Endemic, Indigenous, and Introduced Species in the Freshwater Ecosystems of Nueva Ecija and Pampanga: Status, Diversity, and Impacts

Annie Melinda Paz-Alberto
Institute for Climate Change and Environmental Management,
Central Luzon State University, Nueva Ecija, Philippines

Erlene S. Castro
Vincent Lainard Flores
Maria Angelee V. Romero
Central Luzon State University, Nueva Ecija, Philippines

This study was conducted to determine the diversity of endemic, indigenous, and introduced species and to identify the sources and the level of impacts of environmental degradation in the freshwater ecosystems of Nueva Ecija and Pampanga provinces, Philippines. Five freshwater ecosystems in Nueva Ecija were chosen as study areas, and the survey was done in the Pampanga Main rivers and in Candaba Swamp. In each study area in Nueva Ecija, three designated stations were used and in each station ten quadrats measuring 10m by 12m were randomly chosen while ten stations per study area were chosen in Pampanga. Survey, collection, identification, description, classification and observation as well as listing of organisms were conducted. Assessment of the environmental disturbances affecting the freshwater ecosystems of Nueva Ecija and Pampanga was also done to survey the sources and level of impacts of environmental degradation of the freshwater ecosystems.

Ten indigenous species, one endemic species and 16 introduced species were identified in the different freshwater ecosystems of Nueva Ecija. There were 10 indigenous species, one endemic species and 12 introduced species identified in Candaba Swamp and Pampanga River in Pampanga. There are 18 indigenous species, 1 endemic species and 22 introduced species present in the freshwater ecosystems of Nueva Ecija and Pampanga. The introduced species are more abundant and richer

compared to the endemic and indigenous species. Based on the assessment done regarding the sources and levels of impacts of environmental degradation of the freshwater ecosystems in Nueva Ecija, major impacts were contributed by animal and solid wastes, biological pollution, recreational development and establishment of the hydroelectric power plant. Some identified sources of environmental degradation in the freshwater ecosystems of Pampanga are pollution, encroachment, conversion to agricultural purposes and siltation with moderate impacts.

This study has relevant implication to the status of freshwater ecosystems because proliferation of the introduced species may lead to endemic/indigenous species displacement and extinction as well as loss of biodiversity in the freshwater ecosystems.

KEYWORDS: diversity, endemic species, freshwater ecosystems, indigenous species, introduced species

The Philippine freshwater ecosystems are endowed with a rich diversity of flora (1,616 species) and fauna (3,675 species) (DENR, UNDP, 1997). These consist of algae, aquatic macrophytes, aquatic invertebrates, insects and fisheries, which represent the dominant components of the complex food webs that have evolved in the different freshwater ecosystems. While inventories of these groups have yet to cover the 78 lakes, 421 major rivers, and the four major swamps/marshes, the initial biodiversity records are impressive enough.

Endemic species are unique species that occur within a particular geographical area and nowhere else in the world (IUCN & WWF, 1994; Alberto, 2005). A species that is indigenous is native, but not unique for they are also native to other locations as well. These kinds of species are naturally born to a certain area, but they can also be found in other places. Presently, endemic and indigenous species of freshwater ecosystems are in danger of becoming extinct because many rivers, lakes, streams and wetlands are affected by pollution due to human activity.

An introduced species or foreign species is a species grown outside of its natural habitat (Bruton & Merron, 1985; De Silva, 1989). It is a species introduced and dispersed by direct or indirect human activity to a region or location outside the limits of its natural

range. There are many ways in which the introduction of non-native or exotic species negatively affects our environment and the diversity of life on our planet. Foreign species may be introduced deliberately (for ornamental, aesthetic, medicinal, or agricultural reasons by humans) or accidentally (through animal vectors, water discharge, movement of people, or by trading of nursery stock). In the Philippines, introduction of foreign/exotic species were intended for food production, food security, reforestation, and recreation. Today, these invasive species are posing major threats to humans and to terrestrial and aquatic ecosystems.

Studies have indicated that introduced species could alter the evolution of native species by competitive exclusion, niche displacement, predation and ultimate extinction (MacKinnon, 2002). These species are among the top drivers of environmental change globally, and are known to threaten food security, human health and economic development (Joshi, 2005).

In the Philippines, data on the impact of introduced species on various ecosystems are very limited; hence, this study was conducted to determine the status, diversity, and impacts of endemic, indigenous, and introduced species in the freshwater ecosystems of Nueva Ecija and Pampanga in Central Luzon.

OBJECTIVES

The main objectives of this study were twofold: [a] to identify and classify the different endemic, indigenous and foreign/introduced species that are present in the freshwater ecosystems of Nueva Ecija and Pampanga; and [b] to identify the sources and the level of impacts of environmental degradation in the freshwater ecosystems of Nueva Ecija and Pampanga.

METHODOLOGY

Five freshwater ecosystems in Nueva Ecija were chosen as the study areas namely: Talavera River, Talavera; Pampanga River, Palayan City; Tabuating River, San Leonardo; Paitan Lake, Cuyapo; and Pantabangan Dam, Pantabangan (Figure 1). In Pampanga, the survey was done in the Pampanga Main rivers in Apalit, San Simon and San Luis and in Candaba Swamp, Candaba (Figure 2). In each study

area in Nueva Ecija, three designated stations were used and in each station, 10 quadrats measuring 10m by 12m were randomly chosen while 10 stations per study area were used in Pampanga. Survey, collection, identification, description, classification and observation, as well as listing of organisms particularly the mollusks, crustaceans, fishes and macroflora present in all quadrats, were done. FishBase by Froese and Pauly (2006), Philippine Fisheries Profile by BFAR (2004) and Invasive Aquatic Animals in the Philippines by Guerrero (2002) were used as basis for the identification of the aquatic organisms. Authentication was made by fisheries technologists at the Freshwater Aquaculture Center of Central Luzon State University (CLSU), the National Fisheries Research and Development Institute, Department of Agriculture, and by a taxonomist from the Zoology Division of the National Museum. The number of species, frequency (F), relative frequency (RF), dominance (Do), relative dominance (RDo), density (D), relative density (RD), and species importance value (SIV) of each species were determined (Alberto, 2005; Smith & Smith, 2000). The formula for the determination of SIV is RF + RDo + RD. The species diversity of each study area was also computed using the Shannon Diversity Index (Smith & Smith, 2000):

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i)$$

where H' = Shannon index of diversit
pi = proportion of species from the total species
ln = natural logarithm
S = total number of species

An assessment of the environmental disturbances affecting the freshwater ecosystems of Nueva Ecija and Pampanga was also done to survey the sources and level of impacts of environmental degradation of the freshwater ecosystems (Alberto, 2005). This part was conducted by the researchers together with CENRO and DENR personnel in the selected study areas.

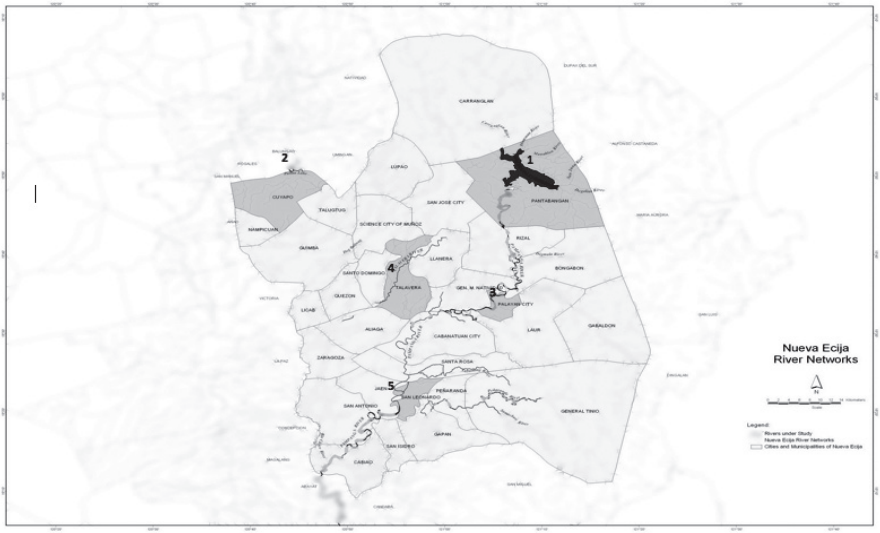

Figure 1. The sampling sites in Nueva Ecija.

Legend: 1—Pantabangan Dam, Pantabangan / 2—Paitan Lake, Cuyapo / 3—Pampanga River, Palayan City / 4—Talavera River, Talavera / 5—Tabuating River, San Leonardo.

Figure 2. The sampling sites in Pampanga.

Legend: 1—Candaba Swamp, Candaba / 2—Pampanga River, San Luis / 3—Pampanga River, San Simon / 4—Pampanga River, Apalit

RESULTS AND DISCUSSION

Endemic and Indigenous Species in Nueva Ecija

One endemic species and ten indigenous species were identified in the different freshwater ecosystems of Nueva Ecija: three freshwater fishes, two indigenous fishes (Channa melasoma and Glossogobius giuris) and one endemic fish (Leiopotherapon plumbeus); two species of freshwater crustaceans (Macrobrachium idella and Metapenaeus ensis); one species of freshwater mollusk (Corbicula fluminea); and five species of freshwater macroflora, namely Polygonum barbatum, Hydrilla verticillata, Ipomoea aquatica, Commelina diffusa and Ludwigia hyssopifolia (Table 1).

Corbicula fluminea and Leiopotherapon plumbeus registered the highest Species Importance Value among the collected freshwater animal species. Ipomoea aquatica had the highest Species Importance Value among the macroflora (Table 1). Not a single native species was found in Talavera River.

Results reveal that the indigenous organisms present in the freshwater ecosystems surveyed in Nueva Ecija are not diverse anymore, for all of them have very low relative values (Table 2). Even though Pantabangan Dam obtained the most number of species, the number of individuals per species is not numerous so it is still not diverse.

Table 1.

Species Importance Value (SIV) of the endemic and indigenous species in the freshwater ecosystems in Nueva Ecija.

Species	Species Importance Value (%)			
	Pampanga River	Paitan Lake	Pantabangan Dam	Tabuating River
Fish				
Leiopotherapon plumbeus	126.55	29.24	31.91	
Glossogobius giuris	25.85	55.23	36.79	
Channa melasoma		27.35	22.06	
Mollusk				
Corbicula fluminea	10.65		15.17	273.07

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Table 1 (Continued...)

Species Importance Value (SIV) of the endemic and indigenous species in the freshwater ecosystems in Nueva Ecija.

Species	Species Importance Value (%)			
	Pampanga River	Paitan Lake	Pantabangan Dam	Tabuating River
Crustacean				
Metapenaeus ensis				42.81
Macrobrachium idella		16.71	20.38	
Macroflora				
Ipomoea aquatica	100.85	102.72	22.79	42.81
Ludwigia hyssopifolia	36.29			
Polygonum barbatum		69.77		
Commelina diffusa			99.05	
Hydrilla verticillata			35.53	

Table 2.

Species diversity values of the indigenous species and introduced/foreign species in the freshwater ecosystems of Nueva Ecija.

	Total Number of Organisms		Species Diversity Value	
Freshwater Ecosystems	Indigenous Species	Foreign Species	Indigenous Species	Foreign Species
Pampanga River	57	102	0.66	0.50
Tabuating River	59	84	0.39	0.87
Paitan Lake	74	492	0.70	0.45
Pantabangan Dam	107	92	0.77	0.83
Talavera River	0	37		0.82

Introduced Species in Nueva Ecija

A total of 16 freshwater introduced species were identified. Seven of these were freshwater fishes namely: Nile tilapia (*Oreochromis niloticus*), Walking Catfish (*Clarias batrachus*), Janitor fish (*Pterygoplichthys disjunctivus*), Large mouth bass (*Micropterus salmoides*), Rohu (*Labeo rohita*), Buan-buan (*Megalops cyprinoides*) and Gourami (*Trichopodus*

trichopterus). Five introduced species of freshwater mollusks were collected namely: Agurong or Pilipit (*Melanoides granifera*), Peewee (*Viviparus intertextus*), *Viviparus mweruensis*, Golden apple snail (*Pomacea canaliculata*) and Black sand shell or Sulib (*Ligumia latissima*). On the other hand, four introduced species of freshwater macroflora were collected namely: water hyacinth (*Eichornia crassipes*), Malakaturay (*Sesbania sesban*), Stonewort (*Chara braunii*) and Baino (*Nymphaea pubesceus*) (See Table 3).

Nile tilapia (*Oreochromis niloticus*) was the most common and the most important introduced freshwater fish while *Pomacea canaliculata*, also called golden apple snail, was the most common and the most important introduced freshwater mollusk in the selected freshwater ecosystems of Nueva Ecija. Moreover, *Eichornia crassipes* was the most common and the most important introduced freshwater macroflora found in the study areas (See Table 3).

The introduced species present in the surveyed freshwater ecosystems in Nueva Ecija (Table 2) are not diverse, but it is quite alarming to note that the number of species (Table 3) and the number of individuals per species (Table 2) are higher compared to the endemic and indigenous species present in the study areas. Moreover, introduced species are present in Talavera River but there is no existence anymore of endemic and indigenous species in this river.

Table 3.

Species Importance Value (SIV) of the introduced species in the freshwater ecosystems in Nueva Ecija.

Species	Species Importance Value (%)				
	Pampanga River	Paitan Lake	Pantabangan Dam	Tabuating River	Talavera River
Fish					
Oreochromis niloticus	236.68	18.95	108.32	103.87	21.67
Pterygoplichthys disjunctivus				17.23	
Megalops cyprinoides		9.18		16.67	42.08
Labeo rohita					
Clarias batrachus		2.9	4.80	15.95	
Micropterus salmoides			12.26		
Trichopodus trichopterus			15.83		

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Table 3. (Continued...)

Species Importance Value (SIV) of the introduced species in the freshwater ecosystems in Nueva Ecija.

Species	Species Importance Value (%)				
	Pampanga River	Paitan Lake	Pantabangan Dam	Tabuating River	Talavera River
Mollusk					
Pomacea canaliculata	15.33	39.82	83.43	24.23	128.69
Melanoides granifera					47.61
Ligumia latissima	6.35	9.35	115.64		
Viviparus mweruensis		4.28			
Viviparus intertextus		4.28			
Macroflora					
Eichornia crassipes	41.63	188.36		57.53	59.87
Chara braunii				64.64	
Sesbania sesban		19.65	4.80		
Nymphaea pubesceus		3.24			

Endemic, Indigenous and Introduced Species in Pampanga

There were 10 indigenous species, one endemic species (see Table 4) and 12 introduced species collected in Candaba Swamp and Pampanga River (Table 5). Five indigenous species of fish: *Dermogenys pusilla* (Halfbeak), *Glossogobius aureus* (Goby), *Hexanematichthys sagor* (River Catfish), *Channa striata* (Mudfish) and *Scatophagus argus* (Spotted Scat); one endemic fish—*Leiopotherapon plumbeus* (Silver Perch); and, two indigenous species of mollusks: the *Pila conica* (Native Snail) and *Corbicula manilensis* (Native Freshwater Clam) were collected. Two collected crustaceans were both indigenous species, *Macrobrachium idella* (freshwater shrimp) and *Macrobrachium rosenbergii* (giant freshwater prawn). *Dermogynes pusilla* (Halfbeak) had the highest Species Importance Value of 67.34 in Candaba Swamp and Pampanga River (Table 4).

Table 4.

Species Importance Value (SIV) of the collected indigenous and endemic species in Candaba Swamp and Pampanga River in Pampanga

Species	SIV (%)
Fishes	
Dermogenys pusilla	67.34
Glossogobius aureus	53.33
Hexanematichthys sagor	52.35
Channa striata	34.80
Leiopotherapon plumbeus	17.66
Scatophagus argus	0.46
Mollusk	
Pila conica	40.10
Corbicula fluminea	3.59
Crustacean	
Macrobrachium idella	15.32
Macrobrachium rosenbergii	4.74
Macroflora	
Ipomea aquatica	10.28

Nine species were identified as introduced fish species, namely *Oreochromis niloticus* (Tilapia), *Cyprinus carpio* (Carp), *Labeo rohita* (Rohu), *Hypopthalmichthys molitrix* (Silver Carp), *Clarias gariepinus* (Catfish), *Pterygoplichthys disjunctivus* (Vermiculated Sailfin Catfish), *Trichogaster pectoralis* (Gourami), *Trichopodus trichopterus* (Gourami), and *Gambusia affinis* (Mosquito Fish) (Table 5). Two mollusks were collected: *Pomacaea canaliculata* (Golden Apple Snail) and *Cristaria plicata* (Freshwater Clam). In addition, there was only one collected introduced macroflora in Pampanga River and Candaba Swamp—the *Eichornia crassipes* (Water Hyacinth).

Among the introduced species collected, Golden Apple Snail (*P. canaliculata*) had the highest Species Importance Value of 83.90 followed by Tilapia (*O. niloticus*) with 75.56 (Table 5).

All the study areas had low species diversity values for both the indigenous/endemic species (0.16) and the introduced species (0.19) in Pampanga. However, from the results obtained the foreign species registered higher number of species and total number of organisms (4825) compared to indigenous species (3753).

Table 5.

Species Importance Value (SIV) of the introduced species in Candaba Swamp and Pampanga River in Pampanga.

Species	SIV (%)
Fish	
Oreochromis niloticus	75.56
Cyprinus carpio	60.80
Clarias gariepinus	4.87
Trichogaster pectoralis	18.57
Labeo rohita	11.84
Hypostomus plecostomus	11.44
Gambusia affinis	3.96
Trichopodus trichopterus	6.20
Hypopthalmichthys molitrix	0.84
Mollusk	
Pomacea canaliculata	83.9
Cristaria plicata	3.90
Macroflora	
Eichornia crassipes	4.71

Sources of Environmental Degradation of the Freshwater Ecosystems in Nueva Ecija and Pampanga

Based on the assessment done regarding the sources and level of impacts of environmental degradation of the selected freshwater ecosystems in Nueva Ecija oil spill, laundry soap, toxic chemical hazards and encroachment had moderate impacts on Talavera River. However, in Pampanga River of Palayan City, only the use of laundry soap recorded a moderate impact. In Tabuating River, pollution such as animal wastes, solid wastes and biological pollution of introduced or alien species contributed major impacts to the river. These may result in loss of precious natural resources or habitat, loss of biodiversity, loss of aquatic ecosystems value, disruption of the local economics or socio-economics, loss of valuable wildlife and damage to water quality.

On the other hand, in Paitan Lake, dredging of water recorded a moderate impact on the lake. In Pantabangan Dam, recreational development and establishment of the hydroelectric power plant contributed major impacts in the area while biological pollution or

introduction of alien or exotic species had moderate impacts on the environmental degradation of the dam. These may result in wildlife extinction, reduction of aquatic productivity, extinction of the native freshwater species and the destruction of the ecological habitat of the native freshwater species. Among the five study areas, Tabuating River in San Leonardo was the most polluted but many introduced species still existed.

Some identified sources of environmental degradation in aquatic ecosystems of Candaba Swamp were solid wastes, animal wastes and laundry soap disposal; encroachment and conversion to agricultural purpose that have moderate impacts on loss of precious natural resources/habitat, damage to water ways quality, adverse effect on other water use, adverse effects on agriculture and downstream water quality, loss of aquatic ecosystem value critical for proper species growth, impairment of beneficial water uses, loss of precious ecology, disease hazards, reduced aquatic productivity, adverse impact on quality of water for new settlers and downstream users and disruption in periodic water flow and changes in water quantity and quality.

However, the sources of environmental degradation in the aquatic ecosystems of Pampanga River were pollution, siltation, encroachment, quarrying, inorganic fertilizer run-off and environmental aesthetic degradation that had moderate impacts on the loss of precious natural resources/habitat, loss of biodiversity, damage to waterways quality, adverse effect on other water use, adverse effect on aquaculture and downstream water quality, serious aquaculture loss, loss of aquatic ecosystem value, hazards to endangered species, loss of aesthetic value/ loss of environmental scenic value, impairment of beneficial water uses, loss of precious ecology, disease hazards aquatic productivity, reduced aquatic productivity, and disruption periodically of water flow and changes in water quantity and quality.

DISCUSSION

Previous studies revealed that endemic/indigenous freshwater organisms such as mollusks and crustacean species in Carranglan freshwater ecosystem, Talavera River, Gapan River, San Jose City River and Valdefuente River in Nueva Ecija are no longer diverse (Salvador & Alberto, 2000; Mendoza et al., 2005; Garcia & Alberto, 2005) due to environmental stresses that are present in those ecosystems. Two freshwater mollusks, namely *Melanoides granifera*

and *Viviparus intertextus* and three freshwater crustaceans such as *Palaemonetes paludosus, Palaemonetes sp.*, and *Paratelphusa sp.* were found in the freshwater ecosystem of Carranglan, Nueva Ecija (Mendoza et al., 2005). Most of the identified species in Carranglan freshwater ecosystem are foreign species except *Paratelphus sp.* whose status is not yet established in the Philippines. Five freshwater mollusks namely *Melanoides granifera, Melanoides tuberculata, Ampullaria sp., Indoplanorbis exustus*, and *Corbicula fluminea* were found in Valdefuente River, Cabanatuan City, Nueva Ecija (Garcia & Alberto, 2005). Talavera River and Gapan River had only two identified freshwater mollusks such as *Melanoides granifera* and *Corbicula fluminea* (Garcia & Alberto, 2005). Only two indigenous species were identified, *Corbicula fluminea* and *Indoplanorbis exustus*. *Metapenaeus ensis*, an indigenous freshwater crustacean, was found in Gapan River, Gapan and Valdefuente River, Cabanatuan City in Nueva Ecija (Salvador & Alberto, 2000). *Paratelphusa sp.* was identified also in Valdefuente River. Two foreign species namely, *Macrobrachium lar* and *Palaemonetes paludosus* were found in San Jose City River, San Jose City, Nueva Ecija. Present findings corroborate the previous findings with regard to the low diversity of the indigenous species in the freshwater ecosystems of Nueva Ecija.

However, the study indicates that the only endemic species, *Leiopotherapon plumbeus*, commonly called Ayungin/Lukaok, is still present in Nueva Ecija freshwater ecosystems and obtained the highest species importance value among the collected freshwater fish species particularly in Pantabangan Dam, Pantanbangan, Paitan Lake, Cuyapo and Pampanga River in Palayan City. This species is very common in the freshwater ecosystems for they can easily adapt to the environment and they usually feed on zoobenthos such as small insects, crustaceans and small fish (Froese & Pauly, 2006). The freshwater ecosystems are still conducive to the habitation of this species due to the availability of food in those ecosystems.

On the other hand, *Corbicula fluminea* is the most important indigenous freshwater mollusk species in Nueva Ecija. Its habitat, which is along the riverbanks and under the rocks, is not affected by the environmental pressures. It is ovoviviparous wherein it reproduces rapidly during its early maturity and its fecundity is high; hence, their abundance in the areas (Heard, 1977; Korniushin & Glaubrecth, 2002). Freshwater mussels generally are intolerant to environmental perturbations and tend to concentrate pollutants in their tissues due to their sessile filter-feeding habits (Cummings &

Mayer, 1992).

Moreover, results revealed that *Ipomea aquatica* (Kangkong) garnered the highest importance value among freshwater macroflora in Nueva Ecija and Pampanga freshwater ecosystems. This aquatic flora usually thrives on the riverside where the water current is calm especially in standing bodies of water. It is very common due to its utilization for human consumption. It is easy to culture due to its rapid growth and it can easily grow and adapt to muddy-sandy substratum. Because of its ability to float on water, it is widely distributed in an open water body.

The high species importance value of *Dermogenys pusilla* in Pampanga Rivers and Candaba Swamp, on the other hand, could be attributed to the presence of worms, crustaceans, and insects that serve as their primary food in the said areas.

With regard to introduced species in Nueva Ecija, Nile tilapia (*Oreochromis niloticus*) has the highest importance value because this species serves as food and source of income to the people living near these freshwater ecosystems. In addition, this fish species is very easy to culture and the people are fond of eating this fish.

Tilapias have great impact on local biodiversity because they dominate the fish biomass of waters in which they become established and compete with indigenous species for food, habitat and breeding sites. They also displace other fish through their aggressive behavior in defending their nests. In addition, tilapias can survive even in poor water quality, can tolerate wide range of environmental conditions, and can adapt to variety of cultured condition (Vera Cruz, 1997). Moreover, its abundance is attributed to its efficiency in reproduction that allows easy and rapid propagation in various tropical and subtropical environments that partially explains the economic interest in these species for fish culture. Likewise, tilapia has precocious sexual maturation that can occur as early as three months and depends on genetic factors, environmental factors such as temperature, food availability, social factors, and so on (Pullin & McConnel, 1982).

Among the introduced species collected, Golden Apple Snail (*P. canaliculata*) had the highest Species Importance Value. The vast dominance of Golden Apple Snail (GAS) in the freshwater ecosystems in Pampanga could be attributed to the presence of muddy bottom of the swamp where the species burrow. GAS can reach reproductive maturity in two months and attain high population densities in the presence of natural predators. It tends to leave the water in the morning and in the evening to lay bright pink batches of 25-200 eggs.

Without water, GAS becomes inactive, but it is able to burrow into the mud and hibernate for several months, re-emerging when water is again available (Cagauan & Joshi, 2002).

Eichornia crassipes also known as water hyacinth is the most common introduced freshwater macroflora in the freshwater ecosystems in Nueva Ecija and Pampanga. It is a free-floating (but sometimes rooted) freshwater plant of the family Pontederiaceae that has proven to be a significant economic and ecological burden to many sub-tropical and tropical regions of the world. It is listed as one of the most productive plants on earth. Water hyacinth has invaded freshwater ecosystems in over 50 countries on five continents. It is especially pervasive throughout Southeast Asia, southeastern United States, central and western Africa, and Central America (Bartodziej & Weymouth, 1995; Brendock, 2003; Lu et al., 2007; Martinez Jimenez & Gomez Balandra, 2007). The habitats for this plant have ranged from shallow temporary ponds, marshes, lakes, rivers and reservoirs. A broad spectrum of physico-chemical environments characterizes these habitats. They range from clean waters that are poor in major nutrients such as rivers and reservoirs to highly polluted waters with large amounts of nutrients and organic matter, as is the case in sewage lagoons (Gopal, 1987). In this study, this plant occurred in polluted Tabuating River in Nueva Ecija as well as in other freshwater ecosystems with moderate pollution.

All the study areas had low species diversity for both endemic/ indigenous species and introduced species in Nueva Ecija and Pampanga that could be attributed to presence of environmental disturbances such as pollution like animal wastes and solid wastes, oil spill, toxic chemical hazards, encroachment, conversion to agricultural purposes, siltation, dredging of water, recreational development and establishment of hydroelectric power plant and biological pollution which is the introduction of exotic species. All of these anthropogenic activities could lead to loss of precious habitats of the organisms and loss of biodiversity. Several factors are responsible for the decline of diversity in the freshwater ecosystems in Nueva Ecija and Pampanga. But, attention must be given to the proliferation of introduced species in the freshwater ecosystems included in this study. Once the exotic/ foreign species are introduced to an ecosystem with no natural predators or competitors and become established in the ecosystem, these species can become aggressive and dangerously invasive like tilapia, carp and catfish (Matthews, 2004); golden apple snail (Guerrero, 2002 and Joshi, 2005) and water hyacinth (Brendock, 2003

and Matthews, 2004). Competition from exotic/foreign/introduced species is a potential threat to native species.

CONCLUSION

There are 18 indigenous species, one endemic species, and 22 introduced species present in the freshwater ecosystems of Nueva Ecija and Pampanga. The introduced species in the freshwater ecosystems of Nueva Ecija and Pampanga are more abundant and richer compared to the endemic and indigenous species. This result is very alarming for this might lead to species displacement and extinction of the native species because of the evident biological pollution. This may result in the destruction of ecological balance in the freshwater ecosystems of Nueva Ecija and Pampanga in the upcoming years.

It is therefore recommended that:

- The Bureau of Fisheries and Aquatic Resources, Department of Agriculture and the Department of Environment and Natural Resources regularly monitor the freshwater ecosystems particularly with regard to the inventory of aquatic species;
- Public awareness on the environmental status of the various freshwater ecosystems be done;
- Establishment of fish sanctuaries be done to maintain the indigenous species left in the freshwater ecosystem;
- Restocking of indigenous freshwater species in the area be done; and,
- Researches be conducted and technology be designed on the propagation of indigenous species.

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