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Abstract: Forty-three greater sandhill cranes (*Grus canadensis tabida*) and 18 Florida sandhill cranes (*G. c. pratensis*) were captured and fitted with plastic neckbands in 1985 and 1986. Nine (15%) died after inserting their bills inside their bands and were unable to free themselves. Death from neckbands occurred in 3 (20%) of 15 radio-tagged cranes, suggesting that the actual mortality was higher than that observed. No neckband-related deaths were observed in cranes < 12 months of age, and females exhibited mortality 2.5 times higher than males. Mortality was equally divided between cranes that received secured and unsecured neckbands. Increasing the height of neckbands from 6.5 to 8.2 cm did not reduce the incidence of death.

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Plastic and aluminum neckbands have been used extensively for color-marking sandhill cranes (Huey 1960; Drewien & Bizeau 1974; Gluesing 1974; Boise 1976: Tacha et al. 1981; Melvin & Temple 1983). The major advantage of neckbands over other markers is their high visibility under almost all field conditions (Marion & Shamis 1977). Neckbands can often be seen when cranes are in tall or thick vegetation, regardless of the position of the bird, and Craven (1978) reported that numerically coded neckbands could be read at distances of up to 600 m.

The major problem with neckband markers on sandhill cranes is the potential for birds to lodge their bill inside the band (Reynolds 1979). Most researchers who have neck-banded cranes have observed 1 or more instances of birds with their bills caught inside the band (Huey 1960; Gluesing 1974; Crete & Grewe 1981; T. Tacha & R. Drewien pers. comm.). Cranes unable to free themselves eventually die from dehydration, stress or are killed by predators.

The frequency of death attributed to neckbands in sandhill cranes and its effect on survival estimates has not been determined. I neckbanded nonmigratory Florida sandhill cranes and migratory greater sandhill cranes during 1985-86 in the Okefenokee Swamp, Georgia. Radio-transmitters were attached to 25% of the neckbanded sample, allowing close monitoring of post-release movements and survival.

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METHODS

Sixty-one sandhill cranes were captured by rocket netting using methods similar to those described by Wheeler & Lewis (1972). Captured cranes were immediately placed in individual burlap bags. Velcro straps were placed around the tibia, tarsus and body to fully immobilize each bird. Cranes were aged by examining their pattern of wing molt per Nesbitt (1987). When single pairs of cranes were captured, sex was determined by behavior and calls.

Cranes were banded with size 9 USFWS aluminum leg bands and white plastic neckbands constructed from 60 x 90 cm sheets of 3 mm thick Gravaply®[1]. Neckbands were initially cut to a height of 6.5 cm and later increased to 8.2 cm. Length of neckbands was 16.5 cm, providing a 50% overlap when rolled. Each neckband was engraved with a unique, 3-digit alpha-numeric code assigned by the Bird Banding Laboratory (USFWS). Neckbands were oven heated until pliable and formed by rolling them around a wooden dowel. The inside diameter of neckbands was 3.75 cm.

[1]*Mention of commercial names or products does not imply endorsement by the U.S. Government.*

Thirty-three (54%) of the 61 cranes were fitted with neckbands that were not secured and 28 (46%) received neckbands which were secured with PVC pipe cement. The secured neckbands were "custom fitted" to each bird, i.e, attached snug enough to ride high on the neck, but still allow ingestion of large food items. Observations of neckbanded cranes were made daily from boats or on foot using 15-45x spotting scopes.

Fifteen (25%) of the neckbanded cranes were fitted with two-stage radio-transmitters powered by rechargeable NiCd batteries and 2 rows of solar panels (Telemetry Systems, Inc., Mequon, Wisconsin), and single stage transmitters powered by lithium or NiCd batteries (Telonics Inc., Mesa, Arizona) were attached to plastic leg bands (Melvin et al. 1983). Antennae were 16-24 cm long and extended vertically down the leg. Total weight of the radio package (leg band and transmitter) was 55-60 g for solar transmitters and 75-80 g for battery transmitters.

Radio-equipped cranes were monitored 4-5 days/wk by ground tracking using Telonics TRC-1 receivers and directional 4 & 8-element Yagi antennae. Receiving antennae were mounted in boats equipped to serve as mobile tracking vehicles. Aerial tracking was accomplished using 2 2-element "H" style directional antennae clamped to each wing strut of the airplane. Reception ranges for transmitters in the Okefenokee Swamp were 2-4 km ground-to-ground and 30-40 km air (1500 km elev.)-to-ground.

RESULTS

Seven sandhill cranes died after lodging their bills inside their neckbands and being unable to free themselves. Two additional cranes were observed with their bills caught, 1 of which was recaptured and the neckband removed. The other escaped and was never seen again. These 2 birds were counted as mortalities because their weakened physical condition at the time of sighting or capture indicated that they would not have been able to free themselves. Neckband-caused mortality occurred in 3 (20%) of 15 radio-tagged cranes and 6 (13%) of 46 of those not radio-tagged. Mortality was difficult to detect in the non-radioed sample and is probably underestimated. Assuming that 20% was the true mortality, 14 cranes may have died from neckbanding.

Eight deaths occurred 5-21 days after banding ($\bar{x}$ -8.3 days). None had dispersed farther than 2 km from the banding site. During the first 7 days after neckbanding, cranes were commonly observed pecking at their bands and trying to remove them. This behavior gradually diminished and was rarely observed in cranes that had been banded 14 days or longer. The high incidence of mortality immediately following banding suggests that most cranes lodge their bills inside the neckbands during the adjustment period. However, 1 greater sandhill crane neckbanded in November 1985 was found dead on the breeding grounds in March 1988 with its bill lodged in its neckband.

Sex was known for a sample of 19 neckbanded cranes. Among this group, 4 (50%) of 8 females (50.0%) and 2 (18%) of 11 died. Although the sample size was small, females exhibited significantly higher ($P < 0.01$) mortality from neckbands than males. No death caused by neckbands was observed in cranes < 12 months of age (Table 1). Mortality rates observed in subadults (12-36 months) and adults (> 36 months) did not differ significantly ($P < 0.05$).

Mortality was equally divided between birds that received secured and unsecured neckbands. Cranes were evidently unable to remove or expand the unsecured bands to free themselves, but several of the unsecured bands slipped down near the base of the neck and were difficult to see. Those were held in place by feathers the birds preened down over the top of the bands, and while that condition did not seem to adversely affect the movements or behavior of cranes, it resulted in minor feather wear and skin infections on several birds.

Death occurred in 7 (13%) of 53 cranes that were fitted with neckbands 6.5 cm high, and 2 (25.0%) of 8 fitted with neckbands 8.2 cm high, but sample size was too small and unbalanced with respect to sex and age class to test for differential mortality related to band height. The height of neckbands was increased to 1. 7 cm to make it more difficult for cranes to insert their bills inside the bands, but after mortality was observed in cranes fitted with the taller model, the use of neckbands was terminated.

DISCUSSION

Neckband-caused death in sandhill cranes may be related to sex, age and behavior of individual cranes, as well as neckband dimensions and application techniques. Mortality from neckbanding Florida and greater sandhill cranes was 2 . 5 times higher among females than among males . A shorter culmen length may enhance the ability of

female cranes to insert their bills inside the neckbands. In addition, neckbands (especially those left unsecured) rode lower on the necks of females due to their smaller neck diameters.

Juvenile cranes are apparently not susceptible to neckband-caused mortality. R. Drewien (pers. comm.) has not observed neckband-related problems in juvenile cranes banded prior to fledgling, maintaining that juveniles are less likely to insert their bills into the bands during the adjustment period. Other researchers who have neckbanded prefledged juveniles have not reported problems related to bill insertion (Boise 1978; Melvin & Temple 1983) .

Although some cranes are able to free themselves after their bills become caught, the risk of death remains throughout the bird's life. One crane which was able to free itself, re-inserted its bill the next week and subsequently died. Crete & Grewe (1981) observed a neckband-related death 7 months after a crane had been banded. In 1976, S . Melvin (pers . comm.) observed a crane with its bill caught inside its neckband at the Jasper-Pulaski Wildlife Area, Indiana. This crane had been banded 3 years earlier in Wisconsin by Gluesing (1974) . It has been suggested that increasing band height and width may reduce or eliminate neckband-induced mortality. T. Tacha (pers. comm.) found that increasing the height of neckbands from 6.25 to 8.75 cm prevented most lesser sandhill cranes (*G. c. canadensis*) from inserting their bills inside bands. However, increasing neckband height from 6.5 to 8.2 cm during this investigation did not prevent mortality in greater and Florida sandhill cranes. Neckbands 9-10 cm in height may be needed to eliminate risk in the larger subspecies. However, while increasing band height may lower the incidence of bill insertion, secondary physiological and behavioral impacts may result if neck movements are impaired.

Neckbands did not appear to adversely affect crane behavior or movements as has been reported for colored leg streams (Wheeler & Lewis 1972) and patagial tags (Tacha 1979) . Cranes with neckbands socially integrated with unbanded birds, paired, defended territories and successfully nested.

CONCLUSIONS

Future research could result in a neckband design which presents little or no risk to a banded crane. The use of a non-rigid material, plastic-coated nylon fabric, for example, may allow the height of neckbands to be increased to 8 or 10 cm without adversely impacting movements or behavior. New neckband designs should be tested on captive birds and their behavior closely monitored during the post-banding adjustment period. Until a satisfactory alternative to rigid materials is tested and found not to pose a threat of injury or mortality, I do not recommend the use of neckbands on sandhill cranes.

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Table 1. Mortality resulting from neckbands among 3 age classes of sandhill cranes.

Age class	N	N deaths	%
Juvenile, < 12 mo	8	0	0
Subadult, 12-36 mo	35	7	17.1
Adult, > 36 mo	18	3	16.6