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Home Range of Plumed Frogmouths *Podargus ocellatus plumiferus* During the Non-breeding Season as Shown by Radio-tracking

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Since discovery of the Plumed Frogmouth *Podargus ocellatus plumiferus* in the Conondale Ranges in 1976 (Roberts & Ingram 1978), the distribution of this subspecies (as distinct from the Marbled Frogmouth *P. o. marmoratus* in north Queensland) has been critically examined (Corben & Roberts 1993), and population status and habitat preferences investigated (Kehl & Corben 1991). However, there are few published observations of foraging behaviour because the birds are difficult to observe in the wild (Schodde & Mason 1980)

We undertook a pilot study to assess the feasibility of radio-tracking Plumed Frogmouths and present information obtained from two radio-tagged Plumed Frogmouths.

Methods

Radio-tracking was undertaken at Booloumba Creek (26°41'S, 152°37'E) at 500 m asl in the Conondale Ranges, approximately 100 km NNW of Brisbane (Roberts & Ingram 1978). Within this region Plumed Frogmouths occur primarily in notophyll vine forests bordering creeks and gullies (Corben & Roberts 1993; authors' pers. obs.), as has been found in the Nightcap Ranges (D. Milledge & T. Meggs pers. comm.).

Two Plumed Frogmouths from separate pairs and territories were caught in different mist nets at heights of approximately 20 m (female 10 March 1993 and male 7 May 1993). Both individuals were banded with ABBBS metal bands (sizes '08' and '09'). Radio-transmitters (AVM single-stage, weighing approximately 4 g) were hot-glued to the under-surface of the two central tail feathers, at their base, according to the method of Fitzner & Fitzner (1977).

The birds were tracked separately for 35 days each, between March and June, by using three and four element hand-held Yagi antennas in conjunction with headphones attached to Telonics and Titley (Regal) receivers. Fixes on birds carrying transmitters were obtained by bisecting the arc between nulls occurring either side of the strongest signal and recording the direction and strength of that peak (very strong, strong, medium, weak and very weak).

Triangulation from three or more sites was carried out at two-hourly intervals through the night so as to obtain mapped positions of birds. These three or more sites were selected from 43 surveyed and mapped receiving stations spread throughout the study area, mainly at the edges of each bird's territory. For each fix, stations were selected as close to birds as possible with-out disturbing them. Fixes were obtained simultaneously by two or three operators working as a team (and usually in radio communication) and/or by operators moving quickly between two or three receiving stations (i.e. 'running fixes').

Bearings obtained from each receiving station were plotted in the field following each two-hourly fix session. The strongest bearings were usually selected to indicate the probable location of the bird during the two-hourly recording session. A commonly used technique in triangulation studies is to obtain a number of bearings and use *ad hoc* criteria to select the best bearings to the estimated location (White & Garrott 1990).

The terrain was heavily vegetated, mountainous and often wet so that radio-tracking was difficult and deflections were common. To reduce biases due to errors, test transmitters were located at surveyed positions in the forest throughout each bird's range and bearings were taken from each tracking station every time that fixes were made. Bearings to each test transmitter were averaged and the mean (with standard errors) mapped for each tracking station to each test transmitter. These deviation maps assisted the *ad hoc* selection of 'best' bearings. In general, deflections were much smaller when tracking stations were close to test transmitters. Error verification is ongoing and details will be published elsewhere.

Bird positions were calculated using the 'best' three bearings according to the Arithmetic average and Priddel methods described by Pyke & O'Connor (1990). Error polygons derived from the intersection of bearings ranged from 0-0.6 ha (mean = 0.09 ha, s = 0.12, n = 41) for the female and 0-0.2 ha (mean = 0.03 ha, s = 0.05, n = 46) for the male. These positions were analysed with RANGES IV software (Kenward 1990). Three models were fitted to the data: (1) minimum convex polygon (MCP), considered to be a standard estimator of home range (White & Garrott 1990); (2) Harmonic mean (Dixon & Chapman 1980); and (3) Kernel (Worton 1989). Harmonic mean analysis calculates a centre of activity and estimates home range from a matrix of reciprocal distances from the centre to fixes centred within grid cells. Kernel analysis is similar, except that a bivariate Kernel function is used instead of inverse reciprocal distances in the matrix (Kenward 1990).

Results and discussion

Daytime roosting occurred in a general area near to but not more than approximately 50 m from Booloumba Creek, amid tangles of thick, hanging lianes. Positions varied from day to day. Pairs were seen roosting together on two occasions, at a height of approximately 3 m. While birds adopted a 'frozen' posture when located, they remained constantly aware of human intrusion, repeatedly opening their eyes. Birds were accidentally flushed from their roost on at least three occasions. Flushing may be common if birds are approached too closely; Czechura (1979) also reports flushing a Marbled Frogmouth from close to a creek in an adjacent state forest.

During the non-breeding season, frogmouths left their roosts silently as darkness fell and returned as dawn approached. They did not call through the night unless provoked. A dawn chorus of a few *gobble* calls were usually heard just before roosting. Birds tended to forage within only a part of their overall home range during one night. However, within the 35-day tracking periods each bird frequently returned to old foraging grounds.

Foraging movements were purposeful and methodical. The male moved regularly along a gully bordered by rainforest; on one night he travelled 520 m from his roost, returning as dawn approached. The female inhabited an adjacent territory and was from a different pair. While typically more restricted in her movements, she crossed an unsealed road on a number of occasions into an area containing a gully with sparse rainforest plants, surrounded by Sydney Blue Gum *Eucalyptus saligna* and Brush Box *Lophostemon confertus*.

Non-breeding home range, as determined by radio-tracking

Based on 92 position fixes for the male and 71 for the female for their respective 35-day tracking periods, both birds appeared to concentrate their activities in and around creek gullies. Less frequent forays were made into drier brush box forest on the margins of wet forest. Birds seemed to favour areas where lianes provided suitable perches from which to hunt.

MCP, Harmonic mean and Kernel modelling generated home range estimates are summarised in Table 1. MCPs drawn around the outermost position fixes of the male and female circumscribed areas of 10.6 and 8.1 ha respectively. The area of overlap between their home ranges (calculated from the overlap of their respective MCPs) was 0.05 ha.

Isopleth areas for the Harmonic mean and Kernel statistics indicate the probability of finding an animal

Table 1 Estimates of home range (ha) for a male and female Marbled Frogmouth from adjacent territories, derived by fitting minimum convex polygon (MCP), Harmonic mean (HM) and Kernel models to the data.

Individual	No. of fixes	MCP	HM[a]		Kernel[a]	
			95%	100%	95%	100%
Male	92	10.6	12.1	31.1[b]	10.8	18.0
Female	71	8.1	9.3	14.7	8.8	15.0

[a] These estimates represent those of the 95% and 100% isopleths (i.e. the areas over which the probability of encountering a bird are 95% and 100%).
[b] A possible over-estimate resulting from the inclusion of outliers in the extreme easterly part of the male's home range.

within these isolines. The 31-ha area defined by the Harmonic 100% isopleth could be an over-estimate, biased by the inclusion of extreme points in the eastern part of the male's range, and includes areas known not to be inhabited by the male. At present it is discounted as an over-estimate of home range for this period.

Estimates of home range varied from 10.6-18 ha for the male (discounting the 100% Harmonic mean estimate) and from 8.1-15 ha for the female (Table 1). Some researchers (e.g. Jaremovic & Croft 1987; Boulanger & White 1990) have argued for the use of the 95% isopleth as a more suitable boundary to the home range estimate. Both the 95% isopleth estimates (Harmonic and Kernel analyses) were closer to each other and to the MCP estimate than the 100% estimates. If the 100% figures were excluded then home ranges varied from 10.6-12.1 ha for the male and 8.1-9.3 ha for the female. All estimates included areas where Plumed Frogmouths were not located during this study. These areas were either too open, lacked rainforest species or did not contain vines which Plumed Frogmouths used for perching.

The home ranges calculated in this paper suffer from several problems. There were difficulties involved in obtaining reliable fixes (see Methods) in some parts of each bird's home range. Therefore, a lack of points in some places, particularly at the edges of home ranges, is partly due to under-sampling in these areas, despite birds frequently returning to these general areas over a number of nights. The data were collected over a short period (35 days), involved only one animal of each sex and only one locality. Furthermore, the data sets used to calculate home ranges contained fewer than 100 points; Goldingay & Kavanagh (1993) showed that such small data sets (less than 100 points) for Yellow-bellied Gliders tended to under-estimate home ranges.

Despite these problems, we present an account indicative of home range for the Plumed Frogmouth. All estimates will be improved with comparable sampling across each bird's home range and increases in sample size.

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Opinion 1764. ***Anas arcuata* Horsfield, 1824 (currently *Dendrocygna arcuata*; Aves, Anseriformes): specific name conserved.**