BREEDING BEHAVIOR OF THE MISSISSIPPI KITE (*ICTINIA MISSISSIPPIENSIS*) IN NORTHWESTERN OKLAHOMA

By

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PREFACE

The purpose of this study was to determine if significant differences existed between the nesting chronology and reproductive success of single nesting pairs and that of colony nesting pairs of Mississippi kites, and to determine to what extent the size of the colony and activity patterns were influenced by the sex of the birds, time of day, stage of breeding cycle, clutch size, and nest height-tree height characteristics. Shelterbelts were selected and inspected periodically to estimate reproductive success and to observe activity patterns. Reproductive success was analyzed by the Mayfield method, and activity patterns were categorized and analyzed from time budget data to identify biotic and behavioral factors that may regulate the success of colony and single nesting pairs.

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I extend my sincere appreciation to my major advisor, Dr. Frank Schitoskey, Jr., for his support and advice during the course of this study and thesis preparation. I also express my sincere thanks to Dr. Larry Talent and Dr. Scott Shalaway for serving as members of my graduate committee and for their assistance in data analysis and editing of the drafts of this manuscript. I am grateful to Dr. William D. Warde who provided statistical and computer programming assistance.

Special thanks must be extended to Mr. and Mrs. Oren Brown and their family for generously providing housing and encouragement during this project. Also, special thanks to the many landowners who graciously allowed access on their land. All personnel of the Oklahoma Cooperative Wildlife Research Unit and fellow graduate students are thanked for their involvement during the project.

My sincerest thanks to my father and mother, Mr. and Mrs. Duane Kinzy, for their love, support and encouragement throughout the project, and to Jesus Christ for the faith, strength and wisdom I received to complete this project.

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CHAPTER I

INTRODUCTION

This thesis is composed of two chapters. Chapter I serves as an introduction. Chapter II is written as an individual manuscript suitable for submission to THE JOURNAL OF WILDLIFE MANAGEMENT and is complete without additional supportive information. Chapter II contains a section on the history and ecology of Mississippi kites, followed by research procedures, data, and conclusions of research on the breeding behavior of Mississippi kites in northwestern Oklahoma. Previous approval for format changes was granted by the Graduate College.

CHAPTER II

BREEDING BEHAVIOR OF THE MISSISSIPPI KITE (ICTINIA MISSISSIPPIENSIS) IN NORTHWESTERN OKLAHOMA

Mississippi kites (Ictinia mississippiensis) were recorded in the Great Plains as early as 1887 (Goss 1887) and numbers were believed to be stable or increasing since 1900 (Parker and Ogden 1979). Early populations of kites nested in natural riparian habitats, but as man-made structures, such as shelterbelts, matured in the last 50-60 years, it was more common to see nesting pairs use these sites.

Mississippi kites are gregarious raptors. Two to three pairs may randomly nest in the same shelterbelt or pairs may nest singly. Wynne-Edwards (1972) stated that this duality in breeding habits provided two separate ways to meet some single common need. Colonial nesting may be beneficial through its effects on improved foraging success (Lack 1968), the impact of predation (Lack 1954, Sears 1979, Sutton 1939), or simply the social attraction of more than one pair nesting together (Parker 1974).

Mississippi kite behavior has not been well documented in scientific papers except for brief narratives on nest building behavior (Ganier 1902), defense behavior (Robinson 1957), and feeding behavior (Sutton 1939). This study will attempt to expand on the many generalized accounts of reproductive behavior in Mississippi kites by providing detailed studies of breeding and reproductive activities that are

presently lacking in the literature. Information obtained from the time budgets and associated environmental variables will expand the data base and understanding of ecological relationships important to species management as well as habitat management. The maintenance of stable nesting populations of Mississippi kites in the Great Plains may depend on the identification of the associated behavioral and biotic factors that regulate the success of colony and single nesting pairs.

METHODS

Preliminary field research began on 24 May 1982 and involved systematic searches for Mississippi kite nests in 60 shelterbelts around Arnett, Oklahoma, in Ellis County. This activity continued for two weeks. Also at this time, I monitored kite behavior activities. Major behavior classification categories included social, flying, foraging, maintenance and reproductive behaviors (See Appendix). Twenty-five shelterbelts contained at least one nesting pair of kites. Shelterbelts were classified into single nesting and colony nesting shelterbelts. Single nesting sites were defined as shelterbelts (linear woodlots) or windbreaks (smaller, squarer woodlots) (Parker 1974) that contained only one nesting pair of kites. A shelterbelt or windbreak that contained more than one nesting pair of kites was classified as a colony nesting shelterbelt. The remainder of the summer was spent collecting time budget data along with information pertaining to reproductive chronology and nest success.

Continuous 20 minute time budget observations (Orians 1961, Altmann 1979) were made from May to July using 7 X 40 binoculars or a 40-power scope. Behaviors were instantly classified and recorded on a cassette

tape. Each day was divided into four equal parts of three hours each, beginning at 0730 and ending at 1930. Optimally, both the male and female of a single nesting pair and the male and female of a colony nesting pair were observed during each three hour time period. However, at certain times only one observable (focal) bird was present or the pair may have been disturbed by my presence. If this occurred, I generally left the shelterbelt and returned another time, as the kites generally remained defensive if they were aware of my presence. The reproductive season was divided into pre-nesting, incubation, and nestling phases. These three phases were used to facilitate the use of the Mayfield method to determine reproductive success. Pre-nesting time budgets were recorded from the time the kites were first observed until at least one egg was laid. Incubation behaviors were recorded from the end of the pre-nesting period until at least one egg hatched, and nestling behaviors were observed until at least one nestling had fledged and left the nest. Attempts were made to observe fledgling behaviors, but the kite family units did not remain near the nesting site and they often expanded their territory becoming socially integrated with other kites.

During the reproductive season a nest census was conducted to determine reproductive success. The numbers of eggs and of nestlings were observed by using a mirror and pole device (Parker 1972). Nests were visited as often as possible until they failed or until the nestling(s) no longer remained on or near the nest. The intervals between visits were unequal but most were between one and two weeks.

All data collected were subjected to analysis of variance (ANOVA), t-tests, chi-square, or means tests through the use of the Statistical Analysis System. Behavioral data were transcribed and recorded to the

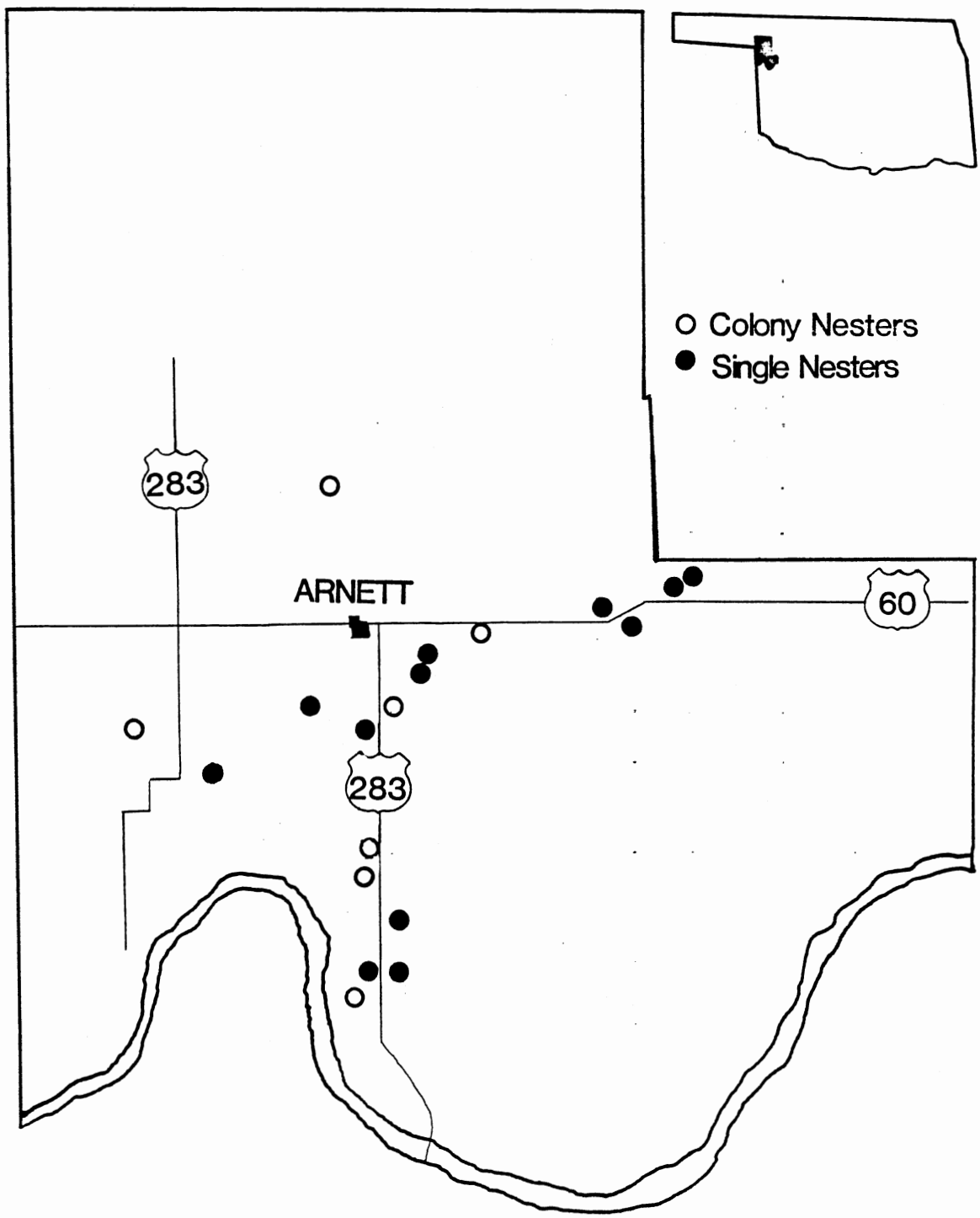
nearest full second. Behavior was quantified into frequency of occurrence using each 20 minute time budget as an experimental unit and recording the presence or absence of each behavior, duration of each behavior using each observation of the behavior in a time budget as the experimental unit, and percentage of total time spent in each behavior, using time budgets as the experimental units. Observed significant levels (OSL's) less than 0.05 were considered sufficient to reject the statistical hypothesis.

STUDY AREA

This study was conducted in Ellis County in western Oklahoma (Figure 1). The grassland vegetation was composed of mixed grass species such as buffalo grass (Buchloe dactyloides), blue gramma (Bouteloua gracillis), side oats gramma (B. curtipendula), and little bluestem (Andropogon scoparius). Additional species in short grass and sand sage grasslands included wire grass (Cynodon dactylon), big bluestem (A. gerardii), sandhill bluestem (A. hallii), Indian grass (Sorghastrum nutans), sand sage (Artemisia filifolia), sand plum (Prunus angustifolia), and skunkbrush (Rhus trilobata). Natural woody vegetation occurred along riparian systems, which were dominated by cottonwood (Populus deltoides), willow (Salix sp.), hackberry (Celtis sp.), and elm (Ulmus sp.), and distinctive regions of shinnery oak (Quercus havardii) (Duck and Fletcher 1944).

Cultivation of such cereal grains as wheat (Triticum aestivum) and sorghum (Sorghum bicolor) was common throughout the area, as were areas of extensive cattle grazing. Windbreaks and shelterbelts were fairly common in the area and they contained a mixture of tree species. Black locust (Robinia pseudoacacia), honey locust (Gleditsia triacanthos),

Figure 1. Location of single nesting and colony nesting Mississippi kites in Ellis County, Oklahoma.



hackberry, elm, osage orange (Muclura pomifera), cedar (Juniperus sp.), mulberry (Morus sp.), and hickory (Carya sp.) were commonly found. The width of the shelterbelts ranged from one tree row up to five tree rows. The windward side of the shelterbelts was generally composed of cedars, with deciduous trees occurring in rows of increasing height and elms comprising the leeward side of most windbreaks.

RESULTS AND DISCUSSION

Nest Success

Nest success is a good indicator of overall productivity and population dynamics of a population. Thirty-one nests were observed during the summer of 1982. Eight of these nests contained only one egg, while 23 nests contained two eggs. Nineteen of the 31 nests were in colonial shelterbelts, and 12 of the nests were in single nesting shelterbelts. Fifty-four total eggs were laid. Eight eggs were laid in one egg nests and 46 eggs were laid in the nests that contained two eggs. Thirty-three of the eggs were in colonial shelterbelts, while 21 eggs were in single nesting shelterbelts. The total number of nestlings that were observed to hatch was 32. Only three nestlings came from one egg clutches, while the remaining 29 were found in two egg clutches. The numbers of nestlings were fairly evenly distributed by breeding strategy. Nineteen nestlings were found in colonial nests and 13 were located in single nests. Only ten nestlings survived to successfully fledge and only one of these fledglings was from a one egg clutch. Colonial nests produced seven fledglings and single nests produced three fledglings.

Nest and egg success were calculated using the Mayfield method (Mayfield 1975). Nest success was calculated for the total number of nests as well as for single nesting pairs and colony nesting pairs. Twelve of

the shelterbelts had only one nesting pair and seven shelterbelts had more than one nest, with the greatest number of kite nests per shelterbelt being four.

Egg and nest days during the incubation period were recorded from the first day an egg was observed in the nest until the nest was destroyed or at least one nestling was seen in the nest. The nestling period began at the end of the incubation period and was completed when at least one nestling had fledged.

Each nest was not visited each day; therefore, Mayfield's (1975) technique of calculating reproductive success was used to provide a close approximation of nesting success. The probability of nest success during the incubation period and the nestling period was 0.5162 and 0.4348, respectively (Tables 1 and 2). There was no significant difference (NSD) in nest success ($P < 0.05$) between colony and single nesting pairs.

Egg survival for the entire incubation period was 0.4679, and the probability that a nestling survived the nestling period was 0.2586 (Tables 1 and 2). There was NSD ($P < 0.05$) in egg or nestling survival between colonial and single nesting pairs.

The probability that a nest survived to fledge at least one fledgling was 0.2608 for colonial nests, 0.1717 for single nests and 0.2244 for all nests combined. The probability of an egg surviving to produce at least one fledgling was 0.1210 for all nests and only 0.0979 for single nesting pairs (Table 3). Chi-square analysis showed NSD ($P < 0.05$) between colony and single nesting pairs.

Parker (1974) noted in his studies that nests that began with two eggs were more than twice as likely to be successful through the nestling period than nests with only one egg. In 1982, nests with two eggs were

Table 1. The probability of nest and egg success for the incubation periods of colony and single nesting pairs of Mississsippi kites.

Period	Total Nest Days	Total Number of Nests	Number of Nests Lost	Nest Success	Total Egg Days	Total Number of Eggs	Number of Eggs Lost	Egg Success
Incubation								
Total Nests	459.5	31	10	0.5162	760.5	54	19	0.4679
Colonial Nests	284.5	19	6	0.5274	483.5	33	12	0.4708
Single Nests	175.0	12	4	0.4991	277.0	21	7	0.4636

Table 2. The probability of nest and nestling success for the nestling periods of colony and single nesting pairs of Mississippi kites.

Period	Total Nest Days	Total Number of Nests	Number of Nests Lost	Nest Success	Total Nestling Days	Total Number of Nestlings	Number of Nestlings Lost	Nestling Success
Nestling								
Total Nests	454.0	31	11	0.4348	641.5	32	25	0.2586
Colonial Nests	292.0	19	6	0.4945	395.5	19	14	0.2936
Single Nests	162.0	12	5	0.3440	246.0	13	11	0.2112

Table 3. The probability that nests and eggs survived through the laying, incubation and nestling periods to successfully produce at least one young in colonial and single nests of Mississippi kites.

Nest Strategy	Nest Survival	Egg and Nestling Survival
Total	0.2244	0.1210
Colonial	0.2608	0.1382
Single	0.1717	0.0979

Table 4. The observed hatching and fledgling success of Mississippi kites in relation to clutch size.

Size of Clutch	N	Hatching Success	Fledgling Success
1 egg	8	4 (50)[1]	1 (25)
2 eggs	23	17 (74)	8 (47)
Total	31	21 (68)	9 (43)

1. Numbers in parentheses are percentages to the nearest whole number for successful nestlings and fledglings.

Table 5. The probability of nest and egg success for the incubation periods for one egg clutches and two egg clutches of Mississippi kites as calculated by the Mayfield Method (1975).

Period	Total Nest Days	Total Number of Nests	Number of Nests Lost	Nest Success	Total Egg Days	Total Number of Eggs	Number of Eggs Lost	Egg Success
Incubation								
Total	759.5	31	10	0.5162	760.5	54	19	0.4679
1 egg clutch	73.5	8	4	0.1867	73.5	8	4	0.1867
2 egg clutch	686.0	23	6	0.7694	687.0	46	15	0.5162

1.5 times more likely to hatch at least one nestling than nests that originated with only one egg. They were also more than twice as likely to successfully fledge at least one young (Table 4). This is further illustrated by comparing nest and egg success between one and two egg clutches using the Mayfield method. The probability of a two egg clutch surviving to hatch at least one egg was 0.5162 compared to only 0.1867 for one egg clutches (Table 5). Thus, two egg clutches were almost three times as likely to successfully hatch one nestling as a nest originating with only one egg. Also, nest success for two egg clutches was 0.4928 compared to 0.2002 for one egg clutches, which is a success rate over two times greater for two egg clutches. However, nestling success during the nestling period was essentially the same for one and two egg clutches at 0.2002 and 0.2660 respectively (Table 6). This would indicate that only rarely do both eggs of a two egg clutch successfully survive to fledge. The probability that a nest originating with two eggs survived the incubation and nestling periods and produced at least one fledgling was ten times greater than for a single egg nest. The probability that at least one egg from a two egg clutch survived to produce at least one fledgling was 0.1373 compared to 0.0374 for single egg clutches (Table 7).

Mortality Factors

Mortality factors included weather, parasites, predation, desertion and brood parasitism. It was not possible to classify each egg, nestling, or fledgling loss to a specific mortality factor. The weather may have had deleterious effects very early in the reproductive season. Rainfall during the month of May was greater than five inches above normal. This excess may have caused a reduction in the number of nests that were constructed by kite pairs. The remainder of the summer was dry and mild and

Table 6. The probability of nest and nestling success for the nestling periods for one egg clutches and two egg clutches of Mississippi kites as calculated by the Mayfield Method (1975).

Period	Total Nest Days	Total Number of Nests	Number of Nests Lost	Nest Success	Total Nestling Days	Total Number of Nestlings	Number of Nestlings Lost	Nestling Success
Nestling								
Total	454.0	31	11	0.4348	641.5	32	25	0.2586
1 egg clutch	65.0	8	3	0.2002	65.0	3	3	0.2002
2 egg clutch	389.0	23	8	0.4928	576.5	29	22	0.2660

Table 7. The probability that nests and eggs survived through the reproductive season to successfully produce at least one young in one egg and two egg clutches of Mississippi kites.

Clutch Size	Nest Survival	Egg and Nestling Survival
Total	0.2244	0.1210
1 egg	0.0374	0.0374
2 eggs	0.3792	0.1373

should have been favorable for successfully raising nestlings, as well as for the optimal producution of prey numbers.

Evidence of external parasites was observed on one nestling. By climbing the tree I was able to see that the nestling was under weight and had open patches in its feather tracts. The parents appeared to be giving the nestling normal parental care including feeding and shading; however, the nestling was too weak and died after approximately two weeks.

Although I never actually observed an avian or mammalian predator eating a kite egg or nestling, there was evidence that predation had occurred at several nests. The most common predatory species that have been recorded are great-horned owls (Bubo virginianus), crows (Corvus brachyrhynchos) and squirrels (Sciurus sp.) (Sutton 1939). On several occasions remains of nestlings were found on the ground, and in one instance a nestling had hanged himself on a branch of the nest tree. This was possibly due to an escape attempt from a predator before the nestling was strong enough to fly.

Nest desertion or abandonment usually occurred after more than 30 days of incubation. Since the normal incubation period is 30 days, mortality led to abandonment rather than being the result of abandonment.

An interesting mortality factor occurred in one kite nest that experienced a unique form of brood parasitism by a roadrunner (Geococcyx californianus). Old World members of the Cuculidae were reported to lay their eggs in the nests of other species and then they would allow that adult to incubate and raise the young (Pettingill 1970, Wilson 1975). In this case, the roadrunner laid three eggs in a nest already occupied by two kite eggs. The only adult observed incubating the eggs was the roadrunner; however, both kite adults were seen nearby the nest, and when

I approached the nest they exhibited typical defensive behavior by vocalizing and flying over the nest and directing their activities toward me. When I later observed the nest after two weeks, there were three roadrunner nestlings and one kite nestling. At this time both species of adults were seen near the nest. One week later there were only two roadrunner nestlings remaining in the nest, and they later fledged. Bent (1938) reported that roadrunner nestlings will evict eggs from the nest and eat younger nestlings. Although the size and coloration of the roadrunner eggs did not mimic the kite eggs, the shorter incubation and fledging periods of the roadrunner, along with larger size due to quicker development, gave the roadrunner a distinct reproductive advantage and caused this kite nest to be unsuccessful.

Tree and Nest Characteristics

Many studies have been conducted in an attempt to relate shelterbelt characteristics (Parker 1974), nest site locations (Newton 1976) and land use patterns (Love 1980) to the reproductive success of raptors in general and Mississippi kites specifically. I supplemented my research by collecting data on tree species, nest height and tree height, and comparing this information with nest success.

Kites, in the 25 shelterbelts studied, nested in eight species of trees (Table 8). Osage orange and the locust species accounted for 72% of the nest trees used in all the shelterbelts. However, when the shelterbelts were separated into single nesting and colonial nesting, the composition and percentages changed. In single nesting shelterbelts, osage orange, mulberry and hackberry composed 76% of the nest trees, whereas in colonial nesting shelterbelts, black locust and osage orange made up 95% of the nest trees.

Table 8. Species of trees used as nest sites in shelterbelts by Mississippi kites.

Species	Number of Single Nests	Number of Colonial Nests	Total Nests
Honey locust (*Gleditsia triacanthos*)	1 (8)[1]		1 (3)
Black locust (*Robinia pseudoacacia*)		8 (40)	8 (25)
Osage orange (*Muclura pomifera*)	5 (42)	9 (45)	14 (44)
Cedar (*Juniperus sp.*)	1 (8)		1 (3)
Mulberry (*Morus sp.*)	2 (17)	2 (10)	4 (13)
Cottonwood (*Populus deltoides*)		1 (5)	1 (3)
Elm (*Ulmus sp.*)	1 (8)		1 (3)
Hackberry (*Celtis sp.*)	2 (17)		2 (6)

1. Numbers in parentheses are percentages for the breeding season rounded to the nearest whole percent.

Parker (1974) found that the average nest height and tree height were 6.53m and 8.82m, respectively, for nest trees in shelterbelts. My results showed slightly lower nest and tree heights of 4.74m and 7.14m, respectively. After grouping the tree species into three classes (locust sp., osage orange, all other species represented) and analyzing any differences in the nest and tree height between the three classes, I found there was NSD ($P < 0.05$).

I next analyzed nest height, tree height, and nest tree species versus nest success using chi-square statistics. Nest height was separated into three classes and tree height into two classes based on the most desirable grouping to perform the chi-square analysis. Nest success was based on the largest number of eggs found in the nest, the number of eggs hatched and the total number of nestlings that fledged. When comparing nest and tree height against egg and nestling success, there was NSD ($P < 0.05$). However, when analyzing success of fledglings, there was a significant difference at the $P < 0.10$ level. These results must be analyzed realizing that there were only 31 nests under consideration and of the four nest and tree classifications, there were some categories that contained only a few observations.

Over 74% of the nests started out with two eggs in the nest (Table 9). (Zero eggs indicates that the nests were not located until after the eggs were hatched; therefore, it was not known if the nests originated with one or two eggs). The tree height-nest height classification 1-2 (shortest tree height, medium nest height) contained over 54% of all nests containing eggs and over half of the nests that contained two eggs. The percentage of the number of nestlings in the nest was essentially even, ranging from approximately 32% for nests with no nestlings and one nest-

Table 9. The frequency with which nests containing 0-2 eggs of Mississippi kites occur in each nest height-tree height category.

Number of eggs	Nest height-tree height categories									
	1-1		1-2		2-2		2-3		TOTAL	
	N	%	N	%	N	%	N	%	N	%
0	0	0	1	3.23	0	0	0	0	1	3.23
1	2	6.45	4	12.90	0	0	1	3.23	7	22.58
2	2	6.45	12	38.71	3	9.68	6	19.35	23	74.19
TOTAL	4	12.90	17	54.84	3	9.68	7	22.58	31	100.00

Table 10. The frequency with which nests containing 0-2 nestlings of Mississippi kites occur in each nest height-tree height category.

Number of nestlings	Nest height-tree height categories									
	1-1		1-2		2-2		2-3		TOTAL	
	N	%	N	%	N	%	N	%	N	%
0	1	3.23	6	19.35	0	0	3	9.68	10	32.26
1	2	6.45	6	19.35	1	3.23	1	3.23	10	32.26
2	1	3.23	5	16.13	2	6.45	3	9.68	11	34.48
TOTAL	4	12.90	17	54.84	3	9.68	7	22.85	31	100.00

ling, to just over 34% in nests with two nestlings (Table 10). Again, category 1-2 was the most successful nest height-tree height classification for successful nestlings at a frequency of 54.84. The frequency of successful fledglings ranged from 5% for nests producing two fledglings to over 57% for unsuccessful nests (Table 11). Nest height-tree height category 1-2 had the most unsuccessful nests, but also had the highest frequency of nests producing one fledgling. The only nest height-tree height category to produce two fledglings was 2-3 (highest nest and tree classifications).

There was NSD ($P < 0.05$) after chi-square comparisons of nest tree species versus nest success. Osage orange species contained 42% of the nests containing either one or two eggs compared to a frequency of 29% for the category containing the other miscellaneous species and 26% for locust species (Table 12). Nestling success was fairly well distributed between the three categories (Table 13). Osage orange contained the only nest to produce two fledglings. Together with the locust species, these two categories contained almost 90% of nests to successfully fledge one or two young (Table 14). This undoubtedly was partly due to their high occurrence in shelterbelt plantings. However, data was not collected that would have determined the relative proportion of all shelterbelt tree species to those used by the kites for nesting.

Behavior Activities

The means of each activity category were separated into period, section, and sex, and analyzed by percentage of time spent in each activity (PCT) and percentage of the number of times performed in each activity (PCN). When all the variables were combined, kites spent almost 60% of their time in social activities, with flight and out of sight activities

Table 11. The frequency with which nests containing 0-2 fledglings of Mississippi kites occur in each nest height-tree height category.

Number of fledglings	Nest height-tree height categories									
	1-1		1-2		2-2		2-3		TOTAL	
	N	%	N	%	N	%	N	%	N	%
0	3	14.29	5	23.81	1	4.76	3	14.29	12	57.14
1	0	0	6	28.57	2	9.52	0	0	8	38.10
2	0	0	0	0	0	0	1	4.76	1	4.76
TOTAL	3	14.29	11	52.38	3	14.28	4	19.05	21	100.00

Table 12. The frequency with which nests containing 0-2 eggs of Mississippi kites occur in each nest tree species category.

Number of eggs	Nest tree species categories							
	Locust species		Osage orange		Other species		TOTAL	
	N	%	N	%	N	%	N	%
0	1	3.23	0	0	0	0	1	3.23
1	2	6.45	4	12.90	1	3.23	7	22.58
2	6	19.35	9	29.03	8	25.81	23	74.19
TOTAL	9	29.03	13	41.93	9	29.04	31	100.00

Table 13. The frequency with which nests containing 0-2 nestlings of Mississippi kites occur in each nest tree species category.

Number of nestlings	Nest tree species categories							
	Locust species		Osage orange		Other species		TOTAL	
	N	%	N	%	N	%	N	%
0	3	9.68	4	12.90	3	9.68	10	32.26
1	2	6.45	5	16.13	3	9.68	10	32.26
2	3	9.68	5	16.13	3	9.68	11	35.48
TOTAL	8	25.81	14	45.16	9	29.03	31	100.00

Table 14. The frequency with which nests containing 0-2 fledglings of Mississippi kites occur in each nest tree species category.

Number of fledglings	Nest tree species categories							
	Locust species		Osage orange		Other species		TOTAL	
	N	%	N	%	N	%	N	%
0	2	9.52	5	23.81	5	23.81	12	57.14
1	3	14.29	4	19.05	1	4.76	8	38.10
2	0	0	1	4.76	0	0	1	4.76
TOTAL	5	23.81	10	47.62	6	28.57	21	100.00

comprising 26% of their total time (Figure 2). There was a definite shift in the PCN values for each activity category during the reproductive season. Social behaviors decreased to 41%. This was in part due to the large amount of time spent perching. When maintenance activities, such as preening, scratching, etc. were interspersed with perching, the PCN for maintenance activities increased. The PCN for flight activities was 35%. The number of times a kite performed flight activities varied depending on the weather conditions and on whether the bird was involved in foraging activities or just soaring. When a kite was mainly soaring, the PCN values were lower; however, if soaring was interspersed with frequent flapping activities and/or diving behaviors in search of food, the PCN values would increase.

Although foraging behaviors were categorized and recorded, the behaviors were quick one or two second activities; thus the PCT values were always less than 0.2%. It was also very hard to observe these behaviors; therefore, PCN values were low, ranging from 0% to 0.4%. For these reasons, foraging behaviors do not appear within any of the final results or figures.

The percentage of time spent in each activity category during the pre-nesting, incubation, and nestling periods was compared to analyze the differences in activity patterns that occurred throughout the reproductive season. As to be expected, reproductive behavior increased from less than 1% in the pre-nesting period to over 20% in the incubation period, followed by a drop to approximately 10% in the nestling period (Figure 3). The low value in the pre-nesting period is due in part to inadequate sample size. Several pairs were observed copulating during this reproductive period, but not all of these observations were included

Figure 2. The percentages for each behavior category during the reproductive season for Mississippi kites (a) Percentage of time spent in each behavior category. (b) Percentage of the number of times performing each behavior category.

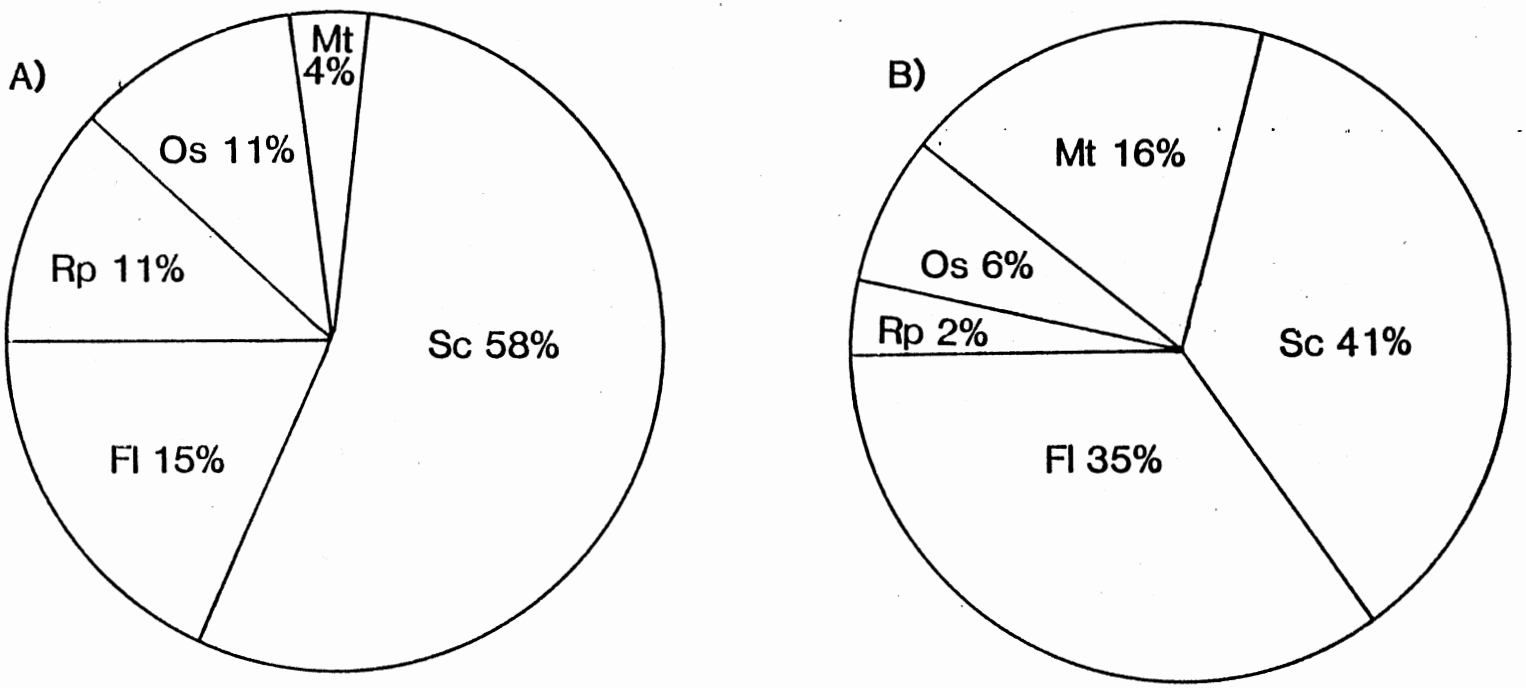
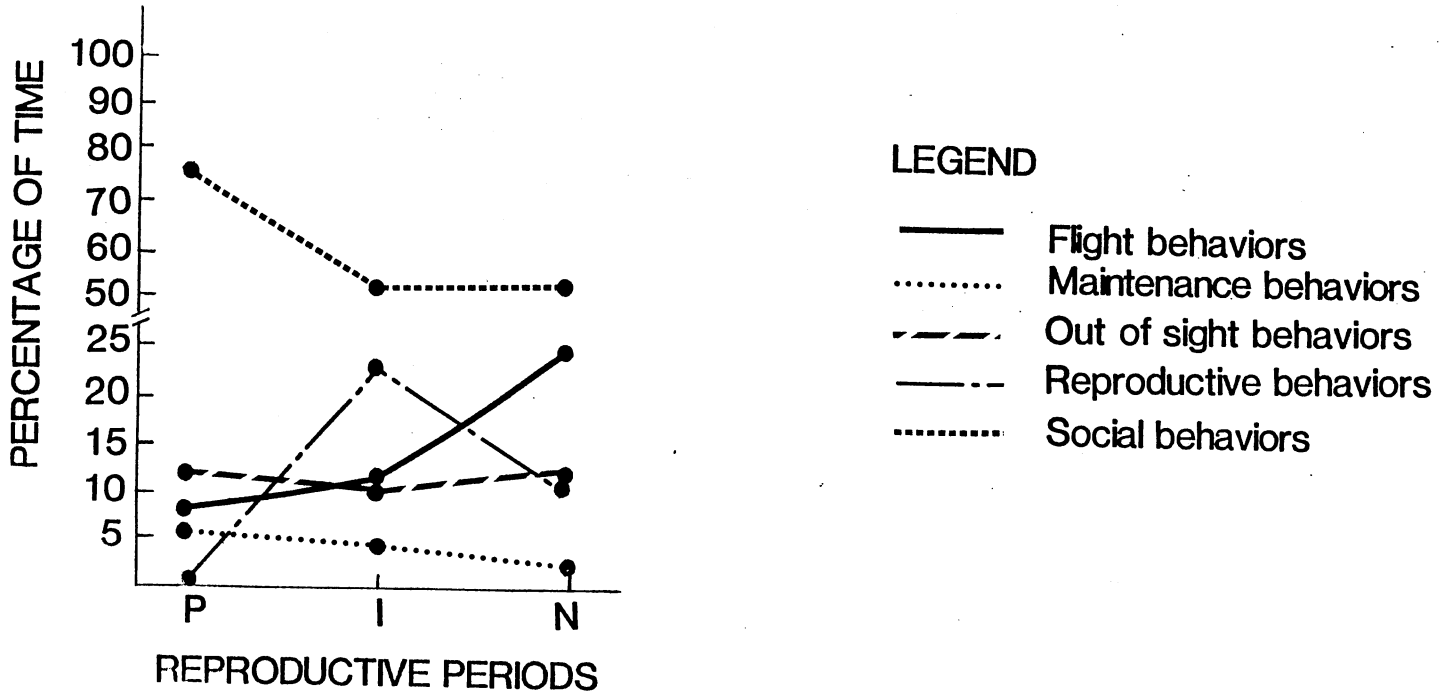


Figure 3. The percentage of time spent in each behavior category during the pre-nesting (P), incubation (I) and nestling (N) periods of the reproductive season for Mississippi kites.



in the time budget analysis. Social behavior dominated kites' activities in all three periods, ranging from 73% in the pre-nesting period to 51% in the incubation and nestling periods. As less time was spent in social behaviors in the nestling period and reproductive activities decreased, an increase occurred in flight activities because the kites spent more time away from the nest due to an increased foraging effort to feed the growing nestlings.

The PCN for reproductive activities does not increase dramatically during the incubation period because most reproductive behaviors during this period were incubation activities, which generally lasted for the entire 20 minute time budget (Figure 4).

Analysis of the differences between time spent in each activity category by sex shows that males spent more time in flight activities than females in all three periods and that males spent over twice as much time flying as females during the nestling period (Figure 5). This increase in flight activity was probably due to increased effort in foraging activity as well as less time needed in reproductive activities. Time spent out of sight was also more for males than females. This difference directly corresponds with the higher amount of time males spent in flying activities. Kites may range at least two miles from the nest site (Fitch 1963) and would often fly further than I could keep them in sight. Also, if I was not positioned properly, they could fly from one side of the shelterbelt to the other and be out of my line of view. Therefore, I used only those time budgets that contained at least ten minutes of visible activities interspersed with out of sight activities.

Times spent in maintenance behaviors were equal for both sexes during the incubation and nestling periods, but males spent 13% of their

Figure 4. The percentage of the number of times performing each behavior category during the pre-nesting (P), incubation (I) and nestling (N) periods of the reproductive season for Mississippi kites.

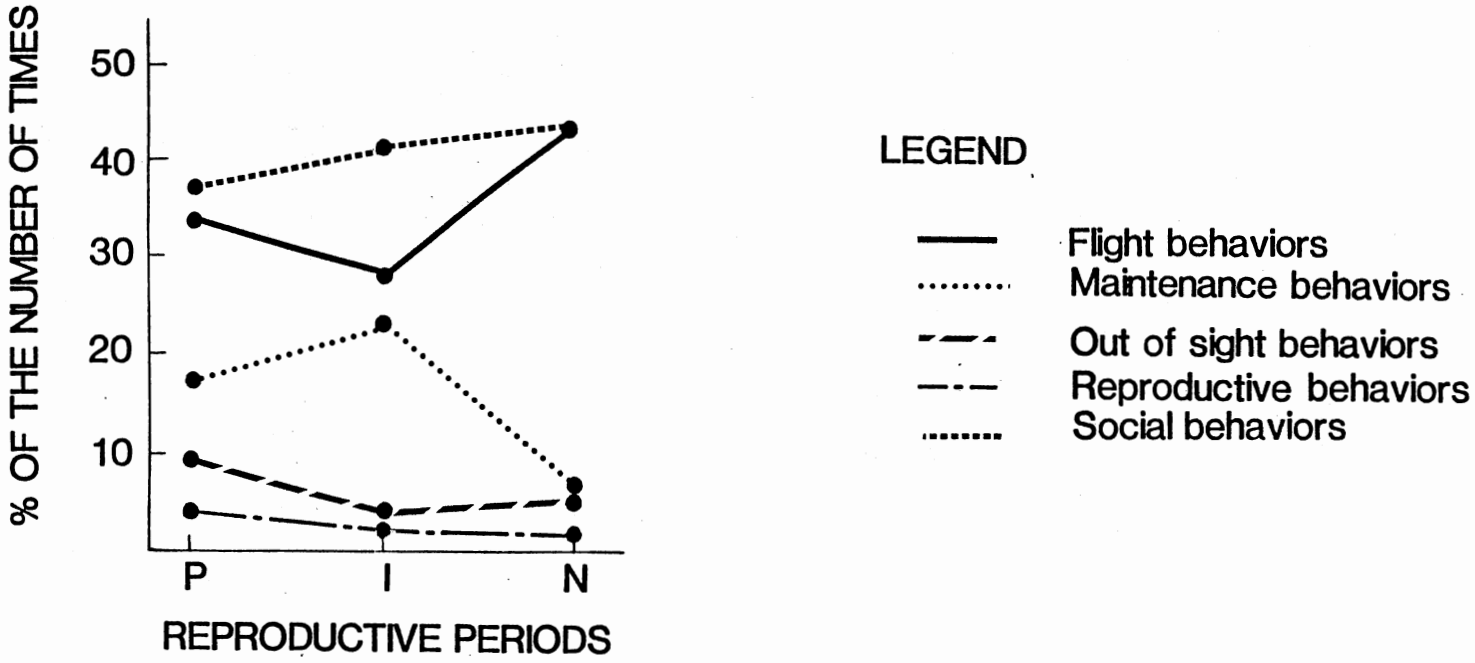
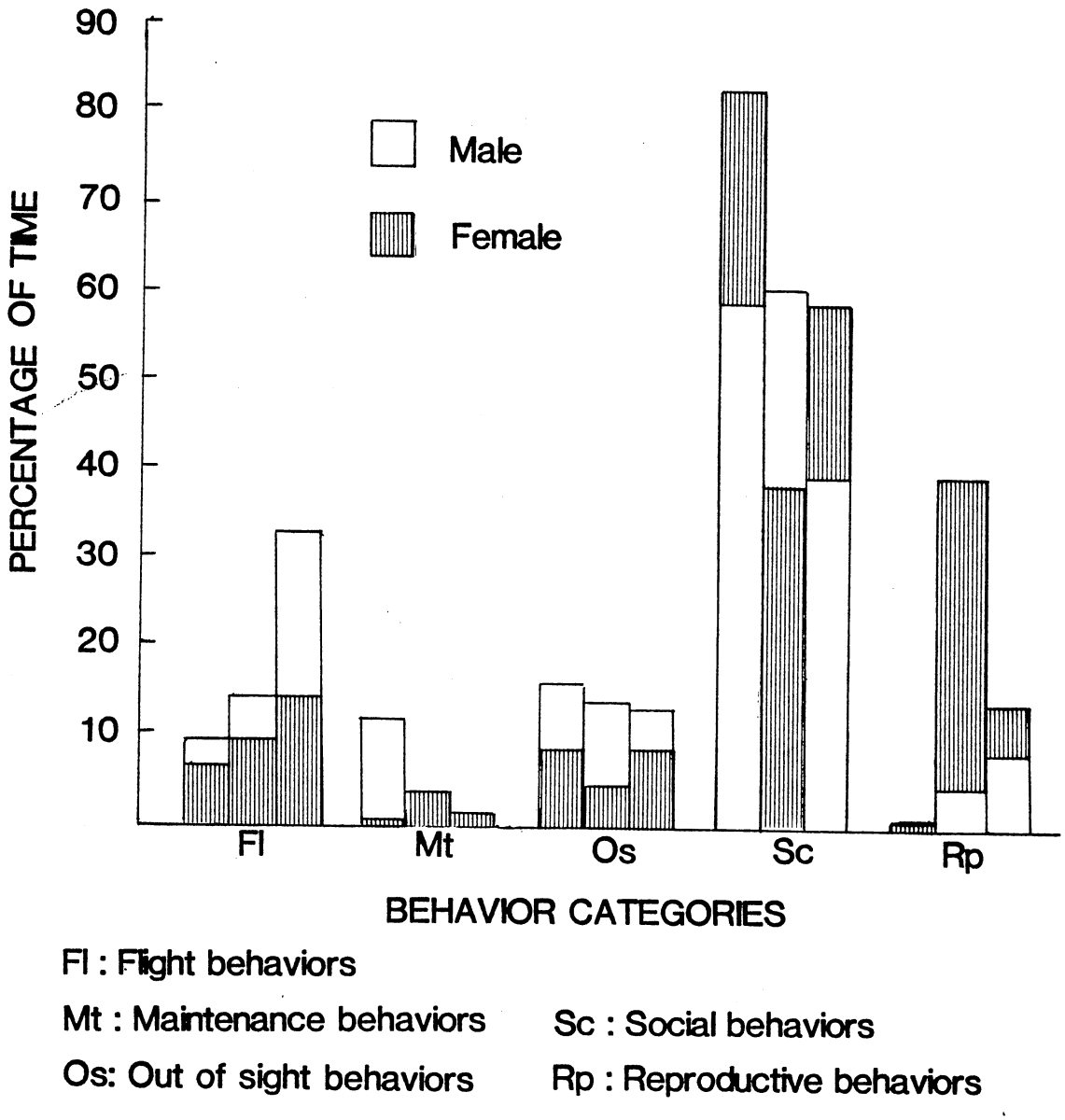


Figure 5. The percentage of times spent by Mississippi kite males and females in each behavior category during the pre-nesting (column 1), incubation (column 2), and nestling (column 3) periods of the reproductive season.



time in maintenance behaviors during the pre-nesting period compared to only 1% for females (Figure 5). This was in direct conflict with visual observations that were made. It was during this period that most copulatory behavior occurred. I noticed that immediately after copulation, the male flew off and reperched. However, the female spent more time in preening, wing stretch and feather fluff activities than did the male. The discrepancy may be in part due to sampling biases.

Females spent more of their time in social activities during the pre-nesting and nestling periods than they did in the incubation period. During the incubation period, females were generally on the nest incubating the eggs, while the male was observed perched near the nest. After the eggs hatched, the female spent less time on the nest, and as the nestling period progressed, she too perched near the nest and appeared to be more vocal than the males. Females spent more time in reproductive activities than males. It was interesting to note that in the incubation period, males did spend a small percentage of their time in reproductive activities. Although the sexes did share in the incubation duties (Bent 1938), they did not appear to share equally (Figure 5).

When the three reproductive periods were broken down into the four daily time sections, it was possible to differentiate when the most time was spent in each behavior category. In the early morning hours between 0730 and 1030 (Section 1), flight and out of sight behaviors occupied only 10% to 15% of the kites' time, while social activities ranged from 64% to 82% of their time throughout the three reproductive periods (Table 15). In general, flight activities were highest later in the day from 1330 to 1930 (Sections 3 and 4), while reproductive behavior was highest in the middle of the day between 1030 and 1630 (Sections 2 and 3).

Because of the low sample size of time budgets during the pre-nesting period, I will not go into a detailed accounting of behavior patterns during this period except to note the enormous amounts of time, ranging from 51% to 99%, that were spent in social activities.

Throughout the day during the incubation period, both males and females spent the highest percentage of their time in social activities. Only between 1330 and 1630 (Section 3) did females spend more time in reproductive activities (Figure 6). The females' social and reproductive behaviors collectively accounted for 73% to 86% of their total behaviors throughout the day. Flight behavior was lowest during the first section of the day at only 5%, but rose throughout the day to 20%. The dominant activity pattern for males throughout the day was definitely social behaviors. Flight activity was similar to the trend for females with a continual rise, except that during the fourth section, flight activity dropped from a high of 30% to 20% (Figure 6). It was also noted that male reproductive behavior rose to 20% during the 1330 to 1630 time section. This increase was probably due to sampling bias as a result of observing a particular male incubating the eggs at that time. However, since so few males were observed incubating, males might not typically perform more reproductive activities during that section of the day.

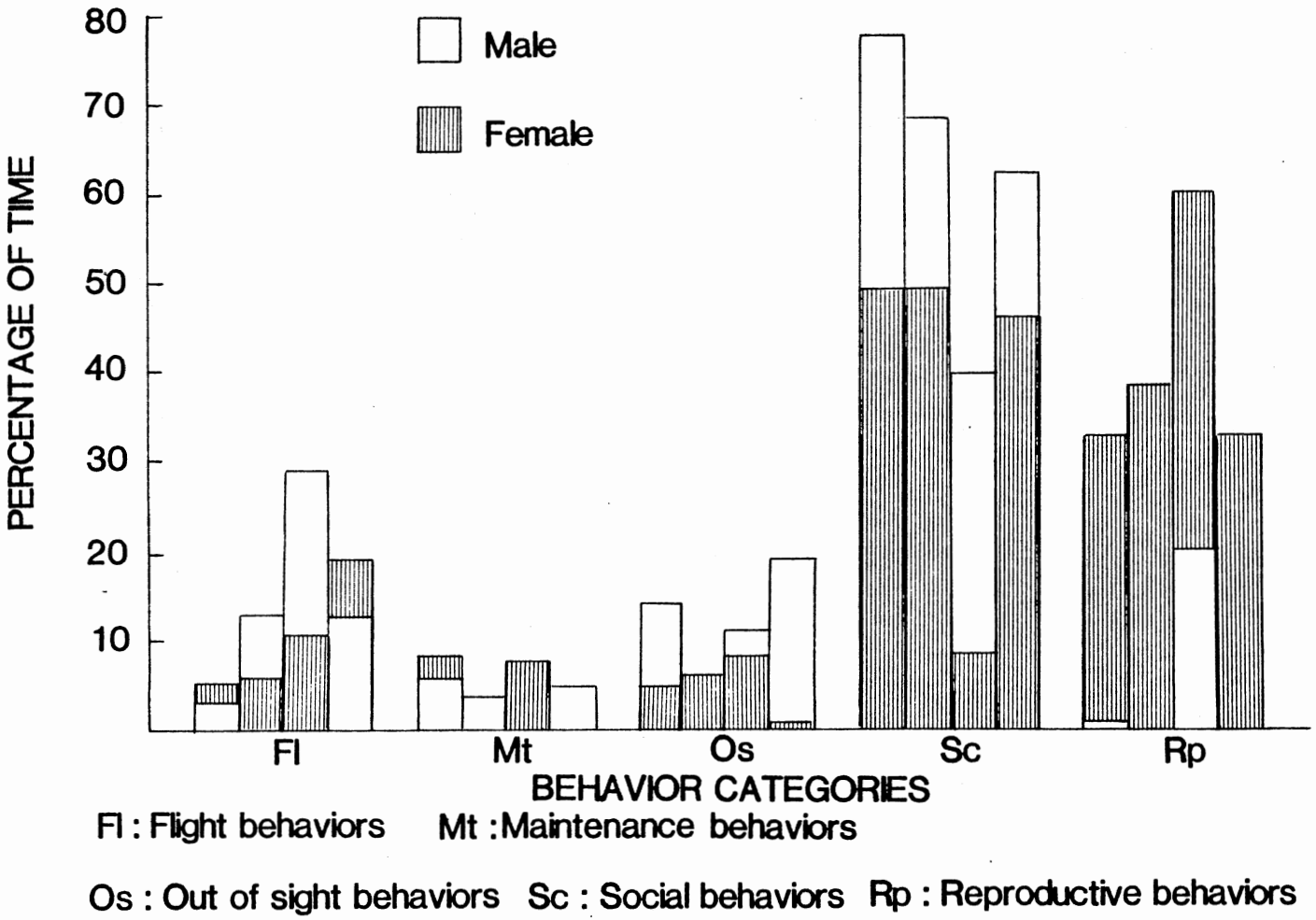
The nestling period was characterized by some of the same general trends as the incubation period. Social behavior was again the dominant behavior pattern, more so in the early part of the day rather than in the late afternoon and evening (Figure 7). Flight activity rose throughout the day for both sexes. Flight behavior in males seemed to show an inverse relationship with social behaviors. As flight activity increased, social behavior decreased. When one sex was involved in reproduction

Table 15. The percentage of time spent in each behavior category during the four sections of the day in the pre-nesting, incubation and nestling periods of the reproductive season by Mississippi kites.

	PRE-NESTING				INCUBATION				NESTLING			
	1*	2	3	4	1	2	3	4	1	2	3	4
Flight behavior	3	18	11	5	4	10	20	16	6	14	29	46
Maintenance behavior	14	2	6	0	7	2	4	3	2	0	6	1
Out of sight behavior	5	7	6	28	10	11	10	10	4	10	16	17
Social behavior	79	73	75	66	64	59	27	55	82	59	38	25
Reproductive behavior	0	0	1	1	17	19	40	17	7	17	11	10

* 1 = 0730-1030: 2 = 1031-1330: 3 = 1331-1630: 4 = 1631-1930.

Figure 6. The percentage of time spent by Mississippi kite males and females in each behavior category during the incubation period throughout each of the four sections of the day.



behaviors, the opposite sex was not involved at all in reproductive behaviors (Figure 8). This may indicate that the sexes alternate their time between feeding and protecting the young, and performing other activities.

CONCLUSION

Nest success is dependent on many variables including mortality factors, nest tree characteristics, and breeding behavior. But these variables are only a limited number of possible variables that may influence the reproductive success of Mississippi kites.

A comparison of nest survival of colonial and single nesting kites revealed that there was no significant difference between the two breeding strategies. This contrasts with Parker's (1974) findings. He found that single nesting pairs were more successful. However, in his study the shelterbelts that contained more than one nesting pair of kites may have contained up to 15 different pairs; thus, the differential success due to increased predation in colonial shelterbelts was not as important a factor for colonial nesters in the current study, because nest density ranged from only 2-4 nesting pairs within one shelterbelt.

Mississippi kites are generally believed to normally produce a two egg clutch. Parker (1974) and I both found that nests that began with two eggs were more than twice as likely to be successful through the nestling period than nests with only one egg. However, Parker (1974) found that nest loss was greater in the incubation or egg period, whereas in this study, nest loss was higher in the nestling period. Therefore, although both eggs of a two egg clutch generally survive the incubation period, only rarely do both eggs successfully survive to fledge. However, two egg clutches are still more successful than one egg clutches at

producing at least one fledgling. Although Parker (1974) speculated that nutrition is not an important limiting factor due to the diversity in the Mississippi kites' diet, in the current study the heavy spring rainfall, combined with mild temperatures, may have been disadvantageous to insect populations, thus decreasing their availability during the nestling period. And, although kites may consume several species of vertebrates in their diet, the energy expended to catch these food items may be greater than the energy received from eating them; therefore, insects are still the preferred item, based on visual observation of feeding activities. Since insect populations may have been decreased, the starvation of the younger of the two nestlings may have been a reproductive strategy to adjust to a decreased foraging capacity in order to insure the success of one young, thus the increased nestling losses.

Despite a small sample size, it appeared that differences in fledgling success at varying nest height-tree height classifications were significant at the $P < 0.10$ level. The second lowest nest height-tree height classification had the most unsuccessful nests, but also the highest frequency of nests producing one fledgling. This lower nest tree and nest position may have been an advantage in terms of nest success against some mortality factors such as weather. The shorter nest tree may have been protected by taller trees from some of the heavy rains that occurred early in the reproductive season, thus increasing chances for nest success.

Social behaviors such as perching, vocalizing, and sunning appear to be the dominant activities for both males and females during all three phases of the reproductive season. Social activities may be an important variable in reproductive success in the sense that they maintain some

sort of sexual and/or group cohesiveness that stabilizes the nesting activities.

Flight behaviors also account for a high percentage of the kites' activities. This behavior may be important in its relationship with foraging activities. Because foraging activities, such as catching the prey and feeding on the wing, were so hard to observe, it was not possible to determine any relationship between this behavior category and the other categories under observation. However, it may be an important variable that needs closer study, as it may be an important factor in enhancing reproductive success of colonial nesters as suggested by Lack (1968).

Further behavioral studies should be supplemented by the collection of complete weather data to determine if the passage of fronts, amount of precipitation, etc. have an effect on behavioral patterns and to determine the relationship of weather to reproductive success. Also, the technique of marking individual adult kites may help to determine if the behavior of colonial nesters is beneficial to all pairs, such as in foraging activity and defense of nests from intruders.

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APPENDIX

GENERAL DESCRIPTION OF BEHAVIORS

SOCIAL BEHAVIORS

Perching: Perching behavior is one of the most common behaviors performed by kites. It occurs during all parts of the day and may occur on a variety of structures including telephone poles, telephone lines, snags, or leafing trees. Kites may perch for short periods in between other activities, or more commonly, they remain perched for long periods of time. The kite will remain in a stationary position often without even turning its head. Occasionally the kite will perform maintenance activities such as preening, feather fluffing, wing stretching, scratching, defecating, yawning, or regurgitating. These maintenance activities last only a few seconds and then the bird will resume its perching posture.

Defense: Craighead and Craighead (1956) define raptor defense behaviors as ranging from vocal protests to blows delivered to the intruder. Kites are a gregarious species and have little or no intraspecific difficulties. However, kites will defend their nesting territories against other birds and mammals. The most notable example is defense against great horned owl (Bubo virginianus) intrusion. The kites will fly at an owl in groups and harass the owl until it flys out of their territory. This harassment involves swooping at the owl and ferocious vocal attacks. An individual kite was also seen defending his territory against an owl as it remained perched in a tree. This behavior was maintained for approximately five minutes.

Vocalization: The Mississippi kite emits a "phee-phew" call. The first syllable is short with a rising inflection, clipped off short, and

the second syllable has a downward inflection, and is drawn out to two or three times the length of the first syllable (Sutton 1939). Kites become vocal when an intruder enters their nesting territory. If a human intruder is observed, the kite remains perched so as to keep both the person and the nest in sight and will usually maintain vocalizations until the intruder leaves the area.

Kites would also emit a "phee-phee-phee-phew" call when they were particularly upset. The first syllables were very short stuttering calls and the last syllable was also cut off short. This call was emitted as a type of warning believed to be directed toward the mate rather than to other kites residing in the same shelterbelt.

MAINTENANCE BEHAVIORS

Preening: Preening involves smearing the substance secreted from the oil gland onto the kites' bill, and then rubbing it off on the various feathers over the body and on the wings (Pettingill 1970). Kites spend much of their time preening while perched. They work to clean the feathers on and under the wing, as well as the back and breast.

Wing stretch: The kite will often extend a wing partially or completely and then retract the appendage (Sutton 1939). This activity is often in association with preening. The wing is usually only extended for one to five seconds, but may remain outstretched for as long as one minute. Only one wing is stretched at a time and it may be extended several times during one maintenance period.

Feather fluff: The activity often occurs as the kite is preening its feathers. The kite will vigorously shake its body and wings to reposition the feathers and then it will resume preening. The activity lasts for only one or two seconds.

Scratch: The bird will pick up one foot and with rapid movements, brush the foot against the breast, neck, or under the wings. This activity lasts only one to three seconds and is probably used to reduce irritation caused by external parasites.

Sunning: This behavior was observed on a clear, hot day with only a slight wind. Five kites were observed perching together on the edge of a shelterbelt. One kite flew down to the dirt road adjacent to the shelterbelt and laid down on its underside with both wings extended. Two other kites joined the first kite and they lay within a few feet of each other. They remained this way for approximately five minutes. They did not move their bodies or wings as in a dusting or panting behavior. It is possible that they were trying to dissipate heat.

Defecate: The kite will lean forward slightly, thus raising the tail. The fecal material is released and the bird resumes its normal perching position.

Yawn: Sutton (1939) describes the yawning behavior as a raising of the head with the mouth opening widely.

Regurgitate: This behavior begins as the kite thrusts its head forward and then opens its mouth wide. The kite shakes its head vigorously from side to side as small pellet fragments are ejected from the mouth.

REPRODUCTIVE BEHAVIORS

Aerial displays: Many species of hawks, including the Swainson's hawk (Buteo swainsoni) and the red-tailed hawk (Buteo jamaicensis) perform aerial courtship displays (Olendorff 1974, Fitch 1963). However, Mississippi kites are believed to be mated when they arrive on the nesting grounds, and therefore, are not known to perform courtship displays.

The male does, however, perform aerial displays in which he cuts through the air with his squeals and chipperings, or plunges from a height to swoop upward effortlessly (Sutton 1939).

Nest building: Both sexes are involved in the nest building process; however, it is usually the male that brings the material to the nest site and the female who models the nest. Nest building occurs at a leisurely pace. The kites dart in among trees breaking off twigs and boughs with their feet and beak. This building process continues for several days. Green leaves are continually added to line the nest until the young are ready to fledge. This nest lining is maintained to reduce parasites caused by excess of decaying food material (Sutton 1939, Wolfe 1967).

Copulating: Copulating behavior by raptors seems often to be initiated by the female soliciting without prior display by the male. However, Fitch (1963) recorded a pair of Mississippi kites copulating in which the birds were perched quietly when the male flew to the female and lit on her back to copulate with no preliminary or observable display by either bird. The bird was receptive but did not crouch in a horizontal position. The mounting lasted for approximately one minute. During the first 30 seconds the male was fully occupied with balancing and positioning himself, and copulation occurred only during the latter half of the mounting. During this interval cloacal contact was affected three times, but was only momentary each time.

Copulation takes place several times each day throughout the pre-laying and laying period (Newton 1979). Copulating behavior was observed both with and without solicitation by the pair of kites. More often than not, the male would approach and mount the female without any observable pre-copulatory behavior. The female would assume a horizontal position

and the male would balance himself and copulate one to several times with the female within a one to two minute interval. At other times it appeared the male was soliciting the female with intermittent vocalizations before copulating. These vocalizations were sometimes responded to by the female and at other times, ignored. After the copulation was completed, both sexes would perch a short distance apart and the female would then spend several minutes preening herself. This maintenance behavior was not as prevalent in the males. Copulatory behavior was most often observed on telephone wires.

Incubation: Newton (1979) characterizes raptor incubation behavior as periods of intermittent dozing and frequent turning of the eggs. However, broad-winged hawks remain continuously alert while incubating and may occasionally stand on the rim of the nest to preen or stretch. Before resettling on the eggs, they may turn the eggs by sweeping the bill gently between them towards the belly (Matry 1974). Both sexes of kites were observed incubating the eggs and, unless disturbed, they usually remained on the eggs through the 20 minute time budget. While the adult was incubating, it would not flush from the nest as easily as during other periods of the breeding season.

Sitting on the nest: The females would often sit on the edge of the nest in an effort to protect the young nestlings and fledglings from the heat of the sun.

Feeding the young: The parents continue to feed the young until they are 29-30 days of age. Feeding periods average once every 8.5 to 10.8 minutes with the parent spending between 30 seconds and one minute at the nest each time. When the nestlings are one to two weeks old, the adult disgorges masticated insects directly into the nest and then places pieces into the beaks of the young. As the nestlings get older, the

adult simply leaves the food in the nest. When the fledglings are able to fly and have left the nest, the adults generally pass food to them directly (Fitch 1963, Brown and Amadon 1968). The adult kites would often come to the nest if they were not aware of my presence and leave the food for the young and fly away. However, if they were aware of me, they would often perch a short distance away from the nest with an insect held either in their beak or claws. They would occasionally make short flights around the nest tree, not alighting on the nest, but rather returning to the original perch site.

FLYING BEHAVIORS

Soaring: The wings are held horizontally, the short outermost primary breaking the line of the front of the wing, the tips of the primaries curving slightly upward. The graceful, deliberate flight is easily maintained by a slight retraction of the wings or turning of the rudder-like tail feathers. The kites can soar continuously for an extended period by circling within the air currents or apparently remaining stationary in space. Only occasional flapping movements to maintain altitude or search for prey interrupt their lazy drifting (Bent 1938, Fitch 1963, Brown and Amadon 1968).

Flapping: Kites will interrupt their graceful flight with deliberate flapping movements to regain lost altitude, to move against a strong wind, or to maintain a particular position while searching for prey. The flapping movements generally are short, 5-20 beats of the wings, unless the kite is purposely moving to another feeding or nesting site, in which case the flapping movements may last for approximately 100 beats.

Diving: In the act of catching insects on the wing, the kite will suddenly spread his tail wide, change his course, hang in midair an instant, half fold in his wings, drop his head downward, and dive downward (Sutton 1939). After a successful or unsuccessful feeding attempt, the kite will resume its leisurely maneuvering, again repeating the diving behavior until it is successful at catching an insect.

FORAGING BEHAVIOR

Catching and feeding: Mississippi kites catch insects on the wing. During the dive, a kite catches the insect in its feet and with its head bent downward toward its feet, picks the insect to pieces with its beak. At times this foraging behavior occurs so rapidly during the dive that it is not possible to tell if the kite was successful until it resumes a level flight pattern and you notice its head tilting down to consume its prey.

OUT OF SIGHT

Out of sight: Because of the kite's wide ranging feeding and soaring range, it would often fly out of sight. Kites also would periodically be out of sight as they flew in and out of the shelterbelt, and to and from the nest or perching site. This was included as a valid behavioral observation unless the length of time out of sight lasted for more than half of the 20 minute time budget.

Table 16. Categories used to analyze time budget behaviors of Mississippi kites.

Major Categories	Individual Behaviors
Social	
	Defense
	Perch
	Vocalize
	Sun
Forage	
	Catch
	Feed
Maintenance	
	Defecate
	Feather fluff
	Preen
	Regurgitate
	Scratch
	Wing stretch
	Yawn
Reproductive	
	Copulate
	Feed the young
	Incubate
	Nest building
	Sitting on nest
Flight	
	Dive
	Flap
	Soar

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