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INFLUENCE OF LANDSCAPE VARIABLES ON THE POPULATION DENSITY AND DISTRIBUTION OF BLACK SHAMA (*COPSYCHUS CEBUENSIS* STEERE) IN ARGAO WATERSHED RESERVE, ARGAO, CEBU, PHILIPPINES

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Abstract-* This study determined the effects of landscape variables on the population density and distribution of Copsychus cebuensis within Argao watershed, a conservation priority area in Cebu Province in the Philippines. Distance point transect sampling method was used in assessing target species occurrence on the different forest patches being sampled. Results show that estimated population density of C. cebuensis were 52 and 53 individuals per hectare in mixed and natural forests and they are widely distributed among these strata especially in the mixed forest.. There were only three and four predictors at landscape and sampling site have explained the behavior of population density of C. cebuensis. Relative humidity and canopy cover were having high positive significant correlations while tree basal area had high negative correlation at landscape. Elevation and canopy cover have positive high significant and significant correlation while slope and shrub cover have negative significant correlation with C. cebuensis population density. The adjusted R^2 values were 0.345 and 0.212 (for landscape and sampling site). These suggest that about 34.5% of the variations at the former have been accounted for and only 21.2% for the later, hence, regression at landscape is better than at sampling site. Thus, it is imperative to conserve, protect, and develop the remaining forest patches in AWR to sustain the population density of C. cebuensis.

Keywords: Landscape Variables, Argao Watershed Reserve, Spatial Distribution of Black Shama *Copsychus cebuensis* Steere

I. INTRODUCTION

Fluctuating environmental variables such as microhabitat and microclimate largely affect survival of many species of birds (12). These responses may vary among species physiological tolerance, and nestlings (14, 12). *Copsychus cebuensis* may be one of those bird species may be affected by these landscape variables. The target species, however, is endemic to Cebu Island in the Philippines and it is sedentary, non-migratory, and insectivorous bird species that feeds on insects normally black beetles (8). It is belong to the order Passeriformis and family of Muscicapidae which may inhabit primary forest and the dense undergrowth of secondary habitats—usually within a few meters from the ground where it is secretive, more often heard than seen, in bamboo grooves, thickets and along steep ravines—particularly beside ridge-top and valley-bottoms with a high percentage of canopy cover (8, 4).

Based on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species in 2012 this species qualifies as endangered as it has a very small range and population, both of which are continuously declining (4). Additionally, it suffers severe fragmentation owing to extreme pressure on the few remaining, already highly degraded, tracts of forest in Cebu Province that still support subpopulations (4). Likewise, biodiversity in Argao watershed is pervasively threatened from degradation posed by human activities including settlement, land use conversion, shifting cultivation, illegal cutting of trees for house construction, firewood gathering and habitat clearance for mining. Consequently, these disturbance may eventually affect the microclimate and microhabitat factors in the watershed area and ultimately the present subpopulations of *C. cebuensis* which are still inhabiting among the remaining forest habitat patches within the watershed.

A number insectivorous species of forest birds like *C. cebuensis* are adapted to changes in microclimate and microhabitat factors (1). While some under storey birds are also correlated with canopy cover, number of trees and ground cover as the consequence of forest edge and gaps. However, birds may respond to one or a combination of these changes in the landscape as a result of various mechanisms, e.g. biological origin (11). Studying bird occurrences, densities and/or populations may therefore give a distinct result because of environmental and habitat changes over the forest in a long time (12). In the study on insectivorous birds in tropical rainforest of Malaysia, arboreal foliage gleaning insectivores were positively correlated with ground cover, light intensity, shrub cover and percent of shrub cover. However, terrestrial insectivores, were sensitive to the forest edge and could indicate the quality of forest interior habitat associated with high humidity, dense canopy cover and deep litter depth (9).

In the study at Subic Bay Forest Reserve (SBFR) in the Philippines found out that some forest birds are positively correlated with vegetation variables such as canopy cover, tree density, height to inversion and ground cover (10). The findings also further showed, that majority of the bird contacts are sensitive to canopy loss and requires canopy cover of 60% or higher in order to maintain

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good environmental condition for the birds (10). Hence, this study was the first attempt to assess the responds of *C. cebuensis* to landscape variables such as microclimate and microhabitat factors in particular, within the selected forest habitat patches Argao watershed.

II. MATERIALS AND METHODS

3.1 Location and Description of the Study Site

3.1.1 Geographic location. The Argao Watershed Reserve (AWR) is located within the municipalities of Argao, Dalaguete, and Badian. AWR has a geographic coordinates of approximately between $9^{o}48'58''$ and $9^{o}56'03''$, north latitudes and $123^{o}34'27''$ and $123^{o}28'$, east longitudes (Fig. 1). It is bounded by municipalities of Dalaguete to the south and southwest, Moalboal to the west, Alcantara to the southwest, Sibonga to the north, and Bohol strait to the southeast and eastern part respectively. It lies in an approximate distance of 81 km away from Cebu City and 15 km from Argao town proper, which can be reached mainly by any type of land transportation. The remote areas can be accessed by foot through established foot-trails or foot-path (5).

3.1.2 Administrative jurisdiction and legal basis. The protected area cuts across three municipalities (Table 1). Thirteen barangays of Argao, seven in Dalaguete, and one in Badian are within the AWR area. A total of 21 barangays compose the entire jurisdiction of Argao watershed. This watershed serves as a vital source of water supply in southern part of Cebu province, specifically Argao municipality. Almost 700 hectares of rice fields in low lying areas benefit as well on water discharged from this watershed (5).

It also supplies the water for domestic use, poultry, and small-scale livestock industries. The Community Water System Service Cooperative or the COWASSCO, the lone water cooperative in town, benefits from the watershed to supply potable water to at least 14 barangays. On June 29, 1994, the President Fidel V. Ramos signed Proclamation No. 414 to officially establish Argao River Watershed Reserve (ARWR) to ensure its protection and development (5). However, prior to the proclamation, several interventions had already been introduced into the watershed area for vegetative and structural rehabilitation, such as timberland areas. Meanwhile, the introductions of rehabilitative measures in alienable and disposable areas were minimal depending on their respective landowners. Landowners mostly plant exotic species, while a few

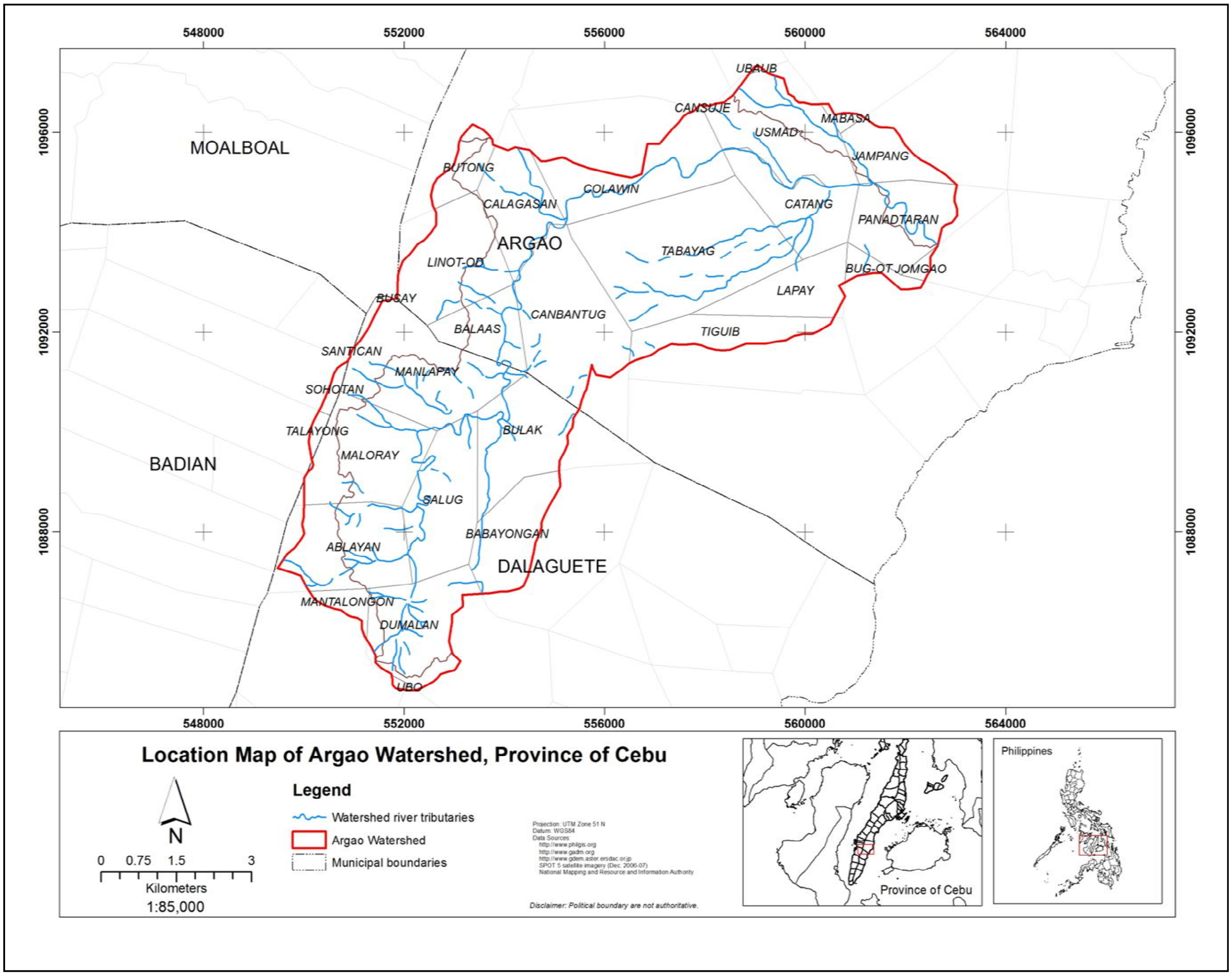

Figure 1. A map showing the location of the study site (with map of Cebu Province below and Philippine map inset)(Data sources: 5, 6)

Table 1. Administrative jurisdiction of Argao watershed Reserve (5).

MUNICIPALITY	BARANGAY
Argao	Lapay
	Cansuje
	Balaas
	Linut-od
	Calagasan
	Butong
	Conalum
	Catang
	Usmad
	Panadtaran
	Canbantug
	Tabayag
	Mabasa
Dalaguete	Dumalan
	Bulak
	Babayungan
	Salug
	Ablayan
	Manlapay
	Maloray
Badian	Santicon

3.1.3 Topography and slope.

The general topography of the area is steep to very steep, with rugged terrain ranging from 12% - 60% slope in any direction (5).The highest elevation is about 1,000m above sea level which is located in Barangay Ablayan, Dalaguete, Cebu in the southwestern part of the watershed where headwaters emanate.

On the other hand, one of the highest mountain peaks within the watershed area is situated in Mt. Lantoy in Barangay Tabayag, Argao with an elevation of about 593m above sea level. This peak has been declared by the International Union for the Conservation of Nature (IUCN) as important bird area (IBA) in 2001 due to the presence of *C. cebuensis*, one of the globally threatened bird species and a high level of threats for habitat loss because of human disturbance (4).

3.1.4 Climatic type.

The climate at AWR is classified under Climate Type III. Rainy season is from May up to November, while dry season is from December to April. Figure 2 shows the Climogram of Mactan, Cebu, the nearest weather station to AWR. The figure shows the average monthly temperature and rainfall data from 1973-2007. The dotted area represent the dry period. The wet season is represented by the gray-shaded area, with rainfall less than 100mm, and black area, with rainfall more than 100mm.

3.1.5 Vegetative cover and land Use.

The area has two different types of forest cover, the naturally grown trees which are indigenous or native species, and the man-made forest which are the plantation, previously managed under Southern Cebu Reforestation Development Project (SCRDP) in the early 1970's. Some remnants of natural forest fragments are found at the peak of Mt. Lantoy, and at the slopes of Argao River. Isolated forest patches are still present in barangays Canbantug, Panadtaran, Usmad, Tabayag, Conalum, and Cansuje. Mother trees of Ipil (*Instia bijuga (*Colebr.) Kuntze)and Molave (*Vitex parviflora* Juss) can be found in these areas. Natural vegetation and plantation forests comprise 29% (1,119.54 ha) of the watershed area (7). Majority of the declared watershed area are A&D lands, and are prone to accelerated erosion. Cash crops, agricultural crops, and corn are cultivated on agriculture areas. There are some scattered patches of second growth forest within forestland, which were established by SCRDP. Also, there are patches of brush land and other cultivations made by forest occupants (5).

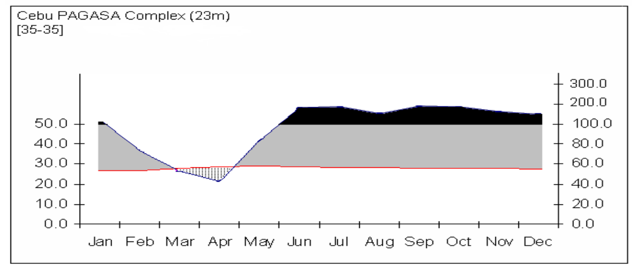

Figure 2. Climogram for Mactan, Cebu, showing average monthly temperature and Rainfall data from 1973-2007. Climatic data were taken from PAGASA-Mactan, Philippines.

3.1.6 Secondary Data Collection. Related information on the study topic were collected through the internet, especially in the directory of open on-line journal in the UP system to acquire published articles/materials, books, monograph, journals, among others which were related to the present work.

III. Relationship between Landscape Variables and Population Density of *C. cebuensis*

3.1 Landscape variables (LV). To determine the relationship between landscape variables and population density of *C. cebuensis* field survey on the selected forest patches in Argao watershed was conducted. The landscape variables (LV) (Table 2) were broadly categorized into the following: (a) physical, (b) habitat disturbance, (c) vegetation, and (d) microclimate variables. Some of these variables were gathered simultaneously with the bird data and some LV were gathered indirectly using field data as input and equations. Table 2 presents the variables that are considered in this study.

3.2 Bird sampling. Data on the population density of *C. cebuensis* was collected using distance point count sampling method (3). A total of 130 circular point count stations with 20 meter radius have been established among the four sampling areas. Twenty six (26) plots in Mt. Lantoy (Brgy. Tabayag), 23 plots in Brgy. Canbantug, 38 in Brgy. Usmad, and 43 plots in Brgy. Cansuje, (Fig. 3).

At each point survey station, the target bird species detected (i.e., either seen or heard) within 20m radius were recorded for about 10 minutes. The distance of every *C. cebuensis* encountered was estimated when first detected and recorded. Other information were also noted such as no. of clusters, time start, time observed, and type of contact, among others. The survey was conducted early in the morning and late in the afternoon (between 0600H to 1000H and 1600H to 1800H and no survey was conducted during bad weather especially during rainfall). This period of time is suitable as most of forest birds are active in early morning and late in the afternoon. All point survey stations were visited just only one time during the whole study period from April 7 to May 28, 2012 (for almost 2-month period).

Table 2. List of landscape variables.

HABITAT VARIABLES	REFERENCES	METHODS OF MEASUREMENT
1. Physical features		
a) Altitude/elevation	Bibby *et al*.,	GPS receiver
b) Slope gradient	2000	Abney hand level
c) Aspect	Bibby *et al*.,	Compass
d) Distance/nearest	2000	
streams/rivers	Bibby *et al*.,	Spatial Analyst (GIS)
	2000	
2. Human disturbance		
a) Dist. from sampling site forest edge/road		Spatial Analyst (GIS)
b) Dist. from sampling site nearest village/com.		Spatial Analyst (GIS)
c) Dist. to agriculture/cult.		Spatial Analyst (GIS)
3. Vegetation structures		
a) Total height (TH)	Bibby *et al*.,	Haga Altimeter
b) Diameter at breast	2000	Diameter tape
height (DBH)	-do-	Densiometer
c) Canopy density	-do-/ Rosli *et*	Computation/equation
d) BA of trees/ha	*al*., (2012)	Computation/equation
e) Tree density/ha	Bibby *et al*.,	Computation/equation
f) % Shrub/herb cover	2000	Ocular observation
g) Number of trees	-do-	Frequency/Counts
g.1 Diameter classe	Rosli *et al*.,	Tally/Counts
g.2 Height	2012/Posa &	Tally/Counts
classes	Sodhi, 2006	Ocular observation
h) Presence and	-do-	(1= presence; 0=
absence of bamboo	Kennedy *et al.*	absence)
thickets	(2000)	Evenness index value
i) Diversity index (H')	Shannon/Weiner	
4.Microclimate		
a) Temperature	Rosli *et al.*	Digital-min/max
b) Relative humidity	(2012)/Posa &	thermohygrometer
c) Light Intensity	Sodhi (2006)	EasyViewDigital
		Light Meter-Model
		EA30

3.3 Calculation Population Density of *Copsychus cebuensis*. Distance 6 Release 2 software program (13) was used in the calculation of the population density or size of *C. cebuensis* using covariates such as the radial distance of the target species from the center of the point transect station and the no. of cluster or individual in each station.

3.4 Regression analysis. An enter method multiple regression analysis was applied to determine the relationship between the landscape variables (25 predictors were tested in the landscape level analysis and only 10 predictors were finally included in the sampling site) and population density of *C. cebuensis* using the equation:

$$Y = Y = bo + b_1X_1 + b_2X_2 \ldots + bqXq + \mathcal{E}$$

Where, Y is the dependent variable (Population density of *C. cebuensis*);

$X_1, X_2, \ldots, X_q$ are the independent variables or predictors (Landscape variables);

$b_0, b_1, b_2, \ldots, bq$ are the partial regression coefficients of independent variables or predictors; and

$\mathcal{E}$= Random error

All statistical analysis were undertaken with SPSS license to UPLB College, Laguna 4031, Philippines.

VI RESULTS AND DISCUSSION

4.1 Relationship between Landscape Variables and Population Density of *Copsychus cebuensis*

4.1.1 Population density estimates for habitat or landscape level (mixed and natural forest). Table 3 however, presents the estimated population density of *C. cebuensis* using DISTANCE 6 release 2 software program (13) for two habitat types where mixed forest had 52 and 53 individuals─$ha^{-1}$for natural forest having the same coefficient of variation (CV) of 10% at 95% confidence interval. It is noted that these two habitat types or strata have more or less equal in the density of population per unit area. This indicates that *C. cebuensis* may have been adapted to this type of habitat conditions in the watershed area where they inhabit. These findings further indicate that *C. cebuensis* are still widely distributed among the remaining forest habitat patches within Argao watershed despite of being highly fragmented and highly disturb watershed landscape.

Table 3. Summary table for estimating population density on *Copsychus cebuensis.*

HABITAT/STRATUM	ESTIMATES (D)	COEFFICIENT OF VARIATION (%CV)	DEGREES OF FREEDOM	95% CONFIDENCE INTERVAL	
Mixed Forest	52	10.70	163.71	42.161	64.250
Natural Forest	53	10.71	164.12	43.276	65.967

4.1.2 Population density estimates at sampling sites. Among the sampling locations, Barangay Cabantug and Barangay Cansuje had the highest pooled population density estimate of *C. cebuensis* with 118 individuals ha^{-1} followed by Barangay Usmad with 114 individuals—ha^{-1}, and the lowest is Barangay Tabayag with 81 individuals─ha^{-1} (Table 4). It can be observed that though Barangay Canbantug and Barangay Cansuje have the same population density estimates but they had different %CV of 40% and 18%, respectively. It was observed further that the higher the number of contacts the lower the %CV whereas, the lower no. of contacts the higher %CV. According to (3), "for a distance sampling method to be adapted especially in point count survey it needs to have at least 80 to 100 individual contacts in order to achieve more reliable estimates of the density of population for certain organism under consideration. Based on these findings it can be inferred that the *C. cebuensis* are still widely distributed among the fragments of forest habitat patches remaining in Argao watershed.

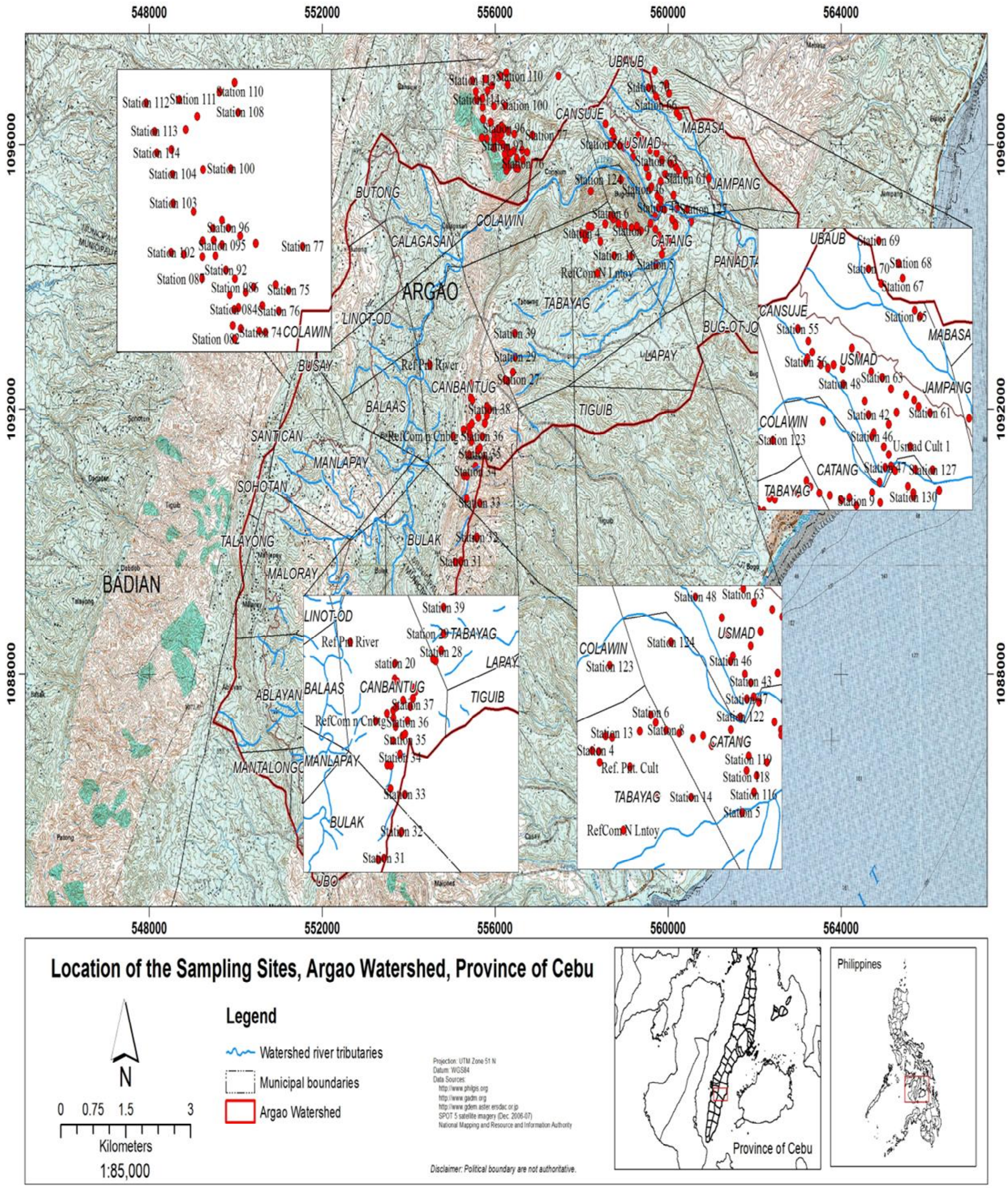

Figure 3. Plotted coordinates for the 130 point count sampling stations within the four respective sampling sites/locations in Argao watershed. (Data sources: 5; http://www.philgis.org; htt://www.gadm.org; http://www.gdem.aster.ersdac.orjp)

Table 4. Pooled density estimates of population density of *Copsychus cebuensis* in four sampling locations.

SAMPLING LOCATIONS (BARANGAY)	POOLED DENSITY ESTIMATES (D)	COEFFICIENT OF VARIATION (CV-%)	DEGREES OF FREEDOM (df)	95% CONFIDENCE INTERVAL	
Tabayag	81.053	38.98	24.24	37.312	176.07
Canbantug	118.55	40.52	22.47	52.860	265.87
Usmad	114.15	20.42	42.18	75.921	171.64
Cansuje	118.61	18.21	50.18	82.514	170.49

4.1.3 Regression analysis between landscape variables and population density of *Copsychus cebuensis* for habitat or landscape level (mixed and natural forest). Table 5 presents the results of regression analysis between the population densities of *C. cebuensis* at habitat or landscape level. The final model shows that: adjusted R^2 = 0.345,F22, 107= 4.093, p< .000 (using the enter method).By looking at the final model (particularly the adjusted R^2 value) this shows that only about 34.5% of the variances of the population density of *C. cebuensis* were being accounted for by the model.

Table 5. Results of regression analysis between population density estimates of *C. cebuensis* at habitat level (with 25 landscape variables)

MODEL	PREDICTORS (CONSTANT)	CODE	UNSTANDARDIZED COEFFICIENTS B	UNSTANDARDIZED COEFFICIENTS STD. ERROR	STANDARDIZED COEFFICIENTS BETA	SIG.
1		(Constant)	.083	44.827		.999
	1. Distance from nearest built-up area	DFNBA	-.001	.002	-.052	.516
	4. Altitude/Elevation	AL	.000	.003	.01	
	5. Slope	SLP	.028	.029	.07	
	6. Distance from nearest stream	DFNS	-.001	.001	-.05	
	7. Temperature	TEM	.437	.293	.14	
	8. Relative humidity	RH	.245	.053	.40	
	9. Light intensity	ILUX	-8.959E-05	.000	-.02	
	10. Tree basal area	TBA	-9.269	1.566	-.66	
	11. Canopy cover	TCPY	.021	.006	.26	
	12. Shrub layer	SHBL	.073	.043	.15	
	13. No. of trees (dbh ≥10-19);	NTB	-.304	1.345	-.01	
	14. No. of trees (dbh ≥20-29)	NTC	-1.031	4.094	-.38	
	15. No. of trees (dbh ≥30-39)	NTD	-.525	4.141	-.13	
	16. No. of trees (dbh ≥40-49)	NTE	-.808	4.106	-.154	.844
	17. No. of trees (dbh ≥50-59)	NTF	-.057	4.126	-.007	.989
	18. No. of trees (dbh ≥60 cm)	NTG	-.312	4.421	-.015	.944
	19. No. of trees (<10)	NTS	6.503	4.532	.407	.154
	20. No. of tree (≥10-19)	NTT	.028	.239	.011	.906
	22. No. of trees (≥30-39)	NTV	.000	.362	.000	.999
	23. No. of trees (≥40-49)	NTW	-2.781	1.998	-.126	[illegible]
	24. No. of trees (≥50)	NTX	-3.495	5.669	-.047	.539
	25. Evenness index value	EIV	18.658	23.786	.067	.435

F (22,107) 4.093 R^2 .457
Sig. of F .000 Adjusted R^2 .345

Only three out 25 predictors have able to explain the behavior of the population density of *C. cebuensis* namely: 1) relative humidity (RH) and canopy cover (TCPY) having positive high significant correlation (beta) with population density, with 0.400 and 0.261, respectively, with p-values at 0.000 and 0.001 with respectively which is < 0.01significant level. These findings indicate that with high RH and TCPY the population density of *C. cebuensis* may increase. While tree basal area (TBA) it has a negative high significant correlation with *C. cebuensis* population density with coefficient (beta) value of −0.660 and a p-value of 0.000 significant at 0.01 level. This finding indicates that if TBA increases the population of density of *C. cebuensis* decreases. The study on insectivorous birds and environmental factors in Malaysia's tropical rainforest showed that terrestrial insectivores were sensitive to forest edge and could indicate the quality of forest interior habitats associated with high humidity, dense canopy cover and deep litter depth (9).

4.1.4 Regression analysis between pooled population density estimates of *Copsychus cebuensis* and landscape variables for sampling sites. Based from the multiple linear regression analysis (using enter method) the results have shown a final model of: adjusted R^2= .212; F10,119=4.474, p< 0.000 with only 10 predictors included in the final analysis. This indicates that the model has accounted only 21.2% of the variation of population density of *C. cebuensis* which is lower by 13.3% compared to what is accounted for in the regression done at the habitat level. Table 6 presents the results of the regression done at this level.

Table 6. Results of the regression analysis between pooled population density estimates in four sampling sites (with 10 predictors included in the analysis).

MODEL	PREDICTORS	CODE	UNSTANDARDIZED COEFFICIENTS B	UNSTANDARDIZED COEFFICIENTS STD. ERROR	STANDARDIZED COEFFICIENTS BETA	SIG.
1	(Constant)		85.333	27.538		.002
	1. Elevation	ELEV	.030	.007	.398	.000
	2. Slope	SLP	-.148	.068	-.178	.032
	3. Temperature	TEM	.651	.680	.097	.341
	4. Relative Humidity	RH	.029	.115	.022	.799
	5. Light Intensity	ILUX	6.542E-05	.001	.007	.938
	6. Tree Density	TDEN	.007	.015	.040	.626
	7. Canopy Cover	TCPY	.186	.091	.177	.043
	8. Shrub cover	SHBL	-.157	.078	-.165	.047
	9. Diameter-at-breast-height	DBH	-.106	.241	-.046	.660
	10. Total Height	TH	-.466	.491	-.101	.345

F (10,119) 4.474
Sig. of F .000
R^2 .273
Adjusted R^2 .212

It has been observed further that there are four predictors have explained the behavior of the population density of *C. cebuensis* namely: a) elevation, b) slope, c) canopy cover, and d) shrub cover. Elevation has positive high significant correlation (beta) with population density of *C. cebuensis* with standardized coefficient of 0.398 and with p-value of 0.000, significant at 0.01 level (Table 6). This means that with increasing elevation the density of population of *C. cebuensis* will likely increase. Bird species richness (BSR) varied considerably with elevation and his difference in BSR among study sites could be due to elevation, and vegetation differences associated with elevation and not caused by the presence of a group of mid-altitude specialists (2).

For slope and shrub cover it is negatively correlated with population density of *C. cebuensis* with coefficients of -0.178 and -0.165 and with values of 0.032 and 0.047 significant at 0.05 level, respectively. These findings indicate that with increasing slope and shrub cover the population density of *C. cebuensis* will likely decreases. Lastly, for canopy cover it had positive significant correlation with *C. cebuensis* population density with coefficient of 0.177 and a p-value of 0.043 which is significant at 0.01 level. This means that with increasing canopy cover the population density of *C. cebuensis* will likely increase.

V. CONCLUSION

In regression analysis, there are only three out of 25 and four out of 10 have able to predict or explain the behavior of the population density of *C. cebuensis* at habitat (landscape) and sampling site level. Predictors which are positively highly significant at the habitat level were the following: a) relatively humidity (0.400, 0.01< p-value= 0.000), and b) canopy cover (0.261, 0.01< p-value= 0.001) while tree basal area is negatively highly correlated (-0.660, 0.01< p-value= 0.000). At sampling site, elevation has high positive significant correlation (0.398, 0.01<p-value= 0.000) with *C. cebuensis* population density, canopy cover has positive significant correlation (0.177, 0.05< p-value= 0.043), whereas slope and shrub cover has negative significant correlation (-0.178, 0.05< p-value=0.032 and -0.165, 0.05< p-value= 0.047). Based from the final model given the two levels of analysis, at landscape results have shown that 34.5% of the variances of the population density of *C. cebuensis* have been accounted for, while at the sampling site it accounts only 21.2%. Thus, regression analysis at landscape or habitat level is better than at sampling site because the former had accounted more variances compared to the later. Lastly, predictors or explanatory variables which appeared to be significant at the landscape especially canopy cover which is consistently significant both at landscape and sampling site level and all of which must be highly considered in the future decision-making process pertaining to the protection, management, and development of the remaining forest patches in Argao watershed in order to sustain *C. cebuensis* subpopulations that are still widely distributed among the forest patches being sampled.

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