

BREEDING ECOLOGY OF THE MISSISSIPPI KITE IN ARIZONA

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ABSTRACT.—The Mississippi Kite (*Ictinia mississippiensis*) recently has extended its breeding range into the southwestern United States and was first recorded nesting in Arizona in 1970. Approximately 25 regularly active nesting sites occur in Arizona in riparian forest-scrubland habitat along the tributaries of the Gila River. Nesting habitat consisted of a structurally diverse (patchy) arrangement of cottonwood (*Populus fremontii*) trees and salt cedar (*Tamarix chinensis*) understory. Cicadas, the principal prey of the kites studied, were captured frequently (41% of all prey captures) by hawking from cottonwood perches within 150 m of nests. Vegetation patchiness facilitated foraging and accounted for 71% of the variation in reproduction. Increased vegetation diversity in the more traditional breeding areas of the Great Plains and in migration and wintering habitats may have enhanced foraging, reproduction, and survival of kites, and may help to explain the recent population increase.

Most nest sites were distributed among four groups. No movement between groups was noted during any one nesting season. Most adult kites attempted to nest, but up to 52% of all nesting attempts failed during courtship and nest-building (44% of all failures), incubation (40%), and nestling (16%) stages. Reproductive success was 0.60 fledglings per nesting attempt, similar to that estimated for kites in the Great Plains. Apparently, reproduction at a nest was not enhanced by close proximity to another active kite nest.

The Mississippi Kite (*Ictinia mississippiensis*) nests in North America from Florida and South Carolina westward through the Great Plains south of Nebraska and, recently, into Arizona, New Mexico and Colorado. It has been reported during spring and summer irregularly from California to Massachusetts (Parker and Ogden 1979). Migration and wintering records for the neotropical region are scarce but show that most individuals may winter in tropical regions (Eisenmann 1963, Parker 1977).

Levy (1971) first recorded the Mississippi Kite in southeastern Arizona in 1970 and estimated that as many as 10 pairs nested along the lower San Pedro River. Observations of Mississippi Kites and possible breeding activity along the Verde River in central Arizona during 1970 and 1973 were reported by Johnson and Carothers (1976). In this paper we examine the breeding ecology of the Mississippi Kite in Arizona and discuss the ecological relationships that influence the presence of this species in the southwestern United States.

METHODS

In 1976 we assessed Mississippi Kite nesting distribution in Interior Southwestern Riparian (riverine) Deciduous Forest and Woodland

(vegetation classification after Brown et al. 1979) along the Gila River and its tributaries. Surveys of kites were begun in 1977 and were intensified in 1978, when we attempted to find every nesting effort in known and potential breeding areas. We visited known nesting areas beginning in early May when kites first arrived, and watched for aerial courtship displays from hillsides that bordered riparian nesting habitats. We then searched riparian forests for nests. Individual kites were counted during initial courtship display flights and throughout the summer during communal foraging and predator-mobbing flights. On several occasions we were able to count what we believed were all of the individual kites occurring in a nesting group. These instances were often prompted by the presence of other raptors, which caused the kites to congregate and emit alarm calls, as well as to soar and stoop at predators. Also, communal hunting over the forest canopy during midmorning and communal soaring during windy periods preceding afternoon summer showers made kites quite conspicuous.

Individual kites were distinguished by molt pattern, sex, and age (adult or yearling). We used hair dye on seven birds to mark rectrices or remiges (after Ellis and Ellis 1975). Kites

were in heavy molt of flight feathers during the nesting season, and distinctive molt patterns were the best aid to individual recognition.

Diet was documented mainly from observations at nests. A total of 2,200 h was spent watching kites from blinds set up near nests (1,708 h) and overlooking nesting and foraging habitat (492 h). Most observations from blinds were made during whole-day periods from 0.5 h before sunrise through 0.5 h after sunset. Blinds were usually in trees 30 to 40 m from the nest. In one instance a 16-m scaffolding tower was erected 10 m from a nest. In all cases the kites accepted the structures after a brief period of defensive calling and stooping, and we believe our presence did not significantly alter normal behavior. We used binoculars, spotting scopes, and tape recorders to observe and record nesting behavior.

Analysis of Mississippi Kite productivity follows the methods and terminology outlined by Postupalsky (1974). We visited most of the active nests weekly. As a measure of nest site quality for use in regression analyses, we noted the number of weeks that a nest remained occupied or active by attending kites. Thirteen weeks were required for successful reproduction from initiation of courtship and nest building through fledging.

Kite nests are relatively small structures, are frequently lost to strong winds and predators, and are easily overlooked by an observer. Nesting areas were intensively surveyed only in 1978, and we suspect that we missed several early nest failures in other years. No attempt was made to correct calculations of reproductive success by estimating the number of undiscovered early nesting failures. Since kite nests that successfully fledged young were conspicuously attended throughout the summer by adults, we probably found all successful nests and thus can compare reproductive success based on fledglings per successful nest in 1976, 1977, and 1978. Nesting success, as shown by the number of fledglings per total nesting attempt, was based only on 1978 data.

Distances between grouped nests and foraging distances from nests were calculated either by direct measurement or from scaled aerial photographs. The species-specific foliage volume and structural horizontal patchiness (I_p , after Anderson et al. 1978) of nesting site vegetation were measured. At a total of 13 sampling sites within 150 m of the nest tree, the distance and species of the nearest vegetation were recorded at height layers of 0.2, 0.6, 1.5, 3.0, 5.0, 6.0, 8.0, 9.0, 12.0, 15.0, 18.0, and 21.0 m. Calculation of I_p was from the volume of the layers sampled rather than from point estimates of the total volume and is pre-

sented as the percent of maximum theoretical patchiness.

RESULTS AND DISCUSSION

DISTRIBUTION AND POPULATION SIZE

From 1976 through 1979 we located 25 kite nest sites in Arizona and believe this number represents the present total nesting population in the state. A nest site, or territory, consisted of the space within at least 50 to 100 m from an active nest and often contained several old nests used in previous years. Nest sites were usually grouped, with nests spaced from 125 to 1,700 m ($\bar{x} = 550$ m, $SE = 81$ m). Six sites were solitary during at least one year and were more than 4 km from other sites. These remote sites were probably frequented by adjacent nesting birds during extensive midday soaring flights. Therefore, we considered the isolated sites to be loosely associated with a group.

Generally, four groups of nest sites existed. (We employ the word "group" rather than "colony" to describe aggregations of kite nests after the strict interpretation of the two words as presented by Wilson [1975].) Two groups (SP1 and SP2) on the San Pedro River occurred along 14 km and 10 km, respectively, of narrow (< 1 km wide) mixed riparian forest-scrubland, 594 to 792 m in elevation. They were separated by 27 km of riparian forest-scrubland and had 10 nest sites each. The third group (G) was along 3 km of the Gila River in a narrow mixed riparian forest-scrubland, 549 m in elevation. It was approximately 21 km from SP2 and had four nest sites. The fourth group (V) occurred along a 2-km reach of the Verde River in mixed riparian forest-scrubland, 457 m in elevation. It was 102 km from Group G (its nearest neighbor) and had one, or possibly two, nest sites.

The nesting activity at each site varied yearly and many sites were neither active nor occupied every year. Of five sites monitored for four consecutive years, two were occupied all four years; two and one were occupied only three and one years, respectively. Of an additional six sites studied for three years, four were occupied all three years, and two were occupied for only two years. Probably 15 to 17 of the 25 known nest sites were consistently occupied during the four years of this study: five to seven in Group SP1, nine in Group SP2, and one in Group G. Group V was occupied only in 1976 and 1977 and was the most inconsistently occupied nest site.

In 1978, because of our familiarity with Mississippi Kite nesting habits, we were able to discover all individuals and nesting attempts and thus to associate the total group popula-

tion with the total number of nesting attempts. We found 25 pairs of adults at nest sites, 7 unpaired adults, and 13 yearlings. These censuses suggested that the number of adult kites in each group closely reflected the number of nest sites in the group. This observation corroborates Parker's (1974) conclusion that adult Mississippi Kites seldom fail to pair and attempt nesting.

Analysis of yearly fluctuations in the number of nest sites was not attempted, since before the intensive effort in 1978, we may have overlooked some nests. However, in Group SP1 the vegetation composing the nesting habitat was relatively open and had been frequented by Glinski since 1974. Here, in 1978, two nest sites were found that probably had not been occupied earlier. It is likely that 7 of the 10 nest sites in this group had been occupied consistently and that the nesting population had increased slightly. Group G had four active nest sites in 1978 and only one in 1979. Group V had one or possibly two successful nesting attempts in 1976, but only one adult bird was present in 1977.

As the nesting season progressed and nest failures occurred, birds that were no longer attending nests remained in the area. They congregated with other nonbreeding individuals near favorite communal foraging areas. Communal perches and foraging areas were frequented by adults still actively breeding. Birds on communal snags were not aggressive toward each other, but they often emitted an alarm call when approached by humans.

We did not observe movements between groups during nesting. Near the end of the breeding season in early August, individuals of a group associated more often, and the number of individuals seen communally soaring or perching increased dramatically. This was not due to the arrival of individuals from other colonies but reflected the appearance of fledglings and successful breeding adults. Our technique of recognizing birds did not enable us to determine the yearly dispersal of individuals, and it is possible that some intergroup movement occurred between years. However, three kites banded at nests in previous years were seen the following year within 2 km of where they were banded.

DIET AND FORAGING BEHAVIOR

During intensive nest observations in 1977 and 1978, we witnessed 2,636 prey deliveries to three nests (Table 1). We were unable to identify 11% of the prey; 7% of the prey were "insects" but for these items no more detailed identification was possible. Prey identification was most difficult during the early and late

days of the nestling period, because the posture of adults while feeding hatchlings and the quickness of ingestion by the older nestlings prevented a view of the prey.

Insects composed 95% of all identified prey and 85% of all prey deliveries. Probably most of the unidentified prey species were insects. Apache cicadas (*Diceroprocta apache*) were the most common prey species, occurring in 71% of the identified prey deliveries, and scarab beetles (*Cotinus texana*) were the second most numerous prey item (Table 1). These two prey items did not always occur simultaneously in the diet of nestlings. Apache cicadas emerged earlier in the nesting season, in late June, and adult male kites occasionally delivered them to incubating females. Scarab beetles, however, were numerous beginning in late July, as cicada numbers decreased, and amounted to a significant percentage of prey delivered to developing nestlings (Fig. 1).

One-half of 112 deliveries of non-insect prey involved the western pipistrelle bat (*Pipistrellus hesperus*), which was fed at all three nests observed. Fifty-four of these deliveries occurred at the 1978 Salt Cedar nest, demonstrating some variability in prey utilization between individual nesting pairs. The Muddy River nests (Table 2) of 1977 and 1978 were only approximately 200 m apart, and the adults were unmarked. We were uncertain if the same kites tended these nests during both years.

Besides the differences in diet associated with a particular nest, the parents delivered different amounts of prey (Table 2). Males delivered nearly twice as many prey items as females ($P = .1$), making 64% of all prey deliveries. Proportions of prey types delivered by either sex were similar except for non-insects, which were delivered mainly by males. The male at the 1978 Salt Cedar nest specialized in capturing western pipistrelle bats, a predilection that accounted for 50% of all non-insect deliveries. Apache cicadas composed the majority of prey deliveries by both sexes at all nests except Muddy River in 1978 (Table 2). However, nearly 70% of the prey at Muddy River in 1978 was recorded from observations of deliveries to older nestlings, a period when numbers of cicadas had generally diminished.

Data on adult food habits during periods other than the nestling stage were difficult to obtain because fewer prey were captured and prey items were not consumed at any one locality. Observations of adults with prey during courtship, nest building, and early incubation suggested that at this time many species of insects, especially orthopterans and odonates, were most frequently consumed.

Kites generally captured prey either by soar-

TABLE 1. Prey delivered to three Mississippi Kite nests in Arizona. Deliveries at each nest are indicated as number of individuals/relative proportion of prey species, with relative proportions of total identified prey given in parentheses.

Prey type	Prey deliveries			Total
	Muddy River 1977	Muddy River 1978	Salt Cedar 1978	
<i>Diceroprocta</i> cicadas	990/0.57 (0.72)	89/0.32 (0.40)	478/0.75 (0.83)	1,557/0.59 (0.71)
Non- <i>Cotinus</i> beetles	157/0.09 (0.11)	33/0.12 (0.15)	0/0.00	190/0.07 (0.09)
<i>Cotinus</i> beetles	98/0.06 (0.07)	23/0.08 (0.10)	0/0.00	121/0.05 (0.06)
Orthoptera	15/<0.01 (0.01)	44/0.16 (0.20)	21/0.03 (0.04)	80/0.03 (0.04)
<i>Specius</i> wasps	49/0.03 (0.04)	0/0.00	0/0.00	49/0.02 (0.02)
Lepidoptera	1/<0.01 (<0.01)	14/0.05 (0.06)	0/0.00	15/<0.01 (<0.01)
Odonata	11/<0.01 (<0.01)	11/0.04 (0.05)	0/0.00	22/<0.01 (0.01)
Miscellaneous insects	14/<0.01 (0.01)	0/0.00	20/0.03 (0.03)	34/0.01 (0.02)
Unidentified insects	173/0.10	0/0.00	0/0.00	173/0.07
<i>Pipistrellus</i> bats	1/<0.01 (<0.01)	1/<0.01 (<0.01)	54/0.08 (0.09)	56/0.02 (0.03)
<i>Bufo</i> toads	11/<0.01 (<0.01)	5/0.02 (0.02)	6/0.01 (0.01)	22/<0.01 (0.01)
Lizards	15/<0.01 (<0.01)	0/0.00	0/0.00	15/<0.01 (<0.01)
<i>Rana</i> frogs	14/<0.01 (<0.01)	0/0.00	0/0.00	14/<0.01 (<0.01)
Miscellaneous non-insects	4/<0.01 (<0.01)	0/0.00	0/0.00	4/<0.01
Unidentified non-insects	171/0.10	55/0.20	58/0.09	284/0.11
TOTAL	1,724/1.00	275/1.00	637/1.00	2,636/1.00

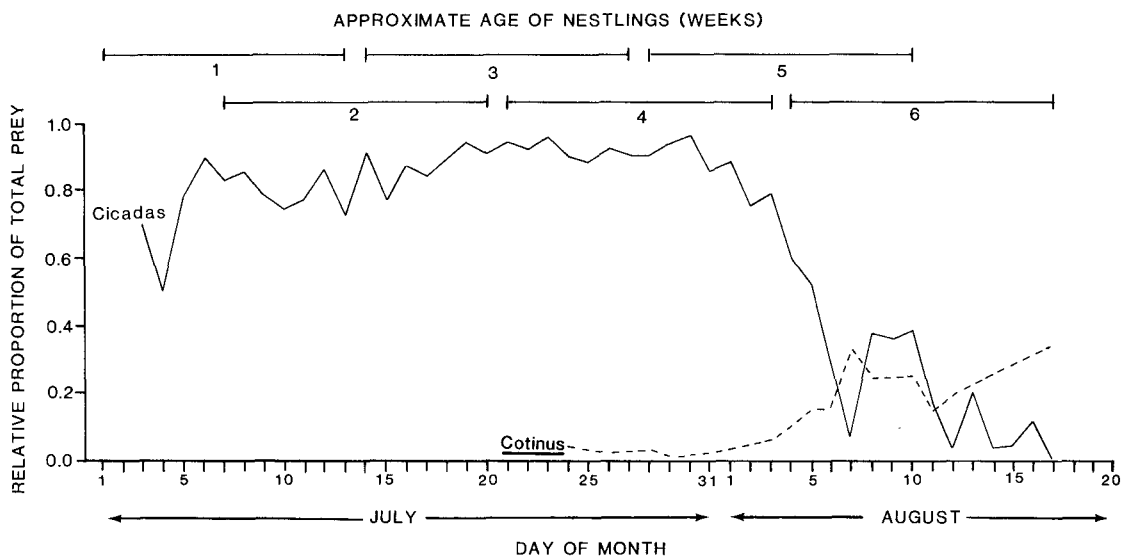


FIGURE 1. Relative proportion of cicadas and *Cotinus* beetles in the diet of Mississippi Kite nestlings in Arizona. Unidentified prey are not included.

TABLE 2. Sex of adult Mississippi Kites delivering prey to three nests (MR, Muddy River; SC, Salt Cedar) in Arizona. Prey types are indicated as number of individuals/relative proportion of prey type for each kite.

Feeding parent	Nest	Total prey	Prey type			
			Insect	Non-insect	Unidentified	Cicada
Female	MR 1977	633/0.37	577/0.91	2/<0.01	54/0.09	324/0.51
	MR 1978	127/0.46	101/0.80	1/<0.01	25/0.20	52/0.41
	SC 1978	202/0.32	178/0.88	6/0.03	18/0.09	162/0.80
	Total	962/0.36	856/0.89	9/0.01	97/0.10	538/0.56
Male	MR 1977	1,091/0.63	931/0.85	43/0.04	117/0.11	666/0.61
	MR 1978	148/0.54	113/0.76	5/0.04	30/0.20	37/0.25
	SC 1978	435/0.68	341/0.78	54/0.13	40/0.09	316/0.73
	Total	1,674/0.64	1,385/0.83	102/0.06	187/0.11	1,019/0.61

ing or by hawking from perches. Soaring occurred from treetop level to altitudes greater than 500 m and was usually performed communally by several birds over a broad area and at various altitudes. Henty (1977) concluded that atmospheric conditions probably were responsible for soaring activity of various raptors in Spain. Soaring usually occurred from 2 to 3 h after sunrise until 2 h before sunset, but this varied largely in response to daily weather conditions. Thermal updrafts and pressure-gradient winds seemed to be important stimuli for soaring. On cloudy, calm mornings soaring commenced later than on sunny, breezy mornings.

Hawking from perches consisted of short flights, usually less than 50 m, and commonly from dead branches protruding 5 to 20 m above the surrounding vegetation. Before taking off, the bird would intently and actively look around to locate insects flying approximately 5 to 20 m above the surrounding vegetation. Perching kites often faced the low morning sun while looking for insects, perhaps using refraction of sunlight passing through the insects' wings to aid in prey location. After leaving the perch and flying toward the prey with deep wingbeats, they captured prey with their feet and fed while gliding back to their perch. Kites were consistently observed hawking from favorite perches near a nest site or hunting area. Hawking from perches usually occurred within 2 to 3 h after sunrise and 1 to 2 h before sunset or during midday when wind conditions were unfavorable for soaring.

During the intensive concurrent observations of foraging behavior and nestling diet at the Salt Cedar nest in 1978, 41% of the prey delivered to the nestlings was captured by adults hawking from perches. Of these prey deliveries, 51% was prey captured during hawking flights from perches less than 50 m from the nest, 78% was from perches less than 100 m from the nest, and 96% was from perches within 150 m of the nest. Thus hawking

from perches within 150 m of the nest was an important means by which adults captured prey during the nestling period, a time when food was presumably most in demand.

Aside from food-capturing, soaring seemed to be associated largely with signaling either groups of kites or potential avian predators. A kite that soared to capture prey for nestlings generally hunted within 100 m of the nest and at an altitude of less than 150 m. After capturing prey, it would usually glide at the same altitude at which the prey was caught until it was nearly over the nest, and then dive almost vertically, with wings folded, to the nest. Such a steep approach to the nest increased the time that the kite maintained altitude, enabling it to stoop down toward another aerial prey. Kites frequently brought two or three insects to the nest simultaneously.

Generally, kites mobbed avian predators that entered nesting areas. During such gatherings, they gave a distress call that attracted other kites farther than 1 km away and stimulated them to join the attack. The flapping and soaring flight above the predator may also have attracted other kites. Near nests, such attacks were sometimes conducted with short stoops into surrounding tree canopies after the intruding predator and lasted as long as an hour. Communal foraging by kites may have served to deter avian predators from approaching nests.

PRODUCTIVITY AND NESTING HABITAT

In Arizona, reproductive activity of Mississippi Kites occurs from early May through early August. From 1976 through 1979, 34 of 63 (54%) known nesting attempts successfully fledged young. In 1978, young were fledged from 13 of 25 (52%) attempted nests. The remaining nesting attempts failed for various reasons. In 1978, nesting failures occurred during these reproductive stages: courtship and nest building (44%); incubation (40%); and nestling (16%). Nesting failures for all known nests occurred during courtship and nest build-

ing (62%), incubation (31%), and nestling stage (7%).

From 1976 through 1979, a total of 44 young were fledged from 34 nests, for a mean of 1.29 fledglings per successful nest (SD = 0.46). The number of fledglings per successful nest varied yearly: 1.14 in 1976 ($n = 7$); 1.60 in 1977 ($n = 10$); 1.15 in 1978 ($n = 13$); and 1.25 in 1979 ($n = 4$). In 1978, a total of 15 young were produced from 13 successful nests and an additional 12 nesting attempts failed, resulting in a mean of 0.60 fledglings per nesting attempt (SD = 0.65). Reproductive rates of Mississippi Kites in Arizona were nearly identical to those in the Great Plains, where Parker (1974) estimated 1.29 fledglings per successful nest and 0.63 fledglings per nesting attempt.

We never saw paired yearlings, although yearlings occasionally joined adults in defensive flocking and calling while we were near nests. Group G contained the most nonbreeding individuals (47%) and produced 7 fledglings from 10 known nesting attempts ($\bar{x} = 0.70$, SD = 0.78). Group SP2 had the fewest nonbreeders (20%) and produced 16 fledglings from 21 nesting attempts ($\bar{x} = 0.76$, SD = 0.61).

The reproductive success of nesting sites was not significantly related to the number of other active kite nests within a distance of 1 km ($r^2 = 0.11$, $P < .05$). Thus, close colonial nesting probably does not guarantee significant additional protection from predators by group defense. Parker (1974) also found no significant relation between reproductive success and colony size and also showed that lone pairs of kites are more productive than colonial nesters.

Of the 48% of all kite nesting failures, the majority (84%) occurred before eggs hatched. We never observed direct mortality of adults or eggs by predators. Chihuahuan (White-necked) Ravens (*Corvus cryptoleucus*) and Cooper's Hawks (*Accipiter cooperii*) commonly nested near (within 100 m) Mississippi Kites, and their breeding seasons completely overlapped that of the kites. Less common potential aerial predators that nested within 1 km of kite nests and during the same months as the kites were the Gray Hawk (*Buteo nitidus*), Zone-tailed Hawk (*B. albonotatus*), Red-tailed Hawk (*B. jamaicensis*), Harris' Hawk (*Parabuteo unicinctus*), Common Black-Hawk (*Buteogallus anthracinus*), Great Horned Owl (*Bubo virginianus*), and Long-eared Owl (*Asio otus*). Tree squirrels (*Sciurus* spp.) were absent from riparian forests in which kites nested, and the only potential mammalian predator was the raccoon (*Procyon lotor*), which was uncommon.

We found large shell fragments from unhatched eggs beneath six abandoned nests. The eggs in these nests could have been eaten by predators. The alternating nest attendance of incubating adults seldom, if ever, permits a predator to enter a nest undetected, but adults experiencing stress at the nest (such as hunger) may be less protective of eggs or young. Also, Mississippi Kite nests are relatively small and shallow for the size of the eggs they contain, and some eggs could conceivably be lost by falling out of nests.

Mortality of nestlings occurred in only 2 of 63 nesting attempts. Once a nestling about two weeks old disappeared from a nest where it had been the only young. Another time a 10-day-old nestling disappeared from a nest containing its older (by about three days) sibling. We had been monitoring the feeding rates of the siblings in the latter case and, based on its feeding rate and weakened condition, we suspect that the younger nestling died from starvation rather than by direct predation.

Nesting habitat for Mississippi Kites in Arizona consisted of cottonwood trees taller than 15 m, arranged in either open groves or scattered clumps and surrounded by dense riparian scrubland of salt cedar (*Tamarix chinensis*) and velvet mesquite (*Prosopis velutina*) 2 to 10 m tall. Mature cottonwood trees commonly sustained partial (5 to 20%) canopy dieout, creating dead limbs from which kites frequently initiated foraging forays. The number of these hunting perches generally was related to the horizontal structural diversity (I_p) of live vegetation, from which kites also foraged. Based on observations of foraging behavior and diet of kites, we postulated that vegetation structure and plant species composition of the nesting habitat was critical to efficient foraging and thus to nesting success of this species in Arizona. Since kites obtained 41% of their prey by hawking insects from perches, nesting sites that contained considerable structural diversity (high I_p value) and high volumes of foliage that harbor dense populations of insects would probably permit greater hunting success than structurally homogeneous habitats with low volumes of foliage supporting fewer insects. Values for I_p ranged from 33 to 96% of maximum theoretical patchiness ($\bar{x} = 66.6\%$, 0.04 SE, $n = 23$) and accounted for 71% ($r^2 = 0.841$, $P < .05$) of the variation in nesting success. The index of foliage volume (m^2/m^3) measured within 150 m of nests ranged from 6.57 to 40.09 ($\bar{x} = 21.81$, 1.78 SE, $n = 23$). Diversity of vegetation at nesting sites was low. Excluding various annuals that were recorded at heights greater than or equal to 0.6 m, percent total volume of species was: cottonwood—48%,

salt cedar—27%, velvet mesquite—17%, seepwillow (*Baccharis salicifolia*)—2%, and miscellaneous plants—5%. Percent total volume of species at heights between 0.6 and 3.0 m was: salt cedar—44%, velvet mesquite—33%, cottonwood—10%, seepwillow—7%, and miscellaneous plants—6%. Values for heights between 3.0 and 12.0 m were: cottonwood—40%, salt cedar—38%, velvet mesquite—18%, and miscellaneous plants—4%. Cottonwood composed 96% of vegetation over 12 m. Miscellaneous plants included Goodding willow (*Salix gooddingii*), wolfberry (*Lycium* spp.), and acacia (*Acacia* spp.).

The Apache cicada, principal prey of Mississippi Kites in Arizona, is especially abundant in salt cedar and cottonwood (Glinski and Ohmart, in press), which made up 75% of the total foliage volume of nesting sites. Reproductive success of kites was related significantly ($r^2 = 0.774$, $P < .05$) to the total vegetation volume within 150 m of the nest, suggesting that areas containing high volumes of vegetation favored by Apache cicadas were important for kites. Also, the inflorescence of salt cedar persisted throughout the summer and provided an important food source for many insects, especially *Cotinus* beetles, on which kites preyed heavily after Apache cicadas were no longer available. Thus the salt cedar-cottonwood plant community may be closely associated with the dietary needs of kites in Arizona.

MISSISSIPPI KITE DISTRIBUTION IN NORTH AMERICA

Since the 1950's, breeding populations of the kite in North America have been increasing and nesting range has expanded westward into Colorado, New Mexico, and Arizona (Parker and Ogden 1979). Reasons for the increased success are speculative since conditions relating to the kites' survival during wintering and migration periods are uncertain. Kite foraging opportunities probably are now enhanced by increased planting of trees for erosion control in the Great Plains, and by clearing of forests for cultivation in the Southeast. The once relatively structurally homogeneous grasslands and forests are now interspersed with trees and shrubs or clearings, which provide kites with better foraging conditions. Similarly, clearing of forests in South America and Central America may have increased the structural diversity of kite wintering and migration habitat, thus possibly increasing survival by providing more hunting areas.

The kite population in Arizona is more stable than that in New Mexico, where kites sporadically nest along the Rio Grande (J. Hub-

bard, pers. comm.). However, in Arizona, the Verde River has only periodically supported nesting kites, whereas the San Pedro and Gila rivers have regularly sustained nesting birds. The Verde River lacks abundant stands of salt cedar, which affords much (27%) of the foliage volume of nest sites along the San Pedro and Gila rivers and which is an important plant for insects preyed upon by kites. Salt cedar and other riparian vegetation, such as cottonwood, willow, and seepwillow, which are capable of sustaining dense populations of Apache cicadas, appear to be critical to the distribution of Mississippi Kites in the Southwest. Presently in southwestern riparian habitats, scattered groves of cottonwoods associated with a dense understory of salt cedar appear to offer ideal foraging and nesting habitat for Mississippi Kites.

The coexistence of cottonwood and salt cedar in the southwestern United States is uncertain, since exotic salt cedar has replaced cottonwood in many drainages (Robinson 1965). On the San Pedro and Gila rivers, cottonwood regeneration is significantly reduced by increasingly dense stands of salt cedar. As the present kite nesting areas shift from a cottonwood-salt cedar mix to a salt cedar monoculture, it seems likely that the occurrence of breeding Mississippi Kites in southwestern riparian habitats may diminish.

ACKNOWLEDGMENTS

This study was made possible by the diligent field assistance of D. L. Griffith, R. L. Hanna, D. L. Strachan, S. D. Zvirgzdins, S. B. Terrill, and N. L. Dodd. R. W. Engel-Wilson provided helpful comments on vegetation analysis and P. C. Glinski assisted in analyzing data. J. W. Parker afforded thoughtful critique of the manuscript. S. M. Cook, J. R. Durham, and C. D. Zisner provided editorial assistance. C. D. Zisner typed the final manuscript. To these people we are deeply indebted. Funding was provided by Bureau of Reclamation Contract No. 14-06-300-2674.

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Condor 85:207

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RECENT PUBLICATIONS

The Thick-billed Murres of Prince Leopold Island/A Study of the Breeding Ecology of a Colonial High Arctic Seabird.—A. J. Gaston and D. N. Nettleship. 1982. Monograph Series No. 6. Canadian Wildlife Service, Environment Canada, Ottawa, Canada. 350 p. \$32.00 (Canada), \$37.50 (other countries). Source: Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec K1A 0S9. Catalogue number CW65-7/6E. Twenty years ago *Uria lomvia* was regarded as one of the most numerous seabirds in the world; since then, its populations have decreased substantially over much of its range. Heavy mortality occurs throughout the year and is attributable to various direct and indirect causes, including deep-water oil drilling and the increased shipping of petroleum. In order to obtain necessary data on the distribution, status, and ecology of seabirds in the eastern Canadian Arctic, the Canadian Wildlife Service launched a comprehensive study in 1971. This monograph reports one aspect of that program, based on three seasons of work at a major murre colony on an island in western Lancaster Sound, the gateway to the Northwest Passage. Subjects of the chapters are as follows: 1—study area and techniques, 2—pattern of attendance at the colony and associated behavior, 3—timing and success of reproduction, 4—the egg and the growth and feeding of the chick, 5—adult weight, diet, and foraging, and 6—synthesis and conclusions about the breeding ecology of Thick-billed Murres, the factors controlling their population size, and prospects for the future. Copious additional data are given in the many appendixes. The

book is impressive not only for its intensive coverage and wealth of information, but also for its careful attention to methods of field work and analysis. It tells us a great deal about the present situation at Prince Leopold Island, and provides baseline data and guidelines for future studies here or elsewhere. Its approach and findings are important for those who study—and carry responsibility for—populations of marine birds in northern oceans. Characteristically of CWS publications, the volume itself is attractively designed and well illustrated with graphs, maps, and photographs, both in monochrome and color. References, no index.

Breeding Biology of the Little Auk (*Plautus alle*) in Svalbard.—Magnar Norderhaug. 1980. *Skrifter* Nr. 173, Norsk Polarinstitutt, Oslo. 45 p. Paper cover. \$7.50. Source: Columbia Univ. Press, 562 West 113th St., New York, NY 10025. Despite its vast numbers, the Dovekie has been one of the least-known alcids, owing to its high arctic breeding range. Three summers of field work on Spitsbergen have yielded the data for this life history study, which concentrates on the development and feeding of the nestling. Illuminating comparisons with other species of alcids contribute to our understanding of adaptive radiation in breeding habits within the family. Finally, the author estimates the total amount of zooplankton consumed by the adults and nestlings, thereby indicating the considerable impact of large Dovekie colonies on the terrestrial ecosystem. Graphs, photographs, and references.