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Use of Male Blue Monkey "Pyow" Calls for Long-Term Individual Identification

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This study examines whether individual adult male blue monkeys (*Cercopithecus mitis stuhlmanni*) can be identified through acoustic analysis of their "pyow" calls. It is possible to reliably assign the pyow call of the blue monkeys of Kibale Forest, Uganda, to the individual caller based on the acoustic properties of the vocalization. Analysis of pyows made by a recognizable male over a 10-yr period shows that the acoustic properties of one individual's pyow call can remain relatively constant over time. Acoustic analysis of pyow calls may provide a relatively easy and reliable method to document tenure lengths of adult male blue monkeys resident in groups. Similar analyses of the loud calls of other species of primates may, likewise, prove to be useful in documenting long-term membership.
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INTRODUCTION

Behavioral and demographic research on primates requires the reliable identification of individuals. A variety of techniques, from simple procedures such as the identification of animals from scars and pelage patterns, to more elaborate procedures such as the darting and marking of animals have been used [Scott et al., 1976; Jones and Bush, 1988; Glander et al., 1982]. For many species, simple procedures are not possible, and reliable individual identification demands the capture and marking of animals. This is usually difficult, time-consuming, and requires skilled personnel. Further, the experience for the animal is traumatic and can result in loss of habituation, injury, or death. In many places the darting equipment and drugs are difficult and expensive to obtain. In addition, tag loss does occur, demanding a second mark.

Several studies have documented consistent acoustic differences between the calls of individual primates [Marler & Hobbett, 1975; Tenaza, 1976; Lillehei & Snowdon, 1978; Snowdon & Cleveland, 1980; Smith et al., 1982a,b; Chapman & Weary, 1990]. Intraspecific responses to the playback of calls of specific individuals have also indicated individual recognition [Hansen, 1976; Waser, 1977; Kaplan et

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al., 1978]. Based on these studies, it seems reasonable that acoustic analyses of calls may be useful in determining long-term group membership. This would demand that (1) the calls of different individuals are acoustically distinct, and (2) that the call of a particular individual does not change over time.

The objective of this study is to examine whether acoustic analyses can be used for reliable, long-term identification of individual primates. We first contrast the loud "pyow" call [Marler, 1973] of different known adult male blue monkeys (*Cercopithecus mitis stuhlmanni*) in Kibale Forest, Uganda, to determine if it is possible to reliably assign the pyow to the original caller based on its acoustic properties. Subsequently, we examine whether the acoustic properties of the pyow call are stable over time, thus making analysis of pyows a reliable method for long-term individual recognition. We assessed this by analyzing the recordings of calls given by one recognizable male made over a 10-yr period. This work constitutes a segment of a long-term study of blue monkeys [Butynski, 1982, 1990].

METHODS

Blue monkey pyow calls were recorded at intervals between October 1978 and December 1990 in the Kibale Forest Reserve, western Uganda (0° 13′–0° 41′N and 30° 19′–30° 32′ E). The reserve is a moist, evergreen tropical forest transitional between lowland forest and montane forest [Wing & Buss, 1970; Struhsaker, 1975; Skorupa, 1988]. About 60% of the Kibale Forest Reserve is characterized by tall forest, with the canopy generally 25–30 m high, but some trees exceeding 55 m in height [Butynski, 1990]. The remainder of the reserve is composed of a mosaic of swamp, grassland, thicket, and colonizing format [Wing & Buss, 1970; Butynski, 1990].

The pyow is a loud, explosive call (between 1.68 and 2.15 kHz dominant frequency) with a duration averaging 0.113 sec [Fig. 1; Marler, 1973]. It is given during the daylight hours by group-living adult male blue monkeys. This call may be given during any time of the day, but is emitted about twice as frequently during the 2 h after dawn and the 2 h before dusk than during midday. The pyow is rarely given by solitary males or after dark. During 2,725 h of contact (by TMB) with five focal groups of blue monkeys, 487 pyow-only calling bouts were noted during all-day samples. On average, the males in these five groups gave pyow cell bouts at the rate of 0.18/h (range 0.16/h–0.25/h). Mean number of pyows per bout was 6.48 (range 5.04–9.16). Mean duration of bouts was 59 sec (range 49 sec–89 sec) and mean inter-pyow interval within bouts was 12.3 seconds (range 10.9 sec–12.5 sec).

Recordings were made with either a Nagra III or a Marantz (PMD 430) tape recorder and Sennheiser MKH 804 microphones. We obtained a sample of 140 calls from 5 individuals, and for the easily identifiable male 68 calls were recorded during five separate years of study. Pyow calls were analyzed with a Kay Sonagraph (7800) set on a 150 Hz bandwidth. We made sonographs of the first five calls recorded in each calling bout. However, since calls within a bout are influenced by similar recording constraints (e.g., animal to recorder distance and background noise), they were not considered independent, and only the pyow of highest recording quality in a sequence was used for comparisons. This produced a sample of 29 calls from 5 individuals and 14 calls for the individually recognizable male. This seems appropriate since there were no differences in any of the parameters measured ($P>0.10$) among the first to fifth calls in the sequence. Similarly, if more than one recording was made on a particular day, only the highest quality recording was used. Generally, recordings were made at a distance of 30 to 50 m.

The male from Group 2 was easily visually recognizable because of a missing

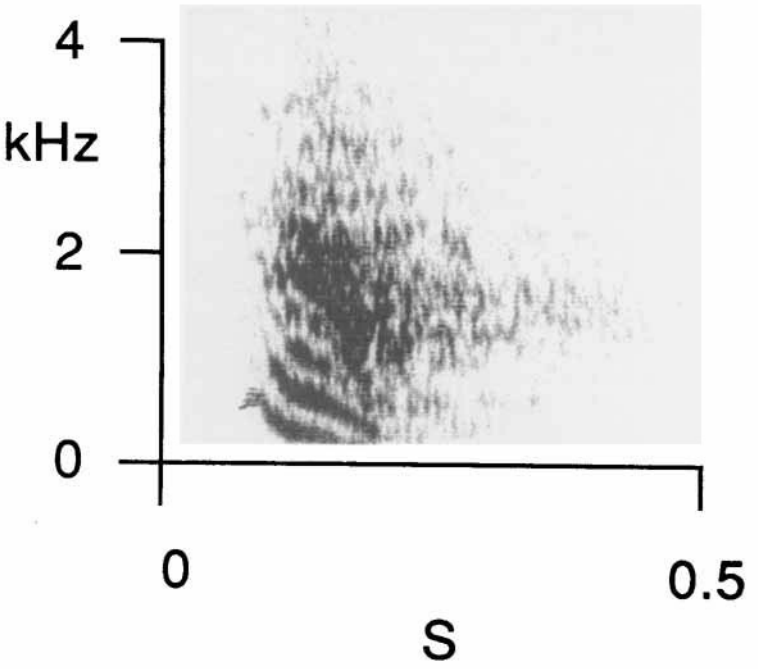

Fig. 1. A representative "pyow" vocalization of an adult male blue monkey recorded in Kibale Forest Reserve, Uganda [see also Marler, 1973].

digit. He was present when the study group began in 1978 and was still present as of July 1991. Most of the adult males in the four other groups were recognizable only after careful observations. The males were members of groups with neighboring home ranges at the Kanyawara study site in the Kibale Forest Reserve.

On each sonogram the following features were measured: the duration of the fundamental, the duration of the first harmonic, the starting and ending frequency (Hz) of the fundamental, the starting and ending frequency (Hz) of the first harmonic, dominant frequency [after Marler, 1973], the number of inflections in the fundamental, and the length and slope of the negatively sloping segment of the fundamental. Acoustic variables were statistically examined using an ANOVA to determine if it was possible to reliably distinguish between callers. In addition, discriminant analysis was used to assess the reliability of identifying individuals based on all of the measures and specific subsets following the procedures outlined by Smith et al. [1982a]. Discriminant analysis reduces the number of variables and creates a number of functions which can be used to classify individual cases (calls) into groups (individuals). Our sample size is somewhat low for this multivariate approach, thus the results should be considered with caution. To determine if the structure of the pyows of the individually recognizable male, which was repeatedly sampled between 1981 and 1990, changed with time, we performed an ANOVA with year as the independent variable on each acoustic parameter measured. Since sample sizes were small per individual, we repeated both analyses using the nonparametric Kruskal-Wallis test. This produced results that did not differ in significance from the parametric tests reported.

TABLE I. Statistical Results of the Differences in Acoustic Parameters of the Pyow Call Among Six Blue Monkeys in Kibale Forest Uganda*

Acoustic parameter	Individuals (Mean/S.D. between males)	Mean/ (standard error)	ANOVA between individuals	No. of individual pairs distinguished (Scheffe)
Duration of the fundamental	1 1.4/0.3 2 1.0/0.1 3 1.5/0.1 4 1.3/0.2 5 1.4/0.1 6 1.4/0.2	1.20/(0.052)	$F = 9.35$, $P = 0.001$	3
Duration of the 1st harmonic	1 2.0/0.5 2 1.2/0.3 3 1.5/1.1 4 1.2/0.3 5 1.3/0.3 6 1.0/0.3	1.29/(0.076)	$F = 3.47$, $P = 0.019$	2
Starting frequency of fundamental	1 0.75/0.22 2 0.65/0.07 3 0.69/0.05 4 0.81/0.12 5 0.58/0.00 6 0.94/0.46	0.708/(0.026)	$F = 5.89$, $P = 0.019$	2
Ending frequency of fundamental	1 0.19/0.05 2 0.24/0.02 3 0.16/0.01 4 0.22/0.05 5 0.16/0.00 6 0.28/0.05	0.226/(0.008)	F-7.19, $P = 0.0004$	5
Starting frequency of 1st harmonic	1 1.08/0.33 2 1.10/0.25 3 1.00/0.16 4 0.81/0.13 5 0.79/0.06 6 1.11/0.09	1.080/(0.043)	$F = 1.114$, $P = 0.371$	0
Ending frequency of 1st harmonic	1 0.30/0.09 2 0.35/0.03 3 0.36/0.05 4 0.31/0.05 5 0.29/0.06 6 0.52/0.13	0.355/(0.016)	$F = 6.32$, $P = 0.001$	5
Dominant frequency	1 1.69/0.13 2 1.93/0.15 3 1.97/0.10 4 2.00/0.01 5 2.17/0.12 6 1.58/0.17	1.896/(0.037)	$F = 6.50$, $P = 0.0007$	5
Number of inflections	1 1/— 2 1.94/0.27 3 1/— 4 1/— 5 1.5/0.7 6 2/—	1.6/(0.094)	$F = 16.17$, $P < 0.0001$	6
Length of the negative sloping segment of the fundamental	1 15.33/3.76 2 10.29/1.38 3 16.33/1.16 4 14.67/0.58 5 15.00/1.14 6 10.67/1.53	12.3/(0.559)	$F = 11.95$, $P < 0.0001$	6

(continued)

TABLE I. Statistical Results of the Differences in Acoustic Parameters of the Pyow Call Among Six Blue Monkeys in Kibale Forest Uganda* (Continued)

Acoustic parameter	Individuals (Mean/S.D. between males)	Mean/ (standard error)	ANOVA between individuals	No. of individual pairs distinguished (Scheffe)
Slope of the negative sloping segment of the fundamental	1 20.33/1.53 2 31.21/2.72 3 24.00/3.46 4 30.33/1.20 5 27.00/7.07 6 32.67/1.16	29.0/(0.898)	$F=9.98$, $P<0.0001$	5
Length of the positive sloping segment of the fundamental	1 9.00/0.00 2 2.50/1.91 3 9.00/0.00 4 9.00/0.00 5 5.50/4.95 6 4.00/1.73	4.7/(0.654)	$F=10.25$, $P=0.0001$	2
Slope of the positive sloping segment of the fundamental	1 29.0/10.95 2 25.0/0.00 3 14.81/4.21 4 0.00/0.00 5 33.7/12.19 6 14.00/7.73	24.0/(3.80)	$F=10.59$, $P=0.002$	1

*The means and standard error for the parameters are given (Frequency in kHz, Duration in 1/100 th of seconds, length in mm; the overall mean, takes into account differences in n values between individuals).

RESULTS

The recognizable male of Group 2 was recorded in 1981, 1982, 1983, 1984, and in 1990. Males from five other groups were recorded in a single year (1990). For all of the parameters considered, with the exception of the starting frequency of the first harmonic, there were significant differences between the pyows of the six individuals (Table I).

Based on a discriminant analysis using all of the parameters measured, pyows were correctly assigned to the caller on 100% of the occasions. Each individual could be correctly distinguished (100%) when he was singularly contrasted against all others. Using just the two most contrasting parameters, total duration of the fundamental and length of the negatively sloping aspect of the fundamental, the pyows were correctly assigned to caller on 71.4% of the occasions. However, with only these two parameters the accuracy that each individual could be correctly distinguished from all others singularly varied from 33% to 100%. The pyows from the Group 2 male were correctly assigned on 85.7% of the occasions. This highlights the importance of considering a number of parameters in the analysis, and not attempting to distinguish between individuals based on one or a small number of parameters.

To test if the identity of blue monkeys can be repeatedly determined from pyows on a long-term basis, we contrasted the acoustic parameters measured for the Group 2 male between years. Of the 12 parameters measured, only one differed over time (slope of the first positive sloping segment of the fundamental). The value of this parameter was high in 1983, but subsequently returned to a more typical value. This suggests that the parameter did not change systematically as the animal aged.

DISCUSSION

While it is possible to recognize individual male blue monkeys visually, the process is generally time-consuming. For other species which have dark pelage and

skin, or for those species in fission-fusion societies where it can be a number of weeks between resightings of the same individual, this task becomes extremely difficult. Recognition of individuals also becomes time consuming when the study requires that a large number of animals be identified and monitored over a long period. Such a study might be one where the primatologist wishes to examine the relationship between group size and male tenure. In this case, one may wish to obtain relevant data on 50 groups every 3 months. This would not be feasible given the absence of a reliable method for the rapid identification of resident adult males. The results obtained here suggest that the acoustic analysis of the pyow call may be both a fast and unambiguous technique for identifying large numbers of adult male blue monkeys. Although our sample size was small for the discriminant analysis they are consistent with the analysis of variance (and Kruskal-Wallis test) which showed significant differences between the pyows of the six individuals for 11 out of the 12 acoustic parameters. With group-living adult males giving two to three pyow bouts per day, it is not difficult for a researcher to record at least one bout of pyows per day. If the researcher is with the blue monkey group at dawn it is likely that a suitable recording will be obtained before mid-morning.

Since the majority of primate species give some form of loud call, this technique may be widely applicable. We caution, however, that our samples are small and, therefore, our results should not be prematurely generalized. We have demonstrated that the pyow calls of male blue monkeys are distinctive among six individuals living in the same forest and that for one male this call remained sufficiently acoustically similar over time to allow for his long-term individual recognition. Until other studies can replicate our findings for a wide range of primate species, all studies should attempt to verify the method on recognizable animals.

CONCLUSIONS

1. Based on acoustic properties of the "pyow" calls of adult male blue monkeys, it is possible to accurately (100%) assign the call to caller, and thus individually recognize six different individuals.

2. Eleven of the 12 acoustic properties of the pyow call of one recognizable monkey male did not change over a 10-yr period, suggesting that acoustic analysis may provide a reliable method to determine long-term group membership.

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