

DIVERSITY OF BATS IN AGRO-ECOTOURISM FARM OF SCIENCE CITY OF MUÑOZ, NUEVA ECIJA, PHILIPPINES AND ITS ECTOPARASITIC FAUNA

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Abstract: Bats are the most diverse species of mammals in the world and are said to be the weapon in the war against insect pests in an agricultural ecosystem. They are also natural reservoirs of variety of parasites that may pose risk to humans. This study has aimed to determine the species of bats and their ectoparasitic fauna in an agro-ecosystem site. Trapping of bats was accomplished using a mist-net meanwhile ectoparasites were collected using fine curved forceps and were cleared for further identification. Five species of bats with a total number of 65 individuals were identified namely: *Cynopterus brachyotis*, *Ptenochirus jagori*, *Macroglossus minimus*, *Scotophilus kuhlii* and *Saccolaimus saccolaimus*. Meanwhile for the ectoparasites, *Nycteribia* sp. and *Spinturnix* sp. were the only species harboured from the captured bats. The diversity of bats in agro-ecotourism farm falls under the category of very low diversity. This could be attributed to the stressful environment in the study area; that could interfere with the activities of bats, especially its reproduction. Relationship of different environmental factors in an agro-ecotourism farm on the diversity of bats should be further analysed. Also, this study recommends determining the level of knowledge of local communities about ectoparasites of bats and its zoonotic implications to humans.

Keywords: agro-ecosystem, bats, diversity, ectoparasites

Introduction:

Bats are the most diverse species of mammals in the world and are disseminated globally; it is most plentiful in tropical countries and does

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not exist in Polar regions (Barlow 1999). Bats are considered as the most successful mammal species in the world that plays a vital role in natural ecosystems in arthropod suppression, seed dispersal and pollinators (Veikkolainen et al. 2014). Furthermore, bats are also said to be the keystone species and play an important role in maintaining the balance of an agricultural ecosystem (Hassi 2018). Aside from its benefits to the environment, bats are also natural reservoirs of large variety of viruses, bacteria and parasites that can cause severe diseases to humans and domestic animals, but are very poorly characterized (Wu et al. 2015). In addition to being diverse, bat ectoparasites also represent a some different evolutionary lineages. These comprise some groups of mites and ticks (Acari) and insects, including true flies (Diptera) and fleas (Siphonaptera). Many of these ectoparasites are host specific or infest a limited range of closely related bat species (Fritz 1983). In fact, it is poorly understood and probably underestimated in the field of epidemiology of most ectoparasite-borne diseases among bats.

Bats make up a vital proportion of mammalian diversity and perform essential roles in sustaining the health and services of the ecosystem. However, in the Philippines, there was only limited information on the species diversity of bats inhabiting agricultural ecosystem; this is because most of the assessment of the Philippine bat diversity was mostly done in caves and forest. In addition, there were only few studies on the taxonomy of bat ectoparasites in the Philippine island, particularly in Philippine agricultural ecosystem. In Central Luzon, agriculture is the major land use, however, due to rapid population growth, human have converted most of the agricultural land to urban areas resulting in human close association with wildlife animals, particularly terrestrial wildlife that causes diseases transmitted to humans. Since bats are one of the most significant and diverse group of animals in the world and play a vital role in the environment; information and knowledge about bat species found in agro-ecosystem

contribute significantly to bat conservation and research efforts. Furthermore this study gains information about the occurrence of ectoparasites of bats in Philippine agricultural settings.

Materials and methods:

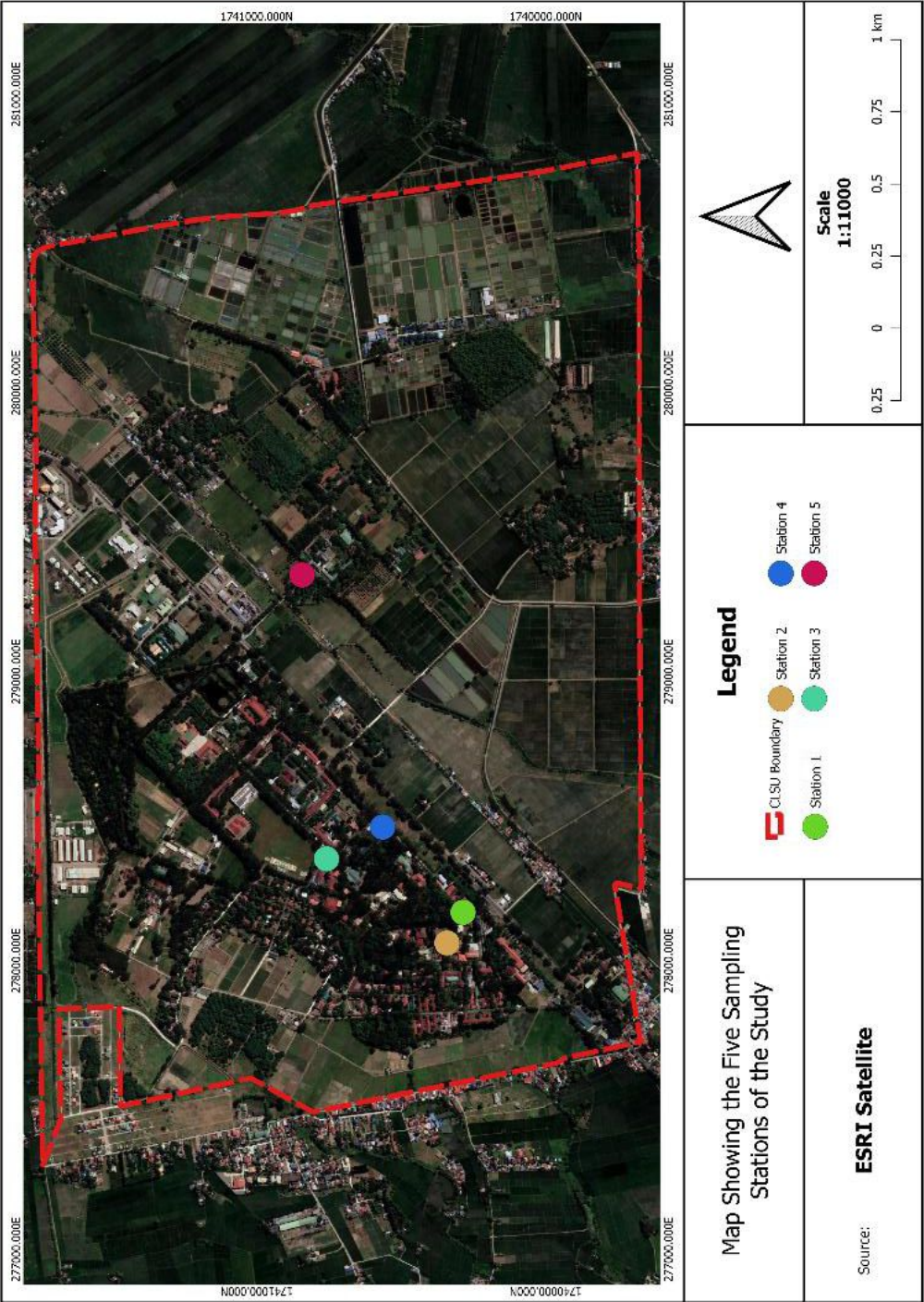
Ethical considerations

Prior to the conduct of the study, the protocol was approved by the research ethical panel of the Institute in accordance with Administrative Order No. 40 series of 1999 otherwise known as “Rules and Regulations on the Conduct of Scientific Procedures Using Animals” pursuant to Republic Act no. 8485 otherwise known as the “Animal Welfare Act of 1998”. Gratuitous permit from the Department of Environmental and Natural Resources (DENR) was secured prior to the collection of samples.

Study area

Central Luzon State University (CLSU) is globally situated at 15.75 °N latitude and 121.08 °E longitude and comprises a total land area of 658 ha which is mainly composed of agricultural rice field and fruit bearing trees (Fig. 1). CLSU can be found in the municipality of Science City of Muñoz, Nueva Ecija, Philippines. It is the leading agency of the Muñoz Science Community and the headquarters of the Regional Research and Development Center in Central Luzon. CLSU is one of Philippines Southeast Asia’s top agricultural institutions. It is also known as one of the most stunning school campuses in the Philippines due to its extensive and rural inspired forest and rice field landscapes and architecture (PRECUP 2009). It focuses on sustainability and ecological balance with rural and modern architecture and for this reason, CLSU was declared as agro-ecotourism farm model in Central Luzon, Philippines.

Figure no. 1 Map showing the five sampling stations of the study



Collection of Bats

Five stations were selected and established; roosting areas, presence of fruit bearing trees and abandoned infrastructure were considered in the site selection. For each sampling area, one mist-net was established during sunset at each night around 17:00-18:00 and retrieved around 5:00-7:00 in the morning. The sampling was done within a period of six months from Aug 2018 to Jan 2019. Bats were removed from the mist-net carefully and pictures of the bats were taken for documentation and further identification using a high resolution camera (Barlow 1999). Marking of bats was also accomplished with the use of chemiluminescent tags. Measurements of the body, tail, ear and forearm and taxonomic features were recorded to confirm species identification. Identification of bats was performed using available book and archive presented by Ingle and Heaney (1992) and Heaney et al. (1998).

Collection and Identification of Ectoparasites

Ectoparasites were collected by fine curved forceps and placed in vials with 70% ethyl alcohol, a different vial being used for each individual bat as described by Almeida et al. (2011). Clearing of ectoparasites was undertaken using standard method from Paller and Bandal (2017). Further identification was done using a compound microscope. Ectoparasites collected were identified based on the taxonomic keys described by Stanyukovich (1997), A Brief Guide to Bat Ectoparasites by Dodds (2018) and with the help of a parasitology expert.

Data Analysis

The data was analyzed using positivity rate and mean intensity (parasite per host) to determine the infestation of ectoparasites in hosts. Shannon-Wiener Index, evenness, dominance, relative dominance, density and relative density were computed to determine

the diversity of Chiropterans. The Diversity index scale was based on Fernando (1998).

Results and discussion:

Species Diversity of Bats in Agricultural Ecosystem

A total of 65 individuals of bats belonging to five (5) species inhabiting agro-ecotourism area namely, the greater musky fruit bat (*Ptenochirus jagori*) (n = 15), the lesser short-nosed fruit bat (*Cynopterus brachyotis*) (n = 39), the dagger-toothed long-nosed fruit bat (*Macroglossus minimus*) (n = 1), the pouched bat (*Saccolaimus saccolaimus*) (n = 2) and the lesser Asian house bat (*Scotophilus kuhlii*) (n = 8) were trapped and identified (Fig.2, Annexes).

The results of this study show that the overall diversity index value of bats collected in the study area was 1.074 with an overall evenness value of 0.667. Based on the diversity index scale developed by Fernando (1998), the computed diversity index of bats in the study area falls under the category of very low. On the other hand, the most dense species of bats collected from this present study is the *Cynopterus brachyotis* (Lesser short-nosed fruit bat) with a relative density of 60% and a total number of 39 individuals. It is followed by *Ptenochirus jagori* (Greater Musky fruit bat) with a total number of 15 individuals with a relative density of 23.077%, while *Scotophilus kuhlii* (Lesser Asian house bat) has a relative density of 12.308% with a total number of 8 individuals. Lastly, *Saccolaimus saccolaimus* (Pouched bat) with a relative density of 3.077% with a total of 2 individuals. Meanwhile, the least dense species is the *Macroglossus minimus* (Dagger-toothed long-nosed fruit bat) with a total number of only one individual and has a relative density of 1.538%. In terms of relative dominance, *Cynopterus brachyotis* (Lesser short-nosed fruit bat) has the highest relative dominance with 83.802%; hence *C. brachyotis* is the most dominant and dense

species among others. Meanwhile, the least dominant species was the *Macroglossus minimus* (Dagger-toothed long-nosed fruit bat) with a relative dominance of 0.055% (Tab. 1).

Table no. 1 Computed Value of Density (D), Relative Density (RD), Dominance (Do) and Relative Dominance (RDo)

Species	D	RD (%)	Do	RDo (%)
<i>Ptenochirus jadori</i>	0.030	23.077	0.053	12.397
<i>Cynopterus brachyotis</i>	0.078	60.000	0.360	83.802
<i>Macroglossus minimus</i>	0.002	1.538	0.0002	0.055
<i>Saccolaimus saccolaimus</i>	0.004	3.077	0.001	0.220
<i>Scotophilus kuhlii</i>	0.016	12.308	0.015	3.526

Identified Ectoparasitic Fauna in Chiropterans

In this present study, *Nycteribia* sp. (bat fly) and *Spinturnix* sp. (bat mite) were the only two ectoparasites collected and identified; they belonging to Nycteribiidae and Spinturnicidae family (Fig. 3, Annexes). A total of 31 ectoparasites were recovered from *C. brachyotis* and *S. saccolaimus*. The *Nycteribia* sp. infested seven individuals from

C. brachyotis with a positivity rate of 17.85% (n = 11) and mean intensity of 0.28 MI (parasite per host). Meanwhile, two individuals of *S. saccolaimus* were infested by both ectoparasites; *Spinturnix* sp. (n = 13) and *Nycteribia* sp. (n = 7) with both a positivity rate of 100% and mean intensity of 6.5 MI and 3.5 MI (parasite per host); respectively (Tab. 2). In contrast, the other three species of bats were not infested by any ectoparasites.

Table no. 2 Percentage occurrence of ectoparasites in different species of bats (n = 65)

Species of Bats	Number of Bats Collected (N=65)	Number of Bats Infested (n = 9)	Genus of Ectoparasites Infesting Bats	Number of Ectoparasites Infestation in Bats	Positivity Rate (%)	Mean Intensity (MI)
<i>Cynopterus brachyotis</i>	39	7	<i>Nycteribia</i> sp. only	11	17.85%	
<i>Saccolaimus saccolaimus</i>	2	2	<i>Nycteribia</i> sp. <i>Spinturnix</i> sp.	7 13	100%	
<i>Ptenochirus jadori</i>	15	-	-	-	-	
<i>Macroglossus minimus</i>	1	-	-	-	-	
<i>Scotophilus kuhlii</i>	8	-	-	-	-	
Total	65	9		31		

Note: MI= Mean Intensity; (-) indicates absence of ectoparasites

The present study has revealed a very low diversity of bats indicating that the ecosystem diversity for bats in the study area is insufficient and not diverse; likewise, that it cannot sustain the necessity of these species resulting in competition and very low diversity. Based on the assumption of the present study, low diversity could be attributed to the unwanted anthropogenic activities occurred during the conduct of the study period. The disturbances such as noise, light and dust coming from the building constructions in the area could be attributed to the findings of the present study. Bats are considered sensitive to noise, dust and light; also, bats are vulnerable to vision impairment when exposed to light pollution that may affect their route choice (Voigt et al. 2017). Further, bats also respond in an aversive way to noise (Luo et al. 2014), whereas dust particles and chemical pollutants may engender disorientation to bats (Li et al. 2016).

Another factor could be due to changes in weather conditions during sampling periods; this can also be seen a contributing factor to the low diversity of bats in the area. During the conduct of the present work, capture rates of bats declines when there is abrupt change in the environment and weather conditions such as phases of the moon, wind and rain that could interfere with the activities of bats. This is in consonance with the study conducted by Aroon (2014), wherein his study confirmed that moonlit nights and rain interfere with the foraging activity of bats. But nevertheless, assessment on the external environmental factors must be considered to further analyze their effects on the diversity and species of bats. The present study revealed that most of the bats that were captured in the study area were *C. brachyotis* and *P. jagori* since these species are commonly found in disturbed and urban areas and have also been reported in degraded habitat (Csorba et al. 2008; Ong et al. 2008).

In addition, the present study shows that presence of numerous fruit bats during the sampling period could probably due to abundance of fruit-bearing trees in the area

such as mangoes (*Mangifera indica*), banana (*Musa* sp.), macopa (*Syzygium samarangense*), papaya (*Carica papaya*), *Ficus* sp. trees and atis (*Annona squamosa*). The collection of data in this work was undergone during the month of Aug to Jan (wet season) wherein several fruit-bearing trees are in their peak season. This observation was coherent with the result of Stoner (2005) where he reported that fruit bats had higher abundance in wet season wherein fruit availability was in peak. Conversely, the assumption of this present study and result of Stoner (2005) stands in sharp contrast with the study of Aroon (2014); wherein he revealed that frugivorous bat abundance is not associated with fruit availability. Hence, this present study suggests to further analyze the relationship of food availability in the abundance of a specific species of bats.

Meanwhile, only two bat species were infested by ectoparasites namely *S. saccolaimus* (Pouched bat) and *C. brachyotis* (Lesser short-nosed fruit bat). Furthermore, *S. saccolaimus* (Pouched bat) was the only species of bats that were infested with both *Spinturnix* sp. and *Nycteribia* sp. Additionally, this bat species obtained the highest number of ectoparasites infestation among other species identified in the present study. Based on the observation, the multi-infestation from *S. saccolaimus* (Pouched bat) can be influenced by its spatial area, wherein it migrates farther to search for food and habitat. In consonance, with the study of Lindenfors et al. (2007), it explained that geographical range is seen as an important determinant of parasite species richness (PSR).

Another factor could be due to the age of the bat; several studies revealed that adult bats had more ectoparasites load than juvenile bats (Zahn and Rupp 2004). However, in contrary with the latter findings, Aroon (2014) reported that several studies found that juvenile bats carried ectoparasites more than adult bats. This may be true, however extensive study on the mean intensity of ectoparasites in different species of bats should be analysed to further provide evidence for this cause. Furthermore, aside

from factors stated above, roosting site can also be seen as a factor with regards to the numerous ectoparasites collected in *S. saccolaimus* (Pouched bat).

The study revealed that *S. saccolaimus* (Pouched bat) is classified as cavity roosting bat since it roosts in structures providing darkness was found to have higher parasite loads. In comparison, *C. brachyotis* (Lesser short-nosed fruit bat) is classified as foliage roosting bat and much more exposed to light rather than the latter species tend to have lower parasitic load; this is same with other species of bats identified in this present study. This assumption has been proven by the study of Bordes et al. (2008), wherein they emphasized that cavity rooster bats have significantly higher parasite loads than those classified as foliage rooster bats.

Additionally, in terms of Host-parasite associations, Marshall (1981) revealed that the association could be classified into monoxenous (utilizing a single host species), oligoxenous (utilizing two or more hosts in the same genus), pleioxenous (utilizing two or more hosts in the same family) and polyxenous (two or more hosts of different families). Thus, this statement confirmed that *Spinturnix* sp. is classified as monoxenous since it was found utilizing a single host species. Meanwhile, *Nycteribia* sp. can be classified as polyxenous since it utilizing two bat species from different families of Chiropterans namely: *S. saccolaimus* (family Emballonuridae) and *C. brachyotis* (family Pteropodidae). Ectoparasites could be a vector-borne which transmit numerous diseases to animals as well as humans.

Conclusions:

Based on the results, the diversity of bats in the agro-ecotourism farm falls under the category of very low diversity. It indicates that the environment in the study area is stressful that it could seriously affect the activities of bats, especially its reproduction to which only certain species of bats could adapt. Unwanted anthropogenic activities

such as construction of new buildings inside the area, resulted to the degradation of its habitat and seen as one possible cause of a very low diversity of bats. All species of bats were captured near buildings, dormitories and houses; hence, residents near established sampling sites are at high-risk of bats zoonotic diseases. Since, only two genus of ectoparasites were identified; it could be concluded that bat flies and mites are the most common ectoparasites in the study area.

Recommendation

This suggested further study about bat and its ectoparasites in agricultural areas. The sampling period of mist-netting was done during wet season, thus present study suggests to also collect data during dry season, to compare the result of the two different seasons, specifically in terms of infestation rate of ectoparasites, diversity of bat species and about how season affects the host and parasite. Additionally, determining the sex of the bat species is recommended for better correlation between ectoparasite and host. The study also suggests to use other capture method such as harp trap in capturing bats to compare the efficiency and effectibility between those methods in an agricultural ecosystem. This study also recommends to compare the diversity and ectoparasitic fauna of bats in different habitat/ecosystem.

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Rezumat:

**DIVERSITATEA LILIECILOR
ÎN FERMA AGRO-ECOTURISTICĂ
A CAMPUSULUI ȘTIINȚIFIC MUÑOZ,
NUEVA ECIJA, FILIPINE
ȘI FAUNA SA ECTOPARAZITICĂ**

Lilieci sunt cele mai diverse specii de mamifere din lume și se spune că ar fi arma în războiul împotriva insectelor dăunătoare într-un ecosistem agricol. Sunt, de asemenea, rezervoare naturale pentru o mare varietate de paraziți care pot prezenta riscuri pentru oameni. Acest studiu și-a propus să determine speciile de lilieci și fauna lor ectoparazită într-un sit agro-ecosistem. Prinderea liliecilor a fost realizată folosind o plasă de ceață, în timp ce ectoparaziții au fost colectați cu ajutorul pensei curbate fine și au fost preparați pentru identificare ulterioară. Au fost identificate cinci specii de lilieci cu un număr total de 65 de indivizi și anume: *Cynopterus brachyotis*, *Ptenochirus jagori*, *Macroglossus minimus*, *Scotophilus kuhlii* și *Saccolaimus saccolaimus*. Între timp, dintre ectoparaziți, *Nycteribia* sp. și *Spinturnix* sp. au fost singurele specii descoperite la lilieci capturați. Lilieci din ferma de agroecoturism se încadrează în categoria de diversitate foarte scăzută. Acest lucru ar putea fi atribuit mediului stresant din zona de studiu, care ar putea interfera cu activitățile liliecilor, în special cu reproducerea acestora. Relația diferiților factori de mediu într-o fermă de agroecoturism cu diversitatea liliecilor ar trebui analizată în continuare. De asemenea, acest studiu recomandă determinarea nivelului de cunoștințe al comunităților locale despre ectoparaziții liliecilor și implicațiile zoonotice pentru oameni.

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Annexes:

Figure no. 2 Five species of bats identified in the study area:

a. Greater Musky Fruit Bat (*Ptenochirus jagori*) has a large eyes and broad and dark head



b. Lesser Short-nosed fruit bat (*Cynopterus brachyotis*) described with white frontal edges in the ear, white color of the bone in the wing, and yellow/orange ruff around the shoulder



c. Dagger-toothed long nosed fruit bat (*Macroglossus minimus*) described with an elongated muzzle and long tongue



d. Lesser Asian house bat (*Scotophilus kuhlii*) described with a long tragus and a simple nose



e. Pouched bat (*Saccolaimus saccolaimus*) described with a black dorsal fur with white spots, round tragus and pointed muzzle



Figure no. 3 Two ectoparasites collected from bats found in the study area: (a) *Nycteribia* sp.; (b) *Spinturnix* sp.

a.



b.

