PARENTAL CARE OF THE EASTERN MEADOWLARK (*STURNELLA MAGNA*)

A Thesis

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INTRODUCTION

Despite extensive studies by Davis (1955), Johnston (1964), and Roseberry and Klimstra (1970) concerning the nesting habits and breeding biology of the Eastern Meadowlark (Sturnella magna), little has been reported relating to parental care exhibited by the species. This probably reflects the difficulties in observing or recording continuous nesting activity.

Numerous devices capable of recording nesting activity of perching birds have been described in past studies, but studies involving ground nesting birds are few. This is probably due to problems inherent in recording ground nesting activity. Kendeigh (1952) noted that ground nesting recorders can cause nest abandonment by the parent birds and that they are subject to predator disturbance.

A recorder utilizing a thermocouple was the most successful device used in recording ground nesting activity (Kendeigh 1952). When heated by the incubating bird, the thermocouple produced an electrical current which activated a chart recorder. However, the thermocouple was effective only during incubation and not during the time nestlings were in the nest, because the nestling's body temperature produced a continuous electrical current.

The instrument chosen for this study was the itograph, described by Kendeigh and Baldwin in 1930. It is activated by an electrical switch which is depressed by the parent bird when

entering and, or leaving the nest. It was first used in recording perching bird activity, but minor switch adjustments adapted it for use with the Eastern Meadowlark, a ground nester.

This paper reports the results of a study conducted on the Eastern Meadowlark at the Kansas State Teachers College's F.B. and Rena G. Ross Natural History Reservation during March through August, 1970, and March through May, 1971. F.B. and Rena G. Ross Natural History Reservation (R.N.H.R.) is a 1040-acre research area utilized by the Kansas State Teachers College's Biology Department. Located approximately 14 miles northwest of Emporia, Kansas, it lies on the eastern border of the Kansas Flint Hills, and portions of it are excellent examples of virgin bluestem prairie. A majority of the acreage is subject to annual grazing and burning, but the state-owned 200-acre portion is ungrazed and unburned. The grazed portion is typical rolling prairie having few scattered trees and shrubs (Fig. 1). The state-owned portion contains the reservation buildings and consists of lush brome and tall grass prairie with scattered sumac and dogwood thickets and Osage Orange hedge rows (Fig. 2).

Data from both field observations and itograph recordings are presented to provide a better understanding of parental care exhibited by the Eastern Meadowlark. Specific objectives were to determine the parental role of each parent bird and to establish the parent birds' daily rhythm of activity at the nest during incubation and feeding of young.

Fig. 1. Rolling, grazed grassland of the Ross Natural History Reservation.

Fig. 2. Lush, ungrazed grassland of the Ross Natural History Reservation.

Definition of Terms

Active day - period of time between earliest and latest activity at nest each day.

Attentive visit - one consecutive length of time when parent bird attends the clutch or nestlings either to incubate, brood or feed.

Brooding - the act of warming the nestlings by setting on them.

Fledging - young birds free of the nest and under care of the parent.

Hatching period - period of time between the hatching of first and last eggs.

Inattentive period - one consecutive period of time parent bird spends away from the nest.

Incubation period - length of time between end of egg laying to the end of hatching.

Night brooding - brooding of young during the night.

Nestling period - period of time between the end of hatching to fledging.

Second nesting - the production of a second clutch after the successful production of a first brood. Not to be confused with renesting which is the production of another clutch after a nesting failure.

METHODS AND MATERIALS

A portable itograph was constructed of the following basic parts: a spring-powered alarm clock, electro-magnet with pen attachment, device for releasing a paper strip at a uniform rate, contact perch (in the form of a treadle), and 6-volt dry-cell batteries (Fig. 3).

The contact switch was a flat, wooden treadle resting on a micro-switch and anchored on a broad wooden base. The micro-switch was attached above the base to protect it from standing water (Fig. 4).

Eastern Meadowlark nests have narrow trails leading to the nest entrance, and it was within these trails the switches were placed. To insure depression of the switch on each visit, a wire funnel was placed between the nest entrance and the switch (Fig. 5). Thus, the bird was directed over the switch when entering and again on leaving the nest. Each visit resulted in completing the electrical circut twice, causing the pen to mark two horizontal lines on the chart paper. Since a known amount of paper was advanced through the itograph each hour, it was possible to calculate the length and approximate time of each visit.

Nests were located by two methods. One involved two men, and required the dragging of a 100-foot rope over a suspected nesting area. If a bird flushed, the immediate area was examined for a nest. The second method required observing a probable

Fig. 3. Homemade itograph showing the spring-powered alarm clock (A), electro-magnet with pen attachment (B), and device for releasing a paper strip at a uniform rate (C).

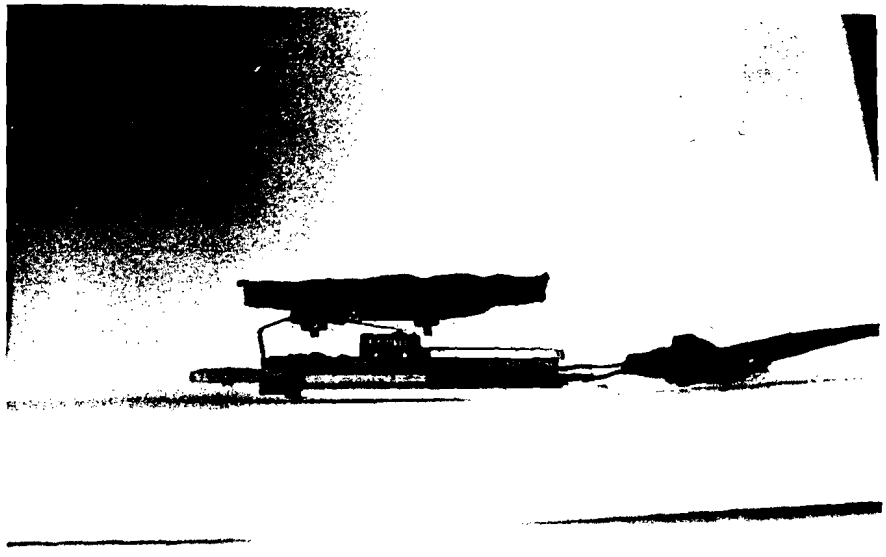

Fig. 4. Treadle, showing the micro-switch, used with the itograph.

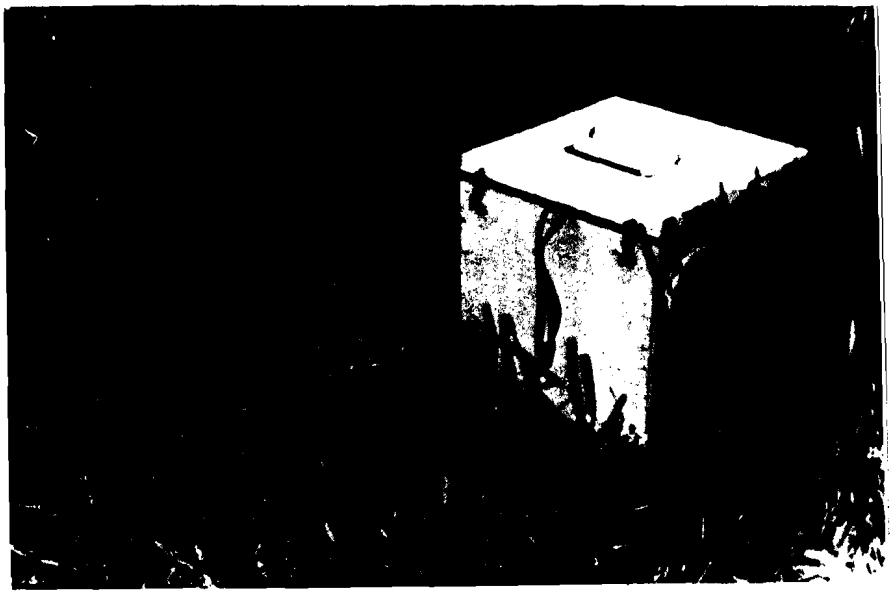

Fig. 5. Method by which the treadle and funnel were set at a nest site.

nesting site and visually marking the location where the birds landed. Once a general nesting area was determined, a careful search for a nest was conducted. To mark the location of each nest, wooden stakes were placed three to four feet in front of the nest entrance.

Daily nest observations were made in order to record abandonments, nest destruction by predators, and nesting success. If a nest was used for itograph recordings, a blind was erected 10 to 12 feet from the nest. The blind was used for housing the itograph as well as for observing nesting activity (Fig. 6).

If itograph recordings were being collected from a nest, the instrument operated continually until the nest was destroyed or vacated by the parent birds and, or, their young. However, until

Fig. 6. Blind used during the study.

the recordings were considered accurate, four to five 90-minute observation periods were conducted each day to check the instrument. Once the itograph was considered operating correctly, sporadic visits, each approximately 20 minutes long, were conducted daily to observe behavioral actions of parent birds and their young.

If the itograph was found to be malfunctioning at any time, observations were extended to collect data which otherwise would have been missed. Most instrument repairs were completed in the blind, and before being left overnight, all mechanical parts were rechecked for accuracy.

For field identification, parent birds were trapped (Fig. 7); adult females were banded on the left leg, and all nestlings were banded on the right leg. Number two, Federal Fish and Wildlife

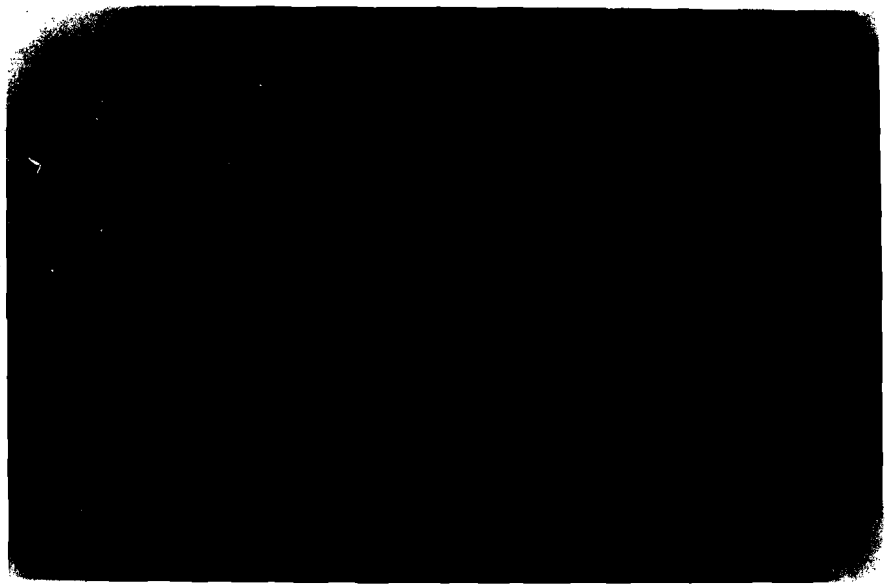

Fig. 7. Wire trap used to capture adult Meadowlarks

bird bands were used on all birds banded. Adult males were not banded but were identified by the shape of the V-pattern upon their breasts.

Figure 8 is an aerial photo showing the 10-acre grid sections of the Ross Natural History Reservation. Nest locations are shown by numbered black dots. The letter A following the nest number refers to the 1970 nesting season, and letter B for the 1971 nesting season. Nests found on the 200-acre, state-owned portion are shown in Figure 9.

Daily temperature and rainfall were recorded by instruments at a weather station maintained at the Ross Natural History Reservation. Temperatures of nesting area were collected with a mercury-column F^{o} thermometer.

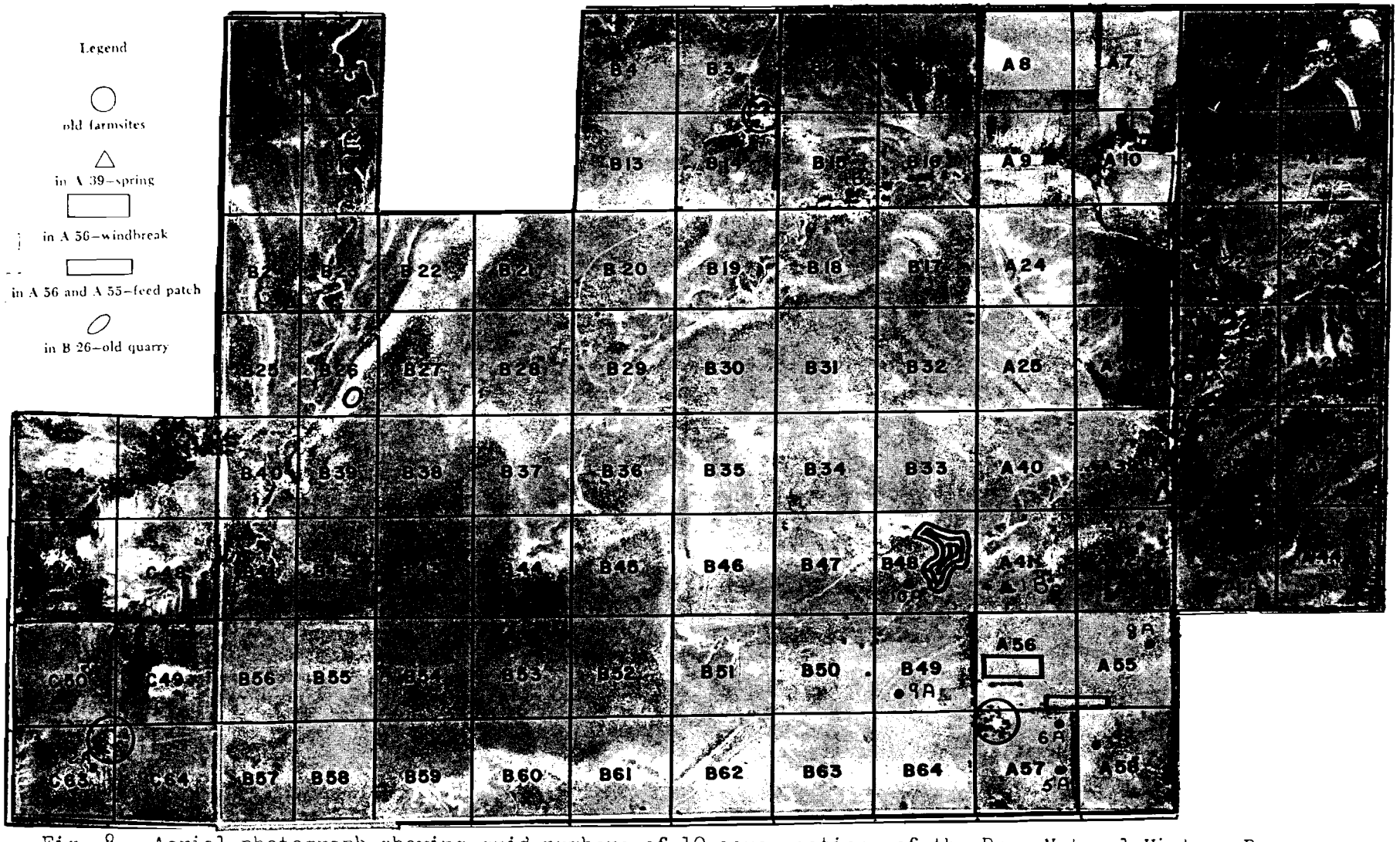

Fig. 8. Aerial photograph showing grid numbers of 10-acre sections of the Ross Natural History Reservation. Nest locations are shown by numbered black dots.

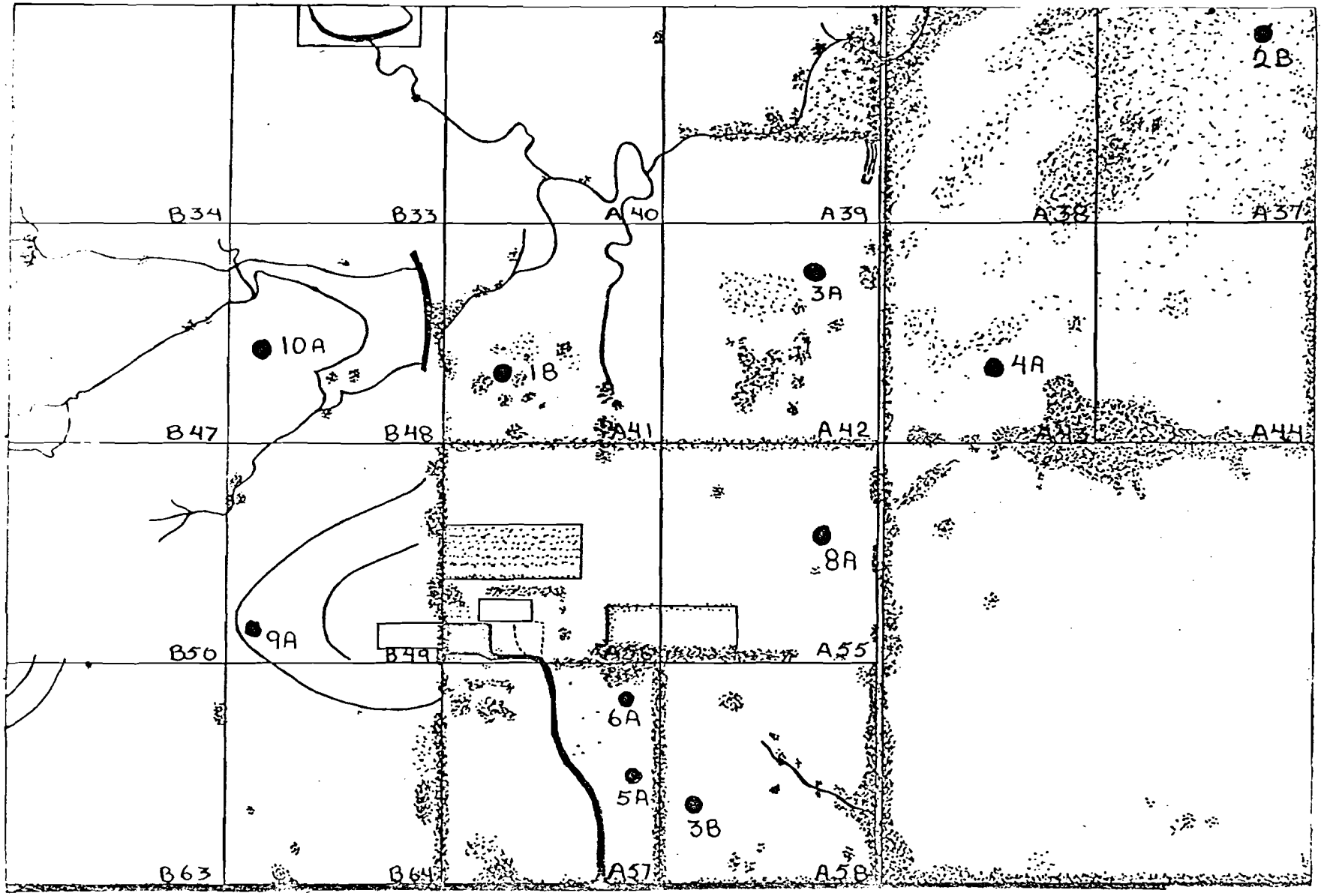

Fig. 9. The 200-acre state-owned portion of the Ross Natural History Reservation. Nest locations are shown by numbered black dots.

Itograph recordings were obtained from four nests as follows: nest 6A (grid A57) from 27 May to 8 June 1970; nest 9A (grid B49) from 10 to 22 July 1970; nest 2B (grid A37) from 14 to 16 May 1971; and nest 4B (grid B15) from 20 to 21 May 1971.

RESULTS AND CONCLUSIONS

Territories

During the initial weeks of the Eastern Meadowlark's nesting season aggressive behavior, displayed by males, played an important role in securing territories. At first, the male visited various perches from which he sang and surveyed the immediate area. As the days progressed, he visited these sites more often. Eventually, one site, normally higher than the others, became his primary perch with the others serving secondary functions during feeding and surveying of the territory. It was from these perch sites that the male sang to attract a prospective mate, but just as important, they served as strategic points from which he gave alarm calls and displayed to discourage nearby rivals. It was within these territorial boundries the male protected his mate, enabling her to construct a nest and produce a brood.

Males were not considered territorial until they were observed using the same perches regularly, and actively protecting a specific area from intruding birds. Such activity was more evident during morning and late evening hours. As the season progressed and fledglings were free of the nest, the male became aggressive for the entire day.

Conflicts with other males were brief, often beginning and ending in a chase. When contact was made it was short and intense with both birds jabbing with feet and bills.

During the 1970 and 1971 nesting seasons the earliest established territories were noted on 4 April and 29 March, respectively. Territories ranged from three to twelve acres in size, depending on the local abundance of competing males. During this study, territory size was estimated according to the area covered by the male during the rounds of his perch sites.

Large territories were found in open, grazed grassland having few scattered trees and shrubs. Few males competed for these areas, enabling single males to defend large territories. Small territories were located in ungrazed grassland having lush ground cover and numerous scattered trees. This I considered prime nesting habitat, and numerous males competed for this limited nesting area. Here, size of territories was determined by the aggressiveness of competing males.

Nests

Nest construction was first noted during early April for both nesting seasons, with the first peak of activity in late April and early May. A second peak occurred in late June and early July and was considered the second nesting period.

Bendire (1891) stated both sexes shared in nest building, but Saunders (1932) reported that no males helped in nest construction. Like Saunders, I found no male aided the female in nest construction. Nest building occurred primarily in the morning, with little activity during afternoon and evening.

Lanyon (1957) indicated a six to eight-day building period for the first nests, with decreasing lengths of time for succeeding nests. Observations of female 2A showed that four to five days were required for her to complete a nest. On 4 May 1970 female 2A was observed carrying nesting material to four locations. Each location revealed what could have been a partially completed nest. One site contained more nest lining than the other sites, and four days later this nest was completed and contained one Meadowlark egg. The other sites yielded no finished nests.

Saunders (1932) and Roseberry and Klimstra (1970) contended that partial building of several nests occurs prior to the female reaching the sexual and physiological stage necessary for intensive nest building. However, female 2A was obviously in an active sexual stage because an egg was laid in the nest two to three days after she was observed carrying nesting material to four locations. She could have been a first-year bird adjusting to her first nesting experience.

Roseberry and Klimstra (1970) indicated that at 38 degrees latitude (same as R.N.H.R.) Eastern Meadowlarks began laying around 10 to 15 April, with peak activity from 29 April to 5 May. On 2 May, a well-developed juvenile was found, as a road kill, seven miles northwest of Emporia, Kansas. Considering a 12 to 14 day incubation period and an 8 to 11 day nestling period, the

fledgling was probably from a clutch started around 8 to 13 April, very close to the dates stated by Roseberry and Klimstra.

Considerable variation in nest structure occurred, but most nests occupied depressions and were lined with long, fine strips of grass. The amount of roofing over the nest depended on the habitat. Well concealed nests occurred in lush cover and open nests, with little overhead cover, were built in late summer brome grass. The runway leading to the nest entrance was not always conspicuous, but could be located after close observation.

Generally, complete clutches consisted of five Meadowlark eggs (Fig. 10), but they were subject to Cowbird (Molothrus ater) parasitism (Fig. 11). Of 14 nests found on the R.N.H.R., seven (50 per cent) contained Cowbird eggs. The maximum number of Cowbird eggs found in any one nest was three (nest 6A) of which one Cowbird survived to fledge (Table I). Lanyon (1957) reported 16 per cent of the nests were parasitized, with a maximum of two Cowbird eggs in any one nest. The high rate of parasitism for the R.N.H.R. probably reflects the high population of Cowbirds in the region.

Saunders (1932) referred to parasitism by the Bobolink and Bobwhite, and Stone (1937) reported Sharp-tailed Sparrow eggs in one Meadowlark nest. No parasitism, other than by Cowbirds, was noted during this study.

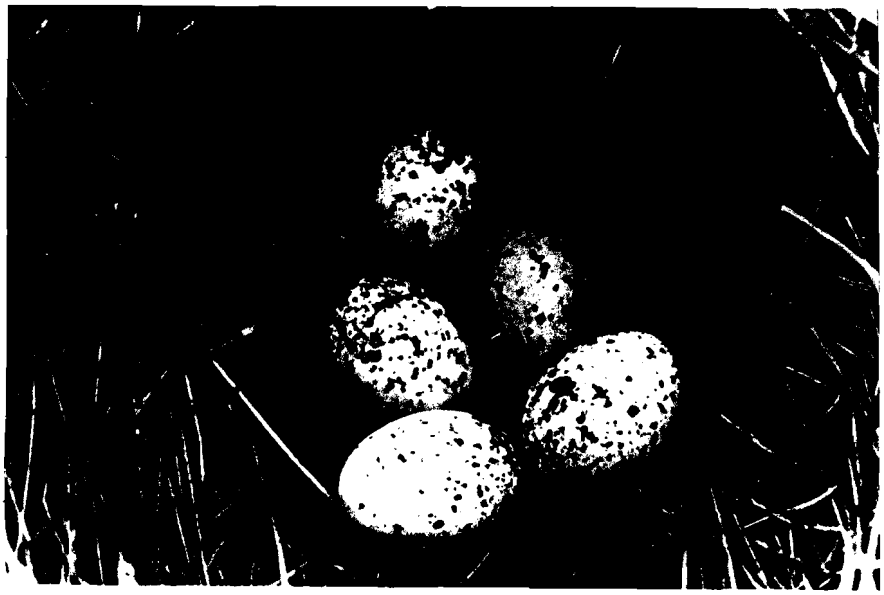

Fig. 10. A clutch of five Eastern Meadowlark eggs.

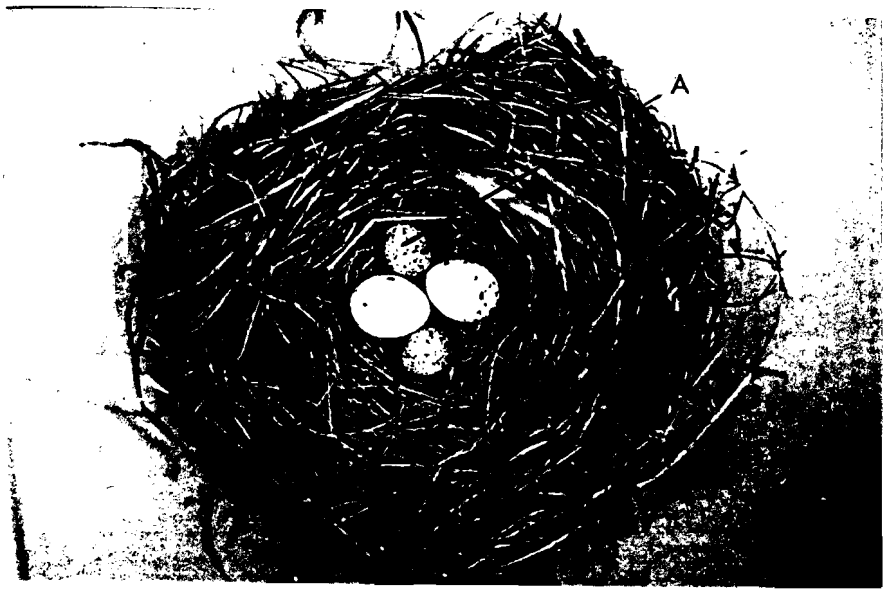

Fig. 11. An Eastern Meadowlark nest parasitized by Cowbird eggs (A).

Table I. Date nests were found, Meadowlark and Cowbird eggs per nest and young fledged from each nest, from nests found on the R.N.H.R. during the 1970 and 1971 nesting seasons; A designates 1970 nests and B designates 1971 nests.

Nest	Date found	Meadowlark eggs	Cowbird eggs	Young fledged
1A	1 May	4	2	... *
2A	8 May	4	...	...
3A	11 May	3	1	...
4A	19 May	5	...	...
5A	25 May	...	...	2
6A	26 May	4	3	2
7A	14 June	...	...	3
8A	19 June	4	1	...
9A	10 July	5	...	3
10A	14 July	2	2	...
1B	10 May	4	2	...
2B	14 May	5	...	...
3B	18 May	5	...	...
4B	20 May	4	2	...

* no data

Incubation

Incubation was performed by the female, with no male observed aiding in the task. Lanyon (1957) reported no male performing incubation, but earlier investigations by Knight (1908) and Roberts (1936) indicated males shared this responsibility. I was not able to determine the exact time incubation started, but Bent (1958) reported incubation beginning one or two eggs prior to completion of the clutch.

Length of incubation was considered to be the time from the end of egg laying to the end of hatching. Observations of two nests outside of the R.N.H.R. (one mile north of Emporia, Kansas, and another three miles north of Baldwin, Kansas) showed 12 and 14 day incubation periods, respectively. Lanyon (1957) indicated similar lengths of time, but he also stated incubation lasting as long as 16 days.

Females were always active during incubation. Egg turning and the changing of setting positions were the most evident activities. Egg turning was a difficult maneuver requiring the female to rise to a crouched position while using her bill to roll one or two eggs. At no time was a female observed turning all of the eggs during one egg-turning period. Often the female turned within the nest when turning eggs, but she always returned to face the entrance before incubating. The female did not leave the nest entrance to turn the eggs.

Vocal communication existed between the male and incubating female. Such behavior could be a means of reinforcing pair bonds and as a means of warning the female of approaching danger. On several occasions female 9A was noted chirping softly in response to the territorial call of her mate. Females 6A and 9A reacted to their mate's alarm call by slipping from the nest and running several yards before flying. This is probably an important mechanism for protecting the female from possible danger. It also made locating nests difficult because the flushing bird gave a false nest location.

Generally, the females adapted to the itograph, and after several visits, lost their fear of entering the nest. However, on 18 May 1971, female 3B failed to enter the nest after the itograph was introduced, and she eventually abandoned the nest.

Determining incubation visits from the itograph tapes presented some problems. Horizontal marks were distributed evenly on the tapes and if observations had not been made from the blind, it would have been difficult to determine between which marks the attentive visit (incubating visits) occurred. During hatching and nestling periods the parent birds fed the young and their activity produced marks on the tape which paired up, thus, making attentive visits easier to determine (Fig. 12).

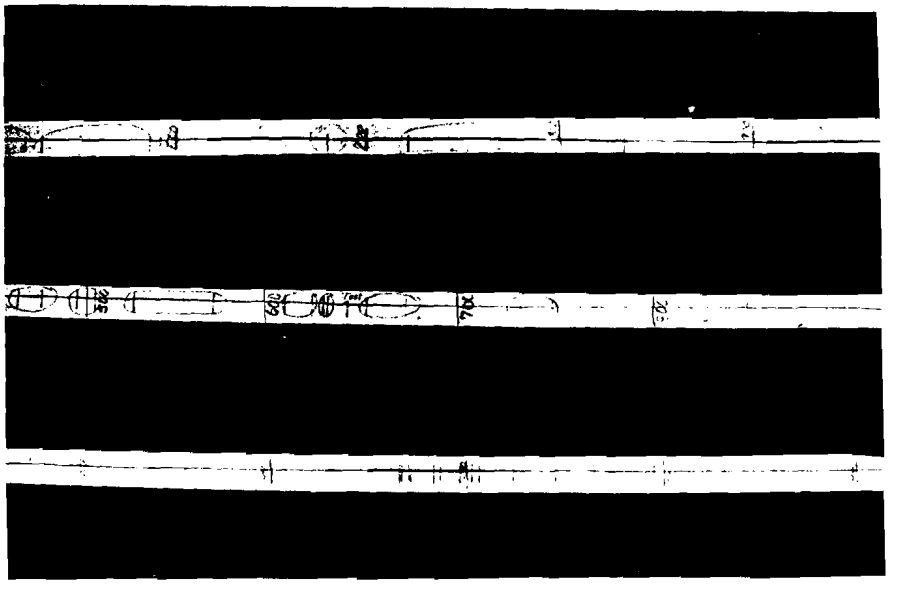

Fig. 12. Itograph tape recordings during incubation (A), hatching (B), and nestling period (C). Attentive visits are circled.

During incubation and over-night brooding, one more inattentive period was recorded than the number of attentive visits. After overnight brooding ceased, one less inattentive period was recorded than the number of attentive visits. The only time the number of inattentive periods and attentive visits were the same was during the days when the birds left the nest after brooding overnight and failed to return for the next night.

There was variation in the number and length of attentive and inattentive periods for different birds and for the same bird on consecutive days (Table II). Despite the differences, females 9A and 2B averaged 67 per cent and 65 per cent, respectively, of the active day at the nest. Saunders (1932) observed an incubating

Table II. Nest, date, minutes of itograph recordings, number of visits and minutes parent birds were at the nest, mean length of attentive visits and inattentive periods, percent time of active day parent birds were at nest, and the number of eggs and young in the nest during single days of incubation.

Nest	Date	Minutes of itograph recordings	Number visits recorded	Number minutes at nest	Mean length of attentive visits (min.)	Mean length of inattentive periods (min.)	Percent of time at nest	No. of eggs	No. of young
6A	27 May	314	15	153	10.20	10.75	49	6	1
	28 May	707	31	250	8.06	14.29	35	5	2
	10 July	410	13	208	16.00	14.44	51	5	0
	11 July	799	20	527	26.35	12.95	66	5	0
9A	12 July	857	19	576	30.32	14.05	67	5	0
	13 July	893	47	298	6.34	12.38	33	2	3
	14 July	897	49	234	4.78	13.26	26	1	4
	14 May	438	14	271	19.36	11.13	62	5	0
2B	15 May	792	27	531	19.67	9.32	67	5	0
	16 May	825	32	543	16.97	8.55	66	5	0
4B	20 May	644	29	438	15.10	6.87	68	5	1
	21 May	851	48	398	8.29	11.28	47	3	3

Eastern Meadowlark for 12 hours and 40 minutes of one day. The bird was attentive for nine hours and 40 minutes, 76 per cent of the active day, which is higher than the 67 and 65 per cent noted in this study. Saunders observed only one day of the incubation period, and the bird was possibly at a peak of attentiveness.

Although females 9A and 2B showed some similarity, they did differ when length and number of attentive visits were compared. Female 9A averaged 19.50 attentive visits per day compared to 29.50 visits for female 2B. Female 9A's attentive visits were longer, averaging 28.34 minutes, compared to 18.32 minutes for female 2B. Clutch 9A was nearing hatching and the female was probably adjusted to long periods of incubation, thus, spending longer visits at the nest and having fewer inattentive periods from the nest. Clutch 2B was recently completed and the female was probably adjusting the behavior pattern necessary for incubation.

Longer attentive visits were correlated with longer inattentive periods. Female 9A showed 13.50-minute inattentive periods for her 28.34 minute attentive visits. Female 2B showed 8.94-minute inattentive periods for her 18.35-minute attentive visits. A similar trend was shown by Kendeigh (1958) with his work on the House Wren (Troglodytes aedon).

Females 9A and 2B showed an increased number of attentive visits and decreased per cent of time each hour as air temperature rose (Fig. 13). Between 0700-0759 hours female 9A averaged one

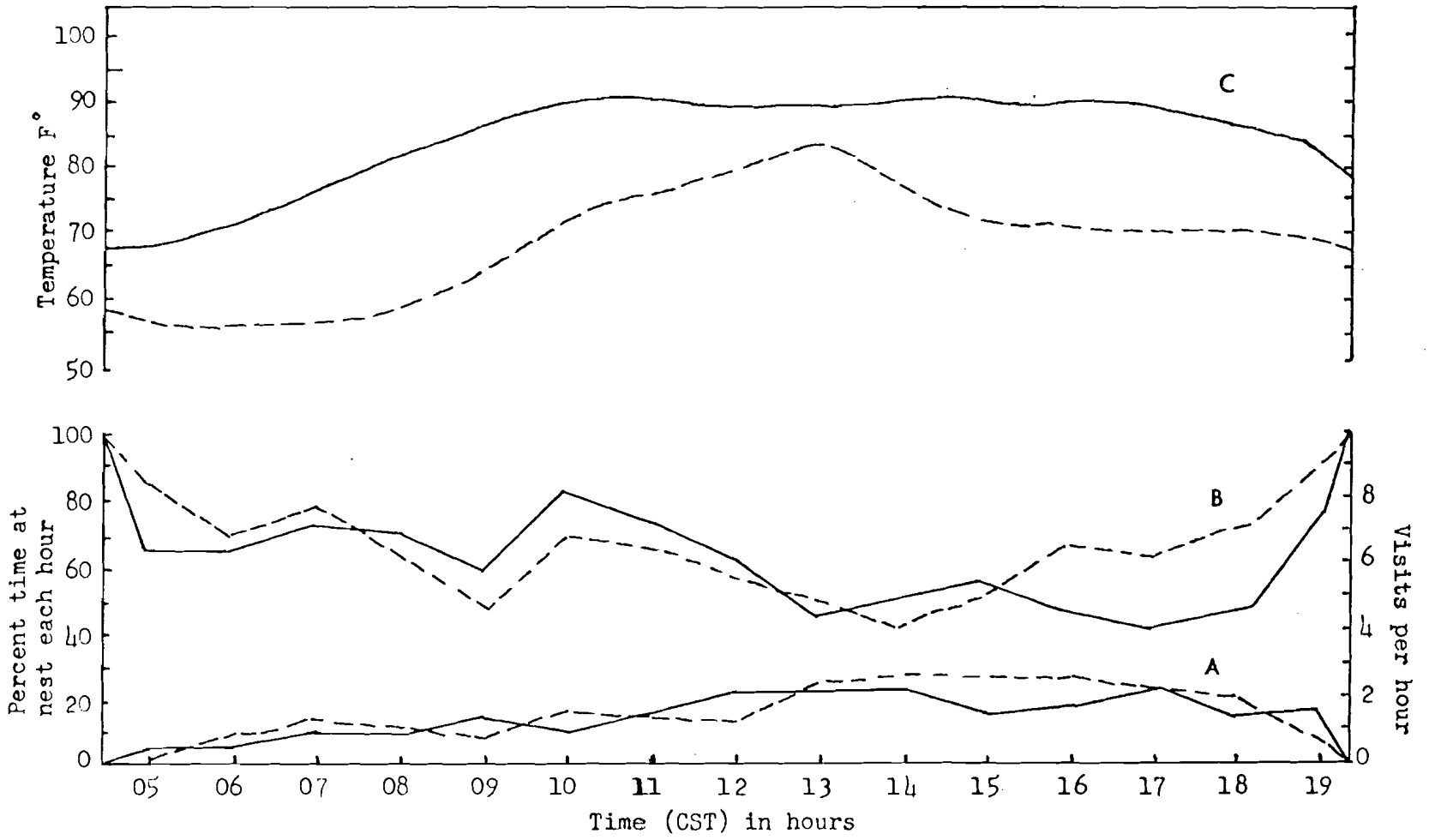

Fig. 13. Influence of median air temperature (C) on nests 9A (—) and 2B (--) during incubation; mean number attentive visits each hour (A) and mean percent of each hour parent birds were at the nest (B). Time designated as 05 includes the period 0400 to 0559 hours.

attentive visit, approximately 67 per cent of the hour, at a temperature near 75°F. By 1300-1359 hours, at a temperature of 91°F, her attentive visits increased to two, with time at nest dropping to around 43 per cent of the hour. Female 2B's trends were similar, but the temperature was lower, dropping close to 57°F in the morning and near 84°F by mid-day. As the day progressed, and the temperature rose, eggs were less apt to cool when the female was off the nest. Also, insects were more active and easier for the feeding bird to acquire.

Hatching

Complete hatching of the clutch required one and one-half to two days, and all egg shells were removed by the female. After the first egg hatched, a noticeable change in the female's attentive behavior occurred. The number of attentive visits increased and became shorter in length, with inattentive periods also shortened. One day prior to hatching (12 July), female 9A made 19 visits, averaging 30.32 in length, and on 13 July, when three young and two eggs were present, she made 47 visits averaging 6.34 minutes each. Length of inattentive periods decreased from 14.05 to 12.38 minutes (Table II).

Figure 14 shows the daily rhythm for females 6A and 9A during hatching. All eggs in clutches 6A and 9A hatched. Clutch 6A produced four Meadowlark and three Cowbird young. Clutch 9A produced a brood of five Meadowlark young. Daily temperatures

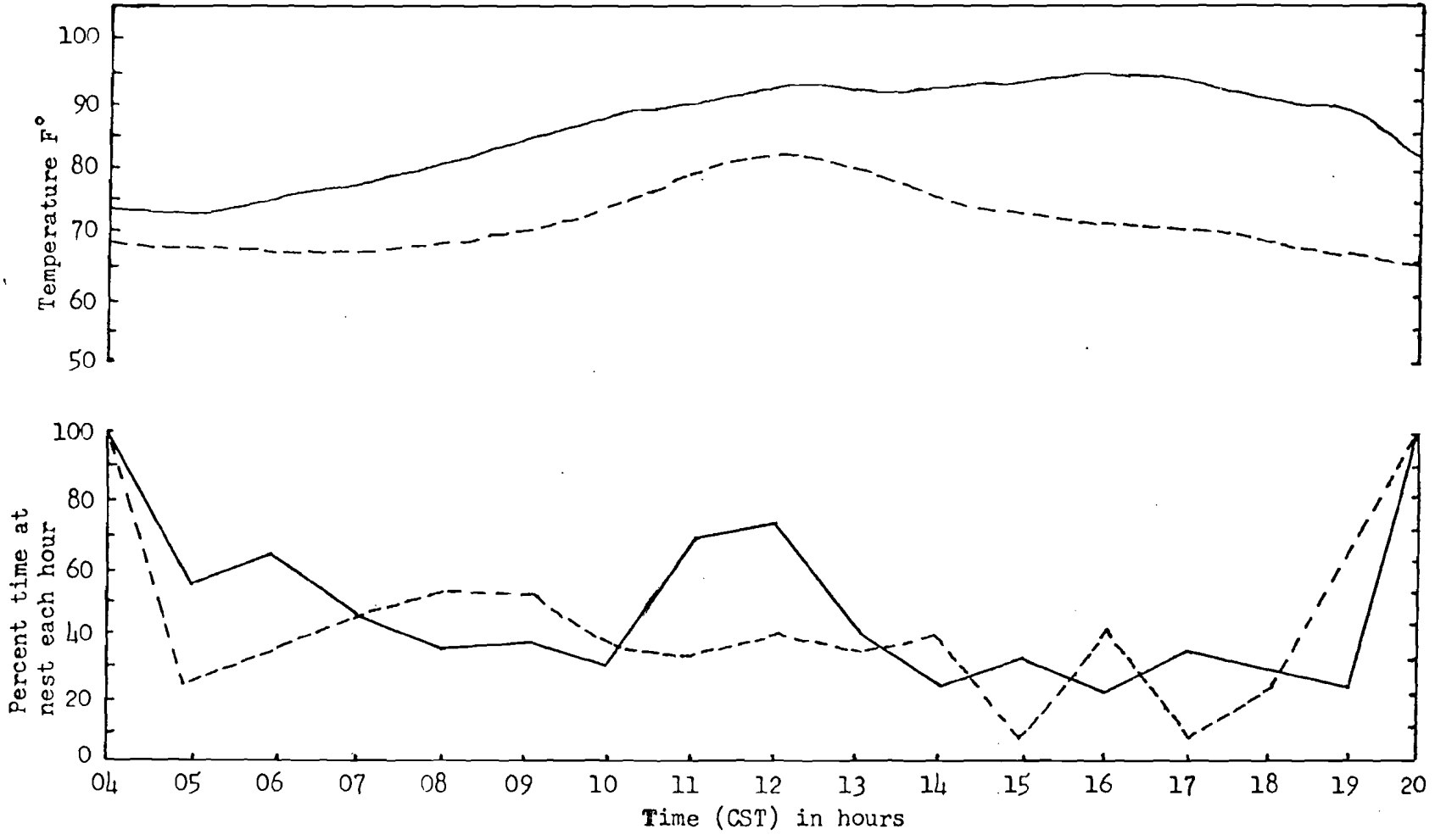

Fig. 14. Mean percent of each hour females 6A (--) and 9A (—) were attentive during hatching compared to median hourly temperatures. Time designated as 04 includes the period 0400 to 0459 hours.

during hatching ranged from 61 to 78°F for nest 6A, and 78 to 98°F for nest 9A.

Female 9A showed two peaks of attentiveness during hatching; one between 0500-0659 hours, when she was at the nest as much as 64 per cent of the time, and again between 1000-1259 hours, when she was attentive 72 per cent of the time.

During the incubation period female 9A was more attentive during the cooler morning hours, and by afternoon, slackened her attentiveness to feed. However, during hatching, she was responsible for feeding and brooding young as well as incubating the remaining eggs. To meet these new needs, she remained longer during 0500-0659 hours to incubate, but slackened her attentiveness between 0700-0959 hours to increase the feeding of the young. Between 1000-1259 hours she increased her incubation again. The remainder of the afternoon she increased her feeding, and her attentiveness dropped again.

Female 6A's attentiveness was more stable than female 9A's during hatching. Between 0500-1459 hours she remained attentive approximately 40 per cent of the time. Between 1500-1759 hours, when the temperature was highest, her attentiveness dropped as low as 10 per cent. During this this time the insects were most active and she increased her feeding.

Brooding and Feeding Of Young

Females assumed a greater responsibility than the male for the care of nestlings. Fecal sacs were removed from the nest and carried away by the female. Female 6A was observed dropping a fecal sac some 200 to 250 feet from the nest. All other sacs were carried beyond sight of the observer. Saunders (1932) reported the eating of fecal material by the parent bird, but no such behavior was observed during this study.

Saunders (1932) indicated young were frequently fed by means of regurgitation, but Lanyon (1957) reported that young were fed solid food with no evidence of regurgitation by the parent birds. Females 6A and 9A were observed regurgitating for the first three to four days after hatching. Regurgitation did not always occur immediately after the female arrived at the nest but occurred once or twice during each attentive visit.

Tables III and IV are records taken during nests 6A and 9A's nestling periods. The nests have contrasting histories. Nest 6A experienced heavy rains for the first four days after hatching was completed and nest 9A experienced hot, dry summer days. Nest 9A's nestling period was eight days and produced three Meadowlark fledglings. Nest 6A's nestling period was 11 days and produced one Meadowlark and one Cowbird fledgling.

Female 9A exhibited behavior which provided the nestlings with a constant supply of food and brooding for warmth. On the first day after hatching (15 July), she made 69 visits, averaging

Table III. Dates, minutes of itograph recordings, number of visits and minutes parent birds were at the nest, mean length of attentive visits and inattentive periods, percent time of active day parent birds were at the nest, and number of young for nest 6A during single days of the nestling period.

Nest	Date	Minutes of itograph recordings	Number visits recorded	Number minutes at nest	Mean length of attentive visits (min.)	Mean length of inattentive periods (min.)	Percent of time at nest	No. of young
	29 May	323	11	83	7.55	20.00	26	7
	30 May	853	41	236	5.76	14.69	28	5
	31 May	844	68	281	4.13	8.16	33	3
	1 June	588	30	214	7.13	12.06	36	2
	2 June	879	66	225	3.41	9.91	26	2
6A	3 June	662	52	52	1.00	11.96	8	2
	4 June	886	76	51	0.67	11.13	6	2
	5 June	855	70	44	0.63	11.75	5	2
	6 June	862	68	45	0.66	12.19	5	2
	7 June	904	53	32	0.60	16.77	4	1
	8 June	780	52	31	0.60	14.69	4	1

Table IV. Dates, minutes of itograph recordings, number of visits and minutes parent birds were at the nest, mean length of attentive visits and inattentive periods, percent time of active day parent birds were at the nest, and number of young for nest 9A during single days of the nestling period.

Nest	Date	Minutes of itograph recordings	Number visits recorded	Number minutes at nest	Mean length of attentive visits (min.)	Mean length of inattentive periods (min.)	Percent of time at nest	No. of young
9A	15 July	914	69	130	1.88	11.20	14	5
	16 July	906	61	185	3.02	11.82	20	4
	17 July	902	68	93	1.37	12.08	10	3
	18 July	892	86	67	0.78	9.71	8	3
	19 July	645	66	50	0.76	9.15	8	3
	20 July	877	87	87	1.00	9.19	10	3
	21 July	877	64	42	0.66	13.25	5	3
	22 July	723	35	14	0.40	20.88	2	3

1.88 minutes in length, or 14 per cent of the active day. Nine brooding visits, averaging six minutes, occurred during the cool hours of morning. At the end of the fourth day (18 July), regurgitation and brooding did not occur, and attentive visits increased to 86, averaging 0.78 minutes, or eight per cent attentiveness for the active day (Table IV).

It was evident female 6A altered her behavior to protect her young from the rain and spent all lulls during the storms in search of food. Heavy rains during the first four days of nest 6A's nestling period (29 May to 1 June) prevented the recording of full day's nesting activity. However, 323 minutes of data for 29 May showed the female making 11 visits averaging 7.55 minutes. On 1 June, 588 minutes of recorded data indicated 30 visits averaging 7.13 minutes each (Table III). Although full days of data are not available, it is evident the length of female 6A's attentive visits remained stable during the storms. On the other hand, female 9A experienced clear weather and 76 to 96^{o}F temperatures (Fig. 15), and showed a gradual drop in the length of attentive visits from the first day after hatching to the fourth day of the nestling period. On 15 July, female 9A's attentive visits averaged 1.88 minutes and at the end of the fourth day (18 July) the average dropped to 0.78 minutes (Table IV).

Low temperatures and rains limited the available food supply for female 6A, resulting in her spending longer periods from the nest in search of insects. Inattentive periods ranged as long as

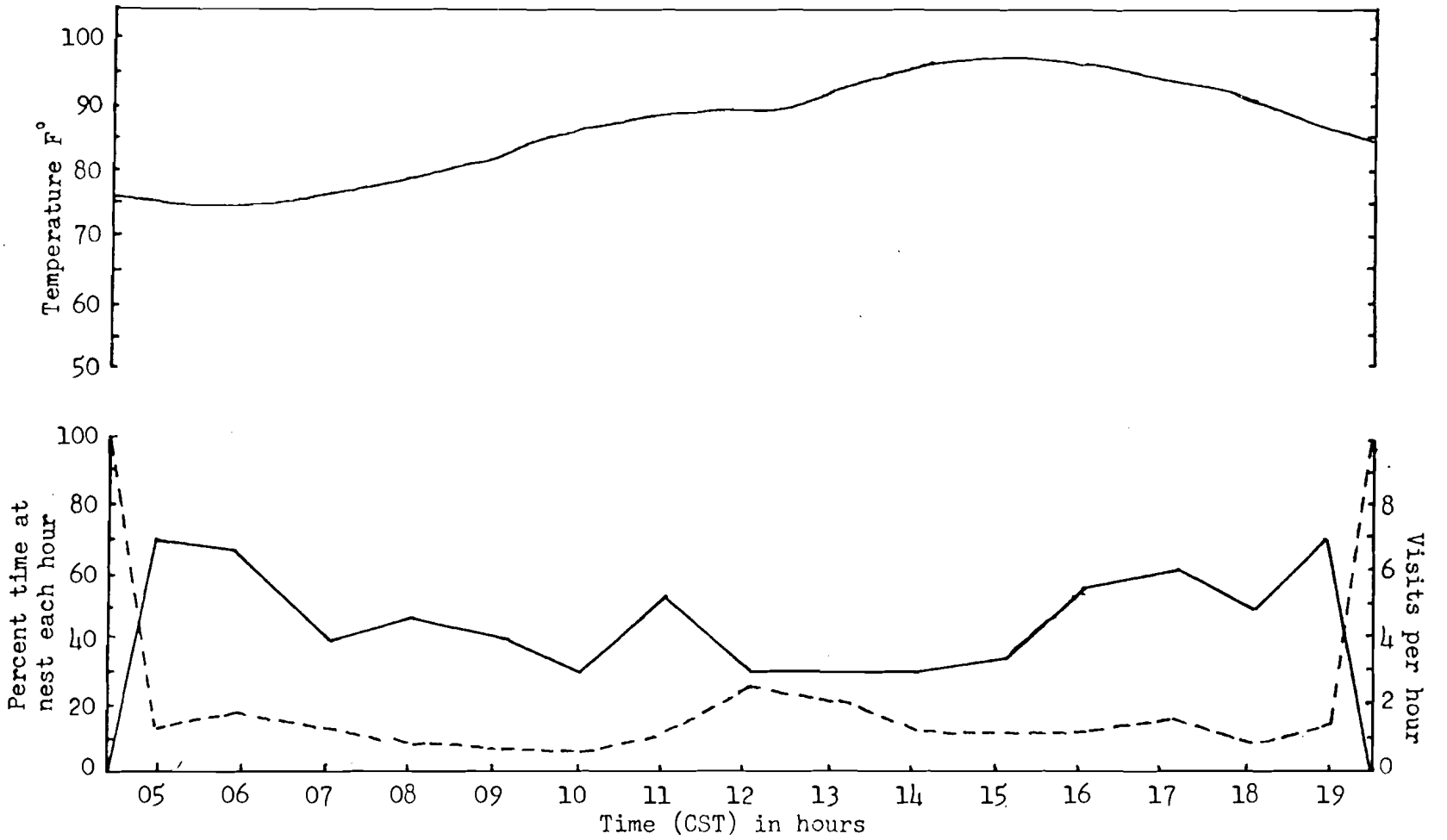

Fig. 15. Percent of each hour parent birds were at the nest and mean number of attentive visits compared to median hourly temperature for first four days of nest 9A's nestling period. Time designated as 05 includes the period 0500 to 0559 hours.

20 minutes, longer than the 11 to 12 minute periods demonstrated by female 9A.

During the first four days of the nestling period (Fig. 15), female 9A showed two major peaks in attentive visits (0500-0659 hours and 1600-1959 hours), and one minor peak (1100-1159 hours). In both major peaks, a mean of seven attentive visits in one hour were made with a high of 5.5 attentive visits for the minor peak. Between 1100-1359 hours, the female brooded as high as 25 per cent of the time. This was the only major peak, of per cent time spent at nest, she showed during the first four days of the nestling period, and it was similar to an attentive peak she showed during 1000-1259 hours of the hatching period.

During the last four days of the nestling period, females 6A and 9A showed similar patterns of attentiveness (Fig. 16). Both birds showed morning and late afternoon peaks in attentive visits. Most visits averaged 0.50 to 0.60 minutes (Fig. 17), and ungraphed data indicated the birds remaining one to three per cent of each hour at the nest. Brooding ceased and the females were constantly feeding their young. Female 9A averaged as high as nine feeding visits during 0600-0659 hours, and female 6A averaged as high as 6.5 feeding visits during 1900-1959 hours.

Females 6A and 9A showed an increase number of attentive visits per day until two to three days before fledging, when the number of visits per day began to decrease (Fig. 18). Nest 6A's reduction in visits may be explained because one of the remaining

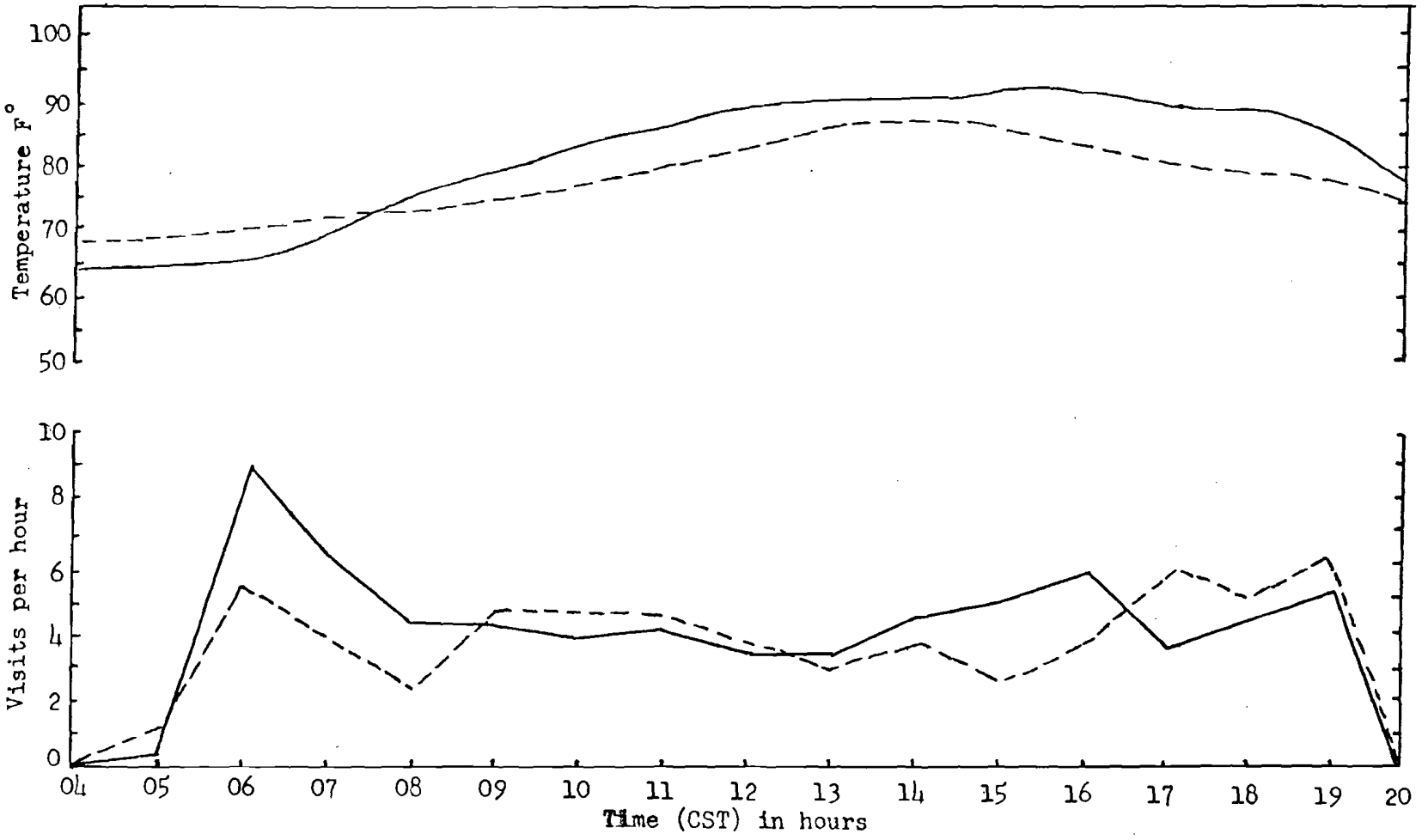

Fig. 16. Mean number of attentive visits each hour for nests 6A (--) and 9A (—) compared to the median hourly temperature during the last four days of the nestling period. Time designated as 04 includes the period 0400 to 0459 hours.

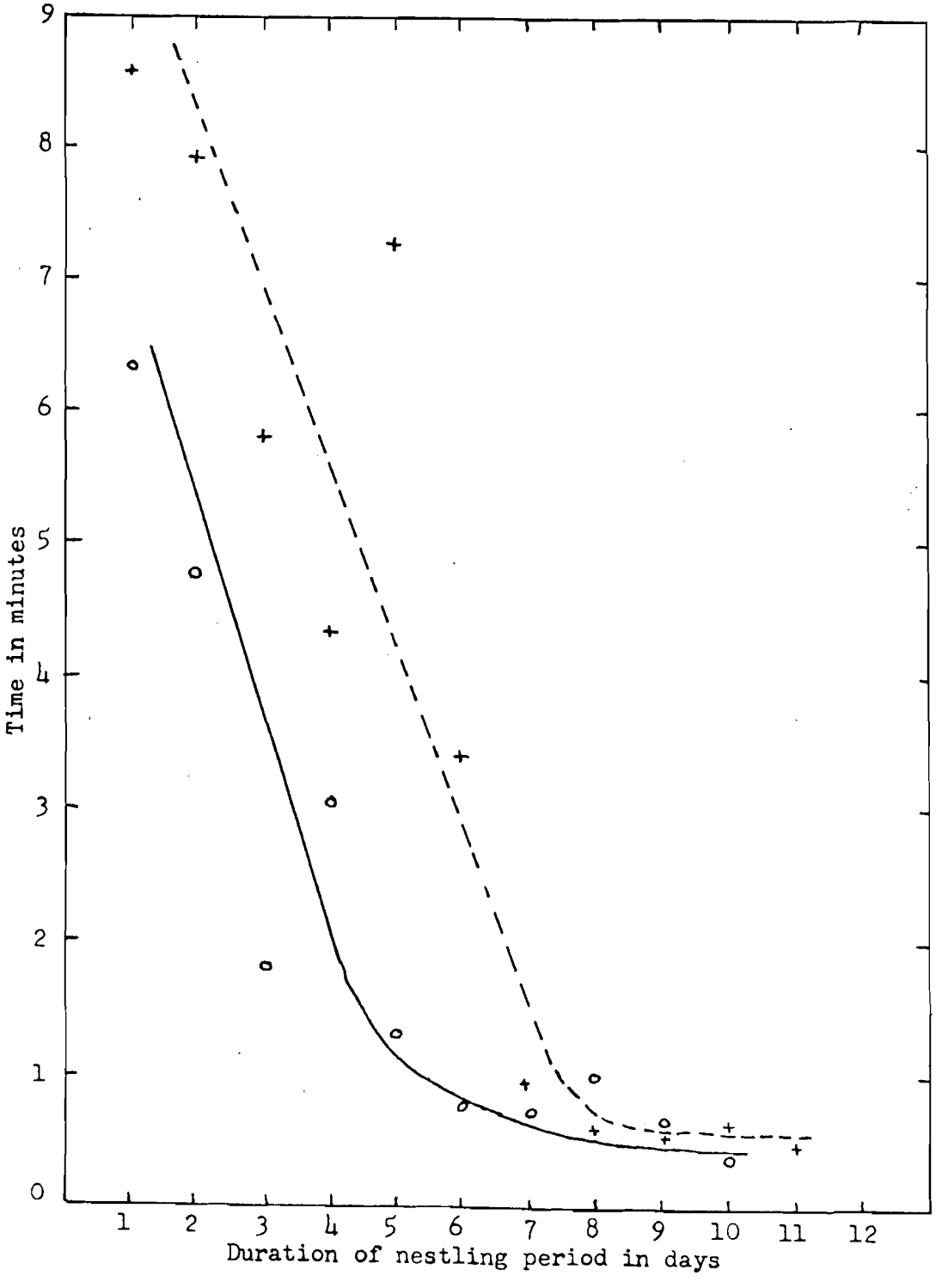

Fig. 17. Mean length of attentive visits for nests6A (--) and 9A (—) during the nestling period.

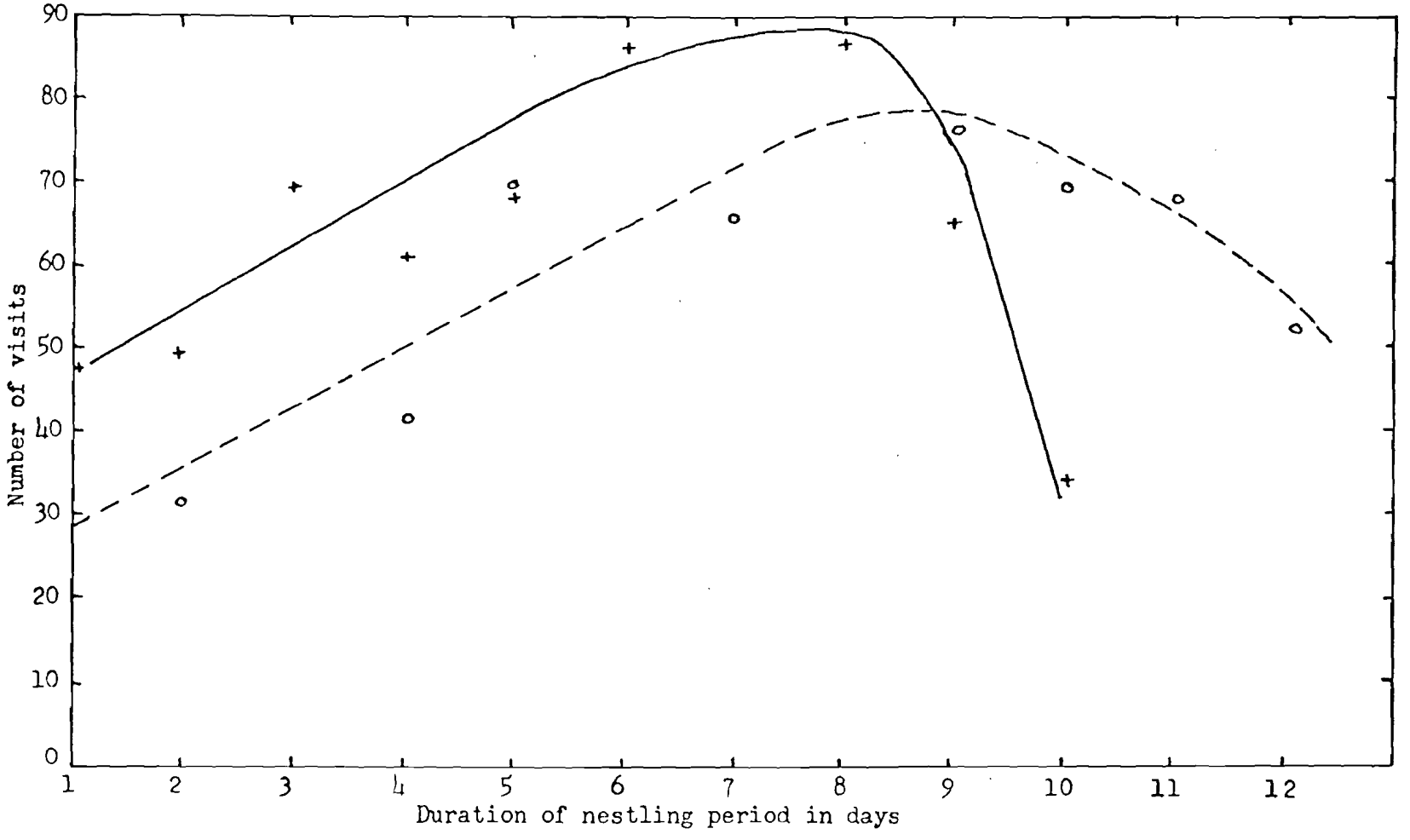

Fig. 18. Number of attentive visits for nests 6A (--) and 9A (—) for nestling period.

two chicks (a Cowbird) fledged two days prior to the remaining Meadowlark chick. A total of 56 attentive visits was recorded during the last full day of recorded activity. This may give some indication of the number of feedings required for a single fledging.

Single nestlings leaving the nest on different days can not explain the decrease in visits for nest 9A because the three remaining chicks fledged within the same few hours. The male parent was noticeably active before fledging. He was highly vocal and made numerous visits to the nest site. An increase in the male's activity and the decrease in feedings may have combined to stimulate the young to fledge.

Female 9A made several visits to the abandoned nest after fledging had occurred. Apparently a short amount of time was required before the female was conditioned to feed the young outside of the nest.

The fledglings remained within the male's territory until they were capable of flight. After that point, it was not possible to determine if the parent birds preferred any one area over another, but it was obvious, from observations, that the parent birds were seen following stray juveniles and attempting to direct them back to the family group.

Mortality

Nest 6A lost five chicks, presumably by starvation, during the first two days of the nestling period. Beetles were the most

readily available insects during the rains and were difficult for the female to break up before feeding to the young. Stomach contents of the dead chicks contained little food material.

Another cause of death appeared to be excessive heat. Nest 9A lost two young when temperatures reached 117 to 121 degrees F within the nest. The nest was open with little overhead cover and offered little protection from direct sunlight. Dead chicks were blistered and dehydrated, and food material was present in the stomachs.

Nest 1A, 2A and 4B were destroyed by grazing cattle. Nests 3A, 4A, 8A, 10A, 2B and 3B were destroyed by unknown predators. All nests, except 10A and 4A, had egg shell remains.

Beginning And Ending Of Day's Activity

Beginning and ending of daily activities varied on consecutive days (Fig. 19). Generally, during incubation, females remained on the nest overnight and left the nest 13 to 90 minutes after sunrise; then returned 15 to 40 minutes before sunset to incubate overnight. During the nestling period, the day's activity started 5 to 13 minutes before sunrise and ended 5 to 15 minutes after sunset. There was a tendency for the daily activity to shorten during heavy rains. Female 6A returned 30 to 70 minutes before sunset when rains necessitated returning early for brooding.

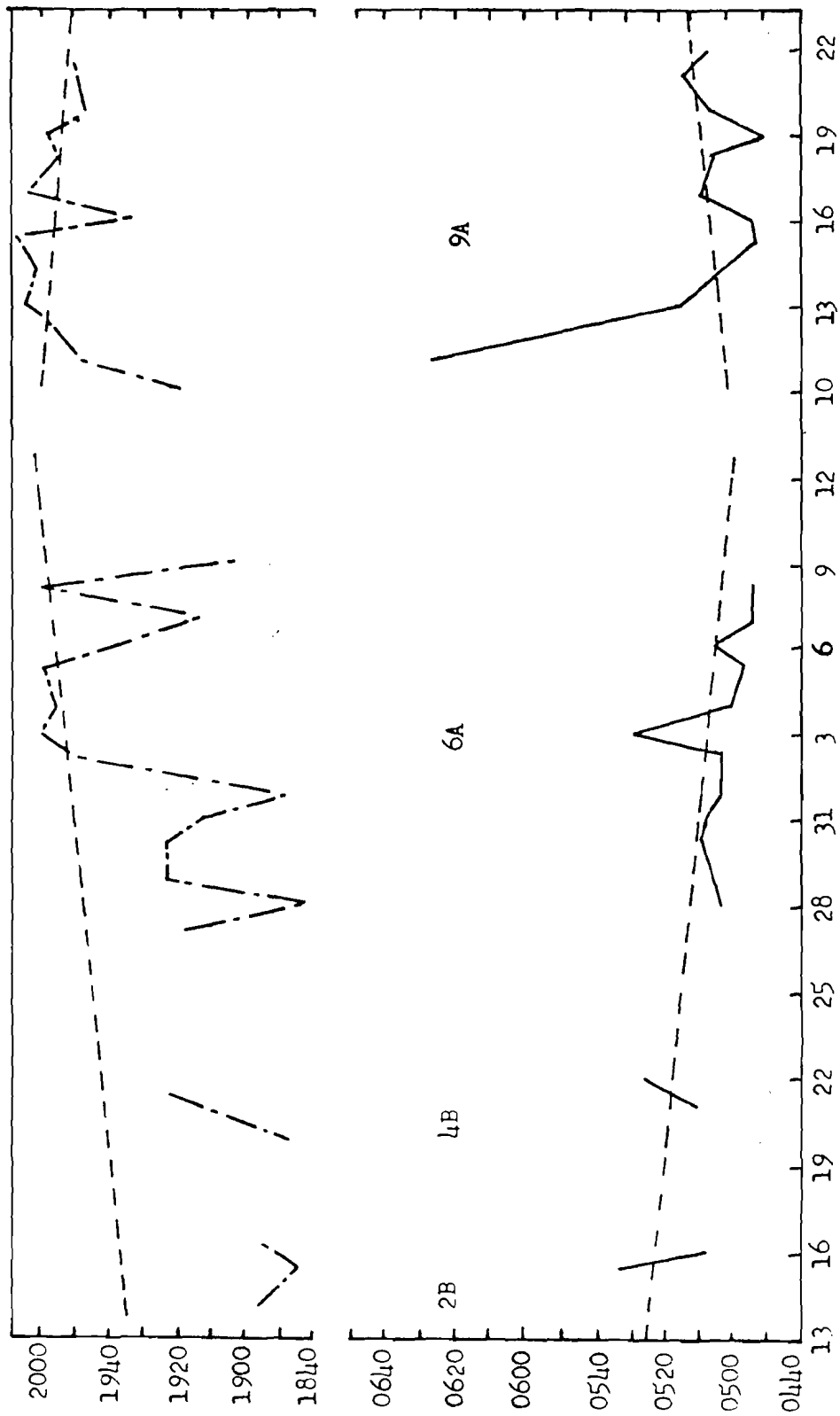

Fig. 19. Beginning and ending of daily activity for nests 2B, 4B, 6A and 9A; line (--) indicates sunrise and sunset, line (—) indicates the starting of activity, and line (— - —) indicates the ending of activity at the nest.

Night Activity

Itograph recordings and nest inspections indicated females remained on the nest for the entire night during incubation and the first two to four nights of the nestling period. Female 6A completed her fourth night of brooding on 2 June and female 9A completed her brooding on 16 July, two nights after hatching had completed. Nightly brooding ended.

Any movement from the nest during the night was the result of the female being disturbed. Recordings indicated female 2B flushed from the nest around 0130 hours (CST) on 17 May 1971. At dawn no eggs were present in the nest. Evidently a predator destroyed the clutch after flushing the female.

Male's Behavior

Observations conducted throughout the nesting season indicated a change in the male's priorities as the season progressed. Early in the season the male's parental instinct appeared subordinate to the courting and mating drives. Male 6A devoted his entire time to protecting his territory and two mates (females 5A and 6A), but was never observed feeding the nestlings.

Later in the season, time spent in territory defense decreased and was replaced by attentiveness towards the nesting site. Male 9A participated in feeding the nestlings, but was inconsistent in doing so. Generally, he fed the young immediately after the female fed them, thus, producing four closely spaced marks on the itograph

tape. By noting this pattern I estimated that the male made approximately eight to ten visits per day.

Second Nesting

Late June and early July was the peak for second nestings. Second nesting was the production of a second clutch after the successful release of the first brood, and must not be confused with renesting, which is the production of another clutch after a nesting failure. New nests were built for each new clutch. Female 9A was observed carrying nesting material during late June within the same territory she was noted in late April and early May. I assumed she was starting her second nest because she was noted, a few days before, feeding fledglings.

SUMMARY

The earliest male Meadowlarks established territories, during the 1970 and 1971 nesting seasons, was 4 April and 29 March, respectively. Territories ranged from 3 to 12 acres depending on the local abundance of competing males. More males competed for the lush grassland with fewer males competing for the open, grazed grassland.

The peak building period for first nests occurred around mid-April with the second nestings peaking during late June and early July. On 2 May 1970, a well-developed juvenile was found as a road kill, and was estimated to be produced from a clutch started around 8 or 13 April.

Incubation lasted from 12 to 14 days and was performed by the female. Males were not observed aiding in the task. Completed clutches generally consisted of five Meadowlark eggs with as high as three Cowbird eggs parasitizing a single nest.

Females 2B and 9A were noted incubating 67 and 65 per cent of their active day. This was considerably lower than the 76 per cent given by Saunders (1932). Both females showed an increase in the number of visits each hour as the atmospheric temperature rose.

Hatching of the clutch required one and one-half to two days to complete. All egg shells were carried from the nest by the female. After the first egg hatched the female's

attentive behavior changed; length of each visit decreased but number of visits increased. Female 9A increased her visits from 19 to 47 and showed a decrease from 30.32 minutes to 6.34 minutes for each visit.

Females assumed a greater responsibility than the male in caring for the nestlings. Fecal sacs were removed from the nest by the female up to a few hours before the young fledged. For the first two to four days of the chick's life the females regurgitated food to the young.

Female 6A altered her behavior during the first four days of the nestling period because of rains. Her attentive visits did not shorten but remained close to seven or eight minutes in length. Female 9A experienced warm, dry weather during the first four days of the nestling period and showed a shortening from 1.88 to 0.78 minutes a visit. After the rains ceased, female 6A progressed to a daily activity very similar to that later shown by female 9A.

The male parent was noticeably active before the young fledged. Male 9A was highly vocal and made numerous visits to the nest site. The male's increased activity, plus a decrease in feedings may have combined to stimulate the young to fledge.

Female 9A was observed visiting the nest site several times after the young fledged. Apparently, a short amount of time was required before the bird was conditioned to adjust to feeding young outside the nest.

The male's priorities changed as the season progressed. Early in the season the male's parental instinct was subordinant to the courting and mating drives. Later in the season, he devoted most of his attention toward the nestlings.

Mortality was high during the first two to four days of the nestlings life. Heat and starvation took a heavy toll of two broods during the study. Nest destruction was high, with grazing cattle causing a major portion of damage. The number and species of predators responsible for nest destructions were unknown, but it seems certain they too played a major roll in nesting failures.

Generally, the second nestings were produced by late June or early July, but due to earlier nesting failures many pairs had only time to rear one brood.

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