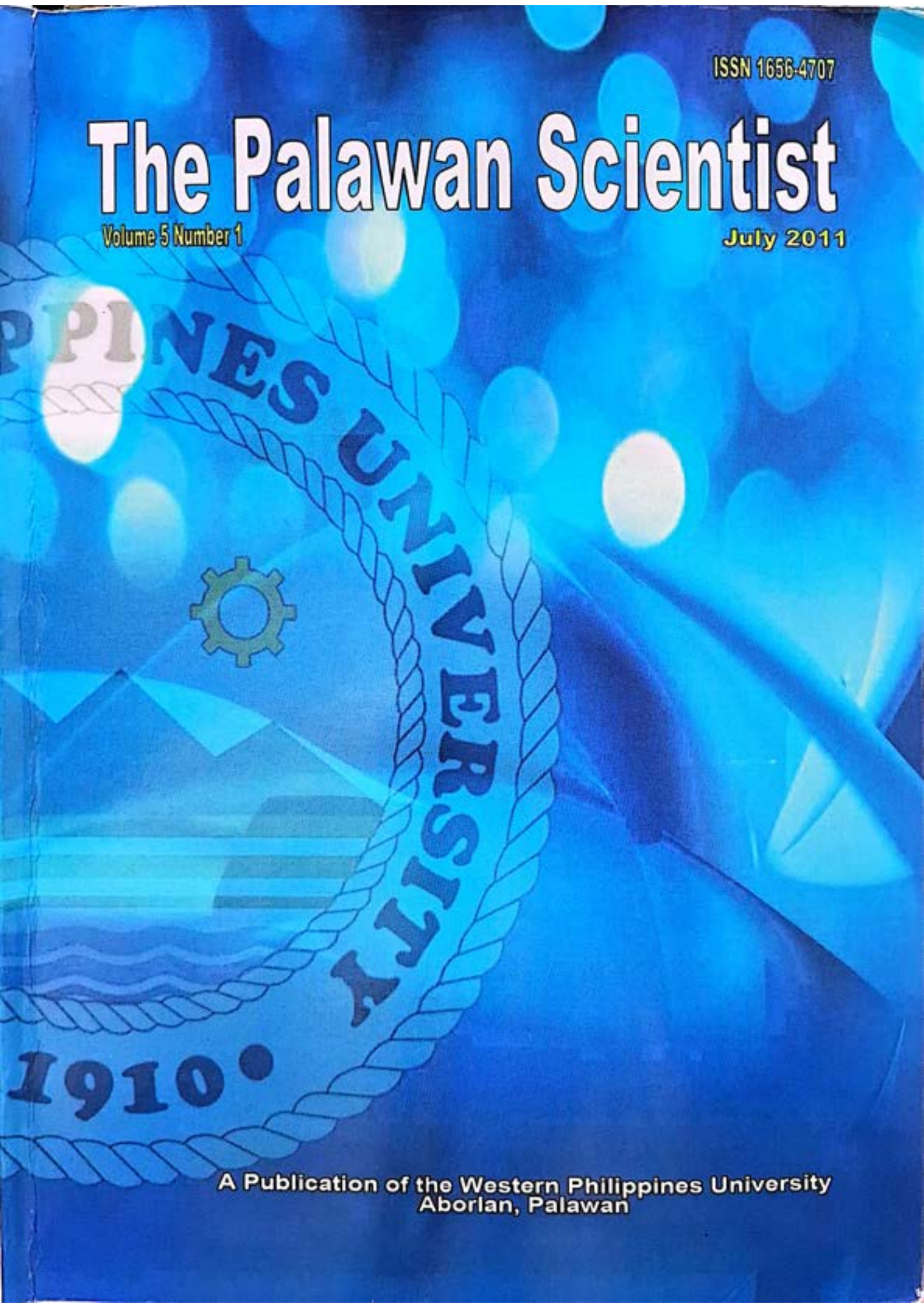
ISSN 1656-4707

The Palawan Scientist

Volume 5 Number 1

July 2011



A Publication of the Western Philippines University
Aborlan, Palawan

The Palawan Scientist
Vol. 5, No. 1 pp. 1-10, 2011

ISSN No. 1656-4707

Vehicle-Induced Mortalities of Birds and Mammals Between Aborlan and Puerto Princesa City National Highway

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ABSTRACT

Building of paved road networks as part of the development in the province causes further habitat fragmentation and the alarming increase in the number of road users intensifies the possibility of vehicle- induced wildlife mortalities.

Despite the risks, the wildlife mortalities resulting from vehicle collision in the province are not yet documented. Hence, this study was conducted to provide a baseline information on the species composition of road killed birds and mammals along the highway section connecting the municipality of Aborlan and Puerto Princesa City. Collection of data was conducted four times a month from January to December 2010 by travelling along the road section on board a motorcycle with an average travelling speed of 40km/hr. Carcasses of birds and mammals found along the road were counted and identified.

A total of 47 mammal and 80 bird carcasses were recorded. Seven species of mammals belonging to 6 families and 33 species of birds representing 22 families were identified. Out of the 40 identified species of animals, 3 mammals and 4 birds were considered as Palawan endemics. Common Palm Civet (*Paradoxurus hermaphroditus*) and Large-Tailed Nightjar (*Caprimulgus macrurus johnsoni*) are the most frequently recorded mammalian and avian species, respectively.

Although most of the identified animals were classified in the IUCN Red List of Globally Threatened Animals (2010) as "least concern", two mammalian and one bird species were listed as "vulnerable" and "near threatened", respectively.

Keywords: birds, mammals, road-kill

INTRODUCTION

The ecosystems of the Greater Palawan Island and its clusters of smaller islands are filled with diverse and unique forms of organisms. This distinct biogeographic region is believed to be influenced by the Sunda shelf ecoregion, the Philippine ecoregion and the existing bio-physical features of the island. According to Critical Ecosystem Partnership Fund (2001), Palawan is politically part of the Philippines, but it is geologically part of the Sunda shelf together with the islands of Sumatra, Borneo, Malay Peninsula and Java.

Palawan is considered as one of the conservation priority areas because of the global significance of its biological diversity. The United Nations Educational, Scientific and Cultural Organization (UNESCO) declare the entire province as a Biosphere reserve. It was also classified as one of the seven endemic bird areas of the Philippines with 11 identified important bird areas.

However, like the other islands of the Philippine archipelago, Palawan's ecological stability is also experiencing tremendous pressures resulting from anthropogenic activities like illegal logging, extensive slash and burn farming, land use conversion for mainstream agriculture, human encroachment, and mining (CI,DENR and Haribon 2008, Sopsop and Buot 2011). Activities that directly affect the wildlife population like hunting for bush meat is still in practiced but is subsistence in nature (Lacerna and Widmann 2008), however poaching for pet trade is rampant and occurring in a much organized manner (Cruz *et al.* 2008).

Another problem that worsens the impact of anthropogenic activities to Palawan's biodiversity is its growing population which expands at a rate of 3.6% (NSO 2002). The high birth rate combined with the influx of migrants from other parts of the Philippines significantly increases the population of the province. This scenario challenges the sustainability of the Palawan's wildlife diversity. Extensive conversion of terrestrial ecosystem to agricultural lands and settlement areas bring further habitat destruction and fragmentation. Aside from these factors wildlife species are also affected by the increasing hunting and poaching activities (Cruz *et al.* 2008).

Another factor that poses hazard to the wildlife population is the existing road network that bisects the already fragmented ecosystems. Building of wider and smoother paved roads and the increasing number of

road users travelling at faster speeds pose risks to the wildlife species crossing the roads. Barthelmess and Brooks (2010) reported that 50% of all the mammal species in their study area were affected by road kill and the rate varied between seasons and species.

In some places where heavy traffic and diverse wildlife meet, mitigating measures designed to reduce the incidence of vehicle-induced wildlife mortality like speed bumps, rumble strips, barriers, culverts and wildlife fence must be established. Schutt (2008) reported that speed bumps constructed in a highway that bisects the Ankarafantsika National Park in Madagascar significantly reduced the road kill incidences across all faunal classes.

Building of wide and paved highway that spans longitudinally in the Eastern part of the Greater Palawan Island and the increasing number of road users travelling at faster speeds endanger wildlife population. However, despite these risks the wildlife species affected by vehicle collision in the province was not yet documented. Hence, this study was conducted to provide baseline information on the species composition, level of endemism and conservation status of road killed birds and mammals along the highway section connecting the municipality of Aborlan and Puerto Princesa City.

METHODS

Time and Place of the Study

The survey of vehicle- induced mortalities of birds and mammals was conducted in a road section of the National Highway connecting the municipality of Aborlan and Puerto Princesa City (Fig. 1) from January to December 2010. The 67 kilometer road section served as an intangible strip transect that traverses different habitat types including grassland, secondary growth forest, mangrove, riparian, swamps, rice fields, coconut and fruit tree plantations, human settlements, shrub lands and coastal area.

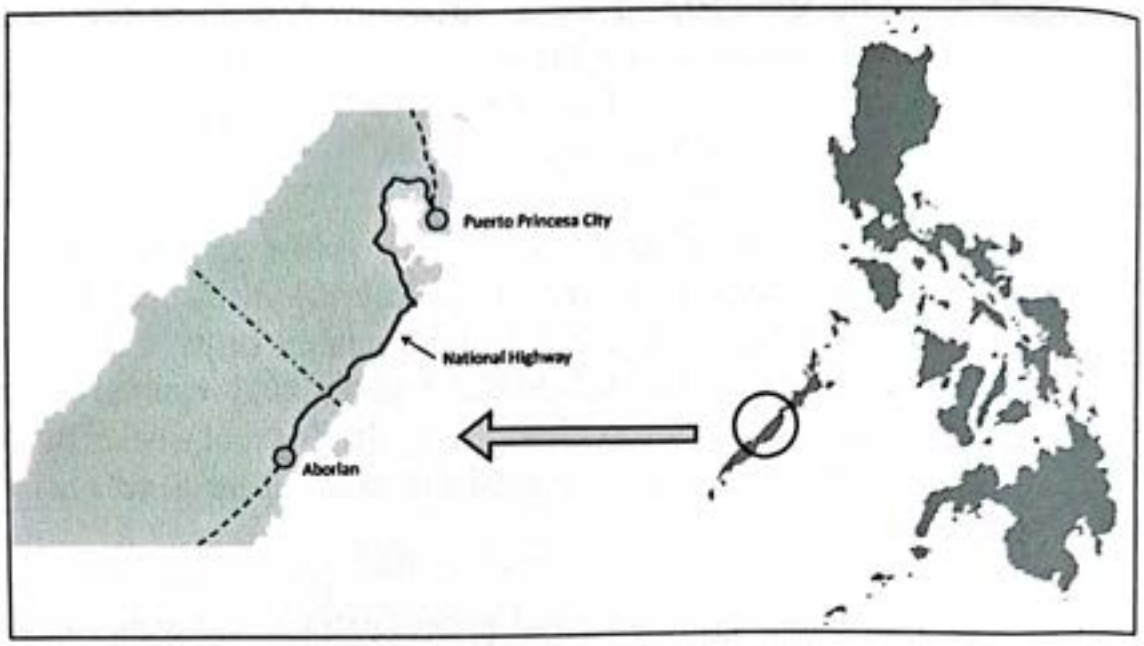

Figure 1. Map showing the portion of National Highway where road killed birds and mammals were surveyed.

Data Collection

Data gathering was conducted four times a month at weekly intervals from January to December 2010. The researcher collected the data by travelling twice along the road section on board a motorcycle with an average travelling speed of 40km/hr. Initial counting was conducted early in the morning to document the road killed nocturnal birds and mammals while another counting was conducted in the late afternoon to document the road killed diurnal birds and mammals. Carcasses found along the road were identified, counted and photographed. Specimens recorded during the initial counting were removed from the road to avoid being recounted in the afternoon.

RESULTS AND DISCUSSION

Species Composition

There were at least 127 carcasses of road killed animals recorded in the study area 47 (37%) of which were mammals while 80 (63%) were birds (Table 1). From the recorded carcasses 33 species of birds representing

22 families and 7 species of mammals belonging to 6 families were identified. Mammals under family Muridae were not classified down to species level because the specimens were totally crushed and identifying it by means of morphologic and morphometric characteristics will give unreliable result.

Most of the bird families recorded were only represented by a single species (Podargidae, Dicruridae, Nectariniidae, Ardeidae, Chloropseidae, Hirundinidae, Turdidae, Pittidae, Sturnidae, Ploceidae, Sylviidae, Turnicidae and Caprimulgidae). The most commonly recorded road killed bird was the Large-Tailed Nightjar (*Caprimulgus macrurus johnsoni*) of the family Caprimulgidae. This Palawan endemic race is a nocturnal bird that commonly feeds by catching insects in midair. The increased density of insects attracted to the lights of the passing vehicles might lured these birds to hunt along the road. It was also noted that road killed Large-Tailed Nightjar is abundant in road sections where swarms of termites in nuptial flight were sighted. Although currently classified as "least concern" in the IUCN Red List 2010, future prospects of this species is still uncertain considering the bulk of the individuals affected by vehicle-induced mortality. The continuously growing number of road users and building of new road networks in the province is a serious threat that might somehow affect the health of the population of this bird. Monitoring the population of this species to serve as basis for elevating its conservation priority status is a must.

On the other hand, most of the mammalian species killed were non-volant. Only two species of volant mammals were recorded during the survey period, the Diadem Roundleaf Bat (*Hipposideros diadema*) and the Short-Nosed Fruit Bat (*Cynopterus brachyotis*).

Of the 7 recorded road-killed families of mammals 5 families were represented by only a single species (Pteropodidae, Hystricidae, Rhinolopidae, Sciuridae and Viverridae), and only one family was represented by two species (Mustelidae).

The most commonly recorded road killed mammal was Common Palm Civet (*Paradoxurus hermaphroditus*) followed by the Palawan Stink Badger (*Mydaus marchei*) with a frequency of 10 and 9, respectively. This report corroborates with the findings of Esselstyn *et al.* (2004) that Common Palm Civet is probably the most common carnivore on the island, hence frequently recorded

road killed samples of these animals were commonly found across different habitat types.

Table 1. Species composition, conservation status, level of endemism and frequency of road killed animals recorded in a road section connecting municipality of Aborlan and Puerto Princesa City, Palawan.

Family	Scientific Name	Common Name	Level of Endemism	Conservation Status	Freq
Birds					
Alcidinidae	*Alcedo meninting amadoni*	Blue-Eared Kingfisher	Palawan endemic race	Least concern	1
Alcidinidae	*Ceryx erithacus rufidorsa*	Oriental Dwarf Kingfisher	Resident	Least concern	2
Ardeidae	*Egretta intermedia*	Intermediate Egret	Migrant	Least concern	1
Caprimulgidae	*Caprimulgus macrurus johnsoni*	Large-Tailed Nightjar	Palawan endemic race	Least concern	17
Chloropseidae	*Aegithina tiphia*	Common Iora	Resident	Least concern	1
Columbidae	*Geopelia striata*	Zebra Dove	Resident	Least concern	1
Columbidae	*Treron vernans vernans*	Pink-Necked Green-Pigeon	Philippine endemic race	Least concern	1
Columbidae	*Treron curvirostra*	Thick-Billed Green-Pigeon	Resident	Least concern	2
Cuculidae	*Centropus sinensis*	Greater Coucal	Resident	Least concern	1
Cuculidae	*Phaenicophaeus curvirostris harringtoni*	Chestnut-Breasted Malkoha	Palawan endemic race	Least concern	2
Cuculidae	*Centropus bengalensis*	Lesser Coucal	Resident	Least concern	3
Dicaeidae	*Dicaeum pygmaeum palawanorum*	Pygmy Flowerpecker	Palawan endemic race	Least concern	1
Dicaeidae	*Prionochilus plateni*	Palawan Flowerpecker	Palawan endemic	Least concern	3
Dicruridae	*Dicrurus hottentottus palawanensis*	Spangled Drongo	Palawan endemic race	Least concern	1
Estrildidae	*Lonchura leucogastra*	White-Bellied Munia	Resident	Least concern	2
Estrildidae	*Lonchura malacca jagori*	Chestnut Munia	Resident	Least concern	3
Hirundinidae	*Hirundo rustica gutturalis*	Barn Swallow	Migrant	Least concern	2
Muscicapidae	*Hypothymis azurea*	Black-Naped Monarch	Resident	Least concern	1
Muscicapidae	*Terpsiphone cyanescens*	Blue Paradise-Flycatcher	Palawan endemic	Near Threatened	1
Nectariniidae	*Nectarina jugularis*	Olive-Backed Sunbird	Resident	Least concern	1
Pittidae	*Pitta sordida palawanensis*	Hooded Pitta	Palawan endemic race	Least concern	2
Ploceidae	*Passer montanus*	Eurasian Tree Sparrow	Resident	Least concern	4
Podargidae	*Batrachostomus javensis chaseni*	Javan Frogmouth	Palawan endemic race	Least concern	1
Pycnonotidae	*Pycnonotus plumosus cinereifrons*	Olive-Winged Bulbul	Palawan endemic race	Least concern	2

Table 1. Contn'n..

Family	Scientific Name	Common Name	Level of Endemism	Conservation Status	Freq
Pycnonotidae	*Pycnonotus plumosus cinereifrons*	Olive-Winged Bulbul	Palawan endemic race	Least concern	2
Pycnonotidae	*Pycnonotus atriceps*	Black-Headed Bulbul	Resident	Least concern	3
Rallidae	*Gallinula chloropus lozanoi*	Common Moorhen	Philippine endemic race	Least concern	1
Rallidae	*Amaurornis phoenicurus javanica*	White-Breasted Waterhen	Resident	Least concern	3
Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	Resident	Least concern	2
Sylviidae	*Orthotomus sericeus*	Rufous-Tailed Tailorbird	Resident	Least concern	5
Timalidae	*Trichastoma cinereiceps*	Ashy Headed Babbler	Palawan endemic	Least concern	1
Timalidae	*Macronous gularis woodi*	Striped Tit-Babbler	Palawan endemic race	Least concern	2
Turdidae	*Copsychus niger*	White-Vented Shama	Palawan endemic	Least concern	2
Turnicidae	*Turnix suscitator haynaldi*	Barred Buttonquail	Palawan endemic race	Least concern	5
Mammals					
Hystricidae	*Hystrix pumila*	Palawan Porcupine	Palawan endemic	Vulnerable	1
Muridae	Unidentified Specimens				20
Mustilidae	*Amblonyx cinereus*	Oriental Small-Clawed Otter	Resident	Vulnerable	2
Mustilidae	*Mydaus marchei*	Palawan Stink Badger	Palawan endemic	Least concern	9
Pteropodidae	*Cynopterus brachyotis*	Short-Nosed Fruit Bat	Resident	Least concern	1
Rhinolophidae	*Hipposideros diadema*	Diadem Roundleaf Bat	Resident	Least concern	2
Sciuridae	*Sundasciurus juvencus*	Tree Squirrel	Palawan endemic	Least concern	2
Viverridae	*Paradoxurus hermaphroditus*	Common Palm Civet	Resident	Least concern	10

Level of Endemism and Conservation Status

Out of the 40 identified species of road killed birds and mammals, 4 birds and 3 mammals were Palawan endemics. Most of the affected birds were resident species and 37% of it were Palawan endemic race.

Although only 12% of the avian species killed by vehicles were classified as Palawan endemics, 30% more have Palawan endemic race (Figure 2). The Palawan endemic birds were the White-Vented Shama (*Copsychus niger*), Ashy Headed Babbler (*Trichastoma cinereiceps*), Blue Paradise-Flycatcher (*Terpsiphone cyanescens*) and Palawan Flowerpecker (*Prionochilus plateni*) (Table 1).

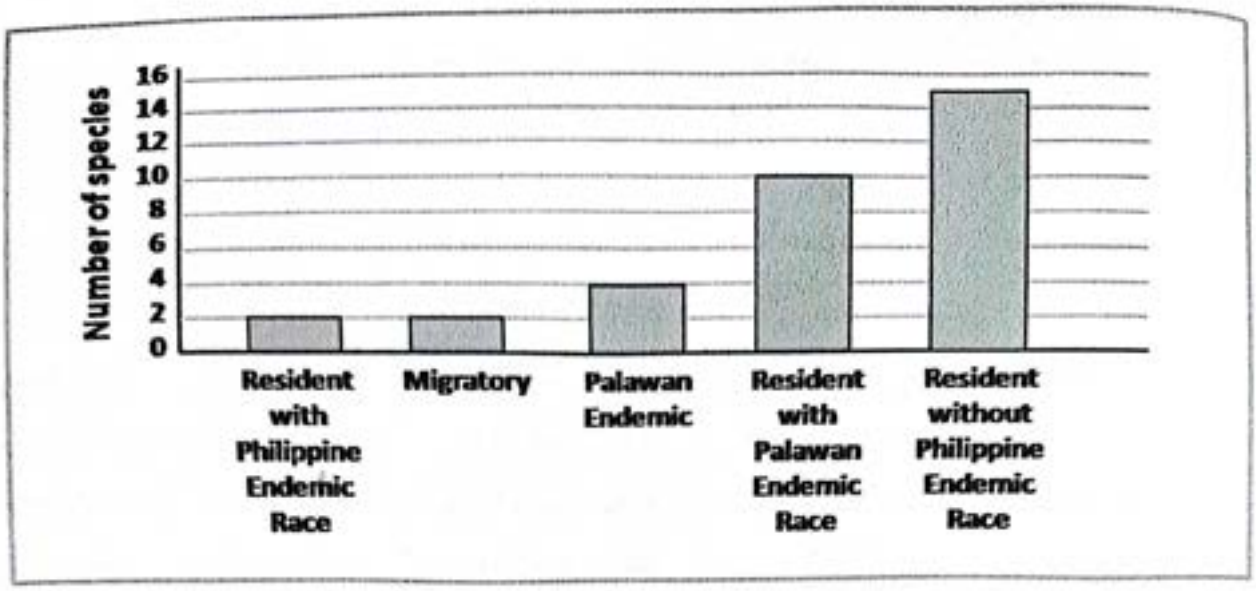

Figure 2. Level of endemism of road killed bird species recorded in a road section connecting the municipality of Aborlan and Puerto Princesa City Palawan

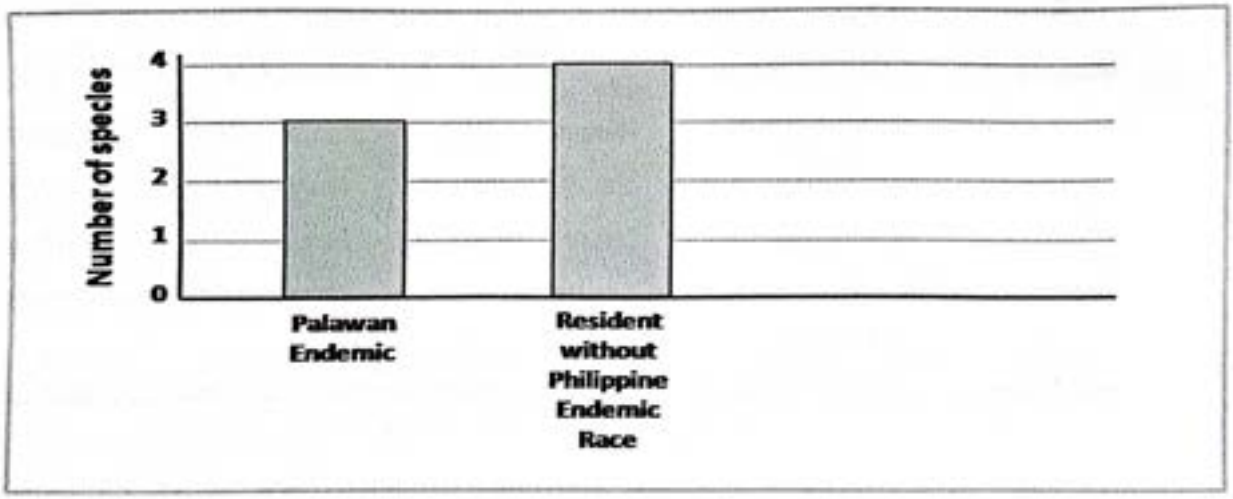

Figure 3. Level of endemism of road killed mammal species recorded in a road section connecting the municipality of Aborlan and Puerto Princesa City Palawan

On the other hand, the Palawan endemic mammals recorded during the census were the Tree Squirrel (*Sundasciurus juvencus*), Palawan Porcupine (*Hystrix pumila*) and Palawan Stink Badger (*Mydaus marchei*). Even though large number of individuals of the family Muridae were not classified to species level, the degree of endemism of mammals was considerably high (43%). This finding supports the level of endemism of non-volant mammals in Palawan which was reported to be 44% (WWF and McGinley 2008). Meanwhile, the two volant mammals recorded

were both non Palawan endemics, these bats were also found all over the Philippines and other Sunda islands as well.

Based on the International Union for the Conservation of Nature (IUCN 2010) Red List of Globally Threatened Wildlife Species, most of the mammalian and avian species killed by vehicles were categorized as "least concern". However, one bird species the Blue Paradise-Flycatcher (*Terpsiphone cyanescens*) is already near threatened, and two mammals the Palawan Porcupine (*Hystrix pumila)* and Oriental Small-Clawed Otter (*Amblonyx cinereus*) were both red listed as "vulnerable". It was also noted that the Blue Paradise-Flycatcher and the Palawan Porcupine were both Palawan endemic species.

CONCLUSION

The study revealed that a rich assemblage of birds and mammals are affected by vehicle induced mortalities. In terms of the number of individuals, species and families, more birds are affected than mammals. Majority of the road killed animals have wider geographic distribution and only few are endemic to Palawan, the level of endemism of mammals is comparably higher than birds.

Based from the Red List of Globally Threatened Animals (IUCN 2010) most of the road killed birds and mammals are classified as "least concern" except for the two mammal species which are classified as "vulnerable" and one bird species which is listed as "near threatened". Because of the stable population and wider geographic distribution of the affected species, most of the road killed birds and mammals were currently given less conservation priority.

RECOMMENDATION

1. A wildlife survey must be conducted to update the conservation status of the wildlife species affected by vehicle–induced mortalities.

2. Information campaign must be conducted to educate the people about the impact of vehicle-induced mortalities to the natural population of wild animals.

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The Palawan Scientist
Vol. 5, No. 1 pp. 11-31, 2011

ISSN No. 1656-4707

Effects of Endomycorrhizal Inoculation on the Growth of *Jatropha curcas* L., *Acacia mangium* Willd., and *Casuarina equisetifolia* J. R. & G. Forst Seedlings in Nickel-Mined Soil in Southern Palawan, Philippines

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ABSTRACT

The influence of vesicular-arbuscular-mycorrhizal fungi (VAMF) on the growth and survival of *Jatropha curcas, Acacia mangium* and *Casuarina equisetifolia* in the abandoned mined areas with 1.01% nickel concentration (161 times greater than the normal nickel concentration for natural soils) was examined at the experimental area of the Western Philippines University (WPU), Aborlan, Palawan for 8 months. The study aimed to determine rehabilitation strategies in the abandoned mined sites in the province. Specifically, the objectives of the study were to: (1) Evaluate the growth performance of *J. curcas, A. mangium* and *C. equisetifolia* seedlings in the fertile and nickel-contaminated soils with VAM inoculation; (2) Determine the phytoremediation potential of three species in the nickel-mined soil. The height, diameter, biomass yield, root volume, root-shoot ratio, were used as parameters to determine the growth and nutrient pattern uptake of the species. Nickel content of plant tissues was used to determine phytoremediation potential of the species.

In the nickel mined soils, *Acacia mangium* (70.19 cms.) obtained significantly better height performance than *Casuarina equisetifolia* (56.12 cms.) and *Jatropha curcas* (24.67 cms.). The *Acacia mangium* also showed no significant difference on biomass yield in the nickel mined soil (22.63g/plant) and fertile soil (29.21g/plant); and root volume at 14.20 cms.^{3} and 16.79 cms.^{3} respectively. The non-significant variations on biomass yield and root volume on both soils indicate that *Acacia mangium* had performed even in the nickel contaminated soil.

VAMF-inoculated seedlings of *Casuarina equisetifolia* were significantly taller with a mean of 2.14 cms. as compared to the non-inoculated seedlings with 0.52 cm. *Casuarina equisetifolia* also registered larger stem diameter by 260% over the non-inoculated seedlings. VAMF influence was evident on the nickel uptake of *Acacia mangium* which accumulated statistically higher amount of nickel content at

12.22 mg/kg. of its dry weight as against the 7.26 mg/kg from the non-inoculated seedlings.

Based on the results, the growth and survival of *Acacia mangium* and *Casuarina equisetifolia* in the nickel contaminated soil manifest tolerance to nickel toxicity and therefore potential as rehabilitation species in the abandoned nickel-mined sites in Palawan.

Keywords: *Mycorrhiza, inoculation, phytoremediation, mine sites, Casuarina equisetifolia, Acacia mangium, Jatropha curcas,*

INTRODUCTION

Mining in the province of Palawan has been operational for almost four decades now. At present, there are four existing nickel-mining concessions in the province. The oldest is the Rio Tuba Nickel Mining Corporation (RTNMC) which started nickel mining in 1969 covering an area of 5,265 hectares of land while the Platinum Group Mining Companies located in Narra, Palawan, and the Berong Nickel Corporation in Quezon, Palawan, started their operations in 2000 and 2006, respectively. The open-pit mining operation involves the flattening of the mountain tops and creating huge craters which is considered destructive because of the use of chemicals to separate the huge volumes of ground rock from the ore. After extraction, the mined areas are abandoned and left with most of the soils under extreme acidity and generally low of microbial populations. The continuous mining activity in the province had resulted to soil degradation and soil infertility.

With the passage of Republic Act No. 7942 known as the Philippine Mining Act of 1995, the government required the rehabilitation of these abandoned mined sites through reforestation. However, due to the infertility coupled with extreme acidity of soils, reforestation species in these abandoned mined areas have low survival rates and poor growth.

The search for tolerant species that can adapt to the harsh conditions is a feasible strategy to achieve success in the reforestation of the abandoned nickel mined sites. The introduction of mycorrhizal fungi could also help in the enhancement of growth of the tree species that will be used to rehabilitate the abandoned mined sites. Mycorrhiza is a symbiotic association that forms between the roots of most plant species and fungi. This symbiotic association enhances the ability of plants to take phosphorus and sometimes other nutrients that are generally immobile and present in low concentrations in the soil solution.

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This study was designed to determine the growth performance of the three species in the nickel-mined soils under Palawan condition. It was designed to evaluate the efficacy of these three species in the abandoned nickel mined sites.

Objectives

Generally, the study was undertaken to determine rehabilitation strategies of the abandoned nickel-mined areas in the province of Palawan. Specifically, the study was conducted to evaluate the growth performance and survival of *Jatropha curcas, Acacia mangium* and *Casuarina equisetifolia* seedlings in the fertile and nickel-mined soils with VAM inoculation and determine phytoremediation potentials of these species in the nickel-mined sites.

Significance of the Study

One of the serious concerns of the people of Palawan is the effect of mining activities in the province. Heavy metals such as nickel are toxic environmental pollutants especially when their concentrations exceed the critical level (Cadiz *et al* 2009). Sadly, more mining claims were subsequently applied for in Palawan. In 2010, mining applications totaled to 429, covering an area of 700,000 hectares or about half of the 1,489,655 total land area of the Province (PCSD, 2010). In 1995, the guiding principles emphasized by the government were the pursuance of responsible mining and rehabilitation of abandoned mined sites to safeguard the ecological integrity of areas affected by mining. However, vast mining areas lie unsightly to the public as they have remained abandoned for decades without any rehabilitation efforts made. Dubbed as the country's last ecological frontier because of its high diversity, Palawan is one of the provinces that have large areas of abandoned mined sites. These areas were left out after several years of mining operations leaving behind toxic waste materials, overburdened areas that are stony, rocky and acidic, open pits and mine tailings. With these, there is the dire need to look for possible strategies to rehabilitate these areas. Hence, this study.

MATERIALS AND METHODS

Duration and Scope of the Study

Seedlings of the three species *Jatropha curcas, Acacia mangium* and *Casuarina equisetifolia* were grown in fertile (garden soil) and nickel-mined soil to

evaluate their growth performance. The study included the assessment of mycorrhizal inoculation on growth performance of the three species. The study was a pot experiment using two soil types undertaken for a period of eight months from July 2008 to February 2009.

Description of the Experimental Site

The experiment was undertaken at the experimental area of the Western Philippines University (WPU), Aborlan, Palawan. The climatic condition during the whole duration of the study was taken from the PAGASA Experimental Station in Palawan from July 2008 to February 2009. No rainfall observed during the months of July and September with low rainfall observed on the month of August with an average precipitation of 3.88 mm. High precipitations were observed on the fourth and fifth month of the study with 36.00 and 10.20 mm, respectively but precipitation decreased thereafter until the termination of the study with mean ranging from 0.40 to 4.40 mm.

Figure 1. The experimental area.

Collection and Preparation of Materials

Description of the Nickel-Mined Site

The nickel-contaminated soils used in the study came from the abandoned nickel-mined site in Narra, in southern Palawan (Figure 2). The area remains unattended since August 2000. Although patches of shrubs, grasses, ferns and trees

flourished in the surrounding area, significant portion of the exposed contaminated soils remains unvegetated. Mined-out areas consist of the open pits which are left behind after the mining operation. These areas are highly deficient in organic matter, nitrogen, phosphorus and potassium while excessive in heavy metals.

Figure 2. An abandoned nickel-mined site, Narra, Palawan.

Planting Materials and Source of Inoculum

The three experimental plants used were: *Jatropha curcas, Acacia mangium,* and *Casuarina equisetifolia.* The vesicular-arbuscular-mycorrhizal (VAM) fungi inoculants of *Glomus tunicatum* obtained from BIOTECH, UPLB was used to inoculate the two types of soils. The inoculum consisted of infected root segments; hyphae, spores, and sand were added to some pots, at the rate of one table spoon per pot (about 10 g).

Experimental Design, Treatments and Lay-out

The experiment was set up as a 3 x 2 x 2 factorial design consisting of three plant species (*Jatropha curcas, Acacia mangium, Casuarina equisetifolia*), two soil types (garden and nickel-mined soil) and mycorrhizal fungus (VAM) with a non-inoculated control which were arranged in a Randomized Complete Block Design (RCBD) with four replicates per treatment combinations giving a total of 48 experimental units for the whole experiment.

Transplanting and Mycovam Inoculation

Jatropha curcas, *Acacia mangium* and *Casuarina equisetifolia* seedlings were placed in black polyethylene plastic bags containing about 4 kilogram of sterilized soils. Inoculation was achieved by mixing 10 grams of the inoculum 1 cm below the roots to ensure better infection. There were no other nutrients added to the soil throughout the entire duration of the experiment.

Nursery Management

All seedlings were hardened off for one month with minimal watering as needed. After hardening, seedlings were transferred to an open area to simulate field conditions. Other than weeding, no maintenance activities undertaken after the seedlings were transferred to the experimental site.

Growth Monitoring /Measurement of Parameters at Harvest

Baseline data on the initial diameter and height of the 3 experimental plants were recorded prior to field experiment which started in July 2008 until February 2009. The monthly incremental height and diameter growth were subjected to statistical analysis. Other parameters to assess the growth and survival of the three species under various treatments and replications were: biomass, root volume and shoot-root ratio.

RESULTS AND DISCUSSION

Properties of Soils Used in the Study

Physico-chemical Properties

The result of the analysis showed that soils used in the study were 4.0% sand, 47% silt and 49% clay in the abandoned nickel-mined soil. The conditions of the abandoned mined soils proved inhospitable for plants i.e., low moisture holding capacity and low nutrient levels. The low N, P and K in the nickel-mined soil (Table 1) were attributed to the open pit cast method that involves scraping of topsoil and excavation of the ground to extract the nickel. The open-pit mining method clears the vegetation which covers the deposits, inevitably exposing the soil and permanently changing the landscape of the area.

Table 1. Initial properties of the two soil types used in the experiment

PROPERTY	GARDEN SOIL	NICKEL-MINEDSOIL SOIL
Physical		
Particle size distribution		
Sand (%)	47	4.0
Silt (%)	32	47
Clay (%)	21	49
Texture	Clay loam	Clay
Chemical		
pH	7.5	6.0
Total N (%)	0.15	0.03
Available P (ppm)	93.0	7.20
Exchangeable K ($cmol^+/kg$	3.79	0.02
Nickel (%)		1.01
OM (%)	3.57	0.93
Biological		
Spore count (per 100 g soil)	95	2

Organic Matter Content and Soil pH

The two soils used in the study differed in their organic matter content as these were obtained from two different sites which were exposed to different environmental conditions. The organic matter of the fertile soil is considered very high at 3.57%; while very low at 0.93% in the abandoned nickel-mined soil when compared with the ideal soil organic matter of 3.0% (Betteridge, 2003).

Nickel Content

The soil obtained from the abandoned nickel-mined site contained about 1.01% or equivalent to 10,100 ppm which is 161 times greater than the normal concentration of natural soils which is set at 62.76 ppm. The fact that the nickel content of the soil used in this experiment is higher than the normal concentration, there is high probability to obtain retarded growth and low biomass production in the seedlings of *J. curcas, A. mangium* and *C. equisetifolia.*

Effect of Treatments on the Growth Performance of the Three Species

Plant Height

Highly significant variations on height growth were observed from the effect of species and soil type, while VAM inoculation became significant only for *C. equisetifolia* on the last two months of the experiment. The interaction of VAM x species and VAM x soil x species were statistically insignificant. Using height as a parameter of growth and survival, it indicates that *Acacia mangium* and *Casuarina equisetifolia* are capable to survive and have tolerance to nickel contaminated soil. The inherent advantage i.e. N-fixing ability of the two species may have an effect on its performance since nitrogen is critical in stimulating growth and development as well as the better uptake of other nutrients (Brady, 1996; Galiana, *et al* 1996).

Table 2. Comparison of cumulative monthly height increment (cm) of three species as affected by soil type for 8 months

SOIL TREATMENT	HEIGHT GROWTH (cm)							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Jatropha curcas								
Garden Soil	3.79[a]	2.57[a]	2.65[a]	3.32[a]	0.18	0.22	0.36	0.69[a]
Nickel-mined Soil	0.87[b]	0.08[b]	0.12[b]	0.03[b]	0.01	0.03	0.01	0.03[b]
LSD test	**	**	**	**	ns	ns	ns	*
Acacia mangium								
Garden Soil	4.39[a]	4.68[a]	5.31[a]	6.81[a]	4.35[a]	0.82	0.88	0.20
Nickel-mined Soil	2.32[b]	2.30[b]	3.71[b]	2.80[b]	1.84[b]	0.68	0.92	0.30
LSD test	**	**	**	**	**	ns	ns	ns
Casuarina equisetifolia								
Garden Soil	5.07[a]	7.62[a]	3.47[a]	6.35[a]	3.01[a]	0.73	0.77[a]	1.29
Nickel-mined Soil	2.15[b]	2.13[b]	1.17[b]	2.39[b]	0.86[b]	0.78	0.20[b]	1.36
LSD test	**	**	**	**	**	ns	**	ns

Under each growing period, means followed by different letters within a soil treatment under a species are significantly different at the 5% probability level by the LSD test.
** = significant at 1% level, * = significant at 5% level, ns = not significant

In the nickel-mined soil, *A. mangium* showed no significant difference on the height increment of seedlings on both soil types from the sixth until eight months of the study which indicate that the species in the nickel contaminated soil were at par with those in the garden soil. The performance of *A. mangium* relative to height growth indicated that it can be a candidate species in the abandoned mined sites as successful species are those which are able to adapt to unfavorable growth conditions.

Casuarina equisetifolia showed the same trend with *A. mangium* in the nickel contaminated soil condition suggesting that the species was able to cope over time with the edaphic condition. The height response of the two species showed that both have the ability to survive, adapt and grow normally even if grown under unsuitable site conditions. These two species by far shows that *A. mangium* and *C. equisetifolia* have survival mechanisms to thrive in a nickel mined soil which is one important criterion used for selecting plants for phytoremediation of abandoned mined sites.

Other attributes that may have influenced on the height performance of *A. mangium* and *C. equisetifolia* were related to their somewhat distinct morphological features i.e., typically possess reduced leaf size in the nickel-mined soil relative to their counterparts on fertile soil; and root systems that are often more developed. These mechanisms i.e. develop tolerance to toxic levels of nickel, and the ability to adapt to edaphic restrictions, such as low nutrients and drought conditions are perhaps the defining characters which make these species candidates in the rehabilitation of the abandoned mined sites.

In this study, there was an inconsistency on the growth performance of *J. curcas* as there was no significant height variation during its fifth to seventh months (November and January) but on the eight month (February) a significant difference on height of seedlings in both soil types was observed showing a poor growth response in the nickel-contaminated soil. This indicates that the seedlings were not able to cope and tolerate the heavy metallic condition of the mined soil. Obviously, the toxic level of nickel, low NPK and low organic matter content of the nickel-mined soil had resulted to the inferior performance of the species relative to their counterparts in the fertile soil. The abandoned nickel mined-out areas were totally devoid of topsoil which contains the physical, nutritional and living microorganisms which plants co-exist with. Thus, it is expected that most plant exposed to abnormal conditions i.e., total rocky mineral media, intense light and heat, droughty and lacking in available nutrients for normal plant growth would end up as a general failure.

VAM inoculation showed no significant effect on the height increments of *J. curcas* and *A. mangium* (Table 3) as shown by the comparable height growth from the first until the eight month of the experiment. However, the VAM-inoculated seedlings of *C. equisetifolia* were significantly higher than the

uninoculated seedlings during the seventh and eighth month (January-February) with a mean of 2.14 cm showing superior growth improvements compared to the uninoculated seedlings with 0.52 cm. The insignificant effect of VAM in the early five month measurement period (July – December) in the case of *C. equisetifolia* could be due to the "lag phase" where the influence of mycorrhizal inoculation is not yet manifested to the host plant (Brandon and Shelton, 1993; cited by Dhungana *et al.*, 2008). Norland (1993) reported that it may take three to four months or even longer for fungal inoculum to germinate and infect a root as spores. This is because in some cases, inoculum remains ungerminated for an extensive period of time due to unfavorable environmental conditions such as insufficient availability of sporophores and lack of spores (Sturges, 2004).

Table 3. Comparison of cumulative monthly height increments (cm) of three species as affected by VAM inoculation for 8 months

INOCULATION TREATMENTS	HEIGHT GROWTH (cm)							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Jatropha curcas								
Control	2.66	1.61	1.25	1.53	0.09	0.14	0.11	0.31
With inoculation	2.00	1.05	1.52	1.81	0.10	0.11	0.26	0.41
LSD test	ns	ns	ns	ns	ns	ns	ns	ns
Acacia mangium								
Control	3.40	3.77	4.53	4.45	2.90	0.66	0.83	0.13
With inoculation	3.30	3.21	4.49	4.44	3.29	0.83	0.97	0.37
LSD test	ns	ns	ns	ns	ns	ns	ns	ns
Casuarina equisetifolia								
Control	3.53	4.36	2.37	4.09	1.87	0.76	1.60	0.52[b]
With inoculation	3.69	5.39	2.27	4.65	2.00	0.75	1.11	2.14[a]
LSD test	ns	ns	ns	ns	ns	ns	**	**

Under each growing period, means followed by different letters within a VAM treatment under a species are significantly different at the 5% probability level by the LSD test.
** = significant at 1% level, ns = not significant

Stem Diameter

The adaptation of *J. curcas* to nickel-mined sites was not realized until the eight month period as shown by the significantly smaller stems of seedlings in the nickel-mined soil. The physical and chemical condition of the nickel mined-soil including the high amount of nickel produces the cumulative effect to which the seedlings of *J. curcas* were not able to overcome. In the case of *A. mangium* and *C. equisetifolia,* a comparable growth increments in the stem diameter of seedlings in the garden and nickel-mined soils were observed during the sixth to eight (December to February) month for *A. mangium* and seventh and eighth month

(January –February) for *C. equisetifolia* which implied adaptation of both species to nickel-mined condition.

Table 4. Stem diameter increment of seedlings of three species grown in garden and nickel-mined soil for 8 months

SOIL TREATMENT	DIAMETER GROWTH (cm)							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Jatropha curcas								
Garden Soil	0.89[a]	1.95[a]	1.94[a]	2.02[a]	1.22[a]	0.59[a]	0.06[a]	0.25[a]
Nickel-mined Soil	0.55[b]	0.43[b]	0.31[b]	0.13[b]	0.02[b]	0.01[b]	0.00[b]	0.02[b]
LSD test	**	**	**	**	**	**	*	*
Acacia mangium								
Garden Soil	0.28[a]	0.37[a]	0.52[a]	0.64[a]	0.40[a]	0.20[a]	0.14[a]	0.02[a]
Nickel-mined Soil	0.23[a]	0.29[a]	0.34[a]	0.15[b]	0.20[b]	0.18[a]	0.11[a]	0.02[a]
LSD test	Ns	ns	ns	**	*	ns	ns	ns
Casuarina equisetifolia								
Garden Soil	0.63[a]	0.88[a]	1.10[a]	0.77[a]	0.87[a]	0.34[a]	0.12[a]	0.11[a]
Nickel-mined Soil	0.42[b]	0.31[b]	0.36[b]	0.21[b]	0.14[b]	0.13[b]	0.13[a]	0.12[a]
LSD test	**	**	**	**	**	*	ns	ns

Under each growing period, means followed by different letters within a soil treatment under a species are significantly different at the 5% probability level by the LSD test.
** - significant at 1% level, * - significant at 5% level, ns- not significant

In this study, the influence of mycorrhizal inoculation was not evident on the diameter growth of *J. curcas* and *A. mangium*. Contrary to the response of these two species, *C. equisetifolia* inoculated with mycorrhiza obtained larger diameter growth which was evident on the later month of its growing period i.e., in January and February. The VAM-inoculated seedlings of *C. equisetifolia* registered larger increments in stem diameter by 260% over the non-inoculated seedlings indicating that VAM inoculation had played significant role on diameter growth of Casuarina (Table 5).

Table 5. Stem diameter increment of uninoculated and mycorrhizal inoculated seedlings of the three species grown for 8 months

INOCULATION TREATMENTS	DIAMETER GROWTH (cm)							
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Jatropha curcas								
Uninoculated	0.75	1.36	1.19	1.05	0.56	0.37	0.00	0.10
With inoculation	0.72	1.01	1.06	1.11	0.68	0.23	0.06	0.18
LSD Test	ns	Ns	ns	ns	ns	ns	ns	Ns
Acacia mangium								
Uninoculated	0.27	0.31	0.48	0.41	0.30	0.21	0.11	0.01
With inoculation	0.23	0.35	0.37	0.38	0.31	0.17	0.14	0.02
LSD Test	ns	ns	ns	ns	ns	ns	ns	Ns
Casuarina equisetifolia								
Uninoculated	0.54	0.61	0.71	0.52	0.45	0.27	0.06[b]	0.05[b]
With inoculation	0.52	0.58	0.75	0.46	0.56	0.20	0.18[a]	0.18[a]
LSD Test	ns	Ns	ns	ns	ns	ns	*	*

Under each growing period, means followed by different letters within a VAM treatment under a species are significantly different at the 5% probability level by the LSD test.
*-significant at 5% level, ns – not significant

Biomass Yield

Highly significant differences in biomass production were observed at the end of the measurement period due mainly to the differences of biomass allocation pattern at the species level and soil type. The effect of VAM inoculation including its interactions with the three species and soil type were statistically insignificant.

Table 6. Biomass yield (g/plant) of three species after 8 months of growing period as influenced by soil type

SPECIES	SOIL TYPE		
	GS	NMS	Difference
Jatropha curcas	57.23	1.48	55.76 **
Acacia mangium	29.22	22.67	6.58 [ns]
Casuarina equisetifolia	29.96	17.97	11.99 *

** = significant at 1% level, * = significant at 5% level, ns = not significant

It is interesting to note that in spite of the soil condition, *A. mangium* in the nickel mined sites (22.63g/plant) showed no significant difference on biomass yield when compared with the garden soil (29.21g/plant) which indicated a comparable growth and nutrient uptake of *A. mangium* even to the high metallic condition of the mined sites. The poor condition of the soil did not stress the seedlings hence producing better biomass.

In this study, VAM fungi did not significantly increase biomass yield which indicates that mycorrhizal fungi did not enhance the growth of the three species in as far as this parameter is concerned. The insignificant biomass production by the inoculated plants could be attributed to the incompatibility of the fungi to host roots and/or possibly due to the unfavorable condition of the soil, as mycorrhiza forms where host roots and compatible fungi are growing in close proximity and environmental conditions are favorable.

Table 7. Biomass yield (g/plant) of three species after 8 months of growing period as influenced by VAM inoculation

SPECIES	BIOMASS YIELD (g/plant)		
	-VAM	+VAM	Differences
Jatropha curcas	29.78	28.93	0.85 ^{ns}
Acacia mangium	22.36	29.49	7.13 ^{ns}
Casuarina equisetifolia	23.61	24.36	0.70 ^{ns}

ns = not significant

Volume of Roots

Highly significant differences in root formation were observed at the end of the measurement period. These variations were due to the differences at the species level and soil type. Other treatments such as effects of VAM inoculation and its interactions with the three species and soil type were statistically insignificant (Table 8).

Table 8. Root volume (cm^3) of three species after 8 months of growing period as influenced by soil type

SPECIES	ROOT VOLUME (cm^3)		
	GS	NMS	Difference
Jatropha curcas	61.64	0.79	60.85 **
Acacia mangium	16.79	14.20	2.59 ns
Casuarina equisetifolia	24.75	14.35	10.40 **

** = significant at 1% level, ns = not significant

The root volume produced by the three species further explains the differences in biomass production as previously presented (Table 7). The *J. curcas* in the garden soil produced significantly higher root volume, however when considering the performance of this species in the mined soil the result showed that it had the poorest performance as a consequence of having shorter roots which reduced the uptake of nutrients and water. The lower root volume of *J. curcas* in the mined sites have also been the effect of nickel toxicity as manifested by having undeveloped roots and non-development of plant tissues which are the symptoms of high nickel concentrations in soil.

However, *A. mangium* grown in an adverse soil condition showed comparable root sizes with a non-significant variation at 16.79 cm^3 in the garden soil and 14.20 cm^3 in the nickel-mined soil. The data obtained in this study revealed that the performance of *A. mangium* in terms of root formation was not affected by the limited nutrients in the nickel-mined soil indicating metal tolerance and/or survival of species in a nickel-contaminated soil.

In this study, mycorrhizal inoculation did not influence the root formation of the *J. curcas* and *C. equisetifolia* as manifested by the similar root volume of inoculated and non-inoculated seedlings. However, the inoculated seedlings of *A. mangium* obtained significantly larger root volumes with 17.26 cm^3 as against the 13.76 cm^3 obtained from the non-inoculated plants indicating that VAM had enhanced nutrient uptake thus resulted to bigger root volume of *A. mangium*.

Table 9. Root volume (cm^3) of the three species after 8 months growing period as influenced by VA mycorrhiza inoculation

SPECIES	ROOT VOLUME (cm^3)		
	-VAM	+VAM	Difference
Jatropha curcas	31.65	30.77	0.88 ^{ns}
Acacia mangium	13.76	17.26	3.54 *
Casuarina equisetifolia	19.36	19.78	0.45 ^{ns}

* = significant at 5% level, ns = not significant

Root-Shoot Ratio

Result indicates that a highly significant difference in root-shoot ratio was observed at the eight measurement period on the three species due mainly to the differences at the species level and soil type. Other treatments such as the effects of VAM inoculation and its interactions with the three species and soil type were statistically insignificant.

Table 10. Shoot-root ratio of three species after 8 months of growing period as influenced by soil type

SPECIES	SHOOT-ROOT RATIO		
	GS	NMS	Difference
Jatropha curcas	2.39	7.75	5.36 **
Acacia mangium	2.40	1.99	0.41 ^{ns}
Casuarina equisetifolia	2.24	2.46	0.23 ^{ns}

** = significant at 1% level, * = significant at 5% level, ns = not significant

Acacia mangium and *C. equisetifolia* appeared to be adapted in the nickel-mined soil as reflected by their respective RS ratio of 1.99 and 2.46 which is statistically insignificant with the RS in the garden soil. Seedlings with better root to shoot ratios have a higher survival percentage when planted in the field (Kung'u, 1995). The *J. curcas* with RS of 7.75 appeared to be non-adapted to the nickel-mined soil as it exceeded the average ideal ratio which ranges from 1 to 3 (Haase 2007; Chayed *et al*, 2009). The higher RS ratio in the nickel mined soil of *J. curcas*

implied further that the seedlings were unhealthy and of poor quality indicating that it can easily be uprooted owing to their smaller root which was not in proportion to its shoot.

Influence of Treatments on Phytoremediation Potentials of Three Species

Highly significant variations in nickel accumulation on the tissues of the three species were observed in the study. Both the species and VAM were seen to be highly responsible for these variations. Relative to the total dry matter yields of the three plant species, inoculation of VAM proved to be beneficial to *A. mangium* as the VAM inoculated seedlings accumulated higher amount of nickel at 12.22 mg/kg as against the 7.26 mg/kg from the uninoculated seedlings (Figure 3). Likewise, *J. curcas* without inoculation accumulated 4.34 mg/kg nickel as against the 0.56 mg/kg with inoculation which indicates that VAM did not play significant role for nickel uptake of the seedlings. Meanwhile, VAM inoculated and uninoculated seedlings of *C. equisetifolia* registered almost the same amount of nickel.

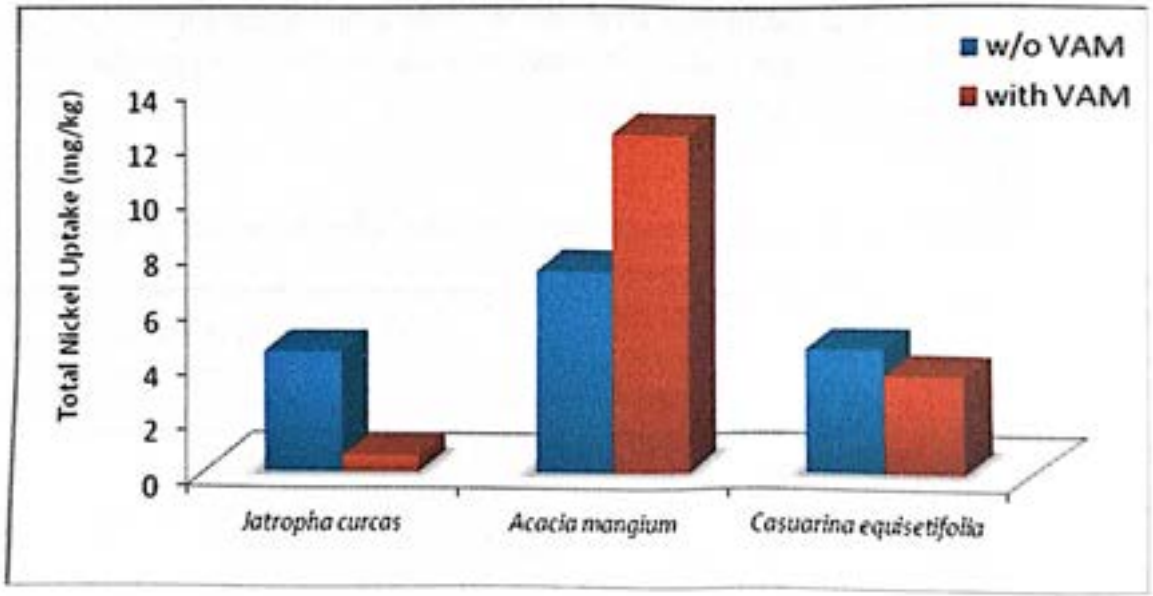

Figure 3. Total nickel uptake (mg/kg) of uninoculated and mycorrhizal inoculated 8-month old seedlings of three species

Based on the result, *A. mangium* grown in the nickel contaminated soil which accumulated the highest amount of nickel in their tissues, and yet survived and performed on most of the different growth paramaters investigated represent a potential species for heavy metal-remediation approach. Also, *C. equisetifolia* performance on mined soils on growth parameters i.e., diameter, height and biomass, registering nickel content at 3.49mg/kg and 4.44 mg/kg, with and without mycovam respectively, could also be a potential species for phytoremediation in the abandoned'nickel-mined sites

The performance of the two species, the *A. mangium* and *C. equisetifolia* are of interest since only a small proportion of plant species on heavy metallic soil show capacity to withstand relatively high concentrations of heavy metals without toxic effects indicating that these plants show the potential for phytoextraction and filtering metals from water onto root systems or rhizofiltration (Schnoor, 1997). In this study, the better performance of these species i.e., their growth response to the elevated nickel content of the soil of about 10,100 ppm which is 161 times greater than the normal nickel concentration for natural soils is of interest. Reeves *et al.*, (2008) mentioned that a natural soil contains about 7-50 mg/kg nickel; plants on these soils generally contain nickel at levels of about 0.2-8 mg/kg. The nickel-mined soils used in this study had nickel at a level of 161 times greater, i.e., from about 700 to 5,000 mg/kg; and most of the plants that survive on these soils showed nickel concentrations about 10 times higher, i.e., from about 2 to 80 mg/kg.

Result of the analysis indicates further that *J. curcas* in this study is not a hyperaccumulator contrary to the claims made by Jamil *et al.*, (2009) which reported that *J. curcas* is a hyperaccumulator as it has potential of establishing itself in a heavy metallic soil and can also accumulate many folds of heavy metals without attenuating its growth. A plant can be considered hyperaccumulator if it can survive and accumulate heavy metals at a level of more than 1,000mg/kg of its dry mass (Reeves, 2008). Many known hyperaccumulators, at least 400 species worldwide, (Proctor, 2003), belong to the family *Euphorbiacea* (where *J. curcas* also belongs) which include the largest number of nickel accumulators in the tropics (Sporne, 1969; Reeves, 2008). In a study by Berazain (1981) on the elemental composition of plant species in the tropics that include New Caledonia, Sabah and Palawan and Mindanao in the Philippines (Kersteri *et al.*, 1979; Jaffre, 1980; Baker, 1992, cited by Reeves *et al*, 2008), he confirmed that many species of *Euphorbiaceae* are noted hyperaccumulators, with maximum nickel concentrations of 4,500 and 7,700 mg/kg dry matter. Proctor *et al.* (2003) listed only three nickel hyperaccumulators in the Philippines and these are: *Phyllanthus balgooyi* (Euphorbiaceae), *Brackenridgea palustris* (Ochnaceae), and *Walsura monophylla* (Meliaceae). The excessive nickel uptake by any plant is of interest, because of its potential for remediation of nickel-contaminated soils (phytoremediation) and for economical selective extraction of metal compounds by cropping hyperaccumulators (phytomining). Besides, a small proportion of plant species on mined soils, perhaps one to two percent of species worldwide show an extraordinarily high uptake of nickel from the soil over 1000 mg/kg (Reeves *et. al.*, 2008, Chayed *et. al.*, 2009).

SUMMARY AND CONCLUSION

Results showed that the seedlings in the nickel mined soil of *A. mangium* and *C. equisetifolia* had the inherent advantage in terms of height growth over *J. curcas* throughout the duration of the study. The highest height growth measured was 70.19 cms in *A. mangium, C. equisetifolia* and *J. curcas* were 56.12 and 24.67 cms, respectively. In the nickel mined soil, *A. mangium* (22.63g/plant) showed no significant difference on biomass yield compared to the fertile soil (29.21g/plant) which indicated a better growth performance of *A. mangium* even to the high nickel content of the mined sites.

In both soils, *A. mangium* produced almost similar root volume as manifested by its non-significant variation at 16.79 cm^3 in the garden soil and 14.20 cm^3 in the nickel-mined soil. The non-significant variation of roots produced either in garden and nickel-mined soil by *A. mangium* proved that it had a survival means to adapt to the high nickel soil condition.

Casuarina equisetifolia and *A. mangium* obtained statistically similar root-shoot ratio in both soil types which indicates that *A. mangium* and *C. equisetifolia* appeared to be adapted in the nickel-mined soil as reflected by their respective RS ratio of 1.99 and 2.46 respectively, which is statistically insignificant with the RS in the fertile soil. VAM inoculation showed no significant effect on the height increments of *J. curcas* and *A. mangium* but VAM-inoculated seedlings of *C. equisetifolia* were significantly higher than the non-inoculated seedlings during the seventh and eighth month with a mean of 2.14 cms showing significantly better response compared to the non-inoculated seedlings with only 0.52 cm. Similarly, VAM inoculated *C. equisetifolia* obtained larger diameter growth which was evident on the seventh and eighth month of its growing period with larger increments in stem diameter by 260% over the non-inoculated seedlings. Meanwhile, VAM inoculated seedlings of *A. mangium* obtained significantly larger root volumes with 17.26 cm^3 as against the 13.76 cm^3 obtained from the uninoculated plants.

Finally, *A. mangium* and *C. equisetifolia* in this study showed tolerance to nickel toxicity and therefore potential species to rehabilitate the abandoned nickel mined sites in Palawan.

RECOMMENDATION

Investigations involving a much longer growing period under field conditions is highly recommended in order to characterize the details of metal tolerance mechanisms, various aspects of the interactions between heavy metals and mycorrhizal fungi, including the effects of heavy metals on the occurrence of mycorrhizal fungi, heavy metal tolerance in these micro- organisms, and their effect on metal uptake and transfer to these plants.

The isolates of indigenous vesicular-arbuscular-mycorrhiza (VAM) fungi in the mined soils could also be explored as indigenous VAMF are probably adapted to local soil conditions as a result from long-term adjustment to soils with extreme properties and probably able to stimulate the growth of *J. curcas, A. mangium* and *C. equisetifolia* in the mined site. Isolation of indigenous and presumably stress-adapted VAMF is a potential biotechnological tool for inoculation of plants in highly disturbed ecosystems. Ecophysiological study of indigenous isolates and knowledge of their stress adaptation and tolerance mechanisms should be of great interest in regard to their potential use for mycorrhizal inoculation in the *J. curcas, A. mangium* and *C. equisetifolia.*

Finally, it is important to conduct further research to identify other fast growing with emphasis on native plants and metal accumulating species with high potential to speed up rehabilitation of the abandoned mined sites in the province.

ACKNOWLEDGMENT

The authors wish to thank SEAMEO-SEARCA, PCARRD and NRCP for funding this study.

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The Palawan Scientist
Vol.5, No. 1 pp. 32-39, 2011

ISSN No. 1656-4707

Occurence of Liverfluke (*Fasciola spp.*) Infestation on Slaughtered Cattle of Brooke's Point, Puerto Princesa City, Rio Tuba, and Sofronio Española, Palawan Abattoirs

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ABSTRACT

Cattle slaughtered at the different abattoirs of Palawan were sampled and examined for presence of liverflukes. The percentage of slaughtered cattle infested with liverflukes and the degree of infestation were also determined. The abattoirs that served as source of slaughtered cattle were the following: Brooke's Point (from September to October 2006); Puerto Princesa City (from February to March 2006), Rio Tuba (from November to December 2006) and Sofronio Española (from January to March 2008).

All cattle at the holding pens of various abattoirs were subjected to ante-mortem inspection while their livers were subjected to post-mortem examinations.

Results showed that of the 211 cattle examined, 6.64 % were infested with the worms. 93.36 % are free from liverflukes. Nine out of 14 (64.3%) and 5 (35.7%) cattle infected with liverflukes came from Sofronio Española and Brooke's Point, respectively.

Keywords: liverfluke, ante-mortem inspection, post-mortem examination

INTRODUCTION

Ruminant health is greatly affected by internal parasites. Parasitic disease is usually treacherous, oftentimes with a combination of several parasites such as liverflukes and stomach round worms. Infestations of these parasites coupled with a lack of nutrition of its host aggravates the disease. Even a mild infection is enough to trigger off a disease manifestation (The Philippine Recommends for Beef Cattle Production, 1999).

Liverflukes are flatworms of the genus *Fasciola.* They live in the bile ducts of ruminants and cause extensive damage to the liver. They appear worldwide and can produce serious and often fatal problems to their ruminant hosts. These problems include anemia, abdominal dropsy, unthriftiness, reduction in milk production among dairy animals, emaciation and jaundice.

To complicate this matter, the common liverfluke of cattle, *Fasciola hepatica* has a bizzare life cycle (Muirson, 1990). The cattle ingests grass with an encysted stage of the fluke present. After the cattle eats this contaminated grass, the juvenile flukes "burrow" through the lining of the intestine, escape into the peritoneal cavity (the inside of the abdomen) and migrate to the liver. The flukes bore their way into the liver and over the next six weeks or more, make their way to the interior of the liver and finally to the bile ducts where they begin to lay eggs. The fluke eggs are shed into the manure of the cattle. These eggs hatch and make their way to fresh water snail, which they infect and undergo additional development. They eventually emerge from the snail as young flukes and encyst on blades of grass. When cattle ingest them, their life cycle is completed. It will be possible to conclude then, that liverflukes can be easily contracted. Liverfluke is a very common disease of cattle. In the Philippines, this disease occurs chiefly in cattle, carabaos, sheep and goats. It also affects man (Diaz and Dagoon, 1994).

Because of the possible occurrence of liverflukes in our locality, updated information about parasitism is necessary. A study on the occurrence of liverfluke will bring awareness to livestock raisers, market sector, even teachers and students of a locality, and the local government units (LGUs), which will definitely result to necessary action in addressing this problem and to prevention of possible widespread infestations to ruminants, including humans.

This study determined: 1) the presence of liverflukes in slaughtered cattle of the various mentioned abattoirs of Palawan; 2) the species of liverflukes that might have infested these slaughtered cattle; 3) the degree of infestation of the affected cattle; 4) the percentage of slaughtered cattle infested with liverflukes; and 5) the areas or possible areas in Palawan infested with liverflukes.

METHODOLOGY

Slaughtered cattle information

Physical examination of the cattle prior to slaughter was conducted. The animals waiting for the procedure at holding pens were also checked for signs of stress and physical disorder while in motion. The area of origin of the animals was also determined through the cattle owners.

Liverfluke infestation analysis procedure

Infestation of liverflukes was determined by post-mortem examination of the cattle liver: One, was by ocular inspection, particularly taking into consideration the weight, color, texture and the presence of abnormalities or spots called milk spots; and, two, was by a procedure enumerated herein: 1) the liver was placed in a chopping board, and was cut into fine slices with a sharp knife; 2) after a cut was made, pressure was applied to the liver to squeeze out the flukes. Then, each piece of the liver was wiped off gently to collect the displaced flukes before making the next cut; 3) when the whole liver organ was sliced, all flesh were placed in a tray and submerged in water; 4) the pieces of liver were removed from the water and were squeezed again; 5) the water with the flukes was poured into a sieve and the collected parasites were washed until cleaned; 6) flukes collected were poured into a petri dish and were counted; 7) when a large number of immature flukes were present, the dilution technique was implemented in counting the parasites; and 8) collected liverflukes were preserved in a vial with preservative.

Identification of liverfluke species

The morphology of the shoulders of liverflukes is a distinguishing characteristic to determine the two common fluke species: *Fasciola hepatica* have shoulders that vary up to 12mm in width (mature) and are pale brown in color, while *Fasciola gigantica* have shoulders that vary up to 8mm in width (mature) and are grayish in color.

Degree of liverfluke infestation

The degree of infestation was determined using the criteria set and approved by the Research Committee of the College of Agriculture (SY:2005-2006) as a parameter for data analysis by the student researcher.

Number of liverfluke collected	Degree of infestation	Equivalent rate
1-3	Slightly infested	+
4-6	Moderately infested	++
7 and above	Highly infested	+++

Data analysis and interpretation

Data gathered were tabulated and analyzed. Percentage and frequency counts were employed in data analysis.

Data Gathered

The data gathered were: 1) age, weight and place of origin of the cattle; 2) health status of the cattle (physical conditions, whether healthy or emaciated); 3) weight, texture and color (including the absence or the presence of milkspots) of the cattle livers; 4) presence of liverfluke; and 5) degree of liverfluke infestation and the percent of animals affected with liverflukes.

Permission Protocol

Formal written requests for permit were facilitated from the concerned personnel prior to the conduct of the study.

RESULTS AND DISCUSSION

Slaughtered cattle information

Table 1 presents the physical cattle information, seventy-seven and seventy-five percent (77.25 %) of the slaughtered cattle fall under the age range of 0-3 years old. A smaller percentage (18.01%) fall under 6 year-old range; 2.84 % fall under the 7-9 year-old range; and 1.9 % under the 10-12 year-old range.

Most of the slaughtered cattle fall under the first two weight categories: 38.86 % and 36.97 %, under the 50-100 kg. and 101-150 kg. weight range, respectively. A considerable portion of 17.54 % fall under the 151-200 kg. weight range, and small percentages of 5.21 and 1.42 were under the 201-250 and 251-300 kg. weight range, respectively.

The biggest percentage of slaughtered cattle came from the municipality of Brooke's Point (41.23%), followed by Sofronio Española (23.22%) and lastly from Puerto Princesa City (19.43%). The rest of the municipal origins of the slaughtered cattle came in small percentages of 6.64 (Dumaran), 3.79 (Bataraza), 3.32 (Roxas), 0.95 (both from Aborlan and Araceli) and 0.47 (Rizal).

Table 1. Age, weight and origin of the slaughtered cattle

	Frequency (n=211)	Percentage (%)
Age (yr.)		
0 to 3	163	77.25
4 to 6	38	*18.01*
7 to 9	6	2.84
10 to 12	4	1.90
Weight (kg.)	--	--
50 to 100	82	38.86
101 to 150	78	36.97
151 to 200	37	17.54
201 to 250	11	5.21
251 to 300	3	1.42
Place of Origin	--	--
Aborlan	2	0.95
Araceli	2	0.95
Bataraza	8	3.79
Brooke's Point	87	41.23
Dumaran	14	6.64
Puerto Princesa City	41	19.43
Rizal	1	0.47
Roxas	7	3.32
Sofronio Española	49	23.22

Appearance of the liver

The weight and appearance of livers are presented in Table 2. Almost half of the livers of the slaughtered cattle weighed 2.0-2.9 kgs. About one-fourth of those fall under the 3.0-3.9 kg. weight range. A little above one sixth of those livers fall under the 4.0-4.9 kg. weight range, while smaller percentages of sample livers fall under the 1.0-1.9, 5.0-5.9, and 6.0 and above kg. weight range, with 8.06 %, 4.74 % and 0.95 %, respectively.

A huge percentage of this sample liver (94.31 %) was smooth while the remaining 5.69 % was rough.

More than 90 % of the sample liver appeared normal, with pinkish color and without liver milkspots, while only 9 % appeared pale and with milkspots. Milkspots are distinguishing characteristics of liverfluke infestations.

Table 2. Weight and appearance of the liver

Weight/Appearance	Frequency (n=211)	Percentage (%)
Weight (in kg.)		
1.0-1.9	17	8.06
2.0-2.9	90	42.65
3.0-3.9	56	26.54
4.0-4.9	36	17.06
5.0-5.9	10	4.74
6.0 and above	2	0.95
Texture		
Smooth	199	94.31
Rough	12	5.69
Color		
Pinkish (Without milkspots=normal)	192	91.0
Pale (With milkspots=infested liver)	19	9.0

Presence of Liverflukes in Slaughtered Cattle

Table 3 summarizes the presence of liverflukes in the slaughtered cattle. A small percentage of the cattle (6.64) were infested with flukes, while 93.36 % of the cattle were free from flukes.

Table 3. Frequency and percentage of cattle infested with liverflukes

	Frequency (n=211)	Percentage (%)
Positive	14	6.64
Negative	197	93.36
Total		100.00

Presence and Degree of Liverfluke Infestation

Table 4 shows the frequency and percentage of liverflukes collected from the livers and the corresponding degree of infestation calculated in the process. A large percentage of the liver sampled were free from liverflukes (93.36 %) while 0.47 %, 0.95 % and 5 % were slightly, moderately and highly infested, respectively. Identification procedures also revealed the prevalence of *Fasciola hepatica* and a few number of *Fasciola gigantica*.

Table 4. Presence of liverfluke and degree of infestation

Number of Liverfluke Collected	Frequency (n=211)	Percentage (%)
0	197	93.36
1-3	1	0.47
4-6	2	0.95
7 and above	11	5.21

Place of Origin of Liverfluke-infested Cattle

Table 5 shows the frequency and percentage of cattle infested with liverflukes and their place of municipal origin in Palawan.

Nine out of 14 (64.3%) cattle came from Sofronio Española. Five cattle (35.7%) came from Brooke's Point.

Table 5. Frequency and percentage of liverfluke-infested cattle and their places of origin

Place of Origin	Frequency (n=14)	Percentage (%)
Sofronio Española	9	64.3
Brooke's Point	5	35.7

CONCLUSION

The study showed that about 93 percent of all the slaughtered cattle at the different abattoirs of Brooke's Point (from September to October 2006), Puerto Princesa City (from February to March 2006), Rio Tuba (from November to December 2006), and Sofronio Española (from January to March 2008) are free from liverflukes and only 6.64 percent are infested with liverflukes.

Results also showed that the municipal places of origin of liverfluke-infested cattle were Sofronio Española and Brooke's Point, with 9 (64.3%) and 5 (35.7%), respectively.

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The Palawan Scientist
Vol. 5, No. 1 pp. 40-49, 2011

ISSN No. 1656-4707

Ability of One Hundred Pesos to Sustain a Day's Expense

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ABSTRACT

This study was conducted during the first semester of SY 2009-2010 to: determine the amount of daily allowance of the respondents; determine who provides the respondent's allowance; determine the respondents' daily expenditures and the corresponding expenses; assess how the respondents allocate a hundred pesos in a day's expense; and to assess whether or not a hundred pesos is enough to sustain the respondents' daily expenses.

The respondents of the study were the 69 first year BSAB students of WPU. Data were analyzed and interpreted using descriptive statistical tools: frequencies, totals, percentages, ranks and averages.

The average daily allowance of the respondents is PhP 78.17 provided mostly by their parents and spent mainly for food with an average of PhP 34.81; fare with an average of PhP 18.46; and photocopying with an average of PhP 16.06. The other expenses of the respondents include: cell phone load, project, internet; and cigarette with an average of PhP 21.02, PhP 20.00, PhP 15.00, and PhP 10.00, per day, respectively.

If given one hundred pesos per day, their priority expenses are the following: food, photocopying, cell phone load, fare, internet, project and cigarette. Almost three-fourths of the respondents perceived that one hundred pesos is more than able to sustain a day's expense.

INTRODUCTION

Money is a very important means used in the conduct of economic activities. Because it encompasses almost every human endeavor, anything that happens to it affects the stability of the economy. Since the day it has been used up to now, money has been a symbolic medium of exchange. Although the coins and

the papers have no intrinsic value of their own, they have become symbols of value created by human imagination (Bello and Costales, 2000).

It is a fact that nowadays money creates the socio economic gaps among people. This is so because the more money a person has, the more things he is able to buy and the better his position in the society. To boost the social value of money, society associated status and prestige are acquired by those who produced, possessed, and accumulated it since by so doing, they contributed to the overall welfare of everyone. Thus, money became a major determinant of the relative importance of privilege of different classes of people in society.

However, the value of money created by the human mind is not at all the same from time to time. The fact that the value of money years ago and now was a significant difference cannot be denied. Years ago, Philippine coins and bills are of a significantly higher value. Filipinos tend to buy what they need and what they want by using only a little of the money they have. This is not the case nowadays. Today, people tend to buy only what they need and sometimes even less because it is just what they can afford. With the same amount of money used for spending years ago, only a little amount of goods can be bought today.

Poverty is one great dilemma of every Filipino family. With the amount of money a breadwinner earns everyday and with the increasing prices of necessities, the Philippines has been confronted with a large number of problems rooted from poverty.

Many of the students are experiencing the effect of the socio-economic problems and are therefore faced with the need to budget the money they received from their parents and other relatives in order to manage their daily spending.

One hundred pesos may have been more than enough for student's daily expenses a couple of years ago. These days, it is playing a large part in the lives of students everyday. In other places especially in Metropolitan areas, spending fifty pesos a day obviously proves to be insufficient while other bills higher than a hundred peso might be too much to spend daily. With the increasing price of goods, spending one hundred pesos is one way of knowing whether what used to be sufficient before is still sufficient or not today. Hence, this study is geared toward determining the ability of one hundred pesos to sustain a day's expense of a student at Western Philippines University (WPU).

METHODOLOGY

All first year BSAB students (69) were interviewed to determine their perception on the ability of one hundred pesos to sustain a day's expense.

An interview schedule was used to gather the needed information such as: respondents' daily allowance, source of respondents' allowance, daily expenditures of the respondents and the corresponding expenses, and respondents rating on the sufficiency of one hundred pesos to sustain a day's expense. It was prepared in English but was translated to Tagalog during the conduct of interview to make sure that the respondents understand the questions and therefore answer them correctly.

The data were analyzed using descriptive method. Statistical tools such as frequency, percentages, totals and averages were used in the analysis of data which were presented in tabular form.

RESULTS AND DISCUSSION

Age and Gender

Table 1 presents the age and gender of the respondents. The age of the respondents ranged from 16 to 24 with a mean of 17.72 years. Majority (73.91%) of the respondents are female and only 26.09% are male.

Table 1. Age and gender of the respondents.

Characteristics	Frequency (n=69)	Percent (%)
Age		
16-18	54	78.26
19-21	14	20.29
22-24	1	1.45
Mean = 17.72 years		
Gender		
Female	51	73.91
Male	18	26.09

Amount and Source of Allowance

Table 2 presents the daily allowance of the respondents. Their allowances ranged from PhP30.00 – PhP 120.00. Majority (46.37%) had allowances ranging from PhP 61.00 - PhP 90.00 and the least (26.09%) received PhP 91.00- PhP 120.00 per day. The average daily allowance of the respondents was PhP 78.18.

The daily allowance of the respondents was provided by their parents (84.06%), by their brothers and sisters (10.14%), by relatives (4.35%), and by guardian (1.45%).

Orot and Burro (2009), in a similar study conducted among first year BS Accountancy students of New Era University (NEU), Quezon City reported that a NUE student had an average daily allowance of PhP145.5. This amount is much higher than the average daily allowance received by a WPU student which is only PhP 78.18 but lower than the amount received by college students in a state university in Davao City which is PhP 50.00 per day (Estremera, 2009). In a students' exchange forum Fiodore (2004) asked an Ateneo de Manila student if a hundred pesos is enough for his daily expenses in school. The student replied that it might be difficult to survive in Ateneo with 100 pesos but 150 pesos will be more than enough.

These findings imply that the allowances received by the students vary according to place where the school they enrolled-in is located.

Table 2. Amount and source of the respondents' daily allowance.

Items	Frequency (n=69)	Percent (%)
Daily Allowance		
30 – 60	19	27.54
61 – 90	32	46.37
91 – 120	18	26.09
Mean = PhP 78.17		
Source		
Parents	58	84.06
Brother/Sister	7	10.14
Relatives	3	4.35
Guardian	1	1.45

Daily Expenses

The daily expenses of the respondents and the amount spent for the different items such as food, fare, photocopying and other expenses are shown in Table 3. The respondents spent PhP 20-60 for food with an average of PhP34.81. They spent PhP 0 – 30 for fare with an average of PhP 16.06. The respondents also incurred expenses for cellphone load which ranged from PhP 10 – 30 with an average of Php 21.02. The respondents spent PhP 10-30 for project with an average of PhP 20.00. Three respondents alloted portion of their allowance for internet with an average of PhP 15.00. One respondent spent PhP 10.00 for cigarette daily.

In a study of Orot and Burro (2009), it was revealed that the daily allowance of the first year BS Accountancy students of NEU was spent for the following expenditures and average amounts: food – PhP67.83, transportation – PhP39.65, Block fund – PhP33.00, computer rental – PhP24.93, photocopying – PhP9.09, and cellphone load – PhP 27.5. In the same way, students in WPU and NEU primarily spent their allowances on food and transportation fare. However, it was observed that the amounts spent for similar items were much higher in NEU which is located in Metro Manila than in WPU which is situated in a far flung province.

Fiodore (2004) in a student forum interviewed an Ateneo de Manila student. The student mentioned that surviving with 100 pesos might be difficult. For sure there are foods available at 60 pesos and PhP 40 will be enough for transportation, but there are too many handouts. Occasionally, there are group meetings at night, and movies/plays they have to see. However 150 pesos will be more than enough.

These findings show that the expenses incurred by a student enrolled in far provinces are much lower than those enrolled in Metropolitan areas. A student receiving less than a hundred pesos while enrolled in WPU will hardly survive once they enroll in other schools located in Metropolitan areas due to higher expense differentials.

Table 3. Amount and daily expenses of the respondents.

Expenses	Frequency (n=69)	Percent (%)
Food		
20-40	45	65.22
41-60	24	34.78
Mean = PhP 34.81		
Fare		
0-9	36	52.18
10-20	24	34.78
21-30	9	13.04
Mean = PhP18.46		
Photocopying		
5-15	35	50.72
16-25	29	42.03
26-35	5	7.25
Mean = Php 16.06		
Load		
10-20	31	44.93
21-30	17	24.64
Mean = 21.02		
Project		
10-20	4	5.80
21-30	2	2.90
Mean = PhP 20.00		
Internet		
PhP 15.00	3	4.35
Cigarettes		
Php 10.00	1	1.45

When the respondents were asked about their perception on the sufficiency of their allowance to meet a day's expense, 66 or 95.65% perceived that their allowance is sufficient or enough while three or 4.35% perceived that their daily allowance is insufficient or not enough to meet their daily expenses because their wants are unlimited and the prices of goods are high (Table 4).

Table 4. Sufficiency of one hundred pesos to cover daily expenses as perceived by the respondents.

Purpose	Frequency (n=69)	Percent (%)
Sufficient	66	95.65
Insufficient	3	4.35

Priority Expenses

Table 5 presents the order of priority of the respondents' expenditures if given one hundred pesos a day. Food ranked first in the priority list of the respondents with a mean score of 4.94. The average amount the respondents intend to use for food was PhP37.61. Photocopying ranked second with a mean score of 3.39. The average amount which the respondents intend to spend for photocopying was PhP 16.49. Cell phone load ranked third in the priority expenses of the respondents with an average amount of PhP 22.32. The other items the respondents intend to spend with one hundred pesos were: fare, savings, projects, internet and cigarettes which ranked fourth to seventh respectively. As stated by Rasmussen (2007), everyone who is capable of earning money should learn how to manage it properly in order to ensure that they will have enough of it to apply to the causes that they choose. Monclava (2009) also emphasized that having a regular college allowance gives the students the ability to independently function in school. Budgeting college allowance is not an annoying task if the students know how to set up a simple and realistic budget that they can stick to so that they will not constantly beg their parents and others for money, as what majority of the BSAB students are doing nowadays. The most important things like food and fare should be prioritized. Thus, students strived to live within their budget.

Table 5. Priority expenses of the respondents with one hundred pesos a day.

Expenses	Average Amount	Mean Score	Rank
Food	37.61	4.94	1
Photocopying	16.49	3.39	2
Cell phone Load	22.32	2.17	3
Fare	19.91	1.75	4
Savings	23.65	0.75	5
Projects	27.05	0.17	6
Internet	15.00	0.13	7
Cigarettes	10.00	0.04	8

Savings Allocation

Table 6 shows the reasons of the respondents for allocating part of their allowance for savings. Twenty-three or 44.23% of the respondents allocated their allowance for savings so that they can use it in case of emergency. Eighteen or 34.61% intended to use the savings for their projects and requirements. The rest of the respondents (21.16%) intended to use it for medicine and for other personal needs. This shows that BSAB students of WPU inspite of the meager amount of allowance received from their parents strived to save for their future expenses. This coincides with the finding of Estremera (2009), that the college students in a state university in Davao City have been used to budget their allowance that they even manage to save some of it because there are days when their school expenses exceed their daily allowance. As emphasized by Dinosaurs (2008), saving money for future use is very important. Students need to realize at an early age that they should spend less than they do, and that saving money for future needs is very important.

Table 6. Reasons for allocating part of allowance to savings.

Purpose	Frequency (n=52)	Percent (%)
In case of emergency	23	44.23
Project/Requirements	18	34.61
Medicine	2	3.85
Personal Needs	9	17.31

Ability to Sustain a Day's Expense

When the respondents were asked to rate the ability of one hundred pesos to sustain their daily expenses, more than three-fourths (75.36%) said that one hundred pesos is more than able to sustain their daily expenses, 20.29% replied that it is able to sustain, and only 4.35% mentioned that one hundred pesos is unable to sustain their daily expenses (Table 7). This result implies that given one hundred pesos a day, a BSAB student of WPU can conveniently meet his daily needs and an allowance of one hundred pesos a day is more than enough for his daily expenses.

Table 7. Ability of one hundred pesos to sustain daily expenses as perceived by the respondents.

Ability to Sustain	Frequency (n=69)	Percent (%)
More than able to sustain	52	75.36
Able to sustain	14	20.29
Unable to sustain	3	4.35

CONCLUSION

Based on the result of the study it can be deduced that for a BSAB student at WPU, one hundred pesos a day is more than able to sustain a day's expenses but fifty pesos allowance a day even in this locality which is far behind Metropolitan areas is no longer enough for a student as reflected in their average daily expenses of PhP 78.17. It is evident that what used to be sufficient before is no longer enough nowadays. This provision of allowance therefore takes proper decision and adjustment as to the amount of allowance parents have to give to the students to sustain their daily expenses.

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The Palawan Scientist
Vol. 5, No. 1 pp. 50-63, 2011

ISSN No. 1656-4707

Ecological Keystones & Resource Management in the Highland of Palawan: A Case Study in the Singnapan Valley

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ABSTRACT

This article examines different types of ecological keystones according to their systemic function, a case study in the upland part of south western Palawan. For this purpose, a basic ethnographical introduction of the different economical activities of a case study is provided. Then, the seasonal resource availability of the most important plant species is analyzed in order to compare it with cultural preferences, daily economic behaviour, and consumption. The result shows the essential and complex role of the different plants as keystone metaphors in a social ecological system. Further, the study can reveal some conclusions to the question whether the evolution of keystones is given by environmental conditions or cultural values.

Keywords: Keystone concepts, resource management, human ecology, habitat use, ethnobotany, Palawan.

INTRODUCTION

More than 45 percent of Palawan consists of mountains with slopes more than 30 percent especially in southern part of the island (Davis *et al.* 1995). Many of these mountainous areas are inhabited by isolated Palawan settlements who are still practicing swidden agriculture with multicropping system and hunting and gathering. Although Palawan is well-known for its high biodiversity, and diverse vegetation types which include beach forest, tropical lowland evergreen dipterocarp rain forest, lowland semi-deciduous forest, montane forest, and ultramafic and limestone forest, wild food resources which can supply a greater extend of human groups in the upland area are always scarce and their availability is highly dependent on different seasonality. The hypothesis, which states that protein deficiency in a tropical rain forest makes it difficult to live for forest dwellers or even impossible for hunter and gatherer groups living independently of agriculture, has been an anthropological point of heated debate for decades (Bailey *at al* 1989,

Endicott & Bellwood 1991, Headland & Bailey 1991). But how do horticultural groups like the upland people of South Palawan can arrange and cover up their nutritional needs in a biologically diverse but quantitatively poor environment and on what should be their economic activities to cope up with the situationare oftentimes a question. To answer this question, a brief and basic ethnographic introduction on the economy of the people of Singnapan is provided. The monthly availability of the most important agricultural and wild food resources based on the data which were gathered during a one year fieldwork to unveil certain times of abundance and scarcity of different food resources is also presented. Combined with quantitative data the results of the time analysis reveals significant differences of preferred non-redundant resources and non-preferred but abundant resources of food which can be classified in certain levels of keystones as essential parts of the cultural ecological system.

Keystone concepts

Highly demanded resources like rice or supplementary agricultural food supply need strategic planning and proper scheduling. The availability of certain harvest and wild food resources can determine the daily action of the dwellers as well as their decision making in selecting activities and investing in a certain work to achieve or heighten their goals. In the observed region some nonseasonal wild forest products, like bamboo shoots are abundant and available at any time but their presence can be ignored if there are other more preferred sources.The question is, are abundant and long storable plant species compulsory representing the cultural preferred main food of a society?

In this article, the ecological concept of keystones to designate and classify the different types of resources according to their availability, management and consumption is used . The concept of keystone species in a culture has a long history in ecological analysis, although its validity is controversial (Paine 1969, Menge *at al.* 1994). A specific ecological keystone according to its systemic function, as having essential role in maintaining certain levels of complexity within a social ecological system is defined. While in many other studies keystones are centred upon a single biological species (Nabhan & Carr 1994, Platten 2007), the keystone concept is more of a metaphorical complex incorporating several material (food resources) and nonmaterial system elements (worldview, daily activity) of a culture rather than a single species itself (Platten 2005; Henfrey & Platten 2006). Moreover, modern concepts of ecosystem structure and dynamics suggest that a single concept of a keystone cannot be appropriated to describe multiple trophic relations in a culture. Holling (1992) gives the clearest statement in extending the keystone hypothesis such as "All ecosystems are controlled and organised by a small number of key plant, animal, and abiotic processes that structure the landscape at different scales." Furthermore, the key organisational roles cannot be reduced to functional non-redundancy (Schulze & Mooney 1994; Grimm 1995), nor ecological dominance (Power *et al.* 1996; Terbough 1986). Depending on the

complexity of a cultural system one society can have different types of ecological keystones (Tanner & Hughes 1994). Some ethnobotanical species which play a key role for the social identity can be used concomitantly with "organisms that by virtue of their usefulness may become ecologically crucial to the maintenance of entire anthropogenic environments, subsistence systems and ways of life" (Ellen 2006).

A further essential characterization of an ecological keystone emphasized in this assessment, is on how to combine cultural or traditional ecological knowledge, biological species and technical practice. Thus, keystones according to their structural roles, within social systems to satisfy elementary needs in a society have been defined. Moreover, keystones as system elements in maintaining any particular level of structural complexity of a culture are described. Decoding elemental keystone in a society needs a comprehensive ethnographical analysis of all sociological and economical variables in a cultural system as well as their mutual relationship to their environment. The classification of several resources as keystones in this article is the implied result of a basic comparison between expressed preferred resources of a group and their resource management. The following sections elaborate these definitions with reference to ethnographic data taken from the very own research of the author on subsistence practices of the upland people in southern Palawan.

Study area

The upland people of the Singnapan Valley are situated along the western slope of Mount Mantalingahan, the highest mountain in the island of c. 2,086 m above sea level located in the southern section of Palawan which belongs to the Municipality of Rizal (Fig. 1). The bowl-shaped valley of Singnapan has a crater-like land formation and encompasses an area of about 856 ha with a general elevation of 240-500 m along the rim and 155 m along the lower part where the Singnapan river dividing the valley with several tributaries in different steeply slopes. The dominant topographic feature of the area is characterized by a deep limestone canyon with numerous sinkholes and caves. With the exception of the agricultural fields, thick tropical primary forest and patches of second growth forest generally cover the area which is characterized by an extremely high degree of biodiversity. The primary forest in the Singnapan valley, like all forest periphery around the Mount Mantalingahan Range, is nowadays threatened by massive encroaching settlements from the lowland despite the fact that the whole range has been declared as a natural protected conservation area by the Philippine Government on June 23, 2009.

METHODOLOGY

In 2010, household and community surveys were done in the whole valley to capture the variation of each settlement size and land uses. Each household was observed with complete information about family composition, different economic activities and agricultural cycle. Location of each household and the agricultural fields were recorded using a Global Positioning System device. These data together with the data aggregated from the household survey, allowed the construction of contextual variables about the different household levels. Household interviews were conducted with male and female household heads as respondents in order to study the local perception of natural environment, and particularly the management and use of planted and wild gathered food resources in general. Names, origin and main characteristics of the crops and forest products utilized by the people were collected on fields under the guidance of local people. Interviews with members of the domestic unit enabled more detailed research on subjects such as networks for trading and sharing of food varieties, farm cycles, selection criteria, decision making, and other subjects related to agriculture, hunting and fishing activities. Qualitative data presented were the results from the analysis of peoples' statements, in an attempt to observe how biodiversity is perceived, named and managed. On the other hand, quantitative data were subjected to basic statistical analysis. Tables were presented to compare the diversity of different food varieties with its different seasonal allocation.

RESULTS AND DISCUSSION

Local settlements

The people of Singnapan are Palawan (Pala`wan, Palawanän) speaking group distributed in 7 local settlements (*rurungan*) with a total number of 54 permanent residential households. There are also a lot of non-permanent residents in the valley who are frequently moving between Singnapan and the adjacent regions like Ugis, Kandawaga, Maktanur, etc. Many of them are maintaining other agricultural fields or have kinships in these areas. Local settlement size ranged from 1 to 8 households and are mainly located in the north and south sides of the Singnapan river. Each local settlement is a simple aggregate of households consisting of a basic uxorilocal structure with the father-in-law as the leader. These local communities (*pinemikitan*) organize the spatial arrangement of families and can be viewed as the locus of social interaction. Moreover, their marriage system is polygamous, that is, a male may have two or three wives. Because of the *pinemikitan* regulation most of the males should produce children to each wife to avoid problems with different fathers-in-law (Macdonald 1972, 1977).

The household (*bamua*) is the smallest social and economic nucleus in a local settlement and it represents the basic unit of production, exchange, and consumption. With the exception of sharing regulation among related households, each of them is self sufficient in terms of food procurement and economic maintenance.

While preparation of the agricultural fields is the main activity during the dry season (January to April), the Tau't Batu inhabit certain caves surrounding the valley during the heavy rainy season in the month of July to September. Although many settlements no longer live in the caves, some isolated settlements in the valley still follow the traditional way of living.

Economy

Agricultural Products

The economy of the people of Singnapan is mainly based on swidden agriculture with multicropping system. At the same time, hunting, fishing and gathering are pursued to complement the carbohydrate diet of the people. All households have their own agricultural fields (*uma*) for wild rice cultivation which is characterized by a yearly cycle starting with field preparation during the months of December to March and harvesting around July and August. Depending on the capability of a household, one can manage between one to three fields in a year. The *uma* is also the main production area for cassava, sweet potato and other plants. Moreover, almost all households have a house yard (*legwas*) like a garden which is planted with which serves as a food reserved area.

Rice (*Oryza sativa Linn.*) is the most important crop in terms of time allocation and labour. The complex values and practices that surround this plant, strongly affect subsistence strategies, social organization, seasonal and daily schedules, and perceptions of social identity and well-being. As has been observed in number of households in the Singnapan Valley, many features of the material culture and social life reflect the unique processing demands and culinary properties of wild rice. The constant tasks of field clearing, planting, harvesting and cooking rice are different major determinants of male and female time allocation and provide an important forum for social interaction and transmission of knowledge. It is surprising that people always expressed that rice is their primary, most valuable and most important food which should be stored in granaries owned by the families, in the time of the researcher's first observation during the month of February to March 2007 and later during the first half of 2010, no family had rice for eating except the seeds they normally use for the fields. Upland rice with its different varieties can be harvested only once in a year (around August) and can sustain a household just for a couple of months depending on the amount of production. That means rice, a non-redundant resource connected with non-substitutable values, beliefs and norms

functionally determines the economic behaviour of the cultural system. In case of the people of Singnapan valley, rice is considered as a *cultural keystone*.

In contrast to rice, cassava (*Manihot esculenta*) which is also planted in the same *uma* field, 2 to 4 weeks after planting rice, can be stored in the soil for more or less 2 ½ years and is not susceptible to diseases. Because of its availability during the whole year, the nutritional role of cassava is of central importance to the diet of these people hence, it represents the most dominant food supply. During the observed drought- or precipitation-induced rice shortages in 2007, 2009 and 2010, the people of Singnapan were subsisting only on cassava, some forest products and on hunting and fishing activities. Whenever people visited households for several purposes it was witnessed that each of them got a small portion of the prepared food which is made up of cassava. It is obvious that cassava plays an important role in food transfer among households, hence vital in their social relationships. The communal sharing system of cassava in a local level is quite free and has no restrictions compared to the sharing regulation of rice which is very scarce and therefore valuable. Despite of its abundance, cassava is not culturally preferred like rice. As previously discussed, keystones are defined in relation to the structure and dynamics of social-ecological systems, but in the case of cassava it is restricted to a single level of system organization. Cassava plays a key role as a dominant basis of food supply and is ecologically non-substitutable hence, we can designate it as a *nutritional keystone*.

A lot of different tuber varieties, vegetables and fruits, which can be classified as supplementary food resources, were planted in the same *uma*-fields as well. But their cultivation takes only a small section in field compared to rice and cassava. Table 1 presents the seasonality of the different plants in a year. The sequence of the food listed in the table is based on a free list interviewing method. To emphasize that rice and cassava are the most important crops their beams have different colours to the rest of the crops. The asterisks (*) on the vernacular names of the resources means that the plants are nonseasonal. That means that the plants are accessible at any time of the year. The yellow columns represents the rainy season.

Table 1: Seasonality of planted crops, vegetables and fruits

Vernacular Name (Scientific Name)	Terrestrial Activities Agriculture, Hunting, Fishing, Gathering (AHFG)
	Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. Dec.
1. Paray *Oryza sativa* Linn.	
2. Kumbahang* *Manihot esculenta* Crantz	
3. Talos* *Colocasia esculenta* L. Schott	
4. Bankuka* *Family Araceae*	
5. Ube *Dioscera alata* Linn.	
6. Punti* *Musa sp.*	
7. Mais *Zea mays* Linn.	
8. Sanglay* *Ipomoea batatas* (Linn.) Lam	
9. Aturay *Setaria italica* (L.) Beauv.	
10. Batad *Sorghum bicolour* (L.) Moench	
11. Lasgoy *Family Gramminae*	
12. Pakpak *Family Bombacaceae*	
13. Niyog *Cocos nucifera* Linn.	
14. Manti *Nephelium lappaceum*	
15. Ampayas* *Carica papaya* Linn.	
16. Antak* *Phaseolus vulgaris* Linn.	
17. Parangi *Ananas comosus* (L.)	
18. Tabu *Elaeagnus philippinensis*	
19. Biga-bajang* *Family Araceae*	
20. Imlung *Cucumus sativus* L.	

The table shows the diversity of food resources of the Tao't Batu people. The plant bulks listed revealed the dispersion of available food resources during the whole year. In a second inspection, one can recognize the existence of two diet periods in which food is generally very scarce: the months of November to December and February to April. After the month of heaviest precipitation (August and September) local groups usually started to clear the fields. Cutting trees and clearing the soil is a hard work in which people need a high amount of carbohydrates. While cassava is available at any time, the harvest arrangement for the time of *Tälos* (taro species), the third most preferred nonseasonal vegetable is intentionally planted after the rainy season. Few other crops like *Tabu* are available in the same time but for a much lesser extent. The period of February to April is also characterized by low alternative source of crops with exceptions of *Ube* (tuber variety) and *Manti* (rambutan). This period is generally marked by field activities like choosing, clearing, preparing, cultivating and seeding.

It is evident that the availability of the most important crops like *Päray*, *Bänkuka*, *Punti*, *Mais*, *Batad*, and *Lasgoy* are significantly concentrated during the months of August and September when heavy rain is coming and, partially, people start to move into the caves. Although hunting and collecting are also practiced during this time, the stored crops in the plots represent the most important and dominant food source for the survival of the group. Especially the highly preferred rice has been eaten in this time, one or two times a day, it is supplemented with gathered products like snails, mushrooms or certain edible vines.

Wild nonseasonal and seasonal vegetables of fruits

An ample diversity of wild fruits and vegetables exist in surrounding forests of the Singnapan-valley. Although some species are abundant and nutritional important, the accessibility of the species is highly depending on a different seasonality for example *Sampatukar* (wild pineapple with red husk), *Ampayas*, *Pahu* and *Bungton* (Table 2). Other nonseasonal wild forests are continuously bearing fruits or have edible roots or stalks like *Batbat*, *Busnig*, *Lagwas* and *Pakis*. But there are significant differences in the available yields and, with few exceptions, almost all of these species are not storable because of the humid tropical conditions:

Table 2. Nonseasonal wild crops/fruits

Vernacular Name (Scientific Name)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Batbat *Arenga undulati*	■	■	■	■	■	■	■	■	■	■	■	■
Badak *Artocarpus champeden* (Lour.) Sprengel						■	■					
Palaw *Landolphia sp.*	■	■	■	■	■							■
Pakis *Acrostichum aureum* Linne	■	■	■	■	■	■	■	■	■	■	■	■
Pahu *Family Anacardiaceae*					■	■						
Lakwas *Hedychium coronarium* Koenig	■	■	■	■	■	■	■	■	■	■	■	■
Sampatukar *Family Bromiliaceae*				■	■	■						
Busnig *Arenga brevipes* Becc.	■	■	■	■	■	■	■	■	■	■	■	■
Bungton *Garcinia mangostana* Linne					■	■						
Paratungon *Elaeis guineesis* Jacq.	■	■	■	■	■	■	■	■	■	■	■	■

Nonseasonal wild products with continuously edible portion are widespread and are constantly used by the Tao't Batu people. Especially *Batbat* is highly abundant, very popular as an additional side dish, closely dispersed in the adjacent forest and is also used as a food reserve in times of emergency. Other nonseasonal wild products like *Pakis* or *Busnig* are more rarely located and their available amount is very scanty and not enough for supplying a greater number of individuals. On the other side the availability of seasonal products like *Badak*, *Pahu*, *Sampatukar* and *Bungton* and many other fruits are concentrated during the months of May to June which represents mostly the time in which people are waiting for their almost harvestable rice crops.

Hunting and Fishing

Although highland people are highly engaged in managing and sustaining their fields for agricultural products almost all observed households are very active in hunting, fishing and gathering too. Classifying small-scale populations in different evolutionary-tined categories like "horticulturalist" or "hunter-gatherers" is very common in the anthropological literature and has significantly been contributing for deep social related analyses. Many horticulturalist groups like some upland Naga-groups in West-Flores in Indonesia or the Yanomami in South America (Lizot 1977) subsist to a greater extend on seasonal swidden agriculture but their food supply depend on hunting and gathering in the same time. In our case it would be a quite unbalanced definition of the economical system of highland

Palawan people classifying them sorely as horticulturalists because their main protein source income usually relying on hunting and fishing activities, although nowadays to a less extend than before.

Especially hunting for wild boar and other games like monkey, bear cat, and fox is an extraordinary important supply of protein and takes a special role in the regulation of sharing in a community. Unfortunately through the introduction of airguns in the beginning of 1990ies, which has almost replaced the blowgun in the observed area, these animals are very rare and seldom to encounter. That's why many hunters are more engaged today in tracing squirrels, turtles and birds which are getting slowly extinct in the whole valley as well. Fishing in the Singnapan river is frequently practised by almost all households during the dry season in January to April. Similar to hunting, they have different methods like stunning or building traps made by forest products.

In the rainy season the game targets of hunting and gathering are oriented to the caves. Related household groups, who residing in the caves during this time, are catching bats through swatting down with a net-like woven palm. Fishing with bamboo made traps (*asag*) is partly possible only on shallow parts of the river close to the caves. But all of these hunted and fished preys are contributing only a small part for the daily food procurement because it takes a lot of time, work, and their availability is limited.
Summarizing the recent hunting situation in the Singnapan-valley, we can state that

a.) there are still existing some local groups who are more *investing* time in hunting and gathering activities (small communities, more highland, more isolated) on the one side and
b.) there are many groups who are mostly *spending* their time for heightening their agricultural products for trading and selling purposes on the other side (bigger communities, buffer-zone and highland, frequently contacts with lowlanders and hence less isolated).

We can find both cases in the Singnapan-valley. The local settlements which are located near to the rim of Kandawaga can be classified with the category a.) while the settlements in the western part belong to the category b.).

SUMMARY

We can summarize that the defined ecological keystones in the case study are complexes of values (rice) *and* practice (cassawa) with different elementary functions to social reproduction and consumption. The ecological keystones are in no case directly equivalent to a single biological species. More important, there are different keystones whose contribution to the cultural and ecological system is of

significant importance. While the decoded cultural keystone is a non-redundant plant species connected with a range of purely subjective factors like beliefs, ideas, norms and values concerning social identity, the nutrimental keystone itself is ecologically crucial and irreplaceable for the maintenance of entire trophic environments and subsistence systems. The analysis suggests that, in a theoretical point of view, societies can potentially choosing their cultural keystone independently to environmental limitations and this shape the way in which particular economically important species are used. However, for a more deeper mutual understanding a more thorough investigation of the keystones in the upland Palawan culture is needed to provide more elaborate work including a more detail analysis in meaning, significance, potential and limitations of the different species as well as time allocation and economic behaviour.

CONCLUSIONS

The seasonal availability of the resources and the economical management of the observed case study lead us to some tentative theoretical thesis which are of significant importance for a deeper grasp of the mutual interrelationship between cultural systems and environmental limitations:

1. Rice is the most preferred food type which is highly valuable, very scarce, labour-intensive and susceptible for diseases (most symbolical crop, *cultural keystone*).
2. Cassava is the main major source of carbohydrates which is not culturally preferred like rice, but high labour-intensive, abundant, not susceptible for diseases and storable in the soil for a long time (*nutritional keystone*).
3. Further planted crops like different tuber species, corn and fruits like pineapples are diverse but their availability are seasonally limited and to a much lesser extend in proportion to cassava (additional food supply).
4. Wild collected vegetables and fruits are abundant and diverse too, but their available yields are very poor, species are seasonally limited and they scarcely dispersed (additional food supply).
5. Meat is a very scarce source, but highly preferred. In the case study big game is very rare and hunting activities are more concentrated in small preys and fishing resources (alternative protein source).

These concluded assertions, particularly in Nr. 2, gives the opposition of that what people constantly expressing as their preferred main food source. The fact that the nutrimental keystone covers almost the essential needs of the people reveals a fundamental function of the evolution of keystones in cultural systems itself. The choice of a keystone is not restricted to single species and, moreover, the selection of a cultural keystone depends on social and cultural system progress and can be generated independently of environmental limitations. According to our analysis,

the cultural keystone is non-redundant and their management is intensively connected with social values, knowledge, cultural daily practice and social identity. In opposition to cultural keystone, the nutrimental keystone is of irreplaceable importance for the survival of the group. As a non-substitutable, environmental non-restricted and therefore abundant species, it can potentially determine the daily consumption habits of a society. The following graphic shows the proportional fractions of the food consumption among the Tau´t Batu:

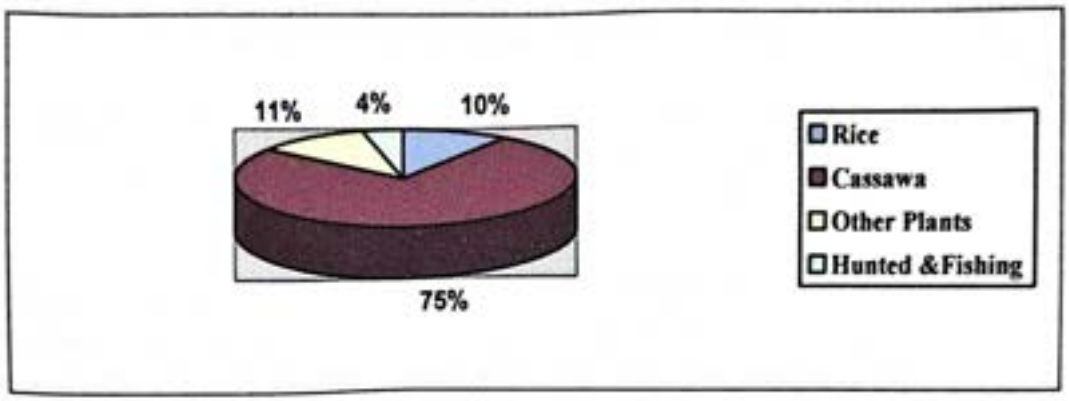

Figure 1 Proportional fractions of food consumption.

The graphic demonstrate the dominant role of cassava consumption. More important, the graphical proportion of rice is almost the same like the item "Other Plants" which is designating different species of tuber, banana, fruits and gathered vegetables. While the availability of tubers and bananas are highly depending on their seasonality and serves sorely a supplementary source, the pointed proportion of "Hunting and Fishing" is problematic. Most of the male members in the different households are spending a lot of hours in a week for hunting birds and squirrels. But these activities are mostly restricted to the dry season and the total game is always small in relation to the invested time. Because of the absence of wild boar in the valley, hunting and fishing has not the same function anymore to serve as protein source like in the past. But it still shapes the daily economic behaviour of the households.

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The Palawan Scientist
Vol. 5, No. 1 pp. 64-73, 2011

ISSN No. 1656-4707

DESIGN, FABRICATION AND PERFORMACE EVALUATION OF MECHANIZED PADDY GATHERER

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ABSTRACT

This study aimed to design, fabricate, and evaluate a mechanized paddy gatherer to lessen the labor cost and time spent in gathering the paddy. Performance evaluation of the machine was based on its capacity (cavan/hr), efficiency (%), economic feasibility and its comparison with the manual or traditional use of paddy gathering.

Evaluation was done in three (3) trials at 50 cavans per trial. Fuel consumption and number of cavan per man-hour was recorded. Results revealed that the machine has a capacity of 110 cavans/hour, far much higher than the traditional or manual use of paddy gathering with 52 cavans/hour. In terms of efficiency, the paddy gatherer has an efficiency comparable to the traditional use with 97.71% and 97.98%, respectively. Its operation cost is only PhP1.18/cavan that includes the labor cost, fuel and lubricants, depreciation charge, repair and maintenance while the cost of operation in traditional way is PhP 3.00/cavan which only includes labor cost.

The cost of machine is approximately PhP 27,598.00 for labor, materials and engine. The computed return of investment (ROI) is 81.55% and payback period is 13.2 months.

INTRODUCTION

Paddy farmers and traders have options with regards to paddy handling. Some can sell it immediately after threshing without the benefit of drying while others can perform drying operations to take advantage of the higher price paid for dried paddy. Drying of paddy assumes that there are available drying facilities and that the conditions are favorable for such an activity.

Farmers and traders commonly exercise the process of drying on flat exposed surfaces after harvesting and threshing (Mendoza, 1982). It is easy to

spread the paddy into the floor but it's too hard and consumes a lot of time to heap and sack the dried paddy. This method is acceptable only in small amount of wet paddy to be dried. But when large volume of paddy is to be collected or gathered, a lot of time and labor is needed.

In sun drying, it relies from the heat of sunlight and this method needs at least three to four persons to perform the drying operation. It takes a mean time of two hours to collect the 50 cavans of dried paddy from drying pavement and it spends 3.00PhP/cavan for collecting the dried paddy (Chiva and Cayapas).

Hence, this machine was designed and fabricated to minimize the time spent and labor cost in the gathering and bagging of dried paddy.

It specifically aimed to design and fabricate a mechanized paddy gatherer; test and evaluate its performance based on the capacity, efficiency (paddy gathered), economic feasibility and compare the economic significance of the machine to the manual gathering and bagging.

METHODOLOGY

Machine Description

The Motorized Paddy Gatherer is composed of six main parts: the frame assembly, conveyor cover, pulley, V-belt, motor and wheels. The machine has a dimension of 62 inches length, 25 inches width, and 34 inches height.

The frame assembly is made up of 1/4 x 1 angular bar which serves as a frame support to the whole structure of the machine.

Its conveyor is made up of a pair of belt that has a width of 4 in. and 10 ft. length each belt which is attached to a bucket with a length of 12 in. and 3 in. width. It has also a gauge 16 of Galvanized Iron (G.I.) sheet cover.

The pulley and V-belt are used in transmitting power and reducing and/or increasing power from the 5 Hp gasoline engine to the conveyor.

The wheel is made of rubber with a diameter of 6 inches. Three (3) pieces of rubber tire are used for easy transport and to operate the machine.

Machine Operation

This Motorized Paddy Gatherer used the conveyor principle to collect the dried paddy. The conveyor moves in clockwise direction and can be speed up by increasing the revolution of the engine.

The scattered paddy can be collected by pushing the machine on the drying pavement. The paddy will continuously move to the feeding hopper of the machine by the use of a conveyor.

Collection of Data

The drying thickness of paddy, the average walking speed of human, and the speed of the engine were considered as bases of analysis. For comparison, the mean capacity of manual gathering is determined through an interview with selected big rice millers and traders. Using 50 sacks of paddy to be collected the mean number of person, payment for labor and duration of manual gathering of dried paddy were determined.

Design Consideration

The Motorized Paddy Gatherer was designed using locally available materials. To attain better efficiency, it is designed to gather a large volume of paddy for reasonable production performance and ease in operation.

Machine Operation/ Process of Gathering

The Motorized Paddy Gatherer uses a belt conveyor to collect the dried paddy from the inlet hopper. As the conveyor rotates, the paddy is carried upward to the discharged hopper where the sack is located. When the sack is already full, it is removed and replaced with an empty one.

Manpower is needed for the forward movement of the machine and for the unloading of filled sack.

Machine Test and Evaluation

In testing the performance and capacity of the Motorized Paddy Gatherer, operators were categorized as non-skilled in collecting the dried paddy using the paddy gatherer and skilled in the traditional method or manual method.

Three non-skilled and skilled operators were employed during the evaluation. In determining the capacity (kg/hr) in both methods of gathering, they were given 50 sacks of paddy to be collected and the time spent in gathering was recorded.

The capacities tabulated were extrapolated from the capacity obtained in collecting 50 sacks of paddy. Each operator was given three trials.

The following formula was used during the performance testing and evaluation of the machine:

$$MC = \frac{SP}{T}$$

where:
MC = machine capacity
SP = no. of sack dried paddy
T = time spent

D. Sun drying / Traditional Method

$$MCs = \frac{SP}{T_T}$$

where:
MCs = Capacity using sun drying
T_T = time spent in paddy gathering using traditional method

E. Motorized paddy gatherer

$$MCs = \frac{SP}{Tm}$$

where:
MCm = Capacity of motorized paddy gatherer
Tm = time spent gathering using traditional machine

Data Analysis

Data gathered during the performance evaluation were subjected to statistical analysis using Complete Randomized Design (CRD).

Assumptions for the Economic Analysis

1. Operation: 2 hours/day
   180 days/year 360 hours/year
2. Labor Cost: P200.00 per day
3. Repair and Maintenance: 5% of Original Cost
4. Depreciation: Salvage Value= 10% of Original Cost
   Life Span = 5 years
5. Payment for Use of Machine: P2.00/cavan

RESULTS AND DISCUSSION

Capacity of Machine and Manual Collection

The mean capacity using machine and manual collection in kilogram per minute is shown in Table 1. The Motorized Paddy Gatherer reaches 88.32 and 43.27 for the manual collection of paddy. As presented in the data, there is a big difference in the capacity of both machines, when analyzed statistically using Complete Randomized Design (CRD). The Analysis of Variance (ANOVA) reveals that there is a highly significant difference for the treatments given to different operators of the machine and manual collection. The mean capacity between the treatments and within each treatment showed highly significant difference.

Table 1. Capacity of machine and manual collection (kg/min)

	Replication			Total	Mean
	1	2	3		
Machine	85.41	93.41	86.14	264.96	88.32
Manual	43.06	43.04	43.70	129.80	43.27
Grand Total				394.76	
Grand Mean					131.59

ANOVA

SV	Df	SS	MS	FC	F tab	
					5%	1%
Treatment	1	3044.704	3044.704	309.025**		
Error	4	39.410	9.853			
Total		3084.115				

** highly significant

Weight of Left Over

The mean weight of left-over using machine and manual method in kilogram is shown in Table 2. Motorized Paddy Gatherer reaches 53.89 and 50.28 for normal collection. The data were analyzed statistically using Complete Randomized Design (CRD). Analysis of variance (ANOVA) revealed that no significant difference was found in replications given to different operators using machine and manual collection. The mean weight of left-over between the treatments showed highly significant difference.

Table 2. Weight of left-over in machine and manual collection (kg)

	Replication			Total	Mean
	1	2	3		
Machine	55	53.33	53.33	161.66	53.89
Manual	55	50.83	45.00	150.83	50.28
Grand Total					
Grand Mean					

ANOVA

SV	Df	SS	MS	FC	F tab	
					5%	1%
Treatment	1	19.548	19.548	1,495^{ns}	18.51	98.49
Error	4	18.271	9.136			
Total	5	71.867				

Comparative Performance to the Manual Operation

Table 3 shows the comparative performance of machine and manual processes of gathering the dried paddy. Machine and manual capacity, efficiency and cost of operation were shown in this table. Motorized Paddy Gatherer has greater capacity (110 cavans/hr) than manual gathering (52 cavans/hr).

For efficiency, both processes are almost the same. Motorized paddy gatherer has a rate of 97.71% and 97.86% for manual. The cost of operation is far less in using the Paddy Gatherer (P1.18/cavan) than manual gathering (P 3.00/cavan).

Comparing the two methods, the amount of paddy gathered showed no significant difference. They both have almost the same amount of left-over in the pavement. But in the duration or time spent of gathering there is a big significant difference using the machine and manual method.

Considering the time, effort and number of laborers in gathering the dried paddy, the manual method is time-consuming, laborious and many laborers are involved in the process of collecting the dried paddy.

In Motorized Paddy Gatherer, although it uses fuel and involves manpower to operate the machine, gathering process is made easier and fast. Motorized Paddy Gatherer uses manpower to guide the machine and to unload the filled sack from the discharge hopper of the machine. In this design, it makes the process of gathering dried paddy faster and economical compared to the manual process. Moreover, this design is more efficient in collecting large volume of paddy.

Table 3. Comparative performance of machine and manual operation

Parameters	Machine	Manual
Capacity	110 cavans/hr	52 cavans/hr
Efficiency	97.71%	97.86%
Cost of Operation	P 1.18/cavan	P 3.00/cavan

Economic Analysis of Motorized Paddy Gatherer

In Table 4, the computation of cost and return analysis is being shown. The Motorized Paddy Gatherer has an assumed maximum service life of five (5) years. The average capacity of the machine per hour is 110 cavans, or 39,600 cavans per year for 15 days operation per month. Based on the assumptions, the total annual cost is P 46,794 (fixed and variable cost) with the gross income and net income of P69,300.00 and P22,506, respectively.

There is a return of investment of 81.55 % for every peso invested. Finally the amount invested for the machine can be generated for a period of 13.2 months (396 hours of operation).

Table 4. Cost and Return Analysis of Motorized Paddy Gatherer

Particular	Values (PhP)
I. Investment Cost	27,598.00
Materials	6,698.00
Labor	5,400.00
Engine	15,500.00
II. Annual Operational Cost	46,794.00
A. Fixed Cost	
Depreciation	4,968.00
Interest on capital (20% of Original Cost)	5,520.00
Total Fixed Cost	5,520.00
B. Variable Cost	
Labor Cost (P200/day x 360 hours/year x 2 laborers)	18,000.00
Repair and Maintenance (5% of Original cost/yr)	1,380.00
Fuel and Lubricant	16,926.00
Total Variable Cost	36,306.00
III. Volume of collected paddy per year	39,600 cavans/year
IV. Gross Income (P1.75/cavan)	69,300.00
V. Net Income	22,506.00
VI. Return on Investment	81.55%
VII. Payback Period	13.2 months

SUMMARY

Result showed that the capacity of the Mechanized Paddy Gatherer is highly significant (110 cavans/hr) compared to the manual gathering (52 cavans/hour). But in terms of their efficiency, they are comparable because the amount of left-over paddy in the pavement is almost the same. The cost of operation of the paddy gatherer is lesser (P1.18/cavan) compared to the manual gathering (P3.00/cavan).

Both processes used non-skilled operators. Therefore, the capacity can be further increased if the operator continuously uses and becomes familiar with the machine operation. Motorized Paddy Gatherer is advantageous over manual gathering in the sense that it is easy to operate and it minimizes the cost and time of paddy gathering.

The machine cost is P27,598.00 as shown in Table 4, however the return on investment (ROI) is computed at 81.55% with a payback period of 13.2 months or 396 hours of operation.

CONCLUSIONS

1. The Mechanized Paddy Gatherer has better performance compared to the manual operation based on its capacity, efficiency and economic feasibility.

2. It also lessens the labor cost and time spent in paddy gathering.

IMPLICATIONS

1. The machine can immediately gather the paddy when it is about to rain. This will save the grain from damage and maintain its quality for a better market.

2. The cost of gathering one cavan of paddy which amounted to P1.75 includes fuel, lubricants, labor, maintenance, and depreciation. While in manual gathering, one cavan costs P3.00 which is higher compared to gathering the paddy using the machine. This increases the farmers income.

RECOMMENDATIONS

1. The width of the inlet hopper could be increased to raise the machine capacity

2. The wheel could be driven by an engine to eliminate the effort of pushing the machine.

3. It can also be used for shelled corn and other grains.

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Author's Guide for Submission of Manuscript

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1. English is the official language of The Palawan Scientist. Manuscripts are accepted on understanding that it has not been published nor submitted for publication elsewhere.

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7. Use metric system and the appropriate symbols (i.e. mm for millimeters, m^3 for cubic meter, µm for micrometer, etc.)

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July 2011 Vol. 5, No. 1

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