ISLANDS IN THE SKY: MAMMALIAN TAXONOMY AND COMMUNITY ECOLOGY OF A NEOTROPICAL MOUNTAIN RANGE

by

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
JULY, 1989

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PREFACE

Tropical ecosystems are among the most endangered and least known on earth even though they contain at least 50% of the world's species. Tropical mountains exhibit a rich diversity of terrestrial habitats produced by altitudinal changes affecting temperature and soil moisture which serve to compress many habitats into relatively small geographical areas. In addition, tropical mountains have acted as refugia for species during changes in the paleoclimate. The diversity of habitats combined with refugial effects and the species packing common to tropical systems should result in communities of unusual complexity and interest in neotropical mountain ranges.

Data were collected from May 1979 - October 1980 in the Serra do Caparaó mountains of eastern Brazil (lat. 20° 22' to 20° 40', Lon. 40'W. to 42'W.) and were used to describe mammalian communities present and the effects of altitude and season on them. MacArthur's (1972) hypothesis predicting lower species diversity on tropical mountaintops relative to their lower elevations when compared to temperate mountains is tested. Results of this study are discussed in light of island biogeography (MacArthur and Wilson 1967), and refugia as a force in tropical speciation (Haffer 1979; Brown 1982) is considered. Taxonomic analyses of Caparao rodents are presented along with life history notes for all species found in the park.

This dissertation evolved out of a project begun while I was a Peace Corps Volunteer assigned to the Instituto Brasileiro do Desenvolvimento Florestal, Minas Gerais, Brazil. It was originally through the foresight and efforts of the Peace Corps, Dr. Tracy S. Carter and particularly Dr. Ivens Pinto Franqueira that this project was created to survey the mammalian fauna of Caparao and other national parks in Brazil with the goal of developing management plans for those few, precious areas. Dr. Iven's determination and dedication to the conservation and wise use of natural areas and resources and his deep concern for the preservation of endangered species and their habitats should be a model for future generations of conservationists in Brazil and throughout the world. IBDF generously supplied equipment, quarters, transportation and all possible support. In particular the assistance of Gloria de Fatima dos Santos Mendes, biologist for IBDF/MG is gratefully acknowledged. The personnel of Caparao National Park itself, both administrators and most especially the park rangers, were enormously helpful and without their day-to-day co-operation and willing hard work, little of this would have been possible. E tambiém, a gente boa do Alto Caparaó - Jovericy, Donna Maria, Macenieas, Hamilton e muitos otros, sem voçes, sem sua amazade é espiranças, nada disso ficaria possivel. Muitas obrigatas tem que ir áos todos de voçes.

Only through the concern and efforts of many people has this dissertation come about. My committee, Drs. James H. Shaw, Bryan P. Glass, Rudolph J. Miller and William Warde have provided guidance, faith and great patience. Many other people have provided support and encouragement as well, particularly Drs. Tracy Carter and Helen Miller and many, many friends (especially Joe and Dixie), professors, colleagues and students along the way. For the loan of specimens or data I am most grateful to The Chicago Field Museum, The U.S. Museum of Natural History, The Museum of Natural History at the University of Kansas and the Stovall Museum at the University of Oklahoma. Finally, the greatest source of strength and consolation along the way: to my parents, Keith and Betty, who taught me determination.

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CHAPTER I

INTRODUCTION

The tropics contain the most diverse and, unfortunately, some of the most endangered terrestrial ecosystems on earth. Twenty-five to 50% of all the world's species occur in tropical forests (Ehrlich and Ehrlich 1981, Kaufman and Mallory 1989) and these forests are being lost at the rate of approximately 100 acres/minute, which had resulted in a 40% reduction from their original area by 1975 and an almost exponential rate of increase (or loss actually) projected over the next decade (Colinveux 1979, Kandell 1984). Recent satellite surveys indicate that the Amazon region had 178,000 fires in excess of one square kilometer in size burning (Dobson, Jolly and Rubenstein 1989) and there are concommitant projected extinction rates as high as 40,000 species per year worldwide by the year 2000 with most of those losses being in the tropics (Ehrlich and Ehrlich 1981, Kaufman and Mallory 1989). It is equally unfortunate that the tropics contain among the most poorly known and understood ecosystems in terms of ecology, evolution, life histories, taxonomy, or even basic species lists for any but a few locations or taxa. Pine (1982:27), in reviewing the status of South American mammalogy, stated "Everyone is agreed that the South American mammal fauna is poorly known....It frequently comes as a surprise to non-mammalogists to find out how poorly known South American mammals are." The importance of understanding the enormous complexity of these major ecosystems with their ability to generate and maintain the greatest number of species in the most complex of terrestrial communities can hardly be overstated.

In South America the two most threatened ecological zones are the Amazon and Atlantic rainforests. The threat to the Amazon lies in the vast number of species it has to lose and the major influx of economic interest in farming, ranching, mining and lumbering that has arisen in the last few decades (Shoumatoff 1986). These economic developments have contributed to great, daily large-scale habitat destruction (Goodland and Irwin 1975, Kandell 1984). However, the Amazon is an enormous system with vast areas still virtually unreachable (at least for the present) and consequently, there is time yet for research and reserves to be effective (Shoumatoff 1986). The Atlantic rainforest of the southeastern coast, unfortunately, had no such protection until it was all but entirely lost to sugar cane, cacao, and coffee plantations (Mares 1982, Almeida and Rocha 1977). As Pine (1982:29) once again comments:

> The unknown original mammalian faunas of some of these areas (rainforests) are likely to remain forever unknown because various recent agricultural pursuits are eliminating the natural communities... If there is a more imperative need for biological

research in any field anywhere, I am unaware of it.

Justification

Community ecology has been studied for a few locations in the Neotropics, some quite intensively, but these are scattered and limited in number. Barro Colorado Island in Panama is the best- studied neotropical forest, and has provided a standard throughout the continent due to the work of many researchers (e.g. Enders 1935; Wenzel and Tipton 1966; Fleming 1970, 1971, 1972; Fleming, et al. 1972; Eisenberg and Thorington 1973). Several long term projects also have been carried out in Venezuela (Handley 1976; Eisenberg 1978) and in the deserts of Argentina and Chile (Fulk 1975; Meserve and Glantz 1978). To a lesser extent, the Caatinga of Brazil (Mares et al. 1981) and the Chaco of Paraguay (Wetzel et al. 1975; Myers and Wetzel 1979) also have received attention. In general, the majority of work has focused on biomass, biogeograpy, taxonomy, and life history strategies. Pine (1982) gives an excellent survey by country and taxonomic group for the status of mammalogy in South America.

The main focus of research within Brazil has been directed toward the Amazon, although certain areas of the southeast where the human population is concentrated also have been the subjects of study (Davis 1947; Moojen 1948; Hershkovitz 1962; Ruschi 1978; Pine 1980). The Atlantic rainforest has been fairly well surveyed taxonomically (Alho

1982), compared to much of the rest of the country, but virtually nothing has been done with the forest's community ecology. These forests along the eastern coast of Brazil have undergone human disturbance as long or longer than any other neotropical ecosystem and now only a few habitat islands remain (Alho 1982). Research in these areas will help not only describe the ecology of what remains of the original systems but should prove invaluable in understanding: 1) how tropical systems respond to human influence and subsequent losses of habitats and species, 2) the effects of insularization, 3) the processes of tropical succession, and 4) which species are most likely to become endangered or to threaten human health or agriculture as pests.

In addition, extending through the southern half of the Atlantic rainforest areas are the Serra do Mar mountains that have been important refugia for tropical forest species during cool, dry periods of the Cenozoic and Quaternary (Moojen 1948; Prance 1979; Brown 1982) (Figure 1). These refugia, as well as others, have been important core areas for neotropical speciation (Haffer 1979; Brown 1982) and species packing and, consequently, diversity is high in them today (see Cerqueira 1982, and Haffer 1979 for a further discussion of the Haffer-Vanzolini model of neotropical speciation). Diversity is high in tropical mountains for a

Figure 1: Map of neotropical refugia (after Ab'Saber 1977, Prance 1979 and Cerqueira 1982).

variety of reasons. First of all, the variability in altitude creates a wide variety of habitats and a corresponding diversity of niches (Simpson 1966). Secondly, their past roles as refugia during climatic changes have created speciation cores surrounding them contributing to the high present-day degrees of endemism (Brown 1982, Cerqueira 1982, Gentry 1986). In addition, MacArthur and Wilson (1967) proposed that mountains are themselves inland islands which isolate populations of temperate or boreal-adapted species by surrounding them with "seas" of low elevation habitats too warm or dry to be crossed. Mountaintop islands of high altitude habitat should be even more strongly isolated in the tropics than in temperate regions according to Janzen (1967), as the degree of difference between boreal and temperate habitats is less severe than that between boreal and tropical. As on true islands, isolation for whatever reason leads to high rates of endemism (Vuilleumier 1970, Gentry 1986) from founder effect, relic populations and/or speciation resulting from drift or selection (Brown 1971; MacArthur 1972; Simpson 1974; Haffer 1979; Prance 1979). Third, the history and bioenergetics of the tropics have given them a tremendous capacity for niche subdivision and a great diversity of species have been generated and maintained. Finally, refugial mountains should show relatively high species packing, diversity, and endemism as a result of receiving alternating waves of species adapted to warm, wet interglacial conditions and those adapted to cooler, drier habitats that even the tropics are subject to during glacial periods. Each adaptive community of species in turn becomes isolated by the next climate change and forms the next speciation core (Haffer 1979; Brown 1982).

MacArthur (1972), however, predicted tropical mountaintops should be even <u>less</u> diverse relative to their lower slopes than temperate mountains, which is apparently at odds with the traditional, sweeping view that the lower the latitude, the higher the diversity (Simpson 1966; Patterson 1980). This low diversity was considered by MacArthur (1972) to be a product of such factors as founder effect, small habitat areas, and ecogeographic isolation, as though these alpine zones were not only very small islands, but also well insulated from colonization. In addition, he predicted that those faunas which do occupy increasingly higher elevations in the tropics should also become increasingly temperate-like both in terms of adaptations and taxonomic affiliations. Briggs (1966) found that for cold-sensitive marine animals on oceanic islands, the degree of endemism was largely explained by the differential temperature changes brought about by Pleistocene glaciations. The more cold stress the habitat was subject to, the fewer endemics were present. Although altitudinal cooling may mimic some temperate seasonal effects by reducing primary productivity and limiting many poikilotherms (thus decreasing diversity both directly and *indirectly); overall, less severe seasonal variation exists in tropical mountains than in most temperate habitats. The basic patterns of seasonality in tropical mountains are provided by rainfall just as it is at lower elevations at those latitudes. This combination of variable rainfall and cold temperatures forms an environment disparate enough with the surrounding lowlands that few tropical species have been able to invade and adapt to it. Species that are found in tropical mountains are frequently either colonizers or remnants from more temperate areas or times (MacArthur 1972).*

High tropical diversity has been documented for neotropical forest mammals as compared to temperate (Flemming 1973) and seems to be generally true for most groups with the exception of aquatic invertebrates (MacArthur 1972). However, this latitudinal gradation of diversity is not as pronounced among mammals as for other groups, especially if migratory bats are omitted from consideration (Wilson 1974).

In order to test MacArthur's tropical mountain hypothesis it was necessary to describe the community ecology of a tropical mountain system and compare the parameters with those of a temperate system of similar age, structure and climatic effect. The Great Smoky mountains of the eastern U.S. were selected based on the above criteria and on the availability of mammalian survey data from which selected community ecology parameters could be generated for comparison to the Caparao range. It was of particular importance to determine if the slope of the diversity gradient from low to high elevation is greater for tropical mountains than for temperate ones as was predicted by MacArthur (1972).

Little is known about the ecology of the Serra do Caparaó. Historically the area was know for excellent hunting, expecially for tapir (probably *Tapirus terrestris*) which were hunted extensively at the higher elevations, capybara (*Hydrochaerus hydrochaeris*) and deer (species undetermined though most probably *Ozotoceros bezoarticus*) (Gripp 1979). A species list has been distributed for the park (Magnanini and Padua n.d.) by the Instituto Brasiliero do Desenvolvimento Florestal (IBDF) which is responsible for the park's management (Appendix A). Forty-four species of mammals are listed, with bats and rodents being poorly represented (Magnanini and Padua, n.d.). Seven of the 44 species on the IBDF list are currently listed as endangered or threatened by IUCN (1972) and Coimbra-Filho (1972). These seven are the maned sloth (*Bradypus torquatus*), woolly spider monkey (*Brachyteles arachnoides*), thin-spined porcupine (*Chaetomys subspinosus*), maned wolf (*Chrysocyon brachyurus*), giant anteater (*Myrmecophaga tridactyla*), pampas deer (*Ozotoceros bezoarticus*), and giant armadillo (*Priodontes maximus*). In addition, 11 species of endangered avifauna are listed.

Ruschi (1978) published a discussion of the ecology of the park with a list of birds and mammals and notes on vegetation but, unfortunately, did not mention when or how surveys were conducted nor in which habitats or areas of the park. He listed 71 mammal species with *Brachyteles arachnoides* as the only endangered species (Appendix B). The Serra do Caparaó has received some interest as a probable refugium during the Pleistocene, in particular with reference to the speciation of plants (Prance 1979), birds (Haffer 1979), butterflies (Brown 1982), primates generally (Kinzey 1981) and marmosets specifically (Cerqueira 1982) and two groups of rodents, the genus *Proechimys* (Moojen 1948) and the Thomosomyini group (*Thomasomys*, *Rhipidomys*, *Phaenomys*, and *Delomys*) (Cerqueira 1982). Within the marmoset genus *Callithrix*, one species (*C. flaviceps*) is endemic to the east slope of the Serra do Caparaó while two others are confined to the Serra do Mar proper (*C. aurita*) or to the low elevation forested strips to the east and to the west of the Caparaó range (*C. geoffroyi*) according to Hershkovitz (1977). The rodents are hypothesized to have speciated due to invasion from the north and west while forests bridged the lowlands during warm wet periods. The genera *Phaenomys*, *Delomys* and *Rhipidomys* each became sequentially isolated in the Serra do Mar region and underwent character displacement sufficient to allow niche subdivision into their present sympatric forms (Moojen 1948, Cerqueira 1982). The other groups mentioned show similar patterns.

Objectives

MacArthur's tropical mountain hypothesis of high tropical altitude/low relative diversity was tested using data gathered from Caparaó to 1) describe the mammal communities present and 2) compare them with those of temperate mountains. For the comparison, a survey of the mammals of Great Smoky Mountains National Park in North America conducted by Linzey and Linzey (1968) was selected. The Caparaó data also contributes to establishing statistical methods which assist in small mammal identifications not only in the Neotropics but potentially in other locations as well. The results of these methods has an additional value in that they may assist in clarifying the taxonomic relationships of certain of the small mammal species found in the Atlantic rainforest. Life history patterns for individual species were also carefully noted and are of interest.

CHAPTER II

METHODS

Site Descriptions

Regional

The Serra do Mar mountains are the coastal range of Brazil extending from southern Bahia to the state of São Paulo along the eastern edge of the Brazil Highlands. The area is of ecological interest due to its great altitude and physiographic effect. The high altitudes (up to almost 2900 m) create cool temperatures that contrast with the surrounding tropical conditions and intercept prevailing sea winds to form areas of both high rainfall and rainshadow. The highest peaks in the range experience freezing temperatures to form islands of cool, dry paramo-type grasslands typical of areas several hundred kilometers inland and to the southwest.

Brazil currently maintains four national parks associated with the southern Serra do Mar and its spur ranges, the Serra do Mantiqueria and the Serra do Caparaó. Tijuca (located in Rio de Janeiro) is a typical low elevation Atlantic rainforest while Itatiaia, in the states of Rio de Janeiro and Minas Gerais, is rocky and paramo-like at high elevations and forested in the valleys. The third park, Serra dos Orgãos, is extremely rugged, but otherwise similar to Itatiaia and also is located in the state of Rio de Janeiro. Caparaó is the most northerly park, located on the border between the states of Espirito Santo and Minas Gerais (Figure 2). It is also the largest park and has the highest altitudes, with four peaks exceeding 2700 m. The highest, Pico da Bandeira, is the third highest mountain in Brazil at 2890 m and was the primary reason for the park's creation.

Caparaó National Park is approximately 35,000 ha with a diversity of habitats due to altitudinal zonation ranging from low elevation Atlantic rainforest to cloud forests, scrub-grasslands, and paramo-like high altitude meadows. Caparao is located between latitudes 20 22' to 20 40' and longitudes 41 40' W. to 42 W. Currently plans exist to expand the park's area and there is interest in increasing its recreational use as well.

Vegetation

Ruschi (1978) gave a general description of the vegetation of Caparaó. The following is a summary from his work supplemented by my own observations. The low elevation

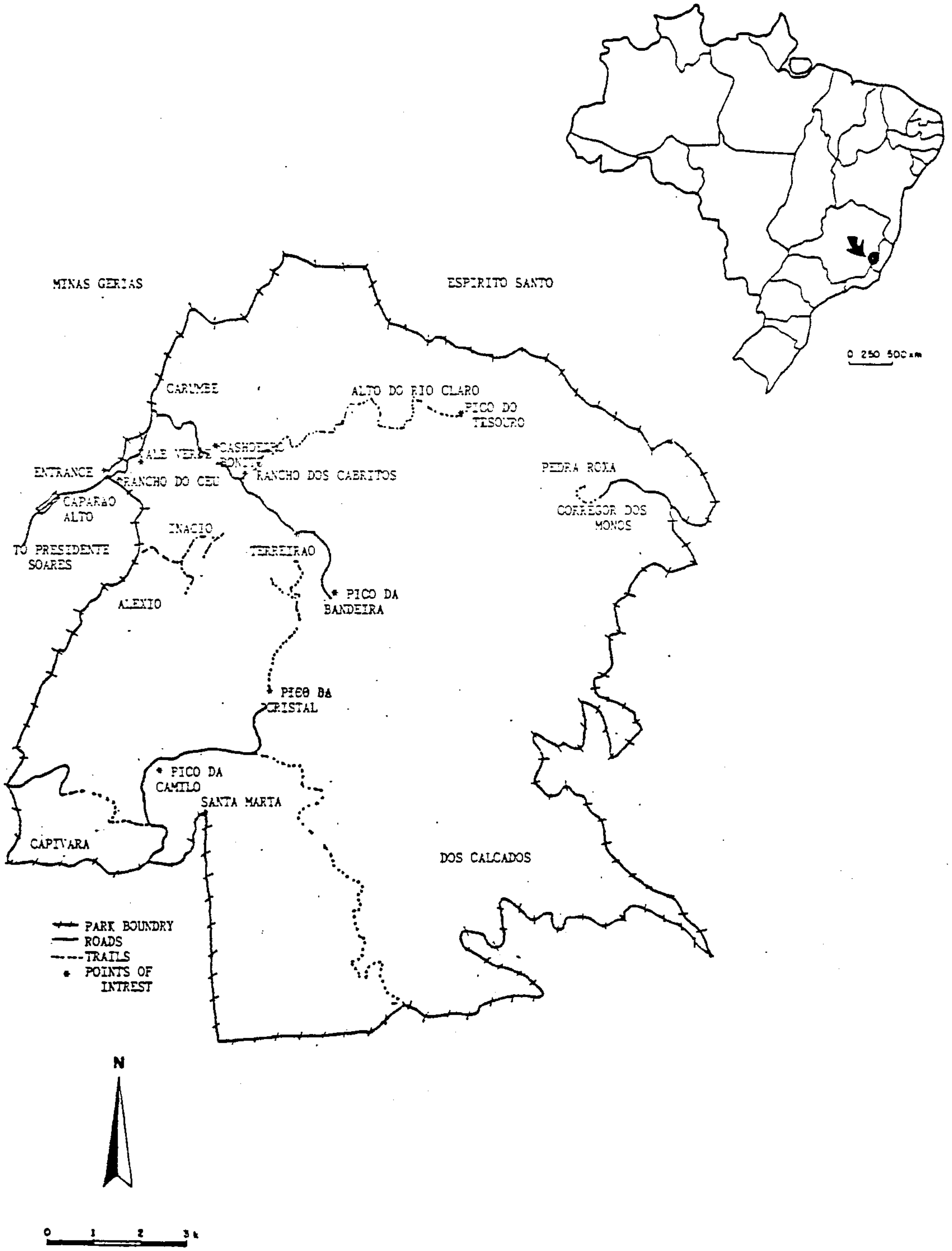

Figure 2: Location and map of Caparaó National Park, Brazil

forest vegetation ranges in height from 20 to 30 m and is domimated by *Tibouchina estrellensis*, *Cassia multijuga*, *Miconia candolleana*, and *Miconia sellowiana*. The transition zone vegetation isless dense and less than 15 m in height with the bamboo genus *Cabralea* common. Some individuals of the Parana pine (*Araucaria angustifolia*) are found in this zone and the next although it is not known if these large trees are remnants of native stands or introduced. Higher still, above approximately 2000 m,the plant communities consist of species adapted to colder, drier conditions with *Roupala*, *Podocarpus* and *Chusquea* present. Chase (1927) described this area as "rich in grasses and composites" (pg.402). Plants endemic to Caparaó or also found only in the Serra dos Orgãos (a southern, inland spur of the Serra do Mar) include members of the genera *Zygocactus*, *Griselina*, *Hymenophyllum*, *Blechnum*, *Polypodium*, and *Azara*. Also, *Anemone decapetala* is found in the park; this is a disjunct population of the species found elsewhere only in Chile, Argentina, Uruguay and Rio Grande de Sul, the southernmost state of Brazil. Epiphytes are common in Caparaó, with over 100 species of orchids and 21 bromeliads listed by Ruschi (1978).

Climate

Temperatures ranged from 13 C to 29 C at 1000 m altitude between February and October of 1980. Although no weather data were taken from May 1979 through January 1980, temperatures were considerably lower during June and July 1979 as water in roof tanks and puddles regularly froze at elevations as low at 800 m, which was not the case in 1980. Annual relative humidity averages between 70% and 78 % (IBDF 1980). Unlike many areas of the tropics, rainfall occurred during all months of the year due to the mountains, although the amount varied considerably. November through February are the wettest months and June through August are relatively dry; between February and October of 1980, 1575 mm of rain was recorded at 1000 m elevation on the western (and drier due to rainshadow) side of the park. Maximum monthly precipitation was 480 mm recorded during February 1980 and the minimum was 25 mm in July (Figure 3). These data do not include the wettest months of the rainy season as weather data were begun in February of 1979 and not taken between mid-December, 1979 and mid January, 1980 due to my absence from the park at the time. As can be seen in Figure 3, the dry season is concomitant with the cold season in these mountains.

In addition to rainfall, water also enters the park ecosystem in the form of condensation of the almost daily cloud cover coming inland from the sea. Heavy fog forms and condenses on the large faces of granite, cooled both by the altitude and the preceding night. Further condensation also occurs directly on the vegetation. It is difficult to estimate how much water is introduced in this manner, but it is considerable.

Habitat Zones

The variations in rainfall, temperature, altitude and human disturbance in the Serra do Caparaó have resulted in several major habitat types of interest. The five used in this study were defined as follows (Figure 4):

Agriculture - Zone 1. These areas are modifications of the original Atlantic rainforest that were produced and maintained by slash and burn tactics and domestic grazing practices until approximately 1975. Weeping love grass (Eragrostis curvula) and greasegrass (Panicum maximum) often were planted in addition to coffee and a variety of fruits, principly banana, and citrus wih some jabucicaba and avacado. Within the park these areas are no longer maintained and are undergoing secondary succession. This habitat type is patchily distributed between 900 m and approximately 1200 m elevation. Although this zone constitutes a relatively small percentage of the park, most of the park boundary is in contact with agricultural lands

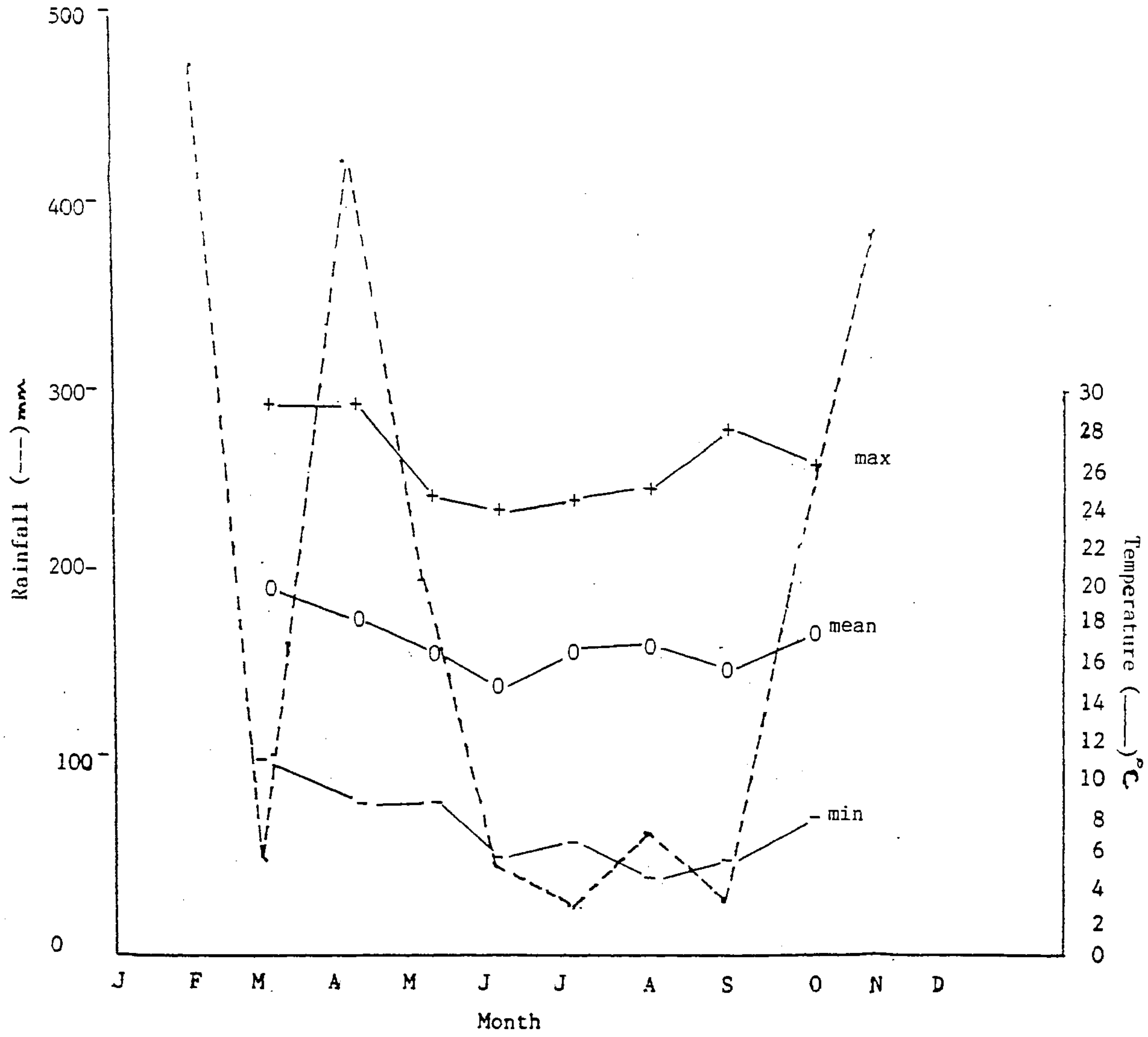

Figure 3: Caparaó National Park weather data at 1000 m. elevation for 1980.

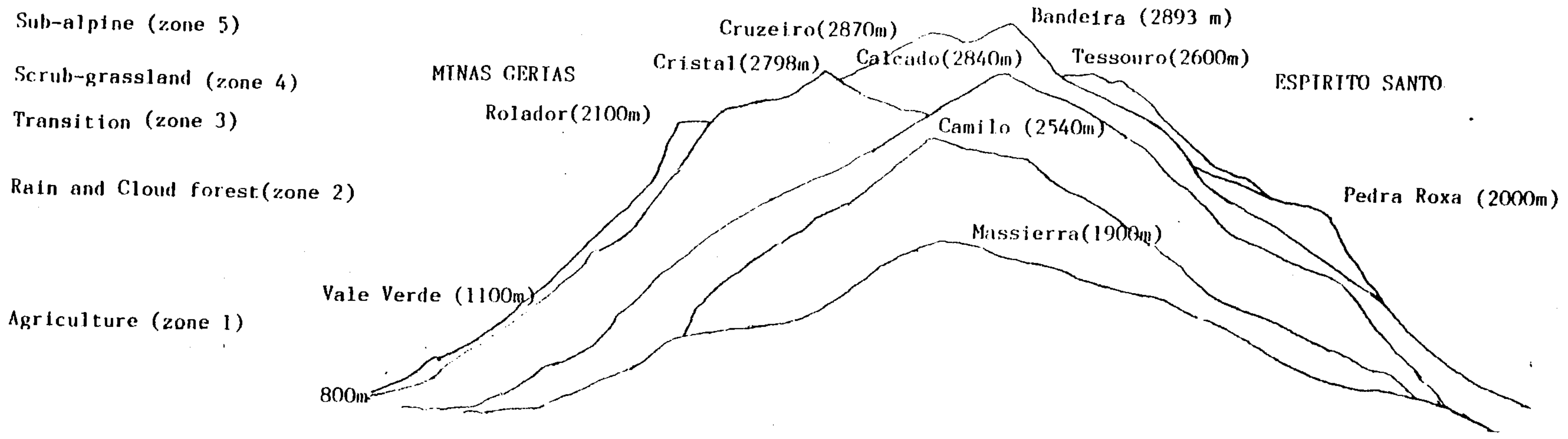

Figure 4: Altitudinal variation in ecological zones of Caparaó National Park.

and any future expansion will almost certainly bring more. Little is currently known about tropical succession and the expanding agricultural programs presently in effect are unlikely to offer many opportunities for study of the topic. These park areas are consequently of great interest.

Rainforest - Zone 2. This consists of Atlantic rainforest (Ab'Saber 1977), although as previously mentioned, the slopes of the Serra do Caparaó resemble a cloudforest due to almost daily cloud and fog cover. Limited modification of this zone has resulted from hunting and firewood cutting. In the past, hunting was intensive and, although now strictly prohibited by IBDF, some poaching still takes place. The topography of this zone is quite rugged with steep valleys, cliffs, and many swift streams. Altitudes range from 900 m to 1500 m, often as vertical rock faces. The vegetation is typical climax Atlantic rainforest with a great diversity of tree species having a canopy in excess of 20 m in height, with a tremendous variety of bryophytes, bromeliads, tree ferns, and orchids (Ruschi 1978).

Transition - Zone 3. At an altitude between 1800 m and approximately 2000 m, changes in temperature and moisture cause the rainforest vegetation to give way to more xeric species as the soil becomes rockier and thinner. Frosts are common between May and September. Gallery forests extend along the water courses in steep valleys and waterfalls are abundant. It is an irregular zone of mixed vegetation types with patchy distributions based on exposure, soil depth, and water availability.

Scrub-grasslands - Zone 4. The elevation of this zone ranges between 2000 m and 2500 m and is characterized by plant species rarely over 1.5 m in height except near water. Species are adapted to both relatively xeric soil conditions and night temperatures which regularly fall to freezing between June and August. This zone is cloud-covered during afternoons throughout most of the year; however by nightfall the clouds settle into the lower elevations causing nights usually to be clear, dry and cold. Both domestic grazing and hunting of tapir (Tapirus terrestris), coatimundi (Nasua nasua), and jaguar (Panthera onca) have been common in the recent past. Domestic grazing was terminated in 1979 with the exception of a small herd of feral goats numbering around 25 individuals according to park rangers. At present, certain areas of this zone are being heavily impacted by tourism from trail erosion, overnight campers damaging vegetation for firewood and a lack of sanitary facilities or protected water supplies. In the months of June and July it is common for as many as 1000 people per month to be concentrated along the trails leading up to Pico da Bandeira and most of those camp overnight in and near Terreirão.

Alpine - Zone 5. The highest zone lies above 2500 m and is typified by low grasses, sedges, oxalis, sundew and heaths (Chase 1927). Freezing night temperatures between May and September are normal. This area contains 4 'lagoas' or peat-like bogs that form shallow lakes approximately 1-2 m in depth during the wet season, persist well into the dry season and then freeze. Each lagoa is the source of one of the major streams or rivers which leaves the park. Human activities at these elevations have been minimal other than limited summer grazing in the past but an increasing number of visitors to the park camp and hike this zone intensively, causing severe erosion of paths and damage to vegetation. Many of the plant species are found in the previous zone and the gradation between the two is gradual. The areas of this zone form islands surrounding and extending downwards from the major peaks of Bandeira/Cruzeiro, Cristál, Tessouro and Calçado.

On the eastern slope of the range, a slight upward shift of all zones exists due to increased rainfall. The Serra do Caparaó runs almost north-south but the prevailing winds off the sea come in from the southeast.

Field Techniques

Specific sites in each ecological zone were selected for trapping, mistnetting and transects (Table 1) although general observations were made at every opportunity. The particular survey techniques varied somewhat as each site varied with the habitat and accessibility, but care was taken to equalize effort between zones and seasons as much as possible. Conservation of the park's fauna was a major

TABLE 1

DESCRIPTIONS AND EFFORT FOR DATA COLLECTION SITES

Site	Elevation (m)	Zone	Trap-nights	Mist nets	Transects (km)
Ranch House	1000	1	262	40	93
Pedra Urubú	1100	1	108	4	97
Pedra Roxa	1000	1	126	6	24
Inácio/Aléxio	1500	1	1464	12	87
Mata Burro	1100	2	323	6	40
Vale Verde	1200	2	1083	30	33
Mata Capivara	1500	2	1262	9	93
Carumbe'	1500	2	420	2	111
Volta da Onça	1700	3	105	-	118
Cachoeira Bonita	1800	3	30	-	99
Massierra	1900	3	-	-	12
Rolador	2000	3	145	7	267
Rancho das Cabritos	2200	4	234	4	52
Morro dos Cavalos Bravos (Terreirão)	2300	4	225	-	
Campo do Jumento (Terreirão)	2300	4	120	-	6
Rio José Pedro (Terreirão)	2300	4	88	-	45
Alto do Rio Claro	2500	5	1205	-	46
Tres Lagoas	2500	5	-	-	14
Arrozal	2500	5	64	-	10
TOTAL			7264	120	1253

consideration and, consequently, IBDF permitted only representative specimens of the smaller species to be collected. All other individuals were released after being identified, sexed, aged (if possible) and marked with tattoos or paint for individual recognition in the event of recapture. Ether was used to immobilize the animals for ease of handling and to assure the measurements taken were accurate. Particular care was taken to release obviously pregnant or lactating females since none of the park species' populations are known. It was IBDF's express concern that none of the populations of the park's species be reduced and I cooperated with their wish as much as possible.

Traplines consisted of four types of live-traps. For smaller mammals a paceline was established at each site with small Sherman traps having a 10 m interval between stations. The number of stations per line varied somewhat depending upon habitat and topography, but pains were taken to equalize trapping effort as much as possible among zones (Table 2). Each area trapped had 3 lines run for 7 to 10 days per line with several areas trapped in each habitat zone. Two medium-sized traps were used, one a standard Hav-a-hart and the other a comparably sized, locally made trap of welded wire with agravity door and suspended bait hook. Unlike the Hav-a-harts, the latter were effective in capturing small mice and marsupials (as well as birds and

TABLE 2

EFFORT FOR TRANSECTS, TRAPPING AND MISTNETS BY ZONE, SEASON AND MONTH

		ZONE*					
SAMPLE METHOD SEASON MONTH		1	2	3	4	5	TOTAL
TRANSECTS							
W	Dec	13	7	12	0	0	
E	Jan	10	3	9	0	0	
T	Feb	19	9	27	6	6	115
W	Mar	26	13	41	8	5	
/	Apr	23	77	41	11	14	
D	May	29	82	35	7	12	424
D	Jun	38	43	40	14	8	
R	Jul	47	36	28	14	8	
Y	Aug	39	31	36	12	4	398
D	Sep	22	43	49	24	3	
/	Oct	20	39	22	8	5	
W	Nov	0	0	0	0	0	316
TRAPNIGHTS							
W	Dec	0	0	0	0	0	
E	Jan	0	315	0	0	64	
T	Feb	84	384	0	0	0	847
W	Mar	0	208	105	234	0	
/	Apr	0	0	0	0	1205	
D	May	0	830	175	0	0	2757

TABLE 2 (Continued)

		ZONE*					
SAMPLE METHOD SEASON	MONTH	1	2	3	4	5	TOTAL
TRAPNIGHTS (Con't)							
D	Jun	0	300	0	225	0	
R	Jul	134	450	0	0	0	
Y	Aug	1246	224	0	0	0	2579
D	Sep	120	201	0	120	0	
/	Oct	286	0	0	88	0	
W	Nov	90	176	0	0	0	1081
		1960	3088	280	667	1269	
MISTNETS							
W	Dec	9	4	0	0	0	
E	Jan	1	2	0	0	0	
T	Feb	8	8	0	0	0	46
W	Mar	2	0	2	0	0	
/	Apr	10	1	0	0	0	
D	May	0	7	3	2	0	16
D	Jun	8	7	0	0	0	
R	Jul	5	2	0	0	0	
Y	Aug	4	5	0	0	0	37
D	Sep	6	9	0	2	0	
/	Oct	7	2	0	0	0	
W	Nov	2	0	2	0	0	89
		62	47	7	4	0	

* 1 - Agriculture; 2 - Rainforest; 3 - Transition;
4 - Scrub-grass; 5 - Alpine

insects). The medium-sized traps were set at every fifth station in the above described paceline as well as at locations where sign specifically indicated activity. For example, traps were placed at the entrances of dens or along trails with a bait that would be appropriate to the anticipated species. If no specific sign was present, baits of banana, sardines or corn/peanut butter/oatmeal were placed alternately in the paceline traps. Three large (1m x 1m x 1m) wooden traps were occasionally used, baited with corn/peanut butter or raw meat to try and catch a specific species even though they had to be transported by mule. Generally though, those species which would be captured in the large traps were readily detected on transects.

Transects for tracks, scats, visual and auditory sign were run daily in all zones while trapping was being conducted and at least twice a month thereafter as time and weather permitted. Transects in Vale Verde were run at least once a week with the exception of late December 1979 and mid January 1980 due to my absence from the park at that time. The road through the abandoned agriculture zone was run twice weekly (Tables 1 and 2). Most transects were along trails or the only road in the park due to the rugged terrain and dense undergrowth in the lower 3 zones. Scats as well as raptor pellets were analysed to assist in documenting small mammal occurrences. The climate usually caused scats to break down within a week, except at the higher elevations, and more rapidly at the peak of the rainy season. Tracks were easily made in all seasons as the soil was usually either muddy or dusty. Tracks and scats were eliminated from each transect as it was run to insure no sign was counted twice.

Mistnets were used at lower elevations and caves were explored for bats. Three caves were near enough to the ranch house that bat populations could be monitored and transects were routed to include them. Mistnets were placed over streams or across trails and natural clearings (Tables 1 and 2).

Small Mammal Identification

Notes on measurements (total length, tail length, hind foot and ear length), pelage and weights were taken on all individuals captured although only a representative sample were sacrificed for voucher specimens and placed with IBDF in Belo Horizonte, Minas Gerais. An additional measurement of the ratio of the tail to the total length was also taken. To confirm identifications statistical comparisons were made with data from species collected from states near the park or through which the Serra Do Mar passes to form a dispersal corridor. The non-Caparaó data are from the collections of the University of Kansas, The Chicago Field Museum of Natural History, the Stoval Museum at the University of Oklahoma, the U.S. Museum of Natural History and from published data. Some specimens were also examined and identifications confirmed by Dr. F.D. de Avilia-Pires.

Twenty-five species which could possibly occur in the park and for which external morphometric data were available from museums or in the literature were all compared using pair-wise general linear model F-tests (due to unequal sample sizes). These were done using Statistical Analysis System (SAS) General Linear Model (GLM) (Helwig 1978). All possible pairs of museum species were compared using all 5 variables. Once each of the museum identified species was determined significantly different from all others by at least one variable (total Length, tail length, hindfoot length, ear length or ratio of the tail to total length) then specimens which had been identified in the park were tested against each museum species to verify the field identifications. Significance was at the .05 level even though many species of rodents are often not identifiable in the field with more than about 75% confidence. Nonetheless, in the majority of cases in this study, species could be distinguished with 95% confidence by at least one of these external parameters. Stepwise discriminant analysis was also used to further clarify the separation between species and to determine the most statistically probable identities of any questionable individuals from the park (Abbott _et al_.1985). This proceedure was carried out using the BMDP7M program (Department of Biomathmatics 1981).

Although the standard total length, tail length, hind foot and ear length were the external measurements relied on, the fifth parameter, the ratio of the tail to the total length, showed little variance within species regardless of sex or age, yet was often discrete at both the genus and species level and proved to be a useful quantitative character. Currently, this ratio is widely used in a general, qualitative sense such as "The tail is normally longer than the head and body..." (Nowak and Paradiso 1983, p. 576) and in many field guides but no effort has been made to use it as a species specific morphometric character as are the other external measurements.

Final decisions for assigning Caparaó specimens to species were based on maximum agreement of field identifications with all characteristics of external measurements, pelage, general cranial characters (including dentition) and recorded habitat preferences. The computer derived identifications based on external measurements were then used to confirm the field identifications and to suggest likely alternates if those field identifications seemed less than certain or for those individual specimens with identities in doubt. In the latter case, the specimen was placed into the species with which it shared the minimum number of significant differences (based on the F-test results) and the maximum number of discriminant function reclassifications. Once again, all available factors of external measurements, pelage, general skull characters and habitat preferences had to be in agreement before the Caparaó specimens were considered correctly identified. All others are referred as either unknown (if neither genus or species is certain) or as the genus with the species designated by a number. The numbering system is consistant throughout with Marmosa sp 3, for example, refers to the same taxon wherever encountered.

Community Parameters

The various parameters for the community ecology portion of this study were calculated both separately and in combination for transect, trapping and mistnet data and were defined as follows:

Number of Species or Species Richness (S)

This should be a self explanatory statistic. According to Poole (1974) this is the most objective measure of diversity, a position strongly reinforced by Green (1979).

Number of Individuals (N)

As above, this should be self explanatory, however it should be noted that this was not used as a population estimate, but only as an index to establish relative frequencies within and between communities.

Index of Diversity (H')

This is the standard Shannon-Wiener index of diversity from Lloyd et al. (1968) and used by Anthony et al. (1981).

$$H' = -\sum pi \ (\log) \ pi$$

where pi is a proportion of the ith species in the sample. The use of this statistic has come under frequent attack in part because it requires 1) a random sample (not really possible in many vertebrate systems with unequal catchability - such as mice in baited traps) and 2) a very large community, also not the case with many organisms. Discussions of the problems associated with this statistic can be found in Pielou (1969), Green (1979) and Krebs (1989). Even so, and perhaps unfortunately, this is one of the most commonly used descriptive and comparative statistics used by community ecologists.

Evenness (J')

This is a component of diversity which measures how evenly distributed individuals are among the species present in a community and is calculated:

$$J' = H'/\log S$$

as taken from Pielou (1966). Climax or undisturbed communities tend to have individuals rather more evenly distributed between species while communities at a lower successional stage are inclined to have individuals unevenly distributed between species. Clearly, the distribution of individuals between species is profoundly affected by many bioenergenic considerations such as trophic level, season or even size that may or may not reflect genuine differences between the communities the species inhabit. Consequently, this statistic should also be used with care and tempered with awareness of biological reality.

Diversity ($\bar{d}$)

This statistic was taken from Green (1979) and was calculated as:

$$\bar{d} = (S-1)/\log N$$

where S is the number of species and N is the total number of individuals of all species. Green (1979, page 101) comments

> If species diversities are desired for comparative purposes,... simple indices such as S and $\bar{d}$ are biologically meaningful measures which are less ambiguous than - and often as informative as - more complex indices such as H and H'.

and further states that "after simulation studies, Green (1979) found that S was a better indicator of biological change than H'" (page 101). In this analysis, all 4 diversity indices (H', J', S and $\bar{d}$) will be presented for comparison.

Endemism (E)

Will be defined as the number of species found inhabiting a single park habitat (Blair 1975; Blair, et al. 1976) rather than, as it is sometimes used, the number of species that have evolved within a habitat and exist nowhere else at all (Gentry 1986). The interpretation of this parameter would be that a species habitat might exist outside the park and consequently so might the species, but that within the park, the species is restricted in distribution. This parameter is important from a management perspective because it measures the number of species that are apparently entirely dependent on a specific habitat and unable to successfully use others. These species may be useful as indicator species as they would be most affected by the loss, damage, or increase of that habitat (Thomas 1979).

Dominance (D)

This is a measure of relative abundances of species in communities especially as these communities shift over an environmental gradient, or it may be used to compare the same two species if they occur in different habitats. It is a specific measurement of paired species interactions within a trophic level and as closely related in niche as possible. Dominance, as defined by McNaughton and Wolf (1970), implies that species within trophic levels are in some competition *with one another for resources and that the species which is most common may be appropriating the niche space of the other in the habitat thus outcompeting the second species, limiting it, and consequently showing a higher relative frequency. Dominance is a within-trophic-level function and dominant species are hypothesized to be slightly more specialized for the habitat than the less common, subordinate member of the pair. Generalist and specialist species are defined relative to one another, however, and a generalist species, by exploiting a wider range of conditions, may be limited by a specialist within a particular habitat (the former showing dominance) but over a <u>range</u> of habitats may maintain a higher overall frequency (Pianka 1978). Dominance is expressed by the equation:*

$$D = 100\ (y1,2/Y)$$

where y1,2 is the abundance of the 2 most common species of the same trophic level. Communities high in diversity yet low in dominance are typically climax communities while those with low diversity and high dominance would be in early successional stages or unsaturated in terms of species (McNaughton and Wolf 1970). In some ways, dominance may be a practical field method to measure certain aspects of competition from a community standpoint. The result of prolonged competition (dominance) between species could be 1) subdivision of niche space and greater specialization or 2) a dynamic equilibrium if the habitat is sufficiently heterogeneous or, finally, 3) competitive exclusion, and perhaps extinction of one species in a particular habitat.

Rarity Index (R)

This parameter was calculated by ranking (from least to most common) the frequencies of occurrence of all species across all zones for each census method. Ranks were then totaled and averaged to give each zone an index value. A lower value means a habitat has more uncommon species (Usher 1986).

The above listed community parameters were tested using chi-square analysis, general linear model F-tests and Mann-Whitney tests for significant variation between the 5 habitats present in Caparaó and also for differences between this tropical mountain range and the Great Smoky Mountains in the temperate zone. The specific tests used are discussed under the results section for each parameter to which they are applied.

CHAPTER III

RESULTS

Results are based on the sample method used and, consequently, reflect two general size classes of mammals. These then are integrated in the section on community ecology.

Identification

Small Mammals

As anticipated, individuals in the Cricetidae proved the most difficult to identify due to the lack of good field characters for some species, the possibility of undescribed species occurring in the park and the confusion over many named forms with disagreements both at the level of species and genus. However, the 35 museum and 10 Caparaó cricetid species tested in this study largely fell into major groups corresponding to their respective genera and even subgenera when discriminant function was applied (Figure 5). Variables that provided best separation between species

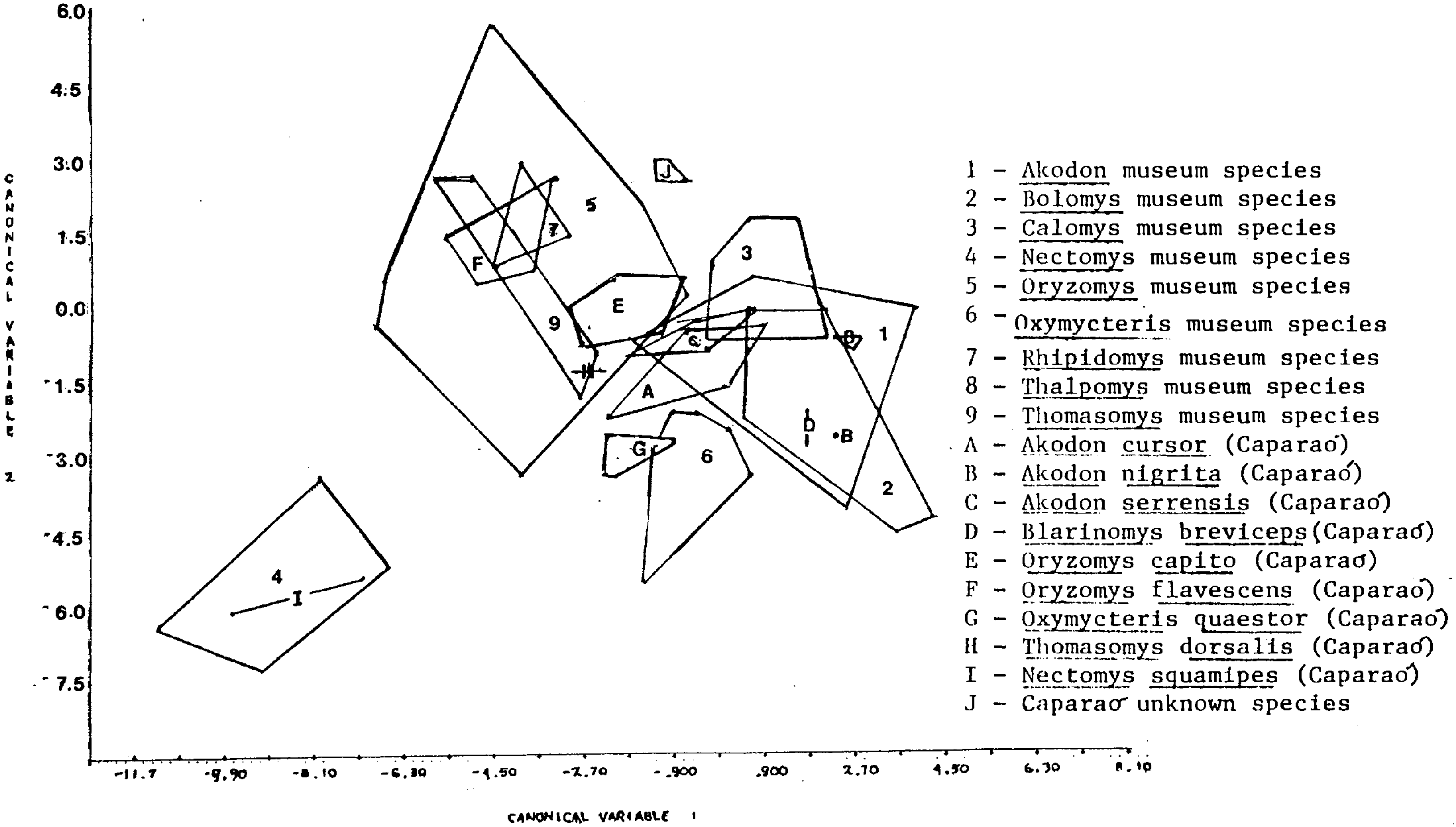

Figure 5: Discriminant function plot of Eastern Brazil Cricetidae.

were: 1) the hind foot length (F=165.25), 2) the ratio of the tail to the total length (F=109.10, 3) the ear length (F=67.05), 4) the tail length (F=48.58) and, finally, 5) the total length (F=38.94) (DF 35,518). It is recognized that these five measurements are not definitive to distinguish all species and this study does not recommend their exclusive use since data from pelage, habitat, karyotypes, DNA and the morphology of teeth, skulls and reproductive structures may all contain unique diagnostic features. Still, external measurements do have certain advantages for use in species identification especially in the field. In particular, 1) they are available for virtually every specimen whether in museums or live in the field 2) they do not require the sacrificing of an individual to obtain and 3) they are in use by almost all field guides and keys as diagnostic in combination with pelage characteristics, range and habitat data and, consequently, are deeply entrenched in both popular and scientific literature.

General comments on Oryzomys. Of the 11 museum identified species compared to one another as 55 pairs using general regression F-tests, at least one of the five external measurments could distinguish between them in all but 3 cases (Table 3). Oryzomys fornesi and O. nigripes were not significantly different at the .05 level nor could O. capito be separated from either O. intermedius or

TABLE 3

P>F FOR GENERAL LINEAR REGRESSION F-TESTS FOR PAIRED SPECIES OF ORYZOMYS

		Measurements				
Species Pairs (Caparaó species #)	DF	Total	Tail	Hind Foot	Ear	Tail/ Total
bicolor/capito	19	.0015	.0469	.0001	.0001	.0001
bicolor/capito#	33	.0001	.0001	.0001	.0001	.0109
bicolor/concolor	15	.0039	.0105	.0004	.0887	.2375
bicolor/eliurus	24	.8353	.0663	.0043	.2418	.0005
bicolor/flavescens	14	.0589	.0027	.0020	.5407	.0068
bicolor/flavescens#	36	.0003	.0001	.0001	.9051	.0001
bicolor/fornesi	12	.5793	.6269	.0336	.0024	.0024
bicolor/intermedius	20	.0001	.0001	.0001	.0001	.1891
bicolor/nigripes	44	.3205	.0066	.0001	.1427	.0004
bicolor/nitidus	49	.0001	.0001	.0001	.0001	.0146
bicolor/ratticeps	13	.0001	.0001	.0001	.0001	.7698
bicolor/subflavus	24	.0001	.0001	.0001	.0001	.6743
capito/capito#	50	.1701	.7254	.0513	.1871	.0001
capito/concolor	28	.9237	.5417	.0387	.0614	.0251
capito/eliurus	38	.0005	.0008	.4222	.0001	.0001
capito/flavescens	27	.0002	.0013	.0001	.1871	.0007
capito/flavescens#	48	.0001	.0001	.0001	.0001	.0001
capito/fornesi	27	.0001	.0001	.0001	.0001	.0001
capito/intermedius	33	.0982	.1747	.4459	.2694	.8992
capito/nigripes	57	.0001	.0001	.0001	.0001	.0001
capito/nitidus	62	.2515	.2895	.3938	.5154	.7592
capito/ratticeps	28	.0001	.0007	.0256	.0830	.8614
capito/subflavus	38	.9559	.7499	.0384	.0416	.1234
capito#/concolor	31	.0013	.0551	.0027	.0007	.0015
capito#/eliurus	41	.0001	.0081	.0001	.0001	.0001
capito#/flavescens#	51	.0044	.2109	.0021	.0001	.0001
capito#/flavescens	30	.0001	.0001	.0001	.0001	.0001
capito#/fornesi	30	.0001	.0001	.0001	.0001	.0001
capito#/intermedius	36	.0001	.0001	.0001	.0010	.2356
capito#/nigripes	61	.0001	.0085	.0001	.0001	.0001
capito#/nitidus	66	.0001	.0001	.0001	.0001	.0291
capito#/ratticeps	29	.0001	.0001	.0001	.0001	.0001
capito#/subflavus	40	.0001	.0001	.0001	.0001	.0001
concolor/eliurus	19	.0013	.0551	.0027	.0007	.0015
concolor/flavescens	8	.2286	.6686	.3441	.0925	.0212
concolor/flavescens#	30	.0035	.5251	.3481	.0015	.0001

TABLE 3 (Continued)

Species Pairs (Caparaó species #)	DF	Measurements				
		Total	Tail	Hind Foot	Ear	Tail/ Total
concolor/fornesi	8	.0358	.1459	.1133	.0068	.3413
concolor/intermedius	14	.0480	.1105	.0002	.0055	.8821
concolor/nigripes	38	.0001	.0113	.0014	.0007	.0008
concolor/nitidus	43	.0014	.0048	.0001	.0001	.8274
concolor/ratticeps	7	.0005	.0020	.0009	.0018	.7989
concolor/subflavus	18	.0082	.0059	.0003	.0001	.4268
eliurus/flavescens	18	.0419	.1010	.0668	.8949	.8357
eliurus/flavescens#	40	.0002	.0001	.0001	.3486	.1438
eliurus/fornesi	18	.4391	.4207	.6465	.0117	.7313
eliurus/intermedius	24	.0001	.0001	.0001	.0001	.0001
eliurus/nigripes	48	.9133	.5089	.0178	.0271	.1396
eliurus/nitidus	53	.0001	.0001	.0001	.0001	.0001
eliurus/ratticeps	17	.0001	.0001	.0001	.0001	.0335
eliurus/subflavus	28	.0001	.0001	.0001	.0001	.0036
flavescens#/flavescens	28	.9291	.2471	.2278	.5467	.8983
flavescens#/fornesi	28	.0006	.0001	.0029	.0118	.1131
flavescens#/intermedius	34	.0001	.0001	.0001	.0001	.0001
flavescens#/nigripes	58	.0005	.0001	.0001	.1442	.0197
flavescens#/nitidus	59	.0001	.0001	.0001	.0001	.0001
flavescens#/ratticeps	27	.0001	.0001	.0001	.0001	.0001
flavescens#/subflavus	38	.0001	.0001	.0001	.0001	.0001
flavescens/fornesi	7	.0603	.0316	.3559	.3302	.8983
flavescens/intermedius	13	.0001	.0023	.0001	.0002	.0034
flavescens/nigripes	37	.0689	.0417	.5527	.7894	.6721
flavescens/nitidus	42	.0001	.0001	.0001	.0001	.0001
flavescens/ratticeps	6	.0044	.2109	.0021	.0001	.0001
flavescens/subflavus	17	.0004	.0033	.0001	.0001	.0001
fornesi/intermedius	13	.0001	.0001	.0001	.0001	.0013
fornesi/nigripes	37	.0911	.1273	.1130	.1593	.7677
fornesi/nitidus	42	.0001	.0003	.0001	.0001	.0001
fornesi/ratticeps	6	.0001	.0005	.0001	.0001	.1847
fornesi/subflavus	17	.0001	.0002	.0001	.0001	.0002
intermedius/nigripes	43	.0001	.0001	.0001	.0001	.0001
intermedius/nitidus	48	.6069	.7849	.0483	.4592	.6440
intermedius/ratticeps	12	.0001	.0001	.0923	.1184	.8275
intermedius/subflavus	23	.1566	.1268	.0068	.9761	.3320

TABLE 3 (Continued)

Species Pairs (Caparaoʹ species #)	DF	Measurements Total	Tail	Hind Foot	Ear	Tail/ Total
nigripes/nitidus	72	.0001	.0001	.0001	.0001	.0001
nigripes/ratticeps	36	.0001	.0001	.0001	.0001	.0066
nigripes/subflavus	48	.0001	.0001	.0001	.0001	.0002
nitidus/ratticeps	41	.0001	.0001	.0017	.1290	.8977
nitidus/subflavus	52	.2728	.1432	.0366	.4520	.1049
ratticeps/subflavus	16	.0001	.0016	.0013	.0006	.5579

O. *nitidus*. Two other pairs were also very similar: *O*. *intermedius* to O. *nitidus* and *O*. *eliurus* to *O*. *flavescens*.

Caparaó *Oryzomys*. Two different *Oryzomys* were trapped in Caparao. The two groups were significantly different in the means of all standard measurements except the tail although they were significantly different in the total to tail ratio (Table 3). The two species could also be differentiated by discriminant function (Table 4 and Figure 6) and in the field by size and pelage. The *Oryzomys* species 1 from Caparaó was not significantly ($P>.05$) different from *O*. *flavescens* in any of the standard external measurements using pair-wise general linear model F-tests. General skull morphology and reddish-ocher pelage was also consistent with *O*. *flavescens*.

Discriminant function was able to distinguish 65.4% of the Caparaó specimens of this type from all other species. The most overlap was with museum *Oryzomys* *flavescens* and 80% of the reclassifications (5 specimens) were placed in that group (Table 4). In general, *O*. *flavescens* is found in campo limpo (prairie) regions east of the Andes, however, the nearest record of *flavescens* to Caparaó is from Rio Grande do Sul (Cabrera 1961) several hundred kilometers south of Caparaó consequently it would be a considerable range extension for this species to occur in the park. Considering that the areas between Rio Grande do Sul and Caparaó include the States of Rio de Janeiro and São Paulo,

TABLE 4

CLASSIFICATION MATRIX FOR DISCRIMINANT ANALYSIS OF 13 *ORYZOMYS* SPECIES

Species	%correct	Species												
		1	2	3	4	5	6	7	8	9	10	11	12	13
(# Caparaó species)		Number classified into each species												
1-*bicolor*	100.0	11	0	0	0	0	0	0	0	0	0	0	0	0
2-*capito*	45.8	0	11	6	0	0	0	0	0	3	0	3	0	1
3-*capito#*	55.6	0	6	15	5	0	0	0	0	1	0	0	0	0
4-*concolor*	60.0	1	0	1	3	0	0	0	0	0	0	0	0	0
5-*eliurus*	46.7	1	0	0	0	7	0	2	2	0	3	0	0	0
6-*flavescens#*	65.4	0	0	0	0	3	17	5	0	0	0	0	0	0
7-*flavescens*	50.0	0	0	0	1	0	0	2	1	0	0	0	0	0
8-*fornesi*	75.0	0	0	0	0	0	1	0	3	0	0	0	0	0
9-*intermedius*	70.0	0	1	0	0	0	0	0	0	7	0	1	0	1
10-*nigripes*	11.8	0	0	0	0	11	2	6	11	0	4	0	0	0
11-*nitidus*	51.3	0	2	0	1	0	0	0	0	8	0	20	0	8
12-*ratticeps*	100.0	0	0	0	0	0	0	0	0	0	0	0	3	0
13-*subflavus*	78.6	0	0	0	0	0	0	0	0	1	0	2	0	11

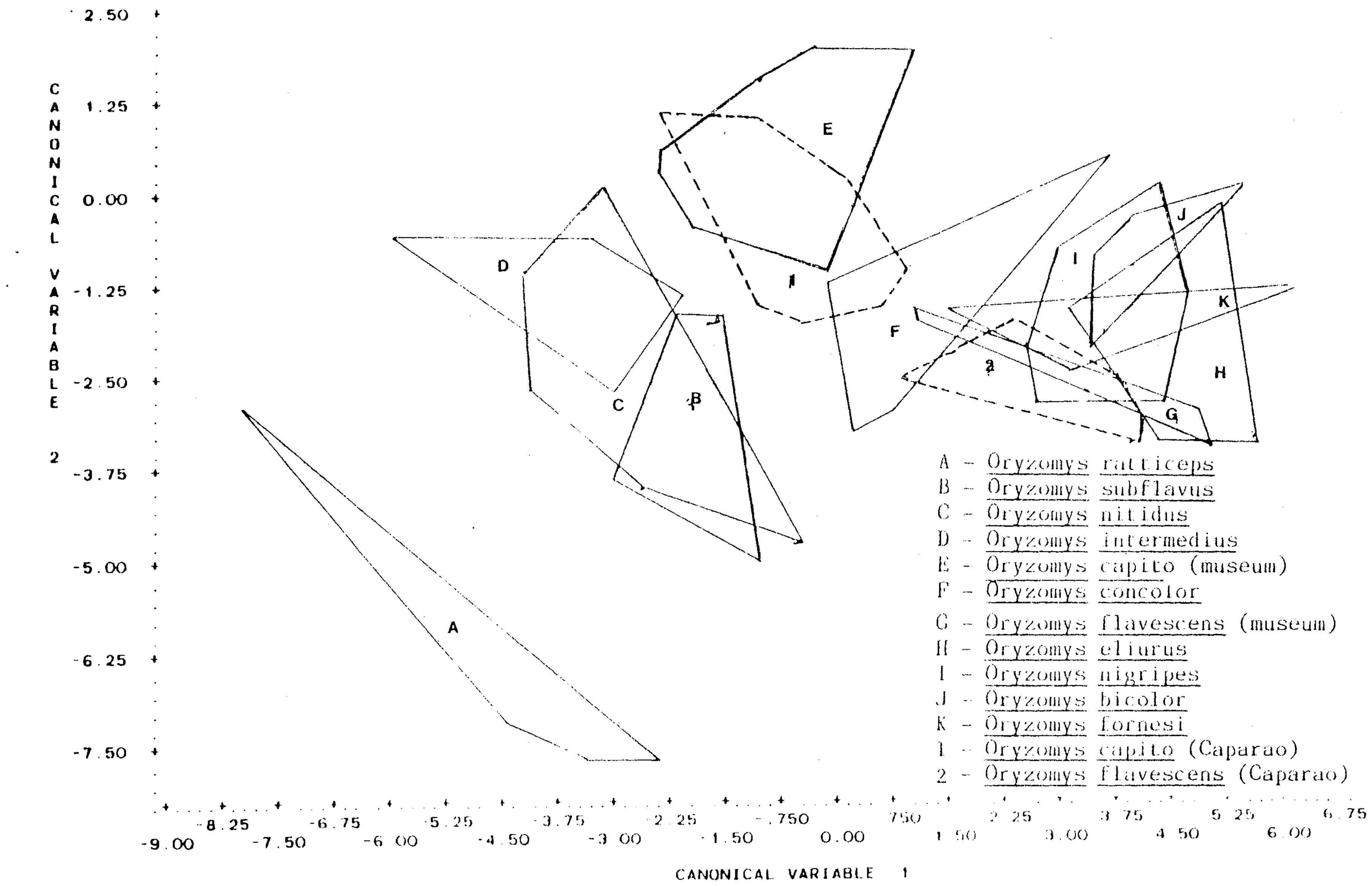

Figure 6. Discriminant function plot of 13 Oryzomys species.

two of the best collected areas in Brazil, this could represent a population disjunct by several hundred kilometers. This is not impossible recognizing the Serra do Mar's position as a refugium and/or dispersal corrider, but it would be a remarkable occurrence. It should be noted, however, that these specimens were taken from park habitats somewhat dissimilar to those in which the species is usually found (Figure 7). They were not associated with the higher altitude campo limpo-like zones 4 and 5 but most abundantly in the rainforest and abandoned agriculture - zones 1 and 2. Consequently, although one species of Oryzomys in Caparaó is most similar to flavescens it may represent a group that has diverged somewhat after isolation in these mountains to perhaps a sub-specific degree having an increased mean tail length and, most importantly, a distinct change in habitat preferance. Alho (1982) does describe flavescen's niche as arboreal, even in the scattered trees of campo limpo, but the increased tail length in the Caparaó group could indicate an even stronger tendency toward arboreality. This is not surprising considering that the park specimens were largely confined to a forested habitat.

Of the 28 specimens identified in Caparaó as Oryzomys capito 12 (43.4%) were classified by discriminant function as belonging to other groups with 6 of those 12 being placed in museum capito (Table 4). Five other specimens were placed in O. concolor which is a species largely Amazonian

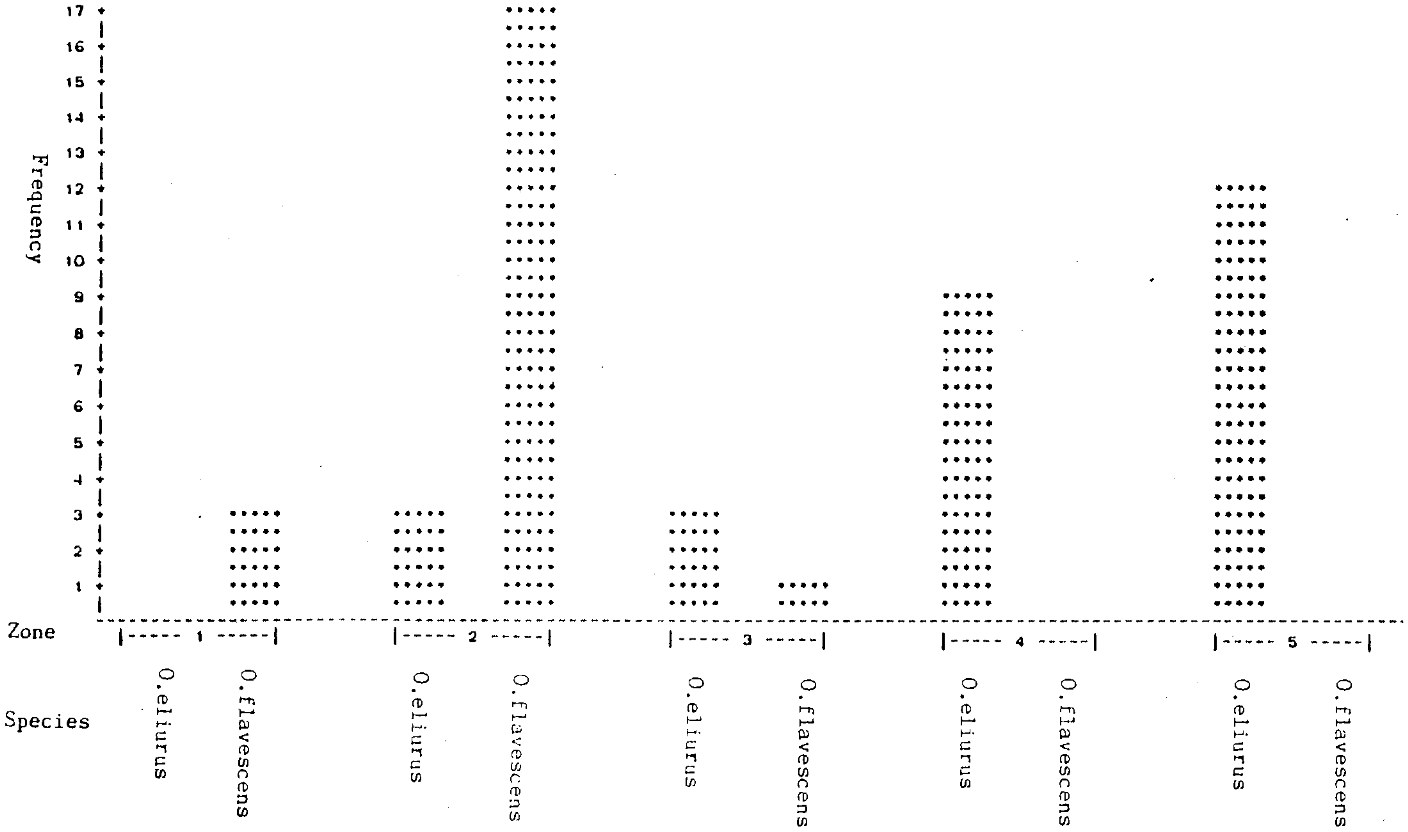

Figure 7: Frequencies of Caparaó Oryzomys species according to habitat.

in distribution but that has been reported in the forested regions of Paraguay and Bolivia. F-tests indicated significant differences between the Caparao specimens total/tail ratio and that of museum *O. capito* and significant differences in between Caparao specimens and museum *concolor* in all five external measurements (Table 3). In addition, the Caparaó mice exceeded the ranges of both *concolor*'s hindfoot and ear lengths (Table 5). *Oryzomys capito* is not usually found in high altitude habitats as it was in Caparaó but the species is adapted to the dry, open country of the chaco, cerrado and caatinga and the higher elevations of Caparaó are dry, open scrub and grasslands, similar to *capito*'s prefered habitats. The high, cold, dry areas of the park are quite unlike the tropical deciduous forests preferred by *concolor*. Consequently, based on discriminant function, F-tests and habitat preferences, the second species of *Oryzomys* found in Caparaó is most probably *capito*.

The two species of *Oryzomys* in Caparaó showed sharp differences in habitat preference with *flavescens* present in zone 1 (agriculture), very common in zone 2 (forest) and rare in zone 3 (transition) while *capito* was present at low frequencies in zones 2 and 3 but was the most common mouse by far in zones 4 and 5 (Figure 7). Where the two species overlapped in the forest (zone 2), *Oryzomys flavescens* was twice as common as *capito*.

TABLE 5

SOUTHEASTERN BRAZIL *ORYZOMYS* SPECIES CHARACTER MEANS AND RANGES IN MILLIMETERS

SPECIES	N	TOTAL LENGTH	TAIL	HFOOT	EAR	TAIL/TOTAL RATIO
O. bicolor	11	193.2	102.0	21.3	15.3	.5290
		(147-225)	(083-118)	(19-23)	(14-17)	(.502-.564)
O. capito	24	245.5	119.9	30.5	20.5	.5164
		(158-330)	(069-170)	(24-36)	(16-25)	(.496-.526)
O. concolor	5	247.6	128.6	27.0	18.2	.5161
		(174-278)	(083-149)	(21-29)	(14-20)	(.477-.541)
O. eliurus	15	194.8	110.8	23.2	14.8	.5681
		(149-230)	(082-131)	(20-25)	(13-16)	(.515-.634)
O. flavescens	4	216.7	122.2	25.0	14.7	.5650
		(197-237)	(112-127)	(23-28)	(11-18)	(.531-.593)
*O. fornesi**	50	188.0	105.5	23.7	13.2	.5633
		(165-212)	(093-118)	(21-26)	(11-14)	(.533-.563)
O. fornesi	4	186.5	105.0	23.5	13.0	.5636
		(165-212)	(093-118)	(21-26)	(11-14)	(.556-.574)
O. intermedius	10	279.6	144.9	35.0	22.2	.5178
		(250-292)	(125-157)	(31-39)	(18-25)	(.480-.543)
O. nigripes	34	199.4	112.4	24.4	14.4	.5618
		(145-230)	(079-132)	(22-28)	(12-18)	(.505-.610)
*O. nigripes**	80	224.8	125.5	24.8	17.4	.5582
		(161-270)	(100-149)	(21-28)	(15-19)	(.551-.621)
O. nitidus	39	288.0	149.1	33.7	22.8	.5175
		(220-325)	(115-175)	(30-37)	(18-26)	(.498-.555)
O. ratticeps	3	404.3	210.0	37.3	24.5	.5235
		(390-412)	(180-221)	(37-38)	(24-25)	(.436-.564)

TABLE 5 (Continued)

SPECIES	N	TOTAL LENGTH	TAIL	HFOOT	EAR	TAIL/TOTAL RATIO
O. subflavus	14	296.2 (236-338)	157.5 (136-179)	32.0 (30-35)	23.0 (20-34)	.5358 (.496-.546)
O. capito#	27	232.8 (219-261)	118.0 (107-129)	28.6 (25-33)	19.7 (17-23)	.5073 (.467-.558)
O. flavescens#	25	216.5 (204-266)	125.1 (119-133)	26.1 (24-29)	15.3 (13-19)	.5789 (.530-.619)

#Caparaó specimens; * Myers and Carlton 1981

General comments on Akodon. Sixteen pairs (5 species) of museum identified species were compared in the genus *Akodon* before the Caparaó specimens were tested. Of the 16, there were significant (.05) differences between all pairs in at least one of the external measurements (Table 6).

Caparaó Akodon. Four species of *Akodon* were found in Caparaó. Species 1 was not significantly different from *Akodon cursor* in four of the five external measurements (Table 6). Discriminant function placed 16 of the 51 specimens identified as *A. cursor* from Caparaó into the museum *A. cursor* category, retaining 19 as discrete (Table 7 and Figure 8). Four of the 23 museum *cursor* specimens were reclassified into Caparaó *cursor*. F-tests indicated the Caparaó group appears to be most similar to museum *A. cursor* as only the total to tail ratio was significantly different between the two groups.

Species 2 was tenatively identified as A. *lasiurus* in the field, but was not significantly different from *Akodon serrensis* in any of the 5 external measurements. Discriminant function reclassified one Caparaó specimen into museum *A. lasiurus* and 1 into museum *A. serrensis* (Table 7 and Figure 8). In the park these mice were found in moderate frequencies in both the forest, transition and alpine zones (Figure 9).

TABLE 6

P>F FOR GENERAL LINEAR REGRESSION F-TESTS FOR PAIRED SPECIES OF *AKODON*

		Character				
Species pairs (# Caparaó species)	DF	Total	Tail	Hind Foot	Ear	Tail/ Total
arviculoides/cursor	29	.0002	.0002	.0001	.0009	.0357
arviculoides/lasiurus	59	.0526	.0315	.0017	.0145	.2083
arviculoides/nigrita	41	.0001	.0001	.0001	.0001	.0019
arviculoides/reinhardti	14	.0001	.0001	.0001	.0001	.1325
arviculoides/serrensis	12	.2017	.0023	.0316	.0024	.0012
arviculoides/cursor#	38	.6789	.3328	.0176	.0568	.0401
arviculoides/ arviculoides#	42	.2187	.0412	.0001	.0557	.0233
arviculoides/serrensis#	19	.0495	.9464	.0564	.2091	.0886
cursor/lasiurus	45	.0001	.0001	.0001	.0001	.0001
cursor/nigrita	57	.0001	.0001	.0001	.0001	.0165
cursor/reinhardti	30	.0001	.0001	.0001	.0001	.0124
cursor/serensis	28	.2110	.8653	.0056	.6226	.1480
cursor/cursor#	54	.1617	.6645	.0829	.4139	.0360
cursor/arviculoides#	38	.5231	.0641	.2569	.3127	.0188
cursor/serrensis#	35	.0150	.7359	.4380	.6222	.0742
lasiuris/nigrita	57	.0001	.0001	.0001	.0001	.1011
lasiurus/reinhardti	30	.0001	.0004	.0001	.0004	.0001
lasiurus/serrensis	28	.0629	.0001	.0002	.0001	.0003
lasiurus/cursor#	54	.0001	.0001	.0001	.0001	.0001
lasiurus/arviculoides#	57	.0001	.0001	.0001	.0001	.0001
lasiurus/serrensis#	35	.0001	.0001	.0001	.0001	.0001
nigrita/reinhardti	42	.4645	.0001	.9791	.0016	.0999
nigrita/serrensis	40	.0001	.0001	.0001	.0001	.0001
nigrita/cursor#	66	.0001	.0001	.0001	.0001	.0001
nigrita/arviculoides#	40	.0001	.0001	.0001	.0001	.0001
nigrita/serrensis#	47	.0001	.0001	.0001	.0001	.0001
reinhardti/serrensis	13	.0001	.0001	.0001	.0001	.0001
reinhardti/cursor#	39	.0001	.0001	.0001	.0001	.0001
reinhardti/arviculoides#	14	.0004	.0001	.0001	.0024	.0001
reinhardti/serrensis#	20	.0001	.0001	.0001	.0001	.0001

TABLE 6 (Continued)

		Character				
Species pairs (# Caparaó species)	DF	Total	Tail	Hind Foot	Ear	Tail/Total
serrensis/cursor#	37	.4112	.8854	.0026	.1466	.3577
serrensis/arviculoides#	41	.0453	.1086	.0001	.1310	.8431
serrensis/serrensis#	18	.2051	.4916	.0177	.2820	.4044
cursor#/arviculoides#	67	.0443	.0923	.0006	.6436	.5894
cursor#/serrensis#	44	.0039	.2792	.7030	.1000	.0589
arviculoides#/# serrensis	48	.0008	.0184	.0427	.8136	.2628

TABLE 7

CLASSIFICATION MATRIX FOR DISCRIMINANT ANALYSIS OF 12 *AKODON* SPECIES

Species (# Caparaó species)		Species											
		1	2	3	4	5	6	7	8	9	10	11	12
	%correct	Number classified into each species											
1-*arviculoides*	28.6	2	0	0	0	1	0	0	4	0	0	0	0
2-*cursor*	30.4	2	7	0	0	2	0	0	1	6	0	5	0
3-*(Z).lasiurus*	50.0	4	0	15	6	2	0	0	0	0	0	0	3
4-*(A).lasiurus*	65.2	0	0	7	15	0	0	1	0	0	0	0	0
5-*(B).lasiurus*	64.7	3	1	7	1	22	0	2	1	0	0	0	0
6-*nigrita*	65.7	0	0	0	0	0	23	6	0	0	0	0	6
7-*reinhardti*	75.0	0	0	0	1	0	1	6	0	0	0	0	0
8-*serrensis*	100.0	0	0	0	0	0	0	0	6	0	0	0	0
9-*cursor#*	42.9	0	3	0	0	1	0	0	1	6	3	0	0
10-*arviculoides#*	28.1	0	6	0	0	0	0	0	6	9	9	2	0
11-*serrensis#*	60.0	0	0	0	0	0	0	0	1	1	0	3	0
12-*nigrita#*	100.0	0	0	0	0	0	0	0	0	0	0	0	1

(Z) = *Zygodontomys*; (A) = *Akodon*; (B) = *Bolomys*

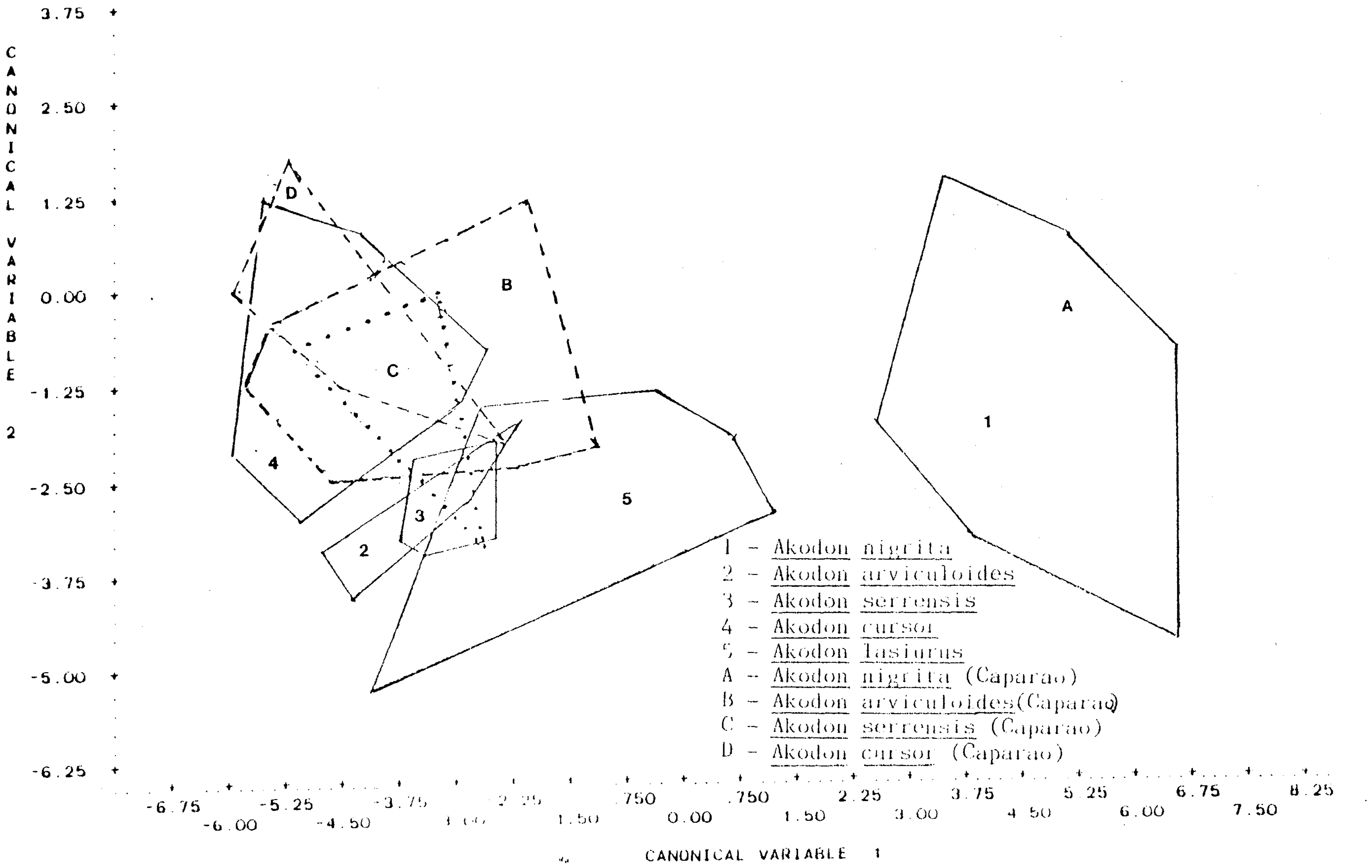

Figure 8. Discriminant function plot of 5 Akodon species.

The third Caparaó species was the most common and was tentatively identified as *arviculoides* in the field. It could not be identified with confidence using either F-tests or discriminant function. F-tests indicated that it was significantly different from both park *cursor* and park *serrensis* and in the field it could be differentiated by the darker pelage and bulkier form. This group did not fit well with any of the museum species although it was plainly an *Akodon*. For the purposes of this study, the third species will be referred to as *A*. *arviculoides*, the species with which it is most closely allied based on its range and mean measurements (Table 8). The fourth species, although represented by a single specimen, was identified as *Akodon*=(*Thaptomys*) *nigrita* both by inspection in the field and by discriminant function. This specimen was examined by Dr. F.D. de Avilia-Pires of the University Rural in Minas Gerais and he concurred on the genus but believed that this individual represented a new species.

Other Caparaó Genera. Most other genera in the park did not occur with the frequency of the preceeding two, and many have characteristics that permit easier identification of them to species (Table 9). However, the same techniques of ANOVA and discriminant function were used for these specimens as well, both to comfirm identifications and to test the methods used.

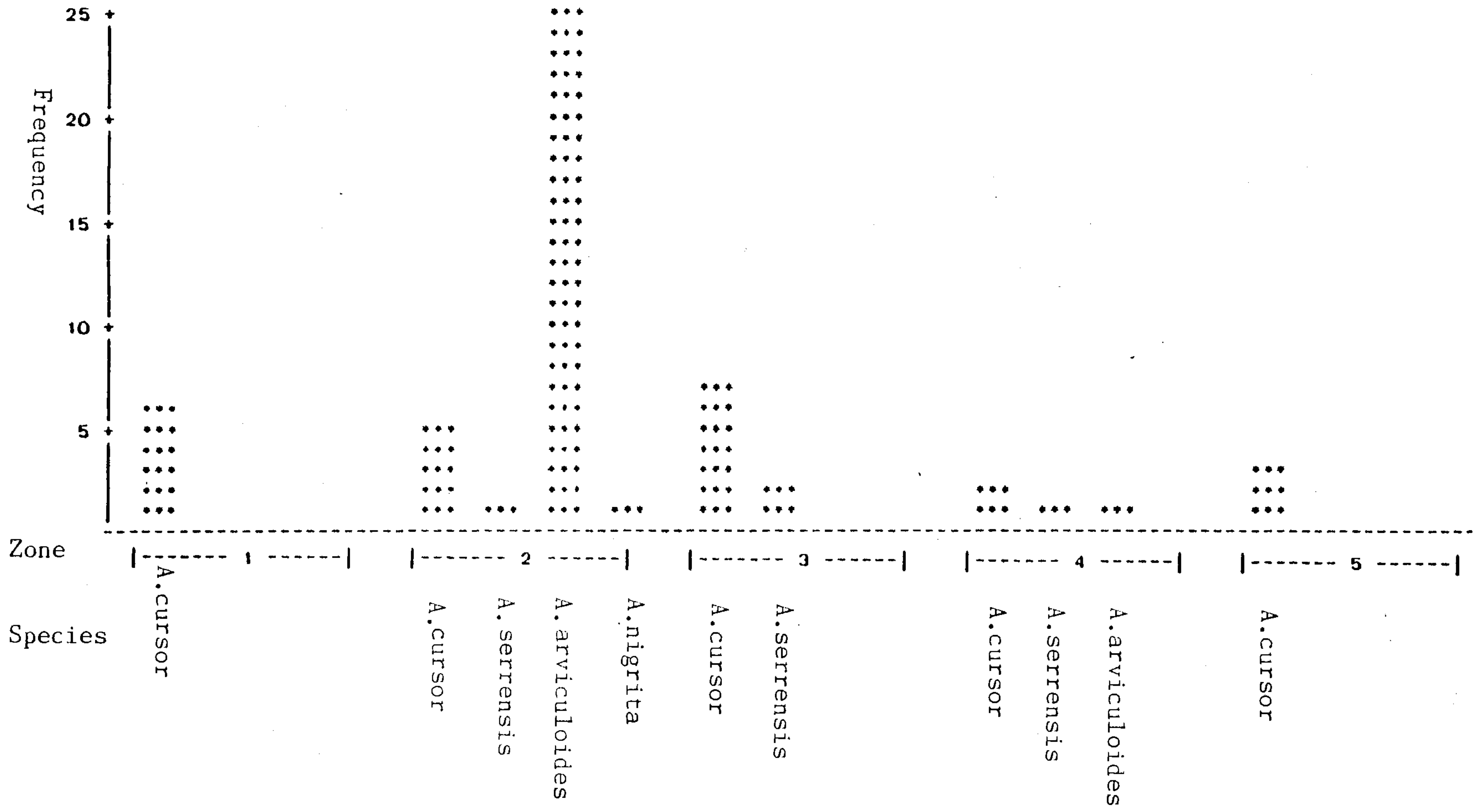

Figure 9: *<u>Akodon</u> species of Caparaó by habitat.*

TABLE 8

SOUTHEASTERN BRAZIL *AKODON* AND RELATED GENERA'S SPECIES CHARACTER MEANS AND RANGES IN MILLIMETERS

SPECIES	N	TOTAL LENGTH	TAIL	HFOOT	EAR	TAIL/TOTAL RATIO
Akodon arviculoides	7	193.1	78.7	22.7	18.4	.4049
		(170-208)	(50-93)	(22-25)	(17-20)	(.294-.448)
A.cursor	23	199.8	84.3	25.3	18.2	.4194
		(132-233)	(50-105)	(21-30)	(16-20)	(.294-.489)
A.serrensis	6	186.8	82.1	22.1	18.1	.4395
		(165-201)	(74-91)	(21-23)	(17-19)	(.420-.454)
A.lasiurus	23	172.6	63.0	20.5	15.8	.3658
		(128-200)	(43-75)	(19-22)	(15-17)	(.236-.453)
Bolomys lasiurus	52	175.4	64.5	21.2	15.3	.3657
		(138-212)	(33-91)	(18-23)	(12-20)	(.246-.423)
Zygodontomys lasiurus	30	178.2	67.3	21.1	15.7	.3757
		(140-208)	(32-82)	(20-24)	(10-20)	(.228-.428)
Thaptomys nigrita	35	132.1	45.3	17.4	11.4	.3472
		(080-155)	(40-51)	(12-20)	(09-13)	(.305-.500)
Thaptomys nigrita#	1	134.0	43.0	18.0	10.0	.3208
		(-)	(-)	(-)	(-)	(-)
"*Thalpomys reinhardti*"*	8	136.3	50.6	17.5	13.2	.3725
		(116-161)	(45-57)	(16-20)	(12018)	(.354-.409)
Akodon arviculoides#	36	191.0	82.6	24.2	17.5	.4336
		(174-209)	(74-99)	(21-26)	(16-19)	(.404-.462)
A.cursor#	32	201.3	88.3	26.2	17.3	.4384
		(164-224)	(65-99)	(22-29)	(14-19)	(.396-.464)
A.serrensis#	13	176.3	79.1	24.5	17.5	.4643
		(157-189)	(71-87)	(21-26)	(16-19)	(.452-.473)

#from Caparaó;
* from University of Oklahoma - I.D. was tentative

TABLE 9

CRICETIDAE OTHER THAN AKODON AND ORYZOMYS CHARACTERS MEANS AND RANGES IN MILLIMETERS

SPECIES (# from Caparaó)	N	TOTAL LENGTH	TAIL	HFOOT	EAR	TAIL/TOTAL RATIO
Blarinomys	2	150.0	50.5	19.5	11.0	.3365
breviceps#		(149-151)	(50-51)	(19-20)	(11-11)	(.331-.342)
Blarinomys	-	147.2	42.5	18.3	9.7	.2774
breviceps**		(129-161)	(30-52)	(16-21)	(8-10)	(.232-.322)
Bibimys	3	162.0	71.5	-	-	.4405
torresi*		(149-175)	(65-78)			(.436-.445)
Calomys	61	151.7	66.9	17.6	14.3	.4398
callosus		(105-215)	(30-87)	(14-23)	(10-17)	(.285-.486)
Calomys	1	138.0	67.0	16.0	14.0	.4850
laucha		-	-	-	-	-
Calomys	13	140.8	62.2	16.58	14.0	.4331
tener		(130-154)	(55-69)	(15-20)	(13-16)	(.369-.468)
Nectomys	2	387.0	196.5	51.0	22.5	.5010
squamipes#		(321-453)	(161-232)	(47-55)	(21-24)	(.501-.501)
Nectomys	17	419.0	215.5	50.6	23.5	.5138
squamipes		(216-484)	(110-252)	(34-58)	(16-25)	(.481-.534)
Oxymycterus	10	271.2	111.9	31.0	23.8	.4122
jubata		(250-295)	(100-120)	(28-40)	(23-25)	(.389-.433)
Oxymycterus	6	262.8	114.4	32.0	19.4	.4441
quaestor#		(149-301)	(68-130)	(24-35)	(15-21)	(.428-.460)
Oxymycterus	13	221.9	89.8	27.8	17.1	.4039
roberti		(196-248)	(76-110)	(26-30)	(16-20)	(.365-.478)
Phaenomys	-	240.0	190.0	-	"small"	.4541
ferrugineus*		-	-	-	-	-
Rhagomys	-	188.0	94.0	-	"short"	.5000
rufescens*		-	-	-	-	-
Rhipidomys	2	270.0	150.0	27.0	19.0	.5535
masticalis		(255-285)	(135-165)	(25-29)	(19-19)	(.529-.578)
Thomasomys	3	252.6	125.0	32.0	21.0	.4950
dorsalis#		(248-262)	(125-125)	(30-33)	(19-22)	(.477-.504)
Thomasomys	18	246.6	118.1	28.2	20.4	.4777
dorsalis		(234-270)	(104-135)	(25-30)	(16-23)	(.444-.521)
Thomasomys	2	309.5	185.5	29.5	22.0	.5990
oenax		(304-315)	(104-135)	(26-30)	(16-23)	(.444-.521)
Wiedomys	-	296.5	182.5	-	"large"	.6155
pyrrhorinos*		(260-333)	(160-205)	-	-	(.615-.615)
Unknown	5	207.0	108.2	14.8	10.6	.5222
specimens#		(199-218)	(103-115)	(14-16)	(10-12)	(.517-.527)

*Nowak and Paradiso (1983); ** Matson and Abravaya (1977)

Caparaó Nectomys. One species of *Nectomys* was found in the park and was identified as *N.squamipes* at that time. Discriminant function placed both of the park specimens in that species (Figure 10). No F-tests were run due to the small number of park specimens. This is a rather large mouse (or rat) with several distinguishing characteristics including glossy pelage, stiff fringe on the feet and close association with water. Both Caparao specimens were caught on stream banks and identified by the above characteristics.

Caparaó Thomasomys. Three specimens identified as *Thomasomys dorsalis* were caught in Caparao. The single reclassification in this group made by discriminant function placed that specimen with museum *T. dorsalis* and 2 of 9 museum specimens were reclassified as park *dorsalis* (Figure 10).

Caparaó Blarinomys. This is a very rare mouse confined to southeastern Brazil which no other Neotropical mammal resembles in appearance. It seems to be the ecological equivilent of the North American short tailed shrew - *Blarina brevicauda* which it strongly resembles and for which it was named. Two specimens were collected in Caparao from the rainforest zone.

Caparaó Oxymycterus. Specimens identified as *O. quaestor* (=*hispidus*) were found in the park. No *O. hispidus* from museums were available for comparisons but two other eastern Brazil species were available, *O. roberti* and *O.*

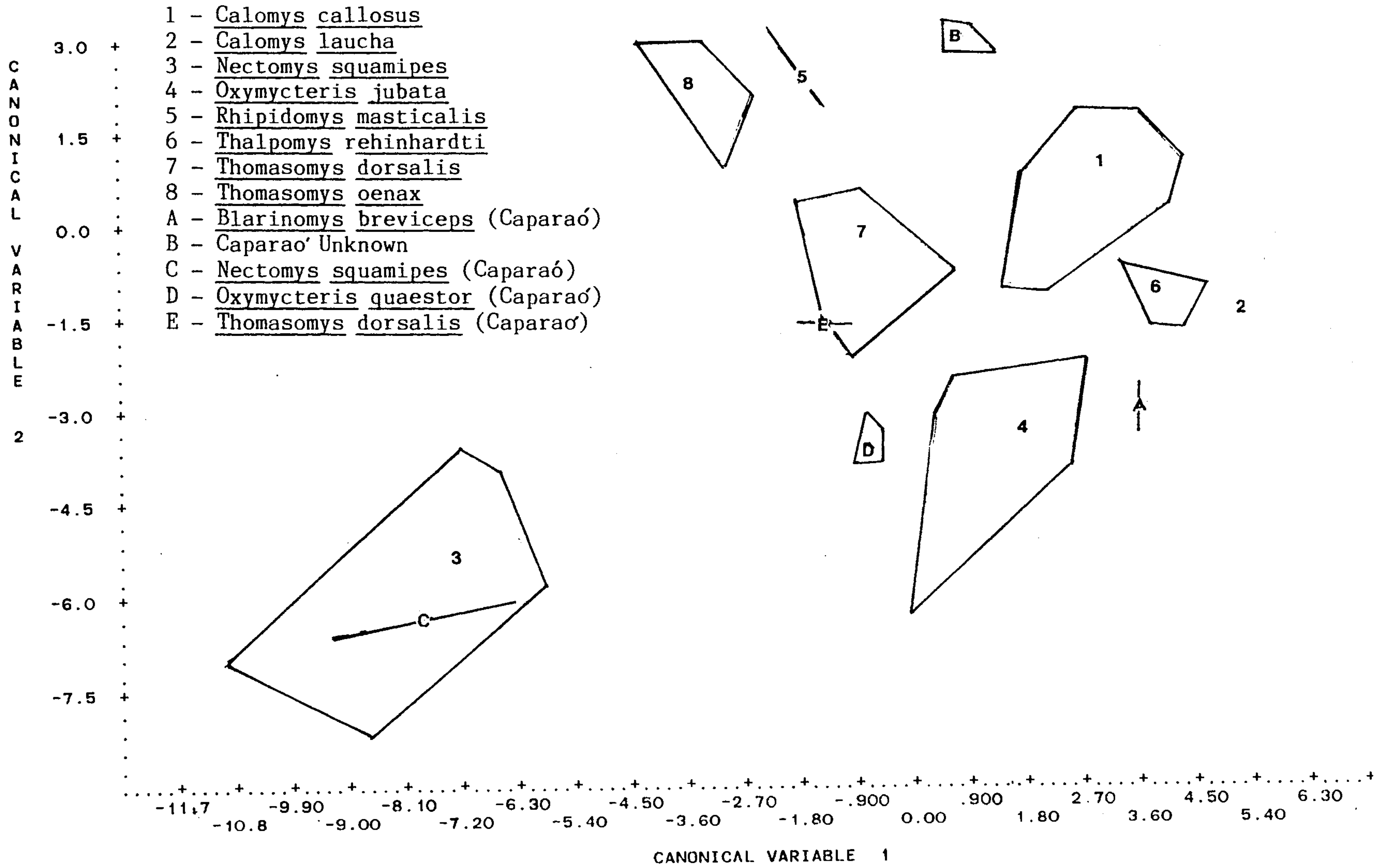

Figure 10: Discriminant function plot of S.E.Brazil genera excluding Oryzomys and Akodon.

jubata and comparisons were made with these two species to insure against misidentification and to give a genus target area for discriminant function analysis. The latter indicated the park specimens did not belong to either roberti or jubata although they did clearly fall into the Oxymycterus genus (Figure 10). No F-tests could be run due to the small number of park specimens.

Caparaó Unknown Species. One Caparaó species represented by 5 specimens was morphologically quite distinct from any other S.E. Brazil species or even genus for which comparative museum or published data were available (Figures 5 and 10). According to discriminant function analysis, this group was 100% isolated with no individuals reclassified into or out of it. Externally, they generally resemble the other montane genera of South America, Calomys, Thomasomys, Phaenomys, Rhagomys, Bibimys (=Scapteromys) and Rhipidomys with dense, soft fur, relatively small ears, tails and hind feet. The Caparao group was distinctive, however, due to the combined features of short ears almost hidden in the dense, dark rufus-chestnut fur and a tail somewhat longer than the head and body. Furthermore, they lack other key features that distinguish several of the above genera, such as distinctive nose markings or skull features. The availability of specimens allowed statistical comparison between the Caparaó group and 3 genera that have been recorded in or near the genera are the three externally most similar to the Caparaó mice. F-tests found the Caparaó group significantly different in all five external measurements from both *Calomys callosus* and *C. tener*. No F-tests could be made with *C. laucha* as only one specimen of the latter was available, but the Caparaó specimens were all considerably larger. Both *Thomosomys dorsalis* and *T. oenax* were significantly different in all external parameters from the Caparaó specimens ($P>.05$). *Rhipidomys masticalis* was represented by only 2 specimens so no F-tests could be run but still the external measurements for this species are all well beyond those for the Caparaó unknown, particularly the ear and hindfoot length. *Phaenomys ferrugineus* resembles the unknown in coloration but the total length is about 30 mm longer, the tail about 80 mm longer and *Phaenomys* (though very rare) is thought to be arboreal (Nowak and Paradiso 1983).

This unknown Caparaó species was ecologically distinctive as well. They were caught only in the high altitude grasslands at near 2500 m., were diurnally active, and found in runways made in the grass and along rocks. All in all, they resembled the North American pine vole *Pitymys* (=*Microtus*) *pinetorum* except for the longer tail and duller pelage. The high altitude habitat of the unknown most closely approaches those of some species of *Thomosomys* and *Calomys* and is quite unlike that of *Bibimys*, *Rhipidomys*, *Rhagomys*, *Phaenomys*. It is worth recalling that the Serra do Mar range has served as a refugium and speciation core for several of the above genera in the Thomasomini group as previously noted. Further data will be needed before the Caparao specimens can be confirmed as new species but present evidence strongly indicates this possibility.

Identification of species from raptor pellets was entirely done by inspecting the remains of skulls. These were compared to skulls of those species captured in the park and identifications made accordingly. Species for which no specimen had been captured that matched or which lacked some distinctive skull character which allowed recognition are noted as "unidentified". Where possible, the group was assigned at least to genus. For example, <u>Marmosa</u> species 3 is the same taxon whether found in raptor pellets or captured but it was unidentifiable to species in either case. Number of individuals is based on either the largest number of skulls or number of jaws from the same side of the body.

<u>Large Mammals</u>

Most observations on transect lines were of taxa with few species in southeastern Brazil; consequently, identifications were seldom difficult, with only occasional problems at the species level within carnivores and xenarthrans.

Within the Xenarthra, burrows were the most common sign and *Euphractus* and *Dasypus* the most common genera. These were distinguished by differences in burrow dimensions, with *Euphractus* constructing a burrow generally wider than high and *Dasypus* digging holes either circular or somewhat higher than wide. It was not possible to tell juvenile *Dasypus novemcinctus* from adult *Dasypus septemcinctus* burrows and both species were hand-captured in the park. Also, a sub-adult *Cabassous tatouay* was captured in the park and the burrow it constructed was similar in appearance to that of adult *Euphractus septemcinctus* in the park and would have been difficult to differentiate. Burrows dug by adults of these two species would have been distinguishable by size, however, as *Cabassous tatouay* is a much larger animal when grown. This technique of species specific burrow identification was also used by Carter and Encarnacao (1983).

Among carnivores, the hoary fox (*Lycalopex vetulus*), brush fox (*Pseudolopex gymnocercus*) and crab-eating fox (*Cerdocyon thous*) could not be differentiated by tracks or in the 186 canid scats collected, although their tracks and scats could be differentiated from those of domestic dogs. They also could not be distinguished in the occasional sighting. Since all three species were likely to be present and as domestic dogs were not considered in the analysis, the general term 'canid' is used throughout to indicate the fox group. Domestic dogs were shot on sight in the park and were seldom noted on transects.

With the exception of margays and little-spotted-cats the tracks of the Felidae could be distinguished based on relative size and conformation, as could 87% of the 151 feloid scats. The greatest difficulty was the overlap in size between juvenile ocelots and adult margay or little-spotted-cats although it was unlikely that an ocelot kitten of comparable size to those other species would be unaccompanied by its mother. Twice on transects tracks in the size range for one of the two smaller cats were noted beside those of an adult ocelot. Margays and little-spotted-cats have different niches and it would be unlikely to find the arboreally-adapted margay in the treeless, high elevation zones. Still, there was no sure way to distinguish the tracks or scats of the two small cats to establish documented differential habitat use with certainty; or was it possible to establish the relative frequencies of the two species in the habitats where both might occur. No domestic cat sign were observed on transects although their tracks were distinguishable from those of the other felids.

It was also not possible to tell which species of Tayassuidae were present based on scats or tracks and there were no visual confirmations.

Pearson correlations were used to determine if there were overall relationships between transect results and several variables that may have had influence on those transect data. Habitat zones were ranked according to their relative sizes and proportion of the total park area since actual acreages were not known. The 5 zones were ranked as follows, from smallest to largest: sub-alpine, abandoned agriculture, transition, rainforest and scrub-grass. The total number of sign in a habitat was correlated with the relative amount of that habitat in the park (r-square = .5939; P>.0633) but the frequency of sign per kilometer of transect in each habitat was not correlated with area (r-square = .0231; P>.3999). The number of species found on transects in each habitat was, at best, only weakly correlated with overall habitat area (r = .3806; P>.1336).

Linear regression tests were run in order to see if there were predictive relationships between the variables of number of species found, number of total sign found, the habitat zone, the number of kilometers of transect in each zone and the frequencies with which sign were found with the following results. The number of species found per habitat was positively correlated with the total number of sign found per habitat (r-square = .8587; P>.0109) but not with the frequency with which sign were found (r-square = .0593; P> .3456). The number of species in each habitat was correlated with the number of kilometers of transect run in each habitat (r-square = .7917; P> .0208) but the frequencies with which sign were found was not (r-square = .4162; P> .1104).

Community Ecology

Small Mammals - Trapping Data

Three species were detected both on transects and captured in traps: Didelphis marsupialis, Metachirops opossum and Cavia aperea and they appear in both analyses as there is presently no index to transform sign transect data into estimates of actual numbers of individuals as can be done using pellet counts for estimatimating deer populations in North America (Caughley 1977). These neotròpical species are simply not that well known.

A tòtal of 18 small mammal species were trapped in Caparaó (Table 10), 8 in agriculture, 14 in rainforest, 9 in transition, 6 in the scrub-grass and 3 in the alpine campo limpo zone. According to a Chi-square goodness-of-fit test (assuming all zones should have the same number of species) only the rainforest and the scrub-grass species richness and the rainforest and campo limpo species richness were significantly (P>.05) different from each other (chi-square values = 4.571 and 8.642 respectively, DF=1). Two species of small mammal were endemic to the rainforest zone (Blarinomys breviceps and Thaptomys nigrita) while the small, red

TABLE 10

TRAPPING RESULTS OF SMALL MAMMAL SPECIES BY HABITAT (EXCLUDING RECAPTURES).

SPECIES	HABITAT**									
	1		2		3		4		5	
	#	%	#	%	#	%	#	%	#	%
MARSUPIALIA										
Didelphis										
marsupialis	3	.17	5	.15	1	.57	0	0	0	0
Metachirops										
opossum	12	.69	14	.43	1	.57	2	.29	0	0
Marmosa										
cinerea	1	.05	0	0	0	0	0	0	0	0
murina	0	0	5	.15	2	.06	0	0	0	0
sp.3	2	.11	0	0	0	0	0	0	0	0
RODENTIA										
Echimys										
medius	1	.05	0	0	0	0	0	0	0	0
Cavia										
aperea	0	0	1	.03	0	0	0	0	0	0
Akodon										
cursor	0	0	16	.50	3	1.71	1	.14	0	0
serrensis	2	.11	3	.09	0	0	0	0	0	0
arviculoides	7	.40	21	.65	9	5.24	4	.60	3	.23
Blarinomys										
breviceps	0	0	2	.09	0	0	0	0	0	0
Nectomys										
squamipes	0	0	1	.03	0	0	1	.14	0	0
Oryzomys										
capito	0	0	8	.25	3	1.71	11	1.64	13	1.02
flavescens	3	.17	21	.65	1	.57	0	0	0	0

TABLE 10 (Continued)

SPECIES	HABITAT**									
	1		2		3		4		5	
	#	%	#	%	#	%	#	%	#	%
Oxymycterus hispidus	2	.11	4	.12	1	.57	0	0	0	0
Thaptomys nigrita	0	0	1	.03	0	0	0	0	0	0
Thomasomys dorsalis	0	0	1	.03	2	.28	1	.14	0	0
Unknown species	0	0	0	0	0	0	0	0	5	.39
TOTAL N	26		82		14		16		18	
TOTAL SPECIES	9		14		9		6		3	

** 1=Agriculture; 2=Forest; 3=Transition; 4=Scrub; 5=Alpine
# = number captured in zone; %= frequency per 100 trapnights

unidentifiable mouse was endemic to the campo limpo. A Mann-Whitney analysis was carried out on species ranked from rarest to most common based on capture frequency per 100 traps. Recaptures were excluded. The zone with the lowest average rank (R) or more rare species, was the forest (R = 15.7), followed by agriculture (R = 16.1), scrub-grass (R = 23.3), campo limpo (R = 27.6) and transition (R = 30.1). This value can be used as a rarity index for a habitat (Usher 1986). Species not present in a zone were given no score. The Mann-Whitney test demonstrated significant differences in the ranks between most zones at the .05 level indicating there were differences between the frequencies with which species occurred (Table 11).

Large Mammals - Transect Data

Transects were run for visual and auditory sign in the form of scats, tracks, sightings and calls and, as would be expected, species varied in the frequency with which they occurred in different habitat zones (Table 12). Because frequency of detectable sign depends not only on actual population size but also life history strategies (e.g. armadillo burrows), species specific variations in territorial scent marking (e.g. most carnivores) or other factors (e.g. primate vocalizations) these data should not

TABLE 11

MANN-WHITNEY RESULTS FOR COMPARISONS OF HABITATS BASED ON SMALL MAMMAL SPECIES' RANKED FREQUENCIES FROM TRAPPING DATA

ZONE COMPARISON	*MANN-WHITNEY VALUE (Z) (adjusted for ties)*	*P>Z*
Agriculture X Rainforest	*.3164*	*.3753*
Agriculture X Transition	*2.4499*	*.0068*
Agriculture X Scrub-grass	*1.8975*	*.0273*
Agriculture X Alpine	*1.7753*	*.0361*
Rainforest X Transition	*2.7202*	*.0033*
Rainforest X Scrub-grass	*1.2447*	*.1055*
Rainforest X Alpine	*1.5231*	*.0618*
Transition X Scrub-grass	*1.1946*	*.1151*
Transition X Alpine	*.8485*	*.2030*
Scrub-grass X Alpine	*.7878*	*.2194*

TABLE 12

LARGE MAMMAL SPECIES' FREQUENCIES PER 100 KILOMETERS OF TRANSECT BY HABITAT

SPECIES	HABITAT*				
	1	2	3	4	5
MARSUPIALIA					
Didelphis marsupialis	4.6	.7	.5	-	-
Metachirops opossum	7.6	.5	.5	-	-
XENARTHRA					
Cabassous tatouay	.3	.2	-	-	-
Dasypus novemcinctus	11.6	5.3	.5	1.8	-
Dasypus septemcinctus	.9	.2	-	-	-
Euphractus sexcinctus	3.3	.2	-	-	-
Myrmecophaga tridactyla	-	-	.2	1.8	1.4
PRIMATA					
Calicebus moloch	-	9.6	-	-	-
Cebus apella	-	6.0	-	-	-
LAGOMORPHA					
Sylvilagus brasiliensis	1.9	.7	1.5	3.6	-
RODENTIA					
Cavia aperea	3.3	2.7	-	.9	-
Coendou prehensilis	-	2.5	-	-	-
Dasyprocta aguti	.3	1.2	-	-	-
Sciurus inhgrami	-	.7	-	-	-
CARNIVORA					
Canid (fox group)	22.5	15.9	5.8	16.5	17.1
Chrysocyon brachyurus	.9	.2	.2	-	1.4
Felis concolor	-	-	.2	.9	-
Felis yagouaroundi	15.6	12.9	5.0	13.7	8.5
Felis pardalis	.9	3.0	1.0	8.2	8.5
Felis wiedii/tigrinus	9.6	10.2	3.9	16.5	17.1

TABLE 12 (Continued)

SPECIES	HABITAT*				
	1	2	3	4	5
CARNIVORA (con't)					
Galictis vittata	5.3	-	.5	8.8	.6
Eira barbara	7.5	4.0	-	-	-
Nasua nasua	7.2	16.9	2.1	13.7	2.8
Procyon cancrivorus	1.6	.7	.2	-	-
ARTIODACTYLA					
Tayassuidae	-	-	1.3	4.5	-
TOTAL SIGN (772)	228	347	49	109	39
TOTAL SPECIES	18	21	15	12	7

*1=Agriculture; 2=Forest; 3=Transition; 4=Scrub; 5=Alpine be considered actual population estimates, but rather as rough indices of relative frequencies. A total of 772 observations resulted in 24 species being identified in the 5 Caparao habitats sampled. In terms of large mammals, the greatest number of species (S) was recorded in the forest zone (21) followed by agriculture (18), transition (15), scrub-grass (12), and campo limpo (7). Although the rainforest had more species than the other zones, this difference was not statistically significant ($P > .05$) using Chi-square goodness-of-fit analysis except between the forest and scrub-grass and the forest and campo limpo (chi-squares = 3.857 and 9.333, respectively, DF=1). The latter in each case had fewer species. The difference of even a single species can be bioloically significant however and the rainforest not only sustained far more species of large mammals, but also had 4 species (the two monkeys, the porcupine and the squirrel) that were were endemic.

Species frequencies of occurrance were expressed per 100 km of transect to compensate for unequal effort between zones. Sign were recorded with the greatest frequency in the scrub-grass (101.2/100km) followed by the forest (93.1/100km) agriculture (90.6/100km) transition (64.8/100km) and alpine (57.1/100km).

Five species or species groups were found in all zones. These were Canid (fox group)*, _Felis yagouaroundi_, _Felis wiedii/tigrinus_, _Nasua nasua_, and _Felis pardalis_. Not surprisingly, the fox (or foxes) were the most frequently encountered sign overall, averaging one track, scat or sighting every .14km. The next most common species were, in descending order, the small spotted cat (or cats), the yagouaroundi and nine-banded armadillo. The rarest signs were those of the naked-tailed and seven-banded armadillos. When species were ranked from rarest to most common (based on sign frequency), the zone with the lowest average rank (R) or more uncommon species, was the forest (R = 20.2), followed by agriculture (R = 32.1), scrub-grass (R = 38.3), campo limpo (R = 46.4) and transition (R = 48.5). Absent species were not scored. The Mann-Whitney test demonstrated significant differences in the ranks between most zones at the .05 level indicating there were differences between the frequencies per kilometer with which species' sign occurred (Table 13).

Chiroptera - Mistnets

Nine species of bats were caught in 3 ecological zones: agriculture, rainforest and transition (Table 14). Although nets were placed in the scrub-grass zone, no bats were captured. No nets were placed in the Alpine zone. In addition, one cave was occupied by a colony of vampire bats (Desmodus rotundus), a rock-slab roost had Glossophaga soricina and a cave with a spring was used casually by Glossophaga, Vampyrops, Desmodus and 2 species of unidentified bats (possibly Myotis and Phyllostomus). These

TABLE 13

MANN-WHITNEY RESULTS FOR COMPARISONS OF TRANSECT DATA BETWEEN HABITAT ZONES

ZONE COMPARISON	MANN-WHITNEY VALUE (Z) (adjusted for ties)	P>Z
Agriculture X Rainforest	2.3607	.0055
Agriculture X Transition	2.3230	.0095
Agriculture X Scrub-grass	1.1606	.1221
Agriculture X Alpine	1.8708	.0290
Rainforest X Transition	3.5113	.0004
Rainforest X Scrub-grass	2.7511	.0030
Rainforest X Alpine	2.6797	.0037
Transition X Scrub-grass	1.4221	.0756
Transition X Alpine	.3928	.3485
Scrub-grass X Alpine	1.2677	.1010

TABLE 14

BATS CAPTURED BY HABITAT ZONE

SPECIES	HABITAT 1	2	3	4	5
Glossophaga soricina	3	18	0	0	-
Desmodus rotundus	28	5	3	0	-
Carollia perspicillata	1	2	2	0	-
Vampyrops lineatus	1	6	1	0	-
Phyllostomus hastatus	0	1	0	0	-
Sturnira sp.	2	1	0	0	-
Vampyressa pusilla	0	3	0	0	-
Uroderma bilobatum	0	1	0	0	-
Histiotus velatus	2	0	0	0	-
TOTAL N	37	37	6	0	-
TOTAL S	6	8	3	0	-

1-Agriculture; 2=Forest; 3=Transition; 4=Scrub-grass; 5=Alpine (no nets set) unidentified bats (possibly *Myotis* and *Phyllostomus*). These areas were regularly monitored for population size and evidence of reproduction. Captured bats were also checked for reproductive status by the size and location of testis and whether or not lactating. One female *Phyllostomus* carrying one young was caught and released in the spring cave in December and 2 lactating *Sturnira* were captured in nets that month. Three lactating *Desmodus* were captured in May. No juveniles were seen in the vampire cave or the *Glossophaga* roost. Numbers in both the vampire cave and the *Glossophaga* roost seemed fairly stable, the *Desmodus* population at 25-30 individuals and the *Glossophaga* population drifting between a high of 15 to a low of 10. There appeared to be more of the latter species (12-15) during the wet season and fewer (10-12) during the dry but it was not statistically significant (Figure 11).

Overall Community Parameters

A minimum of 53 species were documented in Caparaó using data from all census techniques: transects, trapping, mistnets, and raptor pellets. This is expressed as a 'minimum' value since although more than one fox or small spotted cat may have been (and probably was) present, there sometimes was no way to differentiate species, so a composite unit had to be used. Community ecology parameters largely

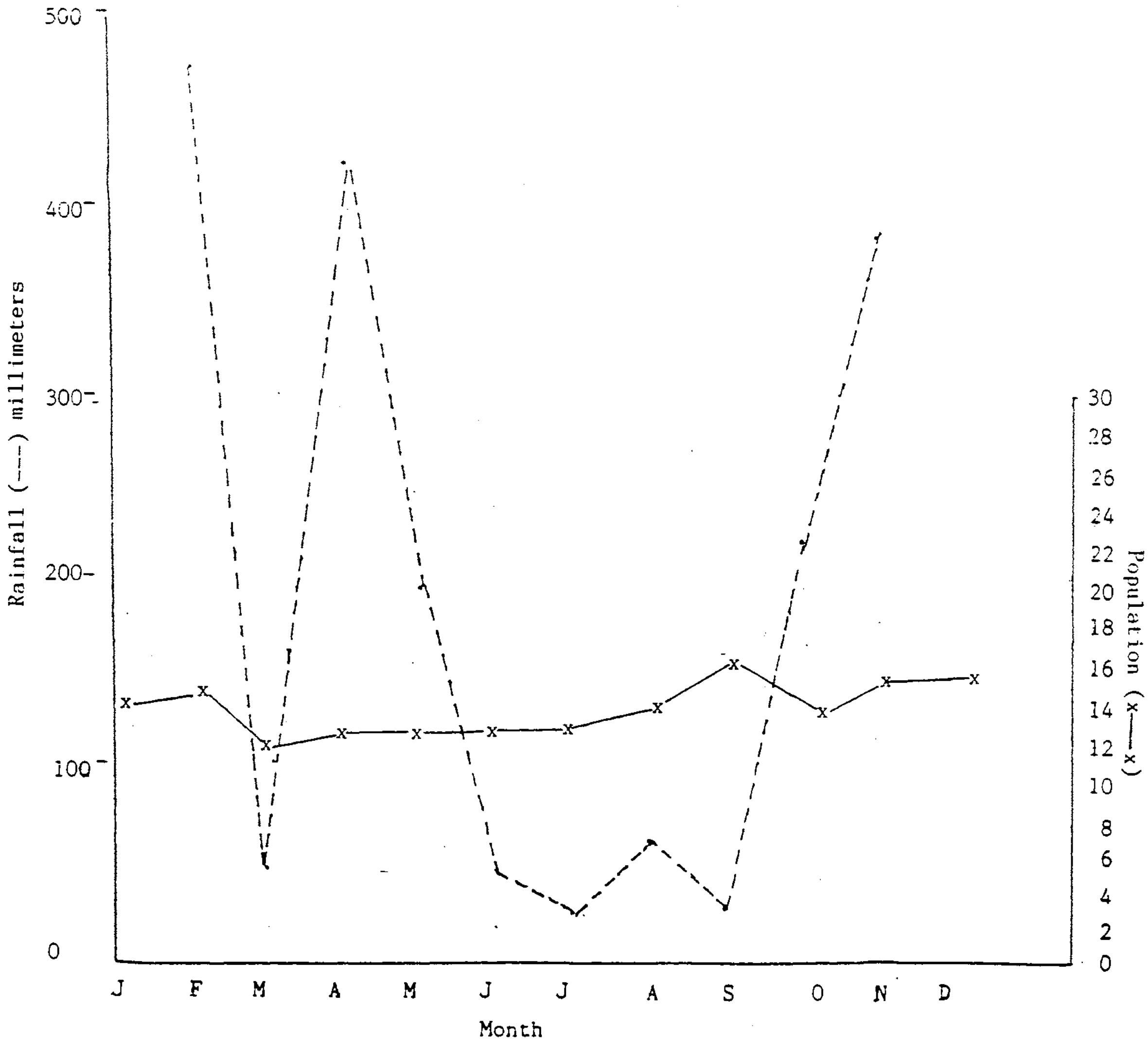

Figure 11: Monthly Glossophaga population from rock-slab roost in Vale Verde.

TABLE 15

COMMUNITY PARAMETERS FOR CAPARAÓ HABITAT ZONES

	PARAMETER						
HABITAT	S	H'	J'	$\bar{d}$	E	D	R
1-AGRICULTURE							
Small Mammals	9	0.7939	.8312	4.9473	3	11.92	16.1
Large Mammals	16	0.7450	.6187	5.9569	0	15.32	32.1
Mistnets	6	0.3992	.5128	3.1883	1	-	8.8
Overall	29	1.0453	.7145	11.3644	1	12.70	19.0
FOREST/PASTURE							
Raptor pellets	23	0.8763	.6434	8.6819	-	-	-
2-RAINFOREST							
Small Mammals	14	0.9420	.8218	6.2532	2	28.26	15.7
Large Mammals	21	0.9885	.7593	7.4794	4	5.71	20.2
Mistnets	9	0.6798	.7519	5.1013	2	-	9.5
Overall	39	1.2793	.8038	14.2353	8	10.72	15.1
3-TRANSITION							
Small Mammals	9	0.8057	.8438	6.1076	0	81.27	30.1
Large Mammals	9	0.9621	.8179	5.3098	0	64.51	48.5
Mistnets	3	0.6090	1.2766	3.8551	0	-	8.0
Overall	25	1.0188	.7282	13.2875	0	68.08	28.8
4-SCRUB-GRASS							
Small Mammals	6	.5768	.7403	3.3219	0	27.03	23.3
Large Mammals	13	.7914	.7100	5.3990	0	33.78	38.3
Mistnets	0	0	0	0	-	-	-
Overall	17	.9958	.8086	7.7643	0	21.96	30.8
5-ALPINE							
Small Mammals	3	.3987	.8343	.7966	1	28.41	27.6
Large Mammals	7	.7901	.9348	3.7712	0	25.82	46.4
Mistnets	-	-	-	-	-	-	-
Overall	10	.8133	.8133	5.5448	1	26.67	37.0

TOTAL SPECIES 53

when this zone was disturbed whether artificially (agriculture) or altitudinally (Table 15). The same pattern was seen in diversity whether expressed by H' or $\bar{d}$. Endemism was highest in the rainforest and the campo limpo of mountain tops.

Dominance was calculated for all trophic levels and all habitats where pairs of species with similar niches were present. Within trophic levels, pairs that were the most common within that trophic level were selected as well as most closely related both ecologically an taxonomically. Dominance was calculated for all these pairs separately and then a mean for each habitat was generated (Table 16). Dominance was lowest in the rainforest zone which is consistant with it being the most stable and successionally advanced. It is of interest to note that the zone next lowest in dominance was the agricultural zone which was undergoing secondary sucession. The zone showing the greatest dominance, or greatest disparity between trophically similar species, was the transition.

The rarity index (R) was calculated for each survey technique and for each habitat (Table 15). Results were consistant with the other community parameters in indicating that the rainforest had more rare species (a low R value) than the other habitat. This parameter reflects the classic discription of rainforest ecology - 'many species but few individuals of each'. Areas of abandoned agriculture had the

TABLE 16

DOMINANCE FOR VARIOUS SPECIES ACROSS HABITATS

SPECIES PAIRS	HABITAT				
	1	2	3	4	5
Metachirops X Didelphis (trapping data)	13.63	11.12	28.53	-	-
Metachirops X Didelphis (transect data)	8.66	.97	-	-	-
Akodon cursor X Akodon arviculoides	-	28.26	127.56	11.31	-
Oryzomys capito X Oryzomys flavescens	-	-	16.25	42.75	-
Akodon arviculoides X Oryzomys flavescens	11.92	-	-	-	-
Akodon arviculoides X Oryzomys capito	-	28.26	100.00	-	-
Oryzomys capito X Unknown red mouse	-	-	-	-	28.41
Dasypus novemcinctus X Euphractus	14.77	3.31	-	-	-
Cavia X Sylvilagus	-	3.23	-	-	-
F.yagaroundi X F.wiedii/tigrinus	14.97	9.21	100.50	13.26	22.99
Nasua X Procyon	4.95	8.79	-	-	-
Canid X F.pardalis	-	3.38	-	20.52	28.65
Canid X F.wiedii/tiginus	34.99	-	-	-	-
MEAN D	12.70	10.72	68.08	21.96	26.68

next lowest R value with the alpine zone showing relatively high frequencies of occurrance for those species present.

Seasonal Effects

Large Mammals - Transect Data.

F-tests were run to test for statistically significant differences between zones and seasons and for interactions using transect data since that was the largest data set taken in the study in which the two variables of season and zone were not confounded. Pooling all species, no significant differences in the frequencies of sign were found between zones ($F = 2.04$, $P>F=.1030$, $DF = 4$) or between seasons ($F = 1.91$, $P>F=.1398$, $DF = 3$) but there was a significant interaction of seasons within zones ($P>F=.0074$, $F =2.59$, $DF = 18$). These results were interpreted carefully, however, since even though one may statistically "pool" mice and foxes and come up with a net change of zero for a season or a habitat, very significant and important changes were occurring within species across zones and seasons, and it is these changes in species that define communities and help understand the processes which shape and maintain them.

Nine species of mammals were consistently detected on transects across enough seasons and habitats to be able to test for changing habitat use with season (Table 17). Chi-square were used to determine statistically significant

(P>.05) changes in the frequencies with which sign appeared on transects for each season.

Furthermore, it was noted that several species not only changed in frequency between seasons and zone but also changed frequencies within each zone according to season, possibly indicating differential seasonal habitat use or reproduction (Table 18). Species by species intensive mark-recapture or telemetry studies would be needed to confirm this hypothesis, but F-tests indicated that statistically significant interactions were present in several species and chi-square analysis indicated significant differences between seasons within species.

Among the armadillos, both Euphractus and Dasypus preferred areas of abandoned agriculture but the former was more common there. Dasypus was in more habitats overall, however, most notably extending up into the transition and scrub-grass habitats. F-tests indicated no significant interaction between zones and seasons overall ($F = .1723$, $P>.9975$, $DF = 18$) although chi-square did show significant differences between specific seasons across zones for this species and for Euphractus as well (Table 18).

Two small herbivores with similar niches, Cavia and Sylvilagus showed distinctive and different patterns. Cavies invaded abandoned agriculture more than did rabbits (Table 17). The former were significantly more common in the wet and dry seasons proper as opposed to the transitional periods, whereas rabbits peaked sharply in the

TABLE 17

FREQUENCIES PER 100 KM OF TRANSECT FOR NINE LARGE MAMMALS BY HABITAT AND SEASON

SPECIES	HABITAT					
SEASON	1	2	3	4	5	MEAN
Euphractus septemcinctus						
W	.07	.11	0	0	0	.09
WD	.10	0	0	0	0	.10
D	.07	0	0	0	0	.07
DW	.09	0	0	0	0	.09
Dasypus novemcinctus						
W	.31	0	0	.14	0	.22
WD	.20	.08	0	.02	0	.14
D	.07	.02	.02	.07	0	.30
DW	.06	.03	0	0	0	.02
Cavia aperea						
W	.10	.03	0	.26	0	.04
WD	.05	.17	0	.02	0	.06
D	.05	.01	0	0	0	.01
DW	.14	.05	0	0	0	.01
Sylvilagus brasiliensis						
W	0	0	0	0	0	0
WD	.39	.08	.2	.4	0	.24
D	0	.03	0	0	0	.03
DW	0	.02	0	0	0	.02
Canid (fox group)						
W	.28	.65	0	0	0	.24
WD	.24	.20	.08	.98	.40	.38
D	.20	.09	.10	.52	.21	.23
DW	.28	.55	0	0	0	.17
Felis yagouaroundi						
W	.06	.40	.0	.0	.0	.14
WD	.16	.12	.07	.50	.16	.20
D	.14	.14	.05	.09	.08	.10
DW	.13	.05	0	0	0	.03

TABLE 17 (Continued)

SPECIES SEASON	HABITAT 1	2	3	4	5	MEAN
<u>Felis pardalis</u>						
W	.01	.04	.05	0	0	.01
WD	0	.02	0	.20	.16	.08
D	0	.03	0	.10	.13	.05
DW	0	.03	0	.04	0	.01
<u>Felis wiedii/tigrinus</u>						
W	.04	.11	0	0	0	.04
WD	.01	.11	.03	.60	.41	.23
D	.06	.09	.06	.10	.17	.10
DW	.18	.04	0	0	0	.04
<u>Nasua nasua</u>						
W	0	1.58	0	0	0	1.58
WD	.02	.14	.02	.40	.05	.14
D	.02	1.22	0	0	.05	.13
DW	.01	.44	0	.02	.08	.16

W (Wet) - Dec, Jan, Feb;
WD (Wet to Dry transition) - Mar, Ap, May
D (Dry) - Jun, Jul, Aug
DW (Dry to Wet transition) - Sep, Oct, Nov

TABLE 18

CHI-SQUARE VALUES FOR SEASONAL CHANGES IN LARGE MAMMAL FREQUENCIES (DF = 1)

	SEASONS			
SPECIES	WXD	WD X D	D X DW	DW X W
Euphractus sexcinctus	.816	8.79**	.401	4.87*
Dasypus novemcinctus	4.68*	14.12**	.105	.033
Cavia aperea	27.24**	2.96	20.20**	19.25**
Sylvilagus brasiliensis	-	23.74**	.245	-
Canid (fox group)	2.74	7.36**	2.60	3.56
Felis yagouaroundi	1.22	10.33**	8.96**	7.87**
Felis pardalis	7.87**	2.20	16.17**	.069
Felis wiedii/tigrinus	17.56**	18.73**	6.14*	.775
Nasua nasua	141.18**	6.93**	19.73**	136.57**

W (Wet) - Dec, Jan, Feb;
WD (Wet to Dry transition) - Mar, Ap, May
D (Dry) - Jun, Jul, Aug
DW (Dry to Wet transition) - Sep, Oct, Nov

* significant at .05 level; ** significant at .01 level

wet to dry transition months (Table 18). F-tests indicated no significant zone by season interaction for rabbits ($F = .85$, $P > .6328$, $DF = 18$) but did for cavies ($F = 1.88$, $P > .0522$, $DF = 18$). Both of these species can reproduce often and it is likely that these peaks represent reproductive bouts and dispersal of young rather than established individuals changing home ranges and habitats.

In addition to being the most common sign present throughout the park and in all habitats, the fox (or fox species group) were the most often directly tracked moving between zones. Their absence from the higher elevations after the dry season and during the rains is interesting (Tables 17 and 18). F-tests indicated no statistically significant overall zone by season interaction however ($F = 1.40$, $P > .1885$, $DF = 18$).

Coatimundis are common throughout the park in general but are ephemeral in any specific location as troops appear to be transient over large territories. There appeared to be one major troop associated with each valley. At the higher elevations no consistant pattern was noted. Consequently, an overall pattern of habitat use is difficult to detect other than very high frequencies in the forest during the wet season (Table 17). F-tests indicated no significant season by zone interaction ($F = .29$, $P > .8800$, $DF = 18$) although chi-square analysis showed highly significant differences in the frequencies with which this species was found in different seasons (Table 18). In addition, juveniles were found accompanying adults during the wet/dry transition months and 4 sub-adults were caught unaccompanied by adults during the last weeks of July or the first week of August (mid to late dry season), 2 were in the scrub-grass and 2 in agriculture bordering forest. Remains of 2 more sub-adults were found on transects in October in the scrub-grass zone.

The cats, too, were found at higher elevations only during the dryer, cooler seasons (Table 17). Significant seasonal differences were seen (Table 18) and zone by season interactions were significant for jaguaroundi ($F = 2.15$, $P > .0250$, $DF = 18$) and for the small, spotted cat (or cats) ($F = 2.24$, $P > .0192$, $DF = 18$) but not for ocelots ($F = 1.42$, $P > .1813$, $DF = 18$).

Small Mammals - Trapping Data

Unfortunately, seasonal effects on trapping data were confounded with habitat as there was not enough time to do replicates of all zones in all seasons as was done for transect data and raptor pellet collection.

Raptor Pellets

Raptor pellets were collected from a site near the base of a large cliff inhabited by several different raptors including hawks, owls and caracaras (*Milvago chimachima*). These birds could have been hunting over either (or both) pastures and forests so there was no way the small mammal skulls collected to be subdivided by habitat. Consequently, these data were not used to generate habitat-specific species lists, diversities or other community parameters. They were useful, however, in contributing to an overall park species list and, most importantly, to check for yearly or seasonal changes in the small mammal populations (Table 19). Pellets were collected every 6 months, at the end of the rainy season (May) and at the end of the dry season (October). In the distribution of the 342 skulls indentified, no significant differences were found between years (Chi-square = .1053, P>F = .7456, DF = 1) but there was a difference between seasons (Chi-square = 23.6842, P>F = .0001, DF = 1).

The skulls of one species, Oryzomys capito, were found in large enough numbers (190 individuals) in raptor pellets to test for yearly and seasonal changes within this species. O.capito was found significantly (Chi-square = 6.82, P>F = .0090, DF = 1) more often from wet season captures than from dry and more often in 1979 than in 1980 (Chi-square = 18.94, P>F = 0001, DF = 1).

TABLE 19

SKULLS COLLECTED FROM RAPTOR PELLETS BY SEASON

SPECIES	END OF WET			END OF DRY		
	1979	1980	TOTAL	1979	1980	TOTAL
Marsupialia						
Marmosa murina	5	5	10	6	7	13
Marmosa cinera	2	2	4	3	1	4
Marmosa species 3	1	1	2	3	2	5
Marmosa species 4	0	3	3	0	0	0
Chiroptera						
Stenoderma sp.	0	0	0	1	0	1
Lagomorpha						
Sylvilagus brasiliensis	2	0	2	0	1	1
Rodentia						
Cavia aperea	1	2	3	0	0	0
Akodon serrensis	3	7	10	0	9	9
Akodon cursor	5	8	13	5	1	6
Akodon arviculoides	0	0	0	1	0	1
Oryzomys capito	75	38	113	50	27	77
Oryzomys flavescens	7	0	7	5	4	9
Oryzomys sp.3	2	0	2	0	3	3
Oryzomys sp.4	4	0	4	2	4	6
Oryzomys sp.5	1	0	1	2	3	5
Thomasomys dorsalis	6	3	9	0	0	0
Thomasomys sp.2	2	3	5	1	3	4
Thomasomys oenax	0	1	1	1	2	3
Oxymycterus hispidus	3	6	9	5	2	7
Cricetidae sp.1	2	0	2	0	4	4
Cricetidae sp.2	2	1	3	0	1	1
Cricetidae sp.3	0	3	3	3	0	3
Cricetidae sp.4	1	1	2	0	1	1
Cricetidae sp.5	1	0	1	0	3	3
TOTAL	123	93	216	45	81	126
WET/DRY		216			126	
1979/1980		168			174	

CHAPTER IV

DISCUSSION

Species Identification

General Taxonomic Comments

Species diversity would be expected to be high in the Serra do Caparaó for several reasons including 1) relict populations from cooler climatological cycles now trapped on the paramo and scrub-grass islands and relic Atlantic rainforest species trapped due to agriculture and other habitat alteration, 2) dispersal of paramo or rainforest species into these habitat islands and 3) local speciation events. The latter could result from drift or founder effect during one of the above circumstances, from lowland tropical species responding to new niche potential created by the presence of temperate-like habitat or from species packing produced by competition and niche subdivision during periods of habitat compression resulting from the climatic cycles. Any of the above could result in the formation or preservation of endemic sub-species or even species in these tropical mountain-islands. Adaptation and niche subdivision should be most apparent in the smaller forms, such as rodents, since their small size and low mobility make isolation relatively easy. In addition, their short generation time facilitates rapid changes in their gene pools. Larger species of mammals may also show the biogeographic and evolutionary effects of isolation on mountains however. They may be mobile over greater distances than small mammals but are subject to higher extinction rates when they do become isolated on islands, even inland islands, (Brown 1971) due at least in part to small population sizes and relatively low reproductive rates (Soule 1983). High rates of endemism in a variety of taxa due to speciation or vicariant distributions is seen throughout the Serra do Mar and its spur ranges as previously noted.

Correct identification of species presented a major difficulty in this study because it is of great importance to determine exactly which species are in which habitat in order to generate many community parameters. Field identification of many groups is difficult in the neotropics as accurate field guides do not yet exist. The Serra do Mar has been a speciation core several taxa, particularly in the family Callithrichidae and in the genera Proechimys and Thomasomys (Cerqueira 1982; Moojen 1948). In addition, niche expansion or alteration for adaptation to an island habitat with a definite cold season so unlike the surrounding typical, tropical lowlands could result not just in physical changes in a species but perhaps in reproductive and/or behavioral changes as well, characterisics not usually recognized in most taxonomic studies. These are particular problems in the neotropics where many species are known only from a few specimens in museums and many of the smaller forms quite probably remain undescribed (Pine 1973). Small rodents are the most difficult group to work with in many ecosystems for although they comprise the bulk of the mammal species, often they are the poorest known. Pine (1982:32) comments "Certain genera such as _Akodon_, _Oryzomys_, _Oxymycteris_, _Proechimys_, _Rhipidomys_, and _Thomasomys_ are in a state of what can only be termed taxonomic chaos". Most of these genera occur in Caparao and the Serra do Mar ranges have been (or are) major centers of speciation for the latter 4 genera. The insularization of the biota of these mountains which could promote differentiation had the potential to further compound the problem of accurate identification. Consequently, identifications made in the field were statistically tested by conparing them to external measurements of specimens from several museums to assure a reasonable match. Further, Dr. F.D. de Avila-Pires confirmed some of the species. Unfortunately, it has not been possible to bring the specimens to the U.S. for direct comparisons.

It is also not possible to obtain data from all nominal subgroups and species in order to test the ability of the five morphometric characters to discriminate among all taxa nor was that the goal of this study. Rather the analysis was intended to help confirm the field identifications of park specimens. External morphometric characters are not always definitive in taxonomy but in the field, when combined with pelage, they are often the only useful characters practical to use if the animals are not to be sacrificed. Standard external measurements are also commonly used in comparative studies to help determine species' relative adaptions to various niches (Nowak and Paradiso 1983, Myers and Carlton 1981). Species were selected from the genera which follow for comparison to specimens from Caparao based on 1) their having been recorded in or near the Serra do Mar, 2) having been recorded in habitats similar to those found in Caparao, 3) physical similarity to specimens taken during this study and 4) availablity in U.S. museums or from published data. Although a revision of these genera was not the intent of this study, still the analyses produced did generate some comparative data that may help distinguish the relative positions of some of the taxa.

Genus Oryzomys. In South America, rice rats (genus Oryzomys) are comparable in many ways to Peromyscus in North America. They are the most diverse, speciose and ubiquitous genus present on the continent. The genus is considered by Nowak and Paradiso (1983) to have at least 59 species with some form found in almost every habitat. Species range in size from a total length of about 160 mm to 450 mm and from 40 to 80 g. Their color ranges from greyish-brown to ochraceous or tawny mice with white or pale buff underparts. The pelage is rather coarse in many, but soft and fine in some. The tail is usually long, sparsely haired and shows annulations.

Nowak and Paradiso (1983) indicate 11 species in this genus ranging through central and eastern Brazil, Paraguay, Uruguay and northeastern Argentina, the areas through which the Serra do Mar runs, or which have habitats comparable to Caparaó. Honacki, Kinman and Koeppl (1982) cite 12 species in the same areas while Alho (1982) lists 14 in eastern and southern Brazil alone. Discrepancies in species lists are due to lack of sampling in some areas or to disagreement between various authorities as to the composition and correct names of several species in this genus. A total of 12 species were obtained for comparisons to the Caparaó groups (Tables 3, 4, and 5). The two species found in Caparaó, O. capito and O. flavescens clearly fall into the ranges of the species to which they were assigned and for which maximun statistical agreement was found based on F-tests and discriminant function analyses (Tables 3 and 4).

Genus Akodon. South American field mice and grass mice belong to the second most speciose and widely distributed genus of Neotropical rodents. The genus Akodon contains 41 species according to Nowak and Paradiso (1983). They are generally small, dark, stocky, vole-like mice wih the tail somewhat shorter than the head and body. The pelage is usually soft and dense ranging in color from grey to dark brown. Some are distinctly rufous. The belly fur is dusky white to grey, often with a fulvous tinge. Members of this genus occur in a wide variety of habitats and altitudes throughout South America.

The same procedures were applied to the genus *Akodon* for the five species for which data were available from museums or the literature and which were recorded near Caparaó or in the Serra do Mar (Tables 6, 7 and 8). This genus is even more taxonomically confused than *Oryzomys*, with as many as 8 different taxa having been removed from *Akodon* by some authorities to form separate genera, or treated in full, or in part, by others as subgenera. Particularly difficult is the status of the genera *Akodon*, *Bolomys* and *Zygodontomys* and the *arviculoides*, *lasiotus* and *lasiurus* species complexes (Langguth 1975). The relationships between many species are not understood and the genus (or genera) is in great need of revision.

The genus *Akodon* is recognized by all authors including Nowak and Paradiso (1983), Cabrera (1961), Alho (1982) and Honacki *et al*. (1983). However, the first two sources considered *Bolomys*, *Thaptomys* and *Thalpomys* subgenera of *Akodon* and *Cabreramys* a distinct genus, whereas Alho (1982) recognized *Akodon*, *Thalpomys* and *Thaptomys* as genera. Honacki *et al*. (1982) placed *Bolomys* and *Akodon* as full genera and included both *Cabreramys* and *Thalpomys* in the former. Based on cytogenetics, Bianchi *et al*. (1971), concluded that all the above taxa except *Cabreramys* were distinct genera. Based on the statistical results of this study, the species *nigrita* is farther removed from the other species in the genus *Akodon* (Figure 8) than several other taxa that are considered to be full genera (Figure 5). This may support the status of *nigrita* in a monotypic genus *Thaptomys*.

Genus Calomys (= Hesperomys). This genus was included in the analysis as it was considered likely to occur in Caparaó and bore a general resemblance to the 5 specimens of an unidentified species (Table 9). Vesper mice are generally montane-dwelling in a variety of habitats from forests to grasslands. Most species are found in the Andes from western Venezuela through northern Bolivia, but a disjunct group of 2 or 3 species are found in the Serra do Mar (Alho 1981; Nowak and Paradiso 1983). Alho (1981) lists *callosus*, *leucodactylus* and *tener* as nocturnal and terrestrial. *Calomys callosus* may include both *C. expulsus* and *C. venustus* (Honacki *et al*. 1982) and *Calomys laucha* includes *C. tener* and *C. leucodactylus* according to Hershkovitz (1962). Discriminant function analysis placed 4 of 11 museum specimens of *C. tener* into *callosus* and 3 into *laucha* while retaining 4 as discrete and reclassified 50% of the *callosus*, putting 9 into *laucha* and 7 into *tener*. F-tests indicated significant differences between *tener* and *callosus* total length ($F = 7.71$, $P > .0092$, $DF = 31$) and hindfoot ($F = 5.98$, $P > .0195$, $DF = 31$) but not the other characteristics.

Genus Wiedomys. The single species of red-nosed mouse, *W. pyrrhorinos* closely resembles *Thomasomys oenax* (Table 9) except for the bright red extremities (nose, feet, rump, and eye ring). It is arboreal in the caatingas and scrub-forests of eastern Brazil (No wak and Paradiso 1983). Alho (1981) equates *Wiedomys* with *Wilfredomys* but de Avila-Pires (1960) used the latter genus for *Thomasomys oenax*. Four skulls of the species were found in raptor pellets at the base of Pedra Urubú in the Park, an area of rainforest mixed with abandoned agriculture.

Genus Rhipidomys. Climbing mice are, as their name suggests, arboreal with long tails (Table 9), soft, velvety fur and long toes. They are found in moist forests and often in buildings as well (Alho 1982, Nowak and Paradiso 1983). Two species *R. masticalis* and *R. maculipes* are recorded from southern and eastern Brazil (Alho 1982; Nowak and Paradiso 1983) although Cerqueira (1982) does record an "unnamed form" (pg. 70) occurring in the Serra do Mar and suggests that there may actually be three separate species involved. He further indicated that the splitting of this genus occurred during the last major dry period when the Atlantic forest was split into refugia. Only two museum specimens of R. *masticalis* were available for comparisons but discriminant function plotted them as a distinct group (Figure 5) without overlaping any Caparaó specimens.

Genus Thalpomys. Eight specimens from the Stovall Museum at the University of Oklahoma were recently collected near Brasilia. These are, in fact, unidentified specimens thought to possibly represent a new species which have tentatively been placed in this taxon. They have been used in this analysis only for comparison with the 5 unidentifed specimens from the park. Discriminant function considered these *Thalpomys* 100% distinguishable from all other groups but closest to *Calomys*. There was no overlap with Caparaó specimens.

Genus Bibimys (= Scapteromys). Crimson-nosed mice, as their common name suggests, are a distinctive genus with a nose Nowak and Paradiso (1983, pg. 598) describe as "bulky and of an intense crimson color." Once again these were included in this comparison as a potential target for the 5 unidentifiable, reddish, sub-alpine specimens from Caparaó. However, the Caparaó unknowns lack several characters described for this genus including an almost black medial line, yellowish chestnut on the sides, a shorter head and body, shorter tail and overall smaller size (Nowak and Paradiso 1983) (Table 9). Alho (1982) considers this group of species as belonging to the genus *Scapteromys* and lists its habitat as Atlantic rainforests in Bahia.

Genus Nectomys. Neotropical water rats are a specialized group of large, aquatically-adapted rats found throughout northern and central South America, usually in forested areas along streams and swamps. There are 2 species presently recognized but only 1, *Nectomys squamipes* is found south of the Amazon (Nowak and Paradiso 1983). They have several distinctive characteristics including large, webbed, hind feet, a keel of hairs on the tail and glossy fur (Ernest 1986) (Table 5 for measurements). Two specimens of N. squamipes were found in Caparaó, both on stream banks, one in the forest zone and one in the scrub-grass. Discriminant function analysis placed both specimens into the museum N.squamipes (Figure 10).

Genus Thomasomys. There are about 25 species of Paramo mice in South America, all but 3 of them have Andean distributions, most in the forests of the eastern slopes. The other 3 form a disjunct species group in the Serra do Mar (Nowak and Paradiso, 1983). Of these, one, Thomasomys oenax has been removed and placed in its' own genus, Wilfredomys by de Avila-Pires (1960). Both T. oenax and the more common T. dorsalis were used for statistical comparisons. Specimens identified as dorsalis in the park fell in the range for this species using discriminant function (Figure 10) although no F-tests were possible due to the small number of specimens. Thomasomys oenax and Thomasomys dorsalis were widely separated on the discriminant analysis plot (Figure 10), more widely than species of any other genera except the two supergenera Akodon and Oryzomys, and T. oenax was 100% distinguishable using only the 5 external measurements with no other specimens re-classified into this species. This may support de Avila-Pires' position of a distinct genus for oenax.

Genus Blarinomys. The aptly named Brazilian shrew-mouse is one of the most distinctive rodents in South America, and its unique position is not presently under taxonomic doubt (Matson and Abravaya 1977). The present analysis concures as distriminant function places this species as 100% distinguishable from all others (Figure 10).

Genus Oxymycterus. This is another relatively distinctive genus of large mice from southern South America. Burrowing mice are found in a wide range of habitats but, as their name implies, they are usually fossorial or semi-fossorial and insectivorous in habits. They are noted for rather weak dentition (Nowak and Paradiso 1983) and long foreclaws. Honaki *et al*. (1982) comments that the genus needs revision, but compared to other South American genera it is quite robust, other than in its relationships to other genera. This study indicates that the 3 species examined using discriminant function seem sound and distinguishable based on the external measurements used (Figure 10). The 3 species ranged from 100% unreclassified (*jubata*), 92% (*hispidus* = *quaestor*) to 80% (*roberti*). The specimens labled "*jubata*" (from the collection of the American Museum) may be an error for the species *judex* as I can find no reference to the former name ever being applied to a member of this genus. If *jubata* is supposed to be *judex*, the later has been placed as a sub-species of *hispidus* according to Cabrera (1961). However, there were no specimens reclassified between hispidus (as represented by the subspecies quaestor) and jubata.

Other Species Potentially in Caparaó

There are, of course, additional species which are quite likely to be present in the park but that escaped detection. It is important to note that work for this project concentrated on the western and northern portions of the park. The eastern, Espirito Santo, side of the park, was not well sampled for logistical reasons. Although it includes approximately 2/3 of the park's area, the eastern slope of Caparaó was almost entirely without access that penetrated more than a kilometer or so into the park. Further, 12 of the 13 park rangers are stationed on the Minas Gerais side to regulate visitors since virtually all visitors use only that entrance due to its accessability. In the two years of this study, of the approximately 6000 visitors to the park about 10 hiked the length of it entirely, entering at Vale Verde (northwest gate) and exiting at Massierra (southeast gate). The factors of accessability and time combined to limit this survey to predominantly the park's west side where concern for human impact and practical considerations dictated the initial work be done.

Certain taxa were also particularly prone to being detectable only by special sampling techniques or because they are unusually time-consuming to find. It is probable that at least one species of sloth is in Caparaó since Cecropia trees are quite common and several people reported having released sloths into the park that they encountered while removing trees in nearby area. The small mammals and bats are also doubtless more diverse than these results would indicate.

However, some of the large, easily detected species seem conspicuously absent from the park's fauna or from this survey for a variety of reasons and may be generally catagorized as follows:

Probable Residents. These include species that were reported by reliable members of the community (e.g.park rangers) but for whom specific, comfirming evidence was not obtained. In particular, it is probable that at least one jaguar (Panthera onca) is present in Caparaó as one ranger reported that he has seen a female with cubs (one of which was black phase) in the S.E. area of the park at the high elevations and periodic livestock losses in that area would support the possibility of a jaguar. Tapir (Tapirus terrestris) are also reported in a rather large, densly forested area in the S.E. quarter of the park near the valley of Santa Marta. Two other species of enormous interest may also be present in this large fragment of Atlantic rainforest and those are the woolly spider monkey (Brachyteles arachnoides) and the golden-lion tamarin (Leontopithecus rosalia). Although woolly spider monkeys were not detected on transects, the transects were not particularly sensitive to arboreal species. Woolly spider monkeys were indeed in residence in the park as recently as 1976 since 21 of the animals were killed by poachers on the east side of the park. This was confirmed by the forest rangers and a newspaper clipping. Although 3 days were spent looking for these animals in the valley near where they were last noted (Pedra Roxa and the Corrigor dos Monos = spider monkey creek), none were found. There is no way at this time to know if that was because they were simply overlooked, if they were in another area or if the species is, in fact, extinct in Caparaó. As for the marmosets, the habitats in the park, especially on the east side, appear quite adaquate to maintain a population of this species and there are reports by the rangers and residents from the Espirito Santo side of the park which indicated that individuals of the *L. r. rosalia* subspecies could be found in the valley of Santa Marta in the S.E.quarter of the park. Once again, searches were unable to confirm the presence of this endangered species in the Serra do Caparaó but there is reasonable evidence suggesting they may be present.

Unlikely Species. This group includes species that are listed by IBDF (Appendix A) as possible in the park but that local residents either insist are no longer present (usually due to hunting) or do not recognize as ever having been in the area. The latter includes the giant armadillo (*Priodontes maximus*) and hognose skunk (*Conepatus semistriatus*). The former group, those recognized by the local residents and said once to be in Caparaó but now believed gone due either to overhunting or loss of habitat include the deer species *Ozotoceros bezoarticus*, *Mazama americana* and *M.simplicornis*, capybara (*Hydrochaerus hydrochaeris*), paca (*Cuniculus paca*) and howler monkeys (*Alouatta fusca*). If these species are indeed gone from the park ecosystem, they include most of the major large food species for the large carnivores and this may explain the goat hair found in the scats of the maned wolf, ocelot and cougar. The goats and peccary would appear to be the only moderately large herbivores left in Caparaó. This could indicate the potential for a release program to be instituted to reintroduce the deer and large rodents into the ecosystem. There has been a proposal to eliminate the feral goat herd but if, at present, they are the only significant large prey base for the larger carnivores if the feral goats are removed without replacing them with populations of native prey species this may drive the large carnivores into preying upon livestock outside the park boundaries. Such a situation could only prove disastrous for the large, endangered, carnivores.

Species of Undetermined Status: This catagory includes the many species that the park appears to have the appropriate habitats to support and whose historical ranges once included the Atlantic rainforest or the Serra do Caparaó but that have avoided notice by either myself, Ruschi (1978 - Appendix B), the park personnel or the local people.

Altitudinal Affects on Community Ecology

Changes in altitude affected all the community parameters measured - species richness (S), diversity ($\bar{d}$ and H'), evenness (J), endemism (E) rarity index (R) and dominance (D). Not surprisingly the rainforest had the highest values of species richness, diversity and endemism, and these values decreased with increasing altitude (Table 15). In addition, the rainforest had the lowest values for dominance (D) and rarity (R) (Table 15).

The one exception to increased altitude depressing the community parameters was the agricultural zone which had the lowest elevation but did not have the highest community values; a result of reducing the Atlantic rainforest to pasture and coffee fields, altering the original ecosystem through human mechanisms rather than physiographic ones. What was surprising was not that fewer species inhabited the areas of old agriculture than inhabited the rainforest, but how many and which species were capable of doing so (Tables 10, 12 and 14). Among marsupials, both four-eyed opossums and white-eared opossums increased in frequency in zones of secondary succession and human disturbance, as did all 4 armadillos, with *Dasypus novemcinctus* (the species most generalized over a broad range of conditions) showing the greatest increase. The Brazilian cottontail also responded to secondary succession with increased frequencies, as did guinea pigs, the latter more strongly than the former. The fox (or foxes) were more common in agriculture than in rainforest, but somewhat less common than in the higher elevation habitats of the park. Nonetheless, they were the most common large mammal in the agricultural zone. The endangered maned wolf was detected twice on the edges of old pastures. The jagaroundi and the small spotted cats which were present showed an increased frequency of occurrence in the zone of abandoned agriculture. Interestingly, the ocelot was occasionally detected near the edges areas of abandoned agriculture or secondary regrowth, but not out in them. Four other carnivores were found to use the agricultural zone; grison sign was not found in the forest, but the frequency of sign between agriculture, transition or scrub-grass were similar; the tayra and crab-eating raccoon appeared at about the same frequencies in agriculture as in the forest; and the coatimundi was less frequent in abandoned agriculture than in the forest and at about the same frequency as in the transition and scrub-grass habitats. For bats, agriculture produced as many individuals as the forest but fewer species (Table 14). Although one species (Histiotus velatus) was found under roof tiles but not in the forest. This may be because no corresponding structure (i.e. trees) in the forest were dismantled in search of them. The bat data are, however, very sparse due to few mistnets being run. Vampires were the only species that were found in significantly greater numbers in areas of abandoned agriculture where the project's horses were frequently preyed on.

Five more species of small mammals were found in the rainforest than in agricultural areas (Table 10), but three species found in the latter zone were not found in the forest: one spiny rat and two types of murine opossums including one that could not be identified to species. The latter were four specimens hand caught in small nests of woven grass 1 m off the ground in small citrus trees. Small mammals present in the rainforest but missing from the agriculture zone included a third murine opossum (<u>Marmosa murina</u>), and seven species of mice.

The transition zone appeared to have no species unique to it, although several species reached their peak frequencies there including many of the carnivores (Table 12). This zone formed the boundary not only for the uppermost limit of several forest species (raccoon, all the marsupials except <u>Metachirops</u>, tayra, and several rodents) but also the lower limit of several other species, particularly the cougar, the endangered giant anteater and the peccary. None of the small mammals or bats were found there in high numbers (Tables 10 and 14) but overall the number of species and diversity were intermediate between the rainforest and the grasslands.

The scrub-grasslands also had no unique species. There were significantly fewer species than in the rainforest and, as previously noted, even the change of a single species between those two zones is biologically important. Once again, it is of interest to note which species seem able to adapt to this treeless zone of grass and scattered brush so unlike the dense rainforest which originally surrounded these areas for many hundreds of miles. Of the large mammals, several occurred here in high frequencies (Table 12) including nine-banded armadillo, the fox (or foxes), maned wolf, ocelot and small spotted cat.

The last zone is the most estranged ecologically from the Atlantic rainforest and chronologically or geographically from similar habitats far to the south or the west. This paramo-like zone above treeline has one apparently endemic (if unnamed) mouse but otherwise is quite impoverished. As MacArthur (1972) noted, the differences between tropical and boreal habitats are too severe for all but a very few species to manage the transition. Still, nine species were present and most were relatively abundant (Tables 10 and 12), especially the felids, the foxes and the giant anteater.

Comparisons with Temperate Mountains

Comparisons were made of the various community parameters between Caparaó and Great Smoky Mountain National

Park in North America. Data for the latter area were derived from a survey done by Linzey and Linzey in 1968 and linear regressions tested the responses of these parameters against altitude. Results indicated that the most significant correlations were for S and $\bar{d}$ (Tables 20 and 21) with H' and J' less significant. For both parks evenness had a slope of 0. The parameters of S and $\bar{d}$ were therefore chosen for comparing these two mountain ranges due to 1) MacArthur's (1972) original hypothesis being in terms of species richness 2) the comments of Green (1972) relating to H' and J' being inappropriate for measuring diversity and evenness in biological systems under the sampling constraints of this study and 3) the results of regression on these data indicating the greater significance of S and $\bar{d}$.

Since the lowest altitude zones of Caparaó are confounded with the powerful affects of agriculture on diversity, regressions were run both with and without this zone for comparison. In addition, the elevations of Great Smoky Mountains National Park do not extend above 2500 m consequently no comparison was possible with Caparaó for those altitudes.

The Smokies were chosen due to their general similarity with the Serra do Caparaó in age, elevation and continental position. The fauna of the Smokies is far better known than that of Caparaó and the species list for the park largely well established as the first extensive mammal survey was done in 1931-33 (Komarek and Komarek 1938) and many studies

TABLE 20

COMPARISONS OF COMMUNITY PARAMETERS FOR CAPARAÓ AND GREAT SMOKY MOUNTAINS

	PARAMETER*				
ALTITUDE	S	H'	J'	$\bar{d}$	E
500 - 1000 m					
Smoky Mts.	52	1.468	.8552	20.4137	17
Caparaó	29	1.045	.7145	11.3641	3
1000-1500					
Smoky Mts.	32	1.305	.8671	14.0814	2
Caparaó	39	1.279	.8038	14.2353	8
1500 - 2000					
Smoky Mts.	32	1.368	.9088	14.3228	0
Caparaó	25	1.018	.7282	13.2875	0
2000 - 2500					
Smoky Mts.	22	1.253	.9333	11.7620	0
Caparaó	17	.995	.8086	7.7643	0
2500 - 3000					
Smoky Mts.	(not present)				
Caparaó	10	.8130	.8130	5.5443	1

TOTAL SPECIES (S) Caparaó = 53 Great Smokies = 54

(* S = species richness; H'= Shannon's diversity; J'= eveness; $\bar{d}$ = Green's diversity; E = endemism)

TABLE 21

LINEAR REGRESSION CORRELATIONS OF COMMUNITY PARAMETERS WITH ALTITUDES FOR CAPARAÓ AND THE GREAT SMOKIES

Parameter	Slope	R-square	Significance
S			
Smokies	-0.0180	.8526	.0376 *
Caparaó (with agriculture)	-0.0120	.7258	.0328 *
Caparaó (w/o agriculture)	-0.0191	.9710	.0057 *
H'			
Smokies	-0.0003	.6597	.0944
Caparaó (with agriculture)	-0.0003	.5055	.0889
Caparaó (w/o agriculture)	-0.0004	.9145	.0203 *
J'			
Smokies	0.0000	.9609	.0078 *
Caparaó (with agriculture)	0.0000	.4406	.1108
Caparaó (w/o agriculture)	0.0000	.1196	.3260
$\bar{d}$			
Smokies	-0.0052	.8061	.0509
Caparaó (with agriculture)	-0.0038	.6019	.0612
Caparaó (w/o agriculture)	-0.0065	.9342	.0149 *

* $P > .05$

have been undertaken since that time while this is the first survey of Caparaó. The species list for the latter region, especially for the rainforest zone, will surely increase as Alho (1982) lists 80 species of rodents in the Atlantic rainforest alone! Still, the baseline data now exist to begin making general comparisons and suggest areas for further study. For the comparison made in this study, data were used only between 1000 and 2500 m altitude as elevations below this in Caparaó are most severely altered due to agriculture, and elevations above this are not available from the Great Smoky's data (Table 20).

The slopes of all community parameters except evenness were found to be negative (Table 21). This indicates that in both tropical and temperate communities, altitude does indeed reduce diversity (however measured). When compared to the Smokys, the slopes of the lines generated for S and $\bar{d}$ for the Caparaó data are very similar. If the low elevation areas of agriculture are included in the Caparaó data the slopes of the lines for both temperate parameters is less than for the tropical mountains. However, if agriculture is omitted and the rainforest used as the low elevation terminus, then the tropical diversity slopes are both greater than the temperate slopes. The difference is not great yet it is present not only in S and d but in H' as well. The drop in diversity and species numbers for the tropical mountains is, in all probablility, even more sharp than noted here, since many more species are certainly present in the rainforest that this initial survey indicates. Consequently, MacArthur's hypothesis seems correct: Even though tropical mountains start out with more species at their lower elevations than do temperate ones, they lose those species, and attendent community diversity, at a greater rate when subject to altitudinal stress.

Dominance, too, largely followed a pattern that would be expected, at least to the extent that the climax rainforest was the zone with the lowest D-value. This was true both for within species pairs comparisons, within trophic level comparisons and for the overall mean D. The only exceptions were the species pairs interactions between _Nasua_ and _Procyon_ and between _Metachirops_ and _Didelphis_. The latter did involve opposite results between the transect generated D values and those which used the trapping data. The higher values may indicate strong competition between the members of the species pairs involved. It was unexpected for the next to lowest community in dominance to be the areas of secondary successsion. It was anticipated that the transition zone and agriculture should both be high and similar in value as both were perceived as disturbed, unstable, intermediate habitats. At this point, few explanations can be offered for the remarkably high values of species richness, diversity, and community stability apparently present for the areas of recently abandoned agriculture. These areas were cleared by slash and burn tactics and consequently had to be recolonized by species from other areas with which they were in contact, in the case of Caparaó, these were Atlantic rainforests. These forests are themselves enormously diverse and speciose and thus provided a large pool of species to enter the agricultural areas. It is not surprising, then, to see almost all the species in these abandoned areas are rainforest organisms, but certain higher trophic level, or very specialized species are still missing from farm lands as would be expected.

It is of particular interest to the study of tropical succession to compare the two zones that directly border the rainforest and should be most similar to it. In Caparaó these two zones are agriculture - which has been directly produced from the original forest by human intervention, and the transition zone which has been produced by elevation supressing certain species of the rainforest. Both the agriculture and transition zones showed values of the community parameters that were depressed from those in the rainforest but very similar to one another. The relatively high diversity and species richness of the two zones may be in part due to the considerable edge they posesses with the gallery forests of the transition and fencelines of agriculture.

CHAPTER V

SUMMARY

Fifty-three species of mammals were found in Caparaó National Park, at least one and possibly three of which may be new. Species complexes changed with changing habitats produced by both agriculture and altitude. Both of these factors acted to decrease species richness and diversity and increase dominance from that found in the climax zone Atlantic rainforest.

Despite their low latitudes and great species richness, tropical mountains not only lose species at a greater rate due to altitudinal effects than do temperate mountains, but they also lose diversity ($\bar{d}$ and H') at a greater rate with altitude as predicted by MacArthur (1972). Diversity is higher in the Atlantic rainforest than in areas of abandoned agriculture undergoing secondary succession, as is species richness, while dominance is lower for the forest. Among the habitats which have been formed by altitudinal factors altering the climax rainforest community, rather than human intervention, the zone most diverse and speciose was the transition, followed by scrub grassland and finally the alpine campo limpo.

No significant seasonal effects were found in the small mammal community nor in the large mammal community when analyzed as a whole. There were significant season/zone interactions, however, and also significant changes within species by season and between zones suggesting differential seasonal habitat use among some of the large mammal species in the park.

A statistical taxonomic analysis based on external morphometric characters was carried out on the Cricetidae of Caparaó to confirm identifications and the results may also serve to illuminate the positions of certain other taxa. In particular, both general linear regression model analysis of varience F - tests and discriminant function analysis of the species nigrita - which is placed by many authors in the genus Akodon - indicate it is at least as far removed from other members of that genus as many species in distinct genera. This supports to the position of some taxonomists that nigrita should be removed from Akodon and placed in Thaptomys. Likewise Thomasomys oenax was quite different from other representatives of the genus, based on the same statistical tests, which may support placing it in the genus Wilfridomys.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The communities of the tropics are among the most complex on earth, and are also the most endangered and least understood. The tropics generate and maintain a tremendous richness of species and tropical mountains have the greatest diversity of habitats within restricted geographical areas. Consequently, tropical mountains present unique opportunities to study community structure since they go from the most complex, high diversity terrestrial communities on earth, the tropical rainforests, to simple, low-diversity, alpine paramos. This gives an opportunity to observe the effects of island biogeography, refugia and habitat gradients on community structure and speciation in a remarkably intricate, ancient and endangered ecosystem. As Daniel H. Janzen, one of our foremost tropical ecologists states (1988, page 244):

> ...and all this is to say that humans have won the battle against nature. Humanity makes its living by preventing restoration. It is up to us to accept the responsibility of putting the vanquished back on their feet, paws, wings and roots. We can do it. Even defeated, tropical nature has too much to offer us to accept a world without it.

Brazil itself is well aware of the scope of destruction that has been wrought on the native ecosystems and the international concern this has generated. Almeida and Rocha (1977) projected the State of São Paulo in southeastern Brazil would go from 82% forested to 5% by the turn of the century. For the whole of the southeast region (including Caparaó and the remains of the Atlantic rainforest) they report only 10.6% of the original forest remains. Estimates of biological loss in Latin America in general - assuming at least all biological reserves are left undisturbed - run from a forest reduction of 693 million original ha down to 366 million ha by the year 2000 with a loss of 15% of the species followed by a worst case future where only the biological reserves are left intact which would result in only 9.7 million ha of forest left and 66% of species lost (Wolf 1988). As for Brazil, by 1977, only 41.4% of its original forested areas remained. There has been some effort on the part of the the Brazilian government to organize a national policy and co-ordination between agencies responsible for regulating conservation, economic development and international aid for several years (IBDF n.d.) although the scope of the problem is not only ecologically but also economically and politically enormous. Important roles must also also played by other countries in the region, the International Monetary Fund and World Bank as well as by the consumer nations of the world.

Recommendations for all of Latin America, or even Brazil are far beyond the scope of this project other than some observations concerning specific species and their apparent responses to habitat alteration. Species could be generally classified based on whether they were positive, neutral or negative in responding to the agricultural areas of the park. Any conclusions at this point would be very tentative, but some trends may be suggested. Certainly, some native species did appear to be favored by human activities (Table 21) based on the frequencies with which they were found in agricultural areas when compared to other, less disturbed park habitats. Those disturbance-positive species may be better adapted to early successional stages. They are for the most part the smaller, more generalist species of their trophic levels. A few species appeared to be agriculture-neutral. The species in these two groups should be able to survive with or without some form of ecological protection. The most concern is for the disturbance-negative species; those that seem incapable of maintaining a stable or increased population outside of relatively undisturbed native habitats. Several of these are presently listed as endangered (if they are large, valuable or charismatic), or likely will become endangered once more is known about them or, alternately, if the present rates of habitat loss continue.

As for Caparao itself, this park is an island in a sea of coffee fields. The best hope for it is to move rapidly to

TABLE 22

CAPARAÓ SPECIES RESPONSES TO AGRICULTURE WHEN COMPARED TO RAINFOREST BASED ON FREQUENCIES OF OCCURRENCE

SPECIES	RESPONSE TO AGRICULTURE (+ positive; 0 neutral; - negative)*		
Didelphis marsupialis	+		
Metachirops opossum	+		
Marmosa cinerea	+		
Marmosa murina			-
Marmosa sp.3	+		
Cabassous tatouay		0	
Dasypus novemcinctus	+		
Dasypus septemcinctus	+		
Euphractus sexcinctus	+		
Myrmecophaga tridactyla			-
Calicebus moloch			-
Cebus apella			-
Carollia perspicilata			-
Desmodus rotundus	+		
Glossophaga soricina			-
Histiotus velatus	+		
Phyllostomus hastatus			-
Sturnira sp		0	
Uroderma bilobatum			-
Vampyressa pusilla			-
Sylvilagus brasiliensis		0	
Cavia aperea		0	
Coundou prehensilis			-
Dasyprocta agouti			-
Echimys medius	+		
Sciurus inghrami			-
Akodon arviculoides		0	
Akodon cursor			-
Akodon serrensis		0	
Blarinomys breviceps			-
Nectomys squamipes			-
Oryzomys capito			-
Oryzomys flavescens		0	
Oxymycterus hispidius		0	
Thaptomys nigrita			-
Thomasomys dorsalis			-
Unknown red mouse			-

TABLE 22 (Continued)

SPECIES	RESPONSE TO AGRICULTURE (+ positive; 0 neutral; -negative)		
Canid (foxes)	+		
Chrysocyon brachyurus		0	
Felis concolor			-
Felis jaguaroundi		0	
Felis pardalis			-
Felis wiedii/tigrinus		0	
Galictus vittata		0	
Eira barbara		0	
Nasua nasua			-
Procyon cancrivorous	+		
Tayassuidae			-
TOTAL	12	13	23

* + positive response = more common in agriculture than in rainforest; 0 neutral response = about the same frequency in both zones; - negative response = less common in agriculture than in the rainforest

secure what little forest remains unburned on its borders. To buy agricultural land and allow it to undergo succession will be quite expensive, especially in a country with the economic problems of Brazil, but it is also necessary for several reasons. First, we do not know how (or even if) tropical forests regrow beyond a realtively low diversity second growth (indications from the Amazon basin (Janzen 1988; Lewin 1988) are that they do not, not on a time scale that is less than geologic in its length, but we must allow the process to start soon or the conditions for regrowth will only worsen. Secondly, as this study indicated, nearly 76% of the species native to the Atlantic rainforest do not need the climax forest exclusively to survive as they were found in other ecological zones in addition to the forest. At least 60% were found to use areas of secondary regrowth and abandoned agriculture. Even the endangered Maned wolf and the spotted cats seem to be able to use areas of regrowth to some extent. Their populations can consequently be maintained and perhaps increased somewhat even without climax forest. Eight species, however, were endemic to the rainforest alone and from them will come the endangered species of tomorrow. Thirdly, such a buffer zone of secondary regrowth around the core of the park, if properly patrolled by rangers, can help insulate the park from some forms of poaching, encroachment, agro-chemical pollution and such catastrophic events as fire. A recent report demonstrates the reality of such a threat; as of March 5, 1989 a wild fire in Bahia, burning for 28 days, had already consumed 80,000 ha of virgin wilderness in eastern Brazil and had entered Monte Pascoal National Park (Associated Press, 1989).

Tourist visitation is already becoming a major problem. This park is easily accessible (except in the rainy season) from three major cities; Belo Horizonte, Vitoria and Rio de Janeiro. It is very popular both for picnics and day hikes as well as for overnight camping due to its spectacular natural beauty and the fact that you can find ice up top in the dry season. This latter characteristic has tremendous popular appeal in a tropical country. Over 3000 visitors passed through the park in June and July of 1980 alone. The problem of overuse of resources is severe. There are only 3 small camping areas (no running water or latrines) in the entire park so the problems with garbage, firewood, water pollution and trail erosion are intensive as well as extensive. The center of this activity is an area called Terreirão which is within 1 km of the areas where endangered ocelot, maned wolf and giant anteater populations also appear centered. A comprehensive human management plan and controlled access are absolutely critical.

In a limited way reintroductions might be very successful in this park as IBDF seems committed to the park's protection and expansion as well as to poaching control. The large numbers and diversity of predators in Caparaó seem unsupportable in the long term without the reintroduction of the major native herbivores. This is especially true since cougar and possibly jaguar exist in the park and the presence of these large cats without a large prey base is bound to create livestock losses. From scat analysis I suspect the feral goats have played an important role in limiting other livestock losses in the area. The park's area and habitats seem adaquate to support one or more deer species at least and, now that human hunting pressure is reduced, it is reasonable to suggest that they at least be reintroduced. Perhaps supplements to the park's small tapir and peccary populations might be successful as well. If careful consideration is given to the genetic stocks in various zoos and in other reserves, it may also reduce the probability of excessive inbreeding in the park's isolated populations.

This park is one of the least recognized outside of Brazil. Only a very few tropical biologists that I have spoken to seem even to have heard of Caparaó and fewer still have actually been there; yet it preserves one of the largest remaining pieces of a tropical rainforest in Brazil once second only to the Amazon in area. That forest is now over 99% gone - converted to coffee, cacao and sugar plantations. As it has gone, it has taken with it an unknown, but doubtlessly large number of species into extinction and endangerment, many of which we do not even know are gone or threatened because we never knew they existed. What is saddest about this forest is that it has *been disturbed for so long without recognition, that it has slipped away acre by acre (and all by hand, axe and mattock) with little notice. Not only has it been deliberately destroyed - this is happening to all rainforests - but this one has been ignored, perhaps terminally; not by the Brazilians this time, but by the international community. As this study has indicated, the piece of forest that has been protected by these rugged mountains is still one where many of the original systems and species of this supremely endangered ecosystem can still be observed, studied and learned from; it may also become a source for regeneration. This study has, I hope again, raised far more questions than it has answered. As a baseline study, that was its function. As a scientist who has been given the rare opportunity to work in a vast and largely unknown place I know I found every day in these mountains a challenge more full of questions than of answers and every day too short. I also found that living in the place the native South American indians called "The Mountains Where Water Is Born" will give a gift that far too few, scientists or not, will ever know if we do not take rapid, determined steps to preserve the Serra do Caparaó.*

> *Delight itself, however, is a weak term to express the feelings of a naturalist who, for the first time, has wandered by himself in a Brazilian forest."*
>
> *Charles Darwin*
> *February 29, 1832*
> *(1967, pg.11)*

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APPENDIXES

APPENDIX A

MAMMAL SPECIES OF CAPARAÓ (MAGNANINI (MAGNANINI AND PADUA N.D.)

DIDELPHIDAE
Didelphis azarae
Metachirus nudicaudatus

PHYLLOSTOMIDAE
Diclidurus alba
Vampyrum spectrum

DESMODONTIDAE
Desmodus rotundus

CEBIDAE
Cebus apella
Brachyteles arachnoides

CALLITHRICHIDAE
Callithrix geoffroyi

MYRMECOPHAGIDAE
Myrmecophaga tridactyla
Tamandua tetradactyla

BRADYPODIDAE
Bradypus torquatus
Bradypus infuscatus

DASYPODIDAE
Dasypus novemcinctus
Priodontes giganteus

SCIURIDAE
Sciurus aestuans

CRICETIDAE
Oryzomys capito
Nectomys squamipes
Phaenomys ferrugineus
Akodon arviculoides

TAPIRIDAE
Tapirus terrestris

TAYASSUIDAE
Tayassu tajacu
Tayassu albirostris

ERETHIZONTIDAE
Chaetomys subspinosus

CAVIIDAE
Cavia aperea
Cavia fulgidae
Cavia porcellus
Galea wellsi
Kerodon ruprestris

DASYPROCTIDAE
Aguti paca
Dasyprocta aguti

HYDROCHAERIDAE
Hydrochaerus hydrochaeris

CANIDAE
Cerdocyon thous
Chrysocyon brachyurus

PROCYONIDAE
Nasua nasua

MUSTELIDAE
Eira barbara
Conepatus semistriatus
Lutra enudris

FELIDAE
Felis pardalis
Felis tigrina
Felis wiedii
Felis yagouaroundi
Felis concolor
Leo onca

CERVIDAE
Ozotoceros bezoarticus

APPENDIX B

MAMMAL SPECIES OF CAPARAÓ (RUSCHI 1978)

DIDELPHIDAE
Didelphis marsupialis
Didelphis aurita
Metachirus nudicaudatus
Metachirops opossum
Chironyctes minimus
Monodelphis scalopus
Monodelphis iheringii
Marmosa cinerea

MOLOSSIDAE
Molossus ater
Eumops auripendulus
Tadarida espiritosantensis

PHYLLOSTOMATIDAE
Phyllostomus hastatus
Chrotopterus auritus
Mimon bennettii
Micronycteris megalotis
Glossophaga soricina
Artibeus jamaicensis
Vampyrops lineatus

DESMODONTIDAE
Desmodus rotundus
Diphylla ecaudata

VERSPERTILIONTIDAE
Myotis nigricans
Lasiurus ega

CEBIDAE
Callicebus gigot
Alouatta fusca
Cebus nigritus
Brachyteles arachniodes

ERETHIZONTIDAE
Coundou prehensilis

CAVIIDAE
Cavia aperea

DASYPROCTIDAE
Dasyprocta aguti
Cuniculus paca

ECHIMYIDAE
Euryzygomatomys guiara
Echmys medius

CALLITHRICHIDAE
Callitrix aurita
Callitrix flaviceps

MYRMECOPHAGIDAE
Tamandua tetradactyla

BRADYPODIDAE
Bradypus tridactylus

DASYPODIDAE
Euphractus sexcinctus
Dasypus novemcinctus

LAGOMORPHA
Sylvilagus brasiliensis

SCIURIDAE
Sciurus inhgrami

CRICETIDAE
Thomasomys pyrrhorhinus
Thomasomys dorsalis
Thomasomys sublineatus
Nectomys squamipes
Rhipidomys masticalis
Phaenomys ferrugineus
Akodon subterraneus
Akodon arviculoides
Oxymycteris nasutus
Blarina breviceps

MURIDAE
Rattus norvegicus
Rattus rattus
Mus musculus

MUSTELIDAE
Tayra barbara
Grison grison

FELIDAE
Panthera onca
Felis concolor
Felis pardalis
Felis wiedii
Felis yaguaroundi
Felis pardinoides

TAPIRIDAE
Tapirus terrestris

CANIDAE
Dusicyon vetulus
Dusicyon thous

PROCYONIDAE
Procyon cancrivorous
Nasua nasua
Potos flavus

TAYASSUIDAE
Tayassu tayacu
Tayassu pecari

CERVIDAE
Mazama americana
Mazama simplicornis

APPENDIX C

LIST OF MUSEUM SPECIMENS USED FOR TAXONOMIC COMPARISONS

University of Oklahoma

Akodon cursor (10 specimens)
17437, 17438, 17439, 17440, 17441, 17442, 17443, 17444, 17445, 17446

Bolomys lasiurus (51 specimens)
17514, 17515, 17516, 17517, 17518, 17519, 17520, 17521, 17522, 17523, 17524, 17526, 17527, 17528, 17529, 17530, 17531, 17532, 17533, 17534, 17535, 17536, 17537, 17538, 17539, 17540, 17541, 17542, 17543, 17544, 17545, 17546, 17547, 17548, 17549, 17459, 17460, 17461, 17462, 17463, 17464, 17465, 17466, 17467, 17468, 17469, 17470, 17471, 17472, 17473, 17474

Nectomys squamipes (10 specimens)
17349, 17350, 17351, 17352, 17353, 17354, 17355, 17356, 17357, 17358

Calomys callosus (17 specimens)
037, 039, 044, 056, 063, 064, 066, 083, 085, 105, 176, 177, 182, 396, 147, 159, 162

Calomys tener (13 specimens)
058, 035, 075, 077, 221, 239, 148, 150, 158, 160, 126, 105, 124

Oryzomys capito (1 specimen)
17475

Oryzomys bicolor (11 specimens)
17476, 17477, 17478, 17479, 17480, 17481, 17482, 17483, 17484, 17485, 17486

Oryzomys concolor (5 specimens)
17487, 17488, 17489, 17490, 153

Oryzomys subflavus (6 specimens)
80, 81, 82, 83, 84, 85

Oryzomys eliurus (14 specimens)
013, 014, 093, 106, 137, 152, 172, 257, 267, 361, 389, 520, 117KE, 117DG

Oryzomys nigripes (7 specimens)
070, 161, 188, 294, 296, 322, 326

Oxymycteris roberti (17 specimens)
17491, 19492, 17493, 17494, 17495, 17496, 17497, 17498, 17499, 17500, 17501, 17502, 17503, 17504, 17505, 17506, 17507

U.S.National Museum of Natural History

Akodon arviculoides (5 specimens)
484227, 484228, 484229, 484230, 484231

Akodon cursor 15 specimens)
485107, 485109, 485111, 485112, 485114, 485116, 485117, 541491, 541492, 541493, 541494, 541495, 543006, 543007, 543008

Akodon lasiurus (30 specimens)
543009, 543010, 543011, 543012, 543013, 543014, 543015, 543016, 543017, 543018, 543019, 543020, 543021, 543022, 543023, 543024, 543025, 543026, 543027, 543028, 543029, 543030, 543031, 543032, 543033, 543034, 543035

Akodon nigrita (39 specimens)
484232, 484233, 484234, 484235, 484236, 484237, 484238, 484239, 484240, 484241, 484242, 484243, 484244, 484245, 484246, 484247, 484248, 484249, 484250, 484251, 484252, 484253, 484254, 484255, 484256, 484257, 485098, 485099, 485100, 485101, 485102, 485103, 485104, 485105, 485106

Akodon serrensis (6 specimens)
485110, 485113, 485115, 543036, 543037, 543038

Akodon sp. (8 specimens)
484518, 484519, 484520, 484521, 484522, 484523, 484524, 485108

Akodon sp. (6 specimens)
543039, 543040, 543041, 543042, 543043, 543044

Akodon varius (1 specimen)
541496

Calomys callosus (61 specimens)
484408, 484409, 484410, 484411, 484412, 484413, 484414, 484415, 484416, 484417, 484418, 484419, 484420, 484421, 484422, 484423, 484424, 484425, 484426, 484427, 484428, 484429, 484430, 484431, 484432, 484433, 484434, 484435, 484436, 484437, 484438, 484439, 484440, 484441, 484442, 484443, 484444, 484445, 484446, 484447, 484448, 484449, 484450, 484451, 484452, 484453, 484454, 485170, 485171, 485172, 485173, 485174, 543054, 543055, 543056

Calomys laucha (1 specimen)
541497

Nectomys squamipes (158 specimens)
484139, 484140, 484141, 484142, 484143, 484144, 484145, 484146, 484147, 484148, 484149, 484150, 484151, 484152,

Nectomys squamipes (continued)
484153, 484154, 484155, 484156, 484157, 484158, 484159,
484160, 484161, 484162, 484163, 484164, 484165, 484166,
484167, 484168, 484169, 484170, 484171, 484172, 484173,
484174, 484175, 484176, 484177, 484178, 484179, 484180,
484181, 484182, 484183, 484184, 484185, 484186, 484187,
484188, 484189, 484190, 484191, 484192, 484193, 484194,
484195, 484196, 484197, 484198, 484199, 484200, 484201,
484202, 484203, 484204, 484205, 484206, 484207, 484208,
484209, 484210, 484211, 484212, 484213, 484214, 484215,
484216, 485058, 485059, 485060, 484061, 485062, 485063,
485064, 485065, 485066, 485067, 485068, 485069, 485070,
485071, 485072, 485073, 485074, 485075, 485076, 485077,
485078, 485079, 485080, 485081, 485082, 485083, 485084,
485085, 542970, 542971, 542972, 542973, 542974, 542975,
542976, 542977, 542978, 542979, 542980, 542981, 542982,
542983, 542984, 542985, 542986, 542987, 542988, 542989,
542990, 542991, 542992, 542993, 542994, 542995, 542996,
542997, 542998, 542999, 543000, 543001, 543002, 543003,
543004

Oryzomys capito (8 specimens)
542922, 542923, 542924, 542925, 542926, 542927, 542928,
542929

Oryzomys fornesi (1 specimen)
541498

Oryzomys nigripes (157 specimens)
484043, 484044, 484045, 484046, 484047, 484048, 484049,
484050, 484051, 484052, 484053, 484054, 484055, 484056,
484057, 484058, 484059, 484060, 484061, 484062, 484063,
484064, 484065, 484066, 484067, 484068, 484069, 484070,
484071, 484072, 484073, 484074, 484075, 484076, 484077,
484078, 484079, 484080, 484081, 484082, 484083, 484084,
484085, 484086, 484087, 484088, 484089, 484090, 484091,
484092, 484093, 484094, 484095, 484096, 484097, 484098,
484099, 484100, 484101, 484102, 484103, 484104, 484105,
484106, 484107, 484108, 484109 484110, 484111, 485022,
485023, 485024, 485025, 485026, 485027, 485028, 485029,
485030, 485031, 485032, 485033, 485034, 485035, 485036,
485037, 485038, 485039, 485040, 485041, 485042, 485043,
485044, 485045, 485046, 485047, 485048, 541499, 541500,
541501, 541502, 541503, 541504, 542930, 542931, 542932,
542933, 542934, 542935, 542936, 542937, 542938, 542939,
542940, 542941, 542942, 542943, 542944, 542945, 542946,
542947, 542948, 542949, 542950, 542951, 542952, 542953,
542954, 542955, 542956, 542957, 542958, 542959, 542960,
542961, 542962, 542963, 542964, 542965, 542966, 542969

Oryzomys nitidus (49 specimens)
484022, 484023, 484024, 484025, 484026, 484027, 484028,
484029, 484030, 484031, 484032, 484033, 484033, 484034,

Oryzomys nitidus (continued)
484035, 484036, 484037, 484038, 484039, 484040, 484041, 484042, 485001, 485002, 485003, 485004, 485004, 485005, 485006, 485007, 485008, 485009, 485010, 485011, 485012, 485013, 485014, 485015, 485016, 485017, 485018, 485019, 485020, 485021

Oryzomys ratticeps (3 specimens)
484112, 485049, 485050

Oryzomys subflavus (9 specimens)
484113, 484114, 484115, 485051, 485052, 485053, 485054, 485055, 542967

Oxymycteris judex (10 specimens)
543045, 543046, 543047, 543048, 543049, 543050, 543051, 543052, 54305

Oxymycteris roberti (1 specimen)
543121

Rhipidomys masticalis (1 specimen)
543005

Thomasomys dorsalis (11 specimens)
484217, 484218, 484219, 484220, 484221, 484222, 484223, 484224, 484225, 484226

Zygodontomys lasiurus (68 specimens)
484258, 484259, 484260, 484261, 484262, 484263, 484264, 484265, 484266, 484267, 484268, 484269, 484270, 484271, 484272, 484273, 484274, 484275, 484276, 484277, 484278, 484279, 484280, 484281, 484282, 484283, 484284, 484285, 484286, 484287, 484288, 484289, 484290, 484291, 484292, 484293, 484294. 484295, 484296, 484297, 484298, 484299, 484300, 484301, 484302, 484303, 484304, 484305, 484306, 484307, 484308, 480309, 484310, 484311, 484312, 484313, 484314, 481315, 481316, 481317, 481318

Field Museum of Natural History

Akodon cursor (12 specimens)
26578, 26580, 26581, 26583, 26584, 26623, 26625, 26626, 26627, 26630, 26632, 26632

Akodon nigrita (1 specimen)
26628

Bolomys lasiurus (1 specimen)
19531

Oryzomys intermedius (10 specimens)
18874, 18875, 93063, 94544, 94545, 94546, 94547, 94548, 94549, 94550

Oryzomys nigripes (120 specimens)
26599, 26600, 26601, 26602, 26603, 26604, 26604, 26605, 26607, 26608, 26609, 26610, 26611, 26612, 26613, 26614, 26615, 26616, 26617, 26618, 26619, 26620, 26621, 26622, 26873, 26874, 93051, 93052, 93053, 93054, 93055, 93056, 93057, 93057, 93058, 93059, 93061, 93062, 94554, 94555, 94556, 94557, 94558, 94559, 94560, 94561, 94562, 94563, 94564, 94565, 94566, 94567, 94568, 94569, 94570, 94571, 94572, 94573, 94574, 94575, 94576, 94577, 94578, 94579, 94580, 94581, 94581, 94582, 94583, 94584, 94585, 94587, 94588, 94589, 94590, 94591, 94592, 94593, 04594, 94595, 94596, 94597, 94598, 94599, 94600, 94601, 94607, 94608, 94609, 94610, 94611, 94612, 94613, 94614, 94615, 94616, 94602, 94603, 04604, 94605, 94606, 94617, 94618, 94619, 94620, 94621, 94622, 94623, 94624, 94625, 94626, 94627, 94628, 94653, 94654, 94655, 94656, 94657, 94658, 94659

Oxymycteris quaestor (6 specimens)
26588, 26590, 26591, 26592, 26593, 26594

Thomasomys dorsalis (7 specimens)
26872, 26596, 26597, 26598, 53871, 53872, 53873

APPENDIX D

SPECIES LIFE HISTORY NOTES

Life history data were gathered on all species throughout the course of this study. The following is a summary by species for that data and includes descriptions of all specimens collected. All specimens were originally cataloged under my field numbers (indicated by KBB) since there was no official catalog for the park. They were then placed with IBDF in Belo Horizonte, Minas Gerais. Data collected are given in the following order for each specimen: total length (Tt), tail length (Tl), hindfoot (Hf), ear length (Er) and weight (Wt). For bats these measurements also include tragus (Tr) and forearm length (Fm). These were recorded in millimeters and grams unless otherwise noted. Age and reproductive condition was also recorded whenever possible. Reproductive condition was noted by such charateristics as descended testis, lactation, or embryos present. Age was considered as either juvenile or adult for most species and individuals were adults unless otherwise noted.

Marsupials

__Didelphis marsupialis__ *Gambá*

Nine individuals (not including pouched young) of this species were captured in the park of which one adult male (KBB#88; Tt 724mm, Tl 368mm, Hf 61mm, Er 53mm, Wt 1347gm) was sacrificed for a voucher specimen. D. marsupialis was captured in the agricultural (3 individuals), rainforest (5) and transition (1) zones but never above 2000m in the scrub-grass or alpine habitats. Trapping results were about the same in the rainforest and agriculture zones (trapping successes of .15 captures/100 traps and .17/100 respectively) but transect data indicated opossum sign occurred almost 5 times more commonly in the old agriculture zones than in the forest or transition zones (4.7 sign/100 km of transect, .75/100 and .52/100 respectively) demonstrating a positive correlation with habitat. Further, an additional 6 individuals were removed from the nearby village of Alto Caparaó where they were inhabiting attics (2 cases) or raiding chicken houses (4 cases). These individuals were trapped, marked and released into the park in the interests of increasing the life history data base as well as fostering an attitude of good will and protective cooperation toward the park and its animals among the local people. This species of opossum seems to be opportunistic and no more adversely affected by human environmental impact than its North American relative. From these few individuals, no reproductive trends could be reliably detected although one sub-adult male, about 3/4 grown was captured in August, near the end of the cold-dry season and 2 females were captured with young still in the pouch, one in May (11 young averaging 72 mm head and body length) and one in September (10 young averaging 161 mm head and body length). Both females were captured in the low elevation rainforest of Vale Verde. Fleming (1973) found the litter size ranged between 2 and 9 and averaged 6 for this species in Panamá. From 2 areas of Columbia mean litter sizes were 4.5 and 6.5 with an overall range between 1-11 young (Nowak and Paradiso 1983) and O'Connell (1979) found a mean litter size of 6.7 in northern Venezuela. Davis (1947) found a mean litter size of 8.5 from Teresopolis in southeastern Brazil.

Whenever individuals were trapped they were marked for future identification by tattooing a number on the lightest-colored part of the ear with a rapidograph pen and spray painting an approximately 3-4 inch diameter patch of rump fur. Each individual in a trapping area was given a different color for easy identification should it happen to be spotted on transects. In the Inácio-Aléxio valley, an area of mixed adandoned agriculture and forest, one marked animal was recaptured. The previously mentioned sub-adult male, in a two week trapping period between 31 July 1979 and 13 August, was caught on two consecutive nights in the same trap and two nights later in a trap 50 m away in the same creek bed. O'Connell (1979) reported an average distance of 46.6 m between recaptures for males and 80.7 m for females. In the same trapping period and same trapline, two adult males and one adult female were also caught. The males were both caught the same night in traps 100m apart (one in the same trap that a few days later caught the sub-adult) but none of the adults were recaptured. The female was caught in the same creek bed 500 m from the loci of males.

Metachirops opossum Cuica

Both the genus *Phylander* as well the genus *Metachirops* are widely applied to both the gray (*M. opossum*) and the black (*M. mcilhennyi*) four-eyed opossums but Nowak and Paradiso (1983) follow Pine (1973b) and place the species *nudicaudatus* (brown 4-eyed opossum) in *Phylander* and both *opossum* and *mcilhennyi* to *Metachirops*. Two park specimens were put up as vouchers, KBB#76 (male) and KBB#89 (female) although both were originally cataloged under the genus *Phylander*. Measurements were also taken for 5 other adult individuals and follow (in mm and gm): male #76, 498-262-39-30,300g; female #89, 619-262-39-33,410g; female 593-258-38-30 male, 61-261-40-31; male, 297-180-34-28; male, 302-197-33-28; male, 598-260-40-32.

The grey 4-eyed opossum (named for the white superorbital spots) was one of the most ubiquitous of the lower elevation complex and was trapped commonly in abandoned agriculture and rainforest and more rarely in the transition zone. A total of 29 individuals were captured in the park and an additional 4 were removed from human habitations and chicken houses (these, too, were released in the park). Transect sign of this species was vastly more common in the areas of abandoned agriculture (7.6 sign per

100km transect) than in the forest (.502/100) although trapping success was not dramatically different between the two (excluding recaptures, .006 for agriculture and .004 for rainforest). Fleming (1972) found the population density of this species to be .55 per ha in mature forests and .65 per ha in secondary forests in Panama with an average home range of .34 ha.

Live-trapped individuals were marked using the same techniques as used on Didelphis. In Caparaó this species proved to be easily captured and recaptured even to the point of breaking into baited but unset traps and managing to become caught in Sherman livetraps - difficult as it is to imagine a 600 mm, 400 gm animal forcing itself into a 100mm by 300mm space. They seemed to respond equally well to all baits including peanut butter, table scraps, sardines, bananas, and corn nor did they appear to become trap shy with 79% of individuals being recaptured at least once and one individual recaptured 8 times. Another individual was trapped and removed 5 times (the last 3 times quite forcefully) from the house in which I was living. It is also of interest to note that on 6 of 8 traplines on which this species occurred, these opossums showed a clumped pattern of captures and recaptures. There was usually only one 'group' per trapline with individuals being caught repeatedly in the same traps. These groups along the traplines did not appear to be associated with either food or water resources. The food in the traps could not be considered a "clumped" resource since the traps were equidistant and only 10m apart. Multiple capture traps could not be explained based on different baits (P>.43, chi-square = 1.48, Df=2). All but 4 individuals (not including those trapped in houses) were caught within 20 meters of another Metachirops and most were taken either sequentially in the same trap and/or simultainously in adjacent traps. On 2 occasions a pair of adults was captured in the same trap at the time. Four of the capture-groups were male/female pairs, 1 was a male/male pair, 3 were groups of 3 (mixed sexes), 2 groups of 4 and 1 of 5 individuals (both the latter groups of mixed sexes). One of the groups of 3 and 2 of the pairs were composed of juveniles less than 230mm head and body size (Fleming 1972). In addition, the adult male/male pair (caught simultainously in the same trap) and 2 of the groups of 3 were each observed to use common dens. It seems that some degree of social interaction must have been present in this species.

The two adult males caught together in the same trap (1 was sacrificed - KBB#76) were kept together for 2 weeks in the same cage for observation. The cage was approximately 1m X .5m X .5m and they were fed bananas, sardines and rice and beans. They showed no aggressive behavior toward one another. Each would simply grab a mouthful of food and retreat a few inches to eat it. They did not contest nor did one appear to be overtly dominant over the other since they ate and drank peacefully and slept curled up together. This was not due to an overall peaceful nature since, during the

2 week period, they did not reduce their aggressive behavior toward me or other things outside their cage at all but demonstrated gape-threats, hisses and attempted to bite at every opportunity. There was just no con-specific aggression noted.

Hunsaker (1977) indicated this species is reproductively active year-round but peaked between March and August. Fleming (1977) suggested *Phylander* is polyestrous with breeding extending from late January through November. Davis (1947) found the breeding season to be between August and February. No pouched young were found in the 6 Caparaó adult females (specimens were taken between April and October) although 7 sub-adults were caught in late July through early August indicating birth near the end of the previous rainy season (approximately late February).

Marmosa cinerea Marmosa

This species of ashy opossum was taken once on a trapline in abandoned agriculture and once in the forest and was found in raptor pellets on 8 occasions (5 in 1979 and 3 in 1980). It did not appear to be a common species. Two specimens were put up (KBB#138, male Tt 354mm, Tl 207mm, Hf 24mm, Er 23mm, Wt 70gm and KBB#181, male Tt 361mm, Tl 211mm, Hf 25mm, Er 23mm, Wt 70gm) in addition to the skulls in the raptor collection.

Marmosa murina Marmosa

The murine opossum was the most common mouse opossum in the park and, according to the local people would sometimes even enter houses in search of bananas. Remains of 23 individuals were taken from raptor pellets (10 from the rainy season, 13 from the dry) and 7 were trapped, 5 in the rainforest and 2 in the transition zone in a riparian area. One marked female was recaptured once. Twice males and females were caught in adjacent traps. No females were found with young and all individuals appeared to be adults. Four specimens were put up (KBB#78, 79, 100 and 104) with measurements as follows (in mm and gm): male #78, 276-151-20-22-25; female #79, 297-166-20-20; male#100, 319-191-19-21-20; female#104, 263-152-18-24-30.

Marmosa species 3 Marmosa

I was unable to identify this small species of murine opossum as I was not allowed to remove the specimens to the U.S. for comparative work. It does not appear to fit any published descriptions including those of Tate (1933), Hershkovitz (1959), Cabrera (1961), Collins (1973) Pine (1973a, 1973b, 1975, 1977, 1979, 1981), Pine and Abravaya (1978), Handley and Gordon (1979), Mares et al.(1981), Pine and Handley (1984). Three specimens were collected of which 2 were sacrificed (KBB#189, male and KBB#158, female) and one female was measured and released. A fourth individual escaped. The measurements were as follows (in mm and gm): male#137, 189-102-14-18, 15g; female#158, 182-100-15-20,15g; female, 185-99-16-18, 20g.

The specimens were all a very distinctive ashy-rose color with a medium dark eye ring and overall quite different from either <u>cinera</u> or <u>murina</u>. The dorsum was a medium pale grey which faded into pink on the sides. The creamy white fur of the belly, throat and feet retained a pinkish cast that was almost irridescent, becoming more pronounced and strongly pigmented toward the urogenital region of both sexes. The overall effect was strikingly like that of mother-of-pearl. The male's scrotum was dark black. The first two individuals were caught by hand in a small area of abandoned pasture and lime trees. Traps were extensively deployed with a variety of baits but no specimens were captured in them. Five nests were then examined and 2 additional specimens were hand caught. All the nests were 1 m off the ground in or near extensive, active tent catepiller webs in the lime trees. The nests were globular, 10-12 cm in diameter made of woven dry grass blades 4 mm wide and 6-10 mm long. One tree contained 2 nests, all others were one nest per tree. Remains of 6 individuals of this species were found in raptor pellets as well.

Chiroptera

Carollia perspicillata Morçego

Twelve individuals (6 males, 6 females) of this species were mistneted in the park of which 2 were put up as specimens (KBB#144, male, Tt 84mm, Tl 0, Hf 15mm, Er 14mm, Tr 7mm, Fa 64mm, Wt <10gm and KBB#187, male, Tt 85mm, Tl 0, Hf 14mm, Er 14mm, Tr 7mm, Fa 63mm). Population densities appeared to be highest in the transition zone between the forest and the higher elevation grasslands (.285 individuals/net), lowest in the abandoned agriculture zone (.080/net) and intermediate in the rainforest habitat (.106/net). None were caught in the scrub-grasslands or alpine zones. All these bats were adults, no females were carrying young, were lactating or appeared pregnant. Females were caught in April, May, September, October and December. An additional 10 individuals of this species were caught in October, 1978 at the Estacao Ecologia da Tapacurá near São Lourenco da Mata in the Northeastern state of Pernembuco, Brazil. None of the 3 females from that site were lactating although 3 of the males had descended testes.

Desmodus rotundus Vampiro

This was the most commonly netted bat in the park. In addition, one cave was continually inhabited by this species with approximately 20-30 individuals and was located near the house where I stayed. The horses I used (the only livestock allowed in the park) were bitten at irregular intervals. There would be periods of several weeks or occassionally months when they were never bitten and then weeks when at least one of them (and often two or more) were fed on every night with 2-3 fresh wounds per night. The mule was very rarely biten and the brown mare noticably more often than the white mare or white gelding. Two foals were born during my stay and they were bitten more the first few weeks of life then less with age. Other livestock was present outside the park boundaries but still within 3 km of the cave.

A total of 35 individuals were netted in the park, of which 5 were sacrificed as voucher specimens whose measurements follow: male #71, 74-0-17-14-6-60; female #72, 86-0-17-15-4- 68; male #73, 78-0-17-14-6-64; male #150, 84-0-15-14-7-64; female #151, 90-0-18-16-9-63.

The vast majority (28) of these bats were caught in the agricultural zone. Five were taken in the forest and 3 in the transition zone. As a rough estimate of density, there were .45 individuals taken per net in the agricultural zone, .10/net in the forest and .42/net in the transition zone. Individuals were netted in the months of April, May, July, August, September, October and December in Caparaó and males were found with descended testes only in May. In Pernembuco (the same site described under <u>Carollia</u>) males had descended testes and females were lactating in October.

Local residents that at one time grazed livestock in the scrub-grass and alpine zones above 2000 m reported vampires did use those upper zones to forage in but that there were not as many bites on animals as in lower zones. The local ranchers also insisted that there was a cave harboring a vampire colony at the base of Cristál mountain although I was unable to locate it. This would have been at an altitude of at least 2300 m.

<u>Glossophaga</u> <u>soricina</u> Morcego-chupa-flor

Twenty-one individuals of this species were netted in the park of which 7 specimens were preserved. Their measurements follow: male #80, 67-6-13-21-6-40; male #81, 58-6-9-19-5-36; male #82, 65-6-9-18-5-36; female #116, 60-3-10-14-6-38; female #117, 59-3-11-16-4-33; female #145, 55-3-11-12-4-36; male #147, 53-3-11-10-4-35.

In addition a roost of approximately 12-15 individuals was kept under regular observation for changes in its numbers or evidence of reproduction. descended testes were noted in all 3 males taken in May but not in those taken in April, September or December. Females taken in July (2) and December (1) were not lactating and had no embryos. No juveniles were ever noted in the roost. As previously noted, the population in the roost was slightly higher during the warm, wet season (September through February) and lowest during the cold, dry season (March through August). In

Pernembuco, 1 male and 1 female were taken in October. The male's testes were not descended and the female was not lactating. These data, though far from conclusive, do suggest breeding at the begining of the dry season.

This species was most common in the rainforest zone (18 individuals captured or .38/net) and less so in the agricultural areas (5 individuals or .08/net). They were never caught in the other zones.

<u>Histiotus velatus</u> Morçego

One specimen (KBB#143, male, Tt 64mm, Tl 50mm, Hf 12mm, Er 29mm, Tr 14mm, Fm 47mm) was found under a roof tile in an abandoned agricultural area the park in December. Another male was netted but released a few days later in the same zone.

<u>Phyllostomus hastatus</u> Morçego

One individual male was netted in July in the forest zone and released.

<u>Sturnira lilium</u> Morçego-estriado

Specimens of this bat were taken three time in nets in the agricultural zone (August and December) and once in the forest (August). Female #149, taken in December, had 1 embryo. measurements are as follows: female #128, 58-0-9-13-5-36; male #129, 58-0-11-14-5-37; female #149, 68-0-15-14-4-44

Stenodermatinae

A single skull of a bat, unidentified to genus or species, from this subfamily was recovered from raptor pellets. Another striped-faced phyllostomid bat, probably of this sub-family, was noted in a cave in Vale Verde forest carrying a single young (ventrally) in December and on 2 other occasions solitary individuals of this sub-family were seen in the same cave.

Uroderma bilobatum — Morcego-estriado

One individual male of this species was netted in the forest zone but was too badly damaged by a vampire caught in the same net to salvage. Measurements were Tt 55mm, Tl 0mm, Hf 9mm, Er 15mm, Tr 5mm, Fm 40mm. Vampires were noted on several occasions to attack and damage other bats (as well as the net) if they were not removed immediately after capture.

Vampyessa pusilla — Morcego-estriado

Three individuals of this species were caught in August in the forest zone of which one (KBB# 195, male, Tt 51mm, Tl 0mm, Hf 7mm, Er 12mm, Tr 4mm, Fa 32mm, Wt (10gm) was sacrificed. The female caught at the same time was lactaing and so was released.

Vampyrops lineatus Morçego-estriado

This was the third most commonly caught bat in Caparao with a total of 9 individuals netted and two more (male and female) knocked from a jabucicaba tree in July. A total of 3 were from the agriculture zone (.01/net), 6 from the forest (.12/net) and 1 from the transition zone (.14/net). Four specimens were put up with the following measurements (in mm): male #115, 78-0-12-18-7-48; male #127, 61-0-11-18-6-42; male #146, 79-0-12-16-6-39; male #148, 69-0-13-14-6-40.

Six females were caught (April, July, September and October) but none were lactating or appeared pregnant.

Primata

Callicebus personatus Macaco-guigo

Individuals of this species were noted in the forest of Vale Verde although none were captured. On October 12, 1980, an adult female was confiscated by the park rangers. She was said to have been taken from the park area as a baby several years previously. She was brought to me to return to the Vale Verde forest where a troop often ranged within one-half km from my house and just across the river. The evening she came the wild titi monkeys could be heard calling across the valley. She was very agitated, vocalizing loudly until dark and fought the chain attemping to go toward the sounds. The next morning she had escaped although she still had a leather dog collar around her waist.

This species was noted only in Vale Verde and that was largely due to the unusual acoustics of the granite cliffs which formed the narrow valley. Within the valley forest proper, very little could be heard above the sounds of the waterfalls and cascades and even that was often muffled by the dense vegetation but from outside and slightly above the valley (where my house was situated) a wide variety of bird and mammal calls could be clearly heard ampliphied by the cliffs. Calls could then be located and the specific area where they had been noted could be searched with a trip to the valley floor. This technique worked well for this species. They tended to stay high in the trees and gave group 'choruses' usually in the mornings but occasionally evenings on an approximately weekly cycle from August 14, 1979 through October 18, 1979 and from June 18, 1980 through October 14, 1980. This period of time encompassed the mid-to-end dry season up to the begining of the rains. An isolated chorus was also given on March 13, 1980. The calls seemed to be made by 2 to 5 or 6 individuals although the actual troop size when encountered in the forest ranged from 1-4. On one occasion a group of 8 was noted. The calls consisted of individual, rather high pitched cries that were generally piping yips, hoots, and trills. My impression was that the group moved up and down the valley, perhaps according to seasons, as they seemed to show up on the Vale Verde transects at about the same time both years, particularly at the end of the dry season until the rains began. The monthly totals of times troops were observed were as follows: March (1 troop), June (5), August (5), September (7), October (6).

These monkeys were not noted in either Mata Capivara or in Carumbe, the other 2 isolated valleys on the west side of the park that retained forests of roughly comparable size to Vale Verde. One juvenile (1/2-3/4 grown) was seen in October of 1979 accompaning a troop with 3 other individuals.

Cebus apella Macaco-prego

Once again, it was only in Vale Verde that these monkeys were noted. Other than occasional alarm calls directed at me, no vocalizations were noted. This species was only noted 6 times on the transects and group size varied considerably, from 2 solitary individuals to one each of groups of 2, 3, 8 and one of 12-15. My impression was that they usually stayed far up the valley. There seemed to be no pattern to their rare occurrences on the transects.

This species, too, had a reintroduction of a captive female into Vale Verde on May 17, 1980.

Xenarthra

Myrmecophaga tridactyla   *Tamananduá-bandeira*

Sign of this endangered species, in the form of damaged ant and termite nests with identifiable claw marks or feces, was noted 4 times in Caparaó, once in the transition zone, once in the scrub-grass and twice in the alpine areas. In addition, in July of 1980, I was stopped by 3 frightened campers who insisted they had just seen a big, shambling, waist-high gray 'bear' between Terreirão and the Pico in the alpine zone, an area where I had previously found flipped rocks and disturbed grassy ant nests. Although I went in immediate pursuit, I was unable to confirm the sighting but still I am reasonably sure that they did see a giant anteater.

Cabassous tatouay   *Tatú-rabo-mole*

Burrows of this species were noted twice on transects, once each in the agriculture and forest zones and one individual was captured in a nearby coffee field and removed to the park. Burrows of this species could be distinguished from ***Dasypus*** *in that they were somewhat broader than high and from* ***Euphractus*** *by their larger size. The captured individual (male) was allowed to dig several burrows for comparison to those of the other species before he was* marked and released in an ecotone area between forest and abandoned agriculture well up into the park.

In all cases, any armadillos that were seen in the park were run down either on foot or horseback and caught. They were then sexed and marked with a 3-4 inch patch of spray paint on the rump or tail. Each individual had a unique combination of color and location of patch so that they could thereafter be individually identified without recapturing them. It was important to place the paint in an area of the carapace which would have little friction when the animal burrowed. The basal 1/3 of the tail or the rump just above it to the peak of the hips seemed to work well. The paint generally lasted 2-3 months in the dry season, probably somewhat less during the rainy months. One adult female Dasypus was captured first in late April, seen on a transect in early July and then re-captured in September. Although not visible from a distance at that time, her paint color could still be seen in the cracks between her scutes. A male caught in March was seen on a transect in May with the paint still detectable through binoculars.

Euphractus sexcinctus Tatú-peludo

The six-banded armadillo was overall about 1/3 as common as the nine-banded. In addition, Euphractus was found only in the lower 2 zones and was far more common in the *agricultural areas (3.3 sign/100km) than in the forests (.25/100km). No juveniles or lactating females were noted.*

Dasypus novemcinctus *Tatú-galinha*

This species was found in all habitats of the park except the highest alpine zone. In the forest sign (tracks, scats, burrows or sightings) was found at only 5.3 per 100 km of transect while in the other three zones where they were noted they were noted at frequencies of 11.96/100km (Agriculture), .52/100km (Transition) and 1.83/100km (scrub-grass). Remains of this species were found once in regurgitated stomach contents beside the tracks of a Maned wolf in the scrub-grass zone but as there was no way to tell where it had originally been consumed (and so presumbly lived) this individual was not entered as data. Juveniles (accompanied by mother) were noted once each in March (very young), April and June while sub-adults (at least 1/2 grown and not accompanied by mother) were noted in October and December. Those caught in October were 3 young males about 1/2 grown while that in December was a solitary female about 3/4 grown. Although these data are few it would appear that, in this area, this species reproduces so that the young are born near the end of the rainy season in February or early March. Litter size ranged from I-3.

Dasypus septemcinctus — Tatú-galinha

This species, represented by a single litter of three females, was caught once in an area of abandoned agriculture. No burrows were noted on transects that would correspond to the small adult size (about 1/2 the size of D. novemcinctus) of this species. These were caught in April unaccompanied by an adult. Although these were about the same size and weight as the nine-banded juveniles that were seen in April, they were obviously physically more mature and seemed about 1/2 to 3/4 grown. If they were typical, that would put the young of this species being born nearer to the end of the dry or in the early rainy season (approximately September or October).

Lagomorpha

Sylvilagus brasiliensis — Tapeti

Sign of this species was found on transects in the agricultural, forest, transition and scrub-grass zones of Caparao. Pellets were the most common sign followed by occasional sightings. Sign densities were highest in the scrub-grass (3.66/100 km), moderate in agriculture (1.96/100 km) and transition (1.5/100km) and lowest in the forest (.75/100 km). Skulls were taken from raptor pellets 3 times and rabbit hair also occurred in 11.3% (11 out of 97) canid scats and in 8.2 (6 of 73) of felid ones. However, these latter incidents of remains in scats were not recorded as sign of rabbits on those transects where the scats were found since those predators all regularly crossed back and forth between habitat zones and, consequently, it was not possible to determine which habitat the rabbit had actually been using.

Rodentia

<u>Sciurus</u> <u>inhgrami</u> Caxinguelé

This species was seen only 3 times on transects, twice in March and once in April. Not surprisingly this squirrel was found only in the rainforest zone. It was not detected in any predator scats nor were any specimens collected in traps set in trees.

<u>Cavia</u> <u>aperea</u> Preá

This species was noted at a frequency of 3.32 per 100km of transect in areas of abandoned agriculture not counting those that lived near my house or the guard station. The latter were seen almost daily and often hourly but were not actually on transects. Still these individuals contributed information of interest. On forest transects cavies were noted at a frequency of 2.78/100km and one was seen on a scrub-grass habitat transect (.91/100km). Three individuals were found in raptor pellets, all taken during the wet season. Juveniles were noted in February and July on transects and in every month except December and January (rainy season) around the houses. On transects these animals were seen singly except for 2 (presumed females) each of which was accompanied by a juvenile although those animals that lived near the house and station seemed to be in small colonies of from 3-4 individuals up to about 10-12. On two occasions grison (Galictis vittata) were seen pursuing cavies. Both chases were in broad daylight, one being at near noon and the other at about 4 PM. Neither cavy was caught at those times as both reached shelter before the grison got to them, one under a large rock, the other in a small burrow. Both cavies were very vocal (squeals and whistles) while being chased.

This conspicuous species was not found either near the house or on the agricultural zone transects that ran through the lower Vale Verde (along Vargem Alegre and along the road that led up into the Vale Verde forest) until February of 1980. After that they steadily increased in frequency. This species appeared to be dispersing into these areas of secondary regrowth and sucessfully colonizing them.

Dasyprocta azarea or prymnolopha Acutí

As none of these animals were caught in traps allowing a detailed examination, it was not possible to tell which species was present or, perhaps, if both were. Agoutis were found infrequently on transects in the forest zone (at a frequency of 1.2/100km) and the abandoned agriculture (.33/100km). In addition, bones of a single, dried forelimb (humerus, radius, ulna, carpals, metacarpals and phalanges) were found in an area of abandoned agriculture which had forest within 50m. The skull and the rest of the body could not be located. Once again this individual was not counted as a transect point since there was doubt as to which habitat it had occupied.

<u>Coendou prehensilis</u> Cuandú-acú

This species was found on 2 occasions in the park, once remains were found in the forest of Carumbe near the stream bank and in once the scat of a cougar (<u>Felis concolor</u>). The latter was found in the transition zone and was composed of hundreds of spines of this species of prehensile-tailed porcupine. The latter incidence was not counted as a transect data point however, once again due to the inability to tell which habitat the porcupine had come from. A third individual, yet another dead one unfortunately, was brought to me by one of the local boys. They had been cutting and burning forest at the very edge of the park (abutting the Carumbe forest) and this specimen had been killed. Both of the dead individuals were too damaged to put up but their skulls were cleaned and placed with the other park voucher specimens at IBDF headquarters in Belo Horizonte, Minas Gerais.

Cricetidae

Rato-do-mato

The ecology of the park species in this family have already been discussed in the earlier sections of this manuscript. Consequently, the comments included here will be confined to those few species for which notes on reproduction or other general life history information may be available. An overall summary table of reproductive information follows:

TABLE 28

SUMMARY OF NUMBERS OF OBSERVATIONS FOR REPRODUCTIVE DATA FOR CRICETIDAE

Species	Month	Characteristic* t	l	p	j
Akodon cursor	September	2			
Oryzomys eliurus	September	2			
	May	1			
	June				1
Oryzomys flavenscens	May		1		
Akodon serrensis	July		1	2	
	September			2	
Nectomys squamipes	October			1	
Oxymycteris sp.	October				1

Characteristic:t=testes descended; l=lactating; p=pregnant; j=juvenile

Botfly larvae (genus and species unknown), were found in 2 specimens taken in Carumbé forest. One was in the single Thaptomys nigrita taken in the park (KBB# 101, female) and the other in one of the 2 Blarinomys breviceps (KBB# 96, male). These larvae were preserved in alcohol and placed with the mice from which they were collected.

Carnivora

Cerdocyon and/or Pseudoalopex Raposa, Cachorro do mato

As previously mentioned, none of these animals were actually captured (although they were occasionally seen) and could not be differentiated by tracks or scats on transects. The following comments can only be taken in a general 'fox' context and not as species specific implications, none the less, strong trends were observed. Fox sign were, overall, the most commonly observed of the carnivores in all habitats. Sign were most commonly observed in the areas of abandoned agriculture (22.5 sign/100km), were rarest in the transition (5.8/100) and were of intermediate frequencies in the other 3 zones of forest (15.9/100), scrub-grass (16.5/100) and alpine (17.1/100).

No pups were noted or other indicators of breeding season.

Chrysocyon brachyurus Lobo-guara

The endangered Maned wolf was a rare and ephemeral species in the park but definitely present as identified by scats, tracks and calls. Surprisingly, it was found in all zones except the transition although sign was most commonly encountered in the alpine zone (1.4/100km). Scats were found on 3 occasions one of which contained rabbit fur in addition to jurubeba fruit seeds, one contained only plant remains and the last contained goat hair. This scat was found on the face of Rolador where a small herd of feral goats are probably the most numerous remaining large herbivore in the park. In addition, as previously mentioned, regurgitated stomach contents which included 9-banded armadillo scutes were found next to Maned-wolf tracks. The whooping, barking cry of this species was heard on one occasion in late July, 1979 echoing from the crest of Rolador. A camper reported seeing an individual between the area of Tres Lagoas and Cristál mountain in August 1980. In September of the same year an individual came down the mountain following the main (and only) park road. The tracks were first noted near the entrance gate and Mata Burro and were backtracked for a distance of 3 km until the tracks were lost above the forest of Carumbé.

Felis yagouaroundi Gato mourisco

This was the most common felid in the park. The voucher specimen (KBB#190) was not captured during this study but was confiscated in October 1980 by the guards from a farmer on the east side of the park in the Pedra Roxa valley. This animal, a black phase male, had been recently poached from the park. Another black phase individual was seen on 3 different occasions crossing the road by the gate. In all 3 cases it was traveling from Mata Burro along a small watercourse down toward the abandoned agriculture (and, unfortunately, not far beyond are occupied farms) along the stream of the Vargem Alegre (Rio Caparaó). Jagaroundi tracks were often seen crossing the road near this point. Overall this species was found in all zones but sign was most common in the areas of abandoned agriculture (15.6/100km), scrub-grass (13.7/100km) and forest (12.9/100km) and least common in the alpine (8.5/100km) and transition zones (5.0/100km). A set of tracks that were clearly a juvenile of this species were recorded alongside those of an adult in May near Cashoiera Bonita in the transition zone.

Felis concolor Suçuarãna, Onça vermelha

Scats of this species were found twice in the park, once in the transition zone, full of the spines of a prehensile-tailed porcupine and once near the Rancho dos Cabritos in the scrub-grass. The latter contained goat hair.

Felis pardalis Jaguatirica, Gato-do-Mato

This endangered species was found in the park in all zones although those sign found in abandoned agriculture were in an area of older, denser secondary regrowth or near the margins of the forest. Sign was rarest in these old fields (.96/100km of transect) followed by transition zone (1.0/100km) and forest (3.0/100km). Ocelot sign was most common in the high elevation zones of scrub-grass (8.2/100km) and alpine (8.5/100). The pug marks of this species were easily distinguished as they were almost twice as broad (5.5cm) as those of the two smaller spotted cats _F.wiedii_ and _F.tigrinus_ (3.5cm). The scats were also larger. Ocelots were twice seen crossing the park road at night and once in the day. All three sightings were in forest habitat. In October a female which was obviously heavily lactating was seen scavenging table scraps that had been used to bait a sign-station at Terreirão in the scrub-grass zone.

A voucher specimen (KBB#191, male) was obtained in October 1980 when it was confiscated from a farmer who said it was killing chickens and he shot it as it fought with his dog. His farm is near the park in Carumbé. Unfortunately, the skin had disappeared (the farmer said his dog ate it but the guards believed he sold it illegally) but the skull was found. It was a mature individual with fully closed sutures, well developed sagittal crest and moderately worn teeth. However, the lower left molar was broken and cracked down through the root. This injury had happened while the animal was still alive since the bone was eroded, swollen and necrotic consistant with the tooth being abcessed.

Felis _wiedii/tigrinus_ Maracajá, Gato-do-mata

These two species, as mentioned earlier, could not be differentiated in tracks, scats or on sight. Consequently there was no way for to establish which one or if both were present in Caparaó. Sign were very common in the higher zones of the park (17.1/100kms for the alpine, 16.5/100km for scrub-grass), were intermediate in the forest (10.2/100km) and agricultural areas (9.6/100km) and least common (although not rare) in the transition zone (3.9/100km). An adult with one kitten following was seen by the park guards in Carumbé forest in April.

Eira barbara Irara

Tayra were found in the areas of abandoned agriculture (7.5 sign/100km) and rainforest (4.05/100km). However it should be noted that these incidents in agriculture were all margins where those areas bordered on the rainforest. Sightings during the day were the most common sign of these animals and they often occurred as pairs. No juveniles or groups larger than pairs were noted.

Galictis vittata Furao

This strikingly marked species was also often seen on transects although scats and occasional tracks were also found. Overall sign was most common in the scrub-grass and abandoned agriculture zones (8.8/100km and 5.3/100km respectively). It was recorded at a frequency of only .5/100km in the forest. As previously noted, on 2 occasions solitary grison were seen pursuing cavies and 3 individuals were observed at 11 am following along behind me robbing a trapline as I set it. They passed within 3 m and obviously saw me, one sitting up on the hind legs to get a better look (it appeared from this glance to be a female), and then ambled off seemingly unconcerned. They traveled in more or less single file, investigating stones and the bases of grass clumps as they went. They were all the same size and at least one was making a quiet, but audible, chirping purr. Yet another individual was killed in a hen house at night when it attacked the boy trying to run it off. The body was not recovered from a dog in time to salvageble.

Nasua nasua Cuatí

This was another very visible, widely distributed species in the park. Coatimundi were found in all zones but were most frequent in the forest (16.9 sign/100km) and scrub-grass (13.7/100km). They were intermediate in abandoned agriculture (7.2/100km) and lowest in the transition (2.1/100km) and alpine (2.8/100km) areas. These animals were usually noted in groups with observed troop sizes between 2 and 14 individuals. A sub-adult (1/2-3/4 grown) was noted with a troop in August. There was evidence suggesting dispersal of sub-adults may be occurring in this species at the end of the cold, dry season (July-August) when these animals would be about yearlings. I encountered or had brought to me 4 sub-adult (but almost grown) individuals during the last week of July and the first weeks of August (2 in 1979 and 2 in 1980). Three were caught (roped by 2 area muleskinners) in broad daylight with no troop in evidence. Two of these were young males traveling together in the scrub-grass zone. Both were very dark with an unusually high degree of melanism. The other was also a young male captured in an old pasture near Vale Verde. The fourth, a female, was caught in a live-trap set on the fenceline of Mata Capivara with forest on one side and pasture on the other. She had 3 infected puncture wounds, (1 on the back, 2 in the neck) that looked liked bites from an animal with about 2 inch canines. In September the partial skeleton of a sub-adult (judging by suture closings, tooth eruption and wear) that had been dead only a few weeks (from the condition of the bone and skin) brought to me and in October I found another in a similar state. Both of the latter came from the scrub-grass zone. The trapped female's wounds were treated then she was marked and released at point of capture. The male roped near Vale Verde died and was put up (KBB#134 Tt 1117mm, Tl 488mm, Hf 97mm, Er 43mm, Wt 4.95kg). The skulls and skeletal material were also placed in the mammal collection (KBB#188 and #189). The two males caught in the scrub-grass were marked and released in Mata Burro where there was no resident troop. One (recognizable by the melanistic fur pattern) was killed a few weeks later by a nearby farmer. Whether he was poached within the park or if he actually travelled that far (including crossing the river) is impossible to say. The other remained in residence in Mato Burro and was still there at the time I left Caparaó.

Procyon cancrivorous Mão pelado

The crab-eating raccoon was found in the lowest 3 zones of the park. It was most common in areas of abandoned agriculture (1.9 sign/100km), rarest in the transition zone (.26/100km) and intermediate in the forest (.75/100km). Sign of this species was never found far from water in any zone however. It is interesting to note the way this species was always near water even though the streams in Caparao were apparently devoid of any aquatic organisms for them to feed on. The water of the park was very cold and fast moving along shelves and granite boulders. A water sample was taken by the government from the Vargem Alegre river just where it left the park to test water quality for the town of Alto Caparaó and found no algae and very few micro-organisms. From my own observations I found no algae, fish, tadpoles, aquatic arthropods or snails until the stream left the park, passed through the village and into a flood plain about 3 kms below the park. There were many frogs, snails and insects in the park and several were observed to use bromeliads, hollows in trees and temporary pools for breeding, but for all the quantity of water in these mountains, it was oddly sterile to have such appeal for crab-eating raccoons.

Artiodactyla

Tayassuidae — Queixada, Caetetu

The two species of peccary possible in the area of Caparao (*Tayassu pecari* and *T. tajacu*) could also not be distinguished by tracks, scats or other sign. No peccary was captured or seen which would help with identification. Sign of these animals was confined to the transition (1.3/100km) and scrub-grass (4.5/100km) habitats. Groups appeared to have few individuals in them judging from the frequency of sign in an area when it was detected.

VITA

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Canidate for the Degree of

Doctor of Philosophy

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