	2.72 (-1.19)
October	3.12 (+0.35)	4.45 (+1.68)	1.93 (-0.84)	1.93 (-0.84)	1.07 (-1.70)
November	1.88 (+0.33)	2.01 (+0.46)	0.61 (-0.94)	1.60 (+0.05)	0.36 (-1.14)
December	1.75 (+0.61)	1.22 (+0.08)	0.33 (-0.81)	1.19 (+0.05)	0.81 (-0.33)
Annual	45.36 (-0.92)	48.34 (+2.06)	32.99 (-13.29)	47.12 (+0.84)	32.72 (-13.56)

[a]Source: U. S. Dept. Commerce, National Oceanic and Atmospheric Administration. 1978. State, regional, and national monthly and annual total precipitation weighted by area (Jan 1931 - Dec 1977). National Climatic Center, Federal Bldg., Asheville, N. C.

[b]Parentheses indicate departures from normal precipitation.

conditions were correspondingly good. Drought conditions were present during 1974 and 1976 when average precipitation values were 13.29 and 13.56 cm below normal. Smallest numbers of broods were present on sample plots during 1976.

Vegetation

Native and tame grasslands occupy more than 65% of the land area in South Dakota (Johnson and Nichols 1970). Vegetation types generally conform to the precipitation patterns in the state. Potential natural vegetation consists of tall grass prairie in the eastern third of the state, a mixed grass transition zone in the James River Lowland, and mixed grass prairie in the Missouri Coteau and west (Johnson and Nichols 1970). Small grain is replacing grasslands in South Dakota. Less than 25% of the land west of the Missouri River is cultivated. Much of the uncultivated land is used as rangeland. Short grass species increase where grazing pressure is intense (Johnson and Nichols 1970). Trees commonly occur in artificially planted shelterbelts east of the Missouri River. Northern floodplain forest is found along most major rivers of the state.

METHODS

Brood data was collected from 1973 through 1976 on 476 randomly selected legal quarter sections (64.8 ha). Legal quarter sections were selected because boundries are easily distinguished by roads, fence lines, or shelterbelts.

A two-stage cluster sampling design was used (Steel and Torrie 1960:422-425). This permitted a large sample to be obtained with reduced driving distances between plots. Selection of sample plots (Fig. 1) is described by Brewster et al (1976).

Data Collection and Analysis

Brood counts were conducted in July of each year. Broods were also noted as they were encountered during May and June breeding pair counts. Broods were censused by a walk-wade method and breeding pair counts were made by walk-wade and vehicular methods as the situation dictated (Hammond 1969, Brewster et al. 1976). Additional brood observations were made on wetlands located off the sample plots to increase the sample size. These non-random observations were conducted during the July brood counts and again in August. Counts made off the study plots were concentrated in the eastern and northeastern parts of the state in the areas of highest wetland and waterfowl densities (Ruwaldt 1975, Brewster et al. 1976) Distributions of broods observed off the study plots are illustrated in Appendix A. Henceforth, the terms "on-plot" and "off-plot" will refer to censuses conducted on and off study plots respectively. Off-plot counts were conducted by observers who sat on slopes above relatively open wetlands and used spotting scopes. Broods were identified and aged as they emerged from cover. Dates of breeding pair and brood censuses are summarized in Table 3.

Broods were aged using the age classification system of Gollop and Marshall (1954). Nest initiation dates were obtained by subtracting the average incubation and laying periods from the hatching dates (Bellrose 1976).

Nest initiation dates were analyzed in relation to several environmental variables using multiple regression analysis (Table 4). Nest initiation dates comprised the dependant variable while independant variables were recorded at the location of each brood observation. The first 50% of the brood observations of each species (chronologically) was used in the analysis to eliminate renests which are not likely to be affected by the same factors as are first nest attempts. This procedure was used by Kieth (1961). Weather data for each nest initiation date was obtained from records of the nearest National Oceanic and Atmospheric Administration (NOAA) weather station.

Analytical procedures in this project were complicated by missing data; none of the habitat variables were recorded during off-plot counts. Furthermore, weather data was obtained for periods beginning on 1 March of each year. Hence, the date of last snow cover was not recorded for any observation which was located on a sample plot where measurable snow did not occur after 1 March. When all variables were entered in the multiple regression analysis, those cases (nest initiation dates with associated independant variables) which included missing values were eliminated from the analysis. This resulted in a reduced sample size

Table 3. Dates of breeding pair and brood counts.

Year	May breeding pair	June breeding pair	July brood (on and off-plots)	August brood (off-plots)
1973	8 May - 1 June	3 June - 21 June	9 July - 30 July	6 August - 10 August
1974	13 May - 27 May	10 June - 20 June	8 July - 17 July	5 August - 9 August
1975	12 May - 30 May	10 June - 21 June	8 July - 21 July	5 August - 8 August
1976	10 May - 21 May	7 June - 12 June	7 July - 12 July	No count made

Table 4. Independant multiple regression variables.

Independant variable	Explanation
Lattitude	The lattitude of the brood observation site.
Isocline	The temperature isocline in which the brood site is located. Isoclines were constructed using 1.1° C gradients of the average maximum daily temperatures during April and May.
Total no. wetlands	The total number of wetlands on the cluster.
May and June wetland diversity (two variables)	The diversity of wetlands containing water in May and in June. This was computed using a Shannon-Weaver diversity index (Shannon and Weaver 1963).
May and June wetland density (two variables)	The number of wetlands containing water in May and in June on the cluster.
May and June wetland fraction (two variables)	The fractions of wetlands which contained water in May and in June on the cluster.
Last Snow	The last date on which one inch of snow was recorded at the nearest weather station.
7 and 14 day temperature dates (six variables) Temp.date-1 (date of 1 week minimum) Temp.date-2 (date of 1 week mean) Temp.date-3 (date of 1 week maximum) Temp.date-4 (date of 2 week minimum) Temp.date-5 (date of 2 week mean) Temp.date-6 (date of 2 week maximum)	First date that minimum, mean, and maximum temperatures reached computed temperature criteria. Temperatures were week and two week average values. The temperature criteria were as follows: The daily minimum, mean, and maximum temperatures were averaged individually over 7 and 14 day periods before each nest initiation date. These values were determined from NOAA weather records of the weather station nearest the brood location.
7 and 14 day temperature values (six variables) Temperature-1 (1 week minimum temp.) Temperature-2 (1 week mean temp.) Temperature-3 (1 week maximum temp.) Temperature-4 (2 week minimum temp.) Temperature-5 (2 week mean temp.) Temperature-6 (2 week maximum Temp.)	Minimum, mean, and maximum temperatures averaged over 7 and 14 day periods prior to the date by which five percent of nest initiations had occurred for each species. Variables determined from NOAA weather records of the weather station nearest the brood location.
East - west River	Location of brood observation site - east or west of the Missouri River.

and lower precision. To increase precision, I removed variables for which values were missing. This increased the sample size, but resulted in fewer variables being evaluated.

Multiple regression analysis of nest initiation dates was accomplished by 4 approaches. The first was with all variables considered. Broods lacking recorded values for any of the variables were deleted. This resulted in the smallest sample sizes. Habitat variables associated with wetland diversity, wetland density, and water conditions were excluded in the second run. Since date of last snow cover was included in this run, cases which had missing values for this variable were eliminated. Date of last snow cover was excluded from the third run, but all habitat variables were included. Broods lacking recorded values for habitat variables (off-plot broods) were eliminated from this run. Date of last snow cover and the habitat variables were excluded from the fourth run. Since values were recorded for the remaining variables in all cases, no broods were eliminated from this run which entailed the largest sample sizes.

Caution must be used in interpreting the 4 multiple regression runs. Each variable interacts with the remaining variables. The amount of variation explained by an individual variable and the order in which that variable enters the regression depends on how much correlation exists with the remaining variables. When a variable (or variables) is deleted, the order in which the remaining variables are listed and the number of significant variables may also change. Changes in sample size further complicate interpretation since this alters the degrees of freedom used to determine F test criteria. The 4 analyses are therefore not comparable and should be viewed separately. Each is a valid assessment of the variation in nest initiation dates, but only for the variables considered.

Variables

This section is an extensive description of the independant variables used in the multiple regression analyses. Three classes of variables were evaluated. These included habitat, climate, and physiography.

Habitat was measured in terms of wetland conditions on each sample cluster. Several approaches were used in this assessment. Total numbers of depressions holding or potentially holding water were recorded. Numbers of wetlands holding water in May and in June comprised two variables. Diversities of wetlands holding water in May and in June were computed using a Shannon-Weaver index (Shannon and Weaver 1963). Classifications used in the computation of this index included natural wetland classes 1 through 6 and cover types 1 through 4 described by Stewart and Kantrud (1971). In addition, there were 4 types of annually disturbed wetlands and 9 types of artificial wetlands (Table 5). The 4 cover types were applied to all 19 wetland types making a possible total of 76 classifications. The number of classifications used was less than 76, however, as some wetland types are almost always of 1 cover type. These include wetlands in annually disturbed basins without aquatic vegetation. Two final habitat variables included the fractions of wetlands containing water in May and in June on each cluster.

Climatic variables were used to evaluate effects of temperature, day length, and snow cover on nest initiation dates. Temperature was examined in three ways. First, I wanted to see if nest initiation dates

Table 5. Descriptions of annually disturbed and artificial wetland types and natural streams.

Annually disturbed wetlands

1) tillage ponds (ponds in basins that are cultivated to the extent that aquatic vegetation is absent; no evidence of artificial drainage). This includes sheet water that stands in cropland fields in shallow basins or depressions where no artificial drainage has been carried out.

2) tillage ponds (same as above, but where drainage has been artificially improved to speed runoff of temporary water). Drainage normally consists of some sort of open ditch or possibly tile.

3) pasture ponds (ponds in basins so heavily grazed that aquatic vegetation is absent; no evidence of artificial drainage).

4) pasture ponds (same as above, but where drainage has been artificially improved).

Artificial wetland types and natural streams

1) dugouts in natural basins containing water or within 50 m of such basins.

2) stockponds

3) intermittent streams

4) permanent streams

5) drainage ditches

6) roadside ditches

7) dugouts in dry basins or within 50 m of such basins.

8) dugouts not in or within 50 m of natural wetland basins.

9) other wetlands (including reservoirs, sewage lagoons, quarries, and borrow pits).

were influenced by location of the nests within temperature isocline zones. Zones were based on maximum daily temperatures averaged over April and May and were established for temperature increments of 1.1 centigrade degrees beginning with 10 C. Zones were delineated by drawing lines around areas containing weather stations with readings falling within a given increment (Appendix B). Integer values were assigned to each zone beginning with 1 for 10.0 C to 11.1 C, 2 for 11.1 C to 12.2 C, and so forth. Each nest initiation date was assigned the integer value of the zone in which the brood was located and these zones were incorporated in the multiple regression analysis.

Two other methods were used to evaluate temperature. One approach was to set a temperature and use the date at which that temperature was exceeded as a variable. The other approach was to set a date and use the temperature measured during an interval ending on that date as the variable.

The date in the first method was derived as follows: Floating point temperature curves were established for each weather station in the state. One curve was established using a 14 day interval and the other using a 7 day interval. Abscissa values of the curves were days of the months March, April, May, and June. Ordinant values were the minimum, mean, and maximum daily temperatures averaged during the intervals which ended on each day. Minimum, mean, and maximum daily temperatures were then averaged during 7 and 14 day periods prior to the hatching date of each brood observation of each species. This yielded 6 values; minimum, mean, and maximum temperatures averaged over 7 and 14 day periods, which served as the set temperature criteria for each species. The last step was to go back to the individual floating point temperature curves at the weather station nearest each brood observation. The dates (Julian) by which the 6 temperature values of a species were exceeded by values on the 6 temperature curves at the weather station constituted the independent variables for each nest initiation.

The temperature value in the final method used to evaluate temperature was obtained as follows: the date by which 5% of the nests had been initiated was determined for each species. The minimum, mean, and maximum daily temperatures averaged over 7 and 14 day periods were then recorded from the floating point temperature curves for periods ending on the date by which 5% of the nests had beer initiated. These values were obtained from the weather station nearest the cluster on which each brood was observed. Two time periods with 3 levels of temperature readings comprised 6 independent variables.

Latitude was recorded to the nearest tenth of a degree at the location of each nest initiation. This variable was correlated with day length, temperature, and migration distances from wintering grounds. Spring thaw might also be expected to follow lines of latitude.

A single geographic variable was evaluated. Nest initiations east and west of the Missouri River were assigned values of 0 and 1 respectively and included in the multiple regression. This variable was used to assess whether or not there was a difference between nest initiation dates of broods located in the glaciated and unglaciated regions of the state.

DISCUSSION AND RESULTS

Nest Initiation and Hatching Chronology

Some species such as mallards and pintails are early nesters and a substantial number of these were fledged before the August counts. Many broods of the later nesting species, blue-winged teal, gadwalls, American wigeons, and northern shovelers, had not hatched by the time of the July counts. Hence, it was not possible to completely census all species in a single count. Few broods were noted during the May and June pair counts (Table 6).

Temporally, July and August counts constituted 2 separate samples of the population of broods in South Dakota. When the 2 counts were combined as 1 sample, broods hatched before July counts and not yet flying by August counts were contributed from each count. Broods flying before August counts were represented only in the July counts while broods hatched after the July counts were represented only in the August counts. Hatching (nest initiation) histograms which were constructed using data from both July and August counts contained an artificially elevated midrange of hatching dates. There was a substantial number of broods which could not have been censused during either the July or August counts (Table 7). Hatching (nest initiation) histograms which utilized only one or the other count did not contain a complete range of hatching (nest initiation) dates for each individual species. The hatching period generally overlapped the time span over which broods reached flight capabilities. Hence, no matter when a census was scheduled, broods would have been missed because they had not yet hatched or had

Table 6. Numbers of broods observed during May, June, July, and August counts.

	May		June		July		August	
Species	on plot	off plot	on plot	off plot	on plot	off plot	off plot	total
Blue-winged teal	0	0	5	4	239	255	304	807
Mallard	2	0	29	3	102	108	198	442
Pintail	4	3	23	7	43	60	42	182
Gadwall	0	0	3	0	35	80	265	383
Northern shoveler	0	0	1	1	17	42	21	82
Ruddy duck	0	0	0	0	1	0	0	1
American wigeon	0	0	1	0	6	4	15	26
Wood duck	0	0	3	0	0	0	0	3
Green-winged teal	0	0	0	0	1	0	0	1
Canvasback	0	0	1	0	4	5	7	17
Redhead	0	0	2	0	4	19	27	52
Lesser scaup	0	0	0	0	0	2	1	3
Unknown	0	0	8	0	62	21	23	114
Total	6	3	76	15	514	596	903	2113

Table 7. Numbers of broods not subject to census during one of either the July or August counts.[1]

Species	No. August broods hatched after end of July count	No. July broods reaching flight before August count	Total No. broods not subject to one census
Blue-winged teal			
1973	0	13	
1974	14	19	
1975	39	1	
1976	-	-	
Total	53 (.174)	33 (.003)	86 (.107)
Mallard			
1973	0	26	
1974	8	22	
1975	17	18	
1976	-	-	
Total	25 (.126)	66 (.270)	91 (.206)
Pintail			
1973	0	12	
1974	2	34	
1975	3	28	
1976	-	-	
Total	5 (.119)	74 (.529)	79 (.434)
Gadwall			
1973	2	3	
1974	24	7	
1975	17	6	
1976	-	-	
Total	43 (.162)	16 (.136)	59 (.154)
Northern shoveler			
1973	0	7	
1974	1	19	
1975	3	1	
1976	-	-	
Total	4 (.190)	27 (.443)	31 (.378)
American wigeon			
1973	0	1	
1974	1	0	
1975	3	0	
1976	-	-	
Total	4 (.267)	1 (.091)	5 (.192)
Canvasback			
1973	0	0	
1974	0	1	
1975	1	0	
1976	-	-	
Total	1 (.143)	1 (.100)	2 (.118)
Redhead			
1973	0	2	
1974	2	4	
1975	6	0	
1976	-	-	
Total	8 (.296)	6 (.240)	14 (.269)

[1]Parentheses indicate fractions of total numbers of broods censused. Dashes appear in rows for 1976 when no August counts were conducted. Fractions of total numbers of broods not subject to census as well as numbers of July broods reaching flight before August counts were computed using July broods of 1976 incorporated into the total numbers of broods. Both on-plot and off-plot broods were used in computation of this table.

already attained flight capabilities. If a gap existed between the period of hatching and the period when ducklings fledged, the sampling effort should have been scheduled during this gap. In this way, all broods would have been potentially subject to census. When overlap occurred, as generally was the case, it would have been ideal to conduct 2 or more censuses and eliminate exagerated midranges of hatching curves by use of a correction factor. This could have been accomplished if the censuses were conducted using the same methods. In this project, however, different methods were employed and a problem arose in combining data from July and August counts. Broods hatched before July counts and flying after August counts were represented in both counts. Broods flying before August counts or hatched after July counts were represented in only one or the other count. Age-classes of broods hatched before July counts and flying after August counts were potentially subject to sampling during both counts, even though different areas were censused and different individual broods were sampled. A brood flying after August and censused in July in one area was "duplicated" by counting a different brood hatched before July counts and censused in August in another area. It is not known what portion of broods was sampled using each sampling method so no correction factor could be determined to eliminate age class duplication.

In cases where numbers of broods which could have been duplicated were comparable to numbers which could not have been duplicated, the distortion of hatching and nest initiation histograms was great. If the portion of broods which could have been duplicated was great, the effect was essentially a double sample of the same population and the form of the hatching (nest initiation) histogram was a valid representation of the hatching (nest initiation) chronology of that population. If the portion of broods that could have been duplicated was small, this indicates that there was either a natural break in hatching (nest initiations) between the time of the two censuses or the censuses were conducted too far apart and some broods may have hatched after the first census and reached flight before the second census. In this case, a third census should have been conducted between the other 2. The last situation was not evident in this study. The first 2 did occur, however, depending on species.

Some mallard, pintail, northern shoveler, and redhead broods could not have been counted during one of either the July or August counts (Table 7). If counts were combined for these species and duplication not eliminated, then the midranges of hatching (nest initiation) periods were exagerated. So few redhead broods were observed during July counts, however, that combining the 2 counts was necessary to achieve a valid sample. Some broods of all species could not have been counted during the July on-plot counts because they hatched after these counts were completed. This must be remembered when viewing hatching (nest initiation) histograms constructed from the on-plot counts. It was not known what numbers of broods were present throughout the state during the July and August counts or what were the relative efficiencies and intensities of methods used to census on-plot versus off-plot broods. Hence, the histograms may be weighted toward one or the other count. Least squares analysis indicated that the mean hatching (nest initiation) dates of blue-winged teal, mallard, pintail, and gadwall broods censused on the study plots (primarily July counts) were significantly earlier ($P<.01$)

than the mean hatching (nest initiation) dates of broods censused off the study plots - primarily August counts (Table 8). Mean hatching dates of northern shoveler broods censused on study plots were also earlier ($P < .05$).

Although least squares analysis indicated differences in mean nest initiation dates between years of the study and between on-plot and off-plot samples, the magnitude of these differences had to be considered before deciding whether or not to pool data. Given a possible error of 5 to 10 days in estimating nest initiation dates by backdating from brood age classes, a statistically significant difference of a couple days in mean nest initiation dates would not be of concern. Differences on the order of 5 to 10 days, however, would be adequate to avoid pooling data from different years and between on-plot and off-plot samples.

Least squares analysis provides a method of eliminating the effect of unequal sample sizes on estimates of the population mean. Mean nest initiation dates within each sample classification (years or on-plot versus off-plot) are adjusted so that the relative contribution of each class to the population mean is equal. Hence, least squares adjusted means are a better representation of differences between mean nest initiation dates of different years as well as between samples collected on-plots versus off-plots than are raw means. Least squares adjusted means of hatching (and consequently nest initiation) dates were found to differ by at least 5 days among years and between on-plot and off-plot samples (Table 9).

Given the problems associated with sampling, I am presenting one set of nest initiation and hatching histograms using the July on-plot counts

Table 8. Least squares analysis of differences in nesting chronology associated with varying geographic and temporal aspects of brood observations. [1]

Species	on-plot - off-plot	Year	Strata[2]	East - west river	Isocline[3]
Blue-winged teal	**	**	**		*
Mallard	**		*		**
Pintail	**	*			**
Gadwall	**				**
Northern shoveler	*	*			
American wigeon			*		*
Canvasback					
Redhead					

[1] *indicates significant differences (P <.05).
**indicates significant differences (P <.01).

[2] See Fig. 1.

[3] See Appendix B.

Table 9. Least squares adjusted means of hatching dates.

Species	Year	Adjusted mean	Sample location	Adjusted mean
	1973	7/01	on-plot	6/26
Blue-winged teal	1974	6/29		
	1975	7/04	off-plot	7/06
	1976	6/30		
	1973	6/26	on-plot	6/16
Mallard	1974	6/24		
	1975	6/18	off-plot	6/29
	1976	6/25		
	1973	6/19	on-plot	6/06
Pintail	1974	6/10		
	1975	6/04	off-plot	6/23
	1976	6/23		
	1973	7/04	on-plot	6/27
Gadwall	1974	7/01		
	1975	6/26	off-plot	6/15
	1976	7/05		
	1973	6/19	on-plot	6/15
Northern shoveler	1974	6/10		
	1975	7/01	off-plot	6/25
	1976	6/19		

and a second set using the combined July and August counts which were conducted both on and off plots. Both sets of histograms incorporate broods observed during May and June breeding pair counts. May and June counts were conducted using less intensive sampling methods and probably underrepresent the earliest broods. So few broods were hatched at these early times, however, that I did not consider the aberrant sampling to be a problem.

I leave the choice of which histograms to use at the discression of the reader with the following suggestions: Due to the random distribution of the study plots, histograms constructed from brood data taken from study plots are more representative of the natural distribution of broods in South Dakota. Since mallard, pintail, northern shoveler, and redhead data sets contained intermediate portions of age-groups which could have been censused during both the July and August counts, histograms constructed from the combined counts are exagerated in the middle ranges. So few of the American wigeon, canvasback, and redhead broods were seen on sample plots that there was little alternative but to combine on-plot and off-plot data to obtain realistic sample sizes. All hatching (nest initiation) histograms constructed from on-plot data lack some later brood hatching (nest initiation) dates.

Numbers of broods observed on study plots provide an index to change in brood abundance between years (Table 10). More broods of all species but pintails and gadwalls were observed in 1973 than any other year of the study. Numbers of broods observed during the other 3 years varied depending on species. Since relative abundance of broods varied between years, combining years would result in underrepresenting some years (the

Table 10. Numbers of broods observed on and off plots by years.

Species	Year	On-plot	Off-plot
Blue-winged teal	1973	121	171
	1974	55	241
	1975	42	140
	1976	26	11
Mallard	1973	58	98
	1974	22	126
	1975	22	77
	1976	31	8
Pintail	1973	16	17
	1974	13	46
	1975	23	48
	1976	18	1
Gadwall	1973	8	89
	1974	12	173
	1975	11	79
	1976	7	4
Northern shoveler	1973	9	16
	1974	5	33
	1975	2	15
	1976	2	0
American wigeon	1973	4	5
	1974	1	6
	1975	1	7
	1976	1	1
Canvasback	1973	4	2
	1974	1	5
	1975	0	5
	1976	0	0
Redhead	1973	6	9
	1974	0	24
	1975	0	13
	1976	0	0

drought year of 1976 in particular) and overrepresenting other years (notably 1973 when water conditions were good). One would have to assume that nesting chronology was comparable in different years to justify pooling unequal sample sizes. Least squares analysis (Table 8) indicated that there were significant differences in mean nest initiation (and likewise hatching) dates between years of the study for blue-winged teal ($P<.01$), pintails ($P<.05$), and northern shovelers ($P<.05$). Nesting chronology histograms (Figs. 3-18) visually indicate disparities in the distribution of nest initiation and hatching dates of different years. Furthermore, the off-plot sampling effort was not monitored. Since more off-plot broods were observed during 1974 than the other three years and this was not the year of greatest brood abundance, it would appear that the off-plot sampling effort was more intensive during 1974 (Table 10). Almost no effort was made to sample broods off the study plots in 1976. Given the yearly differences between mean hatching dates, sample sizes, and off-plot sampling effort, I felt that hatching histograms should be presented by individual years. A histogram constructed using data from all 4 years of the study would likely be an innacurate generalization of the nesting chronology of a given species.

Nest initiation, hatching, and flight histograms are presented in Figs. 3-18. Sets of histograms are presented by year using on-plot data (Figs. 3-10) and separate sets using combined on-plot and off-plot data (Figs. 11-18). Off-plot observations were made during all 4 (May, June, July, and August) counts, though most intensively in August. On-plot observations were made in May, June and July. The vast majority of broods was observed during July. Yearly statistics on nest initiation and

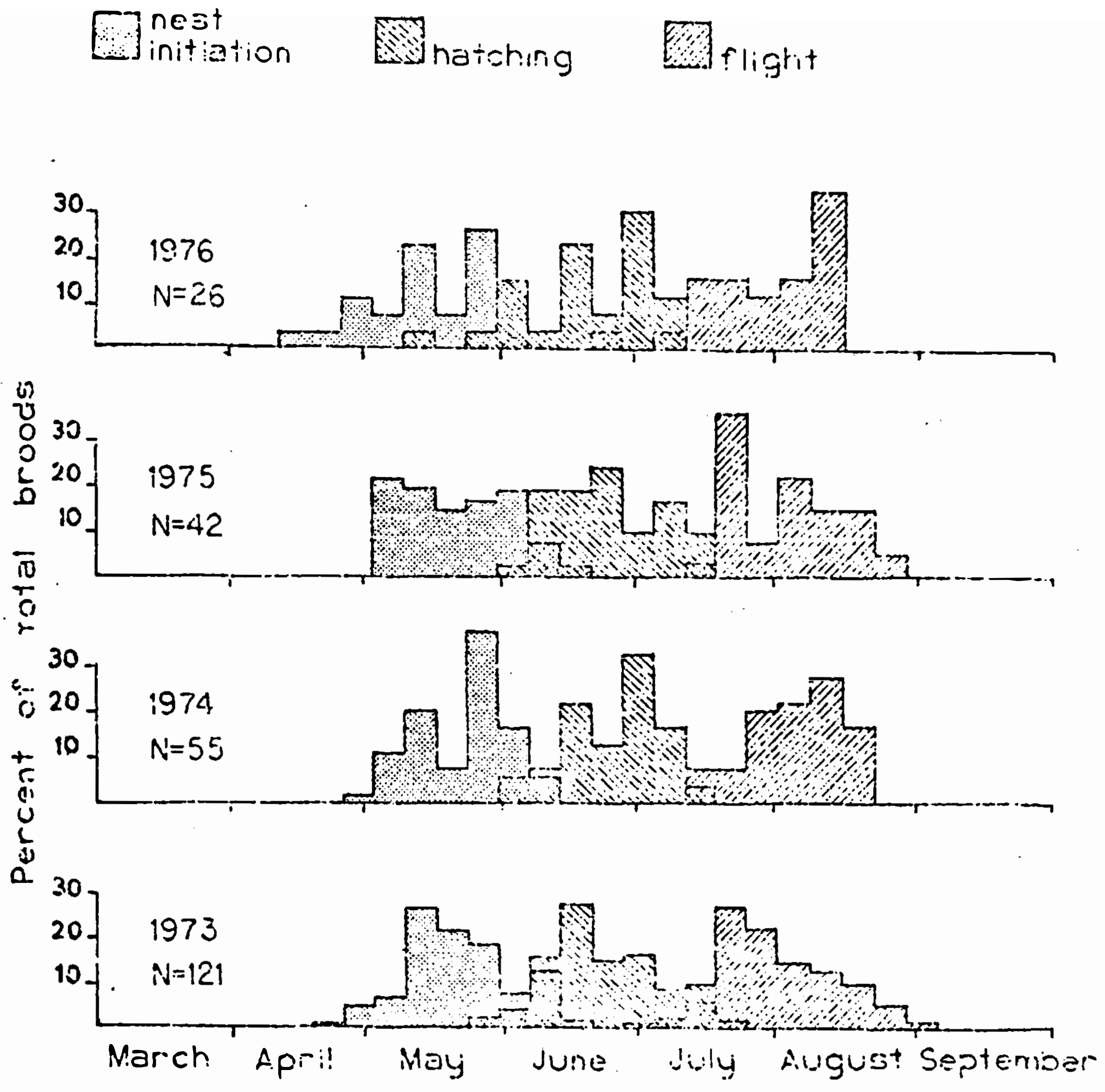

Figure 3. Blue-winged teal - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

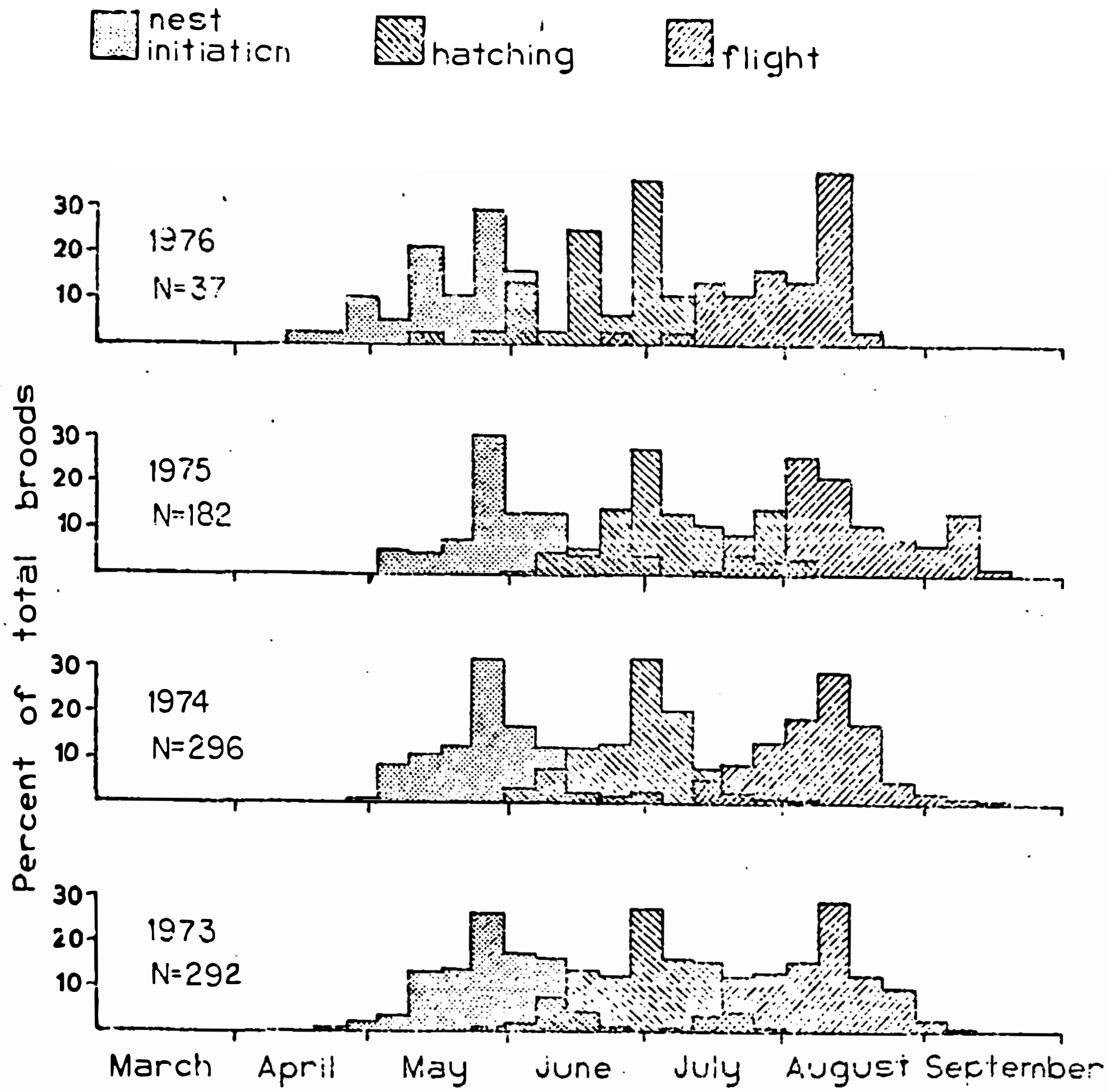

Figure 4. Blue-winged teal - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

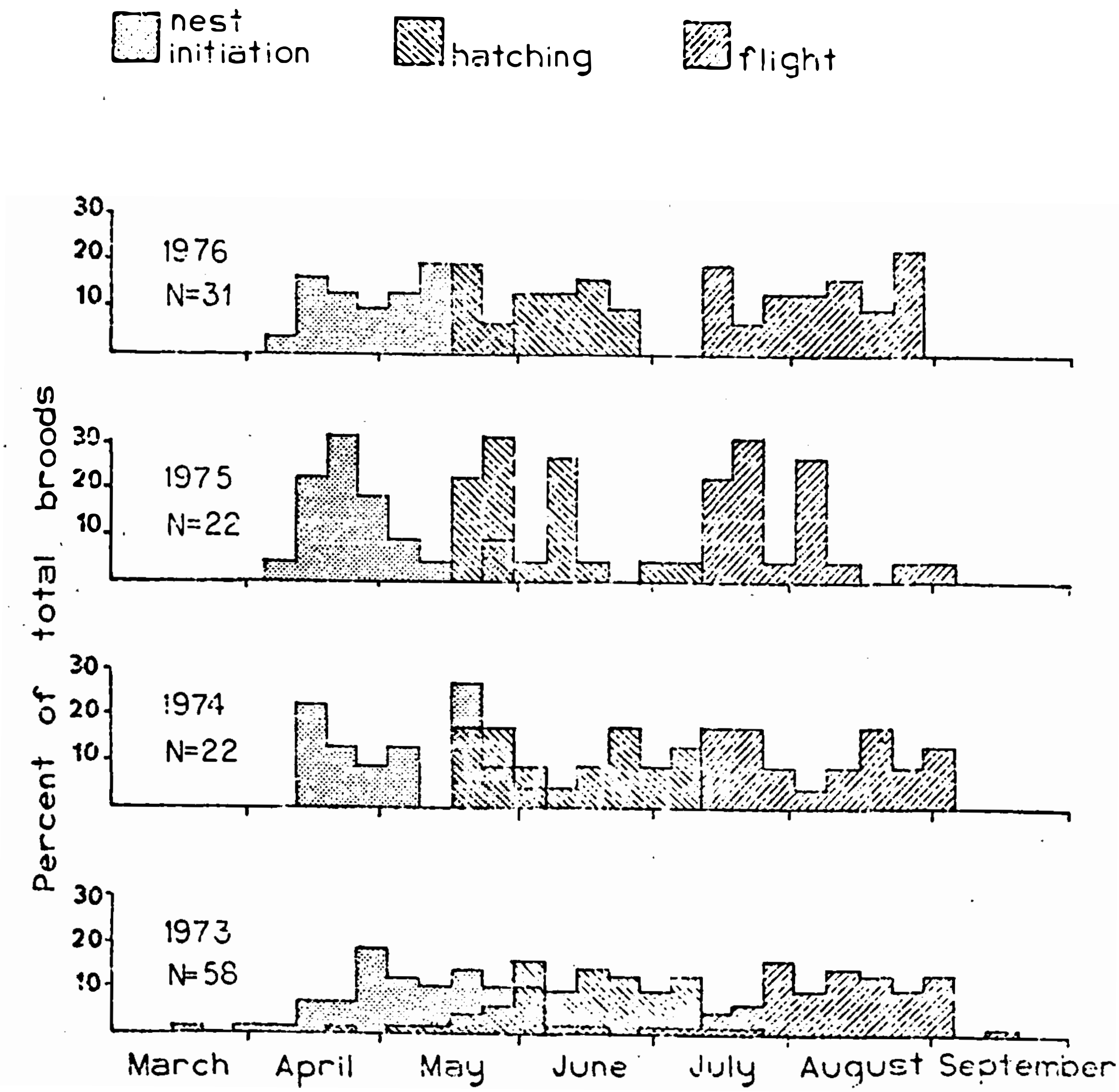

Figure 5. Mallard - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

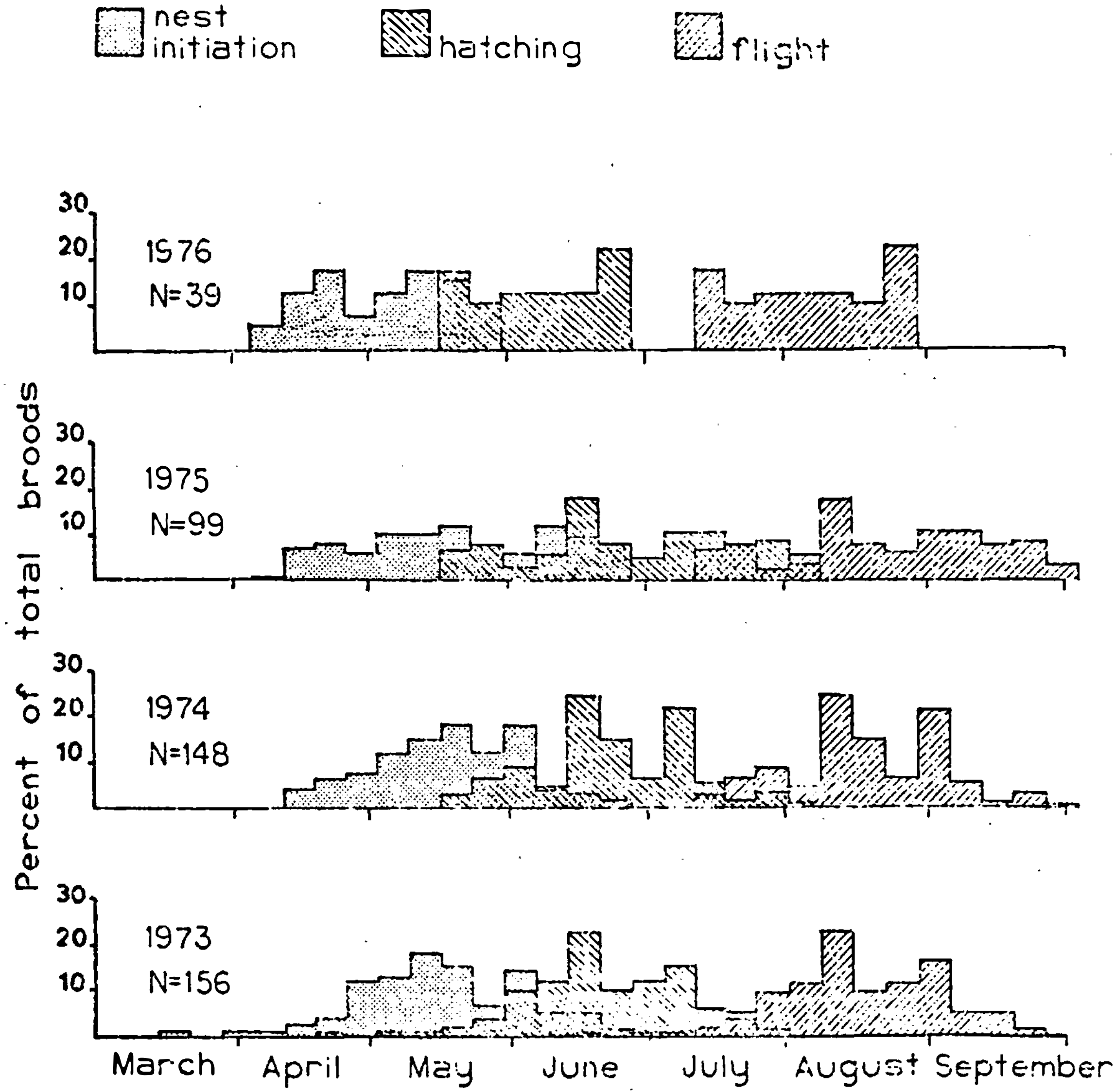

Figure 6. Mallard - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

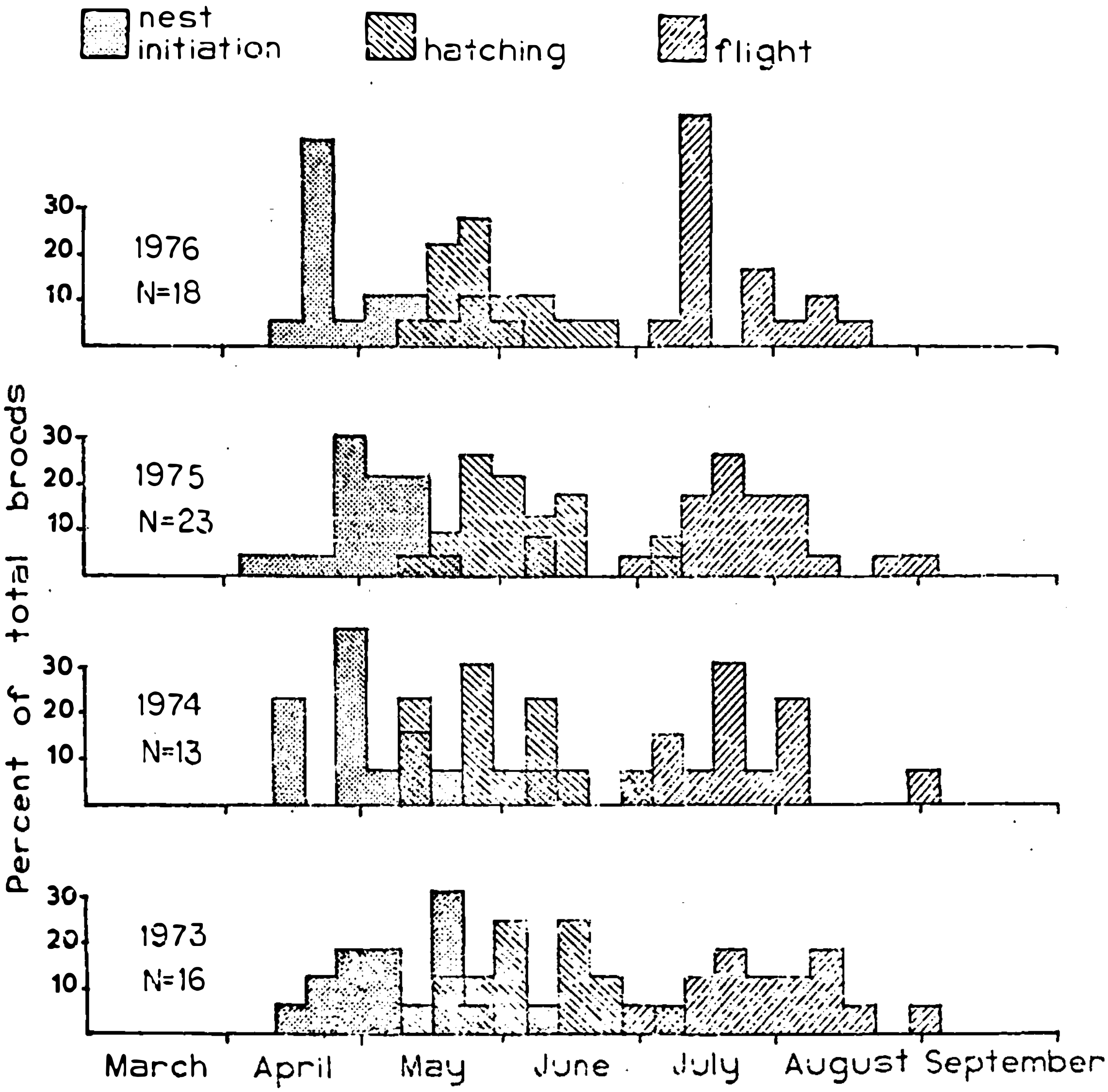

Figure 7. Pintail - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

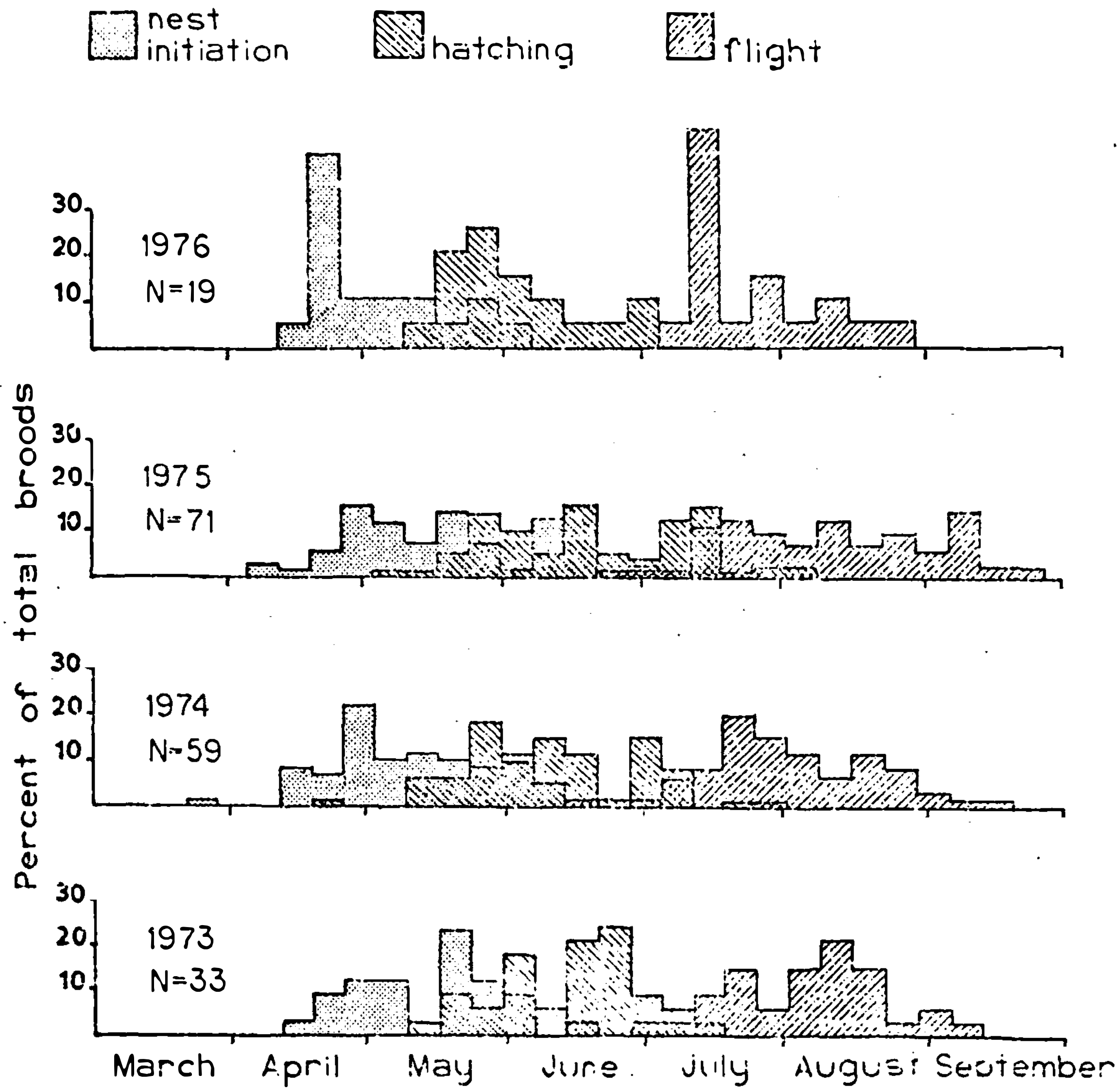

Figure 8. Pintail - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

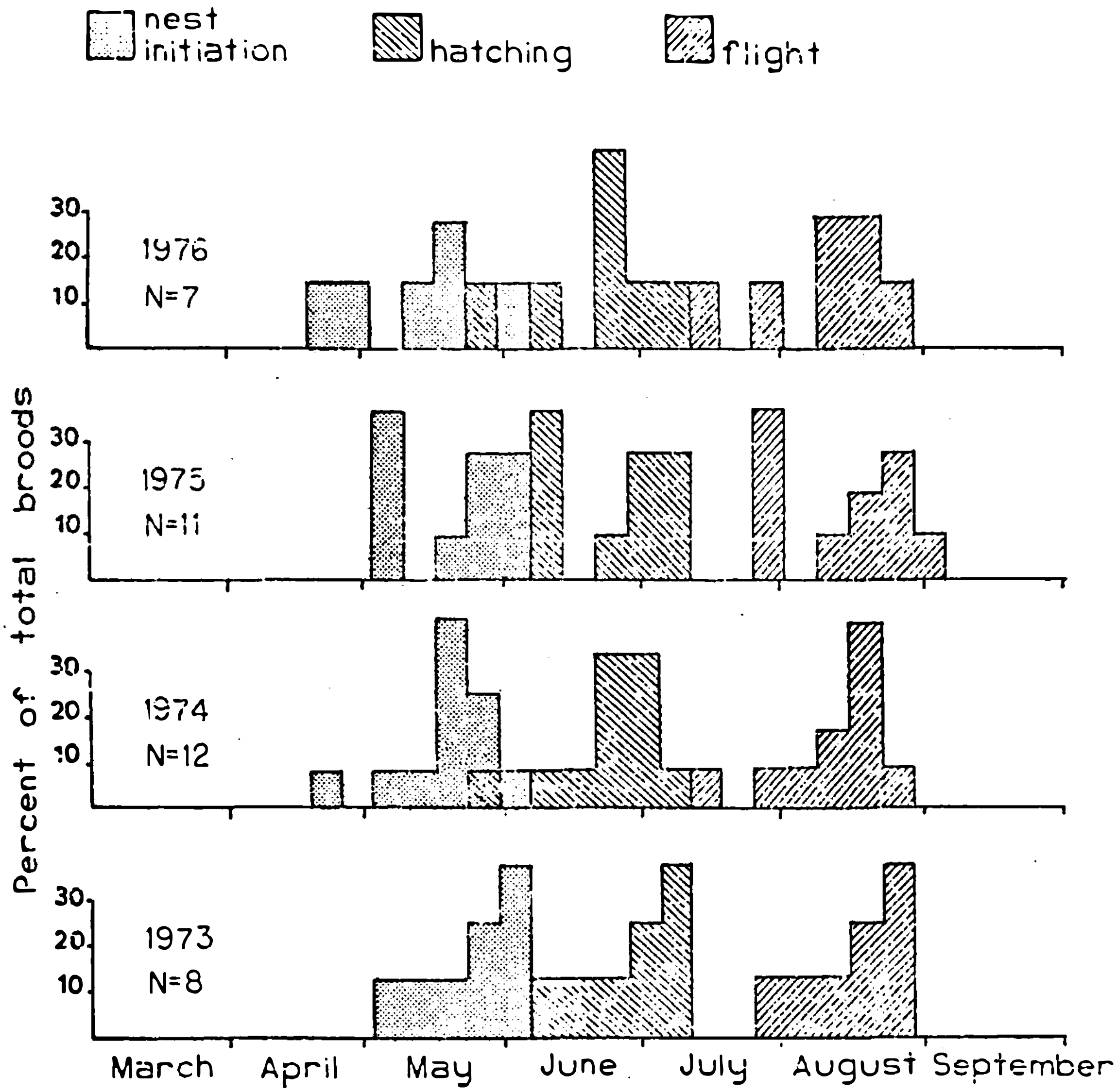

Figure 9. Gadwall - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

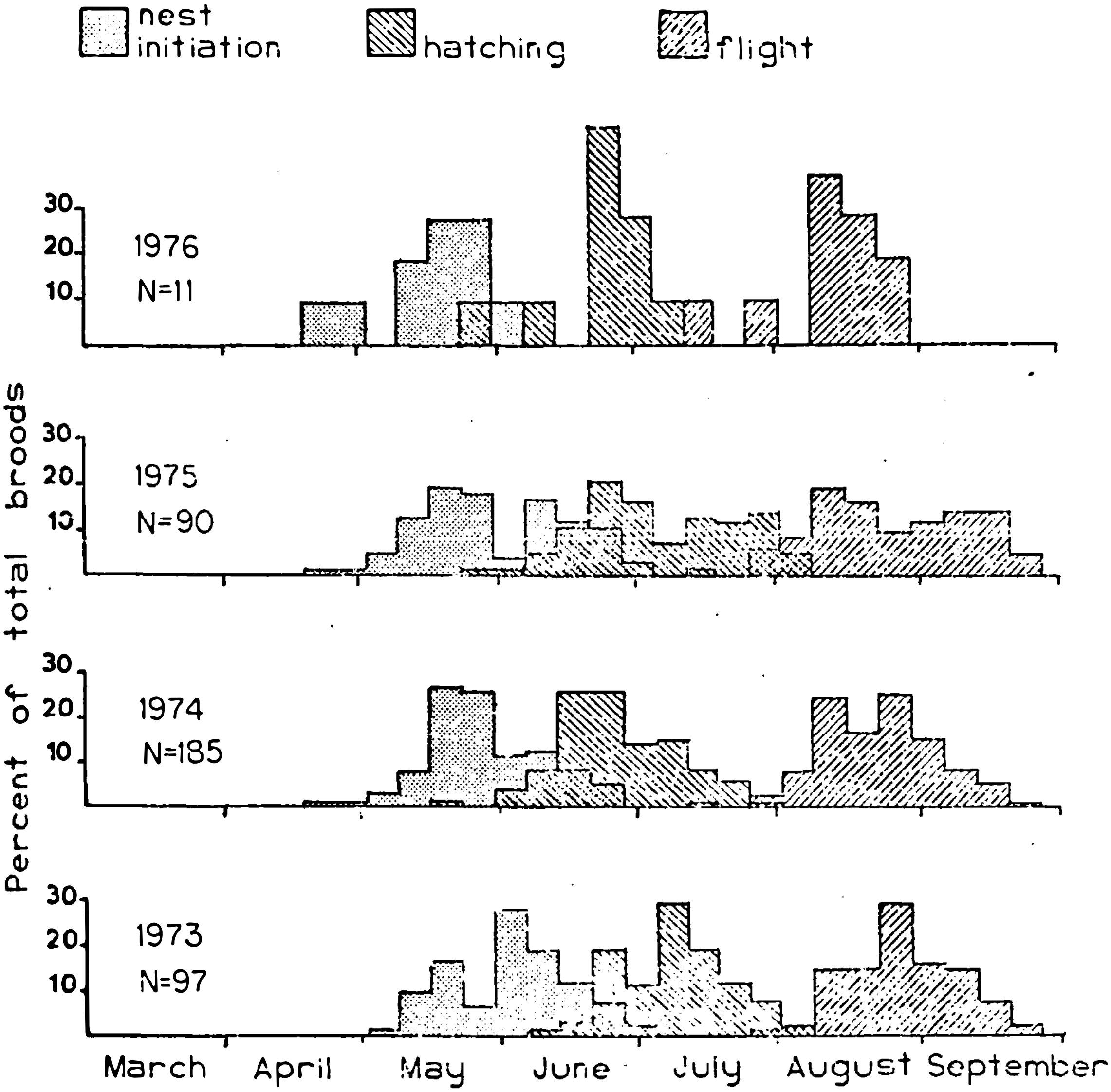

Figure 10. Gadwall - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

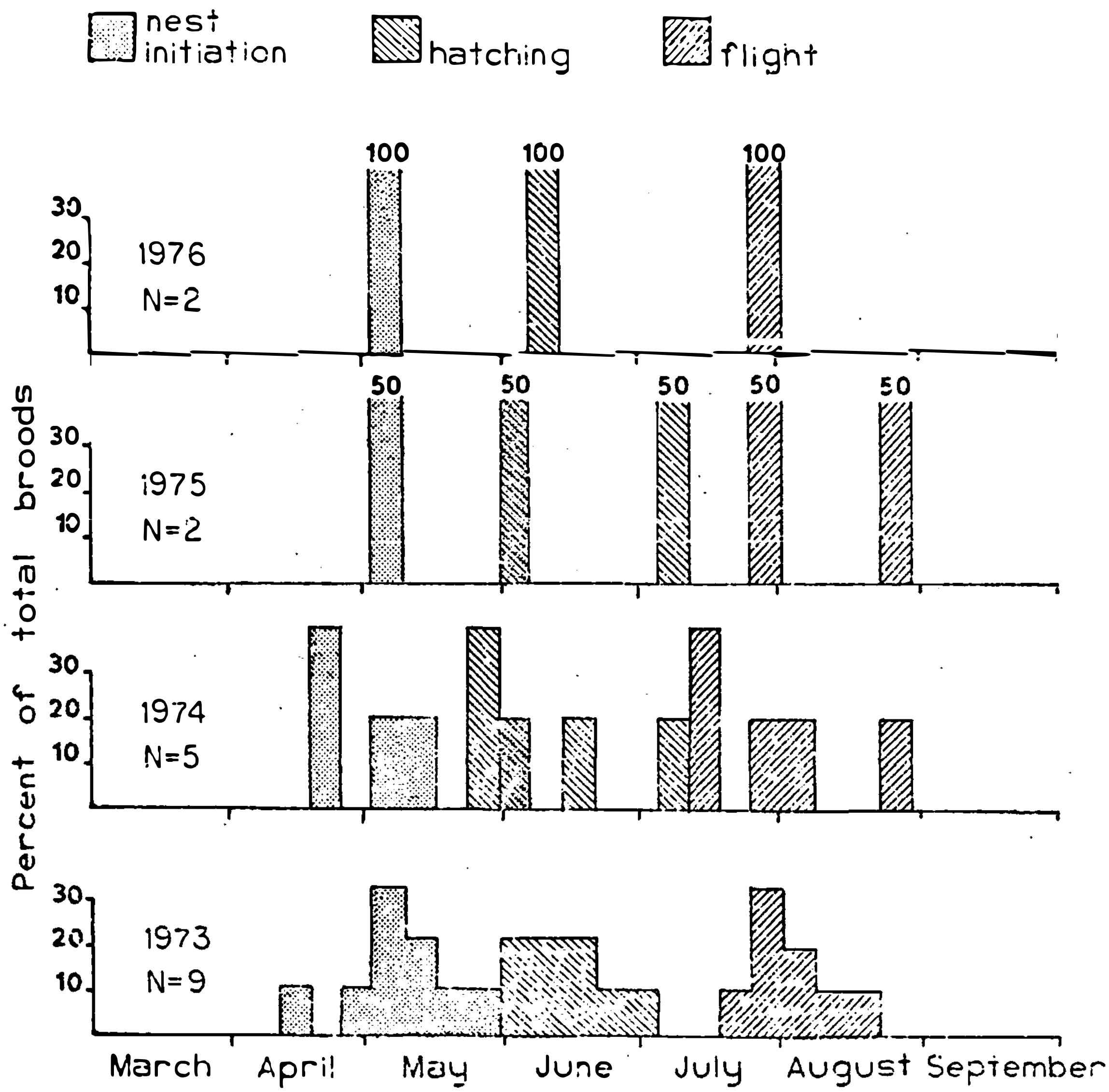

Figure 11. Northern shoveler - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

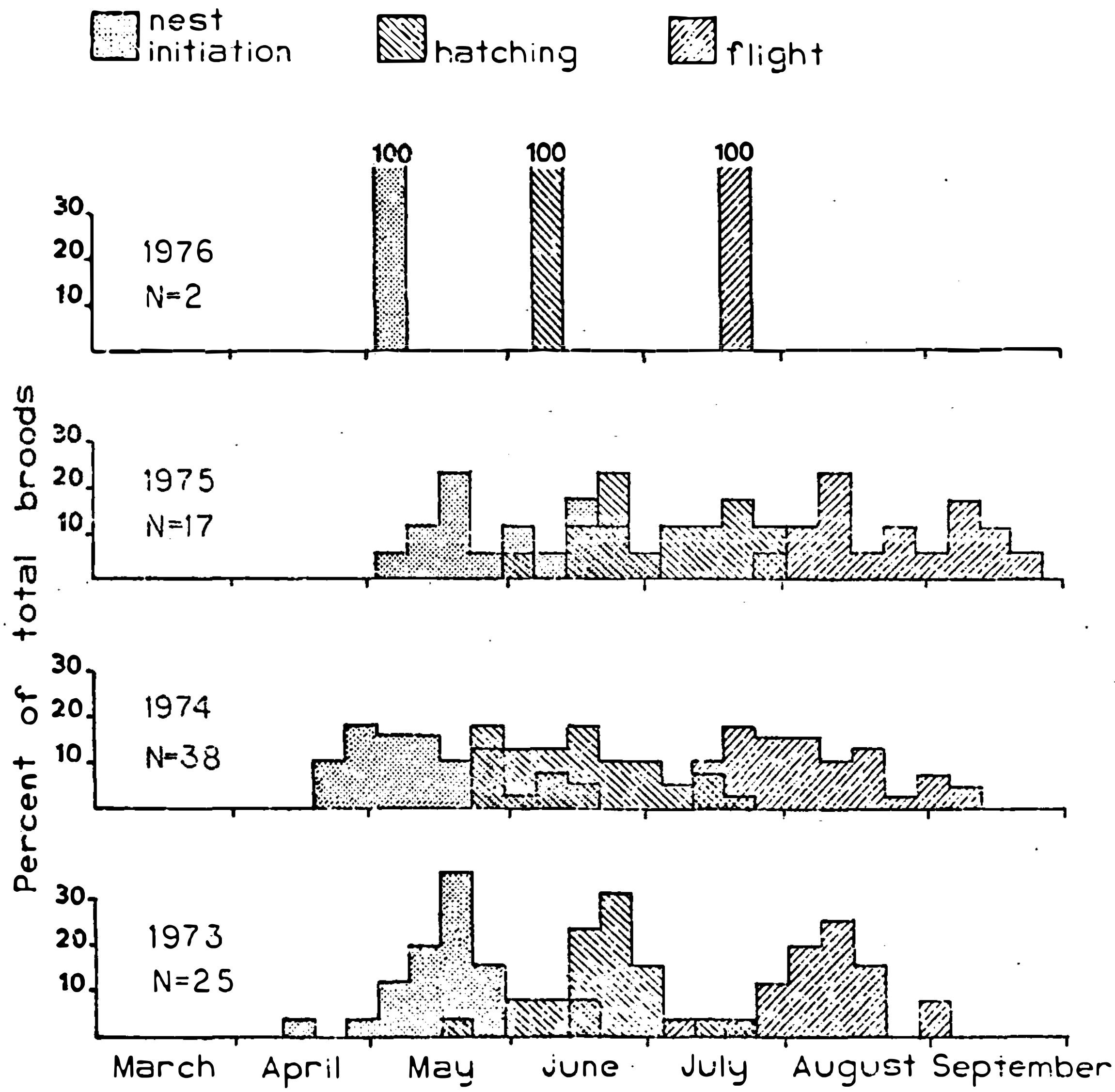

Figure 12. Northern shoveler - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

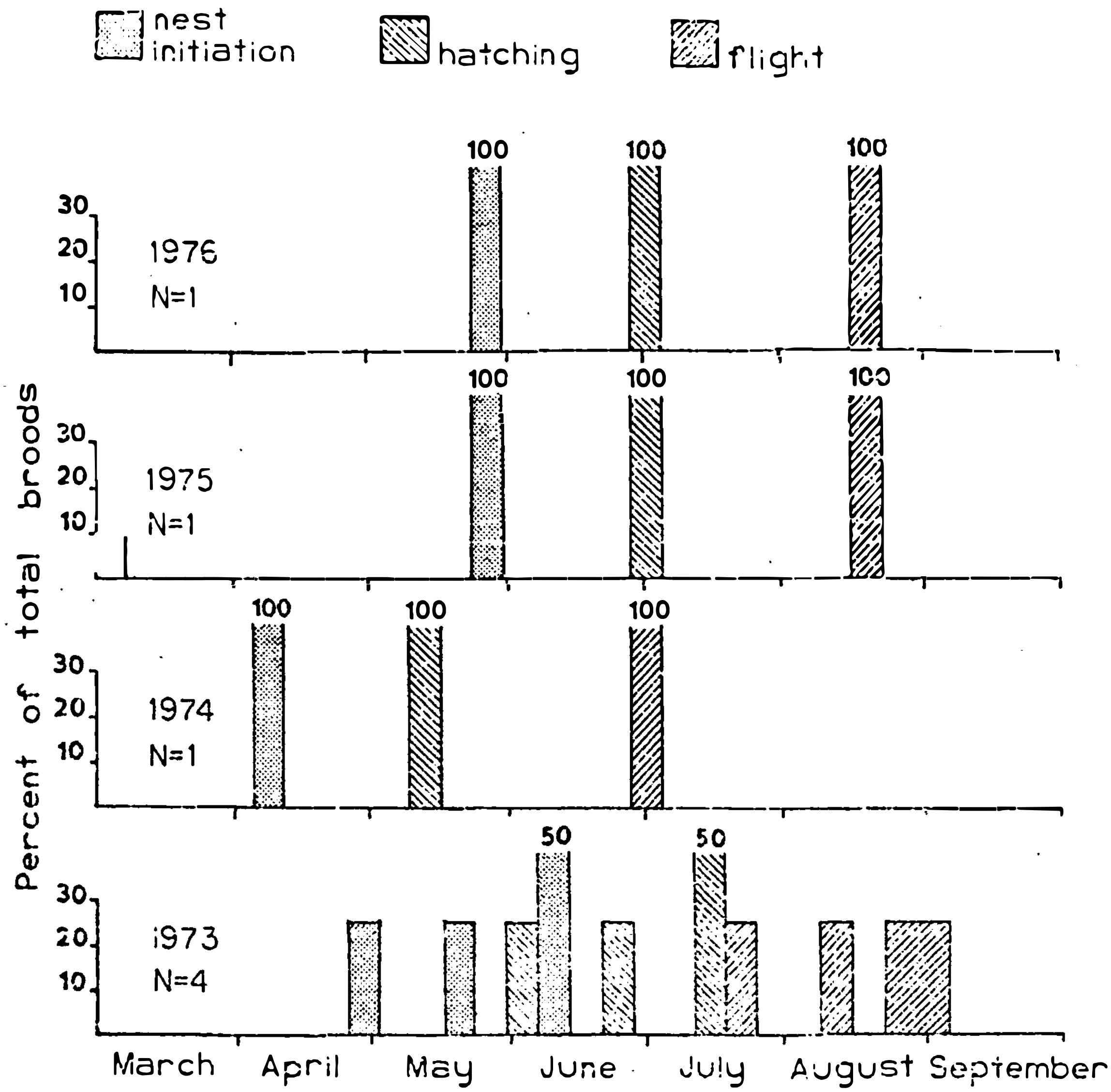

Figure 13. American wigeon - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

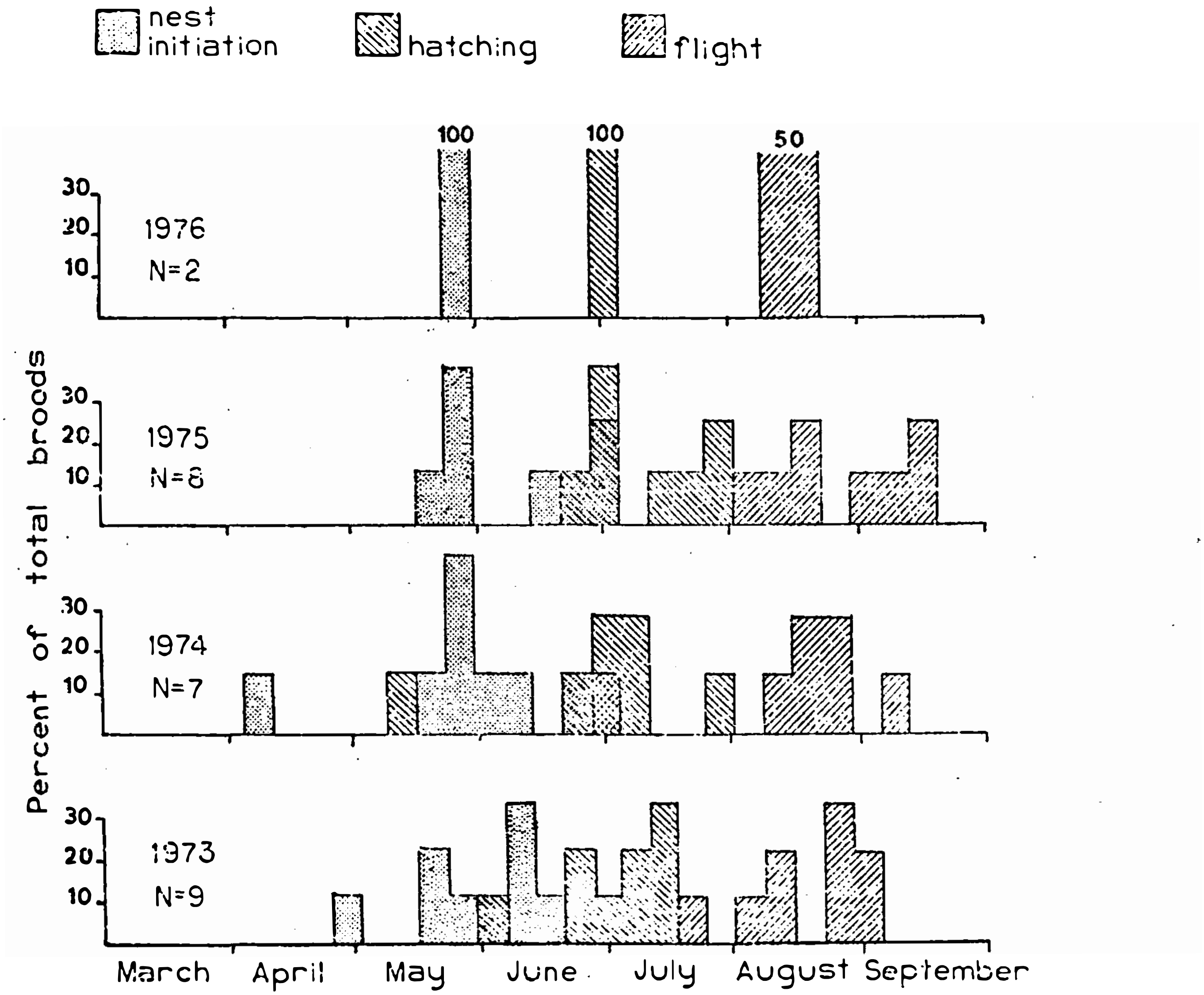

Figure 14. American wigeon - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

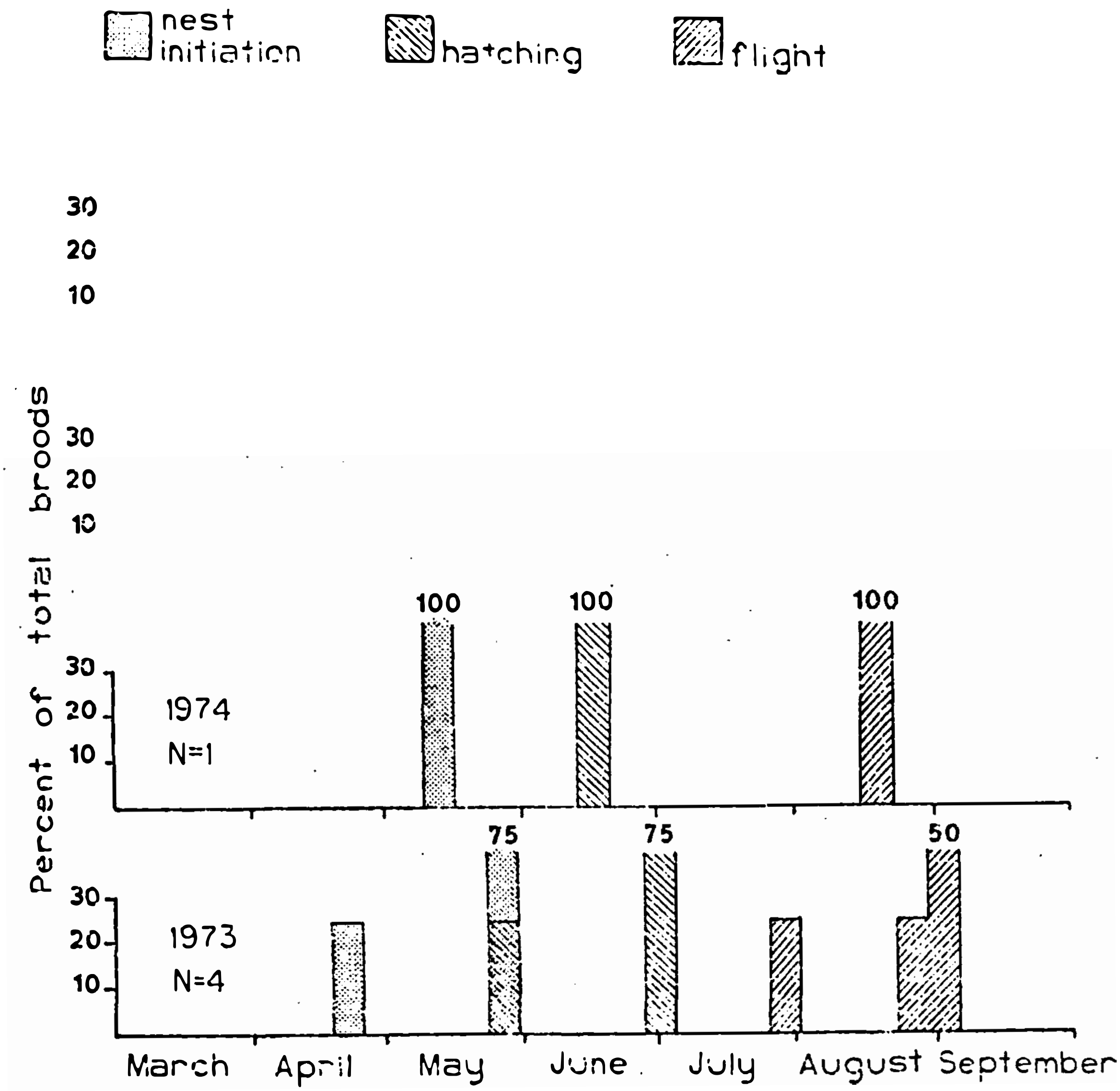

Figure 15. Canvasback - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

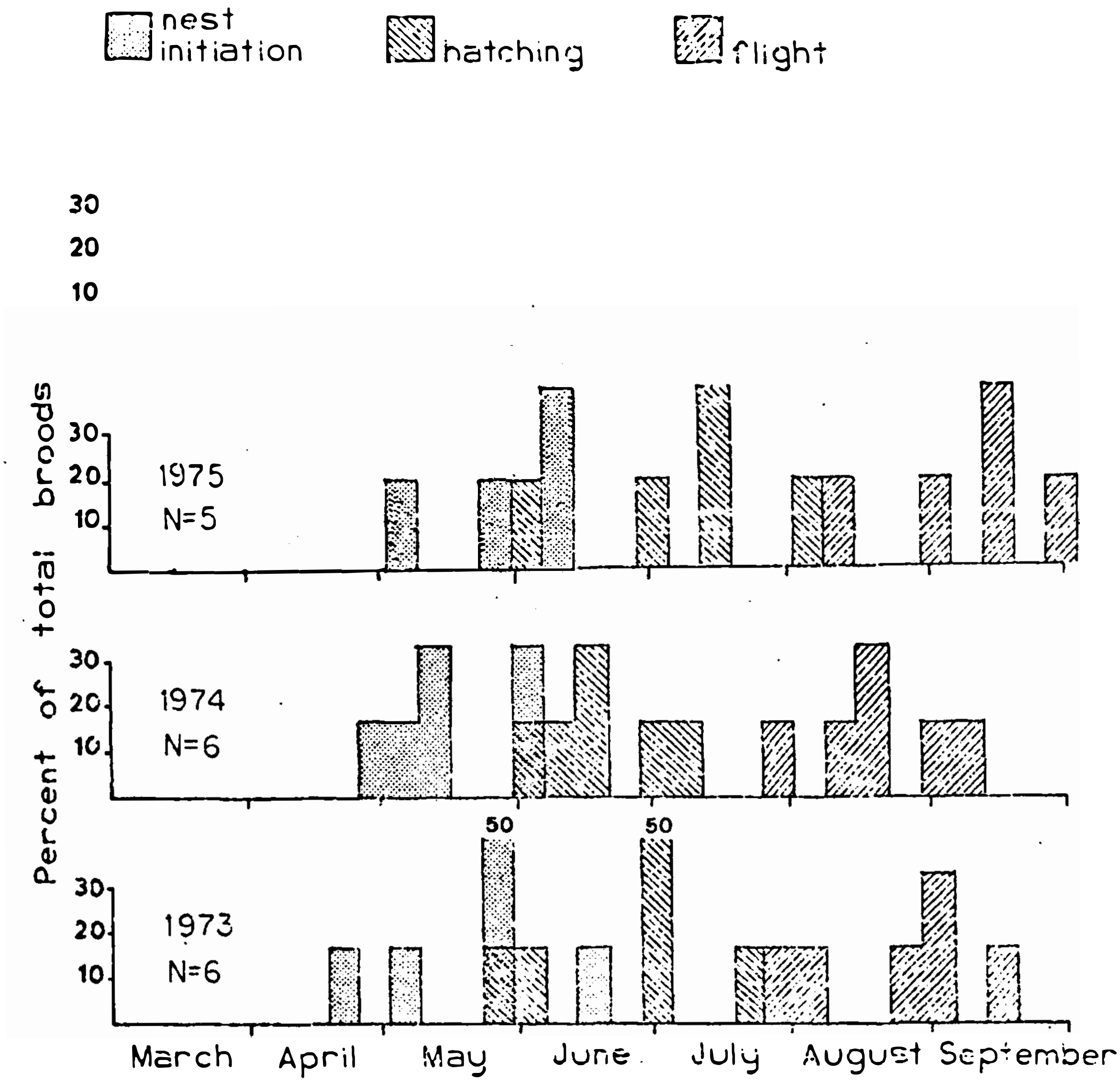

Figure 16. Canvasback - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

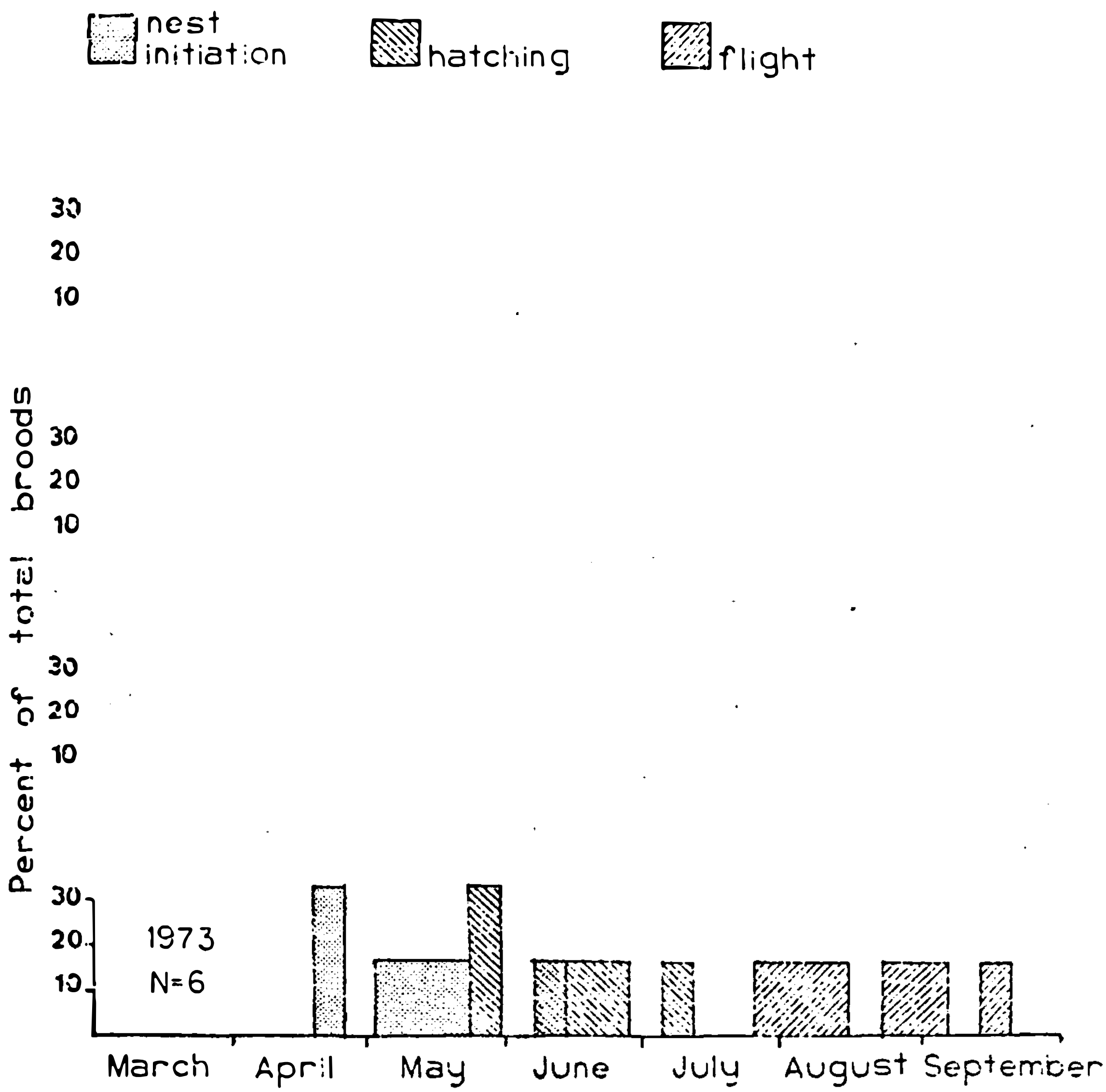

Figure 17. Redhead - nest initiation, hatching, and flight histograms. Histograms are based on broods observed on sample plots.

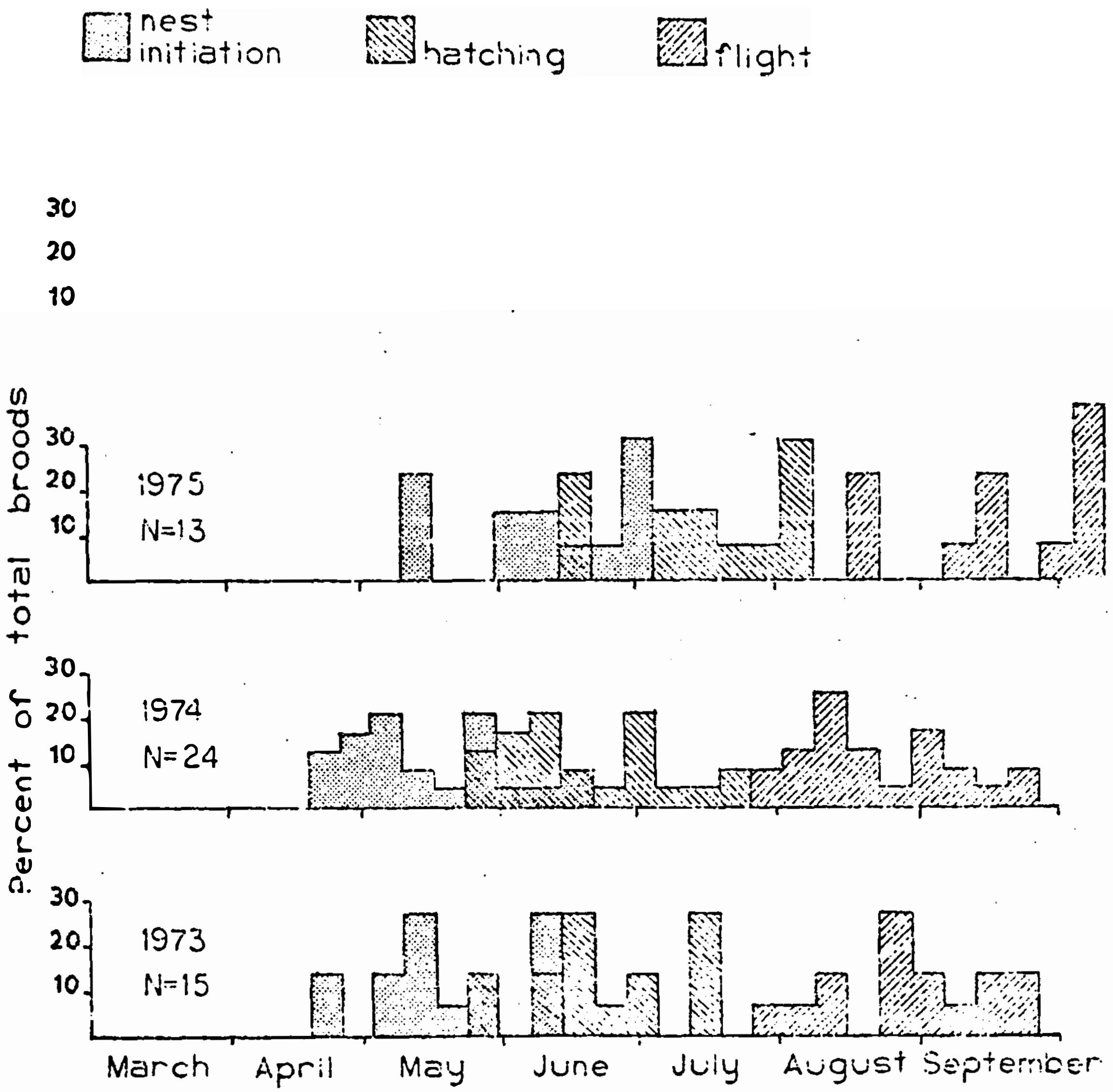

Figure 18. Redhead - nest initiation, hatching, and flight histograms. Histograms are based on broods observed both on and off sample plots.

hatching chronology are summarized (Tables 11-14). Included in these statistics are numbers of broods censused, first and last dates of nest initiations (brood hatchings), lengths of nest initiation (hatching) seasons, and average nest initiation dates.

Sampling problems that mandated presentation of nest initiation and hatching histograms separately by year and using on-plot and combined on-plot and off-plot data have been explained. There are other sampling problems which extend over either method of presentation and affect interpretation of these histograms.

The method used to observe off-plot broods permitted greater accuracy in identification and aging of species than methods used in on-plot sampling. A smaller fraction of the broods observed were placed in the "unknown" category (Table 6). Consequently, more of the observed broods were included in the sample.

Younger broods of mallards, pintails, and blue-winged teal are more secretive and tend to use denser cover than older broods (Ringelman 1977). Young broods of all species are probably missed with greater frequency during brood counts. Consequently, hatching (nest initiation) histograms derived from brood counts may not include a representative sample of the younger age-classes.

Wetland characterictics vary in different geographic regions of the state, particularly east and west of the Missouri River. Natural wetlands with dense emergent cover typify the eastern part of the state. Wetlands west of the Missouri are generally man-made with sparcer emergent cover. Many glacially formed lakes in the east exceed the largest stock ponds in size. Because of this, I feel that a larger portion of the available

Table 11. Nest initiation chronology of broods observed on plots.

Species	Year	No.	First nest	Last nest	Average initiation date	Season length (days)
	1973	121	4/21	6/17	5/20	57
Blue-winged	1974	55	5/02	6/09	5/23	40
teal	1975	42	5/03	6/14	5/22	42
	1976	26	4/12	6/02	5/16	51
	All	244	4/12	6/17	5/21	66
	1973	58	3/15	6/16	5/09	93
Mallard	1974	22	4/12	5/31	5/05	49
	1975	22	4/11	4/29	4/27	48
	1976	31	4/10	5/26	5/05	46
	All	133	3/15	6/16	5/05	93
	1973	16	4/13	6/09	5/09	57
Pintail	1974	13	4/13	6/11	5/03	59
	1975	23	4/10	6/09	5/06	60
	1976	18	4/14	6/03	5/04	50
	All	70	4/10	6/11	5/06	62
	1973	8	5/03	6/03	5/24	31
Gadwall	1974	12	4/21	6/01	5/18	41
	1975	11	5/04	6/05	5/20	32
	1976	7	4/20	6/03	5/15	44
	All	38	4/20	6/05	5/19	46
	1973	9	4/18	5/29	5/09	41
Northern	1974	5	4/24	6/03	5/08	40
shoveler	1975	2	5/03	6/05	5/20	33
	1976	2	5/07	5/08	5/08	1
	All	18	4/18	6/05	5/10	48
	1973	4	4/30	6/12	5/26	43
American	1974	1	4/11	4/11	4/11	
wigeon	1975	1	5/30	5/30	5/30	
	1976	1	5/29	5/29	5/29	
	All	7	4/11	6/12	5/21	62
	1973	4	4/24	5/30	5/20	36
Canvasback	1974	1	5/14	5/14	5/14	
	1975	0				
	1976	0				
	All	5	4/24	5/30	5/18	36
	1973	6	4/22	6/10	5/12	49
Redhead	1974	0				
	1975	0				
	1976	0				
	All	6	4/22	6/10	5/12	49

Table 12. Nest initiation chronology of broods observed on and off plots.

Species	Year	No.	First nest	Last nest	Average initiation date	Season length (days)
Blue-winged teal	1973	292	4/21	6/25	5/27	65
	1974	296	5/01	7/02	5/27	62
	1975	182	5/03	7/01	6/03	59
	1976	37	4/12	6/03	5/18	52
	All	807	4/12	7/02	5/28	81
Mallard	1973	156	3/15	6/22	5/16	99
	1974	148	4/12	6/26	5/17	75
	1975	99	4/11	6/27	5/21	77
	1976	39	4/10	5/27	5/05	47
	All	442	3/15	6/27	5/17	104
Pintail	1973	33	4/13	6/16	5/16	64
	1974	59	3/26	6/28	5/12	94
	1975	71	4/05	7/06	5/22	92
	1976	19	4/14	6/03	5/04	50
	All	182	3/26	7/06	5/16	102
Gadwall	1973	97	5/03	6/30	6/03	58
	1974	185	4/21	6/29	5/29	69
	1975	90	4/22	6/28	5/31	67
	1976	11	4/20	6/03	5/18	44
	All	383	4/20	6/30	5/30	71
Northern shoveler	1973	25	4/18	6/19	5/19	52
	1974	38	4/24	6/17	5/15	54
	1975	17	5/03	6/28	6/02	56
	1976	2	5/07	5/08	5/08	1
	All	82	4/18	6/28	5/20	71
American wigeon	1973	9	4/30	6/15	5/30	46
	1974	7	4/11	6/23	5/27	73
	1975	8	5/20	6/25	6/08	36
	1976	2	5/26	5/29	5/28	3
	All	26	4/11	6/25	6/01	75
Canvasback	1973	6	4/24	6/15	5/21	52
	1974	6	4/27	6/06	5/17	40
	1975	5	5/09	6/29	6/06	51
	1976	0				
	All	17	4/24	6/29	5/24	66
Redhead	1973	15	4/22	6/13	5/20	52
	1974	24	4/19	6/15	5/15	57
	1975	13	5/12	6/30	6/11	49
	1976	0				
	All	52	4/19	6/30	5/23	72

Table 13. Hatching chronology of broods observed on plots.

Species	Year	No.	First brood	Last brood	Average Hatching date	Season length (days)
Blue-winged teal	1973	121	5/25	7/21	6/23	57
	1974	55	6/05	7/13	6/26	38
	1975	42	6/06	7/18	6/25	42
	1976	26	5/16	7/06	6/19	51
	All	244	5/16	7/21	6/24	66
Mallard	1973	58	4/21	7/23	6/15	93
	1974	22	5/19	7/07	6/11	49
	1975	22	5/18	7/05	6/03	48
	1976	31	5/17	7/02	6/11	46
	All	133	4/21	7/23	6/11	93
Pintail	1973	16	5/13	7/09	6/08	57
	1974	13	5/13	7/11	6/02	59
	1975	23	5/10	7/09	6/05	60
	1976	18	5/14	7/03	6/03	50
	All	70	5/10	7/11	6/05	62
Gadwall	1973	8	6/08	7/09	6/29	31
	1974	12	5/27	7/07	6/23	41
	1975	11	6/09	7/11	6/25	32
	1976	7	5/26	7/09	6/20	44
	All	38	5/26	7/11	6/24	46
Northern shoveler	1973	9	5/21	7/01	6/11	41
	1974	5	5/27	7/06	6/10	40
	1975	2	6/05	7/08	6/22	33
	1976	2	6/09	6/10	6/10	1
	All	18	5/21	7/08	6/12	48
American wigeon	1973	4	6/02	7/15	6/28	43
	1974	1	5/14	5/14	5/14	
	1975	1	7/02	7/02	7/02	
	1976	1	7/01	7/01	7/01	
	All	7	5/14	7/15	6/23	62
Canvasback	1973	4	5/28	7/03	6/23	36
	1974	1	6/17	6/17	6/17	
	1975	0				
	1976	0				
	All	5	5/28	7/03	6/21	36
Redhead	1973	6	5/27	7/15	6/16	49
	1974	0				
	1975	0				
	1976	0				
	All	6	5/27	7/15	6/16	49

Table 14. Hatching chronology of broods observed on and off plots.

Species	Year	No.	First brood	Last brood	Average hatching date	Season length (days)
	1973	292	5/25	7/29	6/30	65
Blue-winged	1974	296	6/04	8/05	6/30	62
teal	1975	183	6/06	8/04	7/07	59
	1976	37	5/16	7/07	6/21	52
	All	807	5/16	8/05	7/01	81
	1973	156	4/21	7/29	6/22	99
Mallard	1974	148	5/19	8/02	6/23	75
	1975	99	5/18	8/04	6/27	78
	1976	39	5/17	7/03	6/11	47
	All	442	4/21	8/04	6/23	104
	1973	33	5/13	7/16	6/15	64
Pintail	1974	59	4/25	7/28	6/11	94
	1975	71	5/05	8/05	6/21	92
	1976	19	5/14	7/03	6/04	50
	All	182	4/25	8/05	6/15	102
	1973	97	6/08	8/05	7/09	58
Gadwall	1974	185	5/27	8/04	7/04	69
	1975	90	5/28	8/03	7/01	67
	1976	11	5/26	7/09	6/23	44
	All	383	5/26	8/05	7/05	71
	1973	25	5/21	7/22	6/21	62
Northern	1974	38	5/27	7/20	6/17	54
shoveler	1975	17	6/05	7/31	7/05	56
	1976	2	6/09	6/10	6/10	1
	All	82	5/21	7/31	6/27	71
	1973	9	6/02	7/18	7/02	46
American	1974	7	5/14	7/26	6/29	73
wigeon	1975	8	6/22	7/28	7/11	36
	1976	2	6/28	7/01	6/30	3
	All	26	5/14	7/28	7/04	75
	1973	6	5/28	7/19	6/24	52
Canvasback	1974	6	5/31	7/10	6/20	40
	1975	5	6/12	8/02	7/10	51
	1976	0				
	All	17	5/28	8/02	6/27	66
	1973	15	5/27	7/18	6/24	52
Redhead	1974	24	5/24	7/20	6/19	57
	1975	13	6/16	8/04	7/16	49
	1976	0				
	All	52	5/24	8/04	6/27	72

broods was censused west of the Missouri than east. Furthermore, broods are not uniformly distributed throughout the state. Locations of brood observations made on sample plots are depicted in Appendix C. This provides a rough illustration of brood distributions in the state. On a per unit area basis, the coteau regions had a denser concentration of brood observations except during the drought year of 1976 when a larger fraction of broods was observed on stock dams west of the Missouri River.

If nest initiation and hatching histograms are to equitably represent all areas of the state, there should be no regional variation in nesting chronology. Least squares analysis indicated that this assumption may not be correct (Table 8). Unfortunately, no absolute statement can be made. There was a difference in nesting chronology of broods observed on-plots versus off-plots. This was undoubtedly due to differences in time of sampling. The off-plot data was much more regionalized than the on-plot data and off-plot data was not collected equitably in different years of the study. Hence, differences that show up between strata, isocline zones, and years may be due to disproportionate numbers of off-plot samples falling within the various increments of these variables. In other words, an increment containing a large proportion of off-plot samples might be expected to have a later average nest initiation date simply because the average nest initiation date of off-plot broods was later than that of on-plot broods. Sample sizes were too small to permit examination of interaction effects between type of sample (on-plot or off-plot) and strata, isoclines, or years.

Histograms cannot be said to represent the natural distribution of broods in South Dakota nor can they be said to represent a uniform density of broods sampled throughout the state. Histograms constructed from on-plot data approximate the natural distribution of broods in the state since this data was collected in a random fashion. When off-plot data are added, histograms become regionally biased.

Nest initiation dates computed from brood observations are not a realistic array of actual nest initiation dates. Brood observations represent only successful nests. Nest initiation histograms are consequently weighted toward later nest initiations of successfully renesting ducks.

With the preceding discussion on sampling biases in mind, I caution the reader that these nest initiation and hatching histograms are not intended to be definitive. They are approximations of nesting chronology of ducks in South Dakota.

Two former studies which present nesting chronology information were conducted in South Dakota. Evans and Black (1956) constructed nest initiation curves for broods of blue-winged teal, gadwalls, mallards, and pintails observed near Waubay in 1950 through 1953. Unfortunately, these curves are not easily comparable to my histograms because they were constructed on the basis of cumulative percent of all nests initiated. The histograms in my study were constructed on the basis of weekly percent of all nests initiated. Peak initiation periods were obscured in the Waubay curves, but they occurred where there were maximum percent increases in nest initiations over a given time interval. Times of peak nest initiations were highly variable both in my study and the Waubay study. Comparing my combined on-plot and off-plot histograms to the Waubay curves, blue-winged teal began nesting at about the same time, but the Waubay curves indicated that nest initiations extended later into the summer. Gadwalls began nesting later and continued to initiate nests later at Waubay. Duration and timing of mallard and pintail nest initiation histograms are roughly comparable to the Waubay curves. Early curtailment of nest initiations in 1976 is indicated for all species in my study. This is probably due to the lack of off-plot sampling effort in 1976 which excluded later broods from the sample. It is doubtful, however, that there were many successful late nest attempts during this year due to drought conditions and receding water levels in wetlands.

Duebbert (1969) determined weekly nest initiation totals for mallards, gadwalls, pintails, green-winged teal (Anas crecca), blue-winged teal, american wigeons, and northern shovelers from nests found near Hosmer, Edmunds County, during 1968. Comparing Duebbert's results to my combined on-plot and off-plot nest initiation histograms, peaks of nest initiations are roughly equivalent for mallards (mid May), gadwalls (late May), and blue-winged teal (late May). Sample sizes in Duebbert's study are too small to permit meaningful comparison for the remaining species. In all cases, my histograms indicate both earlier and later nest initiations. This is probably consequent to my data being collected over 4 years with varying climatalogical conditions while Duebbert's data was collected during only 1 breeding season. No statement can be made regarding green-winged teal as only 1 brood was aged in my study.

All species were subject to the same sampling procedures during the course of this project. Some valid comments may therefore be made concerning relative nest initiation chronology of successfully nesting ducks (Table 12). The same comments apply to hatching chronology. Data used in comparisons encompasses both on-plot and off-plot samples collected in all 4 years of the study.

Mallards and pintails were the earliest nesting species and nest initiations extended over the longest periods of time. Average nest initiation dates were 17 and 16 May respectively. Lengths from first to last nests were 104 and 102 days respectively. Average nest initiation dates indicated northern shovelers, redheads, and canvasbacks to be intermediate nesters in South Dakota. These dates were 20 May, 23 May, and 24 May. Blue-winged teal, gadwalls, and American wigeons were late nesters with average initiation dates of 28 May, 30 May, and 1 June. Span of the nesting season was variable between species of intermediate and late nesters.

Weller (1964:36) has compared nest initiation data from past studies and presents 2 week peaks of nest initiation activity for several species. My conclusions regarding relative timing of nest initiations largely agree with Weller's results, except for redheads. Weller indicates redheads to be quite late nesters while my average nest initiation dates place them in mid range of nest initiations.

There were isolated observations of broods of ruddy ducks (Oxyura jamaicensis), green-winged teal, wood ducks (Aix sponsa), and lesser scaup (Aythya affinis). There were not enough observations to construct meaningful nest initiation (hatching) histograms or to run any kind of analysis on factors affecting nest initiation dates. Several ruddy duck broods were seen but due to the difficulty of aging these broods, only 1, a very young brood, was aged. The nest initiation date of this brood was 11 May and the hatching date was 11 June. Only 1 green-winged teal brood was aged.

The nest initiation date was 9 June and the hatching date was 10 July. Three lesser scaup broods were aged. The nest initiation dates were 9 June, 19 June, and 2 July. Hatching dates were 13 July, 23 July, and 5 August. Three wood duck broods were aged. Nest initiation dates were 11 April, 13 April, and 14 April. Hatching dates were 23 May, 25 May, and 26 May.

Multiple Regression Analysis of Nest Initiation Dates

The reasons I used several of the variables in multiple regression analyses are obscure and require clarification. Variables which may appear superfluous include those that measure aspects of wetland habitat.

Little work has been done to evaluate nesting chronology in relation to habitat. The need for examining relationships between habitat quality and nesting chronology was stressed by Dzubin and Gollop (1972). Some investigators have demonstrated that nesting chronology is altered when certain aspects of habitat quality are suboptimal. Gates (1965) observed delayed nest initiations by blue-winged teal and mallards in areas where development of suitable nesting substrate was retarded. Dzubin and Gollop (1972) concluded that receding water levels during a dry year curtailed later nesting attempts. It is not unreasonable to suggest that other aspects of habitat quality also affect nest initiation dates.

Behavioral and physiological traits of breeding pairs permit speculation that wetland diversity may influence nesting chronology. Dzubin and Gollop (1972) determined that mallards select areas with a diverse community of wetland types. Greater production occurs in a diverse complex of densely scattered wetlands (Jahn and Hunt 1964). There is consequently a greater residual of ducks that could potentially return the following year. Adult females generally home to nest sites of prior years while surviving yearlings are less likely to return to their hatching sites (Sowls 1955). Assuming that ducks select optimum breeding habitat within their traditional nesting areas, yearlings would have to compete with adults for these sites. Yearlings of most species tend to assume reproductive conditions and arrive on breeding areas later than adults (Bellrose 1976). They are excluded from territories which are rigorously defended by breeding pairs of adults. Consequently, yearlings are forced to select inferior nesting sites which are ultimately populated with larger portions of these birds. I could find no evidence to support this hypothesis, but later nest initiation dates would reflect the large yearling component of an inferior nesting area. Measures of wetland diversity, density, and water conditions are indicators of habitat quality and might be expected to correlate with nest initiation dates.

The way I handled temperature as a variable requires further explanation. Several investigators have found relationships between temperature and nest initiation dates. Most of these relationships were not, however, statistically determined. Sowls (1955) demonstrated that nest initiations of mallards, pintails, and blue-winged teal were earlier in a warmer year and later in a cooler year. Cold weather has frequently been related to delayed or interrupted nest initiations. Sowls (1955) attributed delayed nest initiations of gadwalls to cold weather. Mallard nest initiations may be delayed as much as 2 weeks by cold weather (Yocom 1950, Sowls 1955, Evans and Black 1956, Dzubin and Gollop 1972). Pintails are also delayed as much as 2 weeks by cold weather (Sowls 1955, Smith 1971). Blue-winged teal are likewise delayed (Sowls 1955, Dane 1966, Strohmeyer 1967).

A statistical relationship between temperature and nest initiations was determined for several species by Kieth (1961). He computed a "heat sum" by adding the maximum daily temperatures above freezing from 10 to 28 April inclusive. This was correlated with the mean nest initiation dates determined each year of the study by averaging nest initiation dates of all species. The species included pintails, mallards, northern shovelers, American wigeons, redheads, blue-winged teal, gadwalls, and lesser scaup. Kieth did not attribute much significance to his find, however. Blue-winged teal, lesser scaup, and gadwalls arrived on the breeding grounds after the 10 to 28 April period while many mallards and pintails began nesting before this time.

I wanted to include some measurement of temperature in my multiple regression analysis and avoid problems associated with Kieth's heat sum. Rather than use a single period to measure temperature for all species, time periods were defined individually for each species. One and two week periods ended on the date by which 5% of the nests of a given species had been initiated. In this way, the temperature measurements could be directly linked to each species. Variables Temperature-1 through Temperature-6 express this measurement.

A second approach was to find an average temperature which preceded nest initiations of each species. The date at which this temperature was first exceded at the site of a nest initiation served as the independant variable. Again, this approach permitted the variable to be directly associated with the individual species. Variables Temp.date-1 through Temp.date-6 express this measurement.

Sample sizes were small for some of the species in the multiple regression analyses (Tables 15-18). These included northern shovelers when all variables were run, redheads when date of last snow cover was deleted, canvasbacks when habitat variables were deleted, and canvasbacks again when both date of last snow cover and habitat variables were deleted. The high R^2 values in these cases were probably due to the greater possibility of chance linear relationships existing in a small sample. Significant variables ($P<.05$) appear to explain most of the variation in nest initiation dates, but much larger sample sizes would be required to approximate actual linear relationships that might exist between nest initiation dates and independent variables.

Independant variables were selected to determine if temperature, habitat, and physiography affect nest initiation dates of ducks. A large number of variables were significant ($P<.05$) but explained little of the variation in nest initiation dates of most species. There were also several instances where variables were positively correlated when a negative correlation was expected and vice versa. It appears that independant variables exhibit little or no linearity in relation to the dependant variable, date of nest initiation. There may not be enough variation in climate, habitat, and physiography within South Dakota to permit evaluation of potential effects on nest initiations. Consequently, the multiple regression analyses do not provide adequate evidence to accept or reject the independant variables as parameters that influence nest initiation dates. Analysis of environmental effects on nest initiation dates of ducks should be applied to data collected over a broader and more diverse area, the entire prairie pothole region, for example.

Table 15. Stepwise forward multiple regression analysis of nest initiation dates - all variables considered.

Species[a]	Independent variables[b]	Coefficient of determination (R^2)	Change in R^2	Simple corr. coef. (r)	Standardized partial regression coefficient (b)
Blue-winged teal (86 broods)	Last snow	.09298	.09298	-.30493*	-.29849
	May wetland diversity	.11665	.02367	.11792*	.45552
	June wetland diversity	.17067	.05402	-.06772	-.38297
Mallard (60 broods)	Lattitude	.14366	.14366	.37902	.47172
	Isocline	.19679	.05313	.16109*	.37713
	June wetland fraction	.27594	.07916	.11525*	.31582
Pintail (43 broods)	Lattitude	.10854	.10854	.32946	-.32708
	Temp.date-6	.14491	.03637	.27179	.43653
	Temperature-3	.17352	.02851	-.13393	-.63393
	Isocline	.25205	.07853	-.28742	-1.41218
	Temperature-6	.31512	.06307	-.11094	2.53157
	Temp.date-1	.35017	.03505	-.15966*	-1.07924
	No. June wetlands	.37696	.02679	.06013*	.81567
	Temperature-4	.40338	.02642	-.12709	4.51632
	May wetland fraction	.44373	.04035	.03472*	-.51632
	Total No. wetlands	.50475	.06102	-.02246	-.38906
	Temp.date-6	.98363	.09516	-.25022*	.41055
	Temperature-1	.99991	.01623	.31934*	.17931
Redhead ([illegible] broods)	Last snow	.63287	.63287	.79553	.41605
	Temp.date-5	.67291	.04003	.48148	3.69509
	Temperature-6	.69924	.02633	.21748*	.37967
	Lattitude	.71150	.01226	.52742	.15309
	Temp.date-6	.75692	.04542	.03593	[illegible]
	Temperature-1	.77438	.01747	-.36432	.23555
	Temp.date-2	.78840	.01401	.22664	[illegible]
	Temp.date-4	.79584	.00744	.49734	-3.06578
	Temperature-4	.81392	.01798	-.37921	-1.73069
	Temp.date-3	.82762	[illegible]	.01366	[illegible]

[a] Includes only species for which there were significant independent variables (P ≤.05).

[b] Variables are listed in the order of their ability to explain variance in the dependent variable. The first variable listed for each species explains the most variance.

*The correlation signs of these variables are opposite of expected signs.

Table 16. Stepwise forward multiple regression analysis of nest initiation dates - habitat variables deleted.

Species[a]	Independent variables[b]	Coefficient of determination (R^2)	Change in R^2	Simple corr. coef. (r)	Standardized partial regression coefficient
Blue-winged teal (226 brood)	Isocline	.05523	.05523	-.23500	-.09736
	Last snow	.09323	.02801	-.23331*	-.14980
	Temperature-2	.11906	.02582	.17662	.26416
	Temp.date-5	.14418	.02512	.18112	.21913
Mallard (149 broods)	Temperature-3	.02518	.02518	-.15870	-.25026
	Temperature-1	.05870	.03261	.08932*	.20248
Pintail (75 broods)	Isocline	.10504	.10504	-.32410	-.65162
	Temperature-4	.15759	.05255	-.16431	.73954
	Temp.date-5	.21189	.05430	.29490	.41442
Gadwall (136 broods)	Temp.date-3	.05338	.05338	-.23104*	-.31427
	Temperature-1	.09400	.04062	-.12152	-.31783
	East - west river	.13563	.04163	.10693	.22814
Canvasback (6 broods)	Temp.date-4	.43323	.43323	.65820	1.03214
	Lattitude	.88847	.45524	-.46434*	-.78825
	East - west river	.54334	.03859	-.07367	-.26905
	Temp.date-3	.56576	.02242	.18400	-1.39120
	Temp.date-4	.58795	.02219	.22947	1.92004
	Temperature-2	.66328	.07533	-.10640	-2.02413
Northern shoveler (9 broods)	June wetland fraction	.48336	.48336	-.69524	-3.33400
	Total no. wetlands	.66008	.17672	.33313*	-2.75356
	No. June wetlands	.77374	.11366	-.24333	.97213
	East - west river	.87782	.10408	-.12303	1.22737
	Temp.date-6	.98001	.10219	.01926	-1.13076
	Temp.date-2	.99999	.01998	.01504	.68569

[a]Includes only species for which there were significant independent variables ($P < .05$).

[b]Variables are listed in the order of their ability to explain variance in the dependent variable. The first variable listed for each species explains the most variance.

*The correlation signs of these variables are opposite of expected signs.

Table 17. Stepwise forward multiple regression analysis of nest initiation dates - date of last snow cover deleted.

Species[a]	Independant variables[b]	Coefficient of determination (R^2)	Change in R^2	Simple corr. coef. (r)	Standardized partial regression coefficient (b)
Blue-winged teal (170 broods)	Lattitude	.06069	.06069	.24634	.26399
	No. June wetlands	.08750	.02682	-.06072	-.12499
	Temperature-2	.10944	.02193	.06722*	.19375
	Temp.date-6	.12686	.01742	.19488	.16491
	East - west river	.13617	.00932	.05576	.16558
	May wetland diversity	.14771	.01154	.02915*	.37811
	June wetland diversity	.17040	.02269	-.10594	-.30579
Mallard (90 broods)	Lattitude	.08119	.06119	.28495	.28495
Pintail (52 broods)	Lattitude	.13824	.13824	.37181	.50159
	Total no. wetlands	.17556	.03731	-.02526	-.93423
	May wetland fraction	.21168	.03612	.04721*	.80619
	No. May wetlands	.30906	.09738	.09586*	.63538
Redhead (4 broods)	Temperature-3	.92256	.92256	.96050*	.78416
	Lattitude	.99955	.07700	-.74936*	-.32878

[a]Includes only species for which there were significant independant variables ($P < .05$).

[b]Variables are listed in the order of their ability to explain variance in the dependent variable. The first variable listed for each species explains the most variance.

*The correlation signs of these variables are opposite of expected signs.

Table 18. Stepwise forward multiple regression analysis of nest initiation dates - both date of last snow cover and habitat variables deleted.

Species[a]	Independant variables[b]	Coefficient of determination (R^2)	Change in R^2	Simple corr. coef. (r)	Standardized partial regression coefficient (b)
Blue-winged teal (402 broods)	Isocline	.03958	.03958	-.19894	-.04933
	Temperature-2	.05139	.01182	.08859*	.28290
	Temp.date-5	.08819	.03679	.17945	.25578
	Temp.date-2	.10113	.01294	.17082	.27627
	Temp.date-3	.11386	.01274	.04680	-.26426
	Temp.date-6	.12704	.01318	.12049	.27889
	Temp.date-1	.13334	.00629	.15737	-.16665
	Temperature-6	.13838	.00504	.19248*	.41082
	Temperature-4	.14642	.00805	-.11619	-.22513
	Temperature-3	.15502	.00859	.13054*	-.22881
Pintail (91 broods)	Isocline	.06631	.06631	-.25750	-.57229
	Temperature-4	.08800	.02169	-.13972	1.44332
	Temperature-1	.18456	.09656	-.21799	-.89087
	Temp.date-5	.22379	.03922	.25185	.33308
Gadwall (192 broods)	Temp.date-3	.04135	.05135	-.20335*	-.30645
	Temp.date-6	.08033	.03897	.06537	.15686
	Temperature-1	.09242	.01210	-.09373	-.18236
	East - west river	.11356	.02114	.14576	.16395
Northern shoveler (41 broods)	Temp.date-5	.14565	.14565	.38163	.38163
Canvasback (9 broods)	Temperature-3	.23528	.23528	.48505*	-.69079
	Temp.date-6	.29311	.05784	-.28148*	.65479
	Temperature-6	.36182	.06870	-.14592	-1.46593
	Temperature-5	.58454	.22272	.29697*	2.81133
	Temp.date-4	.73340	.14887	.13545	1.41175
	Temp.date-3	.87083	.13742	-.09905*	-2.23779
	Temperature-2	.89265	.02182	.11558*	-.42992

[a]Includes only species for which there were significant independant variables ($P < .05$).

[b]Variables are listed in the order of their ability to explain variance in the dependant variable. The first variable listed for each species explains the most variance.

*The correlation signs of these variables are opposite of expected signs.

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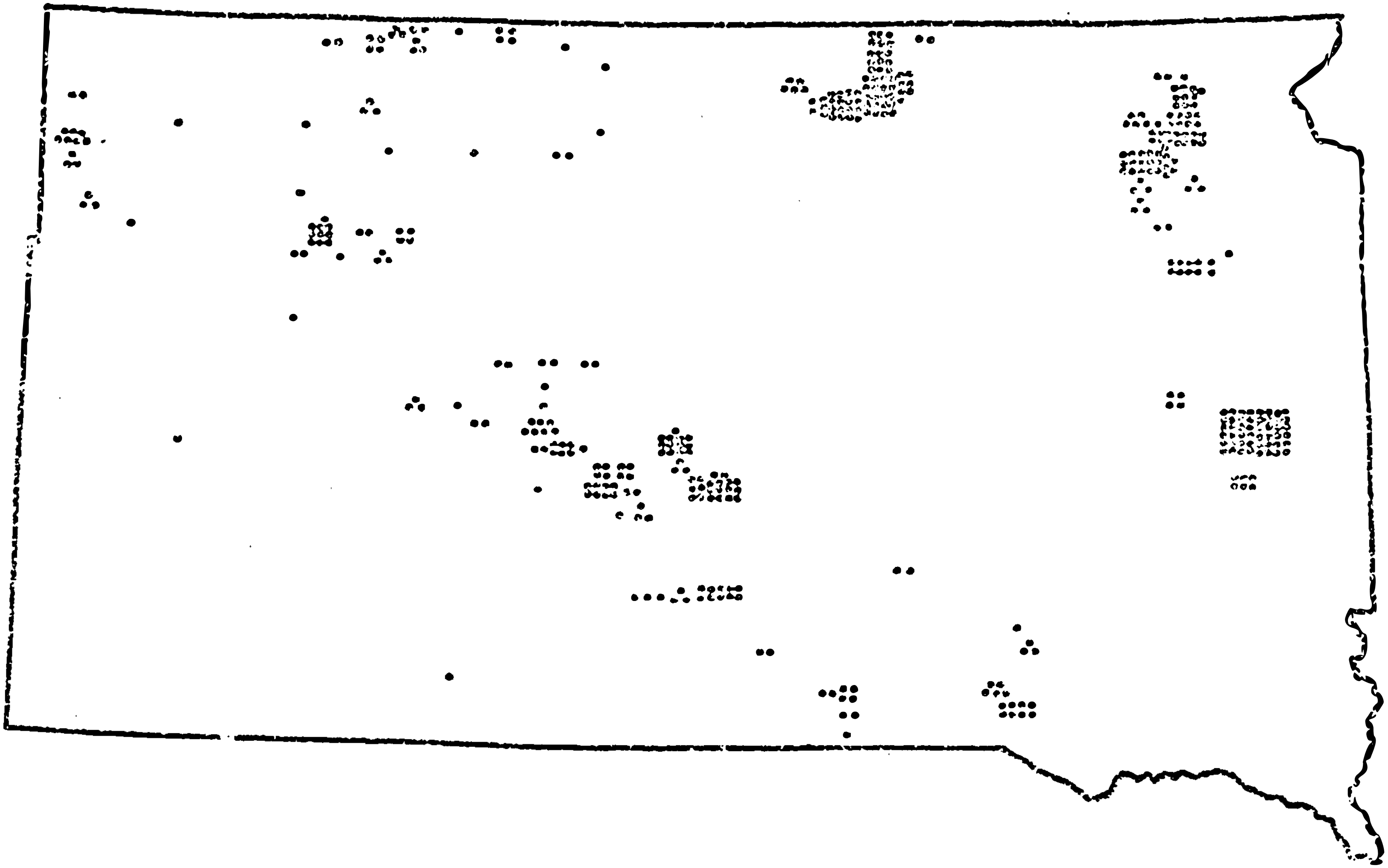
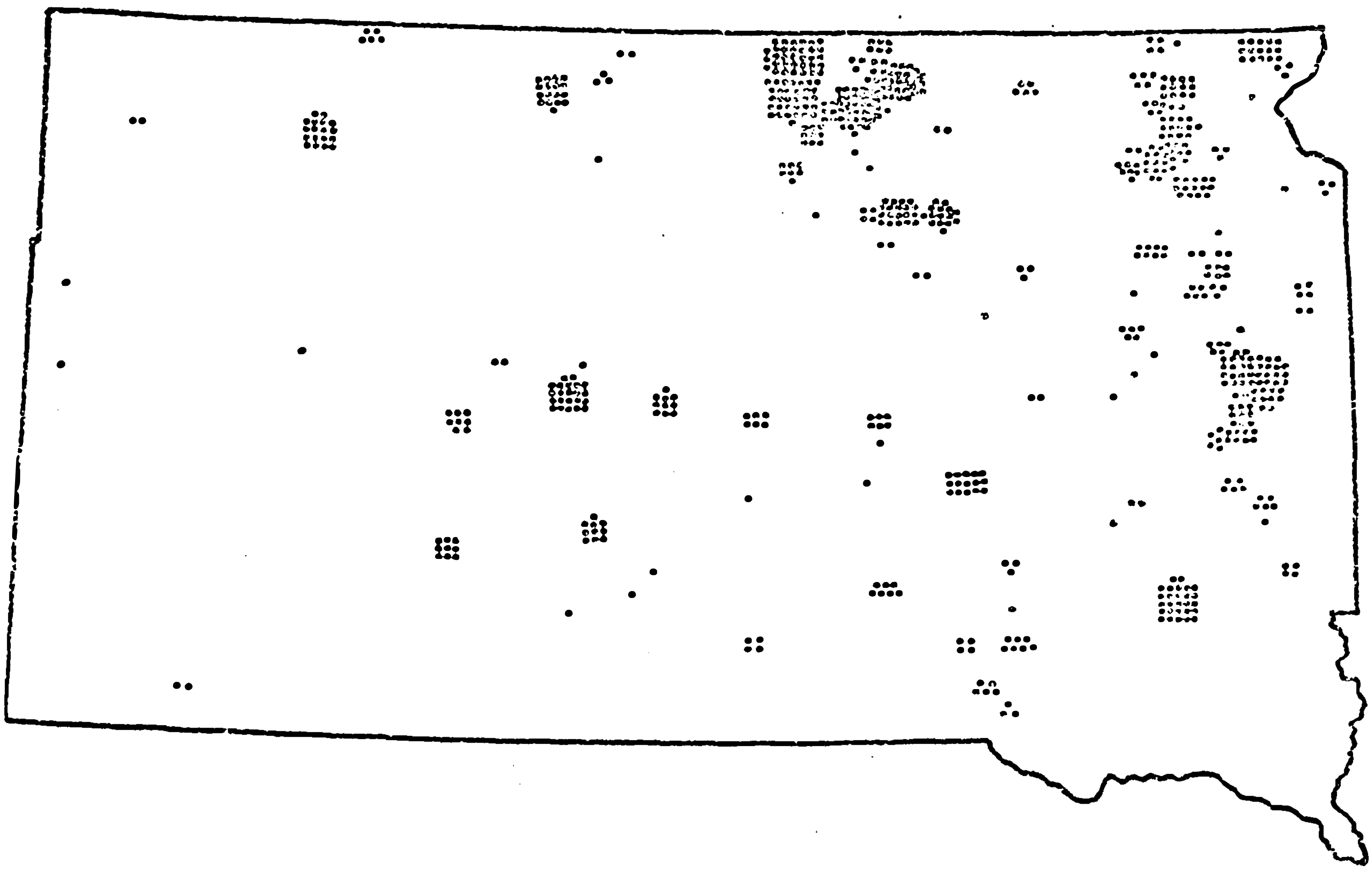
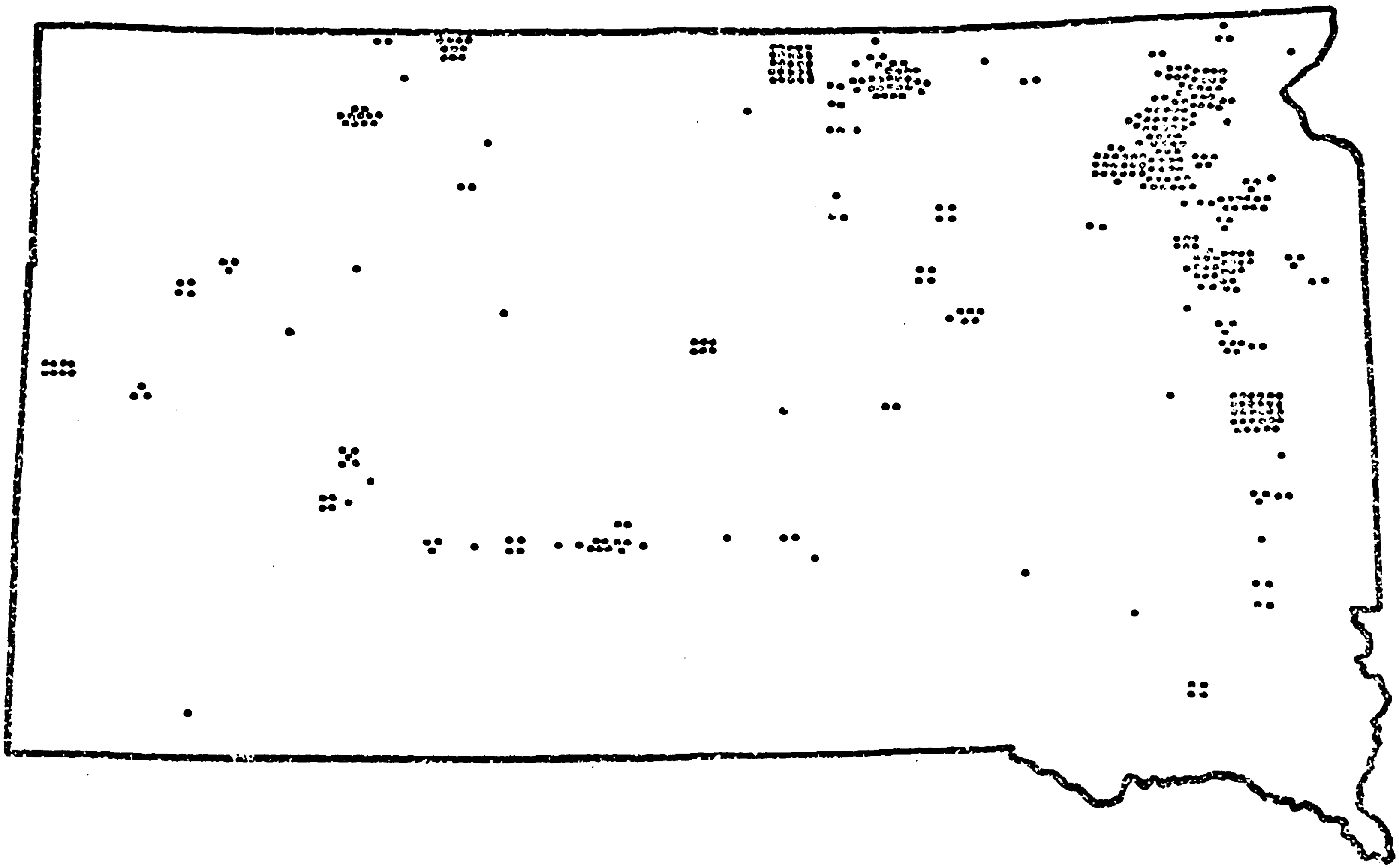
APPENDICES



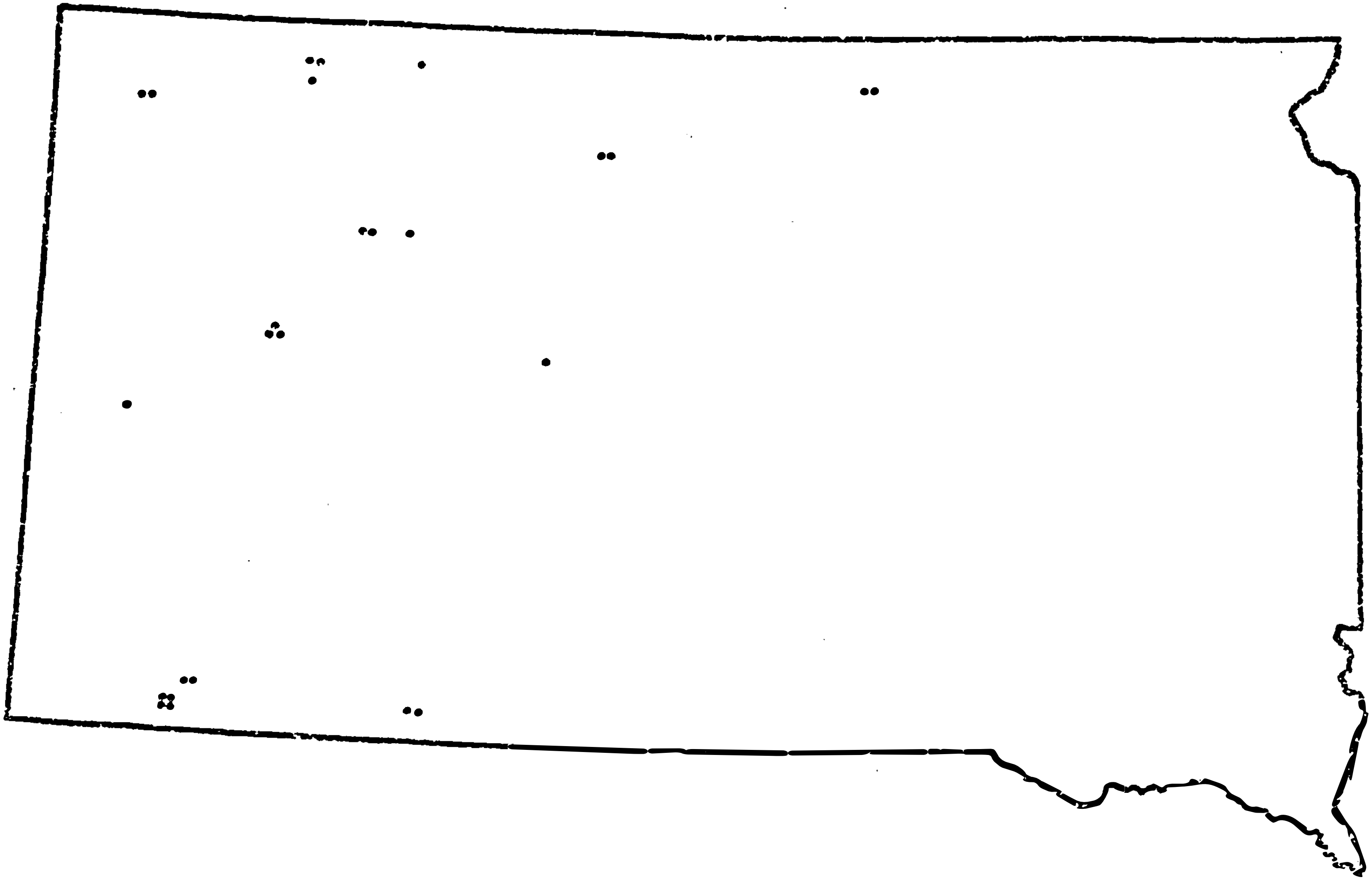
APPENDIX A. Distribution of broods observed off study plots in 1973. Each dot represents 1 brood.



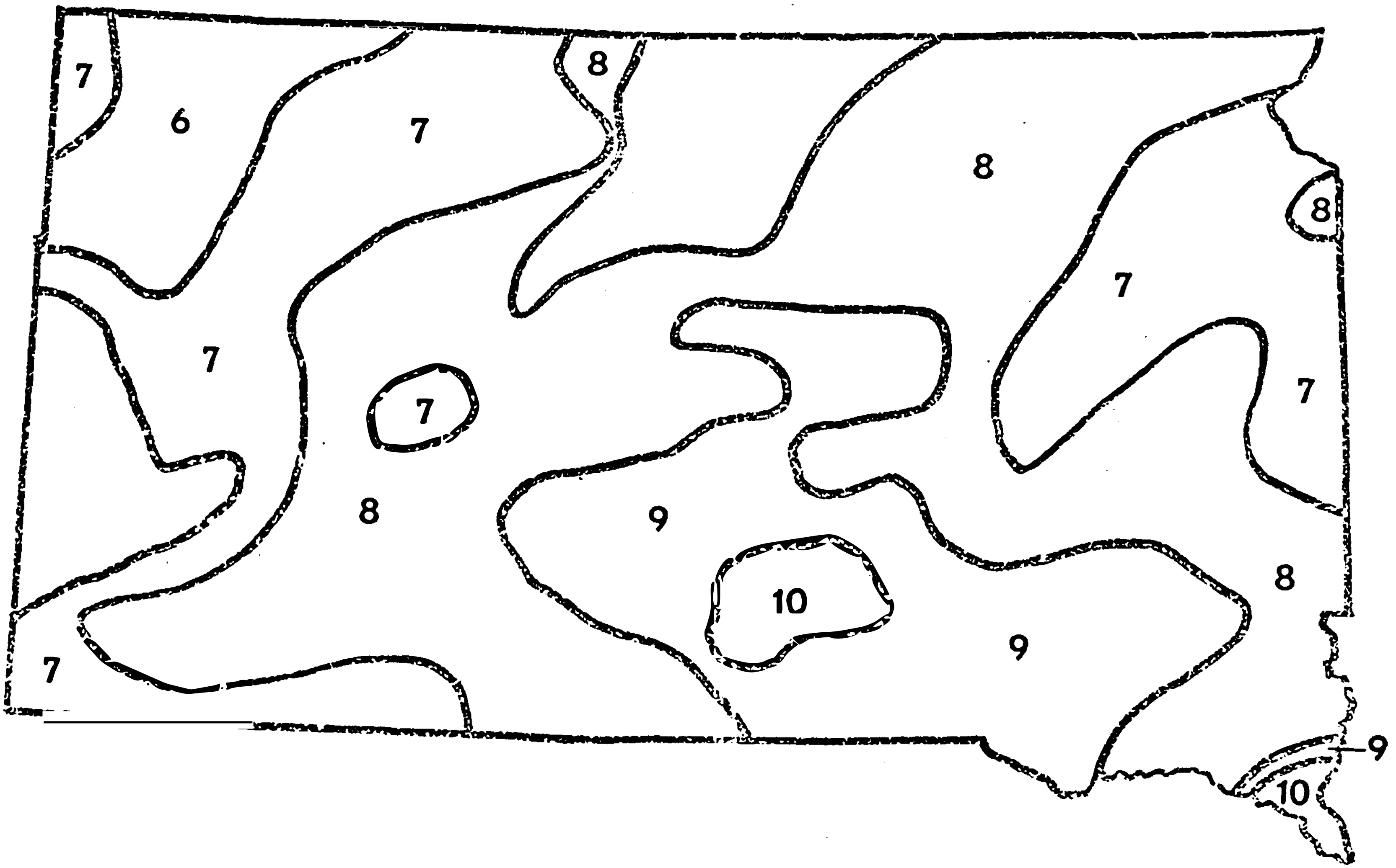
APPENDIX A. Distribution of broods observed off study plots in 1974. Each dot represents 1 brood.



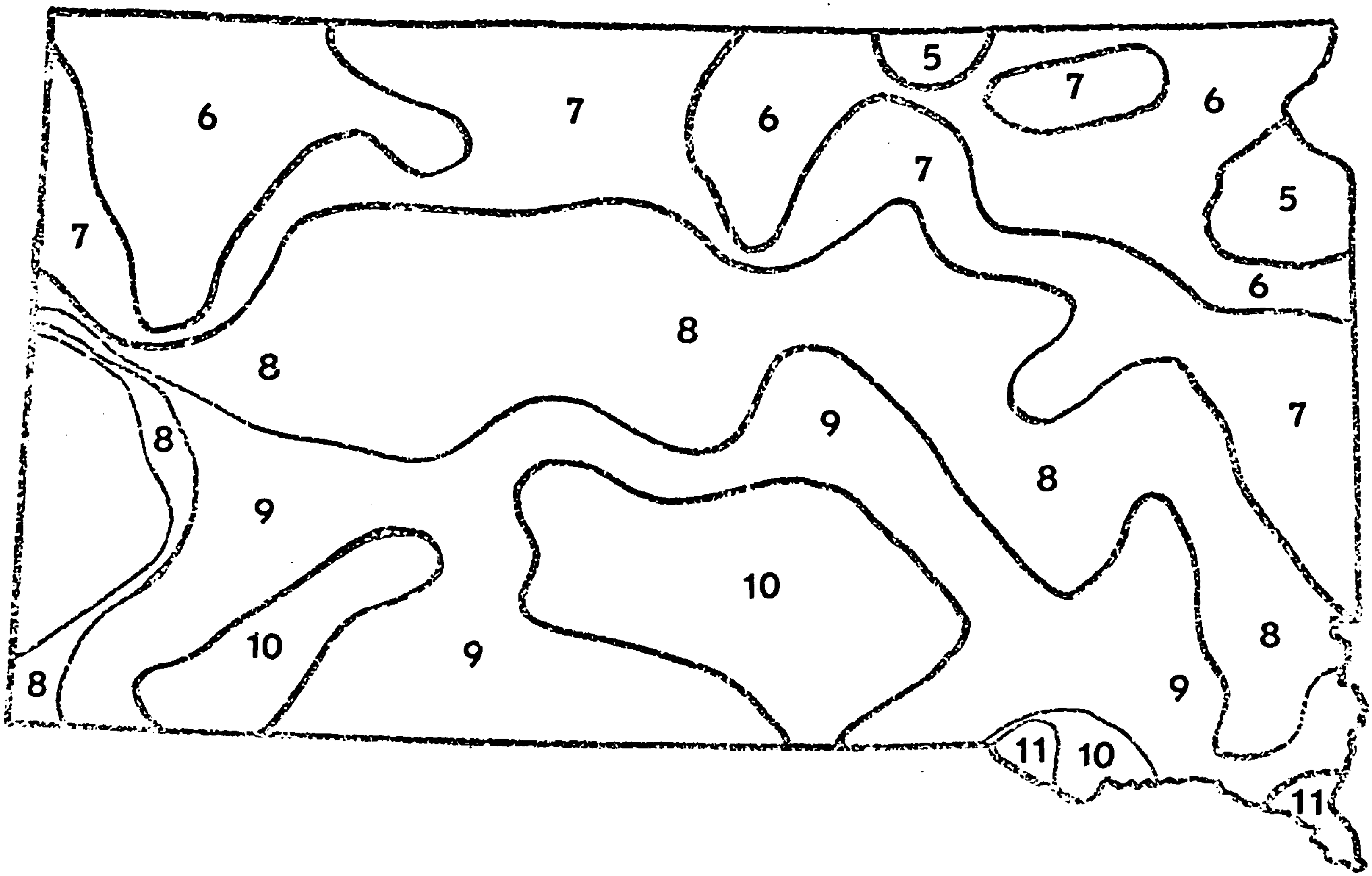
APPENDIX A. Distribution of broods observed off study plots in 1975. Each dot represents 1 brood.



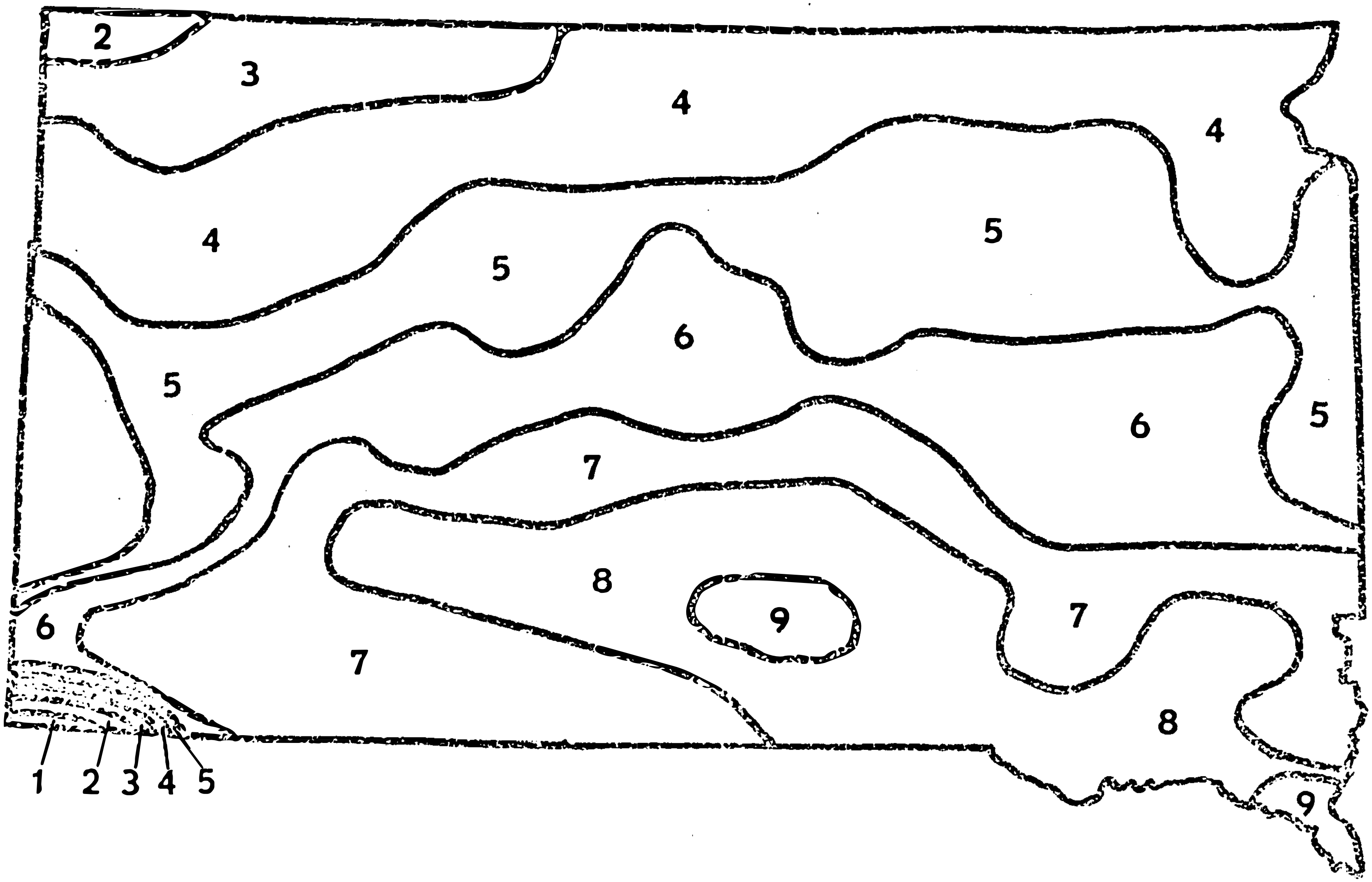
APPENDIX A. Distribution of broods observed off study plots in 1976. Each dot represents 1 brood.



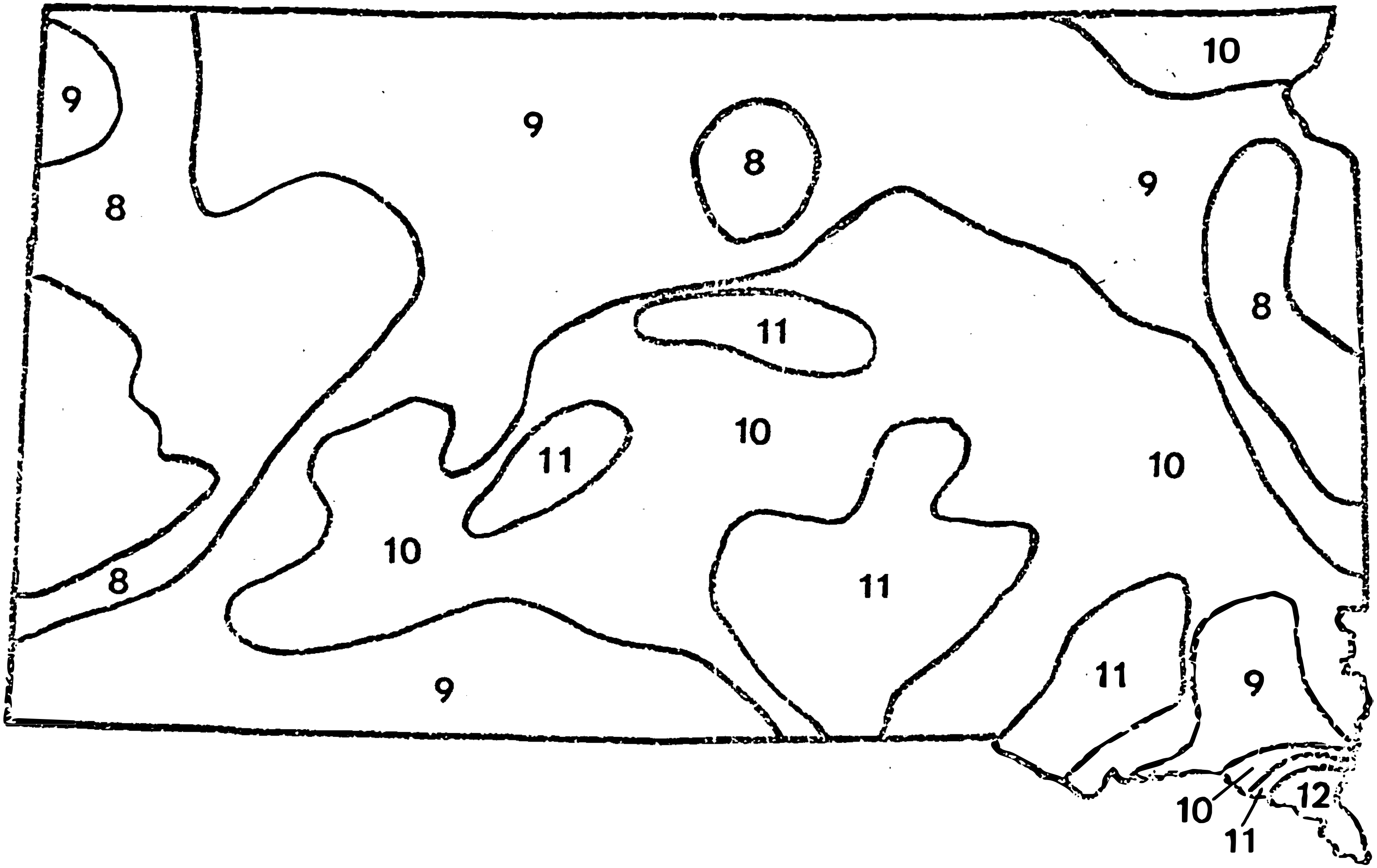
APPENDIX B. Temperature isoclines used in multiple regression analysis of 1973 nest initiation dates. Isoclines are based on maximum daily temperatures averaged over April and May. Each zone represents a 1.1 centigrade degrees range starting with 1 for 10.0° to 11.1° C.



APPENDIX B. Temperature isoclines used in multiple regression analysis of 1974 nest initiation dates. Isoclines are based on maximum daily temperatures averaged over April and May. Each zone represents a 1.1 centigrade degrees range starting with 1 for 10.0^{o} to 11.1^{o} C.



APPENDIX B. Temperature isoclines used in multiple regression analysis of 1975 nest initiation dates. Isoclines are based on maximum daily temperatures averaged over April and May. Each zone represents a 1.1 centigrade degrees range starting with 1 for 10.0° to 11.1° C.



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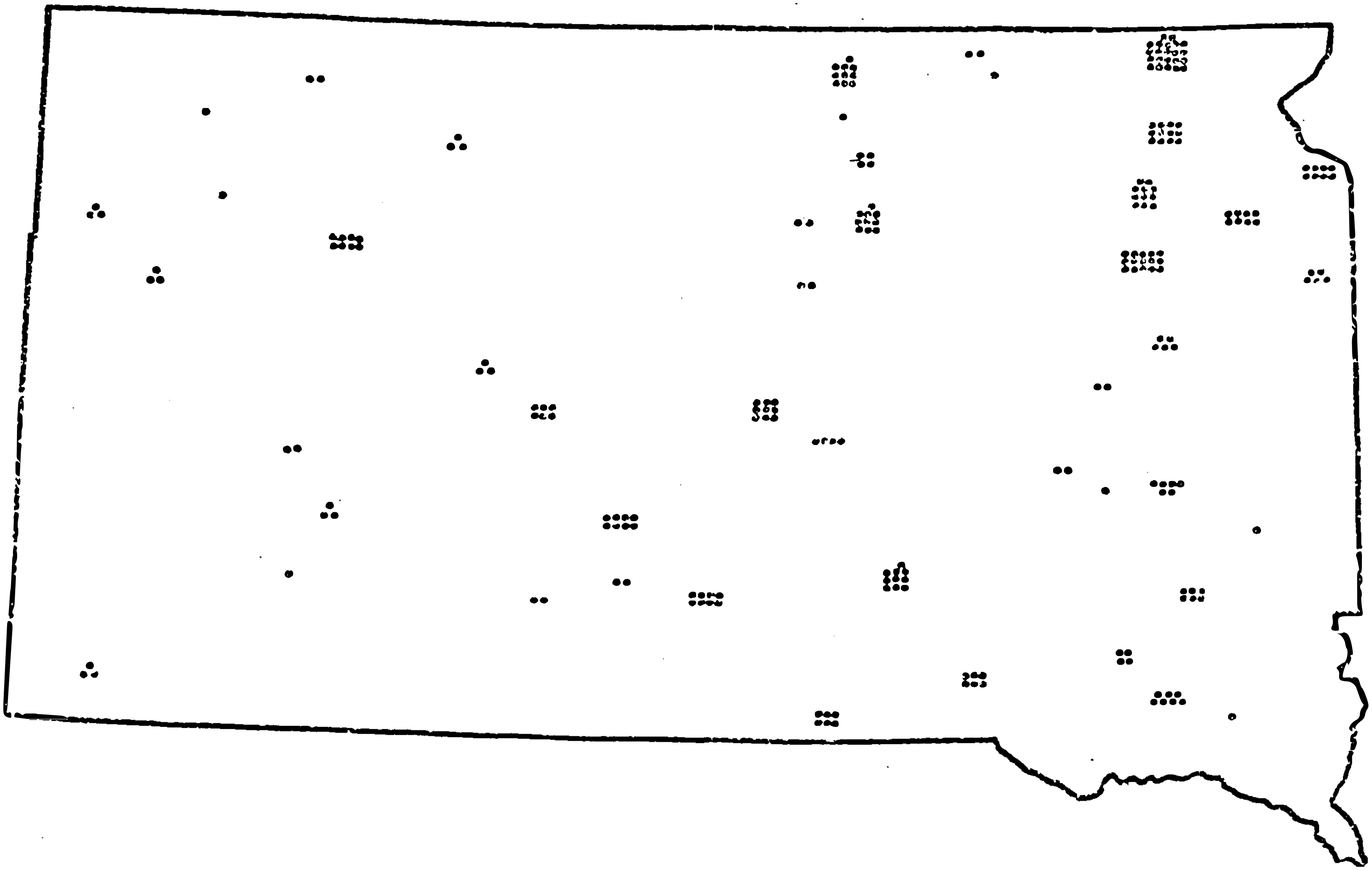
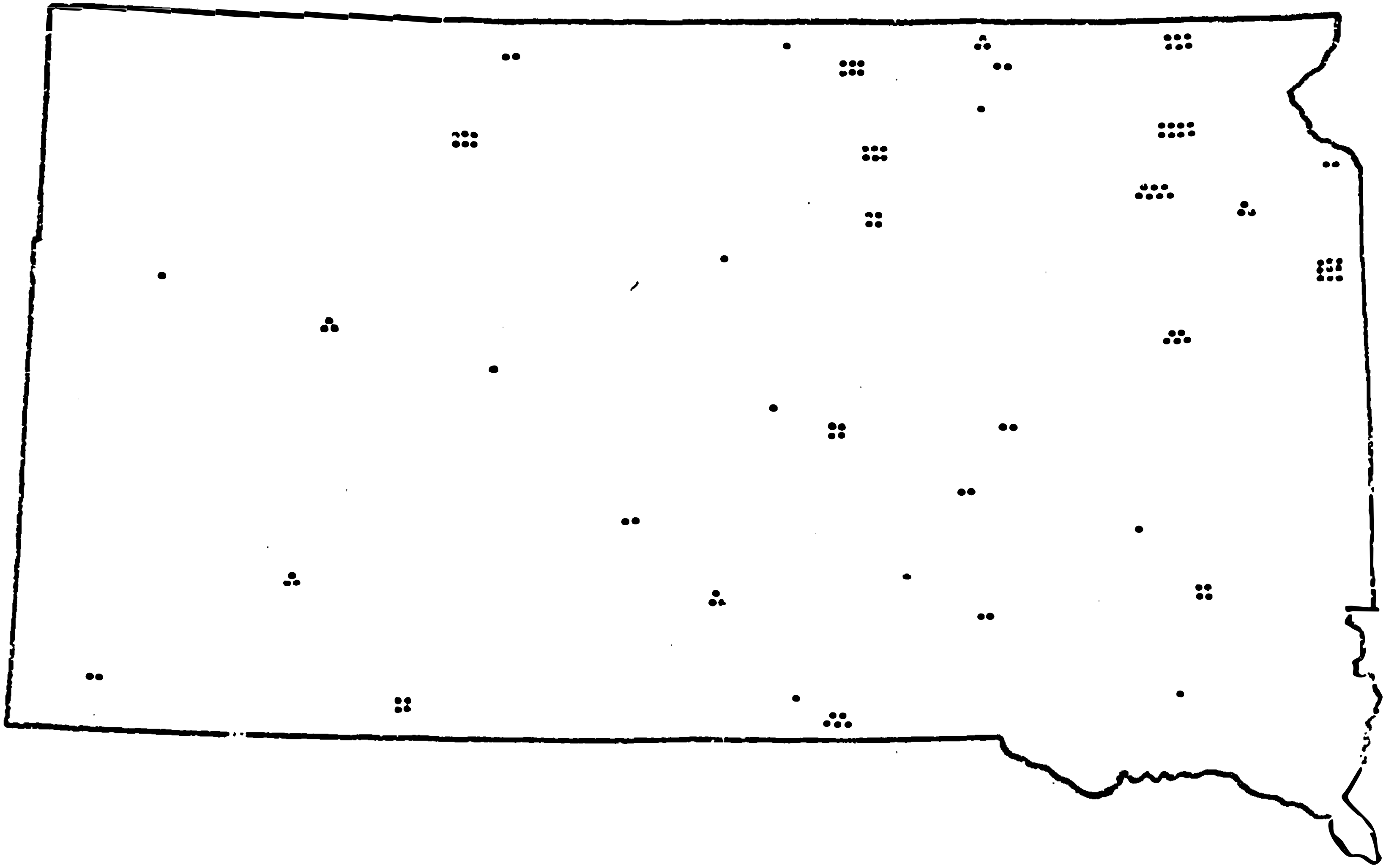
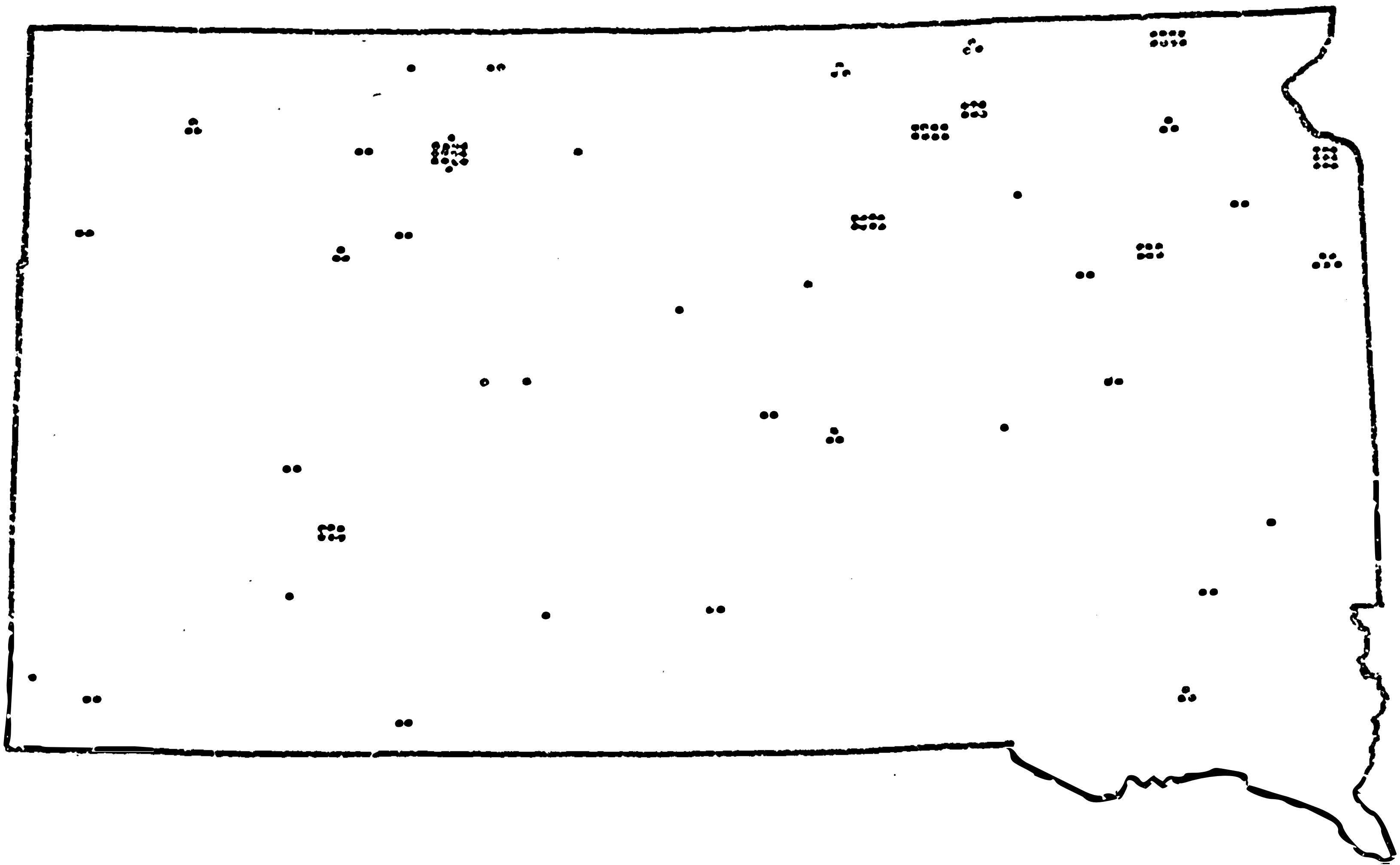


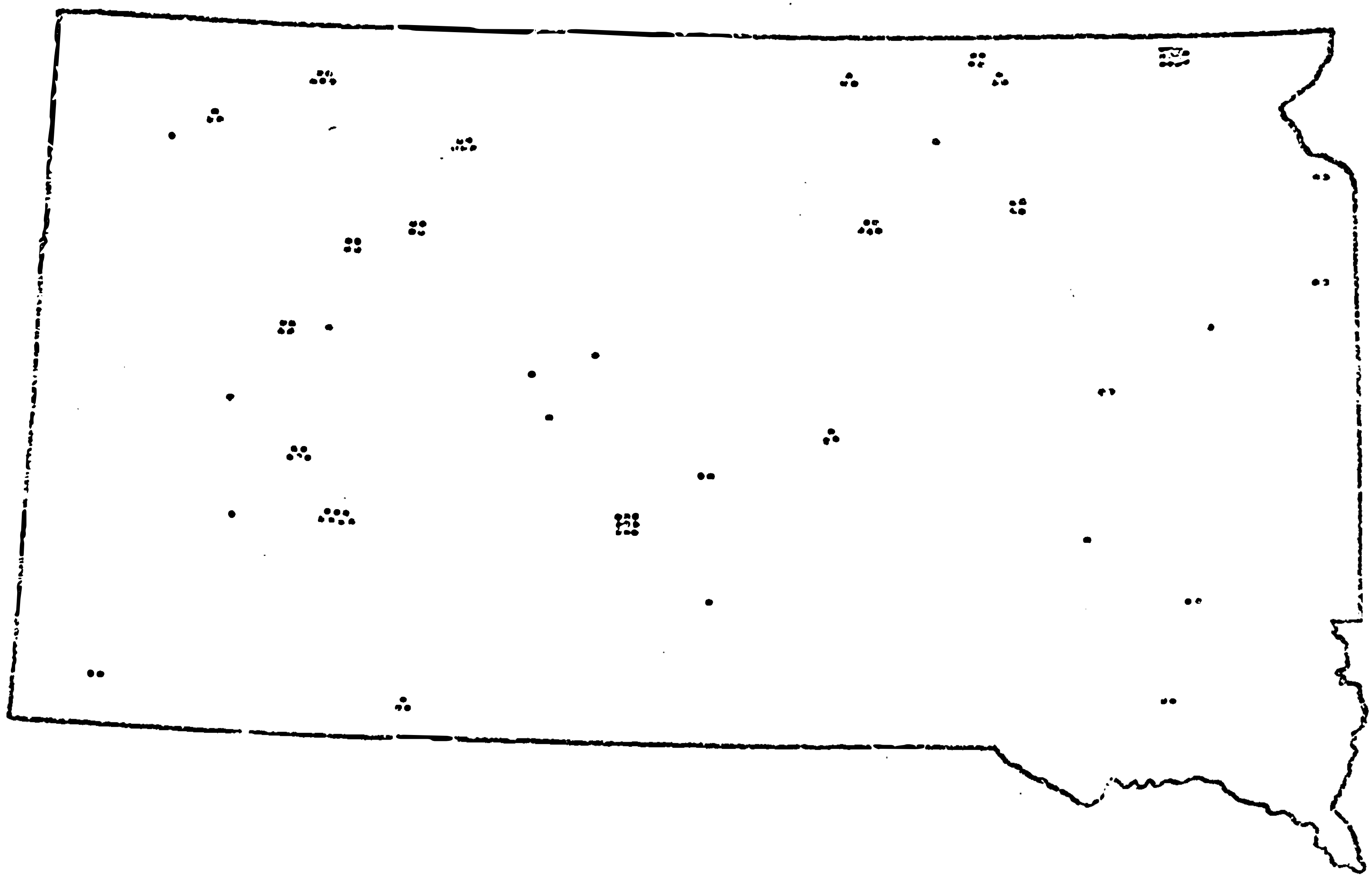
APPENDIX C. Distribution of broods observed on study plots in 1973. Each dot represents 1 brood.



APPENDIX C. Distribution of broods observed on study plots in 1974. Each dot represents 1 brood.



APPENDIX C. Distribution of broods observed on study plots in 1975. Each dot represents 1 brood.



APPENDIX C. Distribution of broods observed on study plots in 1976. Each dot represents 1 brood.