

ECOLOGY OF CENTRAL AMERICAN CACOMISTLES IN COSTA RICAN CLOUD FOREST

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ABSTRACT

Activity, home range and habitat use and selection of six Central American cacomistles (*Bassariscus sumichrasti*) were studied between January-July 1995 in the Barva Volcano sector of Cordillera Volcanica Central Conservation Area, Costa Rica. Based on 1,625 nocturnal radio-telemetry triangulations, nocturnal activity peaked at 18:00 h, stabilized between 20:00 and 03:00 h, then decreased from 04:00 to 06:00 h. Number of active observations were greater than inactive for both sexes ($P < 0.001$). Mean total home range (100%) was 19.8 ha. Male home ranges were greater ($\bar{x} = 23$ ha) than females ($\bar{x} = 16.7$ ha). Mean dry season home range for all six cacomistles was slightly greater ($\bar{x} = 15.8$ ha) than in wet season ($\bar{x} = 14.2$ ha). Mean dry season home range for females was greater ($\bar{x} = 14.8$ ha) than in wet season ($\bar{x} = 10.1$ ha). Mean dry season home range for males ($\bar{x} = 18.9$ ha) was similar to wet season ($\bar{x} = 18.3$ ha). Secondary forest was the most common habitat type within home ranges. Males used secondary forest more (59.4% of locations versus 47.0% availability) and females used secondary forest less (44.8% versus 51.9%, respectively) than its availability. Habitat preferences by both sexes were similar in both seasons, but females were found in secondary forests less in wet season than dry season and in forested pasture less in dry season than wet season. Males were found in the overgrown pasture more in dry season than wet season. Cacomistle home ranges and activity patterns were similar to other nocturnal procyonids, although males had smaller ranges than other procyonids. Their use of several montane habitats suggests they may be an adaptable species.

KEY WORDS: activity, *Bassariscus sumichrasti*, cacomistle, cloud forest, Costa Rica, geographic information system, habitat use and selection, home range, radio-telemetry

RESUMEN

Actividad, radio de acción y uso de hábitat de seis ostoches centroamericanos (*Bassariscus sumichrasti*) fueron estudiados entre enero a julio de 1995 en el sector del Volcán Barva del Área de Conservación del Cordillera Volcánica Central, Costa Rica. Basado en 1,625 localizaciones nocturnas de radio-telemetría, la actividad nocturna fue máxima a las 18:00 h, se estabilizó entre las 20:00 y 03:00 h, luego decreció entre las 04:00 y 06:00 h. El número de observaciones activas fue mayor que las inactivas para ambos sexos ($P < 0.001$). El radio de acción total (media) fue 19.8 ha. Radios de acción para machos fueron mayores ($\bar{x} = 23$ ha) que para hembras ($\bar{x} = 16.7$ ha). Radio de acción de la estación seca (media) para todos los ostoches fue ligeramente mayor ($\bar{x} = 15.8$ ha) que lo de la estación lluviosa ($\bar{x} = 14.2$ ha). Radio de acción de la estación seca para hembras (media) fue mayor ($\bar{x} = 14.8$ ha) que en la estación lluviosa ($\bar{x} = 10.1$ ha). Radio de acción de la estación seca para machos ($\bar{x} = 18.9$ ha) fue semejante al de la estación lluviosa ($\bar{x} = 18.3$ ha). Bosque secundario fue el tipo de hábitat más común dentro de los radios de acción. Machos usaron el bosque secundario más (59.4% de localizaciones versus 47.0% disponibilidad) y hembras usaron bosque secundario menos (44.8% versus 51.9%, respectivamente) que su dis-

ponibilidad. Las preferencias de hábitat por sexo fue semejante entre estaciones, pero hembras fueron encontrados en bosque secundario menos en la estación lluviosa y usaron el potrero arbolado menos en la estación seca. Se encontraron los machos en potreros de avanzado estado sucesional más en la estación seca. Radios de acción y patrones de actividad de ostoches fueron semejantes a otros procyonidos nocturnos, pero los machos tuvieron radios de acción más pequeños que otros procyonidos. El uso de varios tipos de hábitats sugiere que el ostoches puede ser una especie adaptable.

PALABRAS CLAVE: actividad, *Bassariscus sumichrasti*, bosque nuboso, Costa Rica, ostoches, radio de acción, radio telemetría, sistema de información geográfica, uso y selección de hábitat

RESUMO

Atividade, radio de ação, uso e seleção de habitat de seis ostoches centroamericanos foram estudados entre janeiro e julho de 1995 no setor do vulcão Barva da área de conservação Cordilleira Vulcânica Central, Costa Rica. Baseada em 1685 localizações noturnas de radio-telemetria, a atividade noturna foi máxima às 18:00 h, estabilizou-se entre as 20:00 e 03:00 h, depois diminuiu entre as 04:00 e as 06:00 h. O número de observações ativas foi maior que as inativas para ambos sexos ($P < 0.001$). O radio de ação total (média) foi 19.9 ha. Radios de ação para machos foram maiores ($\bar{x} = 23$ ha) que para fêmeas ($\bar{x} = 16.7$ ha). Radio de ação da estação seca (média) para todos os ostoches foi ligeiramente maior ($\bar{x} = 15.8$ ha) que o da estação chuvosa ($\bar{x} = 14.2$ ha). Radio de ação da estação seca para fêmeas (média) foi maior ($\bar{x} = 14.8$ ha) que na estação chuvosa ($\bar{x} = 10.1$ ha). Radio de ação da estação seca para machos ($\bar{x} = 18.9$ ha) foi semelhante ao da estação chuvosa ($\bar{x} = 18.3$ ha). Bosque secundário foi o tipo de habitat mais comum dentro dos radios de ação. Machos usaram o bosque secundário mais (59.4% de localizações versus 47.0% disponibilidade) e as fêmeas usaram o bosque secundário menos (44.8% versus 51.9%, respectivamente) que a disponibilidade deste. As preferências de habitat por sexo foi semelhante entre estações, mas as fêmeas foram achadas em bosque secundário menos na estação chuvosa e usaram o potreiro arvorejado em menor quantidade na estação seca. Os machos foram achados em poteiros em avançado estado sucessional mais na estação seca. Radios de ação e padrões de atividade dos ostoches foram semelhantes a outros procyonidos noturnos, mas os machos tiveram radios de ação mais pequenos que outros procyonidos. O uso de varios tipos de habitat sugere que o ostoches pode ser uma espécie adaptável.

PALAVRAS CHAVE: atividade, *Bassariscus sumichrasti*, bosque nuboso, Costa Rica, ostoches, radio de ação, radio telemetria, sistema de informação geográfica, uso e seleção de habitat

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The genus *Bassariscus* (Family Procyonidae) consists of the ring-tailed cat (*B. astutus*) and the Central American cacomistle. The former species ranges from Kansas and southwest Oregon to central Mexico and its natural history has been studied by Brody and Koch (1983), Toweill and Teer (1981), and Yarchin (1990). The cacomistle remains largely unstudied in the wild because of its nocturnal, arboreal lifestyle in isolated areas. Cacomistles are found

from southern Mexico to Panama (Wilson and Reeder 1993). Estrada and Coates-Estrada (1985) did a preliminary ecological study of five cacomistles in Los Tuxtlas, México. Poglayen-Neuwall (1992a, 1992b) studied behavior of this species in captivity. As a continuation of a pilot project on cacomistle ecology (Vaughan *et al.* 1994) we studied the cacomistle at the same site. We studied the seasonality of activity, home range, and habitat use and selection of cacomistles in a Costa Rican cloud forest to better understand its conservation needs.

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STUDY AREA

The study area was found in the "Cordillera Volcánica Central" Conservation Area (CVC), a 175,000-ha protected area consisting of middle- and upper-elevation cloud forests, which varies in elevation between 500-2906 m (Acuña and Mena 1993). The study site (310 ha) included Barva Volcano (VB)(10°07'N; 84°07'W), from 2600 to 2906 m elevation, located near the town of Sacramento and 23 km northwest of San José, Costa Rica.

Barva Volcano is a volcanic complex dating from the Quaternary Period and has recent evidence of volcanism and inceptisol soils (Gómez 1986). There was little variation in the mean 20°C-monthly temperature (Instituto Meteorológico Nacional 1995). Ninety percent of the annual 3114 mm precipitation fell during wet season (May to November). During dry season (December-April), cloud cover and condensation were common around VB (Instituto Meteorológico Nacional 1988).

Because of its elevation, VB contains among the least biodiversity in the CVC, including 17 mammal species (excluding bats)(Timm *et al.* 1989) and 125 bird species (Rojas 1994). Four habitat types identified in the study site included mature oak (*Quercus* sp) forest, secondary forest, forested pasture and overgrown pasture. Cloud forest trees reached 20 m heights and were heavily covered by epiphytes. Important tree species are: *Schefflera rodriguesiana*, *Quercus* sp, *Brunellia costaricensis* and *Podocarpus oleifolios*.

METHODS

Capture and Handling

Four medium-sized Havahart traps (Model 1045-3, Woodstream Corp., Lititz, Pennsylvania, 17543, USA) were baited with a mixture of raw sugar, bananas and food scraps and placed 5 to 6 m from the base of oak trees, where cacomistles were heard or seen. Captured cacomistles were injected with 8-11 mg of ketamine hydrochloride (Vetalar, 100 mg/ml, Bristol Laboratories, Syracuse, New York 13201, USA) and 0.5 mg/kg of xylazine (Rompun, 100 mg/ml, Mobay Corp., Animal Health Division, Kansas 66201, USA). Cacomistles were weighed, body length measured, sex determined, and fecal samples collected for a posterior, general, ocular examination of contents.

Marking and Radio-Telemetry

Each cacomistle was fitted with a radio-transmitter neck collar and released at the capture site after recovery. Radio-telemetry equipment consisted of: a) a two element "H" antenna, b) a TR-2 receiver, and c) radio-transmitters (Model MD-200, 150-152 Mhz) which weighed 80 g with a 12-18 mo theoretical lifespan (Telonics Equipment, Inc., Mesa, Arizona 85204-6699, USA).

Sixteen permanent radiotelemetry stations (Erts) were placed 100 m apart along a well-established trail leading to

Barva Lake. Geographic coordinates from the Erts were determined with a global positioning system device (GPS, Timble Navigation, Ltd., Sunnyvale, California, 94088-3642, USA). Between 10 and 226 readings were taken at each station with the GPS device to obtain maximum precision. Geographic coordinates were later converted to Lambert plane coordinates using the CONVERT program (Molina 1990). Actual station coordinates are in Garcia (1996).

For each animal location estimation, we recorded the azimuth bearing of the strongest signal captured by the antenna and receiver from each of two radiotelemetry stations. Triangulation was performed from two angles to estimate the animal's location (White and Garrott 1990). Bearings were recorded either simultaneously by two researchers (23% of localizations) or from 2 to 7 min apart by a single researcher (77%). Coordinates were estimated using the computer program Telem88 (Dept. of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA) and corrected with the error angle determined by Nam's (1990) formula with the micro-computer program LOCATE II. Polygon error for radio telemetry triangulation was minimized by being less than 100 m from cacomistles for most localizations and by making an effort to obtain close to perpendicular azimuths (with 100 to 300 m between each Ert per localization).

Only nocturnal activity was documented because previous work showed cacomistles in this area were diurnally inactive (Vaughan *et al.* 1994). Individuals were located hourly from 18:00 h to 06:00 h, either weekly or biweekly from January to July, 1995.

Mathematical independence of successive radio-telemetry localizations was tested using the ratio t^2/r^2 with the INDEPENDEN computer program (McCoy 1985) where t^2 is the mean squared distance between successive locations, and r^2 is the mean squared distance from the center of activity (Schoener 1981, Swihart and Slade 1985). Independence was assumed when the ratio of t^2/r^2 was 2.0 or greater. Independent locations were used to estimate habitat use and selection; all locations were used to estimate activity and home range.

Activity

An animal localization was considered "inactive" if the radio-signal pulse intensity was constant for more than 45 sec at the first radio-telemetry station reading; otherwise it was "active" (Cochran 1980).

Number of active and inactive localizations were grouped by sex and season for six 2-hr time periods beginning at 18:00 h. Percentage of active localizations was calculated for males and females for each 2-hr period.

Home Range

Total home range for the study was estimated for each individual with localizations of all 12-hr data periods using the Telem88 program. Seasonal home ranges for each indi-

Table 1. Seasonal and total home range (ha) for the Central American cacomistle. Seasonal home range includes all localizations (100%) during the dry or wet season. Total home range includes all localizations (100%) during the study. Number of data nights is n. Barva Volcano, Costa Rica, 1995.

Seasonal / Total Home Range	Females				Males				Overall Mean
	F19 (n)	F34	F04	\bar{x}	M15 (n)	M29	M14	\bar{x}	
Dry	12.5 (12)	24.6 (14)	7.2 (14)	14.8 (40)	21.7 (14)	13.0 (15)	16.0 (12)	18.9 (41)	15.8 (81)
Wet	12.5 (12)	11.7 (12)	6.0 (12)	10.1 (36)	19.3 (12)	7.8 (12)	27.7 (12)	18.3 (36)	14.2 (72)
Total	16.4 (24)	25.5 (26)	8.2 (26)	16.7 (76)	25.2 (26)	13.3 (27)	30.5 (24)	23.0 (77)	19.9 (153)

vidual were estimated using all localizations collected during 12-hr periods for each climatic season (wet or dry). To calculate 100% home ranges, we used the minimum convex polygon method (Mohr 1947), which estimates home ranges with small sample sizes (Bekoff and Mech 1984, Swihart and Slade 1985).

Habitat Use and Selection

A habitat map of the study site (based on first estimates of total home ranges, Vaughan *et al.* 1994) was made using an enlarged, 1992 aerial photograph (scale: 1:60,000, Instituto Geográfico Nacional de Costa Rica) and ground surveys with GPS locations taken when needed. The habitat map was then digitalized into the IDRISI computer program for geographic data analysis (Clark Labs for Cartographic Technology and Geographic Analysis, Clark University, Worcester, Massachusetts, USA). Availability of the four habitats (mature forest, secondary forest, forested pasture, and overgrown pasture) for each sex was calculated using the IDRISI program as the percent coverage of each habitat type within each cacomistle's 100% total home range boundary.

Percentages of seasonal and total telemetry locations within each habitat type were calculated to estimate habitat use by each cacomistle. Data of habitat availability and use for all six cacomistles were combined to determine overall habitat selection patterns.

Forest Inventory

A forest inventory was carried out in each habitat type to determine percentage of bromeliad cover and Importance Value (IV) of each tree species. Twenty-two, 200-m long transects were initiated on the main trail and extended almost perpendicularly into the vegetation. Transects were spaced about 60 m apart and alternated in a westerly or easterly direction from the main trail. Two 20-m diameter plots (314 m²) were established on each transect, separated by 100 m on that transect.

We used a densiometer (Model A, Robert E. Lemmon, Forest Densiometer, 5733 SE Cornell Dr., Bartlesville, Oklahoma, 74006, USA) to estimate canopy cover in each plot. To estimate bromeliad cover in each canopy tree, four

imaginary quadrants were visualized in the canopy; the percentage of each quadrant covered by bromeliads was summed and divided by four to give percent bromeliad cover. Bromeliad cover was grouped into categories of very low (<10%), low (10-40%), moderate (40-70%), and high (70-100%).

We counted number of trees per species in each plot. Tree heights were visually estimated into five classes (0-10 m, 11-20 m, 21-30 m, 31-50 m, >50 m). Additionally, trees were measured and placed in diameter classes (10-30 cm, 31-50 cm, 51-80 cm and >80 cm.). This information was used to calculate dominance, abundance and absolute frequency for each tree species in each plot and then the importance value (IV) for each tree species was calculated (Brower *et al.* 1989).

Statistical Tests

Total number of male and female active versus inactive localizations were compared using a G test (Sokal and Rohlf 1981). The replicated G-test (William's correction) was used to compare number of male versus female active localizations between 2-hr periods. Male and female activity dependence between months was tested with a contingency table.

To estimate mean differences in home ranges between sexes and seasons, we used two-way ANOVAs (Sokal and Rohlf 1981). The Kruskal-Wallis test was used when normality, independence, and/or homogeneity suppositions were not fulfilled. Statistical analyses were done with Statgraphics (Statgraphics, Inc. 1988) and Biom programs (Rohlf 1985).

The G-test (William's correction) determined significant seasonal-related differences between cacomistle wet- and dry-season habitat uses. We used the Habuse program (Byers *et al.* 1984) to calculate habitat use by males and females compared to habitat availability (>, =, <) during wet and dry seasons and for the entire study period. The Habuse program also calculated chi-squared values and Bonferroni confidence intervals for use versus availability (Byers *et al.* 1984, Neu *et al.* 1974).

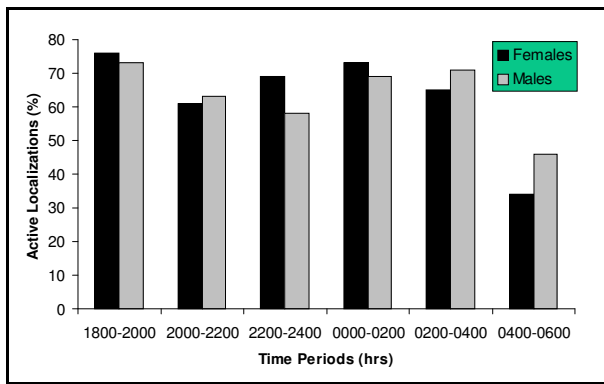


Figure 1. Percent active localizations for male and female cacomistiles by time period for 7-mo study at Barva Volcano, 1995.

RESULTS

Capture, Recapture and Radiotelemetry

We captured six adult cacomistiles (three males and three females). Five of six individuals had been radio-tracked previously during a 6-wk study (Vaughan *et al.* 1994). For the present study, we replaced old radio transmitters with new ones. Fruit placed within Havahart traps was used to recapture cacomistiles and 13 captures were made in 124 trap nights (10.5%) between January and February, 1995. One male was recaptured twice, while a second male was recaptured three times.

Radio-telemetry data collection was conducted from January 19-July 18, 1995. A total of 1,625 locations were estimated for the six individuals in 372 hrs and 102 locations were eliminated due to error. Three females were tracked a total of 77 nights (41 in dry season, 36 in wet season) and three males were tracked for a total of 76 nights (40 in dry season, 36 in wet season). An interval of 2 hrs between successive locations was needed to achieve independence for four animals, but only 1 hr was needed for two animals.

Weights of males and females were comparable (0.95-1.45 kg). Total body length varied between 89-93 cm for females and 93-108 cm for males. Ten cacomistile feces were collected from traps. All cacomistile feces contained insects (Hymenoptera-Ichneumonidae), Coleoptera and Araneae, and seeds, specifically from *Hedyosmum mexicanum* and *Quercus* sp.

Activity

Number of active observations were greater than inactive observations for both males ($G=72$, $df=1$, $P<0.001$) and females ($G=91$, $df=1$, $P<0.001$). Cacomistiles were found active from 55-75% of the time during nocturnal monitoring. Males were slightly more active than females during three 2-hr periods (periods 20-22, 02-04 and 04-06 h) ($G=4.61$, $df=5$, $P<0.5$, Fig. 1). Activity decreased for both sexes be-

Table 2. Predominant tree species and their Importance Value Indices (%), percent canopy cover and Index of Bromeliad Cover for each habitat used by Central American cacomistiles in Barva Volcano, Costa Rica, 1995.

Habitats	Tree Species	IVI (%)	Canopy Cover (%)	Bromeliad Index
Mature Forest	<i>Quercus seemannii</i>	96.1	65.8	4.9
	<i>Hedyosmum mexicanum</i>	27.0		
	<i>Prunus annularis</i>	19.8		
	<i>Ardisia</i> sp.	17.3		
	<i>Weinmannia</i> sp.	8.8		
Secondary Forest	<i>Quercus seemannii</i>	73.9	67.7	3.5
	<i>Oreopanax</i> sp.	51.9		
	<i>Drymis granadensis</i>	41.8		
	<i>Ocotea</i> sp.	35.7		
	<i>Hedyosmum mexicanum</i>	31.0		
Forested Pasture	<i>Quercus seemanni</i>	100.0	58.2	2.9
	<i>Drymis granadensis</i>	32.5		
	<i>Oreopanax</i> sp.	31.9		
	<i>Eugenia</i> sp.	30.1		
	<i>Ardisia</i> sp.	21.4		
Overgrown Pasture	<i>Quercus seemanni</i>	90.1	13.3	1
	<i>Dendropanax</i> sp.	33.8		
	<i>Hedyosmum mexicanum</i>	31.7		
	<i>Viburnum costarricense</i>	24.7		
	<i>Melastomatacea</i>	12.5		

tween 2000-2200h and 0400-0600 h; averaging 38% for females and 52% for males in the latter period (Fig. 1). Cacomistiles were nocturnal though diurnal vocalizations did occur infrequently, beginning at approximately 1400 h during early May. Activity for both sexes increased slightly during wet season (May-July), although activity was independent of month ($G=0.739$, $df=6$, $P<0.5$).

Home Ranges

During the study, 100% total home ranges for all six cacomistiles averaged 19.9 ha ($SD=8.5$) (Fig. 2). Mean male total home range ($\bar{x}=23.0$ ha, $n=3$, $SD=8.8$, 100%) was greater than mean female home range ($\bar{x}=16.7$ ha, $n=3$, $SD=8.6$, 100%), although not significantly ($F=0.8$; $df=1, 4$; $P=0.42$, Table 1.). Mean dry season home range (100%) of all six cacomistiles was slightly greater ($\bar{x}=15.8$ ha, $SD=6.4$, range=7.2-24.6 ha) than mean wet season home range ($\bar{x}=14.2$ ha, $SD=8.1$, range=6.0-27.7 ha), but differences were again insignificant ($F=0.15$; $df=1, 10$; $P=0.70$, Table 1). This increase came from a larger mean home range for females in dry season ($\bar{x}=14.8$ ha) than in wet season ($\bar{x}=10.1$ ha). Mean dry and wet season home ranges were similar for males (18.9 vs. 18.3 ha, respectively).

Habitats and Their Use

Habitat types and their abundance included: a) mature forest characterized by slow-growing trees with >80 cm

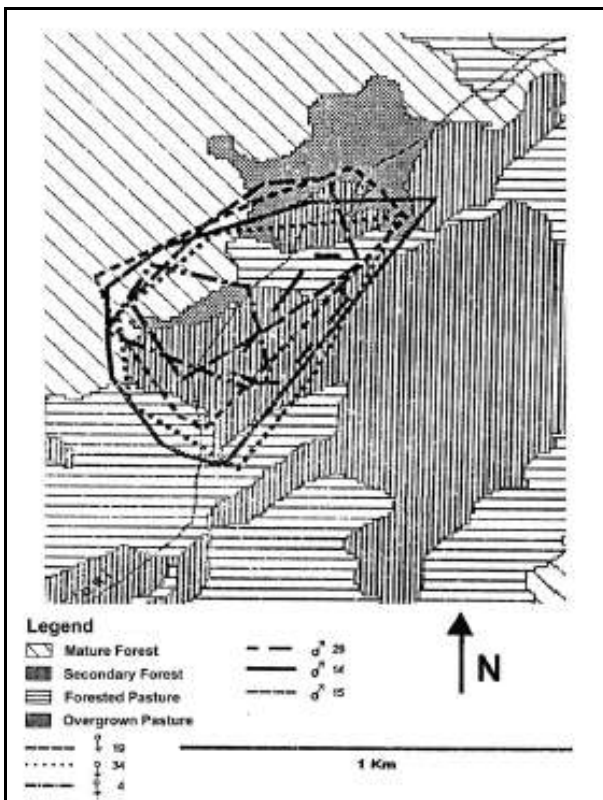


Figure 2. Total home ranges for six cacomistles and habitat types in study site, Barva Volcano, Costa Rica.

diameter (dbh) and a sparse understory (95.2 ha, 30.7% of total study site; b) secondary forest with rapidly growing species and a more dense understory (107.9 ha, 34.8%); c) forested pastures of grasses and sedges (*Pennisetum purpureum*, *Lolium perenne* y *Lolium multiflorum*) with dispersed oak (*Quercus* sp) trees (94.5 ha, 30.5%); and d) overgrown pastures with tree species of approximately 10 cm dbh and abundant shrubs (12.4 ha, 4.0%)(Fig. 2). We identified 30 tree species from 19 families in all four habitats. Mature forest, secondary forest, and forested pasture had between 58-68% canopy cover, mostly due to large oak trees (*Q. seemannii*). Overgrown pasture had only 13% canopy cover provided by the same oak species. The importance value for trees varied from 74-100% due to *Q. seemannii*, with other species (*Hedysomum mexicanum*, *Prunus annularis*, *Drymis granadensis*, *Eugenia* sp, and *Ocotea* sp) contributing between 19-41% (Table 2). The bromeliad index varied from 1 (overgrown pasture) to 4.9 (mature forest, Table 2).

Throughout the study, both sexes used available habitats in significantly different ways (males: $G=318$, $df=3$; $P<0.001$; females: $G=86$, $df=3$, $P<0.001$). Secondary forest was the most abundant habitat type available (52% for females, 47% for males) used by both sexes (44.8% of female locations, 59.4% of male locations), though females used more habitat types than males (Table 3). Females used overgrown

Table 3. Expected and observed habitat use and selection by male (M) and female (F) Central American cacomistles, Barva Volcano, Costa Rica. Habitat avoidance denoted by "-". Habitat preference denoted by "+".

Habitat	Season	Sex	Expected % use (Pie)	Observed % use (Pio)	Bonferroni Intervals
Mature Forest	Study	F	0.179	0.215	0.169<p<0.261
		M	0.198	0.140(-)	0.106<p<0.174
	Dry	F	0.187	0.255	0.186<p<0.324
		M	0.232	0.158(-)	0.108<p<0.208
	Wet	F	0.126	0.172	0.110<p>0.234
		M	0.169	0.121(-)	0.076<p<0.166
Secondary Forest	Study	F	0.519	0.448(-)	0.392<p<0.504
		M	0.470	0.594(+)	0.546<p<0.642
	Dry	F	0.514	0.445	0.367<p<0.523
		M	0.504	0.554(+)	0.514<p<0.594
	Wet	F	0.587	0.446(-)	0.365<p<0.527
		M	0.501	0.635(+)	0.568<p<0.702
Forested Pasture	Study	F	0.192	0.162	0.113<p<0.195
		M	0.200	0.113(-)	0.082<p<0.144
	Dry	F	0.186	0.121(-)	0.070<p<0.172
		M	0.162	0.114(-)	0.070<p<0.158
	Wet	F	0.195	0.190	0.113<p<0.254
		M	0.204	0.111(-)	0.067<p<0.155
Overgrown Pasture	Study	F	0.108	0.181(+)	0.138<p<0.224
		M	0.130	0.152	0.117<p<0.187
	Dry	F	0.112	0.177(+)	0.117<p<0.237
		M	0.099	0.172(+)	0.120<p<0.224
	Wet	F	0.090	0.190(+)	0.126<p<0.254
		M	0.124	0.131	0.084<p<0.178

pasture more than expected and secondary forest less than expected based on habitat availability. However, mature forest and forested pastures were used in equal proportion to availability for females (Table 3, Fig. 2). Males used secondary forest more than expected, mature forest and forested pastures less than expected and overgrown pasture in equal proportion to availability (Table 3, Fig. 2).

Some habitat preferences were seasonal. Females used overgrown pasture more than expected and both secondary forest and forested pastures less than expected in both seasons. Males used secondary forest more than expected in both seasons, overgrown pasture more than expected in the dry season, and both forested pasture and mature forest less than expected in both seasons. Use of other habitats by both sexes depended on availability.

DISCUSSION

Most Activity by Males and in Wet Season

Cacomistles were mostly nocturnal and activity decreased at sunrise. Perhaps males were more active than females because of their larger size. Increased activity during wet season may be related to food scarcity. Perhaps reproductive activities elicited diurnal behavior. We observed sporadic activity in late afternoon and early evening (1600-1800 h) and increased vocalizations and a greater home range size in

May. Poglayen-Neuwall (1992a) and Poglayen-Neuwall and Poglayen-Neuwall (1994) found that captive *B. sumichrasti* exhibited increased vocalizations and social interactions in May with estrus occurring in June.

Male Home Ranges Smaller; Female Home Ranges Similar to other Procyonids

The pilot study (Vaughan *et al.* 1994) of five of the six cacomistles of the present study was limited to 6 wks during dry season and home ranges were smaller than in the present study. Even with the increased home ranges found in this second study, male cacomistle home ranges were smaller than those of other male procyonids. However, female seasonal home ranges in this present study were similar to those of other female procyonids.

Ringtailed cat male home ranges averaged twice (43.4 ha) that of male cacomistles, while female ringtails were similar (Toweill and Teer 1981). In Costa Rica, semi-arboreal *Procyon lotor* males and females had 28 ha and 15 ha home range sizes, respectively, in Costa Rica (Carrillo 1990). Arboreal *Potus flavus* males had home range sizes of 39 ha with 17 ha for females (Julien-Laferriere 1993). Compared with other procyonids, male cacomistles' smaller and more overlapping home ranges suggest that environmental conditions or social organization might contribute to decreased movement (Kaufmann 1982). Poglayen-Neuwall (1992b) observed migrations of cacomistles to lower elevations (<1500 m) during wet season in Chiapas, Mexico. He speculated that food scarcity might cause this increase in movement and home range sizes. Our study animals showed no major difference in seasonal home ranges.

Home ranges of a single male encompassed several female home ranges in our study (Fig. 2). A similar pattern was observed for *P. flavus* (Julien-Laferriere 1993) and ringtailed cats (Toweill and Teer 1981, Yarchin 1990), both classified as solitary and territorial species. Male cacomistle home ranges also overlapped in our study, a similar finding as in two male ringtails (Toweill and Teer 1981). Perhaps our study animals constituted a family group, which may partially explain overlapping home ranges. Future studies of these individuals should involve genetic analysis to confirm or refute this possibility.

Toweill and Teer (1981) documented seasonal home range size differences between ringtailed males and females that were perhaps related to antagonistic and sexual behavior among individuals as observed in cacomistles (Poglayen-Neuwall and Poglayen-Neuwall 1994). Although seasonal home ranges were not statistically different between sexes for our study animals (Table 1), data was not taken for late-wet season months (August-November). Table 1 shows that female home ranges were smallest during wet season (May-July) when they underwent parturition (Poglayen-Neuwall 1991). Time dedicated to care of altricial neonates would explain reduced female activity during this period.

Costa Rican Cacomistles Used Altered Habitat More than in Mexico

We know of no similar cacomistle habitat studies for comparison to our study. However, in southern Mexico, Poglayen-Neuwall (1992a) observed cacomistles in premontane and montane forests, cloud forests, deciduous forests, and semi-deciduous forests. Our study animals were documented in four montane forest habitat types with secondary forest being the most abundant and occupied habitat. Females used the least abundant habitat (overgrown pasture) almost twice as much as was expected (Table 3). The mature oak forest constituted only between 18-20% of home ranges and males used it less than its availability. Interestingly, Poglayen-Neuwall (1992a) found that cacomistles avoided pine forest, oak forest, secondary forest, and overgrown pastures in southern Mexico. In Costa Rica, we observed cacomistles in the latter three habitats. However, intense use of secondary forest by these arboreal animals may be partially explained by its extensive canopy cover and great numbers of bromeliads as compared to other habitats.

Bromeliads contain cacomistle food sources such as invertebrates, small vertebrates and water. Estrada and Coates-Estrada (1985) reported that cacomistles and *P. flavus* spent 60% of nocturnal time in middle (10-20 m) and 40% in lower strata (0-10 m), rarely descending to the ground. They also rested during the day in natural cavities in large trees (Poglayen-Neuwall 1992). Our diurnal telemetry "fixes" showed animals resting in large oak trees, but we were unable to observe specific den sites.

Cacomistles Are Generalist Feeders

Cacomistles appear to be generalist feeders, consuming fruits and other plant parts, various types of insects, as well as vertebrates. Poglayen-Neuwall (1992) reported abundant fruit (*Ficus* sp and *Manilkara* sp), insects (20-30%), and vertebrates (10%) in the diet of cacomistles in Mexico. Additionally, Estrada and Coates-Estrada (1985) estimated 40% fruit and 60% animal parts in cacomistle diets in Mexico. Medium-sized carnivores such as the cacomistle may be important seed dispersers (Chávez-Ramírez y Slack 1993, Estrada y Coates-Estrada 1985, Ewer 1973, Gittleman 1985, Kaufmann 1983, MacNab 1995, Poglayen-Neuwall 1992b). All cacomistle feces collected during the study contained insects (Hymenoptera-Ichneumonidae), Coleoptera and Araneae, and seeds, specifically from *Hedyosmum mexicanum*, and *Quercus* sp. These species also had the highest importance value in secondary forest and overgrown pasture habitats (Table 3). This could explain the use of overgrown pasture and forested pasture by cacomistles, as these habitats contain many edible fruits. Use of overgrown pasture by females might be related to the presence of berries (*Rubus* sp, *Vaccinium consanguinum*, Melastomataceae, Ericaceae and Rubeaceae).

Additional information on cacomistles in Costa Rica is

necessary to better understand their ecological needs. We recommend that future cacomistle research include: a) studying cacomistle ecology over a continuous 12-mo period, b) studying diet while focusing on cacomistles as potential seed dispersers, c) determining cacomistle distribution and population dynamics throughout Costa Rica, and d) assessing population genetics of cacomistles.

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