DIVERSITY OF A HIGHLY VARIABLE LANDSCAPE: THE HERPETOFAUNA OF CENTRAL LUZON STATE UNIVERSITY, NUEVA ECIJA, PHILIPPINES

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Abstract: Central Luzon State University (CLSU) is considered as a large agro-ecosystem. Man-made ponds, grasslands, reforestation sites, and human habitation and facilities are areas within this agro-ecosystem. This study aims to document the species of amphibians and reptiles associated with the different habitats within CLSU and assesses the impact of a continually changing landscape on the distribution and diversity of herpetofauna in the area. A detailed species account for seventeen (17) species of amphibians and reptiles (6 species of frogs, 3 species of gekkonid lizards, 1 species of skink, 1 species of monitor lizard, 5 species of snakes and 1 species of soft-shelled turtle) from CLSU was presented in this study. Five (5) species were introduced species, 8 were native and 4 endemic, found only in the Luzon faunal region.The ability of introduced species to tolerate human presence and their ability to adapt to the regular seasonal changes in the habitat characteristics and structure made them abundant in the area. Invasive species can threaten native fauna by means of competition for resources and active predation. The low number of species recorded in CLSU can be attributed to several factors including frequent changes in microhabitat structure, habitat fragmentation, and anthropogenic disturbances.

Keywords: agroecosystem, diversity, herpetofauna

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Introduction:

The Philippines, an archipelagic country with 7614 islands is home to diverse species of amphibians and reptiles. Studies have listed 112 species of amphibians and 361 species of reptiles in the Philippines (Diesmos et al. 2015, Uetz et al. 2018). Endemism is also high: about 84% of recorded amphibians and 66% of recorded reptiles are found only in the Philippines.

Central Luzon State University (CLSU) is a 658 hectares located at Science City of Muñoz, Nueva Ecija in Central Luzon (Fig. 1). The rainy season falls from June to December while the dry season occurs during the rest of the year. CLSU is characterized by large areas dedicated to growing rice, hence the area can be considered as a large agro-ecosystem. Interspersed within this agro-ecosystem are man-made ponds where tilapia (*Oreochromis niloticus*) are grown, grasslands, reforestation sites, and human habitation and facilities. Natural habitats are usually separated by the presence of buildings and facilities which likely limits species distribution within the area.

Being an agro-ecosystem and with a high number of human population, the area experiences seasonal changes in microhabitat structure. Changes include not only seasonal variation in temperature and precipitation, but also physical changes brought about by the cropping of rice which happens three times per year. The aquatic habitats of the area also changes throughout the year, with some of the ponds drying up during the drier parts of the year. Aside from these changes, the continual human presence in the area has brought about changes in the form of disturbances such as the introduction of waste in the soil and water.

This continuous change in the microclimatic condition, habitat patchiness, physical characteristics of the environment and continuous human presence is likely to have a considerable effect on the species composition of the area. This is especially true for ecologically sensitive animals like amphibians and reptiles whose physiology is easily affected by changing environment. The goal of this study is to document the species of amphibians and reptiles associated with the different habitats within CLSU and assess the impact of a continually changing landscape on the distribution and diversity of herpetofauna in the area.

Materials and methods:

Survey Areas

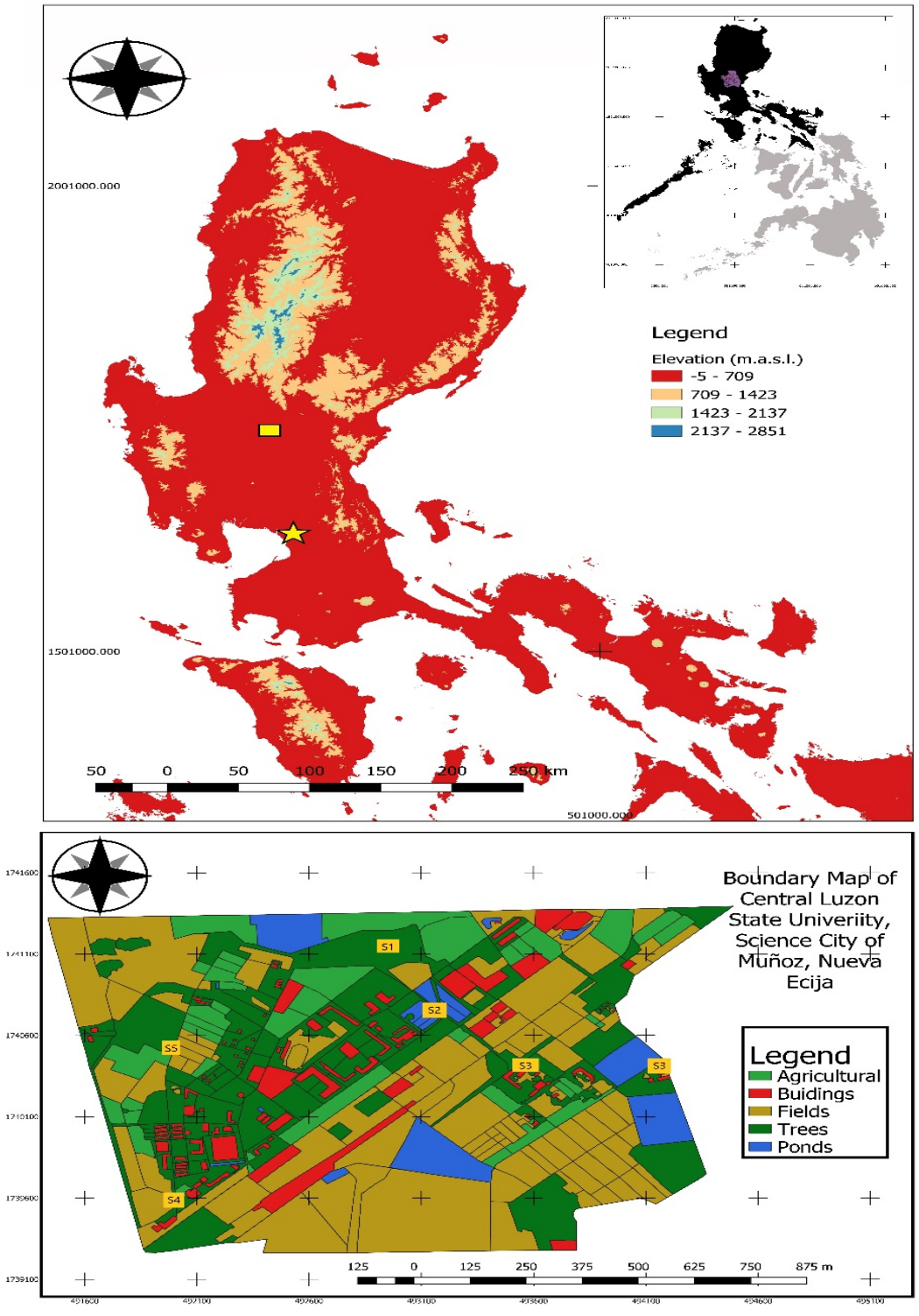
The primary habitats survey included the rice fields, fish ponds, grasslands and reforestation site within the main campus. Additional site surveyed included the rice fields and fish ponds in the College of Agriculture and College of Fisheries which was separated from the main campus by the national highway (Fig. 2, Annexes).

Location 1 (Lingap Kalikasan) (15°44'33.19" N, 120°56'7.01" E): A well-defined reforested area in CLSU. Dominated by numerous large native and introduced species of trees such as mahogany (*Swietenia macrophylla*), acacia (*Albizia saman*), narra (*Pterocarpus indicus*), gmelina (*Gmelina arborea*). It is an unpaved area with c man-made ponds where some aquatic species live and few residential houses.

Location 2 (Nueva Ecija Fish Hatchery Development and Aquaculture Project) (15°44'19.92" N, 120°56'16.01" E): The area is composed of subtle man-made shallow nutrient ponds. A pond in this area occasionally turns to greenish black color due to teeming of algae and aquatic plants. There are some shrubs in the area and patches of grass and trees. This area is also well known as the Baywatch area.

Location 3 (College of Agriculture and College of Fisheries) (15°44'10.60" N, 120°56'27.88" E and 15°44'10.71" N, 120°56'47.56" E): The wide range of agricultural vital areas of natural vegetation into cropland and orchard farm that varies with different woody trees (e.g. acacia, narra, mahogany etc.) and fruit trees (e.g. mango, atis, cacao etc.), shrubs, and pasture lands for livestock production and large ponds.

Figure no. 1 Topographical map of mainland Luzon, Philippines. Inset shows the location of Luzon Island (darkly shaded) in the Philippines, with the violet area indicating the province of Nueva Ecija. Location of the Central Luzon State University is indicated by yellow square. The location of the capital city of Metro Manila is indicated by a yellow star.



Location 4 (Old Research Area) (15°43'40.88" N, 120°55'35.82" E): This area is composed of rice fields and experimental farms planted with rice, vegetables and plants. The area is situated between the Research Avenue and S.H. Escudero Street.

Location 5 (Azucena St.) (15°44'15.68" N, 120°55'35.35" E): This area is composed of mango (*Mangifera indica*) farm, rice (*Oryza sativa*) paddies and shrubs. This area was located near the experimental farms of the Ramon Magsaysay – Center for Agricultural Research and Environmental Studies (RM-CARES) and old dumpsite of CLSU.

Each area was surveyed using standardized 10 m × 100 m strip transects (Supsup et al. 2016; Diesmos 2008; Diesmos et al. 2005; Rödel and Ernst 2004; Heyer et al. 1994). Searches involving 5 persons were conducted from 0800 hr to 1200 hr and 1900 hr to 2300 hr daily. All accessible microhabitats confined within each habitat where animals might have been ensconced were searched by raking the leaf litter, probing epiphytes and tree hollows, upturning rocks and logs, and splitting-open decayed logs (Diesmos 2008). Human habitations were also surveyed for herpetofauna. Road surveys were also conducted by walking along roads and footpath. The vegetation along the fish ponds and rice fields were extensively surveyed for the presence of herpetofauna.

Collected herpetofauna were photographed in-situ. Voucher specimens were not collected during this study. Nomenclature follows Brown et al. 2000, Diesmos et al. 2005, McLeod et al. 2011, Siler et al. 2011, Devan-Song and Brown 2012, Siler et al. 2012, Brown et al. 2013, Diesmos et al. 2015, Leviton et al. 2018.

Results and discussion:

A total of 17 species of amphibians and reptiles (6 frogs, 3 gekkonid lizards, 1 skink, 1 monitor lizard, 5 snakes and 1 soft-shelled turtle) were recorded from CLSU. Five species were introduced species, 8 were native and 4 endemic, found only in the Luzon faunal region. Species accounts, notes on their natural history and habitat, and known distribution records are presented below.

Amphibia
Family Bufonidae

Rhinella marina (Linnaeus, 1758)
This introduced species of toad (Fig. 3, Annexes) is found throughout CLSU. It inhabits the different freshwater habitats, residential areas, school premises, agricultural zones and the reforested site. The toad is active throughout the night especially around freshwater habitats where their calls can be heard. They are also common in lighted areas where they hunt their insect prey. They can be distinguished by their warty skin, stout body and the presence of parotid gland behind the tympanum which secretes poison.

Family Dicroglossidae

Fejervarya moodiei (Taylor, 1920)
F. moodiei (Fig. 4, Annexes) is one of the native frog species which can be found in CLSU. It inhabits the rice paddies throughout CLSU although it is not as common as *Hoplobatrachus rugulosus*. The species can be distinguished from *H. rugulosus* by the yellow coloration on its hindlimb.

Hoplobatrachus rugulosus (Wiegmann, 1854)
Another introduced species, *H. rugulosus* (Fig. 5, Annexes) was introduced in 1996 for its meat. Since then, it has become a common resident of agricultural areas. In some places it has replaced the endemic *Fejervarya vittigera*. Individuals were observed in the rice fields of the Old Research Office, College of Agriculture-College of Fisheries, RM CARES and Lingap Kalikasan. The species are commonly used for dissection.

Family Microhylidae

Kaloula pulchra (Gray, 1831)
This frog species was introduced through the pet trade way back in 2000. Since then it has become widespread throughout the Philippines. *K. pulchra* (Fig. 6, Annexes) can be easily distinguished by the two dorso-lateral stripes in its body and its very distinctive call which can be heard especially during rainy season. Individuals belonging to this species can be found in aquatic habitats, clinging on vegetation or walls throughout CLSU.

Family Ranidae

Hylarana erythraea (Schlegel, 1837)
The first species of frog introduced in the Philippines, *H. erythraea* (Fig. 7, Annexes) to have been introduced accidentally in the 1890s through the plant trade. It can be distinguished by its bright green color and a pair of whitish dorso-lateral stripes. Calls from males which sound like chick-chirps can be heard from the aquatic vegetation on Location 2 (Nueva Ecija Fish Hatchery Development and Aquaculture Project).

Family Rhacophoridae

Polypedates leucomystax (Grayenhorst, 1829)
P. leucomystax (Fig. 8, Annexes) was one of the other native species of frog found in CLSU. Commonly found on vegetation along aquatic habitats, this frog is active at night especially during the rainy season. At times, the species can also be found in residential areas.

Reptilia (Squamata: Lacertilia)
Family Gekkonidae

Gehyra mutilata (Weigmann, 1824)
This common human commensal (Fig. 9, Annexes) is found throughout the Philippines. Unlike other house lizards such as *Hemidactylus platyurus*, *G. mutilata* prefers areas with low lighting. They are found in human habitation, sheds, lamp posts and trees throughout CLSU. The species can be distinguished from other house lizards by the presence of black and white spots throughout its body.

Hemidactylus frenatus (Dumeril and Bibron, 1836)
This species of house lizard (Fig. 10, Annexes) is often found in or around human habitation and cottages built throughout CLSU. Individuals are often active at night, when they are often seen preying on insects around light sources. The species may come with different patterns, but can be distinguished by the presence of projections in its tail.

Hemidactylus platyurus (Schneider, 1797)
Another member of the genus *Hemidactylus* known to be present in CLSU is *H. platyurus*. Similar to its congener, this species is often found in well-lit areas in residential and non-residential parts of CLSU where they are seen preying on insects. Although no individuals were photographed during this survey, we are certain that this species is present since it is a common human commensal found throughout most of the Philippines. The species can be distinguished from *H. frenatus* by the characteristic flat, broad tail with projections.

Family Scincidae

Eutropis multifasciata (Kuhl, 1820)
This species of skink (Fig. 11, Annexes) is commonly found in vegetation along the aquatic habitats in Location 2 (Nueva Ecija Fish Hatchery Development and Aquaculture Project) and Location 1 (Lingap Kalikasan). Individuals can be seen scampering on the leaf litter and grasses, often scampering away when disturbed.

Family Varanidae

Varanus marmoratus
This species of omnivorous monitor lizard is the most commonly encountered species of

Varanus sp. The last confirmed sighting of the species in CLSU was in 2012, when an individual inadvertently entered one of the buildings in the campus. Although we failed to detect the presence of this species during the current survey, it is likely that some individuals are still present in the dense vegetation of Location 1 (Lingap Kalikasan) and Location 5 (Azucena St.)

Reptilia (Squamata: Ophidia)
Family Colubridae

Calamaria gervaisii gervaisii (Taylor, 1922)
This species, although not observed in the sites visited in this study was observed to be common at the College of Science building compound where they are found in the grassy spaces. Young individuals were recorded during the summer months. Two adult snakes were found dead, probably killed out of fear despite the fact that the species is non-venomous.

Chrysopelea paradisi variabilis (Mertens, 1968)
C. paradisi (Fig. 12, Annexes) is a brightly-colored, non-venomous species which can be found in CLSU. Several individuals were reported by students and one was caught near the second gate of CLSU. This arboreal snake is active during the day and can be easily identified by its distinct color pattern of yellow, orange and red on a black body.

Lycodon capucinus (H. Boie *in* F. Boie, 1827)
L. capucinus (Fig. 13, Annexes) is found throughout the Philippines. We recorded two individuals belonging to this species in CLSU. They were found clinging to tree trunks during the night in search of prey. They can be identified by the presence of a black body with white markings. When disturbed, they excrete a foul-smelling substance to deter their predators.

Rhabdophis spilogaster (H. Boie *in* F. Boie, 1827)
One of the three endemic species of herpetofauna so far known from CLSU, *R. spilogaster* (Fig. 14, Annexes) is found only in Luzon and adjoining islands. This non-venomous snake is often found inhabiting vegetation along rice paddies. A single individual, killed by a cat, was collected from the College of Agriculture. The species can be identified by its pale brown coloration and two brown stripes running from the neck to the tail.

Family Elapidae

Naja philippinensis (Taylor, 1922)
Another species endemic to Luzon, a single *N. philippinensis* was recorded within the rice paddies of the Location 4 (Old Research Area) Complex building where it actually hunts for its prey. It is likely that they are more common in CLSU since many reports about cobra have been recorded. Smaller than the king cobra, *Ophiophagus hannah*, the *N. philippinensis* can be identified by the presence of the distinct hood as threat display and a generally black body. Although venomous, the species will avoid human contact and at times often falls victim to farm machineries used in the areas they inhabit.

Reptilia (Testudinata)
Family Trionychidae

Pelodiscus sinensis (Schneider, 1801)
The presence of this invasive species of soft-shelled turtle in CLSU has been confirmed by two collected specimens caught by student in the Location 3 (College of Fisheries) and the ponds in Location 2 (Nueva Ecija Fish Hatchery Development and Aquaculture Project). Hence, no individuals were photographed during this survey. The turtle can be easily distinguished by the presence of the leathery carapace and an elongated snout.

The result of the recent survey provides an updated list of herpetofauna found in CLSU. The number of species recorded in this study represents about 4% of the total Philippines herpetofauna (approximately 473 species; Diesmos et al. 2015; Uetz et al. 2018). The number of recorded species in CLSU is low compared to other sites surveyed throughout

Luzon. Diversity patterns for the reasonably well surveyed areas of Luzon include 72 species for the Cordillera (Diesmos et al. 2005; Brown et al. 2013; Diesmos et al. 2015), 79 species for Bulacan Province, southern Sierra Madre (McLeod et al. 2011; Diesmos et al. 2015), 54 species from the Zambales Mountains (Brown et al. 1996; Devan-Song and Brown 2012; Diesmos et al. 2015), 112 species from northern and central Sierra Madre (Brown et al. 2000; Siler et al. 2011; Diesmos et al. 2015), 61 species from the Bicol Peninsula (Brown and Gonzalez 2007; Siler et al. 2010; Brown et al. 2015; Diesmos et al. 2015) and 66 species from the Caraballo Mountain Ranges (Gojo Cruz et al. 2018; Siler et al. 2009; Fuiten et al. 2011).

The low number of species recorded in CLSU may be attributed to several factors: (1) compared to the complex habitat types in the aforementioned study, CLSU is dominated by simpler habitat types, mostly agro-ecosystems and artificial ecosystems. The simpler habitat structure offer limited niches compared to those present in the forest habitats. The habitats within CLSU are often modified with regularity, such that herpetofauna, especially forest-dependent endemic species, which are sensitive to changes in microhabitat structure, cannot thrive well within CLSU. The few species recorded here are known to be able to tolerate and to some extent benefit from anthropogenic activities; (2) the area where CLSU is currently located has been historically a combination of marshland and grassland, the nearest forested area being Pantabangan Watershed from CLSU. Hence, forest-dwelling species are unable to colonize this area due to distance and differences in microhabitat structure; (3) limited sampling duration and limited number sampling site may also explain the low number of species and individuals encountered. Moreover, the sampling method employed in the survey allows only for the survey of the lower strata vegetation and not the canopy; (4) seasonal variation in species composition which may influence the presence or absence of species in an area; and (5) the cryptic species such as burrowing species of snakes may have been overlooked due to the difficulty in detecting them.

The number of endemic species is low compared to the number of introduced and native species. Four of the six introduced species of frogs in the Philippines were recorded within the study sites. We failed to detect the presence of *Lithobates catesbeianus* and *Eleutherodactylus planirostris* which were also recorded on Luzon Island (Diesmos et al. 2015). *R. marina* was introduced in the Philippines as a means to control population of crop pest in agricultural areas, *Hoplobatrachus rugulosus* and *L. catesbeianus* were introduced through breeding programs for meat farming, and *Kaloula pulchra* was introduced through the pet trade (Diesmos et al. 2006).

Among reptiles, the soft-shelled turtle, *Pelodiscus sinensis* is listed as introduced probably due to the pet trade. This species of soft-shelled turtle is considered as a pest due to its tendency to eat fish hatchlings. Four species of snakes (*Calamaria gervaisii gervaisii*, *Chrysopelea paradisi*, *Rhabdophis spilogaster* and *Naja philippinensis*) were Philippine endemics. These snakes were often found in vegetation along ponds, rice paddies and grasslands.

Threats to the areas' herpetofauna include the presence of introduced species, habitat modification and fragmentation, and persecution.

The abundance of introduced species in the area is attributed to their ability to tolerate human presence and their ability to adapt to the regular seasonal changes in habitat characteristics and structure. Invasive species can threaten native fauna by means of competition for resources and active predation. Initial analysis of the gut contents of invasive frogs were conducted by Diesmos et al. (2006). Invertebrates (insects and mollusk) account for 90% of the diet consumed by invasive frogs. Other herpetofauna listed in the area which relies on the same food source includes *F. moodiei*, *P. leucomystax*, *H. frenatus*, *H. platyurus* and *E. multifasciata*. The abundance of these

introduced frog increases competition for insect prey. Moreover, *H. rugulosus* is a voracious predator known to consume both invertebrate and vertebrate prey. Some of the vertebrate food items found within the guts of *H. rugulosus* include juvenile *C. gervaisii* and *R. spilogaster* (Diesmos et al. 2006). This two species happen to be present in the area, thus *H. rugulosus* can pose threat to these species population through predation.

Being an agricultural area, it is expected that habitats in the area are prone to changes in vegetation characteristics related to cropping patterns. The availability and quality of water also varies depending on the season. The remaining forested and grassland areas are also becoming more fragmented as new facilities are being built. Species which can tolerate such changes may be able to adapt and thrive in these conditions, whereas species with narrow ecological niches may find it hard to adapt to these changes. Most of the species we recorded in the area seem to be able to adapt to these changes, although the abundance and presence of snakes and varanids seems to be the first to be affected by changes in habitat structure.

Human-wildlife conflict is a common occurrence in areas where humans and wildlife coexist. The lack of education and inherited fear of snakes poses a considerable threat to the snakes of the area. Encounters are especially highly frequent in the case of CLSU since farmers and students often frequent the remaining areas were snakes are common. Snakes, whether they pose a threat or not, are killed. This is troubling since most of the snakes recorded from the area are endemic, often with fragmented and low population density. Information campaign on the benefits of snakes and what to do in case of snake encounters is necessary in order to conserve this group of reptiles.

Conclusions:

Based on the results, the low number of species identified in the agroecosystem environment of Central Luzon State University is affected by the changes in vegetation characteristics related to cropping patterns and disturbance in the natural habitats of the species. The presence of invasive species can threaten native fauna by means of competition for resources and active predation. Also, not the whole canopy in CLSU was surveyed thoroughly and there's a possibility that some species located only in Luzon faunal region could inhabit in the area.

This study suggests further study about agroecosystem canopy. The use of other sampling techniques and seasonal sampling that can be utilized for collecting more species to assess and add more sampling effort during sampling. Biological research is also needed to determine the potential impacts of invasive species, how to manage and control them for the benefit of endemic species. It is also recommend focusing the study on the endemic species for their conservative status and more updates on their extinction.

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Rezumat:

DIVERSITATEA UNUI ECOSISTEM FOARTE VARIABIL: HERPETOFAUNA DIN UNIVERSITATEA REGIUNII CENTRALE LUZON, NUEVA ECIJA, FILIPINE

Universitatea Regiunii Centrale Luzon (Central Luzon State University - CLSU) este considerată un vast agro-ecosistem. Din acest agro-ecosistem fac parte iazuri, pajiști, zone reîmpădurite, locuințe umane și infrastructura din zonă. Scopul acestui articol a fost să studieze speciile de amfibieni și reptile asociate diferitelor habitate din cadrul CLSU și să evalueaze impactul unui ecosistem în continuă schimbare asupra distribuției și diversității herpetofaunei din zonă. Cele

șaptesprezece (17) specii de amfibieni și reptile (6 specii de broaște, 3 specii de șopârle gekko, o specie de șopârlă skink, o specie de varan, 5 specii de șerpi și o specie de țestoasă cu carapace moale) din CLSU au fost descrise în acest studiu. Dintre acestea, cinci (5) specii sunt introduse, 8 sunt native și 4 endemice, fiind găsite doar în regiunea faunistică din Luzon. Capacitatea speciilor introduse de a tolera prezența umană și abilitatea lor de a se adapta la schimbările sezoniere regulate în ceea ce privește caracteristicile și structura habitatelor, a contribuit la abundența lor în zonă. Speciile invazive pot amenința fauna nativă prin competiția pentru resurse și prădătorismul activ. Numărul redus de specii înregistrate în CLSU poate fi atribuit mai multor factori, inclusiv schimbărilor frecvente în structura microhabitatului, fragmentării habitatului și perturbărilor antropice.

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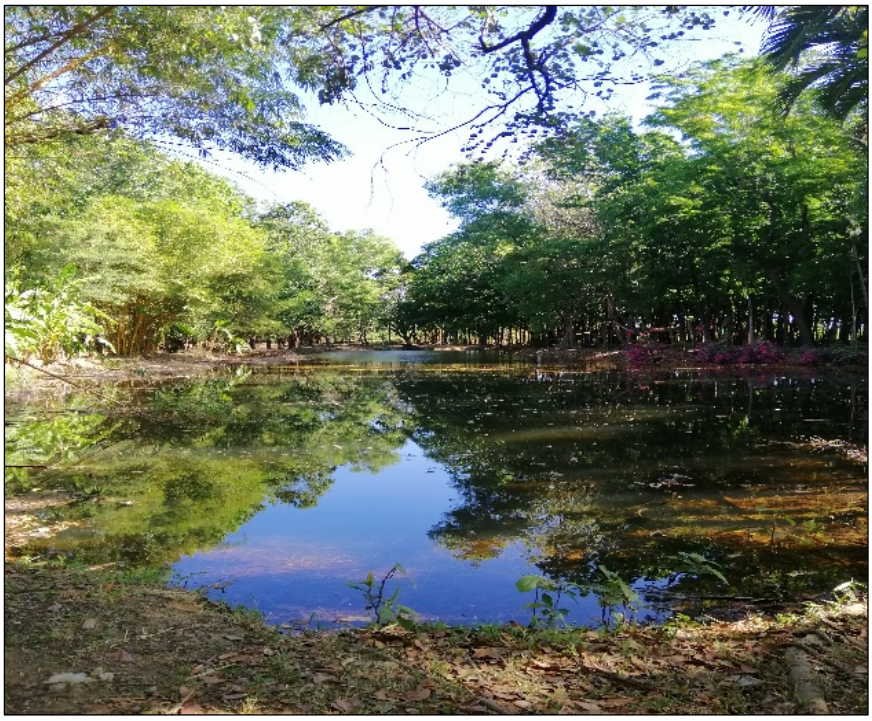
Annexes:

Figure no. 2 Five established sampling areas within the study site

a. Location 1: Lingap



b. Location 2: Nueva Ecija Fish and Hatchery Development and Aquaculture Project

c. Location 3: College of Agriculture

d. Location 3: College of Fisheries

e. Location 4: Old Research Area

f. Location 5: Azucena St.

Figure no. 3 *Rhinella marina* inhabiting one of the ponds in the Nueva Ecija Fish Hatchery Development and Aquaculture Project

Figure no. 4 *Fejervarya moodiei* caught from College of Agriculture

Figure no. 5 *Hoplobatrachus rugulosus* caught from Lingap Kalikasan

Figure no. 6 *Kaloula pulchra* caught from Lingap Kalikasan

Figure no. 7 *Hylarana erythraea* caught from NEFHADP

Figure no. 8 *Polypedates leucomystax* collected from Lingap Kalikasan

Figure no. 9 *Gehyra mutilata* collected from one of the sheds in Lingap Kalikasan

Figure no. 10 A common house gecko (*H. frenatus*) inhabiting the trunk of gmelina

Figure no. 11 A juvenile *E. multifasciata* caught from leaf litter in Lingap Kalikasan

Figure no. 12 A *Chrysopelea paradisi* caught near the second gate of CLSU

Figure no. 13 *L. capucinus* collected from a mango tree in the Old Research complex

Figure no. 14 A dead *R. spilogaster* from the College of Agriculture