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Breeding biology of Henslow's Sparrows on reclaimed coal mine grasslands in Kentucky

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ABSTRACT. Populations of Henslow's Sparrows (*Ammodramus henslowii*) are declining, and loss of habitat is a likely factor. Coal mine reclamation has created grassland habitat in Kentucky and elsewhere, and information is needed concerning the use of these areas by Henslow's Sparrows. We compared the behavior and ecology of populations on reclaimed sites and non-mined sites in west-central Kentucky during the 2000 and 2001 breeding seasons. Territories were smaller on the reclaimed sites than unmined sites, perhaps due to differences in habitat quality. Insect sweeps revealed more prey biomass on reclaimed sites than unmined sites. Twenty-eight of 48 nests (58%) fledged at least one young, and nesting success was similar on reclaimed and unmined sites. Mean clutch size was 3.75, with no difference between reclaimed and unmined sites. Similarly, the mean number of fledglings per nest was similar on reclaimed and unmined sites. Multivariate analysis revealed differences in the characteristics of vegetation on reclaimed areas and unmined areas. Reclaimed areas had more grass cover and greater vegetation density, probably due to differences in management history (i.e., mowing or burning) and species composition. Our results indicate that the nesting success of Henslow's Sparrows on reclaimed surface mines in Kentucky is comparable to that on unmined areas. As such, the thousand of hectares of reclaimed surface mines in Kentucky and elsewhere could play an important role in stabilizing populations of Henslow's Sparrows.

SINOPSIS. **Biología reproductiva de *Ammodramus henslowii* en un hierbazal establecido en donde hubo una mina de carbón en Kentucky**

La población del pinzón *Ammodramus henslowii* se ha reducido y el factor principal parece ser la pérdida de hábitat. La reclamación de terrenos en donde antes hubo minería de carbón, ha permitido la formación de hierbazales tanto en Kentucky como en otras localidades. Se necesitan estudios para determinar si estas áreas están siendo otra vez utilizadas por el pinzón. Durante la época reproductiva del 2000 y el 2001, comparamos la conducta y la ecología poblacional del pinzón en áreas reclamadas y en lugares en donde no había minas (natural) en la parte oeste central de Kentucky. Encontraron que los territorios eran más pequeños en áreas reclamadas que en las naturales, posiblemente por diferencias en la calidad del hábitat. El uso de redes de barrido para capturar insectos dio como resultado mayor biomasa de presas en lugares reclamados que en los naturales. De 28 nidos (de 48), voló al menos un pichón y el éxito de anidamiento fue similar en ambos tipos de localidades, al igual que la camada promedio de 3.75 y el número de volantones. Un análisis multivariable reveló diferencias en las características de la vegetación entre las áreas reclamadas y las naturales. Las áreas reclamadas tuvieron mayor cobertura de yerbas y una densidad mayor de vegetación, probablemente debido a diferencias en la historia de manejo (ej. sgar vs. quemar) y la composición de especies. Nuestros resultados indican que el éxito de anidamiento del pinzón en áreas reclamadas es similar al de áreas naturales. Como tal, los miles de hectáreas de tierras superficiales reclamadas en donde hubo minas en Kentucky, al igual que en otras localidades, puede jugar un rol sumamente importante en estabilizar las poblaciones de Pinzón de Henslow.

Key words: *Ammodramus henslowii*, breeding, Henslow's Sparrow, nesting, reclaimed surface mine, vegetation

Many migratory songbirds are currently experiencing significant population declines, with populations of many grassland bird species declining at rates exceeding those of most forest species. Among the grassland species exhibiting precipitous population declines is the Henslow's Sparrow. Theses sparrows prefer large tracts of tall, dense vegetation, and the scarcity of such tracts may limit their distribution (Herkert 1994). Throughout their range, Henslow's Sparrows have declined by nearly 91% over the past 30 yr (Peterjohn et al. 1994), and, as a result, have been listed as a species of special concern in several states, including Kentucky (Kentucky State Nature Preserves Commission 1992).

Historically, Henslow's Sparrows were limited to prairie remnants east of the Great Plains (Ridgway 1889), and such remnants have mostly disappeared (Noss et al. 1995). However, these sparrows now occupy other types of grasslands, including pastures and reclaimed surface

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mines (Sample 1989; Herkert 1994). Surface mine reclamation, in particular, has created large areas of grassland in the midwest. For example, Bajema et al. (2001) estimated that reclamation in southwestern Indiana alone has created 180 km^2 of "mine grasslands." While Henslow's Sparrows are known to occupy such grasslands (Bajema et al. 2001), no one to date has examined their reproductive success on these sites or compared the structure of these sites to that of other, non-mined sites (hayfields and old fields) used by these sparrows. Because surface mines provide more potential Henslow's Sparrow habitat than more natural sites in many parts of the Midwest, such information is clearly needed to determine if mine grasslands can be a factor in the conservation and management of Henslow's Sparrow populations. The objective of our study was to compare the breeding biology and nesting success of Henslow's Sparrows on natural (unmined) and reclaimed sites in central Kentucky.

METHODS

Henslow's Sparrows were studied at four sites (two unmined and two reclaimed surface mines) from 15 April–1 August 2000 and at a single reclaimed mine site (one of those studied in 2000) from 15 April–1 August 2001. The two mine sites were located 2 km apart on the River Queen Unit of the Peabody Wildlife Management Area, Muhlenberg County, Kentucky. One site (RQ1; 10 ha) was managed as a seed plot for native warm season grasses by the Kentucky Department of Fish and Wildlife Resources (KDFWR) and consisted primarily of big bluestem (*Andropogon gerardii*), switch grass (*Panicum virgatum*), little bluestem (*Schizochyrium scoparium*), and sericea lespedeza (*Lespedeza cuneata*). The other reclaimed site (RQ7; 18 ha) consisted primarily of fescue (*Festuca* sp.), sericea lespedeza, and broom sedge (*Andropogon virginicus*).

The two unmined sites were at the Goodman Army Airfield at Fort Knox, Meade County, Kentucky, and at Green River Lake State Park, Taylor County, Kentucky. The Fort Knox site (7.7 ha) was located between runways and consisted primarily of switch grass, little bluestem, broom sedge, fescue, and sericea. Several patches of willows, blackberries, and milkweed (*Asclepias* sp.) were also present. The Green River site (12.3 ha) consisted primarily of fescue, sericea, blackberries, eastern redcedars, and broom sedge.

Beginning in mid April of each year, Henslow's Sparrows were captured in mist nets and uniquely marked with a numbered aluminum band and three colored plastic bands. The sex of captured birds was determined by the presence of either a brood patch (females) or cloacal protuberance (males). Study sites were subdivided into 40-m blocks to permit more accurate determination of the location of birds, nests, and habitat features. Territory sizes and boundaries were delineated early in the season (1 May) and later (15 July) by flushing males 15 to 20 times and noting all locations on maps of the study areas. Boundaries were determined by observing where a male turned directions more than once when being flushed and by noting the locations of encounters between neighboring males.

Beginning in mid May, we searched for nests by walking through territories, searching likely locations, and by observing the behavior of resident pairs. Nests were monitored twice a week until either fledging or failure.

Insect sweeps were conducted at each study site from 10–18 July 2000. An insect sweep net (30-cm diameter) was swung back and forth while walking a straight 25-m transect located entirely within a territory. Because territories were relatively small and irregularly shaped, transects were typically located where territories were widest.

After young fledged or a nest failed, the characteristics ($N = 20$) of nests and nest sites were determined. We noted the species of plant in which the nest was located and opening direction (each nest had one main opening). Percent concealment of each nest was estimated from one meter in all four cardinal directions and from above. Vertical cover was quantified using a curtain placed 11 m from the nest in each of the four cardinal directions. On the curtain were three 49 cm × 49 cm squares arranged vertically, and each included a smaller grid of 49 7 cm × 7 cm squares. Concealment was then measured for each large square by counting the number of smaller squares at least 50% obscured by vegetation from a kneeling position at the nest.

The characteristics of vegetation around the nests were also quantified. At each of five locations (1.2 meters apart) along 11-m transects extending from the nest site in all four cardinal directions, the height of live and dead plant material was determined (within 1.0 cm of the meter stick). We determined vegetation density by counting the number of "hits" (vegetation passing within 0.5 cm of the stick) of live and dead vegetation below 0.5 m, from 0.5 to 1.0 m, and above 1 m. Litter depth was also measured at each point. A densitometer was used to determine if vegetation was present at each location and, if so, the type of vegetation (grass, forb, or tree).

We had originally intended to examine site fidelity in successive years (2000–2001) at all study sites, but, three of the four sites were either mowed or burned after the first year of the study, leaving only one site (RQ7) undisturbed. Therefore, from 1 May–1 August 2001, we continued the study at RQ7 and noted site fidelity at that site only.

Statistical analyses. We examined possible differences among study sites in nest success using chi-square tests, while possible variation in clutch sizes, number of fledglings, and size of territories over time (early vs. late breeding season) and among sites (reclaimed vs. unmined) was examined using Wilcoxon tests. To examine possible variation among study sites in mean insect biomass, one-way analysis of variance was used. Rayleigh's test was used to determine if nest entrances exhibited a significant mean population direction (Zar 1996).

Mean values of successful and unsuccessful nests as well as used and unused nest sites were compared using multivariate analysis of variance. Stepwise discriminant analysis (backward procedure) was used to identify variables that best discriminated ($P < 0.05$) between nests (successful vs. unsuccessful) and sites (used vs. unused). The cross-validation technique was then used to evaluate model classification efficacy (Williams et al. 1990). Cohen's *Kappa* and its Z value were calculated to test model performance (Titus et al. 1984). All statistical procedures were conducted using the Statistical Analysis System (SAS Institute 1999). Values are presented as means ± 1 SE.

RESULTS

Based on the presence of singing males, at least 45 pairs of Henslow's Sparrows were present on the four study sites in 2000, with eight pairs at Fort Knox (1.04 pairs/ha), 10 at Green River (0.81 pairs/ha), 12 at RQ1 (0.83 pairs/ha), and 15 at RQ7 (1.20 pairs/ha). Two males banded in 1999 at Fort Knox (out of nine Henslow's Sparrows banded; S. Ibarguen, pers. comm.) were recaptured at the same location in 2000. Two of 18 sparrows (one male and one female) banded in 2000 at RQ7 returned to and nested at the same location in 2001.

Territories of Henslow's Sparrow increased in size during the breeding season ($z = 3.46$, $P < 0.001$), with a mean size of 0.31 ± 0.01 ha ($N = 43$) on 1 May and 0.38 ± 0.02 ha ($N = 42$) on 15 July. For males that remained on territories from 1 May to 15 July ($N = 21$), territory size also tended to increase in size ($z = 2.47$, $P = 0.014$), with a mean size of 0.31 ± 0.02 ha on 1 May and 0.40 ± 0.03 ha on 15 July. Territories were generally larger on unmined sites than reclaimed sites, with differences significant on 15 July ($z = 3.22$, $P = 0.0013$) and approaching significance on 1 May ($z = 1.91$, $P = 0.056$). On 15 July, mean territory sizes were 0.45 ± 0.03 ha ($N = 17$) on unmined sites and 0.33 ± 0.01 ha ($N = 25$) on reclaimed sites, respectively. On 1 May, mean territory sizes were 0.34 ± 0.03 ha ($N = 18$) on unmined sites and 0.29 ± 0.02 ha ($N = 25$) on reclaimed sites, respectively.

In 2000, 37 nests ($N = 30$ pairs) were located, with six empty (and, therefore, their outcome unknown) when discovered. Of the 31 nests whose outcome was determined, 23 (74.2%) were successful (fledged at least one young). The Mayfield (1975) estimate of nesting success for 2000 was 32.1%. In 2001, five of 16 nests (31.3%) were successful, or 18.8% as estimated using Mayfield (1975). In all cases, predation appeared to be the cause of failure. Brown-headed Cowbirds (*Molothrus ater*) parasitized one nest in 2000 and no nests in 2001. The single parasitized nest had one cowbird egg and no sparrow eggs, suggesting it was abandoned before initiation of egg-laying.

In 2000, no differences in nest success were found either among the four study sites ($\chi^2_3 = 3.9$, $P = 0.27$) or between reclaimed (11 of 14 nests successful) and unmined (12 of 17 nests successful) sites ($\chi^2_1 = 0.26$, $P = 0.62$). Overall, mean clutch size was 3.75 ± 0.09 ($N = 44$), with no difference between years ($z = 1.85$, $P = 0.06$). Similarly, in 2000, we found

Table 1. Mean values (±SE) of variables permitting the best discrimination between reclaimed and unmined areas.

Variable	Reclaimed sites	Unmined sites
Percentage grass cover	68.33 ± 0.04	54.65 ± 0.03
Vegetation height, live (cm)	73.64 ± 1.36	65.30 ± 2.88
No. vegetation hits <0.5 m, live	6.11 ± 0.21	7.25 ± 0.19
No. vegetation hits <0.5 m, dead	5.93 ± 0.41	4.90 ± 0.32
No. vegetation hits >1 m, dead	0.04 ± 0.01	0.16 ± 0.03
Percentage vertical cover, 0.5–1 m	70.76 ± 3.65	64.53 ± 3.94
Percentage vertical cover, >1 m	13.27 ± 3.04	26.80 ± 3.82

no difference (z = 1.17, P = 0.25) in mean clutch size either between reclaimed ($\bar{x}$ = 3.36 ± 0.27) and unmined ($\bar{x}$ = 3.69 ± 0.12) sites or among months (May vs. June and July combined; z = 1.25, P = 0.22). Overall, the mean number of fledglings per successful nest was 2.64 ± 0.34 (N = 31), with no difference between years (z = 1.9, P = 0.06). In 2000, we found no difference in mean number of fledglings per nest between reclaimed ($\bar{x}$ = 2.42 ± 0.51) and unmined ($\bar{x}$ = 2.35 ± 0.50) sites (z = 0.08, P = 0.93).

In 2000, nine pairs of Henslow's Sparrows were double-brooded (at least one nesting attempt after fledging young from a previous nest), and two pairs successfully raised three broods. In 2001, two pairs attempted a second nest after fledging young from a previous nest, one pair had two failed nests before fledging young from their third nest, and two other pairs had two unsuccessful nests. In 2000, mean clutch size was 3.88 ± 0.10 (N = 26) for first nests and 3.56 ± 0.24 (N = 9) for second nests, and this difference was not significant (z = 1.17, P = 0.24).

In 2000, Henslow's Sparrow nests (N = 35) averaged 17.71 ± 1.17 cm (range, 7.0–37.0 cm) above the ground (measured from the ground to the bottom of the nest entrance). Most (N = 34) nests were located in the base of a thick clump of grass or forb, with one nest located in an eastern redcedar. Orientation of nest entrances (N = 33) differed significantly from random (Rayleigh's test, z = 16.73, $P <$ 0.001), with a mean orientation of 110.6 ± 47.2 degrees.

Mean concealment of nests (N = 36) was 91.2 ± 1.3%, with no difference (z = 1.86, P = 0.07) between successful ($\bar{x}$ = 93.6 ± 1.2%) and unsuccessful nests ($\bar{x}$ = 89.2 ± 1.9%). Similarly, successful and unsuccessful nests did not differ (Wilcoxon tests, $P >$ 0.25) in either height or orientation.

Insect sweeps were conducted in the territories (N = 37) of Henslow's Sparrows in 2000 and the mean mass of insects collected per sweep was 3.82 ± 0.22 grams. Mean insect mass per sweep varied among the four study sites ($F_{3, 33}$ = 7.21, P = 0.008), with greater masses (Tukey's test; $P <$ 0.05) at the two reclaimed sites ($\bar{x}$ = 4.86 ± 0.31 gms; N = 14) than the two unmined sites ($\bar{x}$ = 3.20 ± 0.35 gms; N = 23).

Multivariate analysis revealed no differences either in the characteristics of vegetation around nest sites and unused sites (Wilks' lambda = 0.81, $F_{20, 37}$ = 0.45, P = 0.97) or the vegetation around successful and unsuccessful nests (Wilks' lambda = 0.38, $F_{20,10}$ = 0.82, P = 0.66). However, analysis did reveal differences in the characteristics of vegetation around sites (nest sites and unused sites combined) on reclaimed areas and unmined areas (Wilks' lambda = 0.17, $F_{20, 37}$ = 9.22, $P <$ 0.0001). Stepwise discriminant analysis revealed that seven variables permitted the best discrimination between reclaimed and unmined areas: percent grass, height of live vegetation, foliage density (both live and dead plants) below 0.5 m, foliage density (dead plants) above 1 m, vertical cover between 0.5–1 m above ground, and vertical cover above 1 m (Table 1). A discriminant function analysis using these seven variables correctly classified 94% of the sites on unmined sites and 96% of the sites on reclaimed sites (90% better than by chance alone; Cohen's *Kappa Z* = 6.75, $P <$ 0.001).

DISCUSSION

The size of Henslow's Sparrow territories in our study increased during the breeding season.

Other investigators have reported similar results (Robins 1971; Johnsgard 1979). Robins (1971) noted that territory size increased late in the breeding season (August and September) and this increase occurred as the number of territorial males declined. Other investigators have also reported a relationship between density and territory size. For example, Wiens et al. (1985) reported an inverse relationship between territory size and breeding population densities for Sage (*Amphispiza belli*) and Brewer's sparrows (*Spizella breweri*). However, on our sites the number of male Henslow's Sparrows appeared to remain stable throughout the season. Because territory boundaries were delineated based on where focal sparrows were observed, it is possible that the apparent increases in territory size later in the season may have been the result of increased visibility. Use of certain parts of territories may have become more obvious as adults were observed foraging and flying to nests to feed young. However, some adult Henslow's Sparrows moved into previously unused areas when following and feeding fledglings and such movements did contribute to an increase in the size of some territories.

Territories of Henslow's Sparrows in our study were larger on unmined sites than on reclaimed sites, even though densities were comparable. Territory size may be influenced by habitat quality (Wiens et al. 1985; Smith and Shugart 1987). Specifically, birds in habitats with more or higher-quality resources, such as food, may not need as much space to meet their resource needs (Hunt 1996). Our insect sweep data suggest that prey were more abundant on reclaimed sites than unmined sites, and this difference may have contributed to the observed differences in territory sizes.

Characteristics of the vegetation on reclaimed sites and unmined sites in our study differed, with reclaimed areas having more and taller grass cover and a greater density of dead vegetation close to the ground (<0.5 m), and unmined sites having a greater density of live vegetation close to the ground and dead vegetation above 1 m plus greater vertical cover above 1 m. However, these differences were likely the result of differences in recent management history and species composition. Our unmined sites, Green River and Fort Knox, had apparently been mowed regularly (every 2–3 yr; B. Palmer-Ball, pers. comm.), while the reclaimed coal mine sites (RQ1 and RQ7) had apparently never been mowed. This difference is likely responsible, at least in part, for the greater grass cover and greater density of dead vegetation near the ground on the reclaimed sites.

Successful and unsuccessful Henslow's Sparrow nests in our study did not differ in height, orientation, or concealment. Similarly, Winter (1999) reported no differences in the characteristics of depredated and successful Henslow's Sparrow nests in southwest Missouri. The importance of nest concealment may differ among species because of differences in nest predators. For example, some nest predators, such as birds, are more visually oriented (Burhans and Thompson 1998) and, for species with nests at risk from such predators, nest concealment may be important. However, other predators, such as snakes, may depend more on chemical stimuli (Schaub et al. 1992), and, where snakes are the primary nest predators, nest concealment may be less important. For example, nest cover reportedly had no effect on the chances of nest predation by snakes in other ground-nesting species (Best 1978; Wray and Whitmore 1979). The importance of snakes as predators of bird nests in grasslands is well documented (Thompson et al. 1999), and snakes do prey on the eggs and nestlings of Henslow's Sparrows (Hyde 1939; Graber 1968). However, other, more visually oriented predators, can also be found in or near grassland habitats, including Northern Harriers (*Circus cyaneus*) and American Crows (*Corvus brachyrhynchos*). The presence of a variety of predators using different search strategies may eliminate predictably safe nest sites (Filliater et al. 1994). However, greater nest concealment might reduce the chances of predation by some predators, and explain the high levels of nest concealment observed in our study and other studies (Winter 1999) of Henslow's Sparrows.

Henslow's Sparrows in our study tended to orient nest entrances to the east-southeast. Such orientation may have been due to vegetation structure. Prevailing winds on our study areas caused the clumps of grass in which most Henslow's Sparrows built their nests to lean toward the east-southeast. As a result, it may have been easier for the sparrows to enter and exit clumps from that direction. Another possible explanation is that orienting nest entrances to the east-southeast provided thermoregulatory advantages. Entrances oriented to the east-southeast face away from the predominantly west-northwesterly prevailing winds on our study site, which may provide some thermoregulatory advantage. In addition, nests with openings oriented to the east-southeast may gain an additional thermoregulatory advantage by facing the rising sun in the early morning when temperatures are lower and away from the sun later in the day when temperatures are higher. The latter advantage may be particularly important because temperatures on or near the ground may be higher than those above ground (Sutter 1996). Other investigators have also suggested that birds may orient nest entrances for thermoregulatory advantage (Walsberg 1981; With and Webb 1993).

Nesting success for Henslow's Sparrows in our study was similar for reclaimed and unmined sites, and overall actual nesting success was 61.7% (or 27.5% using the Mayfield method). Winter (1999) reported an actual nesting success of 57.6% (39.5% using the Mayfield method) for Henslow's Sparrows in Missouri. In Michigan, actual nesting success of Henslow's Sparrows was 54.5% (Robins 1971), while, in Oklahoma, actual nesting success was 40.9% (D. Reinking, in Winter 1999). Actual nesting success of Henslow's Sparrows clearly varies among locations and years. However, our overall results (2000 and 2001 combined) suggest that nesting success of Henslow's Sparrows in Kentucky and, specifically, on reclaimed surface mines, was comparable to that on unmined areas.

Nesting success for Henslow's Sparrows in our study was also comparable to that reported for other passerines. For example, Martin (1992) determined that the mean nest success rate for 32 species of passerines was 44%. To determine if levels of reproduction by Henslow's Sparrows in Kentucky and, specifically, on reclaimed surface mines, are sufficient to maintain the current population, one would need information concerning adult survival, fledgling survival, and the fate of individuals that lose nests to predators and then disappear. However, Martin (1992) noted that many passerines maintain populations even when nest mortality rates are 50–60%. Species exposed to such levels of predation may evolve traits that tend to increase levels of reproductive success, including larger clutches and an increase in the number of nesting attempts (Martin 1992). Although additional study is needed to determine this with certainty, the levels of nesting success observed in our study, in conjunction with the near absence of cowbird parasitism and the apparent tendency for double- and even triple-brooding, suggest that populations of Henslow's Sparrows on our study sites (including reclaimed sites) may be self-sustaining and could potentially, given the high rates of nesting success in 2000, serve as source populations. Although additional, more long-term studies are clearly needed, our results, along with those of other investigators (Bajema et al. 2001), indicate that reclaimed coal-mine grasslands could play an important role in stabilizing populations of Henslow's Sparrows.

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