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THE PROPORTION OF SNAIL KITES ATTEMPTING TO BREED AND THE NUMBER OF BREEDING ATTEMPTS PER YEAR IN FLORIDA

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Abstract.—During the breeding season of 1995 we monitored the proportion of adult and subadult Snail Kites (*Rostrhamus sociabilis*) attempting to breed and the number of breeding attempts using radio telemetry. Our sample consisted of 23 adults (14 females, 9 males) and 9 subadults for which we had data over the entire breeding season. All adults attempted to breed at least once with an observed average of 1.4 (± 0.6 SD) breeding attempts per individual. In contrast, only 3 (33%) of the subadults attempted to breed. Of the adults, 15 (65%) made one breeding attempt, 7 (30%) made two breeding attempts, and 1 (4%) attempted three times. Only one bird (4%) successfully raised two broods. Our data are consistent with previous reports that >1 breeding attempt by Snail Kites in Florida is common during some years, although our estimate for 1995 was lower than previously reported estimates. A combination of our estimation procedures, definitions of a breeding attempt, and annual variability of this parameter probably account for the disparity between our data and previous reports.

Understanding the structure and dynamics of any natural population requires knowledge of the birth and death rate of that population

(Seber 1982). From a demographic perspective, what is ultimately of interest regarding birth rate is the number of young produced per female (Caughley 1977). Many species, including Snail Kites (*Rostrhamus sociabilis*), it is difficult to estimate this parameter directly. Thus, it is often derived from estimation of several parameters including the (1) proportion of the population attempting to breed, (2) number of breeding attempts that were successful, (3) number of young produced per successful breeding attempt, and (4) number of breeding attempts per year (Brown 1974, Caughley 1977, Beissinger 1995).

The success per breeding attempt and the number of young produced per attempt are relatively well known for Snail Kites (Sykes 1979, Bennetts et al. 1988, Snyder et al. 1989, Bennetts and Kitchens 1997). In contrast, there has been virtually no empirical data for that proportion of the population attempting to breed, although authors have reported values based on anecdotal observations (e.g., Nichols et al. 1980, Beissinger 1995). Similarly, there has been little evidence for the number of breeding attempts per year. Snail Kites are capable of raising >1 brood per year and attempts at multiple brooding may be fairly widespread (Snyder et al. 1989). Snyder et al. (1989) suggested that individuals have the potential to successfully raise four broods per year, although we know of no documented cases of individuals successfully raising >2 broods in a given year. Snyder et al. (1989) estimated the number of nesting attempts per pair to be 2.7. Their estimate was derived using the number of Snail Kites counted on an annual survey at two locations (Lake Okeechobee and Water Conservation Area 3A) during the fall of 1977 as an estimate of the potential breeding population for 1978. They then used the number and success of nests found at those localities the following breeding season to estimate the number of nesting attempts by that breeding population. Beissinger (1995) later used a more "conservative" estimate of 2.2 attempts per pair in a population viability analysis because the estimate by Snyder et al. (1989) was reported to be "under the best conditions". Here, we present empirical estimates for the proportion of the population attempting to breed and the number of breeding attempts per year for individual Snail Kites during the 1995 breeding season using radio-telemetry.

Study Area and Methods

Snail Kites in Florida consist of one population that shifts in distribution throughout the state, rather than several subpopulations (Bennetts 1993, Beissinger 1995, Bennetts and Kitchens 1997). Consequently, our study area comprised a network of wetlands throughout the Snail Kite's range in Florida (Bennetts and Kitchens 1997). During the breeding season of 1994, 100 radio transmitters were attached on Snail Kites, 60 on adults and 40 on juveniles. The goal was to monitor the breeding status of as many of these birds as possible during the entire 1995 breeding season. Birds whose radio trans-

mitters failed before the end of the 1995 breeding season, or whose location or breeding status were unknown for a period >30 d were excluded from the sample. The 1995 breeding season was considered to extend from November 1994 through August 1995; although actual breeding activity was only observed January to July.

Breeding attempt is defined as initiation coincident with laying of the first egg (Steenhof 1987). However, additional activity associated with breeding, was recorded, including courtship behaviors to enable more comprehensive record of each individual. During the breeding season, we visually located each bird approximately biweekly and determined its breeding status (e.g., not breeding, courtship, or breeding). Birds in which no breeding activity was detected were generally observed for ≥2 hrs and subsequent visits, usually within 10 days, were required to confirm a non-breeding status and to confirm any nests of birds exhibiting courtship behavior. A breeding attempt was considered successful if at least one young reached fledging age (Steenhof 1987). Because birds may or may not be present at the nest after fledging, we defined fledging age as 80% of the average age of first flight (Steenhof and Kochert 1982). Snail Kites are capable of first flight at approximately 30 days of age (Chandler and Anderson 1974); thus, a breeding attempt was considered successful if it produced young that survived to at least 24 d (Bennetts et al. 1988). Survival after this period was estimated using radio telemetry and capture recapture techniques and is reported elsewhere (Bennetts et al. in press).

RESULTS AND DISCUSSION

We were able to monitor the breeding status of 23 adults (14 females and 9 males) and 9 subadults for the entire 1995 season. The average interval between successive observations of breeding status was 14.1 d (± 8.1 SD). All adult birds attempted to breed at least once with an average of 1.4 (± 0.25 SE) breeding attempts per bird. Fifteen adults (65%) made one breeding attempt, 7 (30%) made two breeding attempts, and 1 (4%) attempted three times (Table 1). Only one adult (4%) successfully raised two broods. In contrast, not all subadults attempted to breed; only 3 (33%) were confirmed to have a nest in which at least one egg was laid, and none were observed attempting to breed more than once.

Our data were consistent with Snyder et al. (1989) that >1 breeding attempt by Snail Kites in Florida is common during some years. However, our results did not agree with previous estimates of 2.7 (Snyder et al.1989) or 2.2 attempts per year (Beissinger 1995). The differences between these estimates is large and may have dramatic influence for estimating reproduction. Using a value of 2.7 attempts versus 1.4 would nearly double an estimate of reproduction for a given year if other parameters were equal. Thus, we believe that it is important to understand possible reasons for the disparity of these estimates. A combination of differences in our respective definitions of a breeding attempt, our estimation procedures, and annual variability of this parameter probably account for the discrepancies between these two data sources.

Snyder et al. (1989) considered a breeding attempt to begin with nest building, prior to the laying of the first egg. Although we agree

Table 1. Number of breeding attempts and attempts that were successful for 23 adult Snail Kites during 1995.

Radio Frequency	Gender	Number of Breeding Attempts	Number of Successful Attempts
152.039	F	2	1
152.128	M	1	1
152.169	F	2	1
152.369	F	1	1
152.379	M	2	1
152.494	F	1	1
152.499	F	1	0
152.539	M	1	0
152.584	F	1	0
152.698	F	1	1
152.739	F	3	1
152.777	F	1	1
152.848	M	1	0
152.858	M	1	1
152.869	M	1	1
153.290	M	1	1
153.390	M	1	1
153.496	F	2	0
153.860	F	2	1
153.900	M	1	1
153.931	F	1	1
153.969	F	2	2
153.979	F	2	1

with Snyder et al. (1989) that, for many questions, the failure of nests prior to egg laying may have important biological implications, we disagree that nests during the nest-building stage, for this species, should be considered as a breeding attempt for estimation of reproductive parameters. Nest building is part of courtship for Snail Kites and often involves birds for which a pair bond has not even been established (Beissinger 1988, Bennetts et al. 1994). We observed one radio-tagged male initiate courtship with at least five different females before a pair bond was established. Courtship, including nest building, is often terminated with the passage of cold fronts and resumed at a new site after temperatures return to pre-front conditions (Beissinger 1988, Bennetts et al. 1988, 1994). For demographic purposes, these postponements are viewed as courtship interruptions, rather than multiple breeding attempts with each interruption being considered as a breeding failure. Thus, we agree with Steenhof (1987) and defined a breeding attempt to begin with the laying of the first egg. If our definition were applied to the data reported by Snyder et al. (1989) their estimate would have been reduced from 2.7 to 1.9 breeding attempts per pair (Bennetts and Kitchens 1997).

The assumptions inherent for each of the estimation procedures also can have a dramatic influence on the resulting estimates. The primary assumption of our estimate was that no breeding attempts went undetected during the breeding season. The interval of our breeding status checks could have resulted in failure to detect some birds that initiated a nest that failed early during laying or incubation. However, exclusion of birds from the sample for which we had gaps in the known breeding status helped to minimize this potential bias. Analyses were repeated with a more restrictive criteria for the gaps in observations, such that the average interval between visits was ≤8 d, with a maximum of 21 d between any two visits. This more restrictive criterion reduced sample size ($n = 10$), but did not alter the estimate of the number of breeding attempts per adult ($\bar{x} = 1.38$). Consequently, we believe that the potential bias from having missed breeding attempts probably was very low. Our estimate also was based on a relatively small sample size ($n = 23$), although this does not bias the estimate; rather it reduces the confidence through an increased standard error.

Because Snyder et al. (1989) did not know the breeding history of individuals over the 1978 breeding season, their estimation procedure required several additional assumptions not required had the status of individuals been known. Snyder et al. (1989) pointed out that their procedure assumed (1) the 1977 annual survey was an accurate census (i.e., a complete count of all kites), (2) no birds died between the 1977 survey and the 1978 breeding season, (3) all birds counted during the 1977 survey were potential breeders during 1978, and (4) a 1:1 sex ratio. We suggest that their procedure was not robust to violations of these assumptions, and recent evidence suggests that several of these assumptions were unlikely to have been met.

Because Snyder et al. (1989) used the 1977 survey to represent the number of potentially-breeding pairs during the 1978 breeding season, their approach required a more rigorous assumption regarding closure than they suggested. Their procedure assumed that the two locations they monitored (i.e., WCA-3A and Lake Okeechobee) represented a closed population. Thus, the assumption is not only that there were no deaths between the 1977 survey and the end of the 1978 breeding season, but also that there were no births, immigration, or emigration. Recent data from 271 radio-tagged Snail Kites in Florida indicated that the probability of a bird moving from one wetland to another during a given month is approximately 0.25 (Bennetts and Kitchens 1997). Given that the time between the 1977 survey and the end of the 1978 breeding season was approximately 8-9 months, it is likely that there was substantial immigration and emigration. Further, Bennetts and Kitchens (1997) and Valentine-Darby et al. (1998) found that there is an appreciable shift from peripheral habits, during the time of the sur-

vey, to breeding habitats during spring. Thus, there was very likely a net increase in the "breeding population" which could have substantially inflated their estimate of the number of breeding attempts per pair.

Bennetts and Kitchens (1997) and Valentine-Darby et al. (1998) also found that during late fall, when the annual survey is conducted up to 60% of the population may be in areas not included in the survey or in habitats (e.g., cypress) where detection is difficult. In addition, Bennetts and Kitchens (1997a) and Bennetts et al. (in press) found that the average probability of detecting marked individuals during spring, when birds are more concentrated, was quite low (<25%). Thus the assumption of an accurate census also was unlikely to have been met. Previous reports (e.g., Snyder et al. 1989), and our data confirm, that not all subadults are potential breeders. Thus, the assumption that all birds during the 1977 survey were potential breeders during 1978 also was unlikely to have been met because adults and subadults were not distinguished during the annual survey.

If use of an estimate is extended to years other than one from which it was derived, it must be assumed that the estimate be "representative" of the conditions to which the estimate is being applied. Estimates derived from both our data and that of Snyder et al. (1989) were each based on a single year. Based on the data reported by Snyder et al. (1989), 1978 was an extremely high year for reproduction. Excluding years for which they reportedly did not have extensive field coverage (i.e., before 1970 and after 1983), the number of nests documented during 1978 was nearly 3 standard deviations above the mean number of nests found (based on Snyder et al. 1989, Table 1). Similarly, the number of young banded during 1978 was >3 standard deviations above the mean number for other years (based on Snyder et al. 1989, Table 7). Snyder et al. (1989), apparently recognized the extreme nature of 1978 and correctly limited their inference to that year. Beissinger (1995) later used what he considered a "conservative" estimate of 2.2 breeding attempts per pair in a population viability analysis in order to extend the estimate of Snyder et al. (1989) to other years. Our data suggest that even this "conservative" estimate was likely to be substantially inflated if used as an annual average.

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