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By Robert T. Ngidlo & Nestor M. Baguinon
Ifugao State University, Philippines

Abstract- An aquatic biodiversity analysis was conducted in four rice terraces clusters in the Cordillera region in the northern central part of the Philippines. Data was obtained using the quadrat sampling method. The location of sampling activities are the four rice terraces clusters namely: (1) Asipulo, Ifugao; (2) Natonin, Mt Province; (3) Bagumbayan, Kalinga; and (4) Tanglagan, Apayao. Each place of sampling had two (2) blocks: (1) Rice paddy fields and (2) Irrigation canals/creeks. The number of quadrats randomly taken in each block was ten (10) plots with each quadrat measuring 1m x 1m. The number of plots in all places was 4 sites x 2 blocks x 10 plots = 80 plots. Individuals of shell, crab, fish and frog species circumscribed within plot/quadrat boundaries were counted, identified and sorted according to species. The importance value (IV) of each species in each block was determined. This was done by taking the sum of Relative Density (%) and Relative Frequency (%) of each species in a given block. Importance Value = Relative Density + Relative Frequency. The Shannon Wiener Diversity Index (H), Evenness Index (E) and Simpson's Index (C) was obtained for each species. The higher values of H, E and C means the greater diversity character of the community being evaluated.

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Keywords: rice terraces, aquatic biodiversity, biodiversity indices, importance value, evenness index.

I. Introduction

Over the years, traditional agricultural systems steadily gained recognition and prominence in the national and international development discussions. Their recognition came primarily due to the relevance of knowledge reposed in these agricultural systems and their possible contribution to sustainable development. The Cordillera region in the northern central part of the Philippines is home to the largest and most extensive traditional rice terraces cultivation in the Philippines and perhaps throughout the Asia-Pacific region. The region is politically subdivided into six provinces and occupy a total land area of 19,294 km^2 made up of rows of great mountain ranges occupying half of Northern Luzon in the Philippines. Its rugged mountainous backbone contains many peaks exceeding 2,000 meters in height with rolling hills and stretches of river valleys along its flanks. With its rugged mountainous backbone, the early settlers of the areahas no other option but to build rice terraces along the slopes for their own survival. Acknowledged to be more than 2,000 years old, the rice terraces represents an indigenous farming system which reflects the people's history and culture. Its management is governed primarily by indigenous systems and institutions which is purely organic in nature. Past literatures written on the rice terraces invariably described them as stable and resilient agro-ecosystem. Some of the rice terraces clusters have been declared as World Heritage site by the United Nation Education, Scientific and Cultural Organization (UNESCO). However, over the last 50 years, there were a series of changes that had occurred in the rice terraces. Foremost of these changes is that farmers are shifting to modern farming systems (Ngidlo, 2013). Today, the rice terraces represents a miniature of both modern and traditional farming systems. The use of high yielding rice varieties, commercial fertilizers, pesticides and the adoption of hand tractors are the leftovers of modern agriculture replacing the traditional organic system.

Aquatic biodiversity is a major food item in the rice terraces. Local people depend much on these biodiversity's to sustain their diet and protein requirement (Ngidlo and Ngohayon, 2009). The loss of aquatic biodiversity may mean a significant loss in the food security status of the local people. The study was conducted to determine aquatic biodiversity indices and to identify factors contributing to the loss of biodiversity in the rice terraces. In the end, the paper will hopefully

Author α σ : Faculty, Ifugao State University, Potia Campus, A. Lista, Ifugao, Philippines and Faculty, University of the Philippines, Los Banos , Laguna, Philippines. e-mail: r.ngidlo@gmail.com

provide a platform for discussions on traditional agricultural systems among various stakeholders.

II. Materials and Methods

The organisms subjected to biodiversity analysis were mollusks, gastropods (snails) namely (1) Agurong, *Jagora asperata (Lamarck)*, (2) Birabid, *Lymnaea (Bullastrus) cumingiana* (3) Bisukol, *Pila luzonica Reeves* , (4) Golden Apple Snail, *Pomacea canaliculata ,* (5) Liddeg, *Angulyagra oxytropis (Benson)* Geslacht and pelecypods (bivalves) namely (6) Tukmem, *Turbicula manilensis .* The lone arthropod was the crustacean (7) Talangka, *Sundathelphusa cagayana* . Vertebrate species consists of the following fish species: (8) Jojo fish; *Anquilla japonica* (10) Mosquito carp, *Gambusia affinis,* (11) Million fish, *Poecilla reticulata* (12) Frog/tadpole (*Rana* sp).

The location of sampling activities are four rice terraces clusters located in four provinces in the Cordillera region in the northern central part of the Philippines. The rice terraces clusters are: (1) Asipulo, Ifugao; (2) Natonin, Mt Province; (3) Bagumbayan, Kalinga; and (4) Tanglagan, Apayao. Each place of sampling had two (2) blocks: (1) Rice paddy fields and (2) Irrigation canals/creeks. The number of quadrats randomly taken in each block is ten (10) plots with each quadrat measuring 1m x 1m. Hence, the number of plots in all places was 4 sites x 2 blocks x 10 plots = 80 plots. Individuals of shell, crab, fish and frog species circumscribed within plot/quadrat boundaries were counted, identified and sorted according to species. The importance value (IV) of each species in each block was determined. This was done by taking the sum of Relative Density (%) and Relative Frequency (%) of each species in a given block. Importance Value = Relative Density + Relative Frequency.

The Shannon Wiener Diversity Index (H), Evenness Index (E) and Simpson's Index (C) was obtained for each species. The higher values of H,E and C means the greater diversity character of the community being evaluated.

Ten (10) key informants were interviewed to identify factors contributing to the loss or increase of aquatic biodiversity in the rice terraces.

III. Results and Discussion

a) Profile of the Rice Terraces Clusters

The rice terraces of the Cordillera region in the Philippines has evolved in recent years and no longer the same organic system they used to be prior to the 1980's. Demographic pressures associated with the need to produce more food escalated the adoption of modern farming practices for the last 50 to 70 years. Three of the selected study sites shifted to modern farming practices similar to that of lowland agriculture while one site still adhere to the traditional farming practices. The profile of the rice terraces clusters are indicated in Table 1.

Table 1 : Profile of the rice terraces

Study Site	Status of Farming System
Asipulo, Ifugao	Adopted modern farming system in the early 1990's
Natonin, Mt. Province	Still continuing with the traditional farming system
Tanglagan, Apayao	Adopted modern farming system in the 1980's
Bagumbayan, Kalinga	Adopted modern farming system in the 1980's

b) Aquatic Biodiversity Analysis

The result of analysis in Table 2 shows that the four sites differ with respect to diversity values. For comparing Rice Paddy versus Canal/Creek, Kalinga and Apayao have higher canal/creek diversity than the rice paddy diversity, i.e. Canal/Creek (H=1.55, E=.97, C=.78) versus Rice Paddy (H=1.04, E=.94, C=.62). The case of Mt. Province is similar, except that the difference between Canal/Creek and Rice Paddy diversities are not so much, or in other words, the former is slightly more diverse than the latter. However, the Ifugao case demonstrated a reverse, H and C diversity indices is greater in the Rice Paddy than in the Canal/Creek although the E at the Canal/Creek had greater value. These aforementioned results are expected since the Canal/Creek cases approximate the usually richer natural ecosystem as opposed to the Rice Paddy agroecosystem (man-made). Translating the above table into a line graph (Figure 1), the pattern becomes obvious, for example, the values are down with Rice Paddy then up with Canal/Creek for Mt. Province, Kalinga and Apayao. The lesser H and C in rice paddies in Mt. Province, Kalinga and Apayao is indicative of the continuous collection for food and or given as feed to animals.. In the case of Apayao, the higher H and C for the irrigation canal/creek is that during the time of sampling there was a *lapat* in force for almost 3 months covering the whole stretch of the sampling area (almost 2 kms. of creek) thus, aquatic biodiversity was protected from exploitation during that period of time. Rice paddies are not covered by the *lapat* and the lesser value of H and C can be attributed to the continuous spraying of pesticides in rice paddies. The lesser H and C in Ifugao can be attributed to the excessive collection for food and for sale in the market. It may also be attributed to the presence of invasive alien species (e.g. Golden Kuhol) in the Ifugao Rice Paddy having spread into the Canal/Creeks. The Golden Kuhol's presence is highest in Asipulo, Ifugao and negligibly present in the Rice Paddies of Natonin, Mt. Province and Bagumbayan, Kalinga, but absent in their respective Canals/Creeks. Golden Kuhol was not found in Tanglagan, Apayao. The graph showing the H, E and C of the four study sites is shown in Fig. 1

Table 2 : Importance values (IV) of species in all four sites including corresponding Shannon Wiener Diversity, Evenness and Simpson's Indices and contained IVs of exotic species

Species/Variety	Ifugao		Mt. Province		Kalinga		Apayao	
	Rice Paddy	Canal/Creek	Rice Paddy	Canal/Creek	Rice Paddy	Canal/Creek	Rice Paddy	Canal/Creek
Bisukul	3.43		20.08	35.11	38.67	23.77	52.78	42.13
Agurong	78.07	65.75	39.55	55.32	49.36	49.73	43.65	41.2
Liddig			36.17					
Tukmim						26.49		16.67
Birabid			2.18				3.57	
Tadpole/Frog	54.17	89.01		13.1	87.82	41.67		12.04
Crab				86.9		58.33		12.04
Total	135.67	154.76	97.98	190.43	175.85	199.99	100.00	124.08
Total no. species	3	2	4	4	3	5	3	5
Golden kuhol	18.50	34.25	2.02					
Dojo	20.83	10.99						
Million Fish	25				12.18		100	75.92
Mosquito carp			100					
Total	64.33	45.24	102.02	0.00	12.18	0.00	100.00	75.92
Total no. Exotic species	3	2	2		1		1	1
Shannon Div. (H)	0.7775	0.6818	1.1435	1.2129	1.0364	1.5531	0.8181	1.4552
Evenness (E)	0.7078	0.9836	0.8249	0.875	0.9434	0.965	0.7447	0.9042
Simpson's Index (c)	0.51	0.49	0.66	0.67	0.62	0.78	0.53	0.74

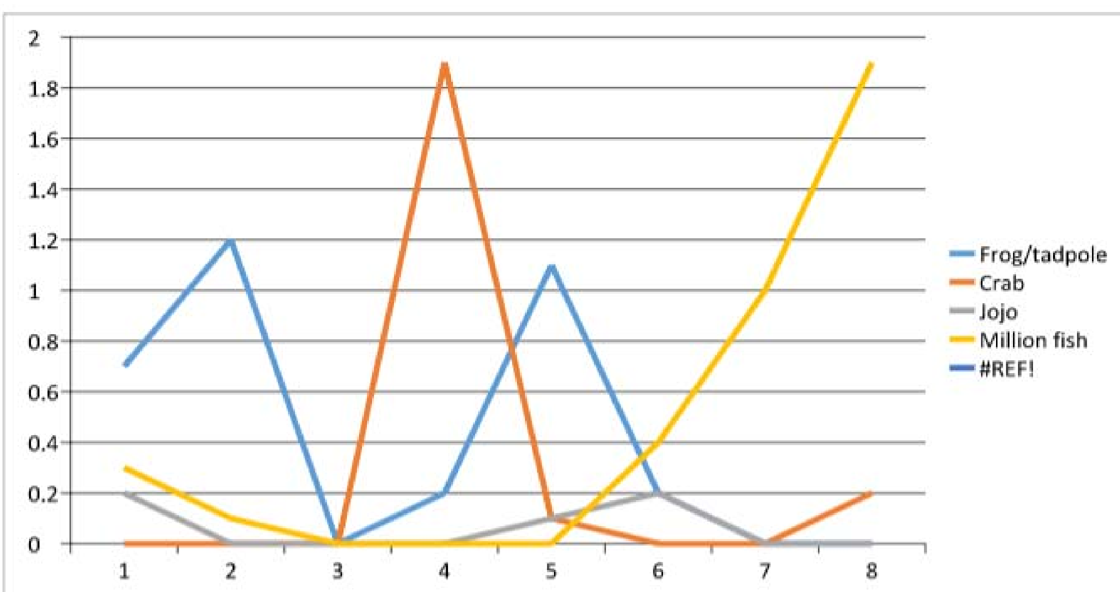

Figure 1 : Graph of Shannon Wiener Diversity, Evenness, and Simpson's Indices of all four sites and corresponding blocks including the sum IV of exotic species per block

The average number of individuals per species per plot was computed and presented in Table 3 and 4. The mollusks were tabulated in Table 3 while the non mollusks in Table 4.

Table 3 : Average number of individuals per plot (e.g. average density/plot) per block among native species of mollusks and exotic Golden Kuhol. (average number individuals/sq.m.)

SPECIES	IFUGAO		MT PROVINCE		KALINGA		APAYAO	
	Rice Paddy	Canal-Creek	Rice Paddy	Canal-Creek	Rice Paddy	Canal-Creek	Rice Paddy	Canal-Creek
Bisukol	0.2	0	4.3	1.9	3.3	1.9	6.3	2.3
Agurong	30.9	18.5	12.7	5.7	6.2	6.2	6.1	2.2
Liddig	0	0	12.9	1.8	0	0	0	0
Tukmim	0	0	0	0	0	3.8	0	0.9
Birabid	0	0	0.2	0	0	0	0.2	0
Golden kuhol	1.9	4.2	0.1	0	1.6	0	0	0

Table 4 : Average number of individuals per plot (e.g. average density/plot) per block among non-mollusk species (tadpole/frog, fish and crab)

Species	Ifugao		Mt. Province		Kalinga		Apayao	
	Rice Paddy	Canl/ Creek	Rice Paddy	Canl/ Creek	Rice Paddy	Canl/ Creek	Rice Paddy	Canal/ Creek
Frog/tadpole	0.7	1.2	0	0.2	1.1	0.2	0	0
Crab	0	0	0	1.9	0.1	0	0	0.2
Jojo	0.2	0	0	0	0.1	0.2	0	0
Million fish	0.3	0.1	0	0	0	0.4	1	1.9
Mosquito carp	0	0	84.2	0	0	0	0	0

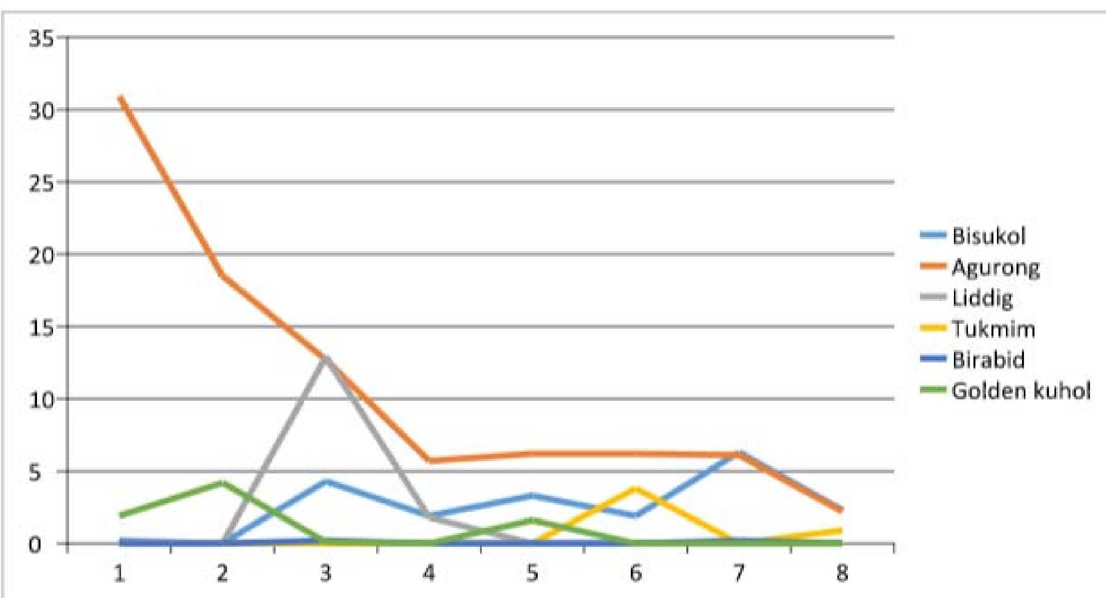

Figure 2 : The average density per plot for the mollusks

The values in Table 3 were line graphed and shown in Figure 2. Golden apple snail had the highest values in Asipulo, Ifugao. It is also interesting to note that the Native Snail (bisikul) is very low in both Rice Paddy and Canal/Creek of Asipulo, Ifugao while the population density of Golden apple snail is considerable. The data implies that Golden apple snail is outcompeting the native strains of edible snails (bisikul) and perhaps may push the latter to further endangerment or worst even possibly to extinction. The data shows that as the population of golden apple snail decline, there is a corresponding increase in the population of the native strains of the native edible snails (bisikul). Agurong, *(Jagora asperata Lamarck)* is dominant in all the sites. Agurong is a prolific breeder and least preferred for food by collectors.

The pattern of non-mollusks show little information about the impact of alien fishes to the densities of native species. This could be explained partly by the difficulty of sampling highly mobile subjects, such as swimming fish species, unlike among mollusks which are quite sedentary. Hence, in Figure 3, there is only little pattern to merit explanation. Frogs/tadpoles are high at Canal/Creeks in Ifugao and Mt. Province than corresponding rice paddies, but the reverse is true in Kalinga while their presence in Apayao is zero. The zero population of frogs/tadpoles in Apayao can be attributed to the negative impacts of pesticides continually used by farmers. There is an extremely high density of Talangka (crabs) at the Canal/Creek in Natonin, Mt Province but in the other cases the density is negligible or absent. The rice terraces clusters in Natonin still carry 100% the traditional farming systems which is purely organic in nature. For mobile organisms, such as fishes and crabs, a zero value does not mean they are absent. The sampling method applied, such as random quadrat or plot sampling, may not be the best procedure because they are mobile and therefore their spatial distribution/dispersion in space could be extremely clumped and not normal. For mobile organisms, ecologists usually employ the so called capture-recapture method to determine their population densities. However, the capture-recapture method is applicable for terrestrial organisms and not for aquatic animals.

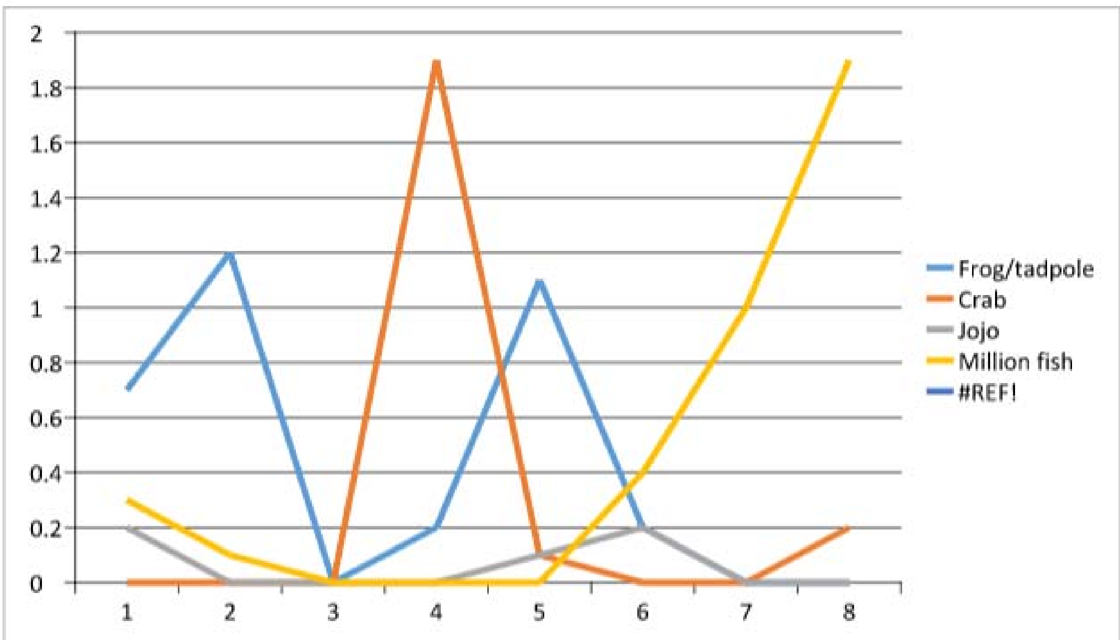

Figure 3 : The average density per plot for the non-mollusks

There are no historical data to compare the biodiversity of aquatic animals in the rice terraces before and after the transition to modern farming systems. Testimonial evidences provided by key informants confirmed a more diverse past than what it is today. Farmers ascribed the reduction in the population of aquatic biodiversity to four factors: a) impacts of pesticides applied in the rice terraces b) overexploitation or excessive collection c. frequent drought and d. replacement with introduced invasive species such as golden apple snail. For the rice terraces clusters that adopted modern farming practices, majority claimed that the use of pesticides is the primary factor causing the decline in the population of aquatic biodiversity followed by excessive collection and the impacts of alien invasive species such as golden apple snail. Farmers in Tanglagan, Apayao although they have shifted completely to modern farming systems, they still continue to practice an indigenous form of conservation which the locals call *"lapat system"* wherein a portion of a river system of about 2-3 kilometers in length is declared off limit to exploitation for several months or even years. The "lapat" is declared in honor of a person who died in the community and the length of which depends on the prominence and status of the person who died in the community. Table 5 shows the causal factors for the decline in the population of aquatic biodiversity as viewed by farmers.

Table 5 : Causal factors in the loss of biodiversity in the rice terraces

Causal factors of the loss of aquatic biodiversity	Location				Total
	Asipulo, Ifugao	Natonin, Mt. Province	Bagumbayan, Kalinga	Tanglagan, Apayao	
Use of pesticides	6	0	8	10	24
Excessive collection either for human food or animal feed	3	2	2	0	7
Insufficient water supply	1	0	0	0	1
Introduced invasive species (golden apple snail, torachuk)	0	8	0	0	8
Total	10	10	10	10	40

IV. Conclusion and Recommendation

The four rice terraces clusters vary in terms of their biodiversity indices. Canals/creeks are more diverse than the rice paddy system. The canals and creeks are natural ecosystems less disturbed by human activities. The use of pesticides is clearly altering the population of aquatic biodiversity. On the other hand, invasive species such as golden apple snail pose a threat to the population of the native strains most preferred by the local people for food. In areas where golden apple snail is prevalent, it may be necessary to encourage their removal not by chemical means but by manual collection and given to animals as feed materials.

For hundreds of years, the varied aquatic life found in the rice terraces customarily meets the protein requirement of the local people. The loss of these aquatic biodiversity certainly affects the food security status of rice terraces farmers and their families. Efforts should be made to protect aquatic biodiversity by limiting the use of pesticides and other forms of harmful chemicals. The farming community in Tanglagan, Apayao have shown an excellent form of conserving aquatic biodiversity through the *"lapat system"* handed down from past generations and carried over by the present generation. The *"lapat system"* can be replicated to other areas in the Cordillera region where rice terraces cultivation persists. However, since the *lapat system* is indigenous only to Apayao and not to the other provinces in the Cordillera region, their adoption requires the enactment of local policies by the Local Government Units to establish a framework for their adoption and transfer to the other provinces.

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