

and G. LeFebvre, pers. comm.), which are presumably more abundant in thorn forest than in thorn scrub during the dry season.

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Brood-rearing and postbreeding habitat use by Virginia Rails and Soras.—Virginia Rails (*Rallus limicola*) and Soras (*Porzana carolina*) are abundant summer residents in upper midwestern marshes. Relatively little is known of their ecology because of their secretive nature and the dense vegetation that they inhabit. Recent research has focused on their breeding habitat (Weller and Sparcher, Iowa Agric. and Home Econ. Exp. Stn. Spec. Rep. 43, 1965; Andrews, M.S. thesis, The Ohio State Univ., Columbus, Ohio, 1973; Baird, M.S. thesis, Fort Hays State College, Fort Hays, Kansas, 1974; Tacha, M.S. thesis, Fort Hays State College, Fort Hays, Kansas, 1975; Griese et al., *Wilson Bull.* 92:96–102, 1980; Johnson, M.S. thesis, Iowa State Univ., Ames, Iowa, 1984), but their brood-rearing and postbreeding habitat use and movements are virtually unknown. In 1982, a biotelemetry study was conducted to identify these features of their ecology.

Study area and methods.—The study was conducted on Dewey's Pasture and Spring Run Game Management Areas in northwestern Iowa. Dewey's Pasture is a 136-ha wetland complex in Clay and Palo Alto counties (Weller, Proc. Iowa Acad. Sci. 86:81–88, 1979), including 45 ha of seasonal and semipermanent marshes. Dewey's Pasture wetlands are dominated by emergent stands of cattail (*Typha glauca*), sedges (*Carex* spp.), bulrushes (*Scirpus acutus*, *S. fluviatilis*), and bur reed (*Sparaganium eurycarpum*). Spring Run in Dickinson County covers roughly 200 ha. Krapu et al. (Iowa State J. Res. 44:437–452, 1970) describe the upland vegetation. Marshes are dominated by cattail, sedges, bur reed, and willows (*Salix* spp.), and are flooded seasonally or semipermanently.

Incubating and brood-rearing Virginia Rails and Soras were located by walking through marshes near known rail territories (Johnson, 1984) and listening for the adult alarm calls (Kauffmann, *Wilson Bull.* 95:42–59, 1983). A trap consisting of a catch box (Baird, 1974) placed at the apex of a "V" formed by two leads of poultry netting was constructed near the calling adult. Rails were driven into the trap by dragging a rope weighted with rock-filled cans and jugs through the emergent vegetation toward the trap.

Captured rails were banded with U.S. Fish and Wildlife Service bands and sexed using characteristics described by Horak (M.S. thesis, Iowa State Univ., Ames, Iowa, 1964). Captured rails were equipped with AVM single-stage transmitters powered by a single Hg575 or Hg41 battery. The transmitting antenna consisted of a 15-cm stainless-steel guitar string. The entire package, encapsulated in Hysol epoxy, weighed 3.6–4.0 g. Estimated package life based on battery size and current drain of individual transmitters was 67–90 days.

The transmitter was held in place by clipping the feathers of the mantle and gluing the package to the skin with commercial eyelash cement. The package was also attached by a harness of braided nylon cord, which was tied around the birds.

Rails with transmitters were relocated at 2-day intervals with an AVM LA-12 receiver and a hand-held Yagi antenna. Locations were plotted on cover maps prepared from aerial photos of the study areas. On 1 August 1982, the Spring Run area was searched from the air.

Results.—From 25 May to 6 July 1982, 10 birds of each species (5 males and 5 females) were equipped with transmitters. Transmitters weighed from 3.9 to 4.4% of rail body weights. The mean duration of contact with birds with transmitters was 27 days \pm 16 [SD]. Contact was lost because of transmitter failure (preceded by an irregular pulse or continuous signal) or the emigration of birds from the study area.

Two brood-rearing female Soras dispersed within 4 days of capture, evidently in response to investigator disturbance. Each was relocated away from the nest vicinity once before contact was lost permanently. A female Virginia Rail died when her transmitter antenna became tangled in vegetation.

Both Virginia Rails and Soras raise their broods to independence as a family group on the breeding territory. Estimates of the home range size were obtained by plotting the outermost locations for both species. The size of this brood-rearing home range is similar to estimates of the size of the breeding territory (Glahn. *Wilson Bull.* 86:206–214, 1974). Virginia Rails and Soras occupy small brood-rearing home ranges of similar size (0.18 ha \pm 0.02 [SE] and 0.19 ha \pm 0.02, respectively). Home ranges were similar for both sexes. The home ranges of male and female Virginia Rails covered 0.16 ha \pm 0.03, and 0.22 ha \pm 0.07, respectively. Sora males and females maintained home ranges of 0.17 ha \pm 0.03, and 0.22 ha \pm 0.01, respectively.

Both members of three Virginia Rail pairs and one Sora pair were captured and equipped with transmitters. Home ranges of paired males and females typically overlapped extensively. The only exception was one pair of Virginia Rails whose combined home range followed the contours of a band of emergent vegetation bounded by upland and open water. The two home ranges formed two equally long arms of a “V.” Each sex occupied one arm, and the home ranges overlapped only at the apex. Locations for both members of the pair were uniformly distributed throughout their home ranges, and no preponderance of locations occurred at the apex. Earlier, this pair occupied a large breeding territory, which may have allowed a greater degree of pair member segregation.

Home ranges during brood-rearing typically were bounded by open water and upland. As with breeding rails, no significant preference was exhibited for any species of emergent vegetation on the home range (Johnson, 1984; Johnson, *Ecology* 61:65–71, 1980). Cover was used as available. The size of home ranges during brood-rearing was not correlated with cover type diversity for either species ($P > 0.10$) (Snedecor and Cochran, *Statistical Methods*, Iowa State Univ. Press, Ames, Iowa, 1967). Territories and home ranges were seldom located over water shallow enough for rails to wade; rather, rails moved about on floating vegetation.

The movements of postbreeding Virginia Rails and Soras preceding migration have been poorly documented. Hon et al. (*Proc. Ann. Conf. S.E. Assoc. Fish and Wildl. Agric.* 31:72–76, 1977) found that the average dispersal distance of 6 coastal Clapper Rails (*Rallus longirostris*) banded in Georgia in March through August, and shot away from the banding site, was 51 km. It is not clear how the movements of postbreeding birds of that presumably nonmigratory population compare with those of migratory Virginia Rail and Sora populations in Iowa.

We maintained contact with 16 birds with transmitters (8 Virginia Rails and 8 Soras)

until late July 1982 when they emigrated. During that time, a female Virginia Rail, already discussed, died after leaving her mate and dispersing from the vicinity of the nest, and a transmitter on a female Sora failed.

At both sites, birds with transmitters left the home ranges they used during the breeding season. Between 19 July and 1 August 1982, 7 Virginia Rails (5 males, 2 females) and 7 Soras (5 males, 2 females) dispersed from their home ranges.

The first dispersal-like movements were recorded on 12 July, when 2 unrelated Virginia Rails (1 male, 1 female) left the nest vicinity. The male was found moving along a sparsely vegetated road ditch 150 m N of previous locations. On 14 July, he was located 100 m E of the nest vicinity, across a gravel road that had previously been a boundary of his home range. He remained there until contact was lost on 19 July. On 12 July a female Virginia Rail moved her brood over 3 days to a small temporary wetland 400 m from her former home range. Another male Virginia Rail was relocated repeatedly as he moved through study area wetlands. Contact was initially lost on 19 July and was reestablished on 20 July on a semipermanent wetland 600 m N of his home range during brood-rearing. On 26 July, he was relocated 550 m SW of that location. Within 2 days, he had moved 175 m NNW. On 1 August 1982, he was located 2.3 km N of the 28 July location (2.6 km N of his home range during brood-rearing).

On 1 August a total of 522 km² surrounding the Spring Run area, including concentrations of nearby wetlands, was searched from the air. A Sora male, originally lost on 19 July, was relocated 4.8 km ESE of the study area in a soybean (*Glycine max*) field, approximately 300 m from a large seasonal wetland. A subsequent ground search for this bird indicated that he was moving. No other rails whose transmitters' signals were lost in late July were relocated in this search.

Adults remained on the brood-rearing home range until Virginia Rail young were 15–42 days old ($\bar{x} = 25$, $N = 7$) and Sora chicks were 16–32 days old ($\bar{x} = 23$, $N = 5$). Most adults emigrated from their home range when their broods were 15–21 days old. The movement of the young at the time of adult emigration is unknown. A fledgling Sora male, the only young-of-the-year with a transmitter, was captured on a Sora breeding territory on 6 July, and remained there until 23 July.

The movements of single pairs of Virginia Rails and Soras suggest that the pairbond breaks down before extensive dispersal occurs. A female Virginia Rail left her mate on 12 July and moved her 17-day-old brood to a weedy cornfield (*Zea maize*) 200 m SW of the former home range. She and her brood remained in the cornfield until 14 July, they then moved 250 m SSW to a temporary wetland where she remained on the upland-wetland interface for 4 days until she died on 18 July. Her mate remained on the family's home range until 26 July. This Sora pair raised their brood to 17–20 days (21 July), at which time the male moved across a gravel road, previously a boundary of the home range, to a 3-ha semipermanent wetland and established a home range 150 m from the female. He remained there until 5 August when contact was lost. His mate remained on the initial home range until 26 July, when she emigrated.

Discussion.—Monitoring the movements of Virginia Rails and Soras indicates that both species raise their broods on a highly localized home range, which was previously the breeding territory. Kauffmann (Ph.D. thesis, Univ. Minnesota, Minneapolis, Minnesota, 1971) noted that 3 family groups of Virginia Rails remained on their breeding territories up to 20 days after hatching, and abandoned the sites only when the marsh was nearly dry. He also noted that chicks older than one week spread out in the home range, stay within its boundaries, and are near an adult only for brooding or feeding. He noted that chicks are fed until they are 2–3 weeks old. Begging by older chicks frequently resulted in attacks by the male. Pospichal and Marshall (Flicker 26:2–32, 1954) observed 1- to 2-week-old Virginia Rail

chicks with adults, but older chicks were not seen with adults. They also noted that at 25 days Sora chicks had almost full juvenal plumage and were independent.

Irish (Jack-Pine Warbler 52:115–124, 1974) interpreted Virginia Rail and Sora responses to tape-recorded calls in July and August as defense of a postbreeding territory, though little evidence is presented to support this hypothesis. By contrast, we observed that chasing and posturing in response to taped calls, the primary means of territory defense (Kauffmann 1983), were rare within several weeks after territory establishment. The frequency of responses to taped calls declined as hatching approached (Johnson 1984). The observations made by Irish (1974) may correspond to the second peak in calling activity observed by Pospichal and Marshall (1954), Glahn (Wilson Bull. 86:206–214, 1974), and Kauffmann (1971). No clearly defined second peak was observed in this study.

Adult Virginia Rails and Soras made a previously unreported dispersal from the vicinity of the home range used for brood-rearing. We believe the stimulus for this emigration is the maturation and increasing independence of the brood. The adult male may stimulate the breakdown of the family group with increasing aggressiveness toward the chicks and his mate. Kauffmann (1971), noting that juvenile and adult rails were always observed alone during late summer, suggested that this solitary behavior was due to increasing aggressive behavior of the chicks. We were unable to determine which sex emigrated from the home range first.

When emigration or dispersal does occur, it appears to involve a fairly long-distance movement between wetlands. Pospichal and Marshall (1954) noted that, in late summer, rails left wetlands for short periods to feed on uplands. Upland areas, including row crops, may serve as initial dispersal habitat. A female Virginia Rail and her brood used a weedy cornfield for 2 days before returning to wetland habitat. A Sora, located after dispersal near an isolated seasonal wetland 5 km from his home range, must have made extensive use of row crops in the 12 days after dispersal and, indeed, was relocated in a soybean field.

The significance of this dispersal is unclear. It may simply act to segregate family members because of increasing aggressiveness, it may be a limited molt migration, or it may be a shift to a fall migration staging area. The extent and pattern of this emigration deserves further investigation if we are to understand the impact of the loss of small private wetlands.

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Growth rates and development of Redhead ducklings.—Variation in avian growth rates has been found to be related to adult body size (Ricklefs, *Ibis* 110:419–451, 1968), feeding ecology (Lack, *Ecological Adaptations for Breeding in Birds*, Methuen, London, England, 1968; Ricketts and Prince, *Ornis. Scand.* 12:120–124, 1981), predation pressure (Lack, 1968; Clark and Wilson, *Quart. Rev. Biol.* 56:253–277, 1981) and precocity of development