Assessing bird species diversity and trophic/taxonomic diversity of the Leaves and Lizards reforestation site

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INTRODUCTION

Fragmented forest creates an isolation island effect on animals and, according to the principles of island biogeography, increased interconnection between isolated patches of forest and larger areas of forest increases the variety and density of species. As observed by Anciaes and Marini (2000), a closed environment, one that is isolated from other areas of forest, limits the variety of species by increasing the difficulty of migration, and favors more mobile species. In addition, as discussed by Orgella *et al* (2001), isolated forest patches limit resources like food and nesting sites for the species within these patches.

This research aimed at measuring baseline information for a study to determine the effects of enhancing the Meso-American forest corridor and creating a strip of continuous or closely connected forest which would allow for migration of animals and the sustaining of endemic species within South, Central, and North America. 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.

Our study of the bird species found at Leaves and Lizards focused on the density and diversity of bird species. In addition, our objective was to detect correlations 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

Data collection took place at the Leaves and Lizards Volcano Retreat outside of La Fortuna, Costa Rica from May 26 – May 31, 2008, within the rainy season. The site is a hilly, tropical wet forest at an elevation of about 500m. It is lies near Arenal Volcano and historically has been impacted by agriculture and grazing.

Bird censusing was conducted daily at fourteen point-count circles. Each location was assigned a letter A – N, GPS data were taken at each site, and the general habitat was assessed to determine percent canopy cover, dominant vegetation, and proximity of buildings and water. A panoramic photograph was taken as a qualitative means of documenting habitat change at each location.

During daily censusing we noted weather conditions and any other variables that might have affect bird abundance. Counts were primarily conducted from 6-8am and 9-10:30am for five consecutive days, and one bird count was conducted from 5-7pm. The order in which the points were visited was varied in order to avoid skewing the relative counts of each point by consistently visiting each point at a specific time of day. A point-count data sheet with radii of 25m and 50m (50m being the limit of recorded observation) was aligned with North and the locations of individual birds sighted were indicated on the datasheet. When it was certain that two birds of the same species were different individuals, a line indicating this was drawn connecting their data points. Each individual bird sighted was also noted on a spreadsheet, along with pertinent data on sex, age, whether the sighting was visual or auditory, behavior, including flocking or territorial behavior, familial groupings, nesting or foraging activity, habitat use, or the event of a fly-over. Each species observed was assigned a code to facilitate the recording of data. Species identification was done either by visual or auditory cues.

At the end of the collection period, the Shannon diversity indices for each count site were calculated, as well as relative avian family densities and distribution of individuals within each avian family. The avian data was further combined with the habitat data collected by the mapping and tree units, and avian diversity was compared to habitat type. In addition, number of individuals per family and relative density per family was compared.

RESULTS

Over the course of the study, 63 species belonging to 23 avian families were observed at the field site. The total number of individual birds sighted was 1,457. Table 1 gives a complete list of the species seen as well as their families, the number of individual birds sighted of each species, and the relative density of each species. As shown in Table 1, the most abundant species on the property were Montezuma Oropendola (*Psarocolius montezuma*), Rufus-tailed Hummingbird (*Amazalia tzacatl*), White-crowned Parrot (*Pionus senilis*), Variable Seedeater (*Sporophila aurita*), and Social Flycatcher (*Myiozetetes similis*). The least abundant species were Cinnamon Becard (*Pachyramphus versicolor*), Little-hermit Hummingbird (*Phaethornis longuemareus*), Violet-headed Hummingbird (*Klais guimet*) , Swallow-tailed Kite (*Elanoides forficatus*) , Mealy Parrot (*Amazona faranosa*), Buff-rumped Warbler (*Phaeothlypis fulvicauda*), Golden-olive Woodpecker (*Piculus rubiginonus*), and Rufous-winged Woodpecker (*Piculus simplex*).

Figure 1 indicates the number of individuals sighted of each avian family. The data shows that the avian families *Tyrannidae,* (flycatchers and kingbirds), *Psittacidae,* (parakeets and parrots), *Thraupidae,* (honeycreepers and tanagers), and *Icteridae*, (cowbirds and oropendolas), were found to have the highest numbers of individual sightings on the property. In addition, these same families were found to have the highest relative densities of all observed families, as seen in Figure 2. Likewise, the families *Parulidae* and *Tityridae* had the lowest number of individuals (Figure 1) and the lowest relative densities (Figure 2).

Diversity of species and families varied according to habitat type. Table 2 compares the habitat of each site to the species seen and the diversity of each site. Figure 3 breaks down the number of individuals of each family, according the habitat in which they were sighted. According to Figure 3, forest edge habitats were found to be more attractive compared to other habitats for the families *Psittacidae*, *Coerebidae*, *Thraupidae*, *Trogonidae,* and *Columbidae.* Likewise, scattered trees were especially favorable for *Formicariidae, Troglodytidae,* and *Accipitridae*. Figure 3 also reveals that the families *Cardinalidae, Cathartidae, and Coerebidae* were sighted almost exclusively in forest-edge habitats.

Figure 4 compares the average avian diversity of each habitat on the Leaves & Lizards property. Figure 5 shows percent total sightings in each habitat type. The percent has been adjusted for the uneven distribution of habitat type among the sites. As seen in Figure 4, avian diversity was lowest in fields and areas with sparse tree cover, while we observed higher diversity in areas with ornamental vegetation, and the highest diversity in areas by forest edges. No observations of forest interior were made. Comparing Figures 4 and 5, habitats with ornamental plants had high diversity but a low percent of the total sightings. Field habitats had slightly lower diversity that scattered tree/ornamental plant habitats, but had a slightly higher percent of the total sightings.

CONCLUSIONS

The highest diversity at Leaves and Lizards was found to be in forest edge with no canopy cover (Figure 3). This was due to the foliage height diversity which positively correlates to bird diversity. Increased foliage height diversity increases the diversity of possible food sources, from fruits within the forest to insects and seeds in neighboring fields, as well as habitats for birds, and thus increases bird diversity. For the same reason, habitat of forest edge and field had the second highest diversity; and in general the difference in diversity was slight (as seen in Figure 3). The lowest diversity according to habitat was found to be in field because the lack of fruit bearing trees and foliage causes the field to be favorable mainly to seedeaters and occasional insectivores. As seen in Figure 2, the families with the most sighted individuals had the highest number of individuals in forest edge habitat. The families with the highest density observed within the property have been known to frequent habitats like forest edge and scattered trees. The family Tyrannidae had the highest relative density of all families seen on the property (Figure 5). This high density might be expected because this family is "the largest avian family confined to the Western Hemisphere" and known to be very diverse (Stiles and Skutch, 1989). Within the family, the species *Myiozetetes similis* (Social Flycatcher) had the highest density. This observation confirms the trend that social flycatchers seek out fields and scattered trees and forge on small insects, berries, and fruits. These conditions were prevalent throughout the property. The second highest density (Table 2) within a family belonged to the *Todirostrum cinereum* (Common Tody- Flycatcher) who is known to seek "second growth, scrub, and boarders of gallery forest and preys on insects such as beetles and wasps. The higher density of the Social Flycatcher over the Common Tody-Flycatcher could result from a larger area of scattered trees rather than scrub and boarders of forest or from the prevalence of small insects over the prevalence of beetles and wasps. In order to understand this trend, further information is needed. Future research could analyze the types of insects and incest density found throughout different habitat within the property to explain this trend. In addition, future research could calculate the total area of each different habitat to see which one has the highest area.

The family with the second highest density was Psittacidae which contains parrots and parakeets. The high species density of this family can be explained by the behavior of flocking. Species within this family generally fly in flocks of between 30-50 birds. Within the family, *Pionus senilis (*White-crowed parrot) had the highest density of 6.658. This species prefers habitats of second growth, forest edge and agricultural fields. The flocks would pass over studied area in order to travel to these fields to forge. *Aratinga finschi* (Crimson-fronted Parakeet) had the second highest density of 3.638 which could be explained by its large flocks or its habitat preferences of open country, scattered trees and second growth. The *Brotogeris jugularis* (Orange-chinned Parakeet) had a density of 2.539. Its habitat preferences are the same as the other species within the family, and its food sources are figs, Cecropia, flowers of *Erythrina*, Guava, and Balsa. *Cecropia*, Guava and Balsa were located within the property, and could explain the prevalence of these species. *Amazona farinose* (Mealy Parrot) had the lowest density of .069 within the family due to its habitat preference of more heavily forested areas, generally keeping to canopy which was not common within the property. Overall, however, the density for the Psittacidae family may have been higher in this time period rather than in another. Since these species tend to flock more during and directly after breeding season, a bird count in a different month would be beneficial in establishing a baseline density for these species. Future research could calculate the density during breeding season and a few months later to determine and note any discrepancies.

The family with the third highest density was Thraupidae, which contains Tanagers and Honeycreepers. Within this family, the species *Thraupis episcopus* (Blue-gray Tanagers) had the highest density of 3.981 which could be explained by its food sources of figs, berries, seeds, nectar from flowers of balsa, and insects. This species was especially prevalent in forest edge habitats which contained many balsa trees. They also frequented the nectar feeders at the observation point adjacent to the main building. Two other species with high densities, the Scarlet-rumped Tanager and the Golden-hooded Tanager, are both known to prefer scattered tress especially where berries, Cecropia, *Piper* spikes (preferred by the Golden-hooded Tanager), and insects may be found. Future research to determine the behavior of this family should study the specific fruiting trees in each bird count point. This information would aid in forming a correlation between food source and the varying densities of species within this family.

The family Icteridae had a next highest density and consisted of *Psarocolius montezuma* (Montezuma Oropendola) which often flock in large groups and nest colonially. This species feeds off of fruit, seeds, *Cecropia*, Balsa trees, and bananas, all of which are common within the property of Leaves and Lizards. The high density of this species is due to the size of these flocks and to their daily migrations from one area of the property to another. Future research could tag these birds or otherwise identify individuals to see if each flock is different or the same one migrating. This could alter the density and give a more accurate representation of the number of individuals on the property.

Finally, the family Trochilidae also had a high density and consisted mainly of the species *Amazilia tzacatl*, the Rufous- tailed Hummingbird. These birds are known to be most abundant where forest has been removed. Some have concluded that this could be due to the fact that hummingbirds are not affected adversely by fragmentation because they are highly mobile and effective at foraging in pastures and forest edges (Orgella *et al* 2001). In addition, hummingbirds are known to prefer open scrub and gardens because they feed off of the nectar of flowering plants. Both of these habitats were prevalent in the property, especially where flowering plants were planted for ornamental effects. Only three species of hummingbirds were observed during the bird counts, and this low diversity can perhaps be attributed to the season. The diversity and amount of hummingbirds tends to increase in December (G. Bogarin, pers. comm.), so it would be useful to have a study in that month and note the difference in variety within this family. The low density of *Klais guimetri* (Violet-headed Hummingbirds) can also be explained by this species' preference to canopy and tall second growth. Additionally, the low density of *Phaethornis longuemareus* (Little-hermit Hummingbird) can be attributed to the rarity of dense forest that this species prefers. As the reforestation project continues and taller trees and denser forests become more prevalent on the property, it is probable that hummingbirds will increase in number.

There were several groups that shared the lowest diversity values. The less common family Tityridae was represented by the species *Pachyramphus versicolor* (Cinnamon Becard). Also less common was the species *Phaeothlypis fulvicauda* (Buff-rumped Warbler) which prefers habitats near rivers and streams. The property did not contain any large streams or ponds and so could not provide the ideal habitat for these families. Two low density species observed were the *Piculus rubiginosus* (Golden-olive Woodpecker) and the *Piculus simplex* (Rufous-winged Woodpecker) both of which frequent canopy and edges of forest. The sighting of these species is a positive indication of the effect of reforestation, since neither of these species would have been sighted before reforestation, when the property was mainly a field. As the planted trees continue to grow and a canopy slowly begins to emerge, these species will probably become more prevalent and have a higher density.

Overall, the density of species found within the property correlated to the availability of preferred habitat or food source. As the reforestation project continues and the habitats change, the density and diversity of bird species will change as well, probably increasingly favoring species that prefer forest and canopy and making a drop in species that prefer open areas. Since the lowest avian diversity was in field habitat, one way to increase bird species would be planting scattered trees in fields on the property. Another possible way to increase bird populations would be increasing the variety of planted trees on the property and including more Laurel, Balsa, *Ficus*, *Cecropia*, and other fruiting trees to provide food sources for a variety of birds. Fruiting trees would be especially beneficial in increasing bird diversity and species density because fruits are more readily available to birds than insects, which are mobile and more difficult to capture. As a result, an increase in fruit trees would probably increase the survival of many bird species. According to Perrins and Birkhead (1984), an increase in available food resources would also aid in species propagation by providing enough food for successful breeding. In addition, the planting of various trees will eventually create a canopy. Other researchers (Guariguata *et al* 2002) have found that due to seed predation by rodents from fields, it is very difficult for canopy to re-grow without aid. By the additional planting of trees, perhaps the effects of such predation will be alleviated and the canopy will emerge more rapidly, increasing the density of species that prefer a canopy habitat.

In order to get more complete baseline data, we recommend further research specifically in forest habitats. All bird count points in this study were done at the forest edge or on a path. A bird point within a forested area would increase accuracy by counting birds that cannot be seen outside of the forest and would offer valuable data about which trees are most significant within that habitat. Additionally, future studies could take place in both wet and dry season to make the changes of avian populations and to establish a more complete baseline. Species found within the property in the dry season will vary from the wet season due to migration, weather conditions, and available food sources. Other researchers have found mist netting to be an effective means to get an accurate bird count (Restrepo and Gomez 1998). Perhaps mist netting in the forest interior during wet and dry seasons might be useful in establishing a more accurate baseline. In addition, other researchers have shown a positive correlation between fruit abundance and bird abundance (Loielle and Blacke 1991). By marking the fruiting trees within each count location and observing whether these trees are fruiting, future researchers might be able to achieve a deeper understanding of density gradients between different families and between species within each family, and would be able to provide information about which trees have the largest effect on bird abundance. This would aid in the reforestation effort by ensuring that new trees being planted would have the maximum effect on species diversity within the property.

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Table 1: Bird species observed at Leaves and Lizards during censusing May 2008

FAMILY	SPECIES	CODE	# INDV	RELATIVE DENSITY
Cuculidae	Ani, Groove-billed	ANgb	37	2.539
Ramphastidae	Aracari, Collared	ARcl	11	0.755
Formicariidae	Antshrike, Barred	ASbr	7	0.480
Tityridae	Becard, Cinnamon	BCcn	1	0.069
Coerebidae	Bananaquit	BQ	7	0.480
Cuculidae	Cuckoo, Squirrel	CKsq	8	0.549
Icteridae	Cowbird, Bronzed	CWbz	10	0.686
Columbidae	Dove, Ruddy Ground-	DVrd	5	0.343
Columbidae	Dove, White-tipped	DVwt	2	0.137
Tyrannidae	Elainia, Yellow-bellied	ELyb	4	0.275
Fringillidae	Euphonia, Yellow-crowned	EUyc	33	2.265
Tyrannidae	Flycatcher, Boat-billed	FCbb	2	0.137
Tyrannidae	Flycatcher, Common Tody-	FCct	57	3.912
Tyrannidae	Flycatcher, Dusky-capped	FCdc	10	0.686
Tyrannidae	Flycatcher, Piratic	FCpi	10	0.686
Tyrannidae	Flycatcher, Sulphur-bellied	FCsb	5	0.343
Tyrannidae	Flycatcher, Social	FCso	68	4.667
Emberizidae	Grassquit, Yellow-faced	GQyf	8	0.549
Trochilidae	Hummingbird, Little-Hermit	HBlh	1	0.069
Trochilidae	Hummingbird, Purple-Crowned Fairy	HBpc	4	0.275
Trochilidae	Hummingbird, Rufous-tailed	HBrt	123	8.442
Trochilidae	Hummingbird, Violet-headed	HBvh	1	0.069
Thraupidae	Honeycreeper, Red-legged	HCrl	13	0.892
Accipitridae	Hawk, Gray	HKgr	2	0.137
Tyrannidae	Kingbird, Tropical	KBtr	40	2.745
Tyrannidae	Kiskadee, Great	KDgr	15	1.030
Accipitridae	Kite, Swallow-tailed	KTst	1	0.069
Icteridae	Oropendula, Montezuma	OPmz	148	10.158
Icteridae	Oriole, Black-crowned	ORbc	7	0.480
Picidae	Piculet, Olivaceous	PCol	8	0.549
Tyrannidae	Peewee, Tropical	PEtr	15	1.030
Columbidae	Pigeon, Red-billed	PGrb	26	1.784
Columbidae	Pigeon, Ruddy	PGrd	3	0.206
Psittacidae	Parakeet, Crimson-fronted	PKcf	53	3.638
Psittacidae	Parakeet, Orange-chinned	PKoc	37	2.539
Psittacidae	Parrot, Mealy	PTml	1	0.069
Psittacidae	Parrot, Red-lored	PTrl	21	1.441
Psittacidae	Parrot, White-crowned	PTwc	97	6.658
Turdidae	Robin, Clay-colored	RBcc	27	1.853

Cardinalidae	Saltator, Black-headed	SAbh	3	0.206
Cardinalidae	Saltator, Buff-throated	SAbt	19	1.304
Cardinalidae	Saltator, Grayish	SAgh	15	1.030
Emberizidae	Seedeater, Collared	SEcl	3	0.206
Emberizidae	Seedeater, Variable	SEva	79	5.422
Emberizidae	Sparrow, Black-stripped	SPbs	7	0.480
Furnariidae	Spinetail, Slaty	STsl	6	0.412
Hirundinidae	Swallow, Northern rough-winged	SWrw	28	1.922
Thraupidae	Tanager, Blue-gray	TAbg	58	3.981
Thraupidae	Tanager, Crimson-collared	TAcc	19	1.304
Thraupidae	Tanager, Golden-hooded	TAgh	22	1.510
Thraupidae	Tanager, Palm	TApa	20	1.373
Thraupidae	Tanager, Scarlet-rumped	TAsr	35	2.402
Thraupidae	Tanager, White-lined	TAwl	9	0.618
Ramphastidae	Toucan, Chestnut-mandibled	TCcm	6	0.412
Trogonidae	Trogon, Violaceous	TGvi	4	0.275
Tyrannidae	Tyrannulet, unknown	TYu	2	0.137
Cathartidae	Vulture, Black	VUbk	34	2.334
Cathartidae	Vulture, Turkey	VUtk	39	2.677
Parulidae	Warbler, Buff-rumped	WBbr	1	0.069
Furnariidae	Woodcreeper, Streak-headed	WCsh	17	1.167
Picidae	Woodpecker, Black-cheeked	WPbc	26	1.784
Picidae	Woodpecker, Golden-olive	WPgo	1	0.069
Picidae	Woodpecker, Rufous-Winged	WPrw	1	0.069
Troglodytidae	Wren, Band-backed	WRbb	18	1.235
Troglodytidae	Wren, Black-throated	WRbt	2	0.137
Troglodytidae	Wren, House	WRho	26	1.784

TOTAL	**66**		**1457**	

Table 2: Bird diversity and habitat attributes at each point location sampled during censusing May 2008

Site	Habitat	# Species	# Individuals	Diversity	canopy cover (percent)	dominant vegetation	prox. of buildings (m)	prox. of water (m)	comments
A	forest edge	27	106	4.192	10	balsa, laurel, rubber	50	>50	semi-road
B	scattered trees, ornamental plants	31	152	3.961	10	balsa, banana	30	25	
C	forest edge	32	89	4.612	20		>50	>50	visually distinct from b
D	forest edge	30	86	4.476	10	almendro, teak, orange	>50	>50	
E	field	27	199	3.207	10	grass, laurel	>50	>50	near boundary, near new building site
F	field	23	63	3.945	0	grass	>50	>50	near new building site
G	scattered trees, ornamental plants	27	113	3.707	10	balsa, poro	15	>50	
H	scattered trees, ornamental plants	21	64	4.027	0	grass, laurel, ornamental	20	>50	hill peak

I	ornamental plants	29	98	4.296	20	ornamental	15	>50	house
J	field	26	102	4.305	30	grass	>50	>50	springs laurel
K	forest edge	26	68	4.415	75	laurel	>50	30	
L	forest edge, field	32	87	4.65	0	grass	>50	45	laurel
M	forest edge, field	23	59	4.161	50	grass	>50	25	
N	forest edge	38	127	4.483	0	bamboo laurel	>50	40	forest edgish

Figure 1 Number of individuals sighted based on avian family

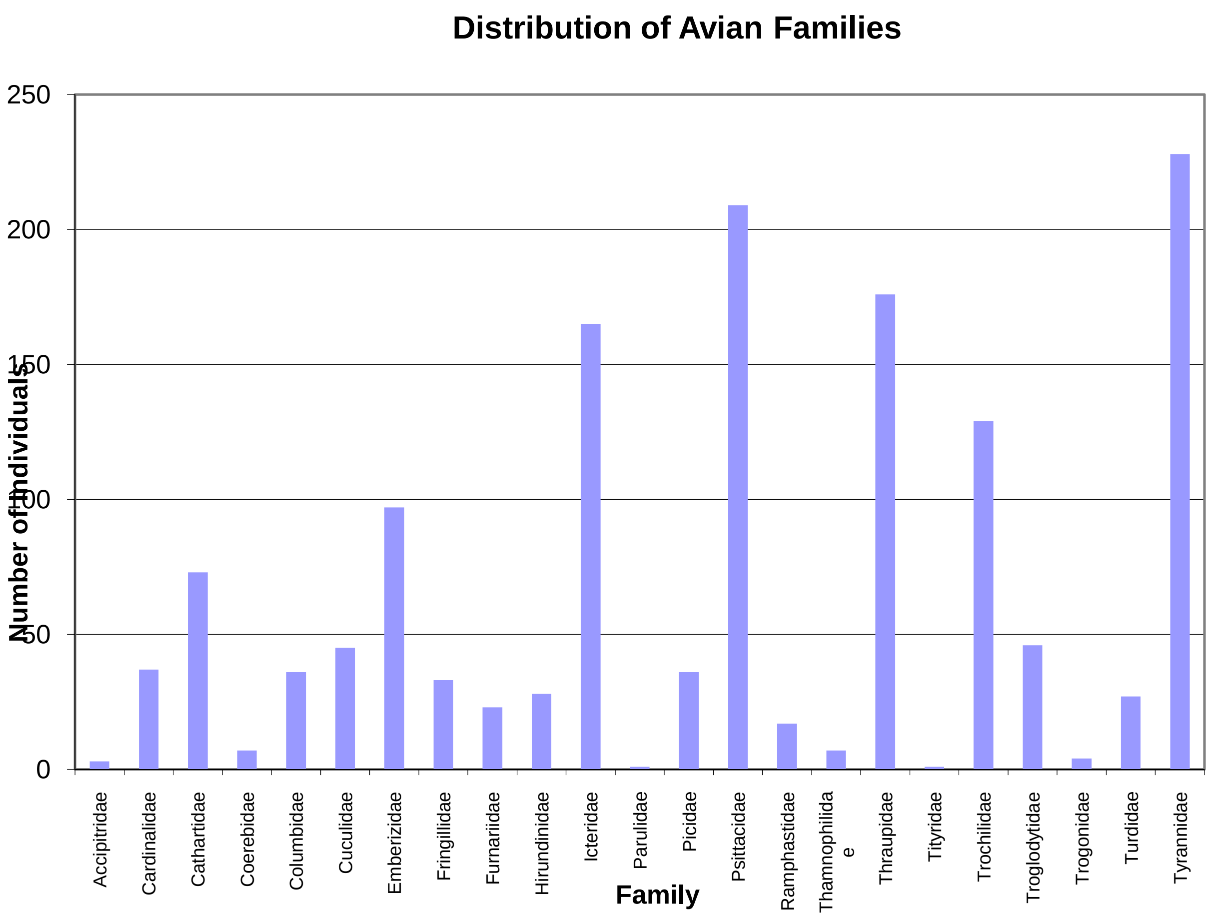

Figure 2 Relative density of each avian family observed during censusing

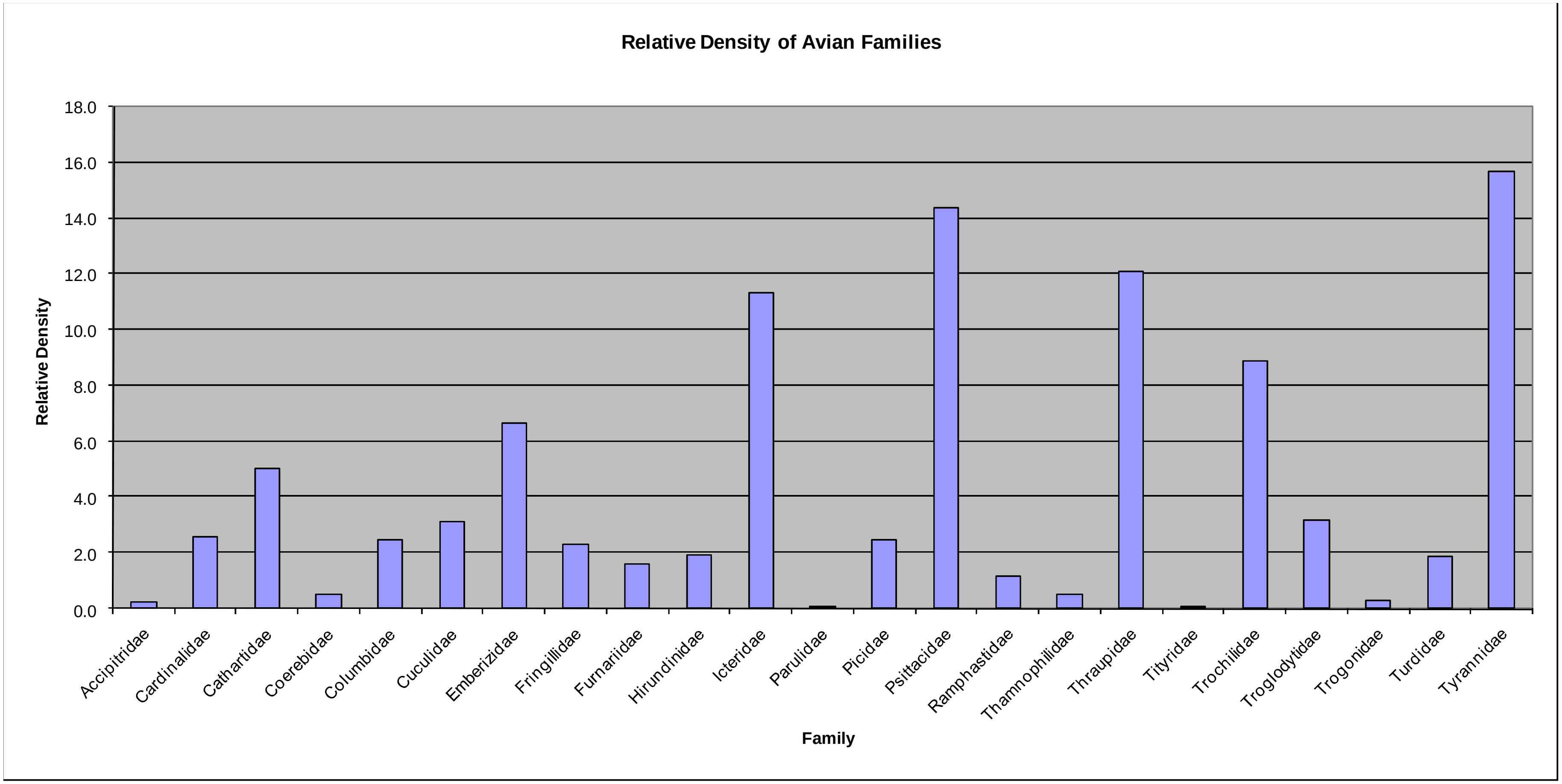

Figure 3 Habitat and number of individual birds observed

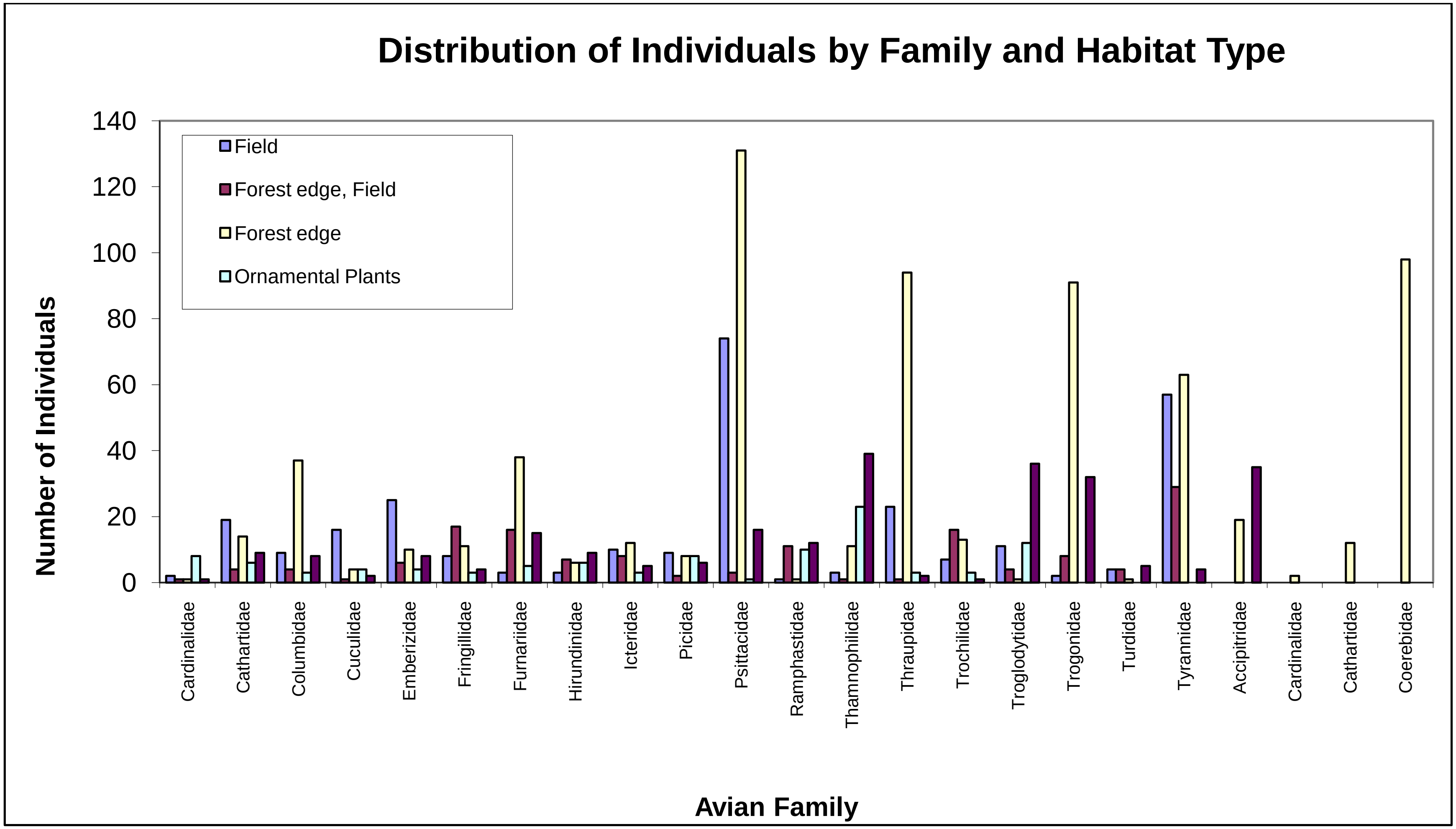

Figure 4 Average avian diversity of each habitat type at Leaves and Lizards

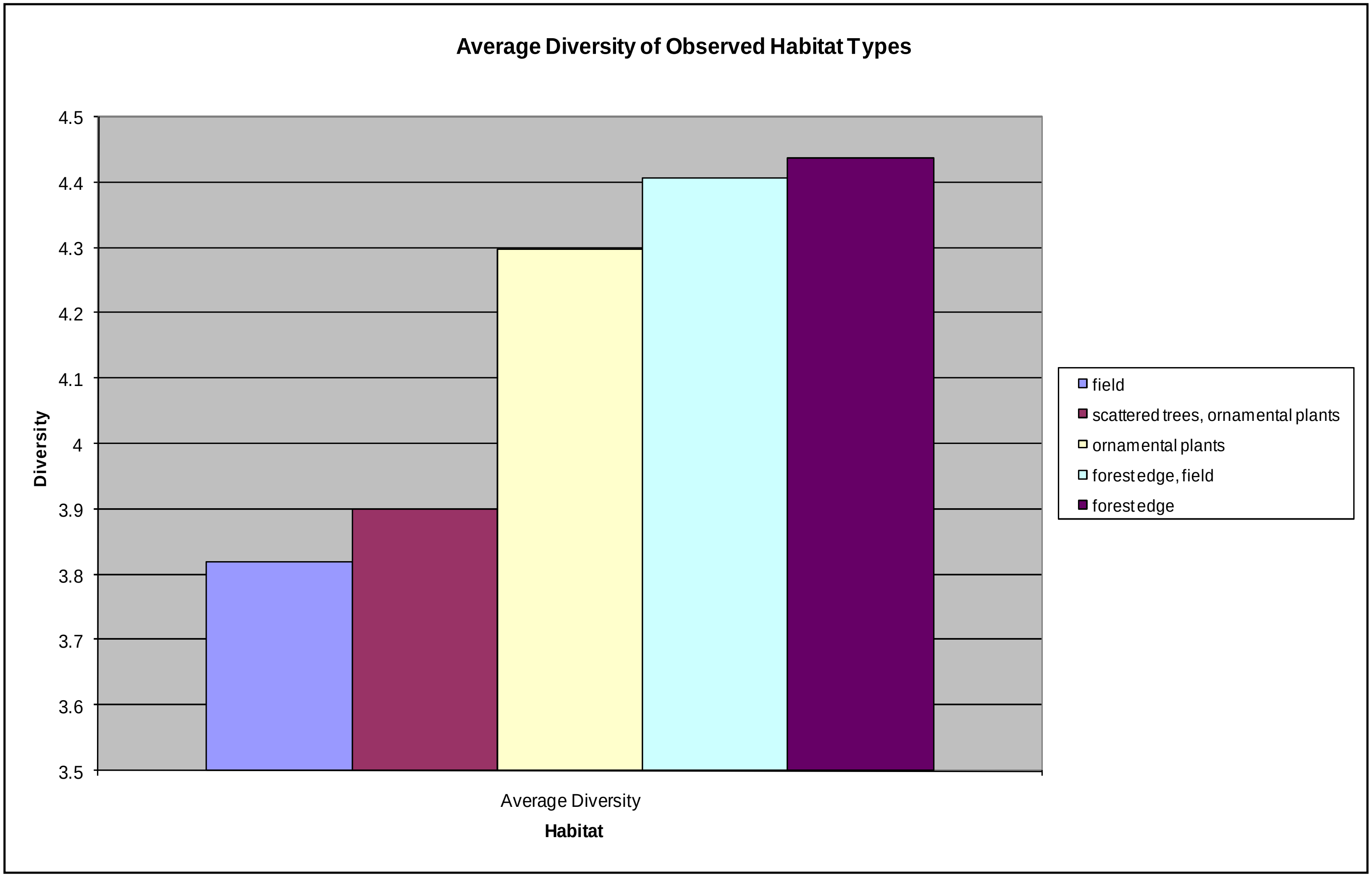

Figure 5 Total sightings in each habitat type