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CAUSES OF MORTALITY OF POST-FLEDGING JUVENILE AND ADULT SNAIL KITES IN FLORIDA

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Previous demographic studies of Snail Kites (*Rostrhamus sociabilis*) primarily have focused on reproduction, though survival may be the most important demographic parameter for this species (Nichols et al. 1980, Beissinger 1995, Sykes et al. 1995). There have been several reports of causes of death of nestling Snail Kites (e.g., Sykes 1987, Bennetts et al. 1988), but such information has been largely speculative for post-fledging juveniles and adults (Beissinger 1986, Sykes et al. 1995). The purpose of this paper is to provide an indication of the relative frequencies of different causes of mortality of post-fledging juvenile and adult kites during our study.

Our study was conducted between April 1992 and April 1995 in central and south Florida as part of a larger study of survival and movements of Snail Kites in Florida (Bennetts and Kitchens 1997). We attached 282 radio transmitters on 271 individual kites; 11 birds were recaptured in a subsequent year and their radios replaced. We monitored birds primarily by aircraft, although verification and retrieval of dead birds was conducted by airboat or on foot. The average interval between consecutive locations of birds was 13.5 (±7.9 SD) days (Bennetts and Kitchens 1997). All radio transmitters were equipped with a mortality switch that altered the pulse rate upon prolonged lack of motion (~6 h); which enabled us to remotely determine if a bird was dead or had dropped its radio. We attempted to find all birds emitting a mortality signal the same day that the signal was detected, although logistic constraints occasionally resulted in recovering carcasses the following day.

We found 31 post-fledging juveniles and 16 adult Snail Kites dead or moribund. We assigned a likely cause of death to 24 (51%) of these 47 birds. Most (81%) dead birds were found using radio telemetry, although we have also included birds found without the aid of radio transmitters (19%). Carcasses (n = 7) in which the fleshy parts had not been consumed or that did not exhibit extreme autolysis were sent for necropsy either to the Laboratory of Wildlife Disease Research, College of Veterinary Medicine at the University of Florida, or the U.S. Geological Survey, National Wildlife Health Research Center. We caution from the outset that the exact cause of death can seldom be determined with certainty without finding each carcass while fresh and conducting a necropsy. Even when a necropsy was performed, a conclusive diagnosis was seldom possible and several contributory factors were often confounded. Despite our effort to minimize the time until a necropsy could be performed, severe autolysis was common in the time interval between death and detection of the mortality signal. Thus, our intention here is to provide a crude indication of the relative frequencies of different causes of death, rather than a definitive assessment.

Table 1. Probable causes of mortality of Snail Kites recovered in Florida from 1992 to1995.

	Juveniles		Adults		Total	
Probable Cause	No.	%	No.	%	No.	%
Predation	10	32.2	7	43.8	17	36.2
Starvation	2	6.5	0	0.0	2	4.3
Disease	0	0.0	1	6.3	1	2.1
Vehicle Collision	1	3.2	2	12.5	3	6.4
Gun Shot[a]	1	3.2	0	0.0	1	2.1
Unknown (undisturbed)[b]	4	12.9	3	18.8	7	14.9
Unknown[c]	13	41.9	3	18.8	16	34.0
Total	31	100.0	16	100.0	47	100.0

[a]Record courtesy of Jon Buntz (Florida Game and Fresh Water Fish Commission).
[b]Birds found with carcasses intact and no indication of predation. One juvenile was not emaciated and in excellent nutritional health. Another juvenile was severely emaciated, which could have been either a symptom of illness or a cause of death.
[c]Birds were too severely decomposed, were potentially disturbed, and there was no evidence of the potential cause of death.

Beissinger (1986, 1988) suggested that adult Snail Kite mortality due to predation was probably rare. In contrast, we found predation the most frequent probable cause of death identified (Table 1). However, we assigned predation to be the probable cause only when we had ancillary information, in addition to the carcass having been eaten. Otherwise, the death was classified as unknown. Four carcasses were found at a feeding or plucking perch with carcasses of other species. Six other kites had been plucked, a behavior not associated with any local scavengers. The predator most frequently suspected was the Great Horned Owl (*Bubo virginianus*). In four cases (not including those listed above) adults were found decapitated on their nest, which is a common behavior of Great-horned Owl predation (Nisbet 1975). In several other cases, a Great-horned Owl was seen in the area. Barred Owls (*Strix varia*) have been previously suspected of killing at least one adult female based on feathers left at the nest (Sykes et al. 1995); although we found no evidence of predation by Barred Owls during this study. Peregrine Falcons (*Falco peregrinus*) also were occasionally observed in the area during migration but have not been reported to take Snail Kites.

Starvation was the second most frequently suspected cause of death for juveniles, although only two cases were diagnosed (N. Thomas, National Wildlife Health Center, unpubl. data). In these two cases, each bird was found alive, but in a severely weakened and emaciated state from which they did not recover. Each of these birds was also found in marine environments (one in Florida Bay and one near Sarasota) where apple snails (*Pomacea paludosa*), the primary food of kites, were completely lacking. These deaths were attributed to inexperienced birds that dispersed in a direction where they were unable to find sufficient food. One band return from a previous study (Bennetts et al. 1988) also was from a juvenile found dead in a marine environment (Sanibel Island). One additional juvenile was severely emaciated at the time of death, but the diagnosis was not conclusive and the bird also may have had an intestinal disease (N. Thomas, National Wildlife Health Center, unpubl. data). In this case, emaciation may have been a symptom of illness, rather than a cause of death. Starvation also may have been underestimated in our sample. For example, juvenile birds dispersing to habitats atypical of adults may have a lower probability of detection due to less intensive searches of these

habitats. These areas also may less predictable food resources. In addition, starvation may be a more frequent cause of death for both age classes during drought years, when food may be scarce (Beissinger 1986); our data were collected only during non-drought years.

Vehicle collisions were a probable cause of death for both age classes and occurred where birds were observed foraging or nesting adjacent to roadways. One adult female probably died of an infection of the coelomic cavity (D. J. Forrester and M. G. Spalding, Laboratory of Wildlife Disease Research, University of Florida, unpubl. data). The skeletal remains of one juvenile had a probable shotgun pellet hole through its sternum, but we were unable to confirm conclusively if this was the cause of death.

Beissinger (1986, 1995) and Snyder et al. (1989) have suggested that most adult Snail Kite mortality in Florida occurs during droughts and is likely caused by starvation or risks encountered during dispersal. This inference was derived primarily from changes in the number of kites counted during an annual survey, rather than from empirical evidence of actual mortality. Although we agree with these authors that an increased risk of mortality during widespread droughts is likely, the actual extent of mortality attributed to specific causes is not known (Bennetts et al. 1994, Sykes et al. 1995, Bennetts and Kitchens 1997). However, we emphasize that our study was conducted during non-drought conditions and our inferences are limited accordingly.

Our inferences also were likely influenced by our methods. For example, two of three birds we found hit by vehicles were found without using radio transmitters. This probably is because they were along roadways where detection of the birds was likely. Finding birds that died of other causes would have been far less likely without the use of radio transmitters. If a study goal is to determine the causes of mortality, it also is imperative that sampling intervals of radio-tagged birds be frequent. Even with our relatively intensive sampling effort, severe autolysis precluded much of the information that could have been derived had the carcasses been found fresh. Decomposition occurs quickly in Florida's subtropical environment. Consequently, causes of death that required examination of soft tissues for diagnosis are likely to have been underestimated in our sample.

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