

## Roaring Rhythms in Black Howler Monkeys (*Alouatta pigra*) of Belize

ROBERT H. HORWICH and KRIS GEBHARD

*Institute of Micro-ontogenetic Ethology  
and Macro-cosmological Ecology*

**ABSTRACT.** Roaring was recorded during 15-min intervals for 55 days from April 29 to July 14, 1981 in the area around Bermuda Landing, Belize. Roaring profiles were compiled to represent four three-week periods in which roaring was graphed against the time of day. Rates of roaring were also calculated for three troops. Results indicate a gradual change in the daily profile of roaring from dry to rainy season. The marked bimodality of roaring at dawn and dusk in the dry season changed to a more dampened bimodality with reduced dawn and dusk peaks and more roaring during the midday in the rainy season. This seems related to the decreased hours of sun and the amount of rain during the wet season. Additionally, literature on monkeys with long range vocalizations suggests that bimodal peaks in calling may be more prevalent in species which display territorial defense.

### INTRODUCTION

Roaring in howler monkeys, their most dynamic behavior, has attracted researchers and laymen alike to hypothesize reasons and functions for it. From the literature it seems fairly certain that it has some function in spacing troops (CARPENTER, 1934; CHIVERS, 1969) although there is some dispute as to whether or not it functions in actually maintaining a territory. In Belize it is also reputed to forecast rain (i.e., howlers roar when the rains come). In this study we recorded daily roaring and compiled three-week profiles to compare the changes from the dry season to the rainy season with the seasonal weather changes.

### METHODS

Daily records were made of general roaring in black howler monkeys, *Alouatta pigra*, at Bermuda Landing, Belize as part of a study on infant development. For additional information on the area see BOLIN (1981). An estimated number of troops (15-20) could be heard within a mile or more surrounding the village. Figure 1 shows a map of the area in which observations were made. Since most of the records were made while observing Troop 1 (Fig Tree troop) and Troop 2 (Cashew troop) a 1-mile radius circle was drawn using a central point between these two troops. Most predawn, post-dusk and midday roaring was noted from the area immediately surrounding our house. Table 1 shows a population sampling of nine troops within the mile radius including the three troops for which a roaring rate was calculated.

Continuous daily records for 55 days during the period of April 29 to July 14, 1981, were made in which roaring was noted whenever it was heard during waking hours (4:30-5:00 a.m. to 10:00 p.m.). Additionally, roaring was recorded when heard from 10:00 p.m. to 4:30 a.m. since we were usually awakened by the sounds. Sampled observations during these

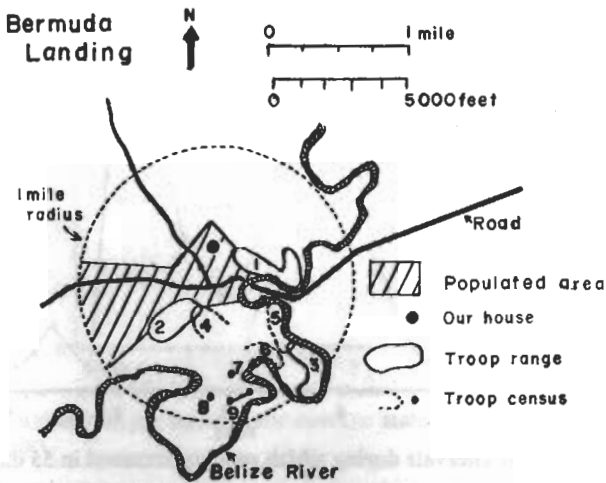


Fig. 1. Map of area surrounding Bermuda Landing showing locations of nine troops censused and observed within a 1-mile radius.

Table 1. A population census of nine troops, including hours each troop was under observation and approximate home range sizes of three troops.

Troop	Adults		Subadults		Juveniles		Infants		Total	Hours obs.	Range (acres)
	Male	Female	Male	Female	Male	Female	Male	Female			
1. Fig tree	2	1	—	1	—	—	—	1	5	167.5	60
2. Cashew	2	2	—	—	1	—	—	1	6	126.5	46
3. Baptiste	2	3	1	—	2	1	1	—	10	28	28
4. Huevos	1	1	1	—	1	—	—	—	4	14	—
5. Down river	1	3	—	—	2	—	—	—	6	3	—
6. Up river	3	2	—	1	—	—	—	—	6	1	—
7. Scar lip	1	2	—	—	2	—	—	—	5	1	—
8.	1	3	—	—	1	—	1	—	6	1	—
9.	2	2	1	—	3	—	—	—	8	1	—

hours when awake showed little roaring, substantiating our data. The occurrences were then grouped into 15-min periods during the day. Seasonally the data were grouped into four periods in which there was an equal number of days (14, one with 13) of roaring records: (1) April 29–May 15; (2) May 16–June 3; (3) June 4–22; and (4) June 23–July 14. The total number of 15-min intervals when roars occurred during those days was plotted against time of day (hours) for each period. Additionally, any roaring heard from troops under visual observation was noted relative to the situations in which they occurred. For three troops an hourly rate of roaring was calculated. Weather data were obtained from the Belize National Meteorological Service which included maximum and minimum temperatures, total daily rainfall and total number of sunshine hours recorded from Big Falls (4 miles away), and barometric pressure readings were obtained from Belize International Airport from the Caribbean Meteorological Institute.

## RESULTS

The total number of days (55) in which roaring intervals were noted showed a distinct equal

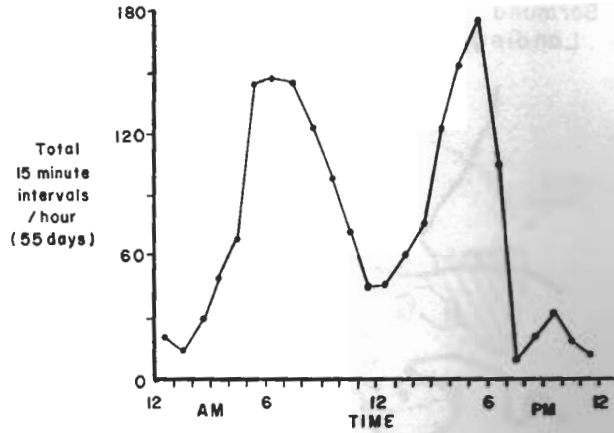


Fig. 2. The number of 15-min intervals during which roaring occurred in 55 days of observation as a function of time of day.

bimodality in which a morning peak occurred between 5:00–8:00 a.m. CST with a more distinct afternoon peak prior to sunset between 5:00–6:00 p.m. (Fig. 2). A slight period of roaring was consistently heard between 9:00–10:00 p.m. as well. The most inactive period during daylight hours was from 11:00 a.m. to 1:00 p.m. in the midday.

When the data are broken into four periods, a gradual change in the daily profile can be

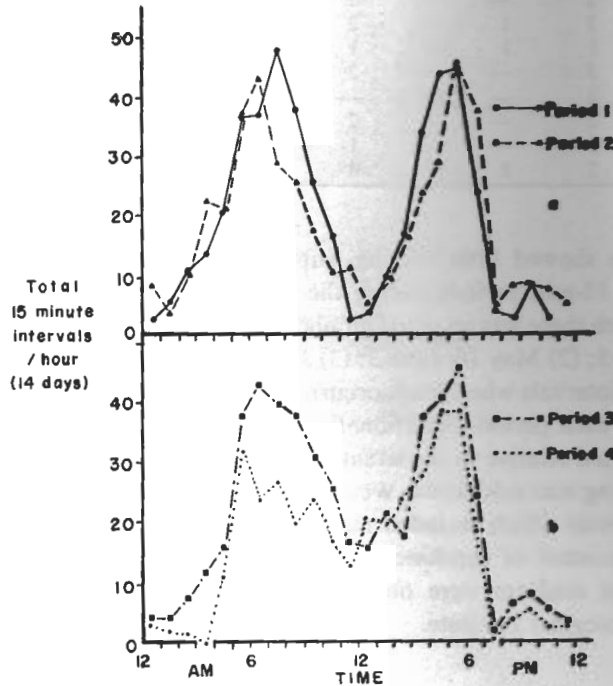


Fig. 3. The number of 15-min intervals during which roaring occurred for four periods of 14 observation days each (13 days for Period 1) as a function of time of day. Period 1: April 29–May 15; Period 2: May 16–June 3; Period 3: June 4–22; Period 4: June 23–July 14, 1981.

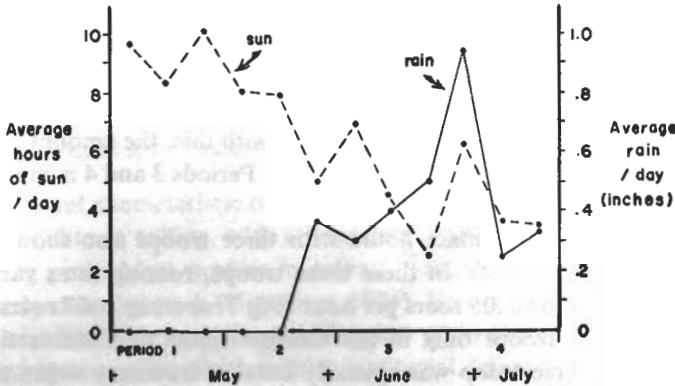


Fig. 4. The average hours of sun per day and the average inches of rain per day which occurred weekly during May–July 1981.

observed between the dry (Fig. 3a) and the rainy season (Fig. 3b). Figure 3a shows data from April 29–June 3 in which little rain had fallen. During this time (Period 1) the distinct bimodality with a low noon period is seen. Figures 3a and 3b show transition times (Periods 2 & 3) in which bimodality is still evident although there is considerably more roaring during the midday. The final Period 4 (Fig. 3b) when most rain and overcast skies occurred, shows a marked reduction in the bimodality especially in the morning peak with a considerable amount of roaring occurring during the middle of the day. Weather data show few trends relative to the daily total of 15-min intervals in which roaring occurs. However, Figure 4, showing sunlight hours and average daily rains, indicates a convergence of markedly less sunshine and an increase in rain during the last Period 4 with a transition in those trends during Period 3. Other weather factors such as temperature and barometric pressure do not show any trends. Table 2 shows average weather figures and measures of roaring for all four periods. As can be seen, certain measures of roaring show a consistent diminishing trend

Table 2. Values of roaring and environmental factors for four chronological periods.

Period	1 Apr. 29–May 15 (13 obs. days)	2 May 16–June 3 (14 obs. days)	3 June 4–22 (14 obs. days)	4 June 23–July 14 (14 obs. days)
Roars/hr (3 troops) <sup>1)</sup>	.15	.12	.09	.00
Amount of roars (rank) <sup>1)</sup>	1	2	3	4
Morning roaring peak <sup>1)</sup>	48	43	43	32
Evening roaring peak	45	46	46	39
Midday low	3	6	16	13
Amount of roaring intervals	35.2	31.7	33.6	26.1
Total rainfall (inches) <sup>1)</sup>	.06	1.49	5.56	7.25
Number of rain days <sup>1)</sup>	1	4	8	10
Hours of sun <sup>1)</sup>	9.37	7.04	4.88	3.81
Maximum temp.	91.8	93.5	89.6	88.4
Minimum temp.	67.7	71.4	73.6	70.5
Barometric pressure (at 6 a.m.)	1011.4	1010.5	1009.9	1012.7
Sunrise (median)	5:30	5:25	5:24	5:29
Sunset (median) <sup>1)</sup>	18:23	18:29	18:36	18:40
Daylength	12'53"	13'4"	13'12"	13'11"

1) Continuous trends.

relative to a consistent trend in measures of sun and rain. The total amount of roaring as determined by the amount of area under the curves in Figure 3 shows a gradual reduction from Period 1 to 4. Additionally, the morning peak of intervals consistently gets smaller from Period 1 to 4. In correlation with this, the total amount of rainfall rises from Period 1 to 4 as does the number of rain days. In conjunction with this, the amount of sunshine hours consistently declines. Additionally, the midday low in Periods 3 and 4 is much higher than in earlier periods.

Roarings noted during 322 contact hours with three troops also showed reduced rates during the rainy season (Table 2). In these three troops, roaring rates varied greatly: .18 roars per hour (Cashew troop), .05 roars per hour (Fig Tree troop), .07 roars per hour (Baptiste troop). Of the three troops only in the Cashew troop were interactions noted with another troop. The Fig Tree troop was spatially isolated from any other troops by about one-eighth mile and the Baptiste troop had a neighbor on one side. The Cashew troop showed an active defense toward one adjacent troop and breeding actually occurred between a female of Cashew troop and the male of the adjacent Huevos troop (HORWICH, 1983). Of the 23 situations in which Cashew troop roared, 91% were within 100 yards of the border across which intertroop interactions occurred and 65% took place at the actual territory line. In 43% of their roars Cashew troop was vocally joined by the adjacent Huevos troop and 30% of their roars occurred on the days in which the female was in estrus. In fact the rates of roaring during the estrus period increased during this time. Roaring during the estrus period was at a rate of .22 roars per hour relative to a .17 roars per hour at other times. While this may be an effect of the estrus, it should be noted that during that period the estrus female and the dominant male of her troop were almost constantly across the territorial line from the adjacent troop.

Roaring rates on specific troops were taken generally between 7:30 a.m. and 5:00 p.m. while studying infants and consequently before and after peak roaring periods. Thus the average rates do not coincide with peak rates. If we consider the number of 15-min intervals in which roars occurred as approximating an hourly rate and average it during our main observation times, it averages 1.78 intervals per hour. When divided by the average hourly rate of the three troops observed (.10), we get an estimate of 17.8 troops heard. This agrees with our subjective estimate of 15–20 troops heard.

## DISCUSSION

### ROARING AND ENVIRONMENTAL FACTORS

What seems most sure from our data is that roaring is affected by extrinsic factors. Roaring has a contagious quality and may be stimulated by other sounds of similar quality (motors, thunder, wind, etc., BALDWIN & BALDWIN, 1976; RUDRAN, pers. comm.; HORWICH, pers. obs.). Additionally, it is indeed affected by the rains and reduced sunlight but not as the Belizean people think it is. From this study and that of CHIVERS (1969), reduced sunlight hours and increased rain seemed to reduce the amount of roaring. These same factors also served to cause the roaring to spread out more throughout the day and consequently reduced the main post-dawn and pre-dusk peaks and increased the level of roaring during the midday. CHIVERS (1969) also found a correlation of the morning roaring peaks with sunrise as was noted in the Nilgiri langur (HORWICH, 1976). From this study it seems as though sunset time

may have been relevant (Table 2). While sunrise time was changing temporally up and down, sunset time was consistently getting later during the study. The profiles of roaring all show a later peak as the season progressed (Figs. 3 & 4).

#### BIMODAL CALLING PEAKS AND TERRITORIALITY

One very significant characteristic of the daily profiles of roaring in *Alouatta pigra* was the presence of bimodality in calling, with a large late afternoon peak which was even sharper than the morning peak. Most profiles in calling of monkeys with long range vocalizations show a main early morning peak (HORWICH, 1976). However, a literature survey of howlers and colobines which exhibit long range calling has given strong suggestion that this double peak occurs mainly in species which exhibit territorial defense. In *A. pigra* there was some indication of territorial defense. The Cashew troop showed 91% of their calls within 100 yards of a border which they actively defended. Additionally, three incidents were observed between them and the adjacent troop in which the resident troop chased the invading troop out of their area across a definitive line (HORWICH, in press). Roaring was noted following these chases and both troops were aware of the line and their dominance on their side of it. In the other two troops observed, no intertroop interactions were observed and both troops showed only a third as many roars.

Of data available on howlers and colobines which show long calling, only *Colobus guereza* and *Presbytis melalophos* show a strong bimodal calling profile as observed in *Alouatta pigra* (OATES, 1974; CURTIN, 1980). *C. guereza* shows both profuse morning calling from 6:00–12:00 a.m. and a very specific high level peak of calling at 6:00–7:00 p.m. (OATES, 1974) while *P. melalophos* shows the most ritualized long calling with specific peaks at 5:00–6:00 a.m. and 6:00–9:00 p.m. (CURTIN, 1980; CHIVERS, 1973). Both species have documented territoriality (MARLER, 1969; CURTIN, 1980). Two other related langurs *Presbytis johnii* and *Presbytis senex* which are territorial (HORWICH, 1972; POIRIER, 1968; RUDRAN, 1973) both show small afternoon peaks in calling along with the much larger morning peaks (HORWICH, 1976; RUDRAN, pers. comm.). *Presbytis obscurus*, another territorial species (CURTIN, 1980) also shows a large amount of afternoon calling although its calls differ from the long calls in being a loud sharp call related to an alarm bark.

In contrast, *Alouatta palliata*, whose territoriality is questionable (CHIVERS, 1969) shows a high level of roaring in early morning which tapers off gradually even though a considerable amount of afternoon calling does occur. This calling seems related to troop spacing (CHIVERS, 1969). In *Presbytis entellus* as well, territoriality is questionable (VOGEL, 1975) and it also shows just the main morning calling peak (BECK & TUTTLE, 1972).

**Acknowledgements.** We wish to thank VALLEN POPE, FALLON YOUNG and Mr. BAPTISTE as well as other residents of Bermuda Landing for their help, information and use of their lands for this study. Thanks also go to Drs. JOHN F. EISENBERG, R. RUDRAN and CHUCK SNOWDON for comments on the manuscript and to Dr. R. SECULIC for her comments. We also wish to thank Miss STEVENS and the Belize Weather Bureau and the Caribbean Meteorological Institute for providing us with weather data.

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—Received September 10, 1982; Accepted November 25, 1982

Authors' Names and Address: ROBERT H. HORWICH and KRIS GEBHARD, *Institute of Micro-ontogenetic Ethology and Macro-cosmological Ecology, Route 1, Box 96, Gays Mills, Wisconsin 54631, U.S.A.*