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SEASONAL PATTERNS OF HABITAT USE BY SNAIL KITES IN FLORIDA

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ABSTRACT.—The movements of 165 adult Snail Kites (*Rostrhamus sociabilis*) were monitored at biweekly intervals in central and southern Florida using radiotelemetry. Over the 3-yr study period (15 April 1992–15 April 1995), 3361 kite locations were obtained. Snail Kite habitats were classified as graminoid marsh, cypress prairie, northern lake, miscellaneous peripheral (e.g., agricultural retention ponds), or Lake Okeechobee. Kites showed seasonal patterns in habitat use. Use of cypress prairies and miscellaneous peripheral habitats showed strong seasonal fluctuations with these areas used primarily during the nonbreeding season (July–December). Kite use of graminoid marshes and northern lakes fluctuated to a lesser extent and was highest during the breeding season (January–June). Use of Lake Okeechobee also fluctuated greatly but showed no obvious seasonal pattern. One potential reason for the high use of cypress prairies during the nonbreeding season was the kites' ability to perch hunt in these habitats, which may offer an energetic advantage over aerial hunting. Birds were less likely to breed in cypress prairies, however, due probably to their greater likelihood of drying down during the breeding season. Snail Kites without transmitters were more difficult to detect in cypress prairie and peripheral habitats due to limited access and dense vegetation. This seasonal use of habitats with lower detectability for kites may have important implications for kite monitoring in Florida.

KEY WORDS: *Snail Kite*; Rostrhamus sociabilis; *breeding season*; *Florida*; *habitat use*; *radiotelemetry*; *seasonal shifts*.

Patrones estacionales de uso de habitat de *Rostrhamus sociabilis* en Florida

RESUMEN.—Los movimientos de 165 *Rostrhamus sociabilis* adultos fueron seguidos en intervalos de 2 semanas en el centro y sur de Florida mediante radiotelemetría. A través de un estudio de tres años (15 de Abril 1992–15 de Abril 1995), 3361 localidades fueron obtenidas. Los habitats utilizados por *Rostrhamus sociabilis* fueron clasificados como pantanos de gramíneas, praderas de ciprés, lagos del norte y áreas periféricas (i.e., pozos de retención de agua para agricultura) o el Lago de Okeechobee. *Rostrhamus sociabilis* utilizó habitats en forma estacional. El uso de las praderas de ciprés y habitats periféricos tuvo fluctuaciones estacionales siendo utilizados durante la época en que no se reproduce (Julio–Diciembre). El uso de pantanos de gramíneas y lagos del norte fluctuó hasta cierto punto y fue mas alto durante la época de reproducción (Enero–Junio). El uso del Lago Okeechobee fluctuó marcadamente sin ningun patrón estacional obvio. Una posible razón para la alta utilización de las praderas de ciprés durante la época en que la especie no se reproduce consiste en la utilización de perchas de caza en este habitat, lo cual ofrece una ventaja energética sobre la caza aérea. Las aves no tendieron a reproducirse en las praderas de ciprés quizas debido a que estas áreas se secan durante la época de reproducción. Los individuos sin radio fueron mas difíciles de detectar en las praderas de ciprés y en los habitats periféricos debido al acceso limitado y la densa vegetación. El uso estacional de habitats y la poca detectabilidad de la especie puede tener implicaciones importantes para su seguimiento en Florida.

[Traducción de César Márquez]

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In the U.S., the Endangered Snail Kite (*Rostrhamus sociabilis*) is found only in central and southern peninsular Florida where it inhabits freshwater wetlands throughout the area that vary in their physical characteristics and plant communities (Sykes et al. 1995). Almost exclusively, kites feed on the apple snail (*Pomacea paludosa*) by hunting for them over open-water patches in emergent marshes, shallow lakes, ponds, ephemeral wetlands, shallow banks of rivers, borrow pits, and canals (Sykes et al. 1995).

The Snail Kite has been described as a nomadic species (Stieglitz and Thompson 1967, Sykes 1979, Bennetts 1993), but until recently no major research effort has monitored individual kite movements throughout the year in Florida. Bennetts and Kitchens (1997) found that the birds routinely move among wetlands within their range. Here, we present an analysis of habitats used by Snail Kites that were radio-tracked over a 3-yr period.

METHODS

Movements of Snail Kites were monitored from 15 April 1992–15 April 1995 in central and southern Florida using radiotelemetry. We restricted our study to adult kites because juveniles do not choose their natal habitat and may remain in these areas for as long as 240 d (66%) of their first year of life (Bennetts and Kitchens 1997). We captured adult kites at their nests with a net gun (Mechlin and Shaiffer 1979). We attached 15-gm radiotransmitters to birds using backpack harnesses. Transmitters had a battery-life of 9–18 mo, so there was some overlap of monitored birds from year to year.

We attempted to locate each instrumented kite once every 2 wk. For the 3-yr study period, the average time between consecutive kite locations was 13.5 d (SD = 7.9). Tracking was done primarily from a fixed-wing aircraft but also occasionally from an airboat or levee. Locations obtained from the ground were usually accompanied by a visual confirmation of the bird's identity from uniquely-numbered anodized aluminum leg bands. Two 2.5–4 hr flights were made each week to cover the large study area. To track birds on a biweekly basis, we generally visited specific wetland systems once every 2 wk.

Once a bird's radio signal was received on a flight, we circled the vicinity several times to determine its exact location. From an altitude of 330 m, with the bird below the plane, we recorded coordinates from the aircraft's GPS and notes on the wetland habitat. If the kite was in an area near the border of two wetland systems (e.g., Big Cypress National Preserve and western WCA-3A), we spent additional time isolating the signal to determine which wetland the bird was using. For the current analysis, we only included Snail Kite locations for which we could identify the habitat type; the one exception to this was Lake Okeechobee, which is discussed below.

Snail Kite locations were assigned to one of five broad

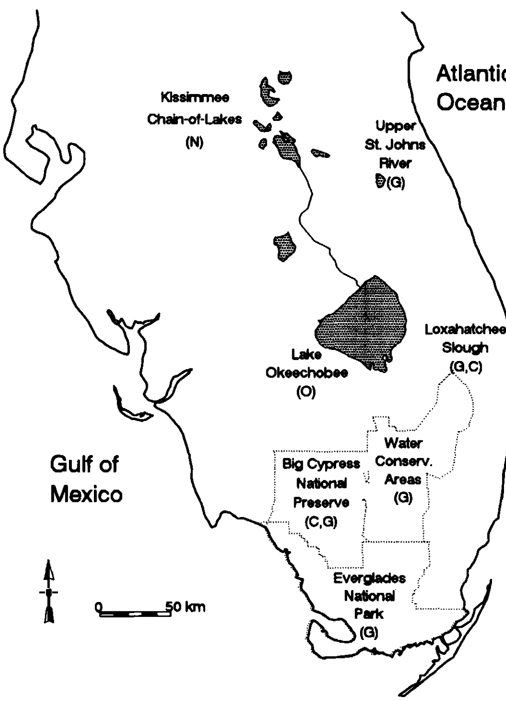

Figure 1. Major wetland systems used by Snail Kites in central and southern Florida. Habitat types are graminoid marsh (G), northern lake (N), Okeechobee (O), and cypress prairie (C). Peripheral habitats were scattered throughout the entire range and are not shown.

habitat categories: (1) graminoid marsh, (2) cypress prairie, (3) northern lake, (4) miscellaneous peripheral, and (5) Lake Okeechobee. All or parts of these habitats are described in greater detail by Loveless (1959), Gunderson and Loftus (1993), Gunderson (1994), and Bennetts and Kitchens (1997). Graminoid marshes were generally slough, sawgrass (*Cladium jamaicense*) marsh, or wet prairie communities (Loveless 1959, Gunderson and Loftus 1993, Gunderson 1994). The dominant emergent vegetation was usually comprised of sawgrass, spike rush (*Eleocharis* spp.), or maidencane (*Panicum* spp.) with scattered patches of woody vegetation. Most of these habitats were found in the Everglades, including Everglades National Park and a series of Water Conservation Areas (WCAs), the Loxahatchee Slough, and the headwater marshes of the St. Johns River (Fig. 1). A distinguishing feature of cypress prairies was a sparse overstory of cypress (*Taxodium ascendens*) with an understory of wet prairie (Duever et al. 1986, Gunderson and Loftus 1993). Cypress trees in our study area usually had a stunted growth form, but taller circular domes or linear strands interspersed with wet prairies also were common. This habitat occurred primarily in the western region of WCA-3A, Big Cypress National Preserve, and portions of the Loxahatchee Slough. The northern lake habitat type primarily consisted of lakes within the Kissimmee Chain-of-Lakes, but also included a few lakes along the Lake Wales Ridge. In contrast to Lake Okeechobee, this habitat type consisted of a narrow littoral zone, often <100 m, usually dominated by maidencane interspersed with patches of bulrush (*Scirpus* spp.) or cattail (*Typha* spp.). The miscellaneous peripheral habitat type was mostly comprised of agricultural areas and ephemeral wetlands scattered throughout the kite's range. These included citrus grove retention ponds, agricultural ditches, and other, usually highly disturbed habitats, including larger nonagricultural canals. We assigned locations at Lake Okeechobee to their own habitat type. The littoral zone of the lake is an extensive system of diverse marsh habitats, and it consequently had elements of at least three of the other habitat types (i.e., graminoid marsh, northern lake, and peripheral). Because of this local habitat diversity, it would have been extremely difficult to assign locations to a particular type without extensive ground verification. Furthermore, birds often used more than one of these habitat types within a given day due to their close physical proximity.

We used log-linear models (SAS Institute 1988, PROC CATMOD) to explore the interaction of habitats, time (year, month, and seasonal effects), and sex on locations of instrumented adult Snail Kites. The model selection procedure described by Hosmer and Lemeshow (1989) for logistic regression was used. We first explored individual first-order interactions (i.e., two-way interactions) using a likelihood ratio test of saturated models (for those effects being evaluated) and the same model without the interaction being tested. At this stage of the analysis, we used a liberal rejection criteria of $\alpha = 0.25$ because of the potential for some interaction effects to be masked. We then constructed a model including all effects meeting the above criteria. At this and all subsequent steps of the analysis, we used a rejection criteria of $\alpha = 0.05$. Although log-linear models are intended to assess interactions, we retained all main effects for any term with a significant interaction in order to account for marginal totals (Everitt 1992). We then used a combination of likelihood ratio tests and Akaike's Information Criteria (AIC) (Akaike 1973, Burnham and Anderson 1992) to determine the most parsimonious model based on all combinations of effects indicated from our preliminary exploration.

We evaluated the influence of time using monthly, annual, and seasonal (i.e., breeding season/nonbreeding season) effects. Monthly effects were determined using calendar months. Annual differences, however, were compared based on a study year from 15 April to 14 April of consecutive years (Bennetts and Kitchens 1997). The reason for this was that adults were trapped during spring, and we usually had a sufficient sample for survival analyses (another aspect of our study) by mid-April. We used this same criterion here because it enabled analysis of three complete study years, rather than two complete (1993 and 1994) and two partial (1992 and 1995) calendar years. Because we suspected that some seasonal differences were attributable to breeding status, we also evaluated the effect of whether or not it was the primary breeding season, which we refer to as the breeding season and define as January–June. Although Snail Kites are capable of breeding throughout the year in Florida, 90% of the breeding occurs during this 6-mo period (Bennetts and Kitchens 1997). We designate the remainder of the year (i.e., July–December) as the nonbreeding season, even though occasional nesting may occur.

We conducted 343 hr of foraging observations in 1993 and 1994. Each snail capture was assigned to one of two Snail Kite foraging methods: aerial hunting (hunting by low flight over the marsh), or perch hunting. We did not attempt to assess foraging energetics among habitat types because foraging is highly dependent upon temperature, season (e.g., fall vs. winter), location, and specific vegetation (Cary 1985, Sykes 1987), and we had insufficient data to partition out these potentially confounding effects.

RESULTS

We instrumented 165 adult Snail Kites (83 females and 82 males). Forty-five kites were captured in 1992, 60 in 1993, and 60 in 1994. From these kites, we obtained 3361 locations in which the habitat type was known.

Our preliminary analysis indicated a strong habitat*month interaction ($\chi^2 = 526.39$, df = 44, $P < 0.001$); however, AIC (AIC = 39613.60 and 26082.35 for models with month and season, respectively) indicated that a model using seasonal (breeding season/nonbreeding season), rather than monthly differences, was more parsimonious (i.e., a fully saturated model with habitat, year, and month effects had 180 parameters compared to 27 using an analogous model with season). Our preliminary analysis also supported using a year effect regardless of whether monthly or seasonal within-year effects were used. We found evidence of a habitat*sex interaction ($\chi^2 = 160.68$, df = 4, $P <$ 0.001) in our preliminary analysis. However, this term was dropped from all subsequent models after we accounted for temporal variation; this was based on both likelihood ratio criteria ($P > 0.05$) and AIC (AIC was substantially higher for all models including a sex term). Thus, our final, most parsimonious, model included annual and seasonal effects on habitat use (Table 1). This model did not include a two-way interaction of season*year, but it did include a three-way interaction for habitat*season*year.

Snail Kites showed seasonal patterns in their use of habitats. The use of cypress prairies and peripheral habitats, in particular, showed strong seasonal (breeding season/nonbreeding season) fluctuations (Fig. 2). Generally, the use of these areas peaked between September–November of each year, except for a peak in February of 1993 for peripheral habitats and a peak in January of 1993

Table 1. Source terms and their corresponding contribution to our final (most parsimonious) log-linear model of the interactions between habitat (HAB), season (SEAS), and study year (SYR) on locations of radio-tracked adult Snail Kites.

SOURCE	df	χ^2	PROB > χ^2
SEAS	1	48.64	<0.001
HAB	4	522.83	<0.001
SYR	2	81.56	<0.001
SEAS * HAB	4	292.10	<0.001
HAB * SYR	8	95.15	<0.001
SEAS * HAB * SYR	8	67.65	<0.001
Likelihood Ratio (Goodness-of-Fit)[a]	2	2.70	0.260

[a] Based on a likelihood ratio test between the model with all terms listed above and a fully saturated model. The null hypothesis of a Likelihood Ratio goodness-of-fit test is that the model fits the data (i.e., a failure to reject indicates fit).

for cypress prairies. These two habitat types were used most extensively in the nonbreeding season. During the times that cypress prairie and peripheral habitats were used the most, graminoid marsh and northern lake habitats were used the least.

Snail Kite use of Lake Okeechobee fluctuated greatly but showed no obvious seasonal pattern (Fig. 2). Use of the lake's wetlands was relatively high for the first half of the study, then dropped to very low in September 1993, and increased again to moderate use in early 1994. The period of low kite use in the fall of 1993 coincided with a period of low water levels at Lake Okeechobee (Bennetts and Kitchens 1997).

We recorded 814 prey captures during our foraging observations. Aerial hunting by Snail Kites accounted for 671 (82%) of the captures, while perch hunting accounted for the remaining 143 (18%) captures. The proportional use of the two foraging methods was highly dependent upon habitat type (χ^2 = 249.78, df = 3, $P < 0.001$), with perch hunting mostly used in cypress prairie habitats (Fig. 3).

DISCUSSION

One possible explanation for Snail Kites shifting into cypress prairies during the nonbreeding season and back into graminoid marsh and lake habitats during the breeding season is their ability to hunt from perches. Perch hunting may require less energy because the only flight required is to and from the prey item or other perches. Aerial hunt-

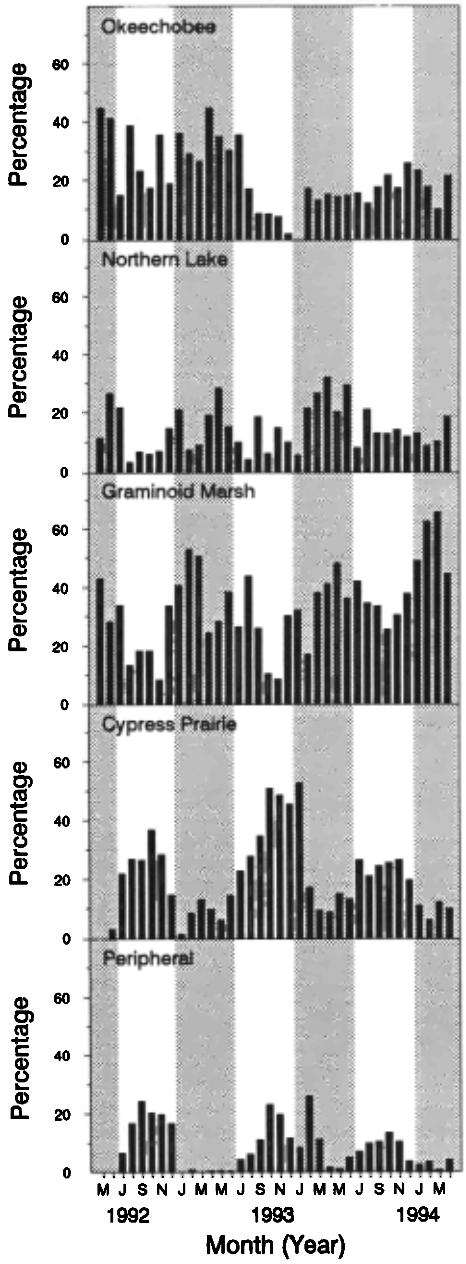

Figure 2. Monthly distribution of instrumented adult Snail Kites by habitat type from 15 April 1992–15 April 1995. The primary breeding season occurs from January–June (shaded) and the nonbreeding season occurs from July–December (white).

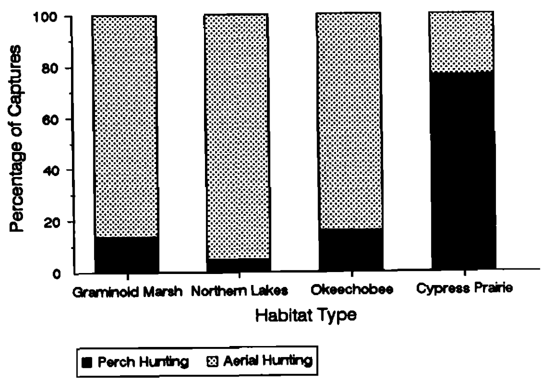

Figure 3. Percentage of prey captures by Snail Kites using perch hunting and aerial hunting in each habitat type. Limited access precluded foraging observations in peripheral habitats.

ing accounted for the majority of the prey captures we observed in other habitats where suitable perches were much less available.

Although perch hunting may provide an energetic advantage in cypress prairies, this habitat is more likely to dry out during the breeding season, which coincides with the drier months of the year in Florida (Duever et al. 1986). During the breeding season, a kite requires a minimum of 10–16 wk at a nest per brood (Snyder et al. 1989). Thus, the risk of an area drying out during a nesting attempt may be too great. Consequently, birds shift back into graminoid marsh and lake habitats to breed.

Our analysis indicated that interannual differences in kite use of Lake Okeechobee were greater than seasonal differences. However, if it had been possible to separate kite locations on Lake Okeechobee into the specific habitat types at the lake (e.g., graminoid marsh, northern lake, and miscellaneous peripheral), seasonal patterns may have emerged.

Although our data are insufficient to determine a causal relationship with any degree of certainty, the high use of Lake Okeechobee from May 1992–July 1993 may be due, at least in part, to residual drought effects from the Everglades. Drought conditions occurred in the Everglades (which includes the WCAs and Everglades National Park) in 1989 and 1990 (Bennetts and Kitchens 1997). Bennetts and Kitchens' observations of foraging Snail Kites suggested that food availability was relatively low throughout the Everglades until at least 1992; during this period, kites moved to other areas, such as Lake Okeechobee, where food availability was likely greater. Bennetts and Kitchens (1997) found that use of the Everglades area by kites, regardless of habitat type, was relatively low during 1992 and the first part of 1993, coinciding with the period of relatively high use of Lake Okeechobee.

Based on field observations, the detectability of Snail Kites without radiotransmitters is very low in both cypress prairie and peripheral habitats compared to graminoid marsh, northern lake, and Lake Okeechobee habitats. Many of the peripheral habitats were either on private land (e.g., agricultural areas) or on public land with limited access. Access to much of the cypress prairie habitat also was limited because airboats are not allowed in some sections of Big Cypress National Preserve. Additionally, large numbers of birds in this habitat type were easy to overlook because of the dense vegetation.

This seasonal use of habitats with low detectability for kites can have important implications for Snail Kite monitoring. An annual survey has been conducted in Florida from 1969–94, usually in November–December (Sykes 1979, Rodgers et al. 1988, Bennetts et al. 1994). This survey coincides with the period of relatively high use of peripheral and cypress prairie habitats. For example, in November of 1993, 55 of 80 (69%) of our locations of instrumented adult birds were in cypress prairie and peripheral habitats. Consequently, the total number of birds detected during a survey may be greatly influenced by the number of kites in these habitats at the time. Additionally, this may greatly influence the variability among counts from year to year.

Beissinger et al. (1983) reported that Snail Kites in Florida have long been known to "disappear" from their usual locations in late summer and subsequently "reappear" in mid-October, and that they may migrate to Cuba during this period. Although movement to Cuba is possible, we suggest that an alternative explanation for the disappearance of kites during summer may be their seasonal shifts into cypress prairie and miscellaneous peripheral habitats, where they are less likely to be observed.

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