Assessing the Distribution of Bird Species Richness, Diversity and Behavior and Trophic/ Taxonomic Diversity in the Tropical Forest of Central America

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Abstract

Disturbed fragmented forest increases the niche diversity which is thought to not only increase avian diversity but also influence bird behaviors, especially responses to environmental conditions, both biotic and abiotic. However, it is also thought that disturbed fragmented forest reduces the species abundance. Tropical forest avifauna from the Leaves and Lizards site, Monterrey, Costa Rica were studied during Summer, 2009 to determine whether climatic conditions, location (elevation and zonal), vegetation type and composition affects their diversity, abundance and behaviors. Behavioral patterns in response to the abiotic and biotic factors during nesting of a specific type of hummingbird species – the Green Breasted Mango were also studied.

Bird species diversity was significantly higher in the Forest edge and field habitats than in the scattered trees and ornamental plant habitats. However, differences in avian abundance among the fewer habitat types were not clear. The summer climatic conditions supported many nesting birds and hummingbird species. The Green Breasted Mango, one of the nesting birds displayed particular nesting practices and responded differently to changes in weather conditions, food availability and other birds and predators. The results are discussed in the context of geological changes in terrain of Costa Rica due to the Arenal Volcano as well as the earth's platonic shifts since the Cretaceous period.

The results highlighted the importance of forest maturity, low altitudinal position of the forests and diversity and development (cover and height) of the shrub layer for forest birds in the region.

Introduction

Disturbed fragmented forest affects adversely affects the animal species composition of a particular location. According to Biernat et al. the fragmented forest creates and isolation effect on animals which will affect their varieties and densities of species. Also, according to Gillespie and Walter (2001), there is a relationship between the habitat characteristics of floristic diversity, composition and vegetation structure and species richness. They also established that there is a relationship between disturbance and species richness where a low disturbance proves the existence of low species richness. Clough et al. (2004) persisted that the species richness of the frugivores, nectavores and to a lesser extent, the insectivores decreased with increasing distance to the forest.

This research study aimed at measuring data according to different criteria in order to determine the effects for enhancing the Meso-American forest corridor. Also, the study intends to create a continuous strip of closely connected forest in order to facilitate the migration of various species of animals in order to preserve the endemic species. In addition, the research gears at obtaining a greater understanding of the behavioral patterns of animals in response to environmental conditions, both abiotic and biotic. It is hoped that ultimately this reforestation project can reduce the fragmented nature of the forests of the western hemisphere, and increase species stability and diversity.

This study of the bird species found at Leaves and Lizards focused on the density and diversity of bird species. In addition, my objective was to continue the previous study done and detect correlations and new changes between habitat, dominant vegetation, and avian diversity and density, in order to aid in future efforts to create a favorable environment for bird populations in the area.

Materials and Methods

The study was conducted at Leaves and Lizards Volcano Retreat outside of La Fortuna, Costa Rica from May 25, 2009 to May 31, 2009, within the rainy season. The site is a hilly, tropical wet forest which is located at an elevation of approximately 500 m. It is located in close proximity to the Arenal Volcano and has been impacted historically by agriculture and grazing.

A bird census was conducted daily at fourteen point-count circles which were established during the previous bird survey in May, 26 – May 31, 2008. The bird points were

re-located and marked, with some points differing in location from the previous year. Each of the 14 locations was assigned a letter A – N and GPS data of each site was taken. In addition, the habitat characteristics of each site were examined to assess changes in percent canopy cover, dominant vegetation and proximity to buildings and water, of which a vast difference in vegetation growth was observed. Panoramic photographs were taken at each site to qualitatively document habitat changes at each location.

During daily censuring, I noted the weather conditions and any other variables that might have affected bird abundance. Bird counts were primarily conducted from 6-8 am and either from 9-10:30 am for three random days and 4-5:30 pm for three days. Point counts on each site were alternated between morning and afternoon counts in order to avoid skewing the counts of each point by consistently visiting each point at a specific time of day. As much as possible, I noted each individual bird in my field notebook along with significant data on sex, the sighting type whether visual or sound-based, habitat – where the bird was sighted, elevation of the birds sighted in meters, behaviors, family type – whether a group of the same individuals were in flocks, territorial behavior, familial groups, nesting or foraging activity, habitat use or the event of a fly-over by the birds sighted. I assigned a code to each species of bird in order to facilitate data recording. Identification of the different species was done either by auditory or visual cues.

Further, a list of many of the nests of bird species on the Leaves and Lizards property and within close proximity to the property were identified, observed, recorded and marked with blue flagging tape. Afterwards, a Trimble GPS was used to record the locations of a total of 16 bird nests, by either standing near to the bird nest and using a satellite signal to record the nest's location or by estimating the longitudinal and latitudinal distance as well as elevation and compass location of the nest from my standing position and using a series of satellite signals to locate the approximate location of the bird nest. This data was then uploaded onto the computer and the location of each nest was pinpointed on a virtual map on the class's website.

In addition to the major bird species counts and observations, a focused qualitative study was conducted on a specific specy of hummingbird – The Green-breasted Mango while it was nesting. Before conducting the study, I identified the bird's nest and marked the Laurel (Cordia alliodora) tree in which I found it. I observed and studied the nest for five days at

durations of one hour each day, alternating the times in order to obtain data for varying times of the day. For three days, I studied the Green-breasted Mango hummingbird (*Anthracothorax prevostii*) from 11-12 am and two days, I studied it from 2:30-3:30 pm. This was done in order to prevent skewing the results to one time of day. I recorded the general nesting behavior of the Green-breasted Mango – its territorial behavior, practices during different times of day in accordance with the changing weather patterns and other general nesting practices. I recorded my observations in a 6 ten minute intervals in my field notebook.

At the end of the collection period, all the data was sorted and calculated, the Shannon diversity indices for each count site were calculated, as well as relative avian family densities and distribution within each avian family. The avian data was combined with the habitat data collected by the mapping and tree units and avian diversity was compared to the habitat type. Also, the number of individuals per family and relative density per family was compared. In addition, the bird nests were examined and discussed in relation to their location in terms of elevation, habitat types and surrounding circumstances. The data from the hummingbird observations were analyzed and discussed in terms of responses to ecological circumstances for the hummingbirds.

Results

General Bird Data

Over the course of the study, 82 species of birds belonging to 26 avian families were observed at the field site. The total number of individual birds sited was 1,612. Table 1 illustrates a thorough list of the species sited as well as their families, number of individuals sited and the relative density of each species. The most abundant species on the property were the Turkey Vulture (139), Blue Gray Tanager (115), Orange-chinned Parakeet (81), Rufous-tail hummingbird (86), Crimson-fronted Parakeet (67) and Clay Colored Robin (62). The least abundant species are the Three-wattled Bellbird, Gray Hawk, White-fronted Parrot, Brown-hooded Parrot, Squirrel Cuckoo, Long tail Barbthroat, Black-crested Coquette, Lineated Woodpecker, Collared Aracari, Slaty Spinetail, Yellow bellied Elaenia, Yellow-tailed Oriole, Scarlet thighed Dacnis and Melodius Blackbird.

Figure 1 illustrates the number of individuals of each avian family that were sighted. The chart shows that *Thraupidae, Tyrannidae, Psittacidae, Emberizidae, Trochilidae* and

Cathartidae have the largest species abundance sighted on the property. Likewise, Figure 2 proves that these same families have the highest relative densities of all the avian families observed. On the other hand, *Cotingidae, Ardeidae*, *Funariidae, Cracidae, Falconidae*, and *Tityridae* have the lowest species abundance. Likewise, Figure 2 shows that these same families have the lowest relative densities.

Varying numbers of individuals and species were sighted at each bird point. Table 2 illustrates the number of individuals of each bird species that were sighted during the census. Bird Point H (182) recorded the most number of individuals whereas point L recorded the lowest (65). However, even though Point N was among the bird points with the lowest number of individuals, it had the highest bird species diversity compared to the other points for example, bird point A which has a species diversity of only 15.77.

Each bird point possessed unique characteristics that allowed it to be a suitable habitat for birds. Table 3 displays the bird diversity and habitat attributes that are unique to each bird point surveyed. Each bird point has a habitat composition of either being a forest edge, scattered trees, ornamental plants, field or a mixture of two or more of these. The most species were observed at point N (17) and E (17) whereas the least number of species were observed at point D and L (9 species each). Points F and H had the largest number of individuals (182 and 157 respectively) whereas points L and K have the lowest (65 and 67 respectively). Each bird point consists of different combinations of vegetation, whether it is acacia, laurel, grass, balsa or ornamental vegetation. In addition, Figure 3 illustrates the species diversity of each site, where point N has the largest species diversity as well as point I. Points C, F and K all has the lowest diversity. Further, Figure 4 displays the species abundance at each site. Again Point N and E has the largest species diversity, whereas point C and L have the lowest.

The field site comprised of many different habitat types. Figure 5 displays the diversity of these habitats. There are significantly much more forest edge, field and forest than they are scattered trees and ornamental plants. Likewise, Figure 6 displays the average sightings at each of the habitat types. Again, the forest edge projected a significantly higher number of sightings compared to the other bird points. The number of sightings in the field and forest are the same. However, ornamental plants and scattered trees continue to project lower sightings of birds. Different bird species prefer different habitat types depending on their food, mating and nesting preferences. Figure 7 illustrates the distribution of the individuals according to their

families and preferred habitat types. The Coerebidae prefers the forest edge and field which seems to be high in demand as a home for other birds as well such as the Trogonidae and Mimidae. The species belonging to the family Psittacidae prefers the forested areas. In addition, all the other habitat choices exist in fairly small amounts.

Nesting Birds

The summer season is a very good nesting season for many of the birds which were themselves or their nests were observed and located and recorded using a GPS device. Table 4 illustrates all the nesting birds, their latitudinal and longitudinal locations, tree type where the nests were found and the elevation where they were located. The most nests were made by woodpeckers. In addition the Laurel, followed by the porro seems to be the preferred nesting site for many of the birds. Most of the nesting elevations were particularly low even though the prominent trees are very tall.

Observations – Green Breasted Mango

During the study, a particular nesting bird was observed for five days. All the Tables under Table 5 displays detailed information about the behaviors and practices of the Green breasted Mango during it's nesting season. The Green Mango responds differently to changes in weather patterns and threats. When it is fairly sunny, the Green Mango will sit in its nest and forage for food. When it is cold or raining, the bird will stay in the nest and avoid foraging. The Green Mango is also very vicious to other birds since it chases away all the birds in the tree. The bird takes the security of its young very seriously since it surveys the nest and the entire tree before it leaves and when it returns.

Conclusions

The highest diversity at Leaves and Lizards was found to be within the terrain of the Forest Edge (Figure 5). This indicates a possible relation between height diversity and species diversity. The differences in foliage height provides a variation in habitat characteristics which offers more in terms of accommodation of a bird's needs for food, nesting, place, mate and shelter. The different foliage heights offer a wide variety of birds a wide variety of foods. Insectivores can obtain insects from the ground layer. Frugivores can obtain fruits from the fruit bearing plants and seed eaters and nectivores can obtain seeds, grains and nectar. Thus bird diversity increases. However, an increase in bird diversity does not necessarily mean that

there is an increase in abundance. Even though bird diversity may be high in some areas, the abundance of the birds may not necessarily be high (Figure 3). Even though Point N which is located on the forest edge has the largest diversity, it registers among the least number of sighted individuals. Point G is a Field habitat and has among the smallest diversities. However, it registers much more individuals than point N. Therefore, bird abundance is not significantly influenced by the diversity of the animal species. Habitat size and behavioral patterns tend to influence the abundance of an area according to Watson (2002). The smaller the habitat size, the less numbers of individuals of birds will be able to inhabit the area, even more so due to behavioral patterns, for which many birds are primarily territorial. In addition, there will be competition for many of the resources the bird desires or needs. For Watson, fragment shape, area, and vegetation are key determinants of species richness. Therefore, even if there is a large diversity of birds in a particular area, there may not be many individuals since organisms, like plants, need space and small spaces cannot accommodate large number of individuals. Birds may visit the field often because it is mainly open land and is a good source of insects and seeds. However, the diversity may not be as high as the forest edge habitat because the fields are restricted to only providing some of the needs of some birds such as a few food varieties and occasional nesting. Also, the field is restricted to be a ground layer habitat with few shrubs. While it may receive visits from more birds, it cannot act as a support of shelter or nesting site for many of the birds. Compared to Miller, Biernat and Smith (2008) who conducted a similar study to this one, the abundance levels and diversity levels are not in correlation to each other. In their study, the forest edge had most individuals as well as the highest diversity. This year it is different and the reasons given before may be the explanations for the phenomena. Compared to Biernat et al. the lowest families with the highest number of individuals sighted had individuals that belonged to the forest edge habitat. This may be due to the maturity changes over the year in the vegetation of the property. More data is needed to fully understand why the birds with high diversities have low abundances.

The families with the highest frequencies observed within the property have been known to frequent habitats like forest edge and scattered trees. The family *Thraupidae* had the highest relative density of all the families seen on the property (Figure 2). This high density was not expected because the family *Tyrannidae i*s “the largest avian family confined to the Western Hemisphere” (Stiles and Skutch, 1989). Thraupidae (Tanagers, Euphonias and Seedeaters) contrasts with Biernat et. Al. whose study proves that Tyrannidae is the most

popular birds specy on the same site. The differences this year may be due to climatic changes, shifts in migration patterns or even, survival fitness (Figure 5). Within the family *Thraupidae*, the species *Traupis episcopus* (Blue-gray Tanagers) had the highest density. This confirms that blue-gray tanagers seek fields and scattered trees in order to forage on small insects, berries and fruits. These conditions were prevalent throughout the property. The second highest density (Table 1 and 3) within the family is the *Cyanerpes cyaceus* (Red-legged Honeycreeper) who is known to seek any shrubs where flowers persist in order to obtain nectar and also probe leaves and barks for small insects that may lurk around. The higher density of the Blue-gray Tanagers over the Red-legged Honeycreeper could result from a larger area of scattered trees and shrubs rather than scrubs and boarders of forest or from the prevalence of smaller insects rather than nectar where no flower shrubs are abundant. In order to understand this trend, further information is needed. According to *Biernet et. Al*, Future research can analyze the types of insects and incest density found throughout different habitats within the property to explain this trend and also calculate the total area of each different habitat to see which one has the highest area.

Two families share the second highest density namely *Tyrannidae* (flycatchers) and *Columbidae* (Pigeons and doves). The vegetation growth and the tropical conditions can explain the reasons for these two families of birds to exist in the same density. *Tyrannidae* birds prefer the tropical climate and a lot of tall trees which is found on the property. The availability of low shrubs and seeds provide a good habitat for these birds because they prefer these conditions. Some of these birds were also seen flocking together in small groups on occasion. Since the bird species that tended to flock the most was the Turkey vultures, the flocking habits of many of the birds seen this year may be primarily for safety purposes. Within in the *Tyrannidae* family, the species *Todirostrum cinereum* (Common Tody Flycatcher) has the highest density of 0.0366. This may be as a result of the open fields that contain a lot of scrubs and boarders which the Common Tody Flycatcher is known to probe in order to seek out small insects, wasps and bees. This specy of bird prefers habitats of second growth, agricultural fields and forest edge. Within the *Columbidae* family, the Ruddy Ground Dove had the highest density. This can attribute to the dove's food preferences which include foraging low shrubs for seeds and insects. This has also been a very frequent phenomenon at the site. What is interesting is that even though the two families share the same density, the *Tyrannidae*

family has higher species diversity than the *Columbidae* family which has a higher abundance even though it just registers three species of birds.

The nesting birds also produced a lot of very interesting data. The most common nesting bird observed is the woodpecker (Table 4). A lot of the birds preferred a low elevation in which to create their nests. Many of the nesting birds also chose to create their nests at high elevations. This is also because of the far reach out of the way of predators as well as a good site for large birds to spot prey or other food sources. This can be attributed to the close proximity to food supplies and concealment from predators. Also, the two most preferred vegetation types are the laurel and porro trees. This can be attributed to their sturdiness and strength in supporting a nest for the desired period of time. An interesting observation of the Common Tody flycatcher, is that it made a large nest for such a small bird. This may be due to security reasons but more information is needed in order to determine this. The close observation into the hummingbird nesting practices revealed a lot about bird behavior. The behavioral study of the Green Breasted Mango revealed important information about the activities and practices of the hummingbirds and all birds in general while their nesting. A rather interesting observation about the Mango bird is that during the entire study, the only parent that attended the eggs was the male. In each observation the male foraged, surveyed the grounds for security and incubated the eggs. The Mango bird is an extremely territorial bird. The entire laurel tree on which it nested was free of other birds and it prevented or chased away other birds from the nest. It has an interesting way of chasing away birds. As observed with the dove, it never comes into contact with the dove physically. This may be due to size difference and intimidation. However, more studies should be done to determine this. The bird also responds differently to climatic conditions and biological circumstances such as food unavailability. When it rains, the Mango bird makes its duty to ensure there is enough shelter from just two leaves on a branch above. The constant probing and surveying habits of the Mango bird ensures its comfort and security respectively. It also seems to have a systematic or routine way of carrying out its activities. From what was observed, it will forage many times during the mornings and forage less and incubate and guard the eggs more in the afternoon, while singing a calm two note sound to warn other birds that this is his territory. All these protective measures are for it and its offspring’s ensured survival. Many more research studies can be done to determine and investigate in more detail the behaviors of the Mango bird. This will be helpful in order to assess behavioral patterns in many different circumstances.

The implementation of some management prescriptions could increase the use of trees by birds, especially forest-dependent species, in the Tropical Dry Forest. Such prescriptions may include conservation of large forest remnants into productive areas to serve as sources of forest species. The conservation and restoration of the ecological forest belts is necessary to provide suitable habitat for many bird species and increase connectivity between forest remnants at the landscape scale. The preservation of native understory and tree regeneration inside plantations are important because they provide food and refuge for many bird species. In general, protection of trees in forests is critical for birds. In addition, I recommend that more studies be conducted on this site in order to keep track of the changes in density and diversity which can subsequently give more information about why the birds exhibit irregular practices and behaviors and migration patterns.

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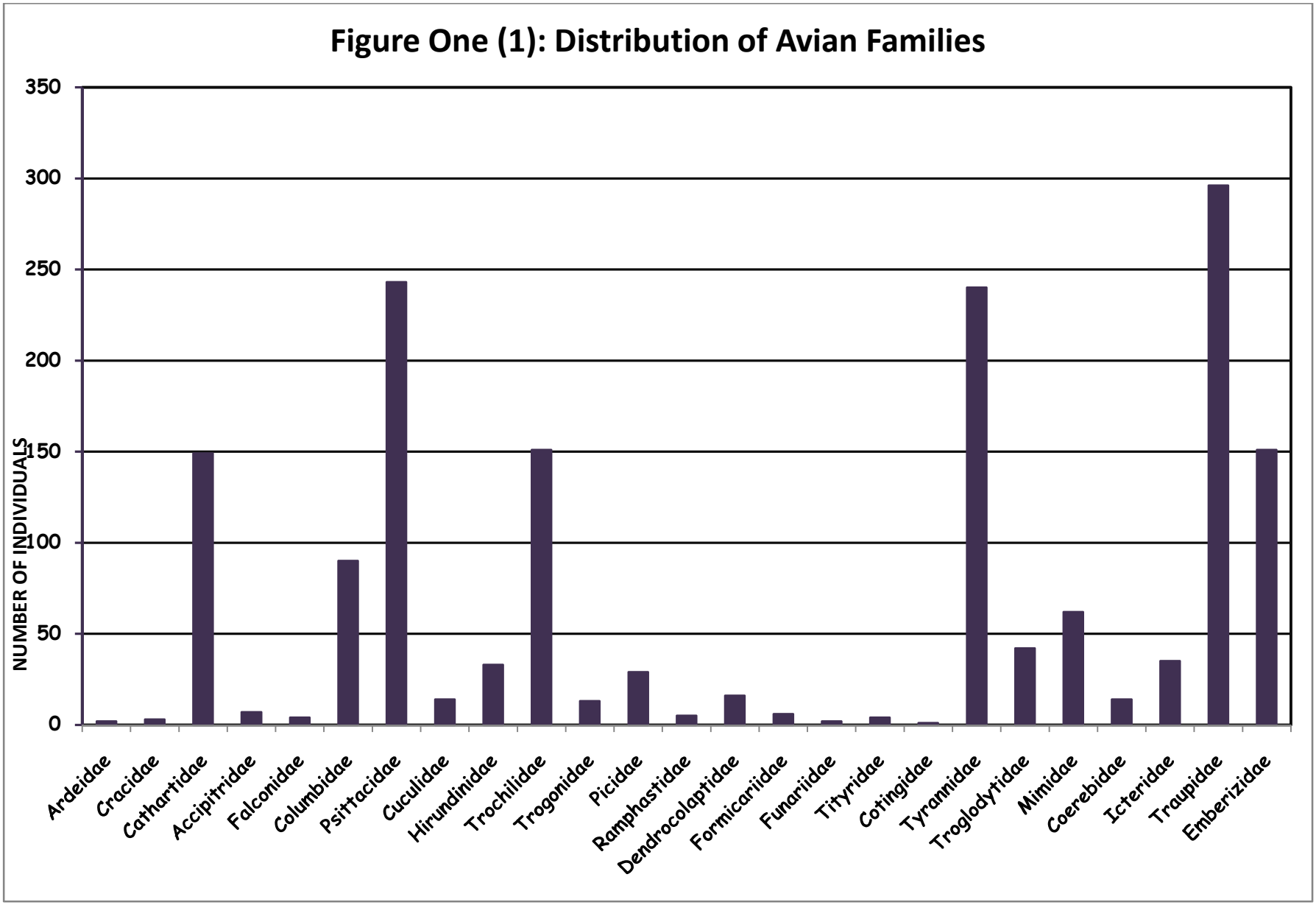
Table One: Bird Species Observed at Leaves and Lizards during Censusing May 2009

FAMILY	SPECIES	CODE	#	RELATIVE DENSITY
Ardeidae	Egret, Great	ETgt	2	0.00012
Cracidae	Guan, Crested	GNcr	3	0.00018
Cathartidae	Vulture, Turkey	VTtk	139	0.08620
Cathartidae	Vulture, Black	VTbk	10	0.00062
Accipitridae	Kite, American Swallow-tailed	KTst	5	0.00031
Accipitridae	Hawk, Gray	HKgy	2	0.00124
Falconidae	Falcon, Laughing	FClg	4	0.00235
Columbidae	Pigeon, Red-billed	PGrb	37	0.02295
Columbidae	Dove, Ruddy Ground	DVrg	46	0.02853
Columbidae	Dove, White-tipped	DVwt	7	0.00434
Psittacidae	Parrot, Red-lored	PRrl	26	0.01612
Psittacidae	Parrot, White fronted	PRwf	2	0.00124
Psittacidae	Parrot, White crowned	PRwc	44	0.02729
Psittacidae	Parrot, Brown-hooded	PRbh	2	0.00124
Psittacidae	Parakeet, Crimson-fronted	PRcf	67	0.04156
Psittacidae	Parakeet, Olive-throated	PRot	21	0.01303
Psittacidae	Parakeet, Orange-chinned	PRoc	81	0.05025
Cuculidae	Cuckoo, Squirrel	CKsq	2	0.00124
Cuculidae	Ani, Groove-billed	ANgb	12	0.00744
Hirundinidae	Swallow,Northern Ruff-wing	SWrw	33	0.02047
Trochilidae	Hermit, Long-tailed	HTlt	2	0.00124
Trochilidae	Barbthroat, Band-tailed	BTbt	2	0.00124
Trochilidae	Hummingbird, Scaly-breasted	HBsb	3	0.00186
Trochilidae	Mango, Green-breasted	MNgb	35	0.02171
Trochilidae	Fairy, Purple-Crown	FRpc	3	0.00186

Trochilidae	Jacobin, White-necked	JBwn	5	0.00310
Trochilidae	Hummingbird, Rufous-tailed	HBrt	86	0.05334
Trochilidae	Coquette, Black-crested	CQbc	2	0.00124
Trochilidae	Hummingbird, Violet-headed	HBvh	13	0.00806
Trogonidae	Trogon, Violaceous	TGvl	13	0.00806
Picidae	Woodpecker, Lineated	WPlt	2	0.00124
Ramphastidae	Aracari, Collared	ACcr	2	0.00124
Ramphastidae	Toucan, Chestnut-mandibled	TCcm	3	0.00186
Picidae	Woodpecker, Golden-olive	WPgo	6	0.00372
Picidae	Woodpecker, Smoky-brown	WPsb	5	0.00310
Picidae	Woodpecker, Black-cheeked	WPbc	13	0.00806
Picidae	Piculet, Olivaceous	PCov	3	0.00186
Dendrocolaptidae	Woodcreeper, Streak-headed	WCsh	12	0.00744
Dendrocolaptidae	Woodcreeper, Black-striped	WCbs	4	0.00248
Formicariidae	Antshrike, Barred	ASbr	6	0.00272
Funariidae	Spinetail, Slaty	STst	2	0.00124
Tityridae	Tityra, Masked	TYmk	4	0.00248
Cotingidae	Bellbird, Three-wattled	BBtw	1	0.00062
Tyrannidae	Kingbird, Tropical	KBtp	20	0.01241
Tyrannidae	Flycatcher, Piratic	FCpt	33	0.02047
Tyrannidae	Flycatcher, Great Kiskadee	FCgk	34	0.02109
Tyrannidae	Flycatcher, Social	FCsc	58	0.03598
Tyrannidae	Flycatcher, Dusky-capped	FCdc	10	0.00620
Tyrannidae	Pewee, Tropical	PWtp	16	0.00993
Tyrannidae	Flycatcher, Common Tody	FCct	59	0.03660
Tyrannidae	Tyrannulet, Yellow-crowned	TNyc	8	0.00496
Tyrannidae	Elaenia, Yellow-bellied	ENyb	2	0.00124
Troglodytidae	Wren, Banded-back	WNbb	9	0.00558
Troglodytidae	Wren, House	WNhs	33	0.02047
Mimidae	Robin, Clay-colored	RBcc	62	0.03846

Coerebidae	Bananaquit	BQ	14	0.00868
Icteridae	Oriole, Yellow-tailed	OLyt	2	0.00124
Icteridae	Oropendola, Montezuma	OPmz	11	0.00682
Icteridae	Cowbird, Bronzed	CBbn	20	0.01241
Thraupidae	Euphonia, Yellow-crowned	EHyc	13	0.00806
Thraupidae	Euphonia, Yellow-throated	EHyt	8	0.00496
Thraupidae	Euphonia, Tawny-capped	EHtc	3	0.00186
Thraupidae	Tanager, Blue and gold	TGbg	3	0.00186
Thraupidae	Tanager, Palm	TGpm	28	0.01737
Thraupidae	Honeycreeper, Red-legged	HCrl	43	0.02667
Thraupidae	Dacnis, Scarlet-thighed	DNst	2	0.00124
Thraupidae	Honeycreeper, Green	HCgn	4	0.00248
Thraupidae	Tanager, Golden-hooded	TGgh	25	0.01551
Thraupidae	Tanager, Blue-gray	TGbg	115	0.07134
Thraupidae	Tanager, Crimson-collared	TGcc	16	0.00993
Thraupidae	Tanager, Scarlet rumped	TGsr	37	0.02295
Emberizidae	Saltatore, Black-headed	STbh	9	0.00558
Emberizidae	Saltatore, Buff-throated	STbt	17	0.01055
Emberizidae	Saltatore, Grayish	STgy	14	0.00868
Emberizidae	Grosbeak, Blue-black	GBbb	3	0.00186
Emberizidae	Seedeater, White-collared	SEwc	27	0.01675
Emberizidae	Seedeater, Variable	SEvr	59	0.0.0366
Emberizidae	Grassquit, Yellow-faced	GQyf	6	0.00372
Emberizidae	Grassquit, Blue-black	GQbb	4	0.00248
Emberizidae	Seedeater, Blue	SEbl	6	0.00372
Emberizidae	Sparrow, Black-striped	SWbs	6	0.00372
Icteridae	Blackbird, Melodius	BBmd	2	0.00248

Figure One (1): Distribution of Avian Families



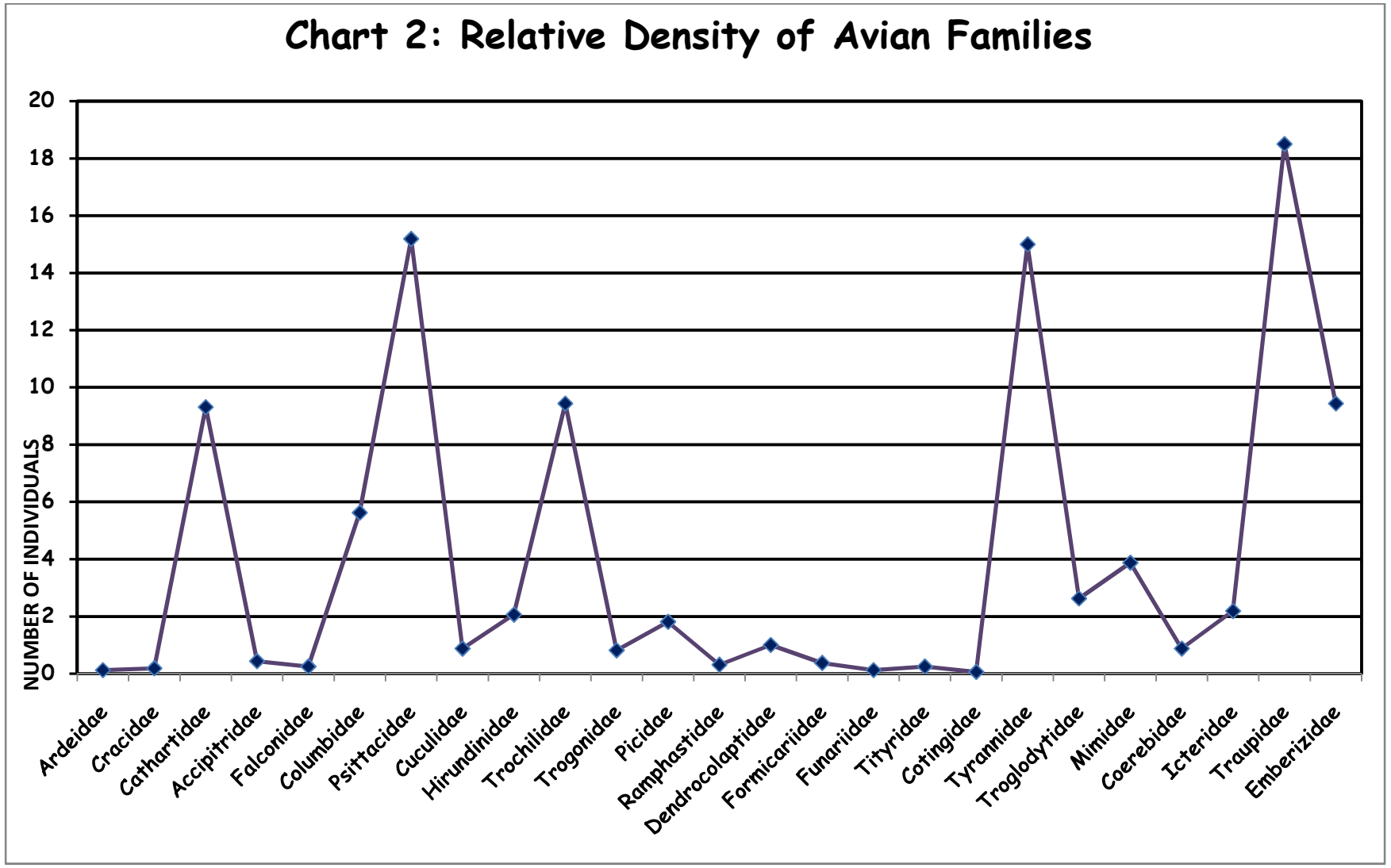


Chart 2: Relative Density of Avian Families
NUMBER OF INDIVIDUALS
20
18
16
14
12
10
8
6
4
2
0
Ardeidae
Cracidae
Cathartidae
Accipitridae
Falconidae
Columbidae
Psittacidae
Cuculidae
Hirundinidae
Trochilidae
Trogonidae
Picidae
Ramphastidae
Dendrocolaptidae
Formicariidae
Funariidae
Tityridae
Cotingidae
Tyrannidae
Troglodytidae
Mimidae
Coerebidae
Icteridae
Traupidae
Emberizidae

Table 2: Total Number of Individuals for Each Bird Species at Each Site

Family	Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	TOTAL
Ardeidae	Egret, Great	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Cracidae	Guan, Crested	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Cathartidae	Vulture, Turkey	0	2	1	7	0	57	0	60	8	0	1	2	0	1	139
Cathartidae	Vulture, Black	0	1	0	2	0	0	0	4	0	0	0	0	0	3	10
Accipitridae	Kite, American Swallow-tail	0	0	0	0	2	0	0	0	0	0	0	0	2	1	5
Falconidae	Falcon, Laughing	0	0	1	0	0	0	0	0	0	0	0	0	2	1	4
Accipitridae	Hawk, Gray	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Columbidae	Pigeon, Red-billed	7	4	5	4	4	1	4	0	0	4	0	0	4	0	37
Columbidae	Dove, Ruddy Ground	0	2	5	0	0	2	9	8	10	8	2	0	0	0	46
Columbidae	Dove, White-tipped	0	0	0	2	0	0	0	0	0	3	0	0	2	0	7
Psittacidae	Parrot, Red-lored	3	2	0	10	0	6	0	0	0	0	0	0	5	0	26
Psittacidae	Parrot, White fronted	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
Psittacidae	Parrot, White crowned	17	0	0	0	4	0	9	0	0	0	0	0	12	2	44
Psittacidae	Parrot, Brown-hooded	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Psittacidae	Parakeet, Crimson-fronted	19	0	3	12	0	8	10	0	7	4	0	0	0	4	67
Psittacidae	Parakeet, Olive-throated	1	0	0	13	0	0	0	5	0	0	2	0	0	0	21
Psittacidae	Parakeet, Orange-chinned	0	0	25	12	8	0	0	13	12	2	0	6	3	0	81
Cuculidae	Cuckoo, Squirrel	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2
Cuculidae	Ani, Groove-billed	0	0	0	0	0	0	4	0	1	0	0	0	4	3	12
Hirundinidae	Swallow,Northern Ruff-wing	0	2	0	0	2	4	9	5	2	0	3	0	1	5	33
Trochilidae	Hermit, Long-tailed	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Trochilidae	Barbthroat, Band-tailed	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2
Trochilidae	Hummingbird, Scaly-breasted	0	1	0	0	0	0	0	0	2	0	0	0	0	0	3
Trochilidae	Mango, Green-breasted	0	0	1	0	3	0	2	0	9	10	6	3	0	1	35
Family	Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	TOTAL
Trochilidae	Fairy, Purple-Crown	0	1	0	0	0	0	0	1	0	0	0	0	1	0	3
Trochilidae	Jacobin, White-necked	2	0	1	0	0	0	0	0	2	0	0	0	0	0	5

Trochilidae	Hummingbird, Rufous-tailed	6	6	10	11	3	9	8	5	13	9	0	3	3	0	86
Trochilidae	Coquette, Black-crested	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2
Trochilidae	Hummingbird, Violet-headed	1	0	2	0	0	3	0	0	4	0	0	1	0	2	13
Trogonidae	Trogon, Violaceous	0	0	1	4	6	2	0	0	0	0	0	0	0	0	13
Picidae	Woodpecker, Lineated	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Ramphastidae	Aracari, Collared	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Ramphastidae	Toucan, Chestnut-mandibled	0	1	0	0	2	0	0	0	0	0	0	0	0	0	3
Picidae	Woodpecker, Golden-olive	2	0	0	0	0	1	0	0	0	0	0	1	1	1	6
Picidae	Woodpecker, Smoky-brown	2	0	1	0	0	0	0	0	0	0	0	0	0	2	5
Picidae	Woodpecker, Black-cheeked	1	0	0	0	3	4	0	0	0	0	1	1	0	3	13
Picidae	Piculet, Olivaceous	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Dendrocolaptidae	Woodcreeper, Streaked-headed	3	0	0	3	4	0	0	1	0	0	0	0	0	1	12
Dendrocolaptidae	Woodcreeper, Black-striped	0	0	0	0	0	0	1	0	0	0	0	0	0	3	4
Formicariidae	Antshrike, Barred	0	1	0	0	0	0	0	0	0	0	5	0	0	0	6
Funariidae	Spinetail, Slaty	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Tityridae	Tityra, Masked	1	0	0	0	0	0	0	0	0	1	0	0	0	2	4
Cotingidae	Bellbird, Three-wattled	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Tyrannidae	Kingbird, Tropical	0	0	1	0	0	2	0	1	0	5	0	3	8	0	20
Tyrannidae	Flycatcher, Piratic	2	0	4	1	0	5	0	8	0	6	0	3	4	0	33
Tyrannidae	Flycatcher, Great Kiskadee	0	0	0	5	2	5	3	4	3	8	0	3	1	0	34
Tyrannidae	Flycatcher, Social	8	10	2	0	0	10	2	5	4	4	3	5	0	5	58
Tyrannidae	Flycatcher, Dusky-capped	3	0	0	0	0	0	3	0	0	4	0	0	0	0	10
Tyrannidae	Pewee, Tropical	0	0	0	0	0	0	7	4	0	0	5	0	0	0	16
Tyrannidae	Flycatcher, Common Tody	6	3	4	8	9	3	0	2	6	2	4	6	4	2	59
Tyrannidae	Tyrannulet, Yellow-crowned	0	1	0	2	0	0	1	0	0	0	2	0	0	2	8
Family	Species	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	TOTAL
Tyrannidae	Elaenia, Yellow-bellied	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2
Troglodytidae	Wren, Banded-back	3	0	0	0	2	0	0	0	0	0	0	2	1	1	9
Troglodytidae	Wren, House	0	1	0	0	7	4	7	3	6	5	0	0	0	0	33
Mimidae	Robin, Clay-colored	7	6	11	2	5	2	0	0	2	10	3	4	5	5	62

Coerebidae	Bananaquit	1	2	4	0	0	0	0	0	4	0	0	0	0	3	14
Icteridae	Oriole, Yellow-tailed	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2
Icteridae	Oropendola, Montezuma	2	1	4	0	0	0	0	0	0	3	0	1	0	0	11
Icteridae	Cowbird, Bronzed	0	3	1	0	0	3	0	6	0	0	0	2	5	0	20
Thraupidae	Euphonia, Yellow-crowned	0	2	1	2	3	0	2	1	0	0	0	0	2	0	13
Thraupidae	Euphonia, Yellow-throated	0	2	1	0	3	0	0	0	0	2	0	0	0	0	8
Thraupidae	Euphonia, Tawny-capped	0	1	0	0	0	0	0	2	0	0	0	0	0	0	3
Thraupidae	Tanager, Blue and gold	1	0	0	0	0	0	0	0	0	0	0	0	0	2	3
Thraupidae	Tanager, Palm	5	0	1	0	0	0	3	4	0	4	0	2	6	3	28
Thraupidae	Honeycreeper, Red-legged	8	3	0	2	5	0	2	1	0	0	8	2	4	8	43
Thraupidae	Dacnis, Scarlet-thighed	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Thraupidae	Honeycreeper, Green	3	1	0	0	0	0	0	0	0	0	0	0	0	0	4
Thraupidae	Tanager, Golden-hooded	1	4	0	3	7	0	0	1	3	0	0	2	0	3	24
Thraupidae	Tanager, Blue-gray	9	17	12	7	6	0	17	11	5	9	7	6	4	5	115
Thraupidae	Tanager, Crimson-collared	0	0	4	0	0	0	7	0	0	3	0	0	2	0	16
Thraupidae	Tanager, Scarlet rumped	0	8	8	3	0	3	1	2	0	5	0	1	6	0	37
Emberizidae	Saltatore, Black-headed	0	0	3	2	0	0	0	0	0	0	4	0	0	0	9
Emberizidae	Saltatore, Buff-throated	4	1	0	0	0	2	2	1	1	0	1	3	0	2	17
Emberizidae	Saltatore, Grayish	1	0	3	0	0	0	0	5	0	0	3	0	0	2	14
Emberizidae	Grosbeak, Blue-black	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Emberizidae	Seedeater, White-collared	0	5	0	0	2	7	0	6	4	0	3	0	0	0	27
Emberizidae	Seedeater, Variable	7	5	2	5	5	10	2	9	3	7	1	0	2	1	59
Emberizidae	Grassquit, Yellow-faced	0	0	0	0	4	1	0	0	1	0	0	0	0	0	6
Family	Species	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	TOTAL
Emberizidae	Grassquit, Blue-black	0	0	0	0	0	0	3	0	0	0	0	0	0	1	4
Emberizidae	Seedeater, Blue	0	0	0	0	0	0	3	1	0	2	0	0	0	0	6
Emberizidae	Sparrow, Black-striped	0	5	0	0	0	0	1	0	0	0	0	0	0	0	6
Icteridae	Blackbird, Melodius	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2
Total Number of Individuals		138	105	125	122	105	157	129	182	115	122	67	65	97	83	1612
Species Diversity of Site		15.77	21.37	14.26	23.88	30.77	12.27	27.82	23.44	36.87	24.04	13.94	22.59	24.44	42.87	

Table 3: Bird Diversity and Habitat Attributes at Each Point Location sampled during Censusing May 2009

SITE	HABITAT	# SPECIES	# INDIVIDUALS	DIVERSITY	DOMINANT VEGETATIONS	PROX. OF BUILDINGS (M)	PROX. OF WATER (M)	COMMENTS
A	Forest edge	13	138	15.77	Balsa, Rubber, Laurel	50 30	>50 25	Semi-road
B	Scattered trees, Ornamental plants	14	105	21.37	Balsa, Laurel Banana	>50	>50	Visually distinct from b
C	Forest edge	14	125	14.26	Acacia, Balsa	>50	>50	Near boundary, near new building site
D	Forest edge	9	122	23.88	Almendro, teak, Orange	>50	>50	Near a new building site
E	Field	17	105	30.77	Grass, laurel	>50	>50	
F	Field	14	157	12.82	Grass, laurel	>50	>50	
G	Scattered trees, Ornamental plants	11	129	27.82	Balsa, Poro, Laurel	15	>50	
H	Scattered trees, Ornamental plants	13	182	23.44	Grass, laurel, Ornamental	20	>50	Hill peak
I	Ornamental plants	12	115	36.87	Ornamental,	15	>50	House
J	Field	11	122	24.04	Grass, Laurel	>50	>50	Springs Laurel
K	Forest edge	10	67	13.94	Laurel, Acacia	>50	30	
L	Forest edge Field	9	65	22.59	Grass, Acacia	>50	45	Laurel
M	Forest edge Field	13	97	24.44	Grass, Acacia	>50	25	
N	Forest edge	17	83	42.87	Bamboo, laurel	>50	40	Lots of trees

Figure 4: Species Abundance at Each Site

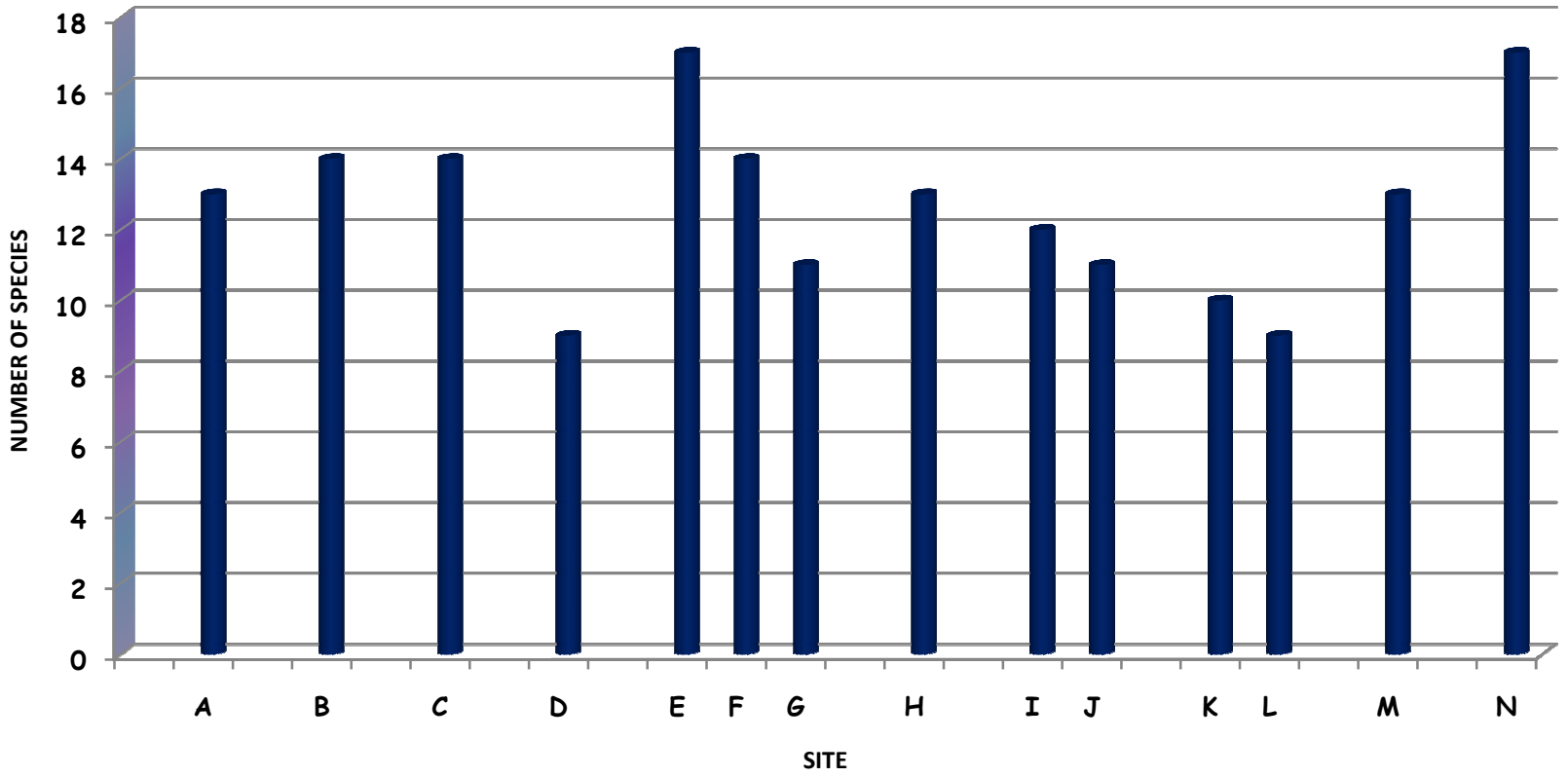


Figure 3: Species Diversity Observed at each Site

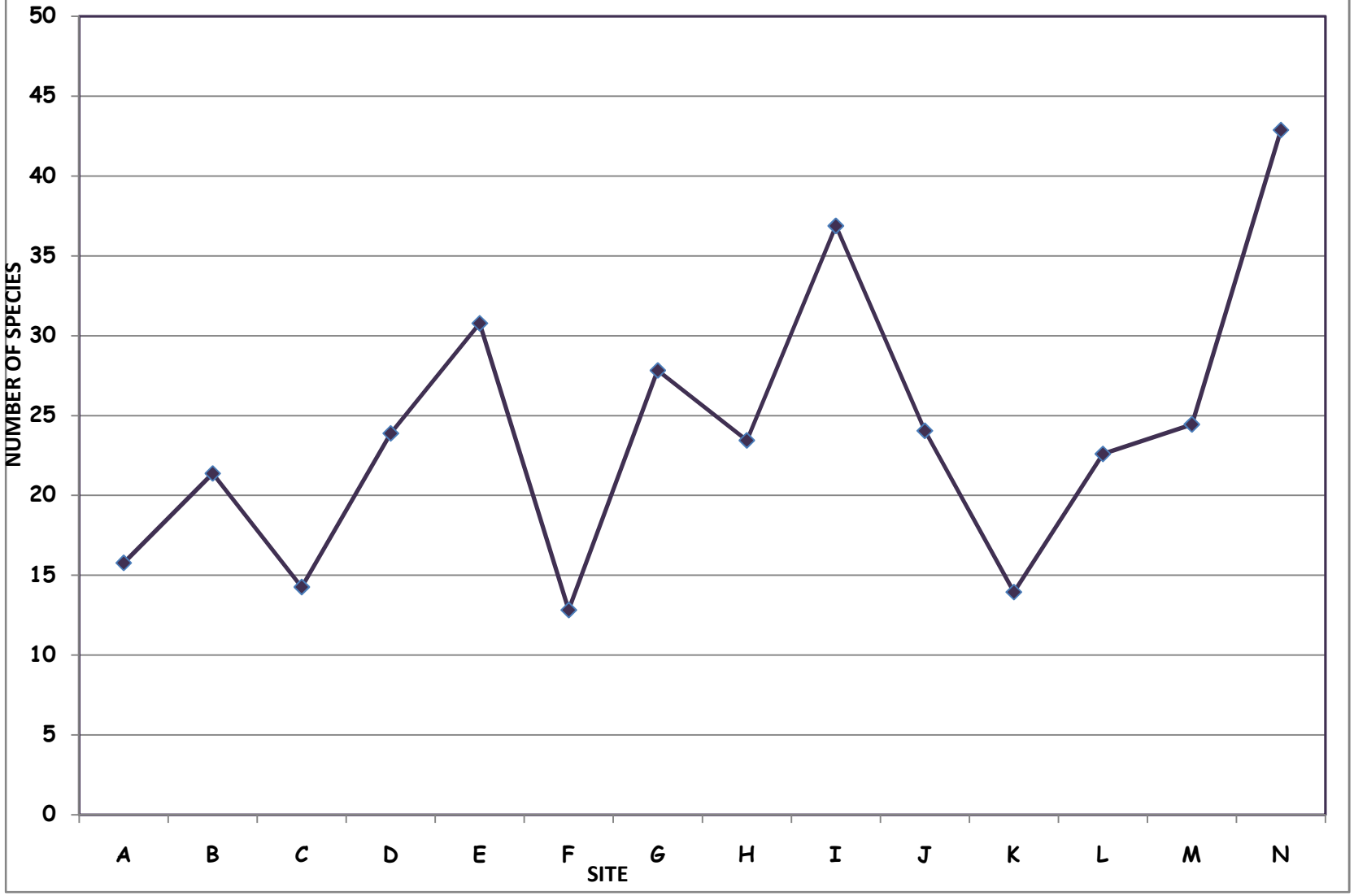
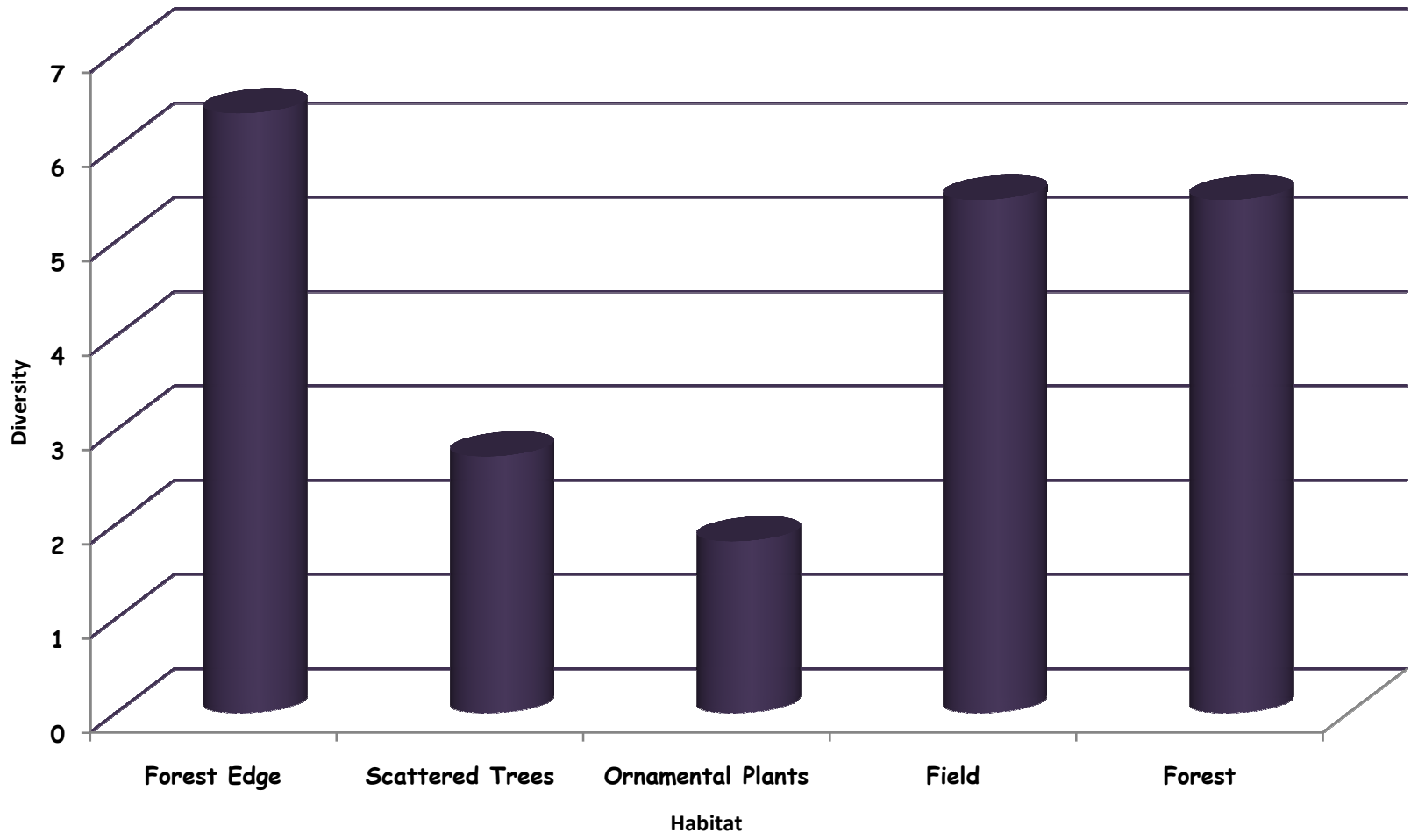


Figure 5: Average Diversity of Observed Habitat Types



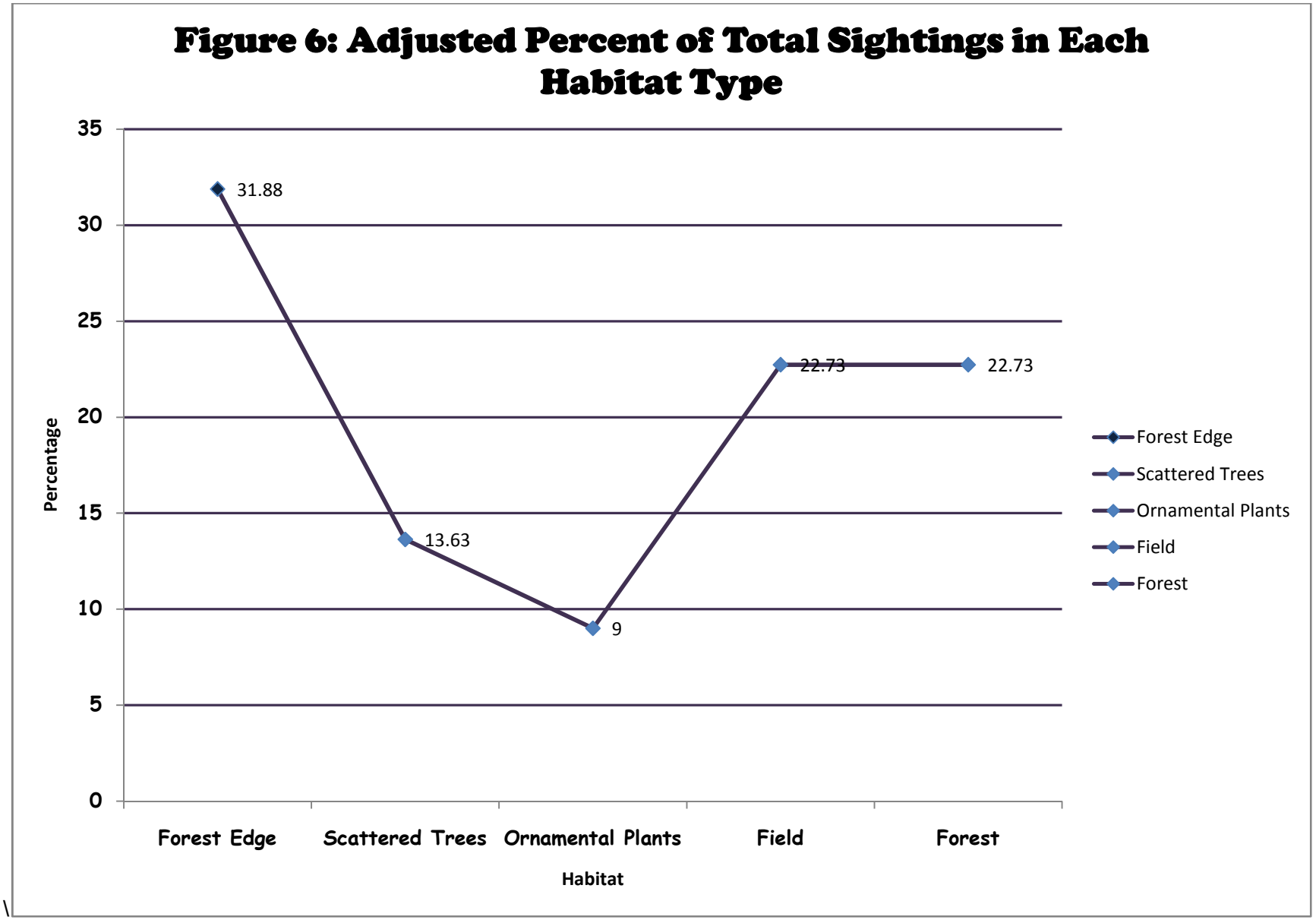


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Table 4: Bird Nests on Leaves and Lizards Property

May 24, 2009 to May 31, 2009

Nest #	Bird Species	Location		Tree Type	Elevation
		Latitude	**Longitude**		
1	Masked Tityra	-84.66161573	10.53075456	Laurel	Low
2	Black cheeked Woodpecker	-84.66161945	10.53075242	Laure	Low
3	Green Breasted Mango Hummingbird	-84.66213161	10.53100048	Laurel	High
4	Barred Antshrike	-84.66226627	10.53026874	Shrub	Low
5	Palm Tanager	-84.66386932	10.53162612	Laurel	Mod. High
6	Tropical Pewee	-84.66460843	10.53182788	Porro	Low
7	House Wren	-84.66467553	10.53214287	Porro	Low
8	Black Masked Tityra	-84.66646616	10.53175918	Laurel	Mod. High
9	Black cheeked woodpecker	-84.66646658	10.531754	Laurel	Mod. High
10	Common Tody Flycatcher	-84.66623843	10.53142161	Orange	Low
11	Black streaked woodpecker	-84.66273508	10.53201631	Laurel	Mod. High
12	Blue grey Tanager	-84.66272116	10.5319741	Laurel	Mod. High
13	Ruddy Dove	-84.66260935	10.53246393	Porro	Low
14	Yellow crowned Euphonia	-84.66266698	10.53247526	Porro	Low
15	Squirrel Cuckoo	-84.66167454	10.5322554	Hibiscus Shrub	Low
16	Ruddy Ground Dove	-84.66508943	10.53130001	Shrub	Low
17	Crimson fronted Parakeet			Laurel	High

Table 5: Observations of the Green Breasted Mango Hummingbird May 26, 2009

TIME	WEATHER CONDITIONS	INVL.	ACTIVITIES
11:00 AM	Warm, Humid, Altocumulus clouds	1ST	- Sitting on nest is the male mango hummingbird - Flies away, probably for foraging - Returns and surveys around nest - Chases away red-legged honey creeper - Sits on nest
11:10 AM	Warm, Humid, Altocumulus clouds	2nd	- Flies away when no birds are around
11:20 AM	Warm, Humid, Altocumulus clouds	3rd	- Returns, perches on nest and turns eggs. - Sits on eggs. - Only bird nesting in the Laurel - Sings, probably to let other birds know that this is its territory.
11:30 AM	Very hot, Cirrus clouds, Humid	4TH	- Before flying away, it surveys the trees to make sure no one is there. - Flies back to nest, surveys branches, sits on nest then hums - Shows off territory by humming and flying around - Returns after a systematic time, even if no food is found
11:40 AM	Very hot, Cirrus clouds, Humid.	5TH	- Another Mango hummingbird perches on the tree, then flies away. - The Mango parent surveys the ground then the tree then flies away.
11:50 AM	Very hot, Cirrus clouds, Humid	6TH	- The Mango parent returns. - Pulls leaves together for shading the nest. - Constantly checks leaves by probing them to make sure they are okay and steady enough. There are two broad laurel leaves above the nest. - Keeps making a relaxed two note sounds in response to another bird.
End - 12:00 MD			

Observations of the Green-breasted Mango Hummingbird May 27, 2009

TIME	WEATHER CONDITIONS	INVL.	ACTIVITIES
02:30 PM	Relatively chilly, Humid, Stratus clouds	1ST	- Mango sits on the nest. - No other birds in the tree. - Mango bird probes at the leaves constantly to make sure that there's enough shade. Quiet, makes no sounds.
02:40 PM	Relatively chilly, Humid, Stratus	2nd	- Mango bird leaves nest following the same pattern of surveying the upper branches before leaving.
02:50 PM	Relatively cold, Humid, Darker cumulus clouds	3rd	- Mango perches on nearby tree and sings calm two note sounds. - Flies back to the nest. - Does not survey surroundings but perches on the nest, probes at eggs. - Surveys surroundings and sits on eggs. - Pulls leaves over nest, Puffs tail up and out of nest and sits firmer on eggs.
03:00 PM	Relatively cold, Humid, Darker cumulus clouds	4TH	- Communicates with other birds using same two note sounds. - Keeps poking at eggs with beak - Squeezes self into nest. - Lots of blue gray tanagers around. - Mango bird keeps surveying surroundings in one direction. - Probes at eggs several times.
03:10 PM	Relatively chilly, Raining, Darker cumulus clouds	5TH	- A Ruddy Ground Dove perches on a lower branch but the Mango hummingbird does not notice. - Mango bird notices and starts flying at the Dove to get it to fly away. - The Mango bird does not physically attack the Dove. Instead, it flies up into the tree, perches on a branch and then flies down at the Dove without hitting. - Mango bird notices that the Dove will not move and sits in nest and remains alert. Dove flies away after a few seconds.
03:20 PM	Relatively chilly, Raining, Darker cumulus clouds	6TH	- Mango bird does not leave nest. - Sits firmer in the nest to warm eggs. - Keeps probing at leaves above to provide more shade

			- Remains alert for other birds - Makes a slow two note sound every few seconds, approximately every 40 seconds.
End - 03:30 PM			

Observations of the Green-breasted Mango Hummingbird May 28, 2009

TIME	WEATHER CONDITIONS	INVL.	ACTIVITIES
02:30 PM	Warm, Humid, Altocumulus clouds	1ST	- Mango bird sits on nest - Flies away, probably for foraging - Returns and surveys around nest - Sits on nest
02:40 PM	Warm, Humid, Altocumulus clouds	2nd	- Sits on top branch of tree and sings a calm two note sound in response to another bird.
02:50 PM	Warm, Humid, Altocumulus clouds	3rd	- Returns, perches on nest and probes eggs. - Sits on eggs. - Sings, probably to let other birds know that this is its territory. - Surveys branches and flies off.
03:00 PM	Very hot, Altocumulus clouds, Humid	4TH	- Has not returned yet.
03:10 PM	Very hot, Altocumulus clouds, Humid.	5TH	- The Mango bird returns, surveys upper branches and lower branches - Perches on nest - Sits on eggs.
03:20 PM	Very hot, Altocumulus clouds, Humid	6TH	- The Mango bird sits on eggs. - Sings a two note song calmly to a bird in a distance. - Mango bird surveys branches and flies off.
End - 03:30 PM			

Observations of the Green-breasted Mango Hummingbird May 29, 2008

TIME	WEATHER CONDITIONS	INVL.	ACTIVITIES
11:00 AM	Warm, Humid, Cirrus clouds	1ST	- Mango bird sits on nest - Flies away, probably for foraging - Returns and surveys around nest - Sits on nest
11:10 AM	Warm, Humid, Cirrus clouds	2nd	- Flies away when no birds are around
11:20 AM	Warm, Humid, Cirrus clouds	3rd	- Returns, perches on nest and probes eggs. - Sits on eggs. - Very territorial – only bird in nest - Sings, probably to let other birds know that this is its territory.
11:30 AM	Very hot, Cirrus clouds, Humid	4TH	- Before flying away, it surveys the trees to make sure no one is there. - Flies back to nest, surveys branches, sits on nest then hums - Shows off territory by humming and flying around - Returns after a systematic time, even if no food is found
11:40 AM	Very hot, Cirrus clouds, Humid.	5TH	- The Mango parent surveys the ground then the tree then flies away.
11:50 AM	Very hot, Cirrus clouds, Humid	6TH	- The Mango parent returns. - Pulls leaves together for shading the nest. - Constantly checks leaves by probing them to make sure they are okay and steady enough. There are two broad laurel leaves above the nest. - Keeps making a relaxed two note sounds in response to another bird.
End - 12:00 MD			

Observations of the Green-breasted Mango May 31, 2009

TIME	WEATHER CONDITIONS	INVL.	ACTIVITIES
10:00 AM	Relatively chilly, Humid, Cirrus clouds	1ST	- The Green-breasted Mango is not present at the nest.
10:10 AM	Relatively chilly, Humid, Cirrus clouds	2nd	- The Mango bird surveys the branch - Perches on nest. - Flies to top of branch immediately. - Sings in an anxious tone. - Sits in the same position - Bird flies by the nest and does not notice - Mango bird flies away without surveying the branch - The sounds it makes are anxious tones - Sits on the edge of a branch and looks around - 2 hummingbirds flew by and it paid no attention
10:20 A,M	Relatively chilly, Cumulus clouds, Dark.	3rd	- Mango bird flew down and away - Piratic Flycatcher lands on three and flies away - Something's wrong with Mango because it stays away too long.
10:30 AM	Relatively chilly, Cumulus clouds, Dark	4TH	- The Mango bird is still away - Red legged honeycreeper landed in tree. - The Mango comes back, surveys constantly and sits and probes eggs - Very alert and agitated - Facing opposite direction from previous days - Keeps moving around then calms down but still very alert - Tail feathers constantly moving up and down
10:40 AM	Relatively chilly, Darker cumulus clouds, Windy	5TH	- Flew off and sat on top branch - Mango flew away - Surveying Common tody flycatcher examined the nest and the branches. Stopped on tree and foraged. Landed near nest - Mango did not return.

10:50 AM	Relatively chilly, Darker cumulus, Windy	6TH	- Mango bird does not return.
End – 11:00 AM			

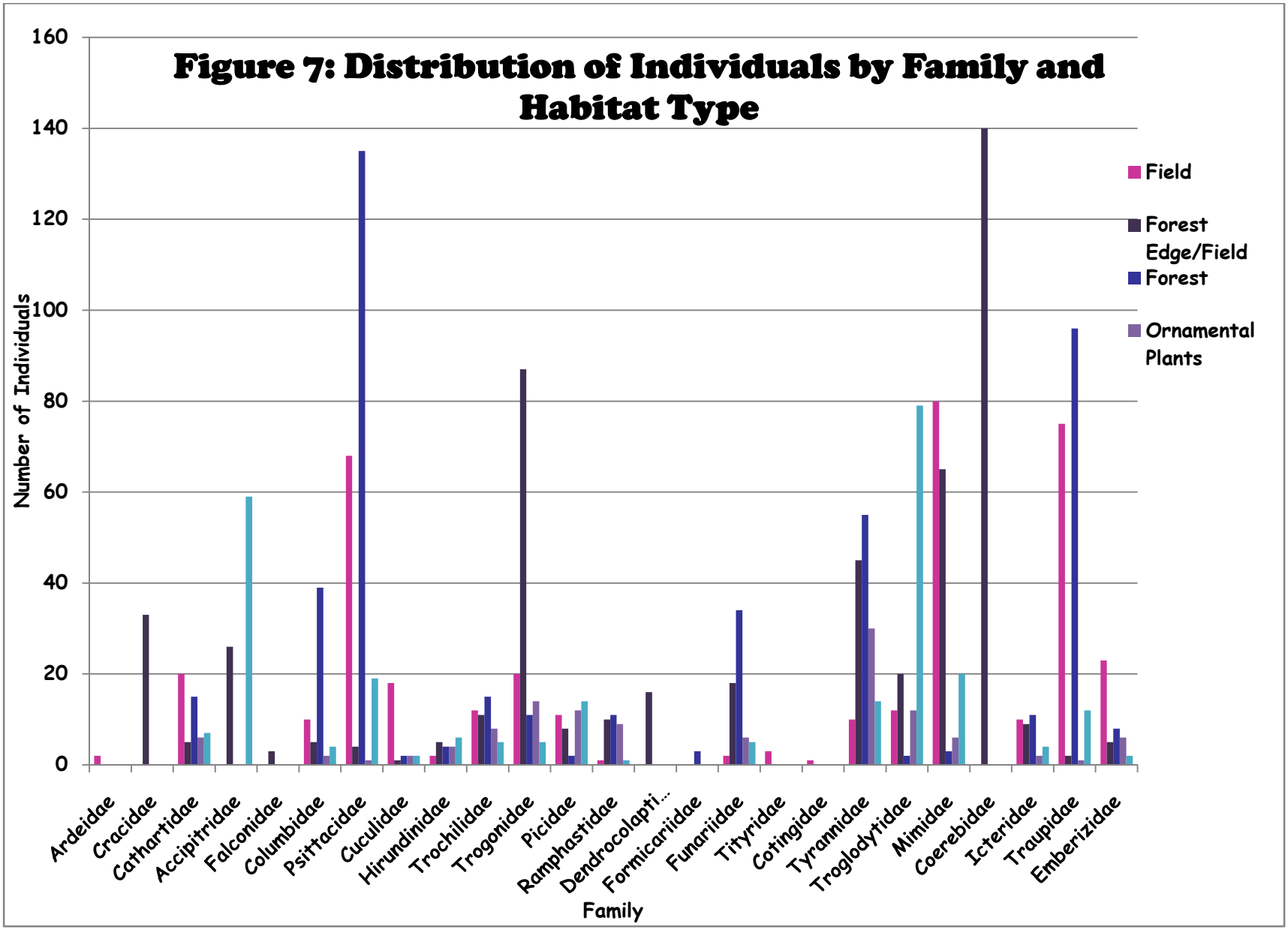
Figure 7: Distribution of Individuals by Family and Habitat Type
Number of Individuals
160
140
120
100
80
60
40
20
0
Field
Forest Edge/Field
Forest
Ornamental Plants
Ardeidae
Cracidae
Cathartidae
Accipitridae
Falconidae
Columbidae
Psittacidae
Cuculidae
Hirundinidae
Trochilidae
Trogonidae
Picidae
Ramphastidae
Dendrocolapti...
Formicariidae
Furnariidae
Tityridae
Cotingidae
Tyrannidae
Troglodytidae
Mimidae
Coerebidae
Icteridae
Traupidae
Emberizidae
Family