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A Comparison of Songs from Four Species of Fairy-wrens (*Malurus*)

Myron C. Baker

Biology Department, Colorado State University, Fort Collins, CO 80523 USA

EMU Vol. 95, 294-297, 1995. Received 18-1-1995, accepted 6-3-1995

The systematic relationships among the fairy-wrens (*Malurus*) have been inferred from morphological data, mainly male breeding plumages, in concert with distributional and biogeographical information (Schodde 1982). Of the 13 *Malurus* species subdivided into five 'sections', nine species and four of the sections occur in Australia (Schodde 1982; Blakers et al. 1984). Ancillary information from songs has been used to support the groupings of species into the sections of phenotypic similarity (Schodde 1982).

The previous examination of songs from these species lacked instrumental analysis and quantitative comparisons. In a brief pilot study in 1991-92, I tape-recorded four species of *Malurus* belonging to three sections. Here, I present sound spectrograms of these species together with a quantitative analysis of their similarities.

Methods

Tape recording was accomplished with a Marantz cassette recorder (PMD 201) and a Sennheiser microphone (MD 402K) mounted in a 40 cm parabolic reflector. Recordings were analysed with a Kay Elemetrics Sonograph (DSP 5500) and sound spectrograms (sonograms) produced with the Kay 5510 printer. Similarities between spectrograms (Clark et al. 1987; Baker 1993) were calculated using the correlation function of Canary software (v1.1, Cornell Laboratory of Ornithology, Bioacoustics Research Program) implemented on a Macintosh computer. Briefly, the digitised sounds representing two songs are overlapped with one another until the maximum degree of matching is found. This results in a peak value correlation coefficient, which is used as an index to overall similarity in the two songs.

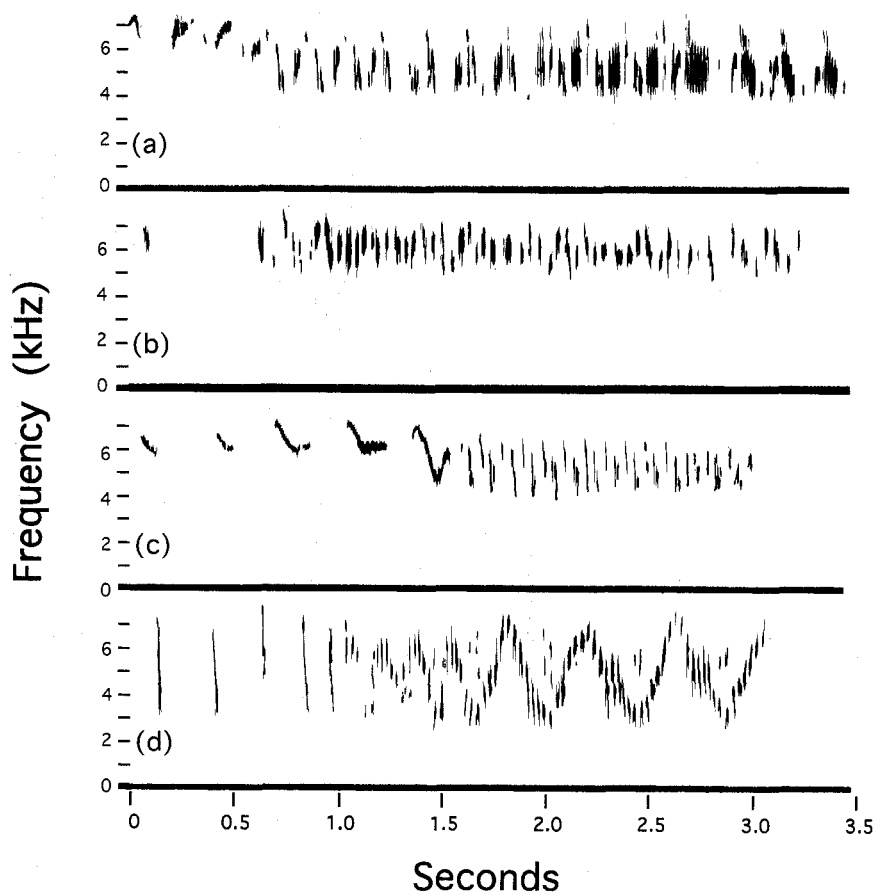


Figure 1 Sound spectrograms of four species of fairy-wrens. (a) *Malurus splendens*, (b) *M. lamberti*, (c) *M. elegans*, and (d) *M. leucopterus*.

All recordings were made in Western Australia: *M. splendens* at Gooseberry Hill National Park west of Perth on 17 October 1991; *M. leucopterus* off Pipidinnny Road north of Wanneroo on 22 November 1991; *M. lamberti* at Pelican Point in Perth on 26 November 1991; and *M. elegans* off Sterling Road north-west of Pemberton on 9 January 1992.

Results

Sound spectrograms of the four species are presented in Figure 1. The song of *M. splendens* included a variety of syllables in an utterance lasting about 3.5 s in a 3.80–7.68 kHz frequency envelope. The song begins relatively slowly with four higher pitched 'chirp' syllables descending into a rapid trill section in which the various syllable types are repeated in strings. The song of *M. lamberti* included several syllable types but they

were much less distinct in their differences than the syllable types of *M. splendens*. There were also introductory chirps, similar in morphology to elements in the trill portion, that start the song with a slower paced series of notes leading into the trill portion. The song was about 3.3 s long in a frequency envelope of 4.60–7.92 kHz. *M. elegans* sang a trill portion that was very similar to that of *M. lamberti* in its relative simplicity and lack of distinctive variety of syllable types. The well-defined set of introductory chirps, however, differed markedly from the elements of the trill portion. The song was 3.1 s long in a frequency envelope of 4.60–7.92 kHz. The song of *M. leucopterus* (subspecies *leuconotus*) differed in a distinctive way from the other three species in the sinusoidal delivery pattern of the trill portion. The song began with an accelerating series of chirps of brief frequency transients followed by a rapid transition into the trill portion. In the trill, the in-

Table 1 Correlation coefficients comparing songs from four species of fairy-wrens.

	<i>M. lamberti</i>	<i>M. splendens</i>	<i>M. leucopterus</i>
<i>M. elegans</i>	0.783	0.608	0.607
<i>M. lamberti</i>		0.530	0.590
<i>M. splendens</i>			0.542

dividual elements were rather uniform in morphology but delivered in a pattern in which the frequency varies in time as a sine wave. The song was about 3 s long in a frequency envelope of 2.44–7.72 kHz. A very similar song was recorded from *M. l. edouardi* on Barrow Island but the recording was too faint to reproduce for publication. The sinusoidal trill, however, was clearly audible.

Results of correlation analyses among these spectrograms are given in Table 1; values are true correlation coefficients and can range from 0–1. The largest correlation was between the song of *M. elegans* and *M. lamberti* and the smallest was between the songs of *M. splendens* and *M. lamberti*.

Discussion

Within *Malurus*, the 'blue' fairy-wren section includes *M. cyaneus* and *M. splendens*. Although I had no recordings of *M. cyaneus*, the published spectrograms and verbal description of song structure (Langmore & Mulder 1992) provide a subjective impression that these two species have a great deal of similarity in their songs. The 'bicoloured' fairy-wren section includes *M. alboscapulatus*, *M. melanocephalus* and the representative recorded in this study, *M. leucopterus*. The 'chestnut-shouldered' fairy-wren section includes *M. amabilis*, *M. pulcherrimus* and the two species of the present study *M. elegans* and *M. lamberti*.

Although not a comprehensive set of comparisons, the correlation values (Table 1) appear to support the current subdivision of the fairy-wrens into the sections outlined above. The highest correlation between songs was for *M. elegans* X *M. lamberti*, both members of the chestnut-shouldered section. All other correlation values derived from comparing member species of two different sections, and overall these values were quite a bit smaller than the single within-section correlation available in this study. A further inference can be made from the spectrographic and verbal description of the

song of *M. coronatus*, a representative of the Crowned fairy-wren section of the Maluridae (Rowley & Russell 1993). These data indicate that the song syllables of *M. coronatus* are delivered at a somewhat slower cadence and extend well into lower frequency ranges, more so than is the case for other *Malurus*, suggesting relative distinctiveness of this species.

The data suggest that analysis of the song structure as a phenotypic trait may be of use in examining hypotheses about relationships among the fairy-wrens. Within the chestnut-shouldered section, for example, opinions vary about the status of the several forms (Ford 1966; Harrison 1972); thus, careful examination of songs could be useful in resolving some of the uncertainties. In addition to the structural comparisons, however, a functional analysis of song may also provide information about relationships. Playback experiments, for example, can examine the responses of birds in the field to songs of their own species (Payne et al. 1988, 1991) and those of other species. A program of song playback experimentation might exploit the earlier findings on fairy-wren responses to model presentations (Rowley 1963). It can be hypothesised that such responses to models will be amplified by addition of vocal signals to the stimulus setting. My observations of *M. leucopterus* and *M. splendens* in a location where both occur found them to be interspecifically aggressive, countersinging and defending territory against each other. Aggressive defense between species appeared to be as vigorous as that occurring within species.

The results reported in this study are suggestive at best and clearly call for a more comprehensive set of comparisons of song structure within and among the species of fairy-wrens. Variation among individuals and between populations are expected and will require both widespread and locally intensive recording efforts. Studies of the vocal displays of birds have made important contributions to phylogenetic analyses (Payne 1985; Miller et al. 1988) and should repay efforts on the fairy-wrens.

Acknowledgements

I am grateful for the assistance of Mike Johnson, Bob Black, Win Bailey, Dale Roberts, Perry de Rebeira, Mike Craig and the staff of the Zoology Department of the University of Western Australia. Thanks to Darren Murphy for recording fairy-wren songs on Barrow Island. Dick and Molly Brown lent generously of their time as well. The manuscript bene-

fitted from comments by Eleanor Russell. Financial assistance was by grants from the National Science Foundation (BNS-87-06526, INT-9113640).

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Gape Width and Prey Selectivity in the Noisy Friarbird *Philemon corniculatus* and Red Wattlebird *Anthochaera carunculata*

A.S.J. Saunders¹, S.J. Ambrose² and S. Burgin¹

¹ Faculty of Science and Technology, University of Western Sydney Hawkesbury, Richmond, NSW 2753

² RAOU, 415 Riversdale Road, Hawthorn East, Vic. 3123

EMU Vol. 95, 297-300, 1995. Received 16-1-1995, accepted 8-5-1995

Optimal foraging theory predicts that predators will select those prey that maximise either energy gain per prey item or per unit foraging time, except when the prey do not satisfy the predator's nutritional requirements (Goss-Custard 1977; Krebs et al. 1977; Avery et al. 1993).

Factors limiting maximum prey size are the gape width of a predator (Zaret 1980; Wheelwright 1985), prey handling time (Recher & Recher 1968; Goss-Custard 1977; Krebs et al. 1977; Sherry & McDade 1982; Avery et al. 1993) and prey defences (Webb &

Shine 1993). The relative importance of each of these factors varies considerably for each predator and its prey. Birds will often spend considerable time bashing prey to improve its palatability; however, swallowing prey whole is a feature of many birds (Lack & Owen 1955, Goss-Custard 1977). Food items are often swallowed whole by frugivorous birds (Wheelwright 1985; White & Stiles 1991; Avery et al. 1993) and insectivorous birds (Lack & Owen 1955). Search time is dependent upon prey availability, and prey handling time by birds is generally determined by prey size rather than