SPRING RANGES, FOOD HABITS, AND HABITAT UTILIZATION OF RINGTAILS IN THE GEYSERS

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ABSTRACT

Four male ringtails (Bassariscus astutus) were radio-collared in the Geysers-Calistoga Known Geothermal Resource Area, Sonoma County, California, and monitored from April through June 1981. Three hundred and forty-one locations of the animals were obtained by telemetry and used to determine home range and habitat utilization patterns. The ringtails occupied exclusive but adjacent home ranges, ranging from 49 to 338 hectares ($\bar{x}$ = 221 hectares). Ringtail preference for each of 10 vegetation types in the area was analyzed by comparing the percentage of area of each type in the home ranges with the percentage of telemetry locations obtained in each type. Riparian woodland was the most preferred type while serpentine chaparral was the most avoided type. Riparian woodland and mixed evergreen forest types were the only vegetation types that occurred in all 4 home ranges.

Forty-one ringtail scats were analyzed to determine spring food habitats. Mammals, birds, insects, and vegetable matter constituted 56.1% 21.4%, 5.5% and 17.0% of the aggregate volume of the scats, respectively.

Simple statistical analyses of telemetry locations in relation to the location of geothermal development did not reveal any direct impacts on habitat utilization from geothermal development. The effect of development is veiled by the complex interrelation of topography, vegetation type, and location of development, and will require more extensive ecological study. However, it is likely that the lack of extensive riparian habitat in the area was more important in limiting the Geysers ringtail population than the current level of geothermal energy development.

INTRODUCTION

The Geysers-Calistoga Known Geothermal Resource Area (KGRA) supports the largest developed geothermal field in the world. Rapid development of this geothermal resource has occurred since 1960. Development has occurred without specific knowledge of the impacts on the ringtail (Bassariscus astutus), which is fully protected under California law (California Fish and Game Code; section 4700(e)).

This study was conducted between March and June 1981 to collect data on the distribution, habitat utilization, and food habits of the ringtail within a portion of the KGRA. Emphasis was placed on identifying the impact of geothermal energy development on the species.

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Information on ringtail distribution and abundance in California has been presented by Grinell, et al. (1937), Schempf and White (1977), Orloff (1980), Belloumini (1980) and Belloumini and Trapp (1981). The only comprehensive ecological studies on the ringtail were conducted in southwest Utah (Trapp 1972, 1978).

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STUDY AREA

The Geysers KGRA is in Sonoma County, California, approximately 150 km north of San Francisco. The terrain is mountainous with elevations ranging from 335 to 1402 meters. Big Sulphur Creek is the major water course draining the study area. Vegetation is typical of the north coast montane region. Ten different vegetation types as defined by Anderson (1981) occur in the study area. A list and description of these types appear in Table 1.

Table 1. List of vegetation types in the Geysers study area.[a]

Vegetation Type	Description
Riparian Woodland	White Adler, (*Alnus rhombifolia*), Horsetail (*Equisetum arvense*), Ferns (*Polypodium* spp.), Willow (*Salix* spp.). Occurs only in a narrow band along major water courses.
Mixed Evergreen Forest	Big Leaf Maple (*Acer macrophyllum*), Madrone (*Arbutus menziessii*), Live Oak (*Quercus* spp.), California Bay (*Umbellularia californica*). Occurs close to major water courses.
Knobcone Pine	Knobcone Pine (*Pinus attenuata*), Black Oak (*Q. kelloggii*).
Coastal Pine Forest	Ponderosa Pine (*P. ponderosa*), Black Oak and wet meadows. Occurs sparingly.
Cypress	NacNab Cypress (*Cupressus macnabiana*), Digger Pine (*P. sabiniana*), Scrub Oak (*Q.* spp.). Occurs in dense stands in dry serpentine soils.
Mixed Chaparral	Chamise (*Adenostoma fasciculatum*), Ceanothus (*Ceanothus* spp.), Manzanita (*Artostaphylos* spp.), Scrub Oak (*Q. dumosa*). Occurs on steep dry soils.
Mixed Conifer	Douglas Fir (*Pseudotsuga menziessii*), Sugar Pine (*P. lambertina*), White Fir (*Abies concolor*), Pacific Yew (*Taxus brevifolia*). Occurs at high elevations.
Serpentine Chaparral	Manzanita, Chemise, Buckbrush (*C. cuneatus*). Occurs on ridge tops and dry south slopes.
Oak Woodland	Oregon Oak (*Q. garryana*), Blue Oak (*Q. douglassi*), Buckeye (*Aesculus californicus*), Interior Live Oak (*Q. wislizenii*). Greater than 25% canopy cover. Occurs in large stands and in patches associated with intermittent streams surrounded by oak savannah.
Oak Savannah	Black Oak, Brome Grass (*Bromus* spp.), Wild Oats (*Avena* spp.). Occurs at lower elevations, canopy cover less than 25%.

[a]Anderson 1981

METHODS

Box traps baited with trout were used to capture ringtails. Trapping effort was distributed so as to sample all vegetation types and all major watersheds in the study area. Captured animals were sedated with an 18 mg intramuscular injection of ketamine hydrochloride (Vetalar, Parke-Davis, Detroit, Mich.). Four of the first 5 ringtails captured (all males) were fitted with radio-telemetry collars (Telenoics, Meza, Ariz.) operating in 159 MHz range. All ringtails were released at the capture site.

In order to gather more information about ringtail distribution within the study area, 15 track stations, consisting of .61 m^2 wooden frames filled with fire clay and baited with trout and commercial raccoon lure (Hawbacker, Ft. London, PA) were set up along road transects.

Radio collared ringtails were located via triangulation using techniques described by Springer (1979). Ninety-five percent confidence limits on directional accuracy were used to construct "error polygons" delineating the animals position.

Attempts were made to locate each animal at least twice a night, five nights a week. In order to assure a nonbiased sample, readings were taken at least 2 hours apart (Dunn and Gipson 1977). Additionally, several times a week den locations were triangulated during daylight, and once or twice a week dens were located by homing.

Telemetry locations for each ringtail were plotted on 1:6000 topographic maps overlaid with vegetation maps. Vegetation types encompassed by the error polygons were recorded. If an error polygon fell over more than one vegetation type, the fractional amount of each type was recorded. Telemetry observations for each animal were totaled by vegetation type to obtain a frequency of use percentage for each type.

Home ranges were constructed using the harmonic mean technique of Dixon and Chapman (1980). Each home range was then transferred to the vegetation map and the amount of each vegetation type in the home range determined with a compensating polar planimeter.

In order to determine if ringtails were avoiding those areas of the KGRA which have been developed for geothermal energy, the distance from the center of each error polygon to geothermal development (power plants, well pads, or construction sites) and paved road was measured to the nearest 100 meters. These distances were then compared with the distances from random points in the home range to geothermal development and paved roads using a difference of the means test (Welkowitz et al., 1971). Because proximity to Big Sulphur Creek appeared to be a major factor in ringtail distribution, a similar analysis was carried out using ringtail and random distances to Big Sulphur Creek.

Ringtail diet was determined by scat analysis. Scats were collected only when they could be positively attributed to ringtails (i.e., from dens or traps). They were analyzed with standard food habit techniques using the facilities of the California Department of Fish and Game Wildlife Investigations Laboratory in Sacramento.

RESULTS AND DISCUSSION

Seven individual ringtails were captured 11 times in 1905 trapnights (capture success = 0.58%). Six of the animals were males, 5 of which exhibited injuries most likely inflicted by conspecifics. All ringtails were captured in riparian woodland or riparian influenced vegetation types, not more than 100 meters from Big Sulphur Creek. No ringtails were captured in riparian vegetation along Squaw Creek, Cobb Creek, or Hot Springs Creek, despite intensive effort in those areas. Intensive trapping effort in the rocky chaparral of Cobb Mountain was also fruitless.

Only one ringtail visit was evidenced by the track stations, on Big Sulphur Creek. All track stations were visited frequently by other animals, including coyote (Canis latrans), bobcat (Felis rufus), grey fox (Urocyon cinereoargenteus), raccoon (Procyon lotor), skunk (Spilogale putorius), wood rate (Neotama fuscipes), deer mouse (Peromyscus spp.), and quail (Lophortyx spp.). An inate aversion for strange substrates may be one reason for the ineffectiveness of the track stations in documenting the presence of ringtails (Grinell et al. 1937).

The track station data does support the evidence provided by the extremely low capture success, indicating that the ringtale population in the study area is small compared to other investigated populations. Belluomini and Trapp (1982) estimate ringtail density along the lower Feather River of California at one ringtail per 3.9 ha. Our trapping and track station data indicate a density approximately one-tenth of this in the KGRA.

Three hundred and forty-one locations of radio-collared ringtails were obtained by telemetry. Error polygons were constructed for each of these locations, 157 (46%) of which encompassed more than one vegetation type. The center of each error polygon was used to determine home ranges for each animal. The Dixon and Chapman (1980) home ranges varied from 49.1 to 338.2 hectares ($\bar{x}$ = 220.7 ha). Size and location of the home ranges are shown in Figure 1. Male ringtails were apparently territorial during the study, as home ranges were adjacent and nearly exclusive. The injuries noted also suggest that the male ringtails were territorial.

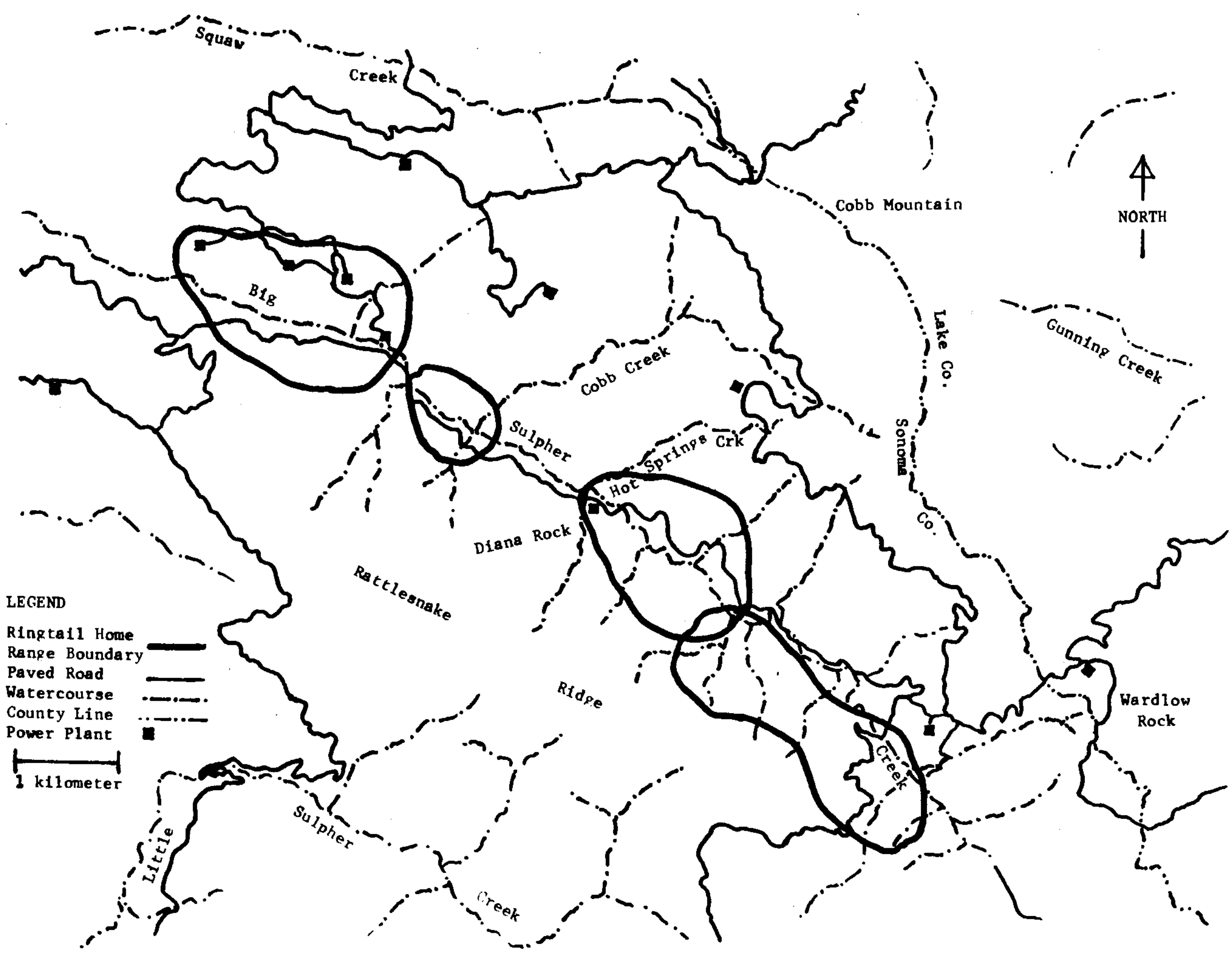

Figure 1. Locations of ringtail home ranges in the Geysers KRGA from March through June 1981.

The results of 41 scat analyses are summarized in Table 2. Small mammals made up roughly one-half of the aggregate volume, while birds constituted more than one-fifth of the aggregate volume. No attempt was made to key out feathers, but judging by the size of feet and claws found in 2 scats, birds at least the size of scrub jays (Aphelocoma coerulescens) were eaten.

Table 2. Contents of 41 ringtail scats collected in Geysers KGRA study area during Spring 1981

		% Frequency of Occurrence	% Aggregate Volume
Birds			
Unidentified birds (feathers, claws, footpads)			21.4
	Subtotal	39.0	21.4
Mammals			
Shrew, Sorex sp. (hair, teeth)		24.4	10.8
Ground Squirrel, Spermophilus beecheyi (hair, teeth)		4.9	3.3
Grey Squirrel, Sciurus griseus (hair, teeth, bones)		9.6	3.3
Deer mouse, Peromyscus sp. (hair, teeth, bones)		22.0	13.9
Dusky footed wood rat, Neotoma fuscipes		22.0	19.4
Harvest mouse, Riethrodontomys megalotis (hair)		9.9	3.4
Cottontail rabbit, Sylvilagus sp. (hair)		2.4	2.0
	Subtotal		56.1
Insects			
Bees, Apoidea (fragments)		4.9	1.0
Ants, Formicidae (fragments)		22.0	3.2
Grasshoppers, Orthoptera (fragments)		2.4	0.2
Caddisfly, Trichoptera (larvae)		2.4	0.2
Unidentified insects, Insecta (fragments)		9.6	0.9
	Subtotal		5.5
Vegetable Matter			
Douglas Fir, Pseudotsuga menziessii (seeds)		22.0	3.0
Oak, Quercus sp. (fruit)		2.4	0.1
Domestic fig, Ficus carcia (seeds)		2.4	1.0
Wild grape, Vitus californicus (immat. fruit, seeds)		17.1	5.8
Wild cherry, Prunus sp. (immat. fruit, seeds)		2.4	0.7
Domestic Apple, Malus malus (seeds)		2.4	0.1
Wild rose hips, Rosa sp. (seeds)		9.6	3.7
Blackberries, Rubus sp. (seeds)		4.9	2.6
	Subtotal		17.0
			100 %

Wild grape (*Vitis californica*) was the major fruit eaten; evidence of blackberry (*Rubus* spp.), wild cherry (*Prunus* spp.), and wild rose (*Rosa* spp.) was also found. No fruit was ripe in the study area at the time of the study; it is expected that as fruit ripens late in the summer it would comprise a larger percentage of the diet.

The only mast occurring in large quantity was Douglas Fir (*Pseudotsuga menziessii*) seeds. Often these seeds were associated with feathers or hair in the scat, and we believe that in most cases they were ingested because they were in the stomach of the prey animal.

Vegetation types and amounts occurring in each ringtail home range appear in Table 3. Electivity indices, after Ivlev (1961), were calculated for each vegetation type in each home range, using the percent of telemetry observations in a given type as the frequency of use and the percent of home range area covered by the type as frequency of availability. These indices were then pooled, and the method of Strauss (1979) used to determine the significance for the population. Riparian woodland was the only vegetation type significantly preferred by the male ringtails and serpentine chaparral the only type significantly avoided. No trends in the use of other vegetation types were noted; riparian woodland and mixed evergreen forest were the only types that even occurred in all home ranges. The preference for riparian areas differed from the findings of Trapp (1978) who observed ringtails in southwestern Utah preferred brushy chaparral areas while using riparian areas only to the extent expected on the basis of the amount of riparian habitat available.

Table 3. Utilization of vegetation types by ringtails in the Geysers KGRA as determined by telemetry, Spring 1981.

	Ringtail 102		Ringtail 103		Ringtail 106		Ringtail 110		
Vegetation Type	Available (312 ha) %	Used (86 obs.) %	Available (338 ha) %	Used (105 obs.) %	Available (184 ha) %	Used (93 obs.) %	Available (49 ha) %	Used (57 obs.) %	Total Ivlev's[a] Electivity
Riparian Woodland	6.7	35.9	8.4	33.5	6.3	17.7	9.2	24.2	+.584[b]
Mixed Evergreen Forest	12.5	14.4	34.4	42.2	7.5	4.3	58.2	71.0	+.142
Knobcone Pine Forest	11.3	14.3	7.1	2.3					-.225
Coastal Pine Forest	0.6	0.7	5.0	1.9					-.448
Mixed Conifer Forest	0.5	0.7	9.3	4.9					-.434
Cypress	1.0	2.7							+.273
Oak Woodland					22.6	23.9	8.4	3.0	+.148
Oak Savannah					63.6	54.1	24.2	1.8	+.017
Mixed Chaparral			32.9	13.9					-.401
Serpentine Chaparral	80.9	2.5	2.9	1.3					-.811[b]
Barren	1.8	0.7							-.429
Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	

a. Ivlev 1961

b. significant at $p \leq .01$

Although ringtails in this study consistently used riparian habitat in greater proportion than its availability, they did use other vegetation types in substantial quantity and appear not to use certain riparian areas (i.e., Cobb, Squaw, and Hot Springs Creeks). This suggests that male ringtails distribution is determined to a large extent by habitat factors other than vegetation type. The varied and complex structure of the riparian habitat along Big Sulphur Creek may be more important to the ringtails than any particular vegetative composition.

The dependence on Big Sulphur Creek cannot be based on the physiologic need for water as there are many permanent springs in the area, and ringtails do occur in very arid areas (Trapp 1978). Nor can this dependence be linked directly to food availability. Some frequently used foods such as wild grape and blackberry are indeed found only along water courses, but the major prey items, Cricetid rodents and small birds, were observed by Meneghin et al. (1977) to be far more abundant in the chaparral areas than in the riparian areas.

It is our hypothesis that interspecific competition with other carnivores may be keeping ringtails out of the more productive habitats. Raccoons, foxes, bobcats, and coyotes were all observed in free ranging situations more often than ringtails (25, 6, 7, and 5 observations, respectively, versus 1 ringtail observation) and the results of the track station visitation have already been described. Ringtails in the study area may be relegated to habitats such as the riparian forest along Big Sulphur Creek for which they have adaptive advantages relative to other carnivores. These relative advantages may enable the ringtail to prey more effectively on riparian species, such as shrews, and/or arboreal species such as birds, grey squirrels, and wood rats, which together comprised over half of the diet. It is interesting to note in this context that shrews, although available, were not eaten by ringtails in Trapp's study (1978). *Neotoma fuscipes*, which occurs in the Geysers in considerably more arboreal than *N. lepida*, the wood rat that occurs in Trapp's (1978) study area, which could make it more susceptible to predation by ringtails in riparian areas.

The comparison of ringtail locations with randomly chosen points showed no significant differences between ringtail and random distances to development and roads, and we concluded that the ringtails were not directly avoiding either geothermal development or paved roads. Ringtails were located significantly closer to Big Sulphur Creek than to random points, indicating a preference for proximity to the creek (Table 4).

There is danger, however, in concluding that geothermal development does not influence the ringtail population in the Geysers on the basis of these simple statistical tests. A least squares correlation analysis between the random distances to development and the random distances to Big Sulphur Creek gave $r = 0.519$ ($N = 341$), a value indicating that 27% (r^2) of the variance in distance to development may be attributed to the variance in distance to Big Sulphur Creek. It would therefore, be nearly impossible for ringtails to show simultaneously a preference for Big Sulphur Creek and an avoidance of geothermal development, simply because of the physical and geographical relationship between Big Sulphur Creek and development. We made no attempt to go beyond locational relationships in discovering any effects development may have on the population. Ringtails in the Geysers may be influenced indirectly by changes in prey base, water quality, vegetation, etc. We were unable to measure these factors. Tocha et al. (1982) have pointed out that biological significance does not necessarily follow from statistical significance (or lack thereof), and that relationships in small populations such as the ringtail in the Geysers are especially tenuous.

CONCLUSION

The study area is apparently marginal ringtail habitat; observed ringtail density was lower than in other areas of California. Riparian woodland was the preferred habitat type, and the lack of extensive riparian habitat was probably the major factor limiting the population. Competition with other carnivores may contribute to the ringtails' dependence on riparian areas. Simple statistical analysis of telemetry locations in relation to the location of geothermal development did not reveal any direct avoidance of development. It is likely that ringtails are affected indirectly by geothermal development, but the methods and short duration of this study precluded evaluation of any such effects.

Table 4. Comparisons of 341 ringtail locations with 341 randomly selected points from ringtail home ranges.

	N	Range	$\bar{X}$	$\bar{X}_1-\bar{X}_2$	Significance
Distance to Nearest Geothermal Development[a]:					
Ringtail (X_1)	341	0-1200	275(159)[b]	58	($\bar{X}_1-\bar{X}_2 < 100$, not significant
Random (X_2)	341	0-1100	333(209)		
Distance to Nearest Paved Road[a]:					
Ringtail (X_1)	341	0-800	161(121)	51	($\bar{X}_1-\bar{X}_2 < 100$, not significant
Random (X_2)	341	0-1000	212(167)		
Distance to Big Sulphur Creek[a]:					
Ringtail (X_1)	341	0-700	131(132)	147	t($\bar{X}_1-\bar{X}_2$ = 5.74, significant at $P \leq .05$
Random (X_2)	341	0-1100	278(169)		

a. Distance to nearest 100 meters

b. (standard error)

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