diet on a biomass basis, and ducks and coots 53% (Table 1). In order to better understand the role of these different prey on eagle numbers, we compared yearly eagle census data with waterfowl and salmon population data.

Waterfowl counts reveal that more ducks were seen in the 1960's than in the 1970's (Fig. 3), yet eagle numbers increased in the 1970's. Apparently eagle abundance was not dependent on the abundance of waterfowl, even though the patterns of winter use of the Columbia River by ducks and eagles were similar. A significant negative correlation ($P < 0.05$) suggests that eagles were not dependent on waterfowl as a major prey source. The number of eagles appears to be related to the number of chinook salmon redds, however (Watson 1970; Fig. 4). In the early and mid-1960's, salmon redds (an indication of salmon abundance) were less numerous than in the late 1960's and 1970's, except for the winters of 1972 and 1974, when they dropped to the lowest levels recorded over the 1961–1977 period. Few eagles were recorded in 1974 and no immature eagles were seen that winter. Salmon redds increased in 1975 as did eagle numbers. Immature eagles also were present in 1975–1977. A nearly significant positive correlation ($P < 0.10$) was found between numbers of eagles and those of salmon redd densities.

The observed increase in wintering eagles may be related to the closure of the Hanford reach to public recreation since the mid-1940's. During the 1960's there was a considerable amount of nuclear reactor construction activity here, but today this section of the river is relatively quiet. It is good waterfowl habitat, particularly because of 20 cobblestone islands which provide ideal resting areas such as have been largely eliminated from the impounded stretches of the Columbia and Snake rivers.

As adjacent lands become more intensively developed and accessible, the Hanford Reservation probably will grow in importance as a sanctuary for waterfowl and salmon, and the Bald Eagles which prey upon them. The recent dedication of the Reservation as a National Environmental Research Park may help to preserve the sanctuary status of the area.

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DEVELOPMENT OF SONG OF A RUFOUS-SIDED TOWHEE RAISED IN ACOUSTIC ISOLATION

DAVID N. EWERT

Passerine birds raised in acoustic isolation or deafened at an early age typically develop songs which are more variable, "buzzier," and less well organized than those of wild conspecific birds (Marler et al. 1962, Konishi 1964, Konishi and Nottebohm 1969, Marler et al. 1972, Nottebohm 1975). Because embryos of some non-passerines are sensitive to sound (Gottlieb 1966) and because passerines can selectively respond to (but not necessarily learn to repeat) specific sounds when they are three days old (Messener *in* Thielcke 1976), the ontogeny of song is preferably studied with acoustically isolated birds that have been raised from the egg. I report here on the songs developed by one male Rufous-sided Towhee (*Pipilo erythrophthalmus*) which was raised to maturity from an egg. This report represents the first study of development of song in the Rufous-sided Towhee.

STUDY SITE AND METHODS

I collected three eggs from a nest at the Kalbfleisch Field Research Station, Huntington, Suffolk County, New York, on 15 July 1974. The eggs were approximately nine days old when taken from the nest. They hatched 18 July 1974 in a sound isolation chamber and on 11 August 1974 each of the two males (sexed by plumage) was transferred to its own sound isolation chamber. The birds were not deafened and could hear themselves. I moved them at night so they could not hear other birds during the move. One male died shortly after being placed in a sound chamber. I periodically monitored and tape-recorded the surviving male with a Uher 4000 Report-L tape recorder and a Uher M512 microphone. The photoperiod was adjusted to roughly correspond with the natural photoperiod except in early spring when I lengthened the photoperiod to induce singing by early April.

The male was first heard singing subsong (terminology follows Nottebohm 1975) on 28 August 1974, when he was 42 days old. A more structured subsong was heard by 17 February 1975 and either "plastic" or "full" song on 13 April 1975. Recordings used for this analysis of song development were made on 8 September 1974 (subsong), 13 April and 1 June 1975 ("plastic" or "full" song), and 10 and 25 May 1976 ("plastic" or "full" song). Song could not be classified either as "plastic" or "full" because I was not certain that the final stage of song development had been reached. The terminology used to describe song follows Mulligan (1966) and Kroodsma (1974). I analyzed 111 songs that

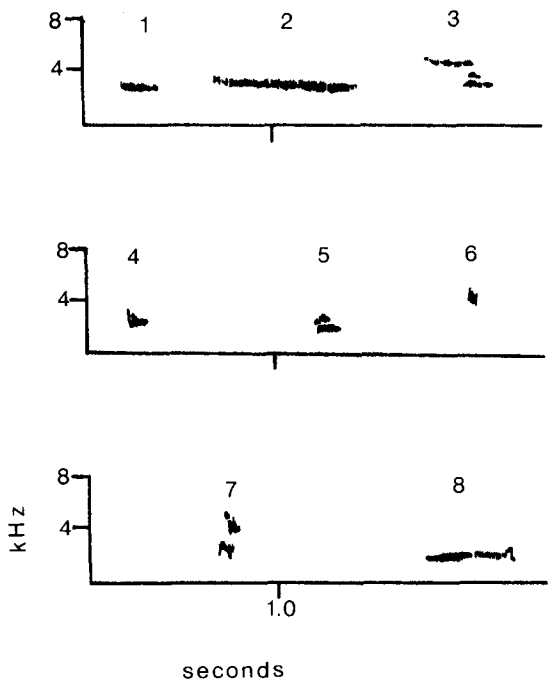

FIGURE 1. Tracings of eight syllables recorded from the isolate male in 1975 and 1976.

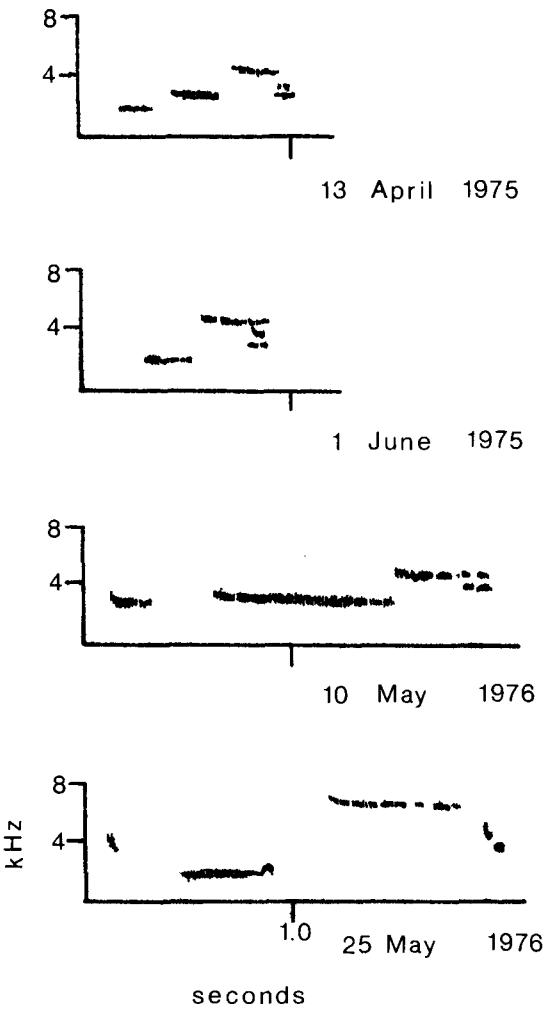

FIGURE 2. Tracings of the modal song of the isolate male recorded on four dates in 1975 and 1976.

were graphed from a continuous spectrum analyzer (described by Hopkins et al. 1974). Measurements were taken from photographs of the graphs. Because the within-variance of songs of the isolate male is not comparable to the pooled variance of eight songs of eight different males from Kalbfleisch, I could not test for significant differences between the songs of the isolated male and the eight free-living males.

RESULTS

Song morphology and organization. At least 23 syllables could be defined from recordings of subsong made on 8 September 1974. These syllables were given throughout the recording period but were not organized into repeated, discrete sequences that could be classified as songs. Eight syllables appeared in "plastic" or "full" song (see Fig. 1). The number of syllables in the repertoire of the "plastic" or "full" song of the isolated male was similar to that of wild towhees which have repertoires of three songs (average repertoire size of birds on Long Island, New York, is 3.5 songs [Ewert 1978]). As in other passerines, subsong of this towhee contained more syllables than occurred in later stages of song development (Nottebohm 1975). Syllables of the isolate male were less stereotyped in structure compared to those of adult, wild birds.

Although too few recordings were made to determine whether the acoustically isolated male ever developed "full" song, "plastic" song may have been the final stage of song development achieved because songs were so variable from one recording session to another, even when the bird was two years old. On each of the four days when I recorded the bird, a different song variant (a unique sequence of syllables not necessarily repeated stereotypically between recording sessions) was favored and none of the approximately 39 different song variants was recorded in all sessions. Of the most frequent song variants that were recorded in each session (see Fig. 2), only one was recorded on another day. The song development of this bird seemed to differ from that of individually isolated Red-winged Blackbirds (*Agelaius phoeniceus*), Western Meadowlarks (*Sturnella neglecta*), and Song Sparrows (*Melospiza melodia*), and deafened Dark-eyed (*Junco hyemalis oreganus*) and Yellow-eyed juncos (*J. phaeonotus*); in these species, songs developed by the bird's first spring remained relatively stable (Marler et al. 1972, Lanyon, pers. comm., Kroodsma 1977, Konishi 1964, respectively). Songs of the experimental male also differed from those of one-year-old towhees in that the sequence of syllables of each song-type was not stereotypic, and each song-type was not repeated in a sequence of songs that was separated by several minutes of silence from a bout of another song-type (a song bout; Ewert, unpubl. data), as is typical of wild towhees.

Although the most common song variant on three of the four days consisted of only three syllables, the number of syllables in other song variants ranged from one to eight. Because song variants differed from one recording session to another and only 21 songs were recorded on 21 April 1975, 56 on 1 June 1975, 17 on 10 May 1976 and 17 on 25 May 1976, a Markov analysis of the syllable sequence of songs was not possible (Chatfield and Lemon 1970, and Slater 1973, discuss

TABLE 1. Characteristics of Rufous-sided Towhee songs of one isolate male and of eight wild males that consisted of one note-complex phrase.

	Individual isolate	Wild birds
Duration of song (s)	1.28 (4)[a] 0.62–1.93[b]	0.74 (8) 0.44–0.89
Freq. range of song (kHz)	3.3 (4) 2.3–5.0	3.5 (8) 2.4–5.3
Max. freq. of song (kHz)	5.5 (4) 5.0–6.9	6.0 (8) 5.1–7.8
Min. freq. of song (kHz)	2.2 (4) 1.9–2.7	2.4 (8) 1.7–2.7
Longest syllable in song (s)	0.58 (4) 0.28–0.87	0.20 (8) 0.06–0.26
Duration of syllables (s)	0.32 (6) 0.03–0.87	0.15 (13) 0.02–0.26
No. notes/syllable	1.3 (6) 1–3	4.4 (14) 1–20
Delivery rate of syllables (syllables/s)	2.52 (4) 1.55–3.57	3.91 (8) 2.86–4.94

[a] Mean (N).
[b] Range.

Markov analysis). However, certain syllables seemed to occur frequently enough in specific parts of song to permit a general description of song. Syllables 1 and 6 occurred more often at the beginning than the end of song, whereas syllables 2 and 3 were found at the end more than the beginning of song (see Ewert 1978). Syllable 3 occurred at the end of 18 of 37 song variants consisting of two or more syllables and the modal song of each day ended with some variation of syllable 3 (see Fig. 2). Syllable 3, which had the highest pitch of any syllable I recorded, always appeared at the end of song except in two variants where it was penultimate. Syllable 1 was at the beginning of more song variants than the total number of song variants that began with syllables 2, 4, 6, and 7, the only other syllables that were at the beginning of song. On days when I heard, but did not record, the towhee, its songs frequently resembled those having a syllable sequence of 1, 2, 3 or 6, 8, 3. This bird tended to initiate songs with syllable 1 and to terminate songs with syllable 3; occasionally, other syllables were used at the beginning or ending of song. Owing to this variation in the sequence and location of syllables, songs of the isolate male were not stereotyped like those of free-living males. No songs of this individual contained trills (rendition of the same syllable three or more times in rapid succession), unlike wild towhees, where every individual I recorded had at least one song-type possessing a trill. As in wild towhees, some syllables occurring in song were also given as calls. Syllable 7, apparently an alarm call as it was repeated rapidly when I entered the sound isolation chamber, appeared in several songs on 10 May 1976.

Quantitative features of song. Characteristics of four songs of the isolate male (the most frequent song on each of the days that I recorded him) were compared with the same characteristics of eight songs that lacked a trill phrase that I recorded from eight individuals at Kalbfleisch (see Table 1). Raw data are presented in Ewert (1978). Although samples are too small for statistical analysis, the isolate male appeared to have had longer syllables, fewer notes per syllable, and a slower rate of delivery than wild birds. I found less consistent or smaller differences in the duration of song, the frequency range, maximum and minimum frequency of the song and in the duration of the syllables. Songs of the isolate tended to be slower than those of the wild males because both the song and its syllables were relatively long. The frequency range of the songs of the isolate was relatively narrow because the maximum frequency of its songs tended to be lower than in wild birds.

DISCUSSION

My results show that one male Rufous-sided Towhee sang abnormal song when raised in acoustic isolation. The greater length of the longest syllable, the reduced number of notes per syllable, and the slower rate of delivery of song, coupled with the harsh sound of the isolate song and the variability of successive songs, easily distinguished songs of this experimental bird from those of wild birds.

My findings parallel those on the development of song in other species of finches (see Table 2 of Kroodsma 1977), where the songs of individually isolated males differed from normal songs in that their syllables had relatively few notes, were longer, sung more slowly, and had a narrower frequency range.

SUMMARY

A male Rufous-sided Towhee raised to maturity from the egg in acoustic isolation did not develop song typical of wild towhees. The sequence of syllables of its songs was less stereotyped and the tempo seemed slower than normal. The isolate male had no songs with a trill, unlike wild towhees.

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FOOD OF SILVERY GREBES (*PODICEPS OCCIPITALIS*) AT LAKE CUICOCHA, ECUADOR

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The Silvery Grebe (*Podiceps occipitalis*) lives in upper temperate and lower paramo zones of the Andes from southern Colombia to Tierra del Fuego, Chile. The northern subspecies (*P. o. juninensis*), which ranges only as far south as Catamarca, Argentina (Meyer de Schauensee, A guide to the birds of South America, Livingston Publ. Co., Wynnewood, Penn., 1970), has been collected from alpine lakes in Argentina, Bolivia, Peru, Ecuador and Colombia (Blake, Manual of neotropical birds, Vol. 1, Univ. Chicago Press, 1977). Except for some anatomical work (Storer, Courtship and mating behavior and the phylogeny of the grebes, Proc. XIII Int. Ornithol. Congr. [1962], 1963) little is known of the biology of the species. It was the intent of my study to determine the food of the Silvery Grebes at Lake Cuicocha, Ecuador.

Lake Cuicocha is a volcanic lake, 3,100 m above sea level, in the extreme northwestern Ecuadorian Andes. Caldera walls completely surround the lake, rising almost vertically as much as 400 m above the lake's surface. In many places the cliffs are so steep that sufficient sediments have not accumulated so that emergent hydrophytes can grow. Even in shore areas with sediment the border of emergent vegetation (*Scirpus* sp., *Myriophyllum* sp., *Pomatogeton* spp.) is rarely more than 5 m wide.

TABLE 1. Stomach contents of three Silvery Grebes.

Stomach contents	No. counted*
Food items	
Aeschna nymphs	14
Total odonates represented	816
Other insects	9
Amphipoda (fam. Talitridae)	9
Nonfood items	
Cestoda (subfam. Hymenolepidinae)**	214
Feathers (shaft ≥ .5 cm)	866

* The data from the three grebes have been combined.
** Cestodes were found in only one stomach, and their presence is probably due to an accident at the time of collection.

The Silvery Grebe population has been censused four times in two years. In January 1974, March 1974, and May 1975 34 adult grebes were counted; in January 1976 44 adults were counted. This population apparently breeds early in the year, as evidenced by the presence of one large downy young in May 1975. In contrast to this equatorial population, Silvery Grebes in Argentina begin breeding between September and November (Burger, Condor 76:301–306, 1974).

In March 1974, I collected three Silvery Grebes at Lake Cuicocha, and immediately preserved the stomachs in 10% formalin. The specimens are in the University of Miami Reference Collection. The contents of each stomach were examined under a microscope, separated by type, and counted (Table 1).

The macro-fauna of the reedy shoreline was sampled qualitatively for potential prey items. No small fish were seen or collected despite a careful search. Samples of inshore fauna contained: Ostracoda (Cypridae); Amphipoda (Talitridae); Odonata (*Aeschna* and *Ischnura*); Diptera (a few terrestrial adults, probably trapped on the water's surface). The odonates were identified to genus by M. Westfall, who concluded that they did not belong to any known species.

All insect sclerites found in the grebes' stomachs that could be identified, belonged to nymphal dragonflies (*Aeschna* sp.). The number of nymphs in each stomach varied greatly, possibly owing to individual differences in the amount of recent feeding and pellet formation. Grebes cast pellets by regurgitation (Storer, Auk 78:90–92, 1961), and grebes that eat highly indigestible food such as insects and crustacea probably cast pellets on a regular basis. The many feathers found in the stomachs probably served as strainers to retain such indigestible material between pellet formation (Storer 1961).

To the best of my knowledge, this is the first time that this lake or its population of grebes have been studied (Francisco Leon, Universidad Católica del Ecuador, pers. comm. 1974). The lake is being developed as a resort, and the future of its Silvery Grebes is uncertain because of habitat destruction, shooting, and pollution.

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