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Species distribution and abundance of amphibians in two vegetation types of Agusan Marsh, Philippines

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Abstract. Agusan Marsh is the 1009th RAMSAR site, a wildlife sanctuary which harbour unique and pristine faunal species. It is considered one of the most ecologically significant wetland ecosystems in the Philippines. The study assessed species distribution and abundance using Geographic Information System Map in Agusan Marsh between Sago Palm and Terminalia Forest. Results showed a total of 322 individuals, 11 species and 6 families of amphibians documented. Of the 11 species of amphibians documented in Sago Palm and Terminalia Forest, 6 were Philippine endemics, 3 were invasive species in the area. Terminalia forest had the highest number of individuals documented during the conduct of the study. Sago Palm and Terminalia Forest have almost the same type of vegetation where amphibian species thrive most. Furthermore, ecological and environmental threats (conversion of Terminalia Forest to agricultural land, run-off of environmental pollutants, pesticides run-off and *Kaingin* or Slash and Burns) being identified in the two habitat types should be given urgent attention. This shows that Agusan Marsh particularly Sago Palm and Terminalia Forest still harbour unique features of endemic amphibian species despite of the on-going anthropogenic activities in the said areas.

Key Words: Abundance, Agusan Marsh, biodiversity, distribution, frogs, Sago Palm, Terminalia Forest.

Introduction. Amphibians around the globe are an important bio indicator of our ecosystem, researchers also uses amphibians such as models of scientific research, biological control, energy flow, source of medicine and some populations consume them as food. Amphibians are the most common vertebrates in many forests and have potential to play an important role in ecosystem dynamics (Wahbe & Bunnell 2003 cited by Almeria & Nuñeza 2013).

Philippines is a globally important hotspot for biological diversity and center for endemism, however, much of the studies are focused in terrestrial and marine biodiversity (Mallari et al 2001; Ong et al 2002). Less is known about the diversity and endemism of anurans in freshwater ecosystem which play a vital role as bio-indicator in the ecosystem.

The Philippine amphibians consist of 107 species with about 85% inhabiting the forested areas (Brown et al 2000; Diesmos et al 2004; Siler et al 2010), and about 78.5% endemicity (Brown et al 2008). The level of endemism for amphibians in Mindanao is 42% where 7 of the 11 recorded species are found only in the Island. Of these, 9 species were in the threatened category, 8 vulnerable and 1 endangered (Nuñeza et al 2010). Nearly half of the Philippine amphibians are threatened with extinction, and because most of the

amphibians inhabit forested habitats, they are most likely to be vulnerable to the continuous forest destruction, habitat loss and degradation (Diesmos & Brown 2011).

Agusan Marsh was proclaimed a Wildlife Sanctuary under the National Integrated Protected Area System (NIPAS Act of 1994 covering 14, 836 ha). It was declared the Agusan Marsh Wildlife Sanctuary (AMWS) by Presidential Proclamation No. 913 in 1996. The AMWS has also been chosen as one of the 10 priority sites under the on-going Conservation of Priority Protected Areas Project (CPPAP) funded by the Global Environmental Facility (GEF) through the World Bank. In 1999, AMWS was designated a Wetland of International Importance by the Ramsar Convention (Primavera & Tumanda 2008). AMWS is a protected area located in the Mindanao Biogeographic Zone, particularly in the province of Agusan del Sur. It stores about 15% of the freshwater resources of the country making it of great hydrological and ecological importance. Agusan Marsh is a home of endemic flora and fauna harbouring unique and pristine habitat types as well as a home of indigenous people called the "Manobo". It is a good avenue for scientific investigations because of its unique biota in terms of freshwater diversity such as anurans, aquatic reptiles, fish, molluscs, shrimps, bivalves and many others. Sago Palm*, Metroxylon sagu* forest is the rarest swamp forest type in Agusan Marsh and in all probability, the one and only in the Philippines. It is also valuable in that it grows on peat, a soil type which is relatively rare in the Philippines. The *Terminalia* forest, so called because it is dominated by *Terminalia copelandii,* is the most extensive area left in the Philippines. Historical records indicate that this subtype of swamp forest was fairly common marshes in the Philippines. However, most of the *Terminalia* forest has been cleared. Hence, it is particularly vulnerable to clearing (DENR-PAMB 1999).

Almeria & Nuñeza (2007) conducted a survey in different habitat types of Agusan Marsh, recorded 18 species of anurans, 4 of which are vulnerable, 1 nearly threatened and 13 species are of least concern. The diversity of anurans in Agusan Marsh is high with 55.55% endemism as has been revealed by the study. Amphibians are now threatened by overexploitation by the Manobo for food and income; pollution of streams and rivers from mine tailings, pesticide and herbicide run-off; draining of water from agricultural areas; and invasive species like *Fejervarya cancrivora*, now the most widespread frog species in the marsh. Despite these threats and disappearance of certain species, frogs continue to be abundant.

The result of this study will provide baseline data on how the population size of the amphibian species change over time. This will provide significant information on the species population, the possible threats that may contribute to the vulnerability of the species, and make available map model on the distribution of these species within selected habitat types of Agusan Marsh as an input for conservation efforts. Existing threats to the amphibian population will also be noted. The status of the amphibian populations can be monitored and appropriate management actions can be taken. Conservation priorities for these species and long-term monitoring programmes in selected habitat types will be established.

Material and Method

Location and duration of the study. The study was conducted in the 2 vegetation types of Agusan Marsh, namely Sago Palm and *Terminalia* Forest at Sitio Kaliluan, Bunawan, Agusan del Sur (Figure 1). Sampling surveys were conducted on September to December 2013 in the areas covered.

Selection of sampling sites. The Sago Palm (*Metroxylon sagu)* forest is located in Sitio Kaliluan, Poblacion, Bunawan, Agusan del Sur. The vegetation type of this area primarily composed of tall grass, vines, shrubs, and epiphytes. This site is a Lanipao - *Terminalia* Forest located in Sitio Kaliluan, Poblacion, Bunawan, Agusan del Sur. The vegetation type of this area is composed of tall grass, vines, shrubs, and epiphytes. The vegetation type of *Terminalia* forest are primarily composed of tall trees such Manga Pajo, Maymayan, Lanipao,

Katumbawon, Kapi-kapi, Salumbayan, Tayapok and Hambabawod. Some of the trees produce fruits that were eaten by endemic birds in the area. Dominate grasses found in the area include Baas, Bagahit, Bakong, Tambo, Muti-muti and Bangiba. While, ground cover plants such Fern and Fern-allies, Pitcher plant, and Badyang were recorded. The bed floor of *Terminalia* forest is watery which is favorable to amphibians for their reproduction activity.

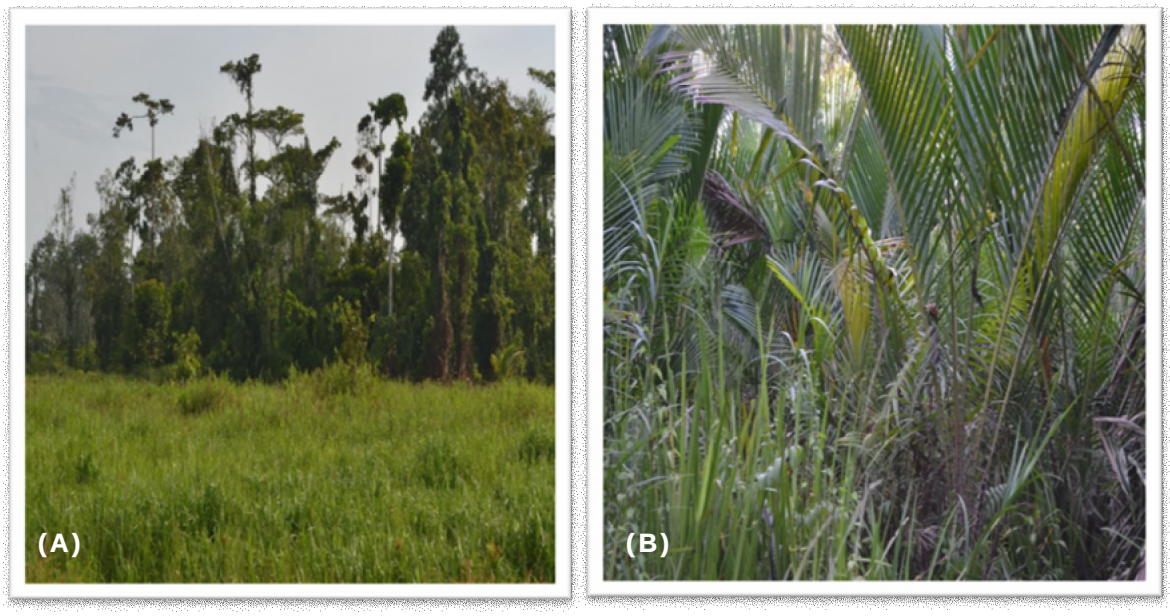

Figure 1. Panoramic view of the two vegetation types of Agusan Marsh (A. *Terminalia* Forest, B. Sago Palm, *Metroxylon sagu*).

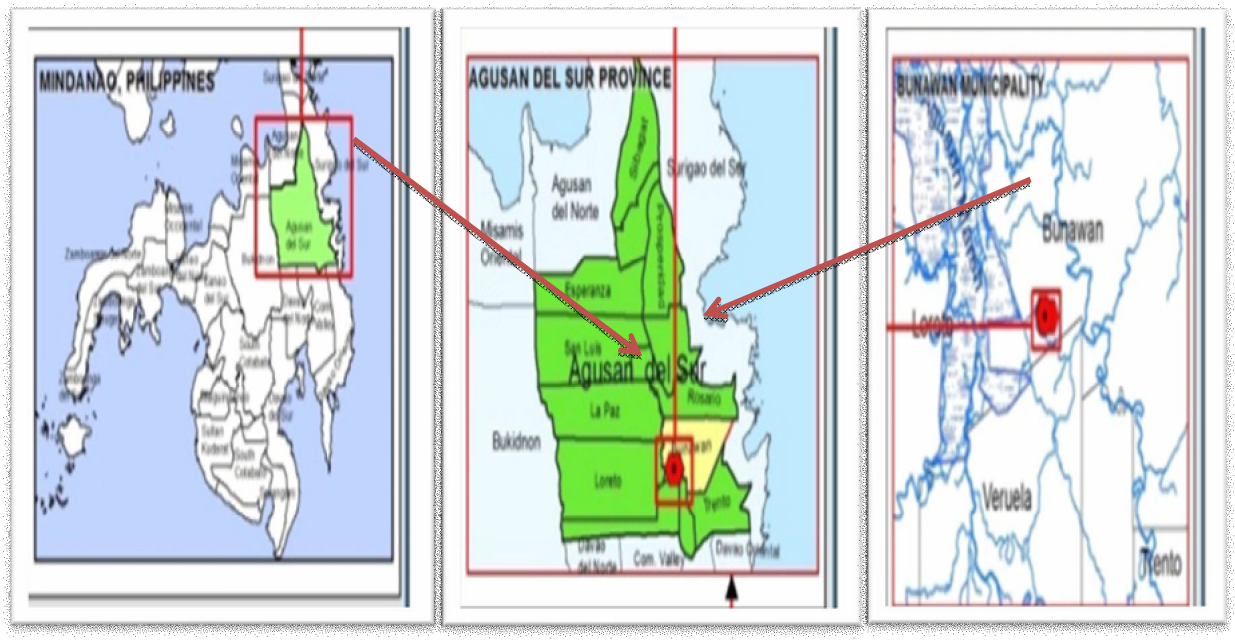

Figure 2. Map of Agusan del Sur showing the two sampling area in Bunawan.

Decayed logs, left litters and tree holes were documented. Located approximately 20 meters from the forest edge of *Terminalia* is a Herbaceous-swamp where the amphibians mate during estrus period being a favorable site for reproduction.

Survey and collection of samples. Random sampling of three 10 m x 10 m plots was conducted per sampling site. Time constrained visual encounter surveys were used as the sampling technique with three people for 4 hours. Aural transects we used to determine the presence of species that were inadequately surveyed with visual methods (Hampson 2001). Transects (100–400 m) were done as visual encounter surveys where perpendicular distances from the transect to frogs were measured (Buckland et al 1993). Moreover, occupancy models, the probability of a site being occupied by a species (Guillera-Arroita & Morgan 2011), were used to determine population trends of frogs. The target species were recorded as detected (1) or not (0) (Dodd 2010). Each site was searched carefully to examine all available refugia.

Sexes and ages were determined and categorized as tadpole, metamorph, juvenile, sub-adult, and adult. Additionally, environmental variables were monitored during sampling periods such as ambient temperature, substrate temperature, relative humidity, and general weather conditions. Rainfall was recorded using a rain gauge.

Microhabitat assessment in Sago Palm and *Terminalia* Forest was classified according to the work of Alcala et al (2012) 1- Non-forest (including near human habitations), 2- Karst (caves, lime stones), 3- Forest streams/ponds, tree holes, 4- Forest (ground, leaf litter), and 5- Forest mainly arboreal. Assessment of threats was done by direct observation and interviews with local people to record the history of human disturbance in the sampling areas.

Two voucher specimens of each species were captured, particularly species unidentified in the field, and prepared as specimens following standardized preservation techniques (Heyer et al 1994). Collected specimens were deposited at Department of Biology, Caraga State University, Ampayon, Butuan City, Philippines. Nomenclature followed Alcala & Brown (1998) for amphibians and IUCN (2012) criteria were used in determining endemic and threatened species. PAST software (2001) was used for the computation of biodiversity indices, cluster analysis and principal component analysis.

Results and Discussion. *Terminalia* Forest is located in Sitio Kaliluan, Poblacion, Bunawan, Agusan del Sur. The vegetation type of this area is composed of tall grass, vines, shrubs, and epiphytes. Tree taxa of *Terminalia* forest was primarily composed of *Mangifera indica* Pajo variety, *Terminalia copelandii* and *Terminalia calamansanay* Rolfe under Family Combretaceae. Some of the trees produce fruits that were eaten by endemic birds in the area. Dominant grasses found in the area were noted. While, ground cover plants such as fern and fern-allies, pitcher plant, and *Alocasia macrorrhizos* or Elephant's ear locally known as Badyang were recorded. The forest floor is wet and favorable to amphibians for reproduction. Located approximately 20 m from the forest edge of *Terminalia* is an Herbaceous-swamp where the amphibians mate.

Moreover, Sago Palm area is located adjacent to the *Terminalia* Forest in Sitio Kaliluan, Poblacion, Bunawan, Agusan del Sur. Approximately Sago Palm area is about 3 hectares with a vegetation type composed primarily of tall grass, vines, shrubs, and epiphytes. Tree taxa noted in the area were Sago stands, Lanipao, Wango, Manga Pajo, Kabihid and Libas. While Baas, Panabog, Dagahit and Ferns (Pako). Bed floor of Sago Palm was watery and presence of rotten logs and leaf litters of Sago Palm were observed. Soil type in Sago Palm was Peatlands. Peatlands are wetlands with a thick water-logged organic soil layer (peat) made up of dead and decaying plant material as documented by Santillan et al (2012).

Environmental parameters in the two vegetation types of Agusan Marsh were recorded such as Ambient temperature were recorded, wet temperature was 31°C while dry

temperature was 30°C, sky during the day was partly cloudy but varied every day during the fieldworks. Relative humidity was 79% while vapour pressure (mmHg) 23.75 mm and Dew point temperature was 42.6 dc. Also, Rainfall (mm) during the sampling period was 376.7 and the average wind speed (mps) was 002 (Data taken from Hinatuan Weather Station).

The abundance of amphibians between two habitat types recorded 110 number of individuals in Sago Palm while 212 amphibian species in *Terminalia* Forest. This implies that *Terminalia* Forest had rich number of individuals may be due to more favorable habitat types for amphibians to name a few such as close canopy of trees with tall grasses, watery bed floor, adjacent to herbaceous-swamp and suitable climatic conditions such temperature. Generally, species diversity of amphibians in Sago Palm and *Terminalia* Forest of Agusan Marsh exhibited moderate diversity (H'=2.14).

Hampson (2001) reported that habitat characteristics correlated to some degree with distance from forest edge, although it is not clear whether any are the underlying causes responsible for frog abundance. Together they may increase microhabitat complexity and local humidity levels, and reduce surface temperatures with distance from forest edge, creating an edge effect likely to influence amphibian distribution and densities. Certain factors were more influential on some species than others like for example *Pandanus spp.* abundance affects *Radopholus similis* density, this semi-arboreal species mostly inhabits understory vegetation, perching on plants, logs and rocks. The entirely ground dwelling *R. woodworthi* was unaffected by *Pandanus* abundance, yet increased with canopy cover, abundance of dead logs and decreased with ground flora density. Nuñeza et al (2010) reported also, that high species richness and high amphibian diversity was documented in the forest sampling sites at high elevation, lowland dipterocarp and in two agro ecosystem areas.

The high species richness and high endemism are attributable combinations of factors that favored speciation in the past, including fluctuating sea levels that created habitats with equable climatic conditions and complex geologic (tectonic) events favoring creation of many microhabitats and promoting geographic barriers to population mixing (Heaney 1985; Sodhi et al 2004; Brown et al 2009).

The study documented 322 individuals of amphibians under 11 species and 6 families from Sago Palm and *Terminalia* Forest of Agusan Marsh, Bunawan, Agusan del Sur. Amphibian species with highest number in terms of family was Dicroglossidae comprised of *Occidozyga laevis, F. cancrivora, Hoplobatrachus rugulosus, Limnonectes leytensis, Fejervarya vittigera.* While, one species from Microhylidae was present, this was *Oreophryne annulata*. Pelobatidae family was documented only *Megophrys stejnegeri* and *Polypedates leucomystax* and *Philautus surdus* from Rhacophoridae. Finally, *Rhinella marina* belongs to family Bufonidae while *Platymantis dorsalis* species categorized as Ceratobatrachidae family.

Studies conducted by Alcala et al (2012) showed that *P. surdus, M. stegnejeri, F. vittigera, P. leucomystax, F. cancrivora, O. laevis, H. rugulosus, R. marina*) were considered as common amphibian species in the Philippines and inhabit forested areas. *O. annulata* and *L. leytensis* were observed as uncommon. Only *Platymantis dorsalis* was held as intermediate species in terms of rarity. *O. annulata* is endemic to 1-2 islands only wherein the population with restricted range and highly vulnerable to climate change as documented by the study of Alcala et al (2012). *P. surdus* and *P. dorsalis* is endemic to Philippines which found in 3-5 islands and refers to species found in the one or two Pleistocene Aggregate Island Complexes (PAICs). While, *L. leytensis*, *M. stejnegeri* and *F. vittigera* were classified as endemic to Philippines; widespread this is distributed throughout the archipelago. Three non-endemic species found in the area like *P. leucomystax*, *F. cancrivora* and *O. laevis* refers to widespread distribution in and out of the Philippines. Lastly, 2 amphibians were alien species like *H. rugulosus* and *R. marina* this alien, invasive species are expected to adapt to a wide range of environmental conditions Alcala et al (2012).

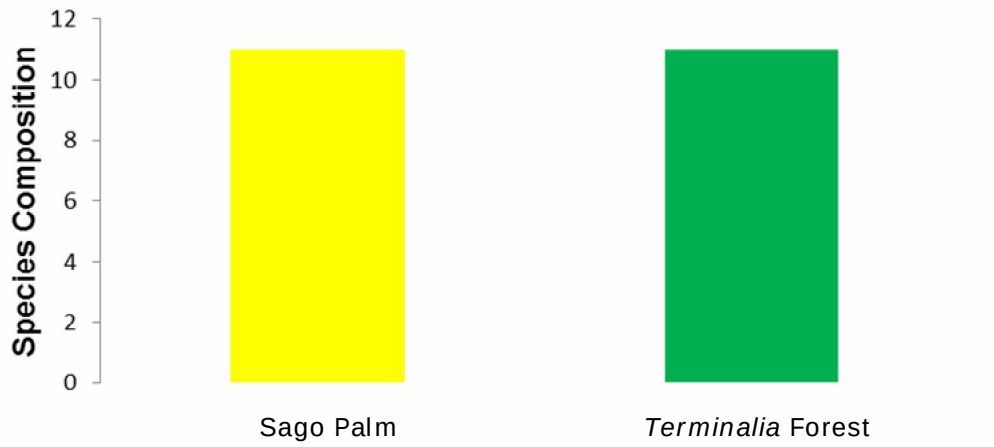

Figure 3. Species composition of amphibians between two forest types in Agusan Marsh.

There were 110 of amphibian species (Figure 3) captured from Sago Palm Forest last September to December 2013. *F. cancrivora* had the highest number of individuals seen in the area followed by *H. rugulosus, F. vittigera* and *R. marina.* While *P. leucomystax* and *P. surdus* had the least number of individuals captured in the area. This is attributed to the fact that *F. cancrivora, H. rugulosus, F. vittigera*, *R. marina, P. leucomystax and P. surdus* were considered common and alien species. Presently, the topographic location of Sago Palm was adjacent to agricultural land where rice insects and other pests harboured. Studies conducted by Santillan et al (2012) on the biophysical, structural and spectral characterization of Sago Palm and its environment found out that the substrate physical appearance of soil in the area was peat land. Peatlands are wetlands with a thick water-logged organic soil layer (peat) made up of dead and decaying plant material. The area with the highest OM content is found in Barangay Nueva Era in Bunawan, Agusan del Sur with an average value of 15.7% and a maximum OM content of 21.3%. Average soil pH was 5.581 and soil moisture of 55.657. Based on their actual observation, the Sago sites in Nueva Era, specifically the substrate, was found to be rich with decayed parts of Sago palm (e.g. leaves, trunk, etc.) and other materials that contributes to high OM content of soil in the said area. This is due to the peatland nature of the substrate.

Terminalia forest had the highest number of individuals seen and captured. *F. cancrivora, H. rugulosus, R. marina* and *F. vittigera* were the top most species found in the area. While *M. stejnegeri, P. leucomystax* and *P. surdus* were the least number of individuals in the area. The vegetation type of *Terminalia* forest are primarily composed of tall trees such *M. indica* Pajo variety, *T. copelandii* and *Terminalia calamansanay* Rolfe under Family Combretaceae. Some of this tree produces fruits that were eaten by some endemic birds in the area. Dominated grasses found in the area such Baas, Bagahit, Bakong, Tambo, Muti-muti and Bangiba were noted. While, Fern and Fern-allies, Pitcher plant, and *A. macrorrhizos* or Elephant's ear locally known as Badyang were recorded. The forest floor of *Terminalia* forest is watery which is favorable to amphibians for their reproduction activity. Presence of decayed logs, left litters and tree holes were documented. Approximately 20 meters from the forest edge of *Terminalia* is the Herbaceous-swamp where the amphibians mate during their mating period and favorable site for reproduction. The flora in the area is threatened with on-going anthropogenic activity of humans such as cutting of *Terminalia-Lanipao*, clearing of the area for agricultural land conversion, wildlife hunting for human consumption, and increasing human settlements in the site.

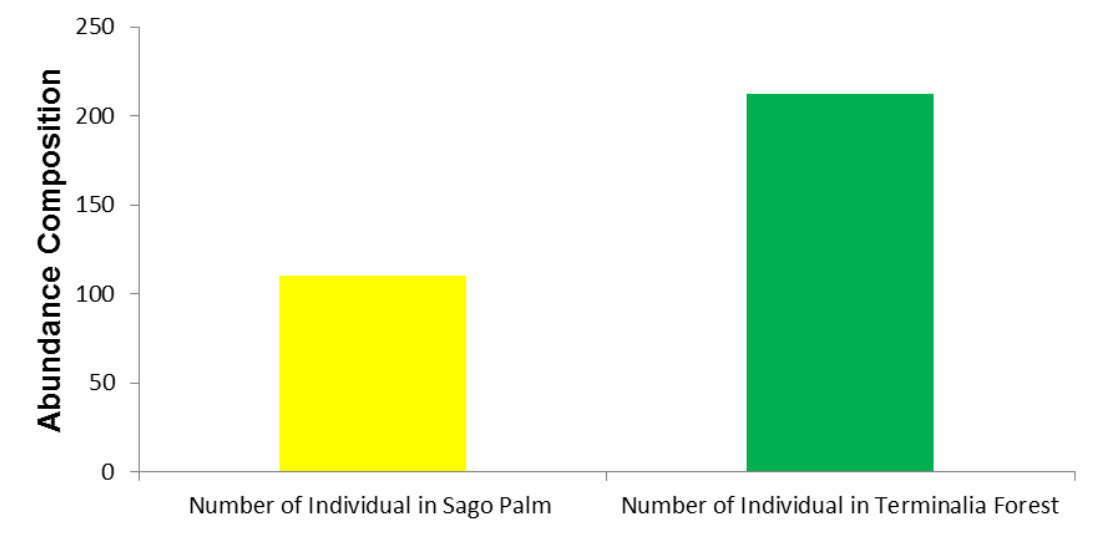

Figure 4. Abundance of amphibian species between forest types.

A total number of 212 individuals were captured (Figure 4) in *Terminalia* forest during the sampling period. Of which, *F. cancrivora* had the highest number of individuals followed by *H. rugulosus, R. marina* and *F. vittigera.* While, *P. surdus, P. leucomystax* and *M. stejnegeri* counted the lowest number of individuals. *Terminalia* forest is a watery area dominated with tall grasses and trees and the canopy of trees are very close from one another. The adjacent area of *Terminalia* forest is rice fields where insects and other micro-pests lived, this insects and micro-pests serves as food for amphibians.

There were 110 amphibian species captured in Sago Palm area of Agusan Marsh last September 2013. *F. cancrivora* had the highest number of individuals seen in the area followed by *H. rugulosus, F. vittigera* and *R. marina*. While *P. leucomystax* and *P. surdus* had the least number of species captured in the area. This might be due to the fact that *F. cancrivora, H. rugulosus, F. vittigera, R. marina, P. leucomystax* and *P. surdus* were considered common and alien species.

Results showed that out of 11 amphibian species (Figure 5) 6 (54.55%) of them were Philippine endemics which includes *O. annulata, P. surdus and P. dorsalis, L. leytensis, M. stejnegeri and F. vittigera. O. annulata* is endemic to 1-2 islands only wherein the population with restricted range. *P. surdus* and *P. dorsalis* is endemic to Philippines which found in 3-5 islands and refers to species found in the one or two Pleistocene Aggregate Island Complexes (PAICs). While, *L. leytensis*, *M. stejnegeri* and *F. vittigera* were classified as endemic to Philippines; widespread this is distributed throughout the archipelago. Three non-endemic species found in the area like *P. leucomystax*, *F. cancrivora* and *O. laevis* refers to widespread distribution in and out of the Philippines. Lastly, 2 amphibians were alien species like *H. rugulosus* and *R. marina* this alien, invasive species are expected to adapt to a wide range of environmental conditions Alcala et al (2012).

In contrast with other studies of amphibians in the Philippines, the degree of endemism of the captured amphibian species was relatively moderate. A study on Anurans in Agusan Marsh conducted by Almeria & Nuñeza (2007) recorded 18 species of anurans of which 4 were vulnerable, 1 near threatened and 13 were least concern and the level of endemism was 55.55%. Relox et al (2010) conducted a study on herpetofaunal endemism and diversity in Mount Hamiguitan and documented five families and nine species of amphibians in the said area, in which 77.8% of them classified as endemic. Another studies conducted by Nuñeza et al (2010) in Mount Malindang, indicate a level of endemism for

amphibians as 42% where 7 of the 11 recorded species were found only in Mindanao. Nine species were in threatened category, 8 vulnerable and 1 endangered.

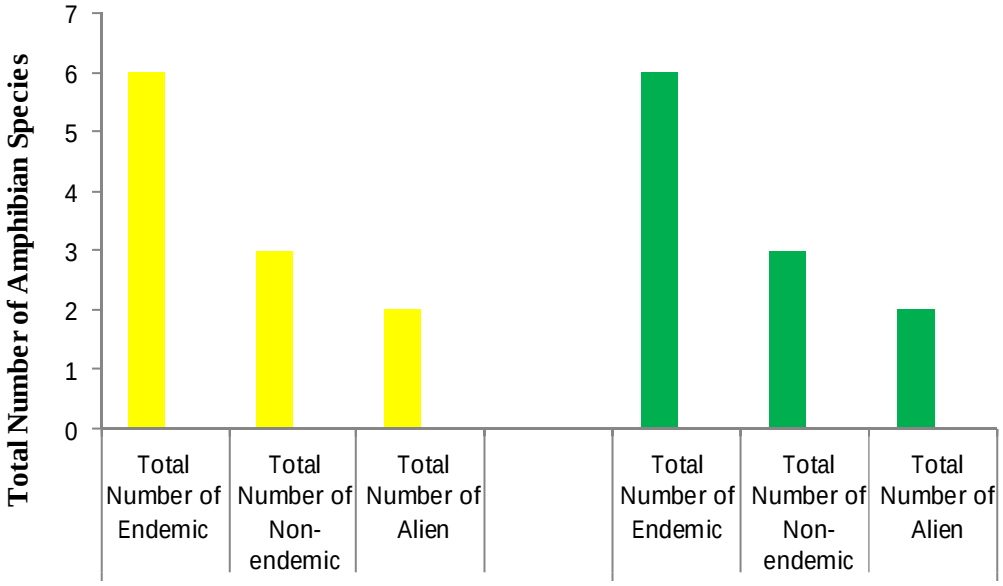

Figure 5. The total number of endemic, threatened, vulnerable and least oncern status of amphibians between the two forest types.

Distribution map in Sago Palm (Figure 6) showed that *F. cancrivora, H. rugulosus, L. leytensis, F. vittigera, M. stejnegeri, R.vittigera, and P. surdus* found in 72 to 89 mean sea level while *R. marina* was seen 70 to 80 mean sea level. *P. dorsalis* and *O. laevis* recorded 80 to 89 mean sea level while *P. leucomystax* 83 to 87 mean sea level. Few of the anuran species were arboreal, preferring low vegetation such as shrubs, pandans, ferns and grasses. Philippine amphibians such as genera of *Oreophryne, Platymantis, Rhacophorus* and *Philautus* which occupy very small arboreal microhabitat spaces (e.g. leaf axils of screw pines, root masses of aerial ferns, mosses on tree trunks and etc.), may not be able to shift to higher elevations because of their limited dispersal ability (Myers 2003; Bickford et al 2010).

In *Terminalia* forest (Figure 7) only *P. surdus* can be found at 80 to 93 mean sea level while the rest of the amphibian species were noted at 80 to 99 mean sea level. Alcala (1986) noted that the land vertebrates of the Philippines are generally distributed in areas covered by natural vegetation, especially forests. Due to the dependence of amphibians on cutaneous respiration and sensitivity to dehydration, they require general availability of continuous moisture, such as presented by tropical rainforests where the relative humidity is always at or near saturation.

There is a higher abundance, species richness, and diversity of herptiles in lowland dipterocarp forest than in upper elevations. Mindanao Island endemics reside only in the vegetation at higher elevations, while Philippine endemics are found at lower elevations. Non-endemics were found to occupy disturb lowland dipterocarp forest along with other endemic species. Anurans prefer riparian, ground and arboreal strata as microhabitats, which are relatively prominent in montane forest and humid lower elevated forests (Relox et al 2010).

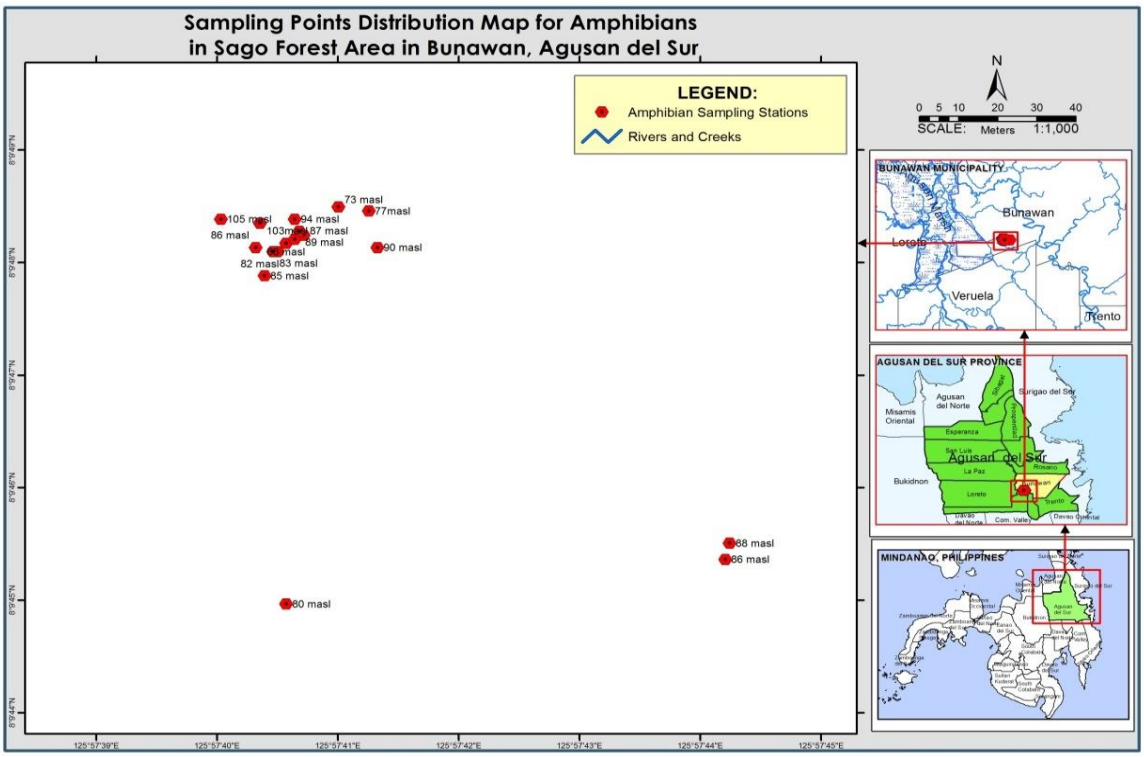

Figure 6. Distribution map showing the number of amphibian species in Sago Palm.

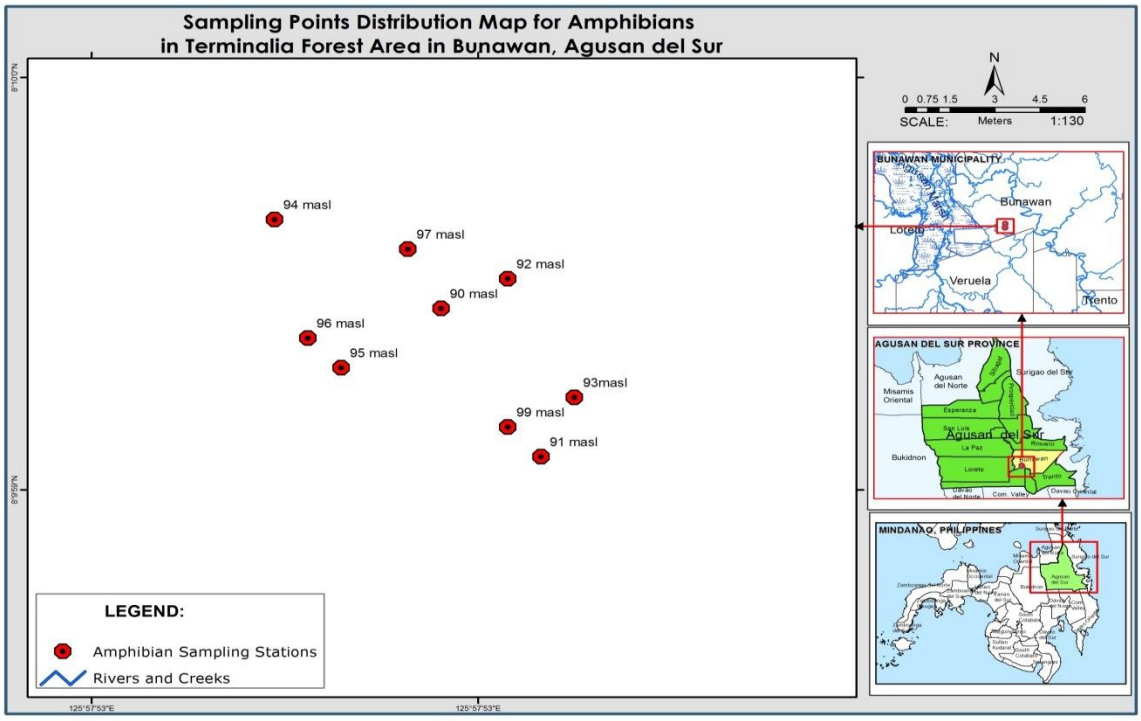

Figure 7. Distribution map showing the number of amphibian species in *Terminalia* Forest.

Nuñeza et al (2010) in Mount Malindang, noted that endemic and some threatened species are also found in the lowland forests, which are mostly threatened by habitat loss. This implies a need to develop management plan for the whole landscape.

The dry month of March to May becomes drier and the wet months of June through November become wetter. Reduction in rainfall in most parts of Mindanao for all seasons is predicted. Stronger southwest monsoon winds are also projected on Luzon and Visayas. Areas with increasing elevation in slope gradients are more vulnerable to excessive rains, landslides, and flashfloods than gently sloping areas at lower elevations. The most inherently sensitive areas due to topography are in central and northern Luzon, Mindanao, and parts of Mindoro, Negros and Panay Islands, which are coincidentally areas of high endemism for amphibians (Brown & Alcala 1970) and mammals (Heaney & Roberts 2009).

Figure 8 shows the Cluster analysis between two habitat types of Agusan Marsh, Sago Palm and *Terminalia* Forest. *F. cancrivora, H. rugulosus, F. vittigera* and *R. marina* have the highest degree of similarity equal to 94% because of their similarity in microhabitat types characterized by in rotten or decaying logs, leaf litters and swampy area near the rice fields. This implies that *F. vittigera* and *R. marina* from both habitat types (Sago and *Terminalia*) ranked highest number of individuals. Moreover, 93% degree of similarity can be seen with *O. laevis, L. leytensis, M. stejnegeri* and *P. leucomystax.* This amphibian species have almost the same number of individuals captured in Sago Palm and *Terminalia* Forest. Microhabitat of *O. annulata* was found under the leaves of some wide-foliaged plants belonging to Pandanaceae, Cyathea (tree ferns) and Araceae. *P. dorsalis* and *P. surdus* were ground-dwellers with 83% degree of similarity. The results of the present study coincided with the data on abundance because Sago Palm and *Terminalia* Forest have nearly similar species composition.

Terminalia forest had diverse number of amphibians with 212 individuals as compared to 110 amphibian species documented in Sago Palm area based on the biodiversity indices of amphibians (species richness, diversity and evenness) between two habitat types (Sago Palm and *Terminalia* Forest). Moreover, the vegetation types of two habitat during the field works were documented to be such vegetations of agro-forest, *Terminalia-Lanipao*, Herbaceous-swamp area, Sago stands with high number of tall grasses and vines were almost similar. Since faunal communities between two habitat types were almost the same, amphibians from Sago Palm area were also seen in *Terminalia* Forest and *vis* a *vis*.

The study conducted by Almeria & Nuñeza (2007) in the 4 habitat types of Agusan Marsh, recorded 207 in Sago Palm while 379 individuals of amphibians in *Terminalia* Forest respectively. This denotes that the two habitat types are diverse sites and are favorable for breeding and reproduction of amphibian assemblages. Bickford et al (2010) predicted scenarios of desiccation of frog eggs laid on arboreal microhabitats, soil and leaf litter; increased tadpole mortality due to insufficient dissolved oxygen level in water; increased susceptibility to disease(s) of eggs and tadpoles; decreased population size due to increased metabolism of adults and attrition of diversity at low and high elevations; and increased competition and change in community composition. These effects, however, will likely vary depending on the ecology and distribution of the vulnerable species. It is obvious, therefore, that the species similarities within the two sub-clusters are not due to proximity but perhaps to similar vegetation structure among these habitats (Varela & Gapud 2004).

Principal Component Analysis (PCA) (Figure 9) is a procedure for finding hypothetical variables (components) which account for as much of the variance in your dimensional data as possible (Davis 1986; Harper 1999). Component 1 has an Eigenvalue of 267.839 or 97.816% variance meaning out of 11 species being documented during the field works there were 7 amphibians being accounted in component 1 such *F. cancrivora, H. rugulosus, L. leytensis, P. dorsalis, O laevis, P. surdus and P. leucomystax.* This means that if most of the variance is accounted for by one or two components meaning the success is scored. While component 2 has an Eigenvalue of 5.97903 or 2.1836% variance. Of the 11 species recorded only 4 amphibian species were accounted in Component 2 namely *M. stejnegeri, R. marina, O. annulata*, and *F. vittigera*. This was very clear that if the variance was spread more or less evenly among the components, the PCA has in a sense not been very successful. Most of the amphibians found in the two vegetation types of Agusan Marsh thrive mostly

in moist and watery environment but some were ground dwellers and arboreal amphibians. Amphibians in both vegetation types have specific habitat types, environmental variables and ecology.

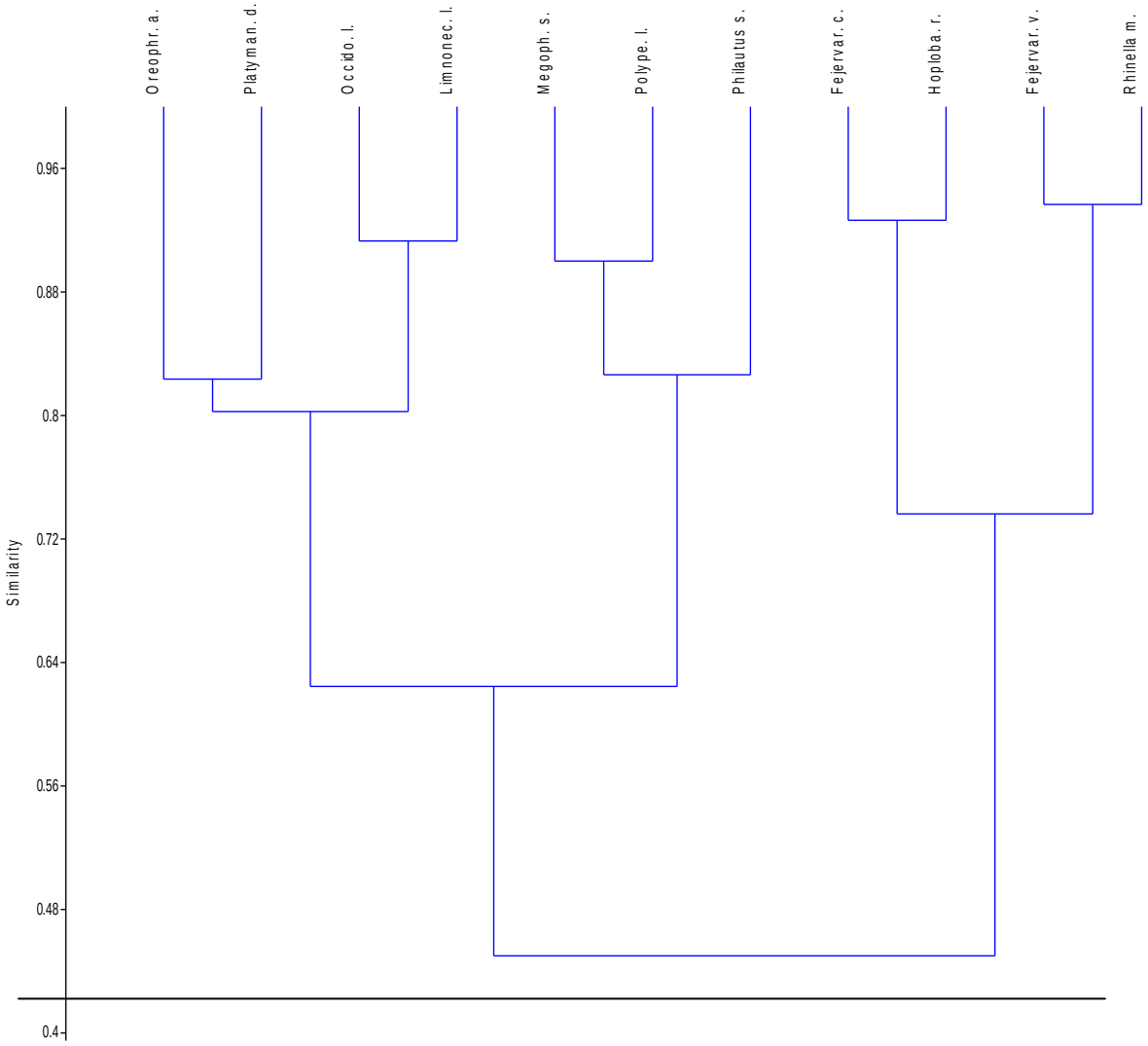

Figure 8. Cluster Analysis of amphibian species in Sago Palm and *Terminalia* Forest of Agusan Marsh with PAST Software using Bray-Curtis Similarity Matrix.

Furthermore, Alien invasive species especially are adaptable to adverse conditions, which behaviors aid their ability to colonize or invade other habitats. Common Philippine species of the genera *Kaloula* and *Fejervarya* burrow into the soil or hide in moist microhabitats to escape periods of drought. *Kaloula* is opportunistic in breeding habits, being able to utilize temporary pools formed by occasional rainfall and their tadpoles develop rapidly into miniature frogs within a few weeks. *F. cancrivora* can utilize as breeding ponds saline water in mangrove swamps. The marine toad, *R. marina*, is adapted to many habitats, including those with saline water. *Rana* (*Hylarana*) *erythraea,* probably an introduced species in the Philippines, is an adaptable species (Alcala & Brown 1998; Diesmos et al 2006), and can withstand flooding and drought conditions.

Finally, *O. annulata* was categorized as highly vulnerable. These species spend virtually entire lives in perpetually moist microhabitats. Most of them utilize, as egg–laying sites, leaf axils of screw pines, root masses of aerial ferns, moss growing on tree trunks, and even top surfaces of broad leaves of forest shrubs. These microhabitats easily desiccate with decreases in atmospheric moisture (Alcala et al 2012).

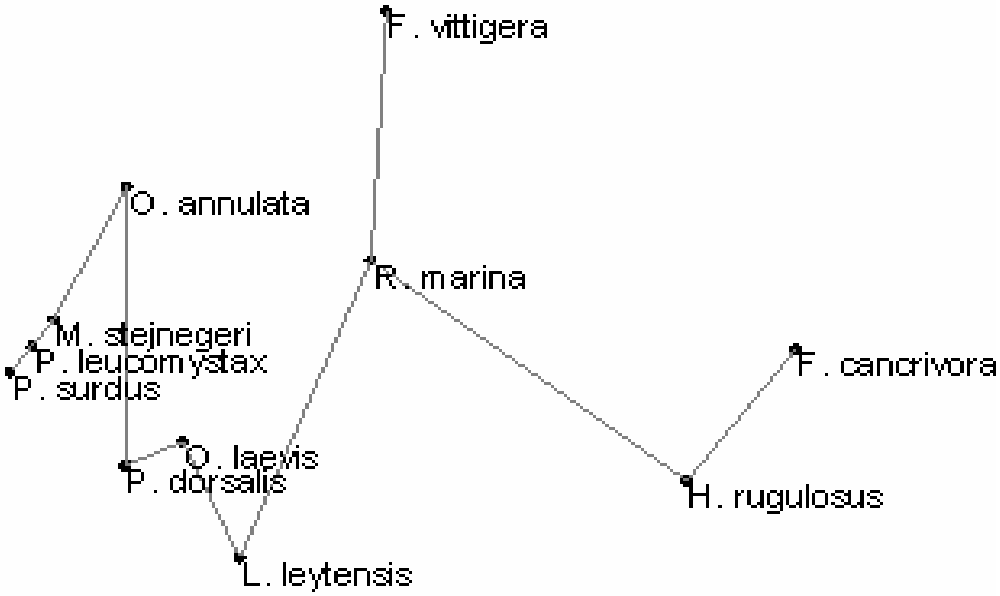

Figure 9. Principal Component Analysis of Amphibian species between two habitat types (*Sago* Palm and *Terminalia* Forest) in Agusan Marsh.

L. leytensis belongs to vulnerable group, consists of both ground-dwelling and arboreal species that lay their eggs in water, on rocks near water, or on vegetation overhanging mountain streams, all with conventional aquatic tadpoles requiring variable periods of time to metamorphose into miniature adults.

Conclusions. The study documented 110 numbers of individuals in Sago Palm while 212 amphibian species in *Terminalia* forest, a total of 322 individuals under 11 species and 6 families in the two vegetation types. *Terminalia* forest had the highest number of individuals while two alien species were recorded in the study such as *H. rugulosus* and *R. marina.* This is very clear that *Terminalia* Forest and Sago Palm still harbour unique features of amphibian species regardless of the on-going anthropogenic activities in the area like *Kaingin* and conversion of *Terminalia* into agricultural land. Data from this study suggest that amphibians in *Terminalia* Forest and Sago Palm need urgent protective measures and management including other wildlife faunal species in the area. Protection and conservation priorities of the amphibian species and long-term monitoring programmes within the two habitat types of Agusan Marsh will be closely monitored by our local and provincial government and some non-government organizations (NGOs) in the country.

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