

I found much variation among females, most birds had some feathers left before beginning to lay eggs in first nests, but most had lost all feathers by the third or fourth day of egg-laying. Some had a few feathers on the second and third days of incubation but none thereafter.

Very few feather follicles remained evident during the incubation period although they were present in non-breeding females.

Selander and Kuich (1963) reported feather loss in Red-wings after injection with a combination of estrogen and prolactin. Their results suggest that in Red-wings, prolactin may be secreted even before egg-laying and would influence defeathering. My results show that defeathering begins before egg-laying but in some females may not be complete until day 3 of incubation. This indicates individual differences either in (1) the quantity or timing of hormone release or (2) the responsiveness of the incubation patch tissues to the hormones.

The incubation patch actually diminishes in thickness before normal incubation ceases in Bank Swallows (*Riparia riparia*) (Petersen 1955) and in the Red-wings reported on here. Incubation constancy in the Red-wings also declines during the final days of normal incubation (Holcomb 1974) suggesting that secretion of prolactin may be declining before the end of incubation.

SUMMARY

Incubation patch tissues were collected from female Red-winged Blackbirds (*Agelaius phoeniceus*) throughout pre-breeding, breeding, prolonged incubation and post-breeding seasons to discover some of the morphological changes that may affect reproductive behavior.

Changes in stratum germinativum cell layers and thickness, dermis thickness, edema, fat cells, smooth muscle, number and size of blood vessels and relative surface area of blood vessels occurred between the time females arrived at the breeding areas in spring until egg-laying. Feather loss began before egg-laying in most females and was usually complete by day one of incubation. During normal incubation, the stratum

germinativum and the dermis of the incubation patch thicken, while the blood vessels increase in size and number. Throughout prolonged incubation, the incubation patch tissues decline only after the time when they would function in brooding.

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LITERATURE CITED

- ALLEN, A. A. 1914. The Red-winged Blackbird: a study in the ecology of a cat-tail marsh. Proc. Linnaean Soc. New York, Nos. 24-25:43-128.
- HOLCOMB, L. C. 1968. Problems in the use of an embryocide to control passerine bird populations. Trans. 33rd North Amer. Wildl. Nat. Resour. Conf., p. 307-316.
- HOLCOMB, L. C. 1974. Incubation constancy of Red-winged Blackbirds. Wilson Bull. 86:450-460.
- JONES, R. E. 1969. Hormonal control of incubation patch development in the California Quail, *Lophortyx californicus*. Gen. Comp. Endocrinol. 13:1-13.
- JONES, R. E. 1971. The incubation patch of birds. Biol. Rev. 46:315-339.
- NERO, R. W. 1956a. A behavior study of the Red-winged Blackbird. I. Mating and nesting activities. Wilson Bull. 68:5-37.
- NERO, R. W. 1956b. A behavior study of the Red-winged Blackbird. II. Territoriality. Wilson Bull. 68:129-150.
- PETERSEN, A. J. 1955. The breeding cycle in the Bank Swallow. Wilson Bull. 67:235-286.
- SELANDER, R. K., AND L. L. KUICH. 1963. Hormonal control and development of the incubation patch in icterids with notes on behavior of cowbirds. Condor 65:73-90.

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INDIGO BUNTINGS IN UTAH WITH SPECIAL REFERENCE TO INTER-SPECIFIC COMPETITION WITH LAZULI BUNTINGS

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The Indigo Bunting (*Passerina cyanea*) appears to be expanding its range into many parts of southern and central Utah. Hardy (1939) listed one male in the collection of Dixie College taken in St. George, Washington County, Utah on 11 July 1937, which is the first Utah record. Cottam (1941), Behle (1943), and Woodbury et al. (1949) listed it as a rare or sparse breeder in streamside or irrigated vegetation in the Virgin River Basin of the extreme southwestern corner of Utah, based on one skin and two sight

records. Wells (1958) cited a case of interspecific competition between the Indigo Bunting and its congener the Lazuli Bunting (*P. amoena*) along the Virgin River drainage at Leeds Creek 10-15 km from St. George, in the Pine Valley Mountains at an elevation of approximately 1,524 m. Wauer (1969) listed the Indigo Bunting as a common breeder in streamside vegetation below 915 m in southwestern Utah.

During the summer of 1973 I found Indigo Buntings to be common in the Virgin River Valley. I secured data for 16 territorial male Lazuli Buntings and 21 Indigo Buntings. It is quite probable that these individuals were "pure" types since examination of skins collected between 1937 and 1968 revealed no evidence of hybridization; all Lazuli Buntings had values of 16 on the Short and Sibley (1959) hybrid index. However, two vagrant hybrids have been recorded in the northern part of the state, one of which is in the University of Utah collection. I subjected the above data to multivariate analysis of variance and discriminant function analysis and found that the habitats utilized by the two species were significantly different at $\alpha = 0.01$ ($F = 6.1425$

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TABLE 1. A list of means (s.d.) of the 10 habitat variables used to compare Indigo and Lazuli Buntings.^a

Variable	Indigo Bunting	Lazuli Bunting
Number of species of trees	00.52(00.51)	00.75(00.44)
Number of trees 3-6 inches DBH	00.09(00.30)	00.00(00.00)
Number of trees 6-9 inches DBH	00.09(00.30)	00.00(00.00)
Number of trees 9-12 inches DBH	00.14(00.36)	00.06(00.25)
Number of trees 12-15 inches DBH	00.29(00.46)	00.18(00.40)
Number of trees 15 inches DBH ^b	00.29(00.46)	00.81(00.75)
Shrub density ^{b,c}	03.24(01.18)	06.12(00.88)
Percent canopy cover	12.86(14.01)	17.19(17.02)
Canopy height	14.76(14.45)	23.50(14.66)
Percent ground cover ^b	67.14(12.60)	49.38(14.70)

^a Measured in 0.1-acre circular plots with a singing territorial male as the center of the plot.

^b Significantly different at alpha = 0.01.

^c Based on a scale of 0-10 with 0 indicating no shrubs present and 10 indicating 100% shrub coverage.

with 10 and 388 degrees of freedom, see table 1). I analyzed these two species with 22 other passerine species totaling 421 individuals, on ten different habitat variables. The results indicate that the Lazuli Bunting prefers areas with higher shrub density and lower ground cover than the Indigo Bunting with the latter most closely associated with hedgerows along alfalfa fields and the former in tamarisk stands.

During April, May and June I recorded no instances of aggression between the two species in the Virgin River Valley although I often observed them within sight or hearing distance of each other.

During the last week of June, 1973, I was studying birds along the Paria River in Cottonwood Canyon, approximately 120 km east of St. George, in south central Utah. The vegetation consists of scattered clumps of tamarix (*Tamarix pentandra*), occasional cottonwoods (*Populus fremontii*) and several species of small woody plants. Owing to the wide range of fluctuations of this river, the larger, more mature plants are far from the main stream channel. In Cottonwood Canyon I found the Indigo Bunting to be scarce with two individuals being recorded in over 20 km of streamside. Behle et al. (1958) did not list the species in the Paria River area. One morning I noticed apparent competition between a male Indigo Bunting and a male Lazuli Bunting. Over a period of 3 days, I observed the two males for a total of 6 hr. They countersang with each other from exposed perches in the tamarix, the Lazuli Bunting signaling and the Indigo Bunting responding. As the Indigo Bunting moved closer to the Lazuli Bunting the latter wiped his bill and raised his crest, and the singing became louder and more excited. When the Indigo Bunting came within approx. 7 m of the Lazuli Bunting the latter chased the former away approximately 200 m and returned to his original perch. I saw this behavior repeated eight times. W. L. Thompson and J. D. Rising (pers. comm.) have noted similar instances of mutual defense of territorial boundaries between the two species during their field work at Chadron, Nebraska.

The literature and the first Utah record suggest that the Indigo Bunting made its first appearance in the southern part of the state about 40 years ago in the Virgin River Valley, probably resulting in competition with the Lazuli Bunting. Since then, movement has continued into the south central part of the state and into the Paria River drainage. I have observed Indigo Buntings along the Colorado

River in tamarisks at Lees' Ferry, indicating possible movement through there while additional recent observations (Scott 1966, 1968) indicate that the Indigo Bunting is moving north also.

As each new area, e.g. the Paria River, is colonized by the Indigo Bunting, competition erupts and results in habitat partitioning, which eventually leads to mutual coexistence, e.g. the Virgin River.

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LITERATURE CITED

- BEHLE, W. H. 1943. Birds of the Pine Valley Mountain Region. Southwestern Utah. Univ. Utah Biol. Ser. 7:1-85.
- BEHLE, W. H., J. B. BUSHMANN, AND C. M. GREENHALGH. 1958. Birds of the Kanab area and adjacent high plateau areas of southern Utah. Univ. Utah Biol. Ser. 11:1-92.
- COTTAM, C. 1941. Indigo Buntings and Band-tailed Pigeons in Utah. Condor 43:122.
- HARDY, R. 1939. Two new bird records from Utah. Condor 41:86.
- SCOTT, O. K. 1966. Great Basin, Central Rocky Mountain Region. Audubon Field Notes 20:537.
- SCOTT, O. K. 1968. Great Basin, Central Rocky Mountain Region. Audubon Field Notes 22:634.
- SIBLEY, C. G., AND L. L. SHORT. 1959. Hybridization in the Buntings (*Passerina*) of the Great Plains. Auk 76:446.
- WAUER, R. W. 1969. Recent bird records from the Virgin River Valley of Utah, Arizona, Nevada. Condor 71:311-335.
- WELLS, P. V. 1958. Indigo Buntings in Lazuli Bunting habitat in southwestern Utah. Auk 75:223.
- WOODBURY, A. M., C. COTTAM, AND J. W. SUGDEN. 1949. Annotated checklist of the birds of Utah. Univ. Utah Bull. 39:31.

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