ECOLOGICAL FACTORS AFFECTING WILD TURKEY NEST PREDATION ON SOUTH TEXAS RANGELANDS [a]

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Abstract: During the summers of 1976 and 1977, predation rates were determined for 350 dummy Rio Grande turkey (*Meleagris gallopavo intermedia*) nests on the Welder Wildlife Refuge in south Texas. Grazing system, pasture deferment time, plant community, and coyote (*Canis latrans*) exclusion significantly affected predation rates. No differences were found for soil type, cover type, egg type, or the effects of hair-catchers at nests. Based on hair samples, striped skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*) were the major nest predators on the Welder Refuge, whereas coyotes and armadillos (*Dasypus novemcinctus*) were of minor importance. No patterns of nest predation could be characterized based on predator sign left at the nest.

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Nest predation is often a serious mortality factor in Rio Grande turkey populations. Glazener (1967) reported one Texas study that showed a nest loss of 47.8% due to predation. On the Edward's Plateau of Texas, Cook (1972) found 61.2% of 121 nests were unsuccessful, with 71.6% lost to predation.

Despite numerous studies of gamebird populations, the overall impact of nest predation as a limiting factor is still, for the most part, poorly understood. Furthermore, the influence of varying ecological parameters on nest predation is even less well documented.

To identify nest predators, biologists generally must rely on sign left at the nest. Several studies using dummy or artificial nests with "known" predators (based on poisoned eggs) have characterized this sign for several species. Subsequently, researchers have relied on these descriptions to identify depredations in the field. However, a comparison among different authors describing "characteristic" sign for the same predators reveals a certain amount of ambiguity. In Alabama, Davis (1959) described the eggs of nests destroyed by striped skunks by stating "invariably the end of the egg will be opened almost as if it had hatched", whereas for the same predator in Maine, Rearden (1951) stated, "a complete chewing of the shells appears to be most common . . . thus the membrane and shell fragments more or less cling together in a shapeless mass". Similar inconsistencies have been found with other nest predators (Darrow 1938, Sowls 1948).

The objectives of this study were to: (1) determine the influence of ecological parameters on predation rates of dummy nests, (2) identify nest predators based on hair samples, and (3) determine to what extent nest predators can be identified based on sign left at the nest. Although dummy nests were constructed primarily to simulate Rio Grande turkey nests, the results of this study may apply to other large ground-nesting birds occurring in similar habitat.

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STUDY AREA

The study was conducted on the 3,158-ha Rob and Bessie Welder Wildlife Refuge and approximately 200 ha of the Rooke Ranch near Sinton in south Texas. Yearly rainfall averages 88.9 cm; however, vegetation is controlled by extremes and many plants of more arid zones occur in the flora. The Welder Refuge occurs in a grassland climax found along the Gulf of Mexico. However, it has presently developed into a brush-grass complex, partially as a result of a long history of grazing use by domestic livestock (Drawe et al. 1978, Lehmann 1969). Drawe et al. (1978) described in detail the climate, soils, vegetation, and land-use patterns.

In August 1974, the Refuge began a long-term comparison of 3 different grazing systems: continuous (CONT), 4-pasture deferred rotation (4PDR), and high intensity-low frequency (HILF). The average stocking rate was 5.1 ha per animal unit. The Rooke Ranch used continuous grazing with a stocking rate of 4.0 ha per animal unit. Both areas operated a cow-calf program which consisted of selling calves produced from relatively stable herds of cattle. The CONT system was year-round grazing with essentially no deferment (rest) periods. The 4PDR system used 3 herds grazing 4 pastures. Each pasture had a 12-month grazing period followed by a 4-month deferment period causing successive rest periods to fall at different seasons. The HILF system had one herd rotated among 7 pastures. Each pasture was grazed from 2-7 weeks. This system had built-in flexibility, since cattle movements depended primarily on range condition, key plant species, and pasture size.

In 1972, a coyote exclosure was erected around Coyote Pasture (4PDR) enclosing 387 ha of primarily a mesquite (*Prosopis glandulosa*) – mixedgrass plant community on clay soil. All coyotes were removed from the exclosure, and bobcats (*Lynx rufus*) were reduced in number. During the study period (1975-77), there were no records of any coyotes inside the exclosure (Drawe, pers. comm.). No attempt was made to control populations of smaller furbearers, such as raccoons and striped skunks.

METHODS

Primarily during the second week of June 1976-77, a total of 350 dummy nests was placed on the study area. Each nest consisted of 10 unmarketable domestic turkey or chicken eggs. Nests were constructed by flattening vegetation, placing the eggs on the ground, and returning vegetation to its natural position. Nests were checked weekly for 6 weeks to simulate the 2-week laying and 4-week incubation period of wild turkeys (Bailey and Rinell 1967). After 3 weeks, the eggs in all surviving nests were replaced with fresh ones. Since potential nesting habitat for wild turkeys essentially included all areas on the Refuge, dummy nests were placed in all grazing systems and major plant communities.

Ecological Parameters Tested

Differences in nest predation rates were determined for grazing system, pasture deferment time, plant community, coyote exclusion, soil type, cover type, egg type, and effect of hair-catchers.

Nest predation rates were compared among grazing systems based on 75 nests in each of the 3 systems: CONT, 4PDR, and HILF. Of these, 165 were on clay soil and 60 were on sandy soil. Differences in pasture deferment time under the HILF system were determined by placing 15 nests in a clay soil pasture deferred 10 days and 15 nests in a similar pasture deferred 10 days and 15 nests in a similar pasture deferred 41 days.

To determine the influence of plant community on nest predation, 15 nests were placed into each of 6 major plant communities under the HILF system on the Welder Refuge: mesquite-mixedgrass, huisache (*Acacia smallii*)-grassland, chaparral-mixedgrass, live oak (*Quercus virginiana*)-chaparral, riparian-woodland, and bunchgrass-annual forb. Plant communities were described in detail by Drawe et al. (1978). Huisache-grassland was a combination of the huisache-mixedgrass (clay soil) and huisache-bunchgrass (sandy soil) plant communities.

The influence of the coyote exclosure on nest predation was determined by placing 35 nests inside the exclosure and 35 nests in an open pasture under the same grazing system in similar habitat. The influence of soil type on nest predation was examined by comparing 180 nests on clay soil to 105 nests on sandy soil. Nests were located in all grazing systems and in all above plant communities, except huisache-grassland. Differences in predation rates due to cover type were determined by placing 100 nests each in good and fair cover. Good cover was subjectively interpreted to include locations with tall or dense herbaceous or woody vegetation, and away from roads, fences, or animal trails. Nests in fair cover were along fences, near roads or trails, or in areas with less dense vegetation. To determine differences in predation rates due to egg type, 60 nests domestic turkey eggs were compared with 60 nests of domestic chicken eggs.

Differences in nest predation rates were tested for significance using chi-square analysis (Conover 1971). Contingency tables were constructed using the number of nests destroyed per week during the 6-week study period for each variable tested. In all cases, deviations from expected values were tested at the 95% probability level.

Nest Predator Identification

The hair-catchers used to identify nest predators were of 3 basic designs not previously described in the literature (unpub. manus.). Essentially, they were constructed of sharpened sheet-metal or braided wire attached to wooden stakes and driven into the ground, leaving 20-35 cm of stake above the surface. To determine the influence of these hair-catchers on the predation rates of dummy nests, 63 nests with hair-catchers were compared to 72 nests without. Nests were in equal proportions in all grazing systems and plant communities evaluated in 1977.

Skunk hair was identified by color and texture (Stains 1958). Other mammalian hair was identified using microscopic characteristics of medullary configuration (Moore et al. 1974) and scale patterns (Moore et al. 1974, Adorjan and Kolenosky 1969). Hair impressions were prepared by spreading a very thin layer of clear fingernail hardener on a glass slide, immediately placing the hair on the slide, and removing it after the hardener had dried.

Nest Predator Characteristics

Description and location of shell remains and general nest disturbance were recorded for each destroyed nest to attempt to identify nest predators based on sign. Eggshell remains were located by searching a 5-15 m diameter area around the nest site. A complete description was recorded for each eggshell found, and data was analyzed by grouping shell remains into 10 categories: (1) 1-3 cm diameter hole in side or end of shell, otherwise intact; (2) at least half of the shell intact, egg broken from end; (3) at least half the shell intact, egg broken from side; (4) less than half the shell intact, egg broken from end; (5) less than half the shell intact, egg broken from side; (6) completely broken, most pieces < 2 cm in diameter, shell fragments separate; (7) completely crushed, fragments held together by shell membrane, shell often curled into a ball; (8) completely broken/crushed, not able to place into category 6 or 7 based on description; (9) OK, eggs possibly moved but not broken; and (10) missing.

Nests were placed into 1 of 3 categories based on location of the majority of eggshell remains in relation to the nest site: (1) close, < 1 m; (2) moderately scattered, 1-3 m; and (3) widely scattered, > 3 m. Based on general nest disturbance, including vegetation trampled, general digging, etc., nests were grouped into 4 categories: (1) none or light, (2) moderate, (3) heavy, and (4) unknown or not recorded. The presence or absence of small (2-5 cm wide by 3-8 cm deep) holes dug at the nest site was recorded for each destroyed nest. Finally, the presence and number of "canine tooth" holes (3-5 mm diameter) in the intact shell remains were recorded whenever observed.

RESULTS AND DISCUSSION

Ecological Parameters

Grazing System: Based on 225 dummy nests, a significant difference was found in nest predation rates among pastures under CONT,. 4PDR, and HILF grazing systems (Fig. 1a). Multiple comparison tests showed that both 4PDR and HILF had higher nest survival than CONT, but that 4PDR and HILF were not different from each other. When grazing systems were analyzed based on soil type, pastures with clay soil (Fig. 1b, 165 nests) had exactly the same differences; both 4PDR and HILF had higher nest survival than CONT. However, on sandy soil pastures (Fig. 1d, 60 nests), no significant differences were found among grazing systems. This apparent difference due to soil type may have been an artifact of experimental design. Statistical analysis on clay soil was strengthened by a sample size almost 3 times greater than on sandy soil. On clay soil, all nests were located in similar plant communities, but on sandy soil, nests in the CONT pasture were in a different community than those in 4PDR or HILF.

Gore (1973) listed overgrazing by livestock as a major cause of habitat loss to Rio Grande turkeys in Texas. Mundinger (1976) studied waterfowl response to rest-rotation grazing, a system intermediate between 4PDR and HILF. From 1973 to 1974, he found the number of breeding pairs of ducks increased 42% and brood production increased 50% under rest-rotation grazing. On the Edward's Plateau of Texas, Merrill (1975) found the density of turkey nests was greater in pastures under 4PDR grazing than under continuous grazing. He also noted that although no nests were found, more broods were seen in pastures under an HILF grazing system than in any other pastures.

My results support these findings and further emphasize the benefits of rotational grazing to nesting success. In addition, rotational grazing often increases forage production for livestock (Merrill 1975). However, the vast majority of Texas rangelands are under continuous grazing. Considering the revenues available through hunting leases, rotational grazing could be doubly profitable to Texas ranchers, as well as beneficial to most wildlife species.

Soil type: Predation rates between soil types were compared for 180 nests on clay soil and 105 nests on sandy soil located in all grazing systems and major plant communities. Intuitively, one might expect higher predation rates on sandy, bottomland soils which were located near the Aransas River, where raccoon populations may have been higher. However, although nest survival appeared lower on sandy soil, the difference was not significant (Fig. 1i). Slower infiltration rates may increase the risk of flooding on clay soil pastures, which can be a major mortality factor of turkey nests (Markley 1967). During the second week of July 1976, heavy rains flooded clay soil pastures with as much as 30 cm of standing water causing many dummy nests to be underwater for as long as a week. No nests were observed flooded on sandy soils.

Pasture Deferment Time: Survival rate was significantly higher in the pasture deferred longer (Fig. 1c). Although there was little difference in deferment time between pastures, the 41-day pasture was deferred during the critical growth period (3 May - 13 June) and produced substantial nesting cover. In the 10-day pasture, cattle were grazed from 8 June to 29 June, which was at the end of spring vegetation production. Vegetation was heavily grazed and had no time to recover before nests were placed in the field. Consequently, there was a visible lack of adequate nesting cover in the recently grazed pasture, which surely must have influenced nest survival. These results support others (Ligon 1946, Kirsch 1969) who found that overgrazing or concentrations of livestock limit nesting success of ground-nesting birds.

Cover Type: Although the survival of nests in good cover appeared higher, the difference was not significant (Fig. 1g). Based on subsequent experience, nests placed in some locations, such as the edge of dense brush, that were initially thought to be in good cover, probably were in fair cover. Nests that had the highest survival were in locations

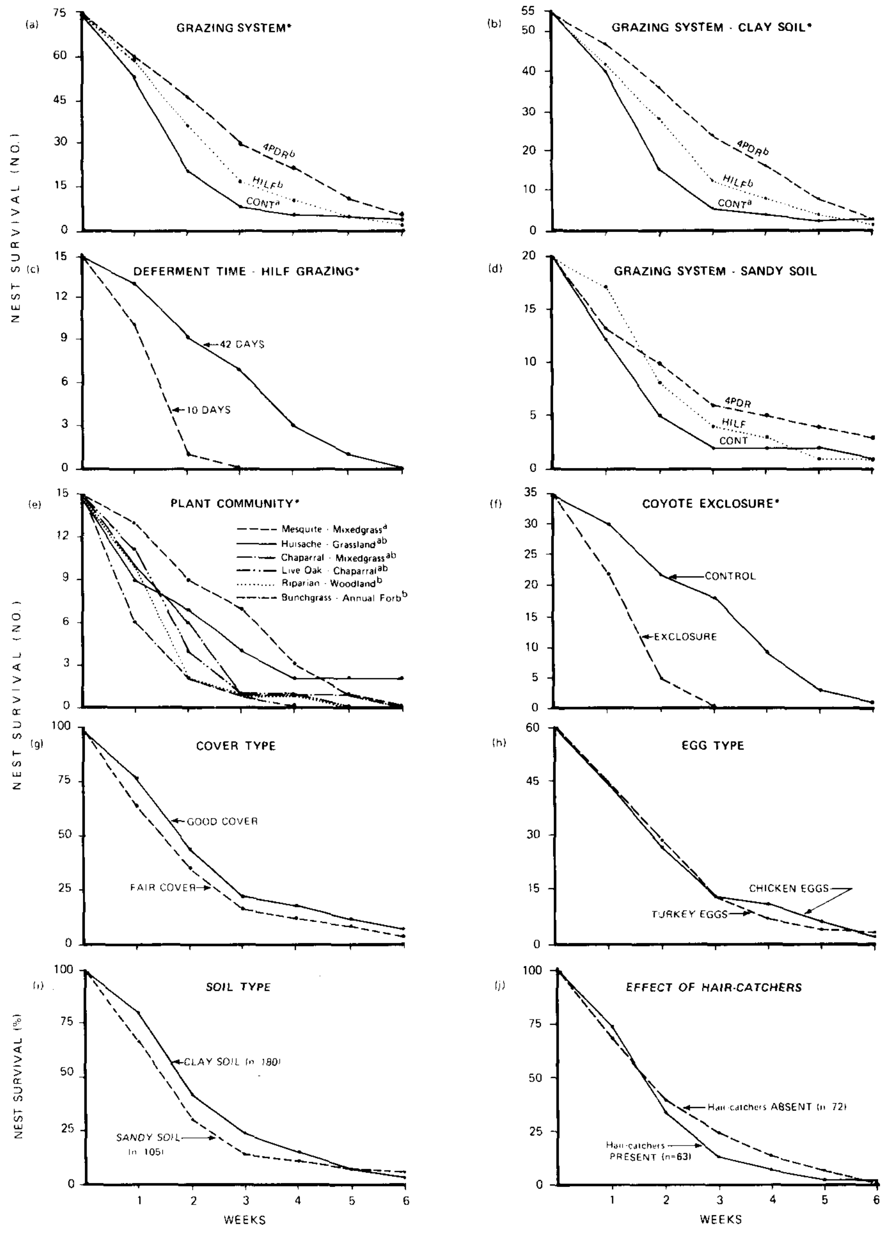

Fig. 1. Ecological factors affecting dummy nest survival on the Welder Wildlife Refuge. An asterisk indicates survival rates were significantly different for 2 or more variables. Variables not followed by the same superscripted letter (a,b) were significantly different.

with dense ground-surface vegetation, away from any trails, fences, or brush with an open understory. In my opinion, cover type may have been a significant factor contributing to nest survival.

Studies of the influence of cover on nest survival have produced varied results. In South Texas, Beasom (1969) found cover type was highly correlated ($r = 0.98$) to nest survival, based on nests in excellent, good, fair, and poor cover. Schrank (1972) found that density and height of waterfowl nest cover increased overall productivity. However, in a study of waterfowl dummy nests in Iowa, Byers (1974) found vegetation cover had no effect on nest survival.

Plant Community: Nest predation rates were significantly different among 6 major plant communities on the Welder Refuge (Fig. 1e). Multiple comparison tests showed that nest survival was greater in mesquite-mixedgrass than in bunchgrass-annual forb or riparian-woodland. No other plant communities were significantly different from each other. Mesquite-mixedgrass occurred on upland, clay soil sites, farthest from the Aransas River bottomlands. Nesting cover was excellent, with many areas of low, running mesquite densely overgrown with grasses. The bunchgrass-annual forb community had a tall, dense canopy of Texas croton (*Croton texensis*), a large forb which shaded-out the ground surface to such an extent that many areas were bare sand. I believe that this lack of cover at the first 15 cm above the ground was primarily responsible for the extraordinary rate of nest predation, 60% after 1 week and 100% after 3 weeks. The riparian-woodland community was immediately adjacent to the Aransas River. The dense overstory of hackberry (*Celtis* spp.) trees effectively shaded-out herbaceous vegetation resulting in inadequate nesting cover in most areas. Locations without a hackberry canopy developed extremely tall, dense herbaceous vegetation, but were limited in size and distribution, and often had sparse ground-surface vegetation similar to the bunchgrass-annual forb community. In addition, raccoon populations were probably high in these riparian areas.

The 3 remaining plant communities had intermediate nest predation rates. Huisache-grassland visually had the best nesting cover of the 6 plant communities. Nest survival might have been higher, had this community not been located adjacent to riparian areas. Chaparral-mixedgrass consisted of large chaparral mottes which offered only sparse nesting cover at the ground surface. Nest survival was understandably poor. Live oak-chaparral had fairly good nesting cover, but nest survival was much lower than expected. Beasom (1969) also found low nest survival in live oak areas of South Texas. The influence of plant community on nest predation apparently was substantial. Differences in available nesting cover probably greatly influenced differences in nest survival. Other factors, such as predator density and diversity, and the juxtaposition of plant communities, undoubtedly influenced survival.

Coyote Exclosure: Nest predation was significantly higher inside the 387-ha coyote exclosure than in an open pasture (Fig. 1f). Plant communities and available nesting cover were similar between areas. A decrease in coyote populations often causes an increase in carnivorous mammal populations (Robinson 1961, Pringle 1977). In coyote-control areas, Robinson (1961) found over a 3-fold increase in striped skunks and an 8-fold increase in raccoons.

Predator identification data (discussed later) indicated striped skunks and raccoons were the major nest predators on the Refuge. Coyote predation on nests was relatively insignificant. On the Welder Refuge, the elimination of coyotes from the exclosure probably caused an increase in raccoons and/or skunks by either or both of 2 possible mechanisms. Either removal of coyotes decreased direct predation pressure on raccoons and skunks or increased the prey base available to raccoons and skunks with subsequent increases in carrying capacity. Young and Jackson (1951) reported the case of a coyote digging out 13 young skunks from a den. There may be other possible causative factors, such as in increase in nest/food searching activities per predator, but I feel these are less likely to be major factors responsible for such dramatic changes in nest predation rates.

Hair-catchers: There were no significant differences in predation rates between nests with and without hair-catchers (Fig. 1j); although they made nests much more visible, and undoubtedly increased the human scent at the nest. Similarly, Keith (1961) found no difference in predation rates between dummy nests with no human scent and no tracks, and nests with fresh human scent and tracks. These results indicate that predators may rely heavily on odors emitted from the eggs to locate dummy nests.

Egg Type: On the Welder Refuge, nearly identical predation rates were found for domestic chicken and turkey eggs (Fig. 1h). Past dummy nest studies were found that used turkey eggs, domestic or otherwise. These results indicate that researchers using dummy nests could use either type of egg to yield the same results.

Egg Freshness: An analysis of the two 3-week check periods following nest placement/egg replacement showed nest predation rates increased each week (Fig. 2). The increase in nest predation rates probably indicated that as eggs began to rot, the increased odors made nests easier for predators to locate. After the first week, unless cracked, eggs did not smell any stronger than when fresh. After 2 weeks, the odor was much stronger and eggs smelled slightly rotten . At the 3-week check period, depending on the amount of shade at the nest, eggs smelled quite rotten at a distance of 3 m, and nests were occasionally smelled before they were seen. Weekly increases in predation rates may also have been related to a simple time-search effect. Matschke (1965) similarly found a

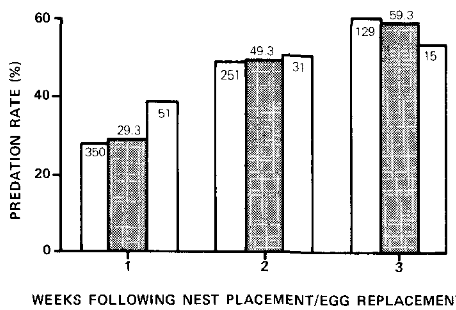

Fig. 2. Weekly differences in nest predation rates on the Welder Wildlife Refuge. Numbers inside clear bars indicate number of nests; numbers over stippled bars indicate weighted mean predation rates.

weekly increase in predation rates. However, rates were higher the first week than the second, presumably because of human odors left during nest construction. These results suggest nest predators relied heavily on smell to locate nests. However, due to differences in smell related to the presence of a hen on the nest and fertile eggs, these results are not directly applicable to actual wild turkey nests.

Welder Refuge Nest Predation

Seventy-seven of 78 nests with hair-catchers were destroyed by predators. Forty-five of these nests had hair-catchers with 1 or more mammal hairs, all of which were later identified. Eighteen nests had raccoon hair, 15 had striped skunk hair, 9 had both striped skunk and raccoon hair, and 3 had coyote hair. Two nests with hair-catchers were probably disrupted by armadillos.

Predators were identified from only 8 of 265 nests without hair-catchers. One nest was possibly disrupted by an armadillo, the eggs were scattered but not broken. Snakes were probably responsible for the destruction of 2 nests in which 4 or more eggs were missing. Two nests had eggs with small, 1 cm diameter, jagged holes in the shell possibly made by roadrunners (*Geococcyx californianus*); crows and ravens did not occur on the

Refuge. At 1 nest, 2 turkey vulture (*Cathartes aura*) contour feathers were found. All eggs were moved slightly from the nest, with 1 broken and the rest intact. Other potential nest predators were either of rare or of hypothetical occurrence on the Refuge.

Raccoons and skunks have been cited as major nest predators in many parts of their range. Davis (1959) found 29% predation by raccoons and 21% by skunks on dummy turkey nests in Alabama. Breece and Causey (1973) found armadillos destroyed 26% of predated dummy bobwhite (*Colinus virginianus*) nests; however, Kennamer and Lunceford (1973) found armadillos walked by or rooted through 21 dummy turkey nests without damaging any eggs. Matschke (1965) found European wild hogs were major predators of dummy nests, although a follow-up study by Henry (1969) could not substantiate this. Although feral hogs were common on the Refuge, no evidence was found to implicate them as nest predators.

Results indicated that raccoons and striped skunks were the major nest predators on the Welder Refuge, coyotes and armadillos were of minor importance, and the effect of other predators was probably negligible.

Nest Predator Characteristics

To identify predator sign at destroyed nests, 45 nests were analyzed based on predator identification from hair samples (Table 1). There were no distinguishing

Table 1. Summary of predator sign left at 45 dummy nests on the Welder Wildlife Refuge. Predators were identified from hair samples caught at the nest.

Variable	*Raccoon*	*Skunk*	*Skunk & Raccoon*	*Coyote*	*Total*
	Number of eggs				
Eggshell remains					
1-3 cm hole in side or end	7	10	0	7	24
Half-broken from end	21	9	8	11	49
Half-broken from side	3	8	1	1	13
More than half-broken from end	19	10	4	2	35
More than half-broken from side	6	6	4	1	17
Completely broken - separate pieces	52	30	24	3	109
Completely broken - crushed	15	12	24	1	52
Completely broken - unknown	8	27	5	0	40
OK	9	19	0	30	28
Missing	41	19	19	4	83
Total Eggs	180	150	90	30	450
Eggshell location	*Number of nests*				
Close	7	4	3	1	15
Moderately scattered	8	7	4	0	19
Widely scattered	3	4	2	2	11
Total Nests	18	15	9	3	45
Nest disturbance	*Number of nests*				
None or light	4	3	2	1	10
Moderate	8	6	2	0	16
Heavy	4	5	4	2	15
Unknown	2	1	1	0	4
Total Nests	18	15	9	3	45
Small holes dug at nest site	3	4	1	0	8

patterns found for raccoons and skunks. Basically, the extreme individual variation made determination of characteristic sign impossible. Based on 3 nests, coyotes showed a tendency to make only a small hole in the egg or break it in half from the end. This generally agrees with Sooters' (1946) results using captive coyotes. However, because of the degree of overlap between coyotes, raccoons, and skunks, predator identification where these species occur may be unreliable.

The interpretation of results based on hair-catchers may be biased. It was possible that a nest was destroyed by a particular species which left no hair, and then another species left hair while examining the nest remains. It was also possible for 2 different species to each destroy a portion of the eggs, thus adding further confusion to predator identification. In support of these statements, 9 of the 45 nests had both raccoon and skunk hair, with no way of knowing which predator did the damage.

Based on "characteristic" sign, biologists could easily identify more than 1 predator for the same nest, depending on which reference is chosen from the literature. Consider the following quotations concerning the remains of eggs destroyed by skunks, "invariably the end of the egg will be opened almost as if it had hatched", Davis (1959); "bites off the top of bobwhite quail eggs and licks out the contents, Stoddard (1932); "bites off the small end and laps the liquid from the ground", Latham (1956); "complete chewing of the shells appears to be most common . . . thus the membrane and shell fragments more or less cling together in a shapeless mass", Rearden (1951); "breaks duck eggs with its teeth, using its paws and tongue to enlarge the opening . . . usually breaking more than half the shell and crushing it", Sowls (1948); "invariably crushes the shells completely", Darrow (1938).

Considering my results and the ambiguity in the literature, I propose that skunks, raccoons, coyotes, and possibly other nest predators cannot reliably be identified by sign left at destroyed nests, unless sign other than method of egg destruction is present.

CONCLUSIONS

During the summers of 1976 and 1977, predation rates were determined for 350 dummy wild turkey nests on the Welder Wildlife Refuge in south Texas. The results of this study yielded the following conclusions:

(1) Nest survival was higher in pastures under rotational grazing systems (4PDR, HILF) than in pastures continuously grazed.

(2) Nest survival was higher in a pasture deferred 41 days than in one deferred 10 days.

(3) Nest survival was lower inside a 387-ha coyote exclosure than in an open pasture. Coyote removal probably caused either a decrease in predation pressure on raccoons and skunks or an increase in their available prey base.

(4) Nest predation rates were significantly different among major plant communities. Survival was higher in mesquite-mixedgrass than in bunchgrass-annual forb or riparian-woodland. Differences in survival were probably related to available nesting cover, juxtaposition of plant communities, or predator density and diversity.

(5) Although nest survival appeared lower on sandy soil than on clay soil, the difference was not significant. During heavy rains, nests on clay soil were more likely to be flooded than nests on sandy soil.

(6) No differences in survival were found for cover type, egg type, or the effects of hair-catchers at nests.

(7) Predation rates increased each week following nest placement/egg replacement, which probably indicated that as eggs began to rot, the increased odors made nests easier for predators to locate.

(8) Raccoons and skunks were the major nest predators on the Welder Refuge. Coyotes, armadillos, and snakes were responsible for relatively few destroyed nests.

(9) Extreme individual variation in the methods predators used to destroy nests made determination of characteristic sign impossible. Based on these results and certain ambiguities in the literature, I propose that skunks, raccoons, coyotes, and possibly other nest predators cannot reliably be identified by sign left at destroyed nests, unless sign other than method of egg destruction is present.

LITERATURE CITED

Adorjan, A. S., and G. B. Kolenosky. 1969. A manual for the identification of selected Ontario mammals. Ontario Dept. of Lands and Forests. Res. Rep. (Wildl.) No. 90. 65 pp.

Bailey, R. W., and K. T. Rinell. 1967. Events in the turkey year. Pages 73-92 *in* O. H. Hewitt, ed., The wild turkey and its management. The Wildlife Society, Washington, D.C.

Beasom, S. L. 1969. Turkey productivity in three vegetative communities in South Texas. M.S. Thesis. Univ. Wisconsin, Madison. 26 pp.

Breece, G. A., and M. K. Causey. 1973. Armadillo depredation of "dummy" bobwhite quail nests in southwest Alabama. Proc. Southeastern Assoc. Game and Fish Comm. 27:18-22.

Byers, S. M. 1974. Predator-prey relationships on an Iowa waterfowl nesting area. Trans. N. Am. Wildl. Nat. Resour. Conf. 38:223-229.

Conover, W. J. 1971. Practical nonparametric statistics. John Wiley and Sons, Inc., N. Y. 462 pp.

Cook, R. L. 1972. A study of nesting turkeys in the Edward's Plateau of Texas. Proc. Southeastern Assoc. Game and Fish Comm. 26:236-244.

Darrow, R. W. 1938. Possibilities of recognizing the evidence of predation and the species involved in the remains of grouse and grouse nests found destroyed. Trans. N. Am. Wildl. Conf. 3:834-838.

Davis, J. R. 1959. A preliminary progress report on nest predation as a limiting factor in wild turkey populations. Pages 138-145 *in* Proc. First Natl. Wild Turkey Manage. Symp., Memphis, Tenn.

Drawe, D. L., A. D. Chamrad, and T. W. Box. 1978. Plant communities of the Welder Wildlife Refuge. Contrib. No. 5, Ser. B. Rev., Welder Wildlife Foundation, Sinton, Texas. 38 pp.

Glazener, W. C. 1967. Management of the Rio Grande turkey. Pages 453-492 *in* O. H. Hewitt, ed. The wild turkey and its management. The Wildlife Society, Washington, D.C.

Gore, H. G. 1973. Land-use practices and Rio Grande turkeys in Texas. Pages 253-262 *in* G. C. Sanderson and H. C. Schultz, eds. Wild turkey management: current problems and programs. Univ. Missouri Press, Columbia.

Henry, V. G. 1969. Predation on dummy nests of ground-nesting birds in the southern Appalachians. J. Wildl. Manage. 33(1):169-172.

Keith, L. B. 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Monogr. 6. 88 pp.

Kennamer, J. E., and W. H. Lunceford, Jr. 1973. Armadillos tested as potential egg predators of wild turkeys in the Mississippi Delta. Pages 175-177 *in* G. C. Sanderson and H. C. Schultz, eds. Wild turkey management: current problems and programs. Univ. Missouri, Press, Columbia.

Kirsch, L. M. 1969. Waterfowl productivity in relation to grazing. J. Wildl. Manage. 33(4):821-828.

Latham, R. M. 1956. Complete book of the wild turkey. The Stackpole Co., Harrisburg, PA. 265 pp.

Lehmann, V. W. 1969. Forgotten legions; sheep in the Rio Grande Plain of Texas. Texas Western Press, El Paso. 226 pp.

Ligon, J. S. 1946. History and management of Merriam's wild turkey. New Mexico Game and Fish Comm. 84 pp.

Markley, M. H. 1967. Limiting factors. Pages 199-244 *in* O. H. Hewitt, ed. The wild turkey and its management. The Wildlife Society, Washington, D.C.

Matschke, G. H. 1965. Predation by European wild hogs on dummy nests of ground-dwelling birds. Proc. Southeastern Assoc. Game and Fish Comm. 19:154-157.

Merrill, L. B. 1975. Effect of grazing management practices on wild turkey habitat. Pages 108-112 *in* L. K. Halls, ed. Proc. Third Natl. Wild Turkey Symp., San Antonio, Texas.

Moore, T. D., L. E. Spence, C. E. Dugnolle, and W. G. Hepworth (ed). 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Dept. Bull. 14. 116 pp.

Mundinger, J. G. 1976. Waterfowl response to rest-rotation grazing. J. Wildl. Manage. 40(1):60-68.

Pringle, L. 1977. The controversial coyote. Harcourt, Brace, and Javannovich, New York. 87 pp.

Rearden. J. D. 1951. Identification of waterfowl nest predators. J. Wildl. Manage. 15(4):386-395.

Robinson, W. B. 1961. Population changes of carnivores in some coyote-control areas. J. Mammal. 42(4):510-515.

Schranck, B. W. 1972. Waterfowl nest cover and some predation relationships. J. Wildl. Manage. 36(1):182-186.

Sooter, C. A. 1946. Habits of coyotes in destroying nests and eggs of waterfowl. J. Wildl. Manage. 10(1):33-38.

Sowls, L. K. 1948. The Franklin ground squirrel, *Citellus franklinii* (Sabine), and its relationship to nesting ducks. J. Mammal. 29(2):113-137.

Stains, H. J. 1958. Field key to guard hair of middle western furbearers. J. Wildl. Manage. 22(1):95-97.

Stoddard, H. L. 1932. The bobwhite-quail: its habits, preservation and increase. Charles Scribner's Sons, New York.

Young, S. P., and H. H. T. Jackson. 1951. The clever coyote. The Stackpole Co., Harrisburg, PA, and the Wildlife Management Institute, Washington, D.C. 411 pp.