Corella, 1995, 19(1): 2–7

DIEL TEMPORAL VOCALIZATION PATTERNS IN THE MISTLETOEBIRD (*Dicaeum hirundinaceum*) AND SEASONAL ABUNDANCE RELATIVE TO THE FLOWERING AND FRUITING OF THE MISTLETOE *Dendrophthoe vitellina*

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Received 23 March, 1993

Mistletoebirds inhabiting open eucalypt forest at Ebenezer, near Windsor, New South Wales, vocalized maximally from about 15 minutes before, until two hours after, sunrise. This contrasted with most other species whose peak vocalizations were before sunrise. There was negligible singing through the day, as in other species. An annual influx of birds into the areas of flowering, then fruiting, mistletoe (*Dendrophthoe vitellina*) was documented annually in late November–early December over five summers using levels of territorial song. Bird numbers were high during years of good mistletoe abundance and productivity, low in the poor years that followed plant die-off. Seasonal movements relative to the berry production cycle in mistletoe are confirmed as a major adaptation in Mistletoebirds.

INTRODUCTION

The study has two objectives: (1) To document diel temporal vocalization patterns in the Mistletoebird *Dicaeum hirundinaceum*; and (2) To quantify the seasonal occurrence of Mistletoebirds relative to the annual flowering and fruiting cycle of the common mistletoe *Dendrophthoe vitellina*. The first part was carried out over eight 4-day periods about 10 days apart from September, 1986 to January, 1987, with an additional April (1988) date being added to increase seasonal coverage. The second part entailed studies between October and January over five years between 1988 and 1993.

METHODS

The study site was a section of open eucalypt forest on Hawkesbury sandstone at Ebenezer, near Windsor, New South Wales — see Keast (1994a). *Dendrophthoe vitellina* is the dominant mistletoe species in the area, outnumbering the other summer-fruiting one, *Amyema pendulatum*, by about 10 to one. Its major hosts are *Eucalyptus gummifera, E. exima, E. paniculata, Acacia parramattensis* and, occasionally, commercial citrus. It annually produces its brilliant red-and-yellow flowers in November-December, and fruits in December-January.

In developing the song data the procedures and methods outlined in Keast (1994a and b) were followed. I operated from under cover at a fixed site at the top of a small escarpment and adjacent to eucalypts that supported 4–5 mistletoe clumps. These, the best group in the immediate area were seasonally the focus of attention by the birds. Song was documented and quantified in successive 5-minute segments. In the first year data gathering extended from 40 minutes before, and continuing until 2.5 hours after, sunrise, by which time singing rates had dropped considerably. Thereafter it was then continued in half-hourly segments through the day using the first 10 minutes of each. Data from different days and seasons were related to sunrise as the common reference point. After the first year, when focus was on seasonal attendance at the plants, monitoring of song was limited to the first two hours after sunrise, the most productive period (see later).

Quantification of vocalization levels entailed multiplying the numbers of songs uttered per minute by an average length of song, determined from sonograms (Keast 1993); This produced a figure for numbers of seconds sound production per minute for each 5-minute, and half-hourly, segment. The results were then plotted sequentially to give the complete song output pattern for the morning and day (Fig. 1.).

To comparatively quantify vocalization levels through the season, and to compare these from year to year for the longer term study, the 5-minute data sets for the two-hour post-sunrise period were added and averaged to give a figure (with standard deviations) for sound output in numbers of seconds per minute for each set of dates. The figures were then plotted linearly (Fig. 2) to bring out changes in song output through the season. Times of flowering and fruiting of *Dendrophthoe* were superimposed on this. This is shown for each of the five years (Fig. 2).

The annual flowering and fruiting of *Dendrophthoe* was monitored at 10-day intervals (Table 1, Fig. 2) over three 500 (width, 50) m transects along a 1 500 m section of demarked trail. To establish basic seasonal occurrence/abundance

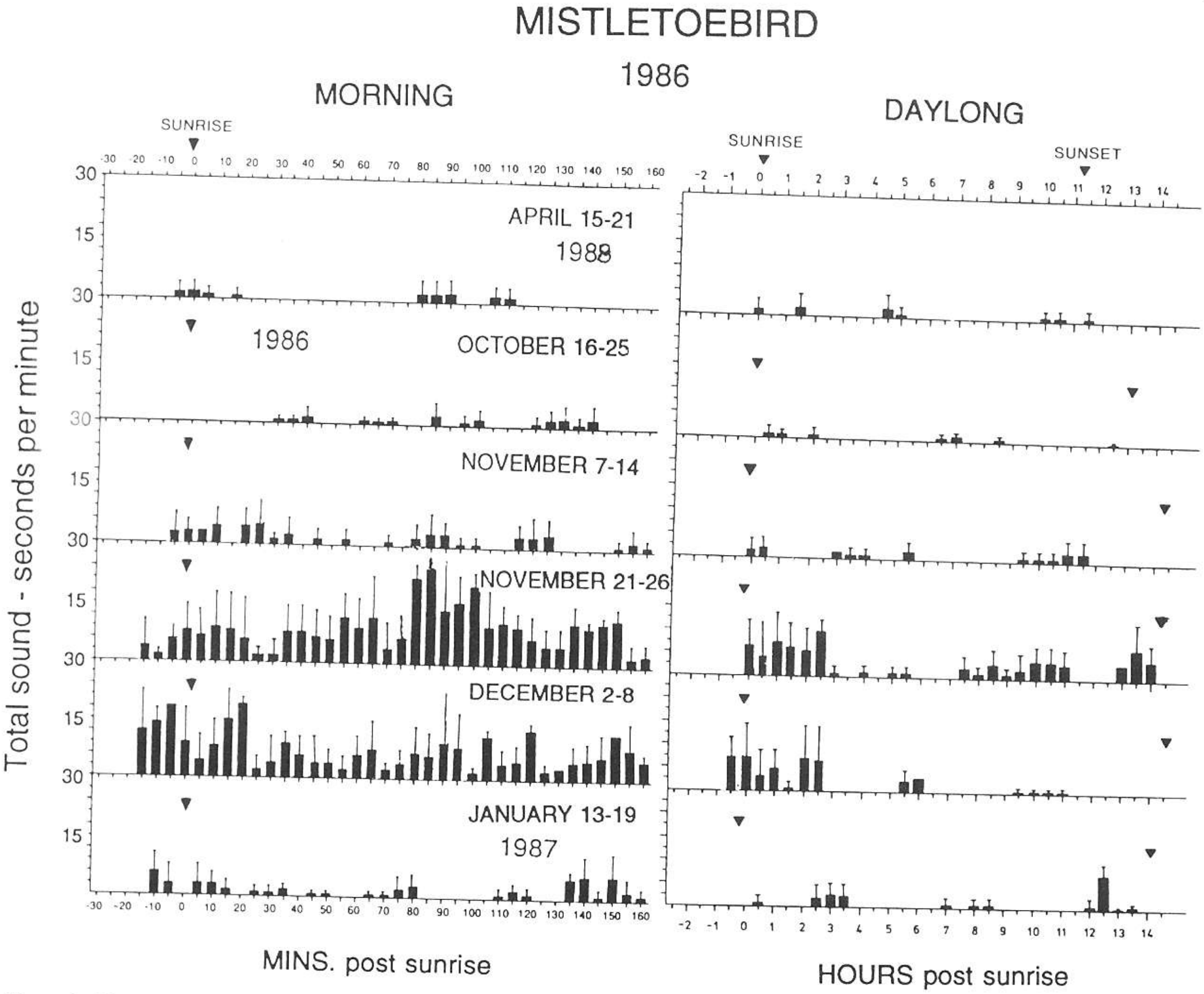

Figure 1. *Morning and daylong vocalization patterns in the Mistletoebird, five 4-day data sets from mid October, 1986, until mid January 1987, plus an April 1988, set. The morning data is based on 5-minute divisions and data is arranged relative to sunrise as the common point. The daylong data is based on half-hourly divisions, the first ten minutes being used. Means and standard deviations.*

patterns of the Mistletoebirds numbers of birds were counted each morning between 0800–0900 hours along the transects. The counts were part of a wider seasonal inventory of bird species. Twelve counts (three of 25 000 m^2 per day) were made for each 4-day cluster. It was found, however, that the high mobility of the Mistletoebirds limited the value of strip counts to indicating presence/absence and major numerical shifts in abundance — see high standard deviations in Figure 3. Subsequently, hence, reliance was placed on the monitoring of vocalization levels at the plants as the more appropriate assessor of seasonal abundance.

RESULTS

Basic song types and lengths

The songs fell into two categories: (1) protracted, multi-syllabled ones, with durations of 2.8–3.8 seconds and; (2) short, sharp, ones about 0.6 seconds long (Keast 1993). The latter were commonly uttered in flight. Pizzey (1980) has likened the former to 'swizit-swizit, weet-weet

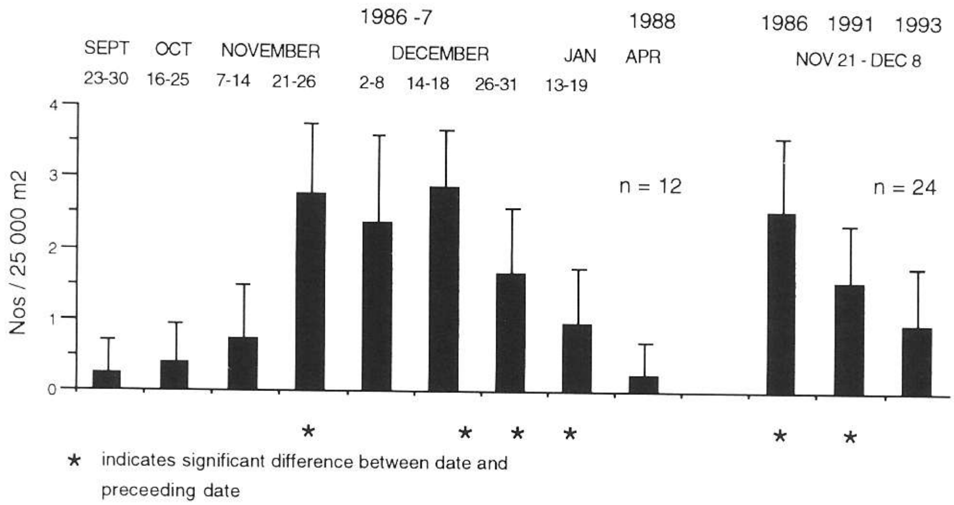

Figure 2. *Average sound production levels (with standard deviations) in seconds per minute for the first two hours following sunrise, spring and summer, five years compared.*

kinsey', and 'wait-abit, wait-abit, shipp', and the latter to 'dzee', and 'tsew'. The longer calls were uttered by individuals at maximum rates of 4–7 per minute in late November–early December.

Temporal vocalization patterns, diel and seasonal

Singing began about 15 minutes before, and continued at a maximum level until two hours after sunrise, then dropped precipitously. The birds sang only occasionally during the hotter parts of the day (Fig. 1). The basic pattern also characterized vocalizations in October, early November, January, and April, when few birds were present.

The seasonal cycle of Dendrophthoe

Dendrophthoe vitellina began flowering in typical years (1986–89) about the third week in November, and continued for about 2.5 weeks (Table 1). Berries were first harvested by the birds about December 5–10 when three-quarters grown and still green. By late December much of the bulk of the berry crop had been harvested. Few berries remained by late January.

Numbers of mistletoe plants and berry production levels were high in 1986–7, 1987–8, and 1989–90 (Table 1). A dry winter and spring in 1990 killed about half of the plants in the area, especially those on the smaller saplings. The year

TABLE 1

Numbers of plants of *Dendrophthoe vitellina* (means and standard deviations) in twelve 500 × 50 m transects (25 000 m^2), and flowering and fruiting dates, November 21–December 8, five summers compared.

Years	1986	1987	1989	1991	1993
Mistletoe plants	2.5 ± 1.9	2.2 ± 1.4	2.3 ± 1.6	0.8 ± 0.8	0.4 ± 0.3
Flowering dates	Nov. 21– Dec. 12	Nov. 18– Dec. 14	Nov. 22– Dec. 11	Nov. 22– Dec. 10	Dec. 11– Jan. 2
Fruiting dates (3/4 to mature size)	Dec. 6– Jan. 10	Dec. 9– Jan. 14	Dec. 10– Jan. 15	Dec. 8– Jan. 16	Dec. 20– Jan. 30

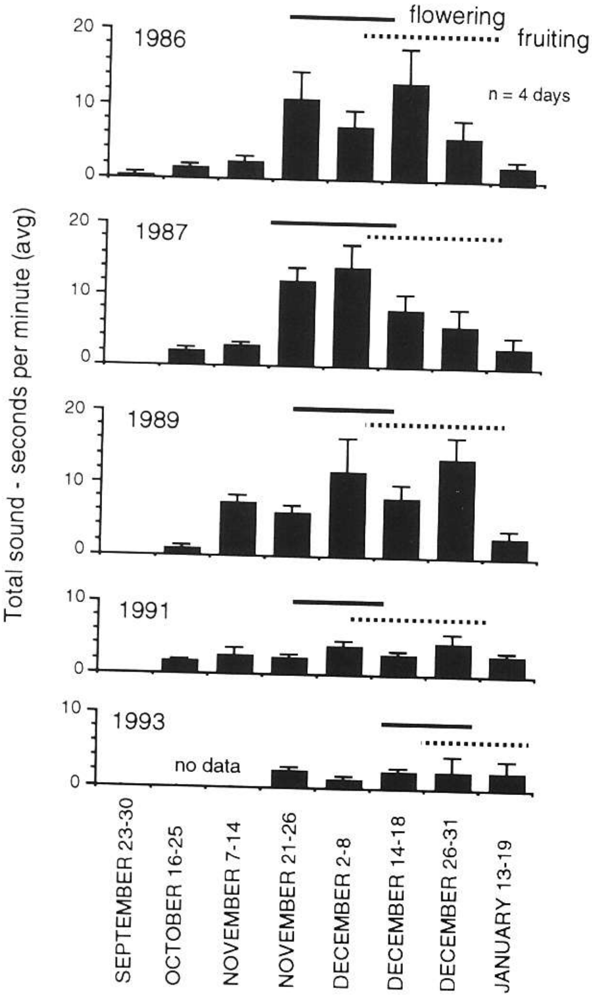

Figure 3. *Strip count data, each column based on twelve 500 × 50 m (25 000 m²) transects between 0800–0900 hrs, means and standard deviations, eight sets of dates 1986–87, plus inter-year comparisons (November 21–December 8), 1986–87, 1991–92, and 1993–94, sample size n = 24.*

1993 was exceptionally dry. A survey in late November of that year showed a reduction in numbers of plants in the count strips to about 25 per cent of the 1986–88 number (Table 1). Many of the survivors were only sparsely foliaged, and bore dead branchlets. Few blossomed and in those that did flowering and subsequently, fruiting, were two weeks late. Duration of the fruiting period was also reduced and in mid-January (1994) a high proportion of still developing berries shrivelled and aborted. (Subsequent rain in early February produced greening of the mistletoe plants and their hosts but no new flowering).

Fruit resources available to Mistletoebirds in November–December, 1990, were estimated to be about half, in 1993 one-quarter, of those available in 1986–88.

Abundances of Mistletoebirds, responses to the cycle in Dendrophthoe

The strip counts (Fig. 3) showed that the areas supported a small resident or semi-resident population of Mistletoebirds (see September data). These counts, and the vocalization data, confirmed that there was a major influx of birds in late November–early December when *Dendrophthoe* started to flower. The numerical increase in abundance suggested by the counts was a significant 7–10 fold (Mann-Whitney U Test, P,0.05) over the October figures. Vocalization levels at the clumps of plants increased by a comparable degree (Fig. 2).

The males were highly vocal in late November and through the first half of December. Most of the song was uttered in the immediate vicinity of the mistletoe clumps and whilst flying rapidly between clumps. In contrast to earlier in the season the songs were of the protracted 2.8–3.8 second variety. Individuals sometimes uttered these songs end-to-end for several minutes at a time. When two males alighted near the same clump the aggressive singing accelerated and was often accompanied by display posturing. Sound output levels of about 15 seconds per minute were then reached.

By late December, as the berry crop waned the clumps were attended with decreasing frequency, the song outbursts were less sustained, and the males were much less obvious. The strip counts (Fig. 3) confirmed that there was a significant drop in numbers of birds in late December–January (Mann-Whitney U test, P,0.05), not just a seasonal drop in their visibility or activity.

In mid to late January mean sound output levels fell to an average of about 2.0 seconds per minute. In April the birds were only rarely encountered during strip counts (Fig. 3) and the birds were heard only occasionally (Fig. 2).

Comparisons of the different years showed a common pattern of abundance increase in mid to late November (Years 1986, 1987, 1988), and a drop in January. With fewer birds the pattern was less discernible in 1991–92, and still less so in the dry 1993–94 year.

When abundances of the birds are compared for late November–early December in the 'good' year of 1986 to the increasingly depauperate ones of 1991–92 and 1993–94, strip counts showed a statistically significant drop in numbers (Fig. 3). Vocalization levels at the plants were markedly less (Fig. 3), down to about 1/5 of the earlier years (Fig. 2).

DISCUSSION

Compared to most other bird species at Ebenezer (Keast 1994b) the Mistletoebird started to sing relatively late: the bulk of the singing being after sunrise. The reason for this is not clear unless it was related to feeding times, and intermale competition, at the plants. The main functions of song in birds are territorial probing and defence, and courtship and pair maintenance (Howard 1920; Marler and Peters 1980; McDonald 1991). No data were developed on which was the more important here. Territorial association with the mistletoe plants was, however, marked. Whether or not the birds defended these plants was not studied. Note that whilst many bird species "defend" nectar sources few defend fruit sources (Snow 1966; Snow and Snow 1984, 1986). This aspect merits examination.

Although little evidence of breeding was found the time of arrival of the birds was several weeks in advance of the documented breeding season near Sydney (Fig. 4). On this basis the high late November–early December vocalization levels could have had a courtship role. Alternatively, if the birds were ultimately to breed only in January, the song activity could have been largely territorial in nature. (Note that the bulk of Sydney breeding records given here are from the Cumberland plain (suburbs of Doonside, Blacktown, St. Marys) where, before the clearing for housing in the 1960's, large numbers of birds concentrated annually on the berries of *Amyema gaudichaudi* on the paperbarks (*Melaleuca*) (Keast 1958).)

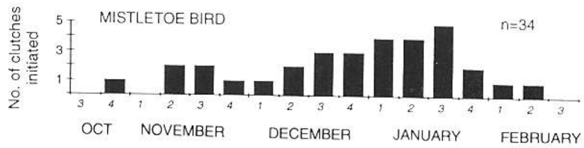

Figure 4. *Clutch initiation dates for the Mistletoebird (n = 34) for the Sydney area, weekly intervals. Data from various sources (see Acknowledgments).*

In its close relationship with the mistletoes (Loranthaceae and Viscaceae), whose berries form its major food (Brittlebank 1908; Chandler 1912; Blakely 1922; Reid 1986, 1987), and with adaptations for berry feeding even extending to gut morphology (Salomonsen 1961), the Mistletoebird is perhaps Australia's most interesting frugivore. Seasonal influxes of Mistletoebirds coincident with the fruiting of mistletoes have now been documented for many areas: e.g. the arid interior (Mathews 1923–1924; McGilp 1923); eastern New South Wales (Hindwood 1936); the Pumiceton Passage area of southeastern Queensland (Liddy 1982), and Adelaide region (Reid 1983). Liddy provides by far the most comprehensive account: his nettings of birds increased 10–60 times over those of the small resident population in July–November when the mistletoe *Amyema cambagei* fruited.

This paper confirms that seasonal movements in association with the annual cycle of dominant mistletoes are a major adaptation in the Mistletoebird.

ACKNOWLEDGMENTS

The present study was carried out when the writer was the holder of a Canadian National Science and Engineering Research Council Award and I would like to thank this body for its support. Breeding (clutch initiation date) data on the Mistletoebird in the Sydney area was kindly supplied by the following colleagues: N. W. Chaffer, R. P. Cooper, K. A. Hindwood, S. G. Lane, J. Rhodes, and E. Woods. Sincere thanks are also expressed to these workers.

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Corella, 1995, 19(1): 7–11

TEMPORAL AND SPATIAL VARIATIONS IN DENSITY OF LANDBIRDS AT AN URBAN BUSHLAND RESERVE

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Received 2 July, 1993

INTRODUCTION

Densities of landbirds have been estimated in heathlands (Pyke 1983), woodlands (Ford and Bell 1981; Ford *et al.* 1985; Gilmore 1985; Keast 1985; Wonarski 1985; Arnold *et al.* 1987) and forests throughout Australia (Recher *et al.* 1971; Bell 1980; Loyn 1980; Shields and Recher 1984; Wardell-Johnson 1984; Collins *et al.* 1985; Kavanagh *et al.* 1985; Pyke 1985; Shields *et al.* 1985). To perform these estimates, standard procedures were adopted (Pyke and Recher 1984; Bell and Ferrier 1985) and the surveyed plots varied in size from a circular area of 0.13 ha (Pyke 1983) to a long rectangular transect of 58 ha (Collins *et al.* 1985). Within each plot, it was implied (or assumed) that the habitat was homogeneous.

Comparisons in bird density can be made between similar habitats in different places and between different habitats. But for these comparisons to be meaningful, variations in density which occur with month of year and in particular pockets of the habitat should be considered. The aim of the present study was to quantify these variations in an urban reserve with a mosaic of different microhabitats.