FISHES AND SHELL DIVERSITY IN MAJOR RIVERS OF BENGUET, PHILIPPINES

Erlinda C. Bestre, Arsenia M. Lumiquio, Jones T. Napaldet

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Abstract: The study documented the fish and shell diversity in major rivers of Benguet, Philippines as part of the overall effort to update the data on fish and shell status in the region. A total of 13 fish species and 9 shells were identified and are reportedly being consumed as food. Among the fish species, 8 were indigenous while 5 were introduced particularly in Ambuklao Dam. *Pseudogobius javanicus*, *Glossogobius circumspectus*, *Anguilla marmorata*, *Misgurnus anguillicaudatus* and *Gambusia affinis* are the most common fish species while *Melanoides maculata*, *Melanoides torulosa*, *Radix rubiginosa* and *Pomacea canaliculata* are the most common shells. An unidentified species of *Radix* locally known as 'ginga' was also documented but is highly endangered. Among the 11 sampled rivers, Ambuklao Dam, Agno River and Amburayan River have the highest diversity index at 1.94, 1.99 and 1.77. However, the high diversity index of Ambuklao Dam and Agno River is mainly attributed to the introduced fishes namely *Leiopotherapon plumbeus*, *Glossogobius celebius*, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis* and *Oreochromis mossambicus*. Other rivers in the study have lower diversity at values ranging from 1.36 to 1.51. Shell diversity index is generally higher than fish except in Ambuklao Dam and Agno River. Amburayan and Dopi Rivers have highest shell diversity index at 1.98 and 1.93, respectively while lowest in Ambuklao Dam at 1.15. The fish and shell composition of these rivers is generally the same as indicated by high index of similarity. Amburayan and Asin-Lewen Rivers slightly differs due to the two fish species namely *Eleotris melanosoma* and *Rhyacichthys aspro* that are not found in other rivers of the province. These results show that the province supports significant diversity of fishes and shells which needs to be considered in the overall watershed management.

Keywords: Benguet, diversity, freshwater fishes, shells

Introduction:

The Philippines is one of the mega diverse countries recognized by the UNEP World Conservation Monitoring Centre but at the same time a biodiversity hotspot (Mallari et al. 2001; Heaney et al. 2004). In terms of fishes, the country hosts about 3,010 fish species with only 343 (10%) occurring in freshwater, of which 83 are endemic, 206 are native, 44 are introduced, and 42 are of uncertain status (Froese and Pauly 2011). Much of the fish studies in the country have been devoted to marine biodiversity, and little is known about freshwater diversity (Ong et al. 2002). However, great potential of species biodiversity lie also on Philippine inland waters. In fact, a number of unique species of

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freshwater fishes are known to be confined only to isolated rivers and lakes in the country (Herre 1953; Paller et al. 2011). Included here are gobies, halfbeaks and pipefishes whose status is not yet fully known (Herre 1953; Butler 2006). The most diverse group of freshwater fishes in the Philippines are gobies, with 16 endemic species (Froese and Pauly 2011; Eschmeyer 2011). Interestingly, the world's only known freshwater sardine, *Sardinella tawilis* occurs only in Taal Lake (Herre 1927; Hargrove 1991).

Rivers in the country, like in other Asian countries, support a rich but barely known biota (Allen 1991). These serve significant functions in human populations, though the majority of these rivers have remained poorly understood and studied (Kottelat and Whitten 1996). Such is the case of rivers in Benguet Province, Philippines. It is a landlocked province from where headwaters of various major river systems in northern Luzon originated. These rivers were endowed with various indigenous fishes, shell and related species which could be unique from lowland rivers owing to the high elevation and cold climate of the province. However, these freshwater resources are not given much emphasis in research studies in the province compared to semi-temperate vegetables.

Freshwater fishes and other macrofauna are among the most endangered groups because of their high vulnerability to aquatic habitat modification (Laffaille et al. 2005; Kang et al. 2009; Sarkar et al. 2008). Among these hazards are habitat degradation, conversion to private use, impacts of climate change and pollution, overexploitation and introduction of invasive species (Bagarinao 2001; Cagauan 2007; Vidthayanon 2007, unpublished data). This could lead to endangering and eventual loss of inherent fish and other faunal population in the area even before they have been studied. Hence, this study has been conducted to document the diversity of fish and shells in major rivers of Benguet Province, particularly those economically important as food.

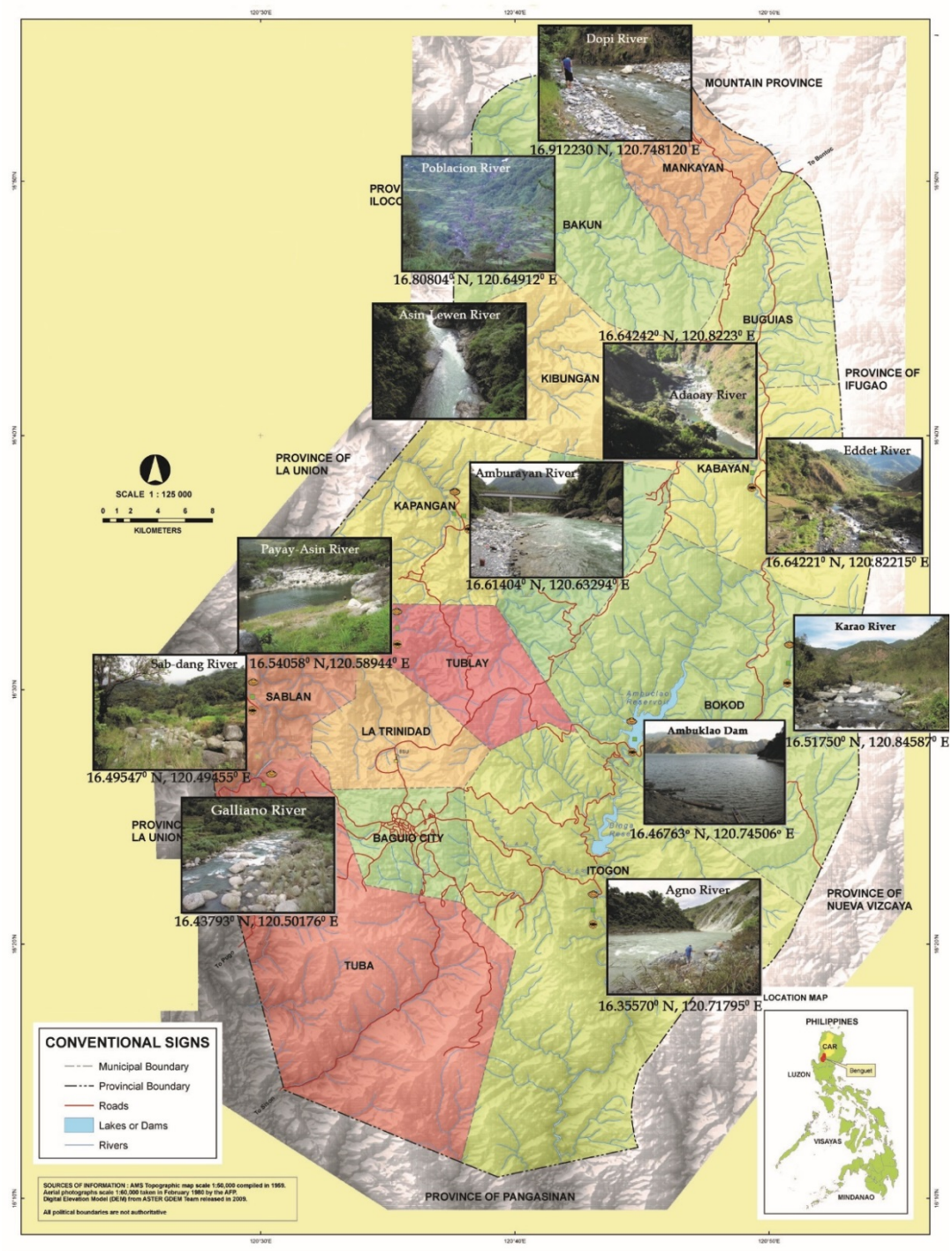
Materials and methods:

Major river systems in the province were identified through records of Provincial Veterinary Office (PVO 2002). Considering this record, rivers that are not heavily polluted by mining activities, agricultural run-off and domestic wastes were selected for sampling. At least one river or tributary per municipality was selected to derive a total of 11 sampling sites. The majority of these were tributaries of the five major river systems in Benguet namely Agno, Amburayan, Amposongan, Galiano and Naguilian Rivers while few were either headwater or tributary of Abra and Bayating River. Five sampling sites were established along Upper Agno River System; two each in Amburayan and Bakun Rivers; and, one each in Galiano and Naguilian Rivers (Fig. 1).

Sampling stations in selected rivers were established where collection spots were randomly set. Fish, shells and other freshwater macrofauna were collected using different gears such as gill net, filter net, hook and line, scoop net and local contrivances such as fish traps, fish arrow and modified fish weir made of bamboo (locally known as "tunol"). Sampling was conducted from June 2008 – December 2009 and carried out during day time and night time. Captured fish, shells and other freshwater macrofauna were immediately counted and identified at lowest possible taxon. Samples were brought in the laboratory for documentation and identity verification using various references such as Kottelat et al. (1993, 1996), Rainboth (1996), Kottelat (2001), Herre (1927, 1953), Conlu (1986). After identification, the specimens were fixed with 10% formalin solution. After a week of fixation, specimens were washed and soaked in tap water with daily water change. Photodocumentation and morphometric characterizations were done while the specimens were soaked in tap water for 5-7 days. The specimens were then subjected to alcohol series (20%, 50%, and 70% ethyl alcohol) for about 5-7 days each. Finally, specimens were sorted per species and summarized per sampling site then placed

in freshly prepared 70% ethyl alcohol for permanent storage. Permanently fixed specimens were deposited and are displayed in Biology Department, Benguet State University.

Figure no. 1 Map of Benguet Province showing the sampled river in the study



Interviews were also conducted with local fisherfolks in communities near the river to verify the collected specimens as well to identify other species that were not caught but do thrive in the river. This is especially true in the case of rare and hard to caught fishes.

Different descriptors of diversity were used in this study. Species richness was determined by the number of species present in a community. The relative abundance, diversity indexes and evenness were calculated using the following formulas:

Relative Abundance (RA)

$$RA = \frac{a_i}{A} \times 100$$

where:

a_i - number of individuals of species *i*

A - total number of individuals collected in sampling areas

Shannon-Weiner diversity index (H')

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

where:

p_i - number of individuals of species *i* / total number of samples

S - total number of species from sampling area

Evenness (J')

$$J' = \frac{H'}{\ln S}$$

where:

S - total number of species

Simpson's index dominance (λ)

$$\lambda = \frac{\Sigma\, n_i\, (n_i - 1)}{N\,(N-1)}$$

where:

n_i - total individual of species *i*

N - total number of individuals of all species

Jaccard index of similarity (J)

$$J = \frac{Sc}{Sa+Sb+Sc} \times 100$$

where:

S_c - number of species common to the two samples

S_a - number of species unique to station a

S_b - number of species unique to station b

Results and discussion:

Fish and Shell Species Composition

A total of 13 fish species and 9 shells were identified in different rivers of Benguet Province and were reportedly economically important as food. Additionally, 2 crustaceans, 1 amphibian and 1 insect species commonly associated with fish and shell were also documented. Among the 13 fish species, 8 were indigenous while 5 were introduced particularly in Ambuklao Dam (see Tab. 1 and Fig. 1a-l, Annexes). Family Gobiidae was the most common among the indigenous fishes represented by 3 species while other families were represented by single species. On the other hand, Family Cyprinidae has highest number of introduced species (3). However, these carp occur only in Ambuklao Dam and most likely in other reservoirs in the province. These carps were deliberately introduced in the reservoir for food and livelihood together with tilapia.

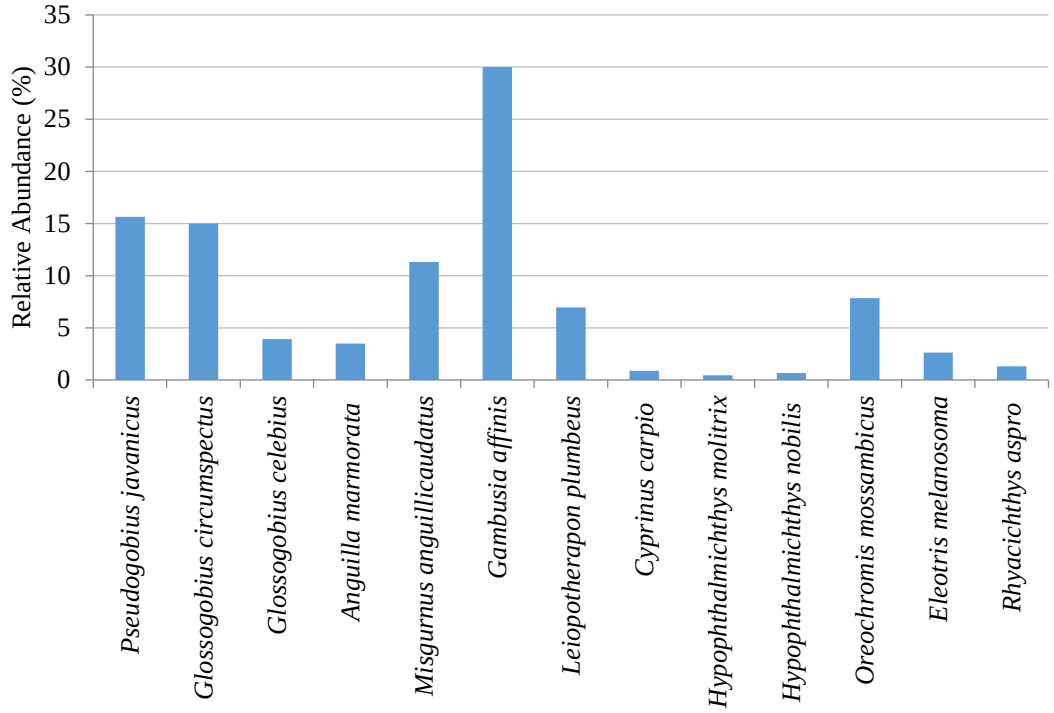
On the other hand, the identified shell species are listed in Table 2 (and Fig 2a-h, Annexes). Mostly, these shells occur in rice paddies but due to their connection via irrigation canals, these shells find their way into rivers and are thriving especially in clayey substratum. Of these, 7 are univalve and 2 are bivalve species.

Additionally, freshwater macrofauna associated with fish and shells are listed in Table 3 and illustrated in Figures 3a-d (Annexes). These include crustaceans, amphibians and insect larvae that are edible. Crabs and freshwater shrimps, both crustaceans, and frogs (tadpoles), an amphibian, are widely distributed in rivers and rice paddies of the province. On the other hand, 'babachi', a dragon fly nymph, occurs in rivers with turbulent flow. They are usually found clinging on rock surfaces. Of these species mentioned, only the freshwater shrimp is commercially marketed in Ambuklao.

Biological Indices

'Wadingan' (*Pseudogobius javanicus*), 'bunog' (*Glossogobius circumspectus*), 'kiwet' (*Anguilla marmorata*), 'yoyo' (*Misgurnus anguillicaudatus*) and 'tamtampi' (*Gambusia affinis*) occur in almost all rivers sampled in the province. Consequently, these are the fish with highest relative abundance, except for 'kiwet' (Fig. 2). Though 'kiwet' occurs in all rivers of the province, their population is relatively scarce. 'Tamtampi' has highest relative abundance which could be attributed to its fast reproductive rate and the relative ease of catching it. The other fishes are very fast swimmers. Also, these fishes are the usual catch reported by fisherfolks in the province except in Ambuklao where introduced fish species are the dominant catch.

Figure no. 2 Relative abundance of fishes collected in major rivers of Benguet

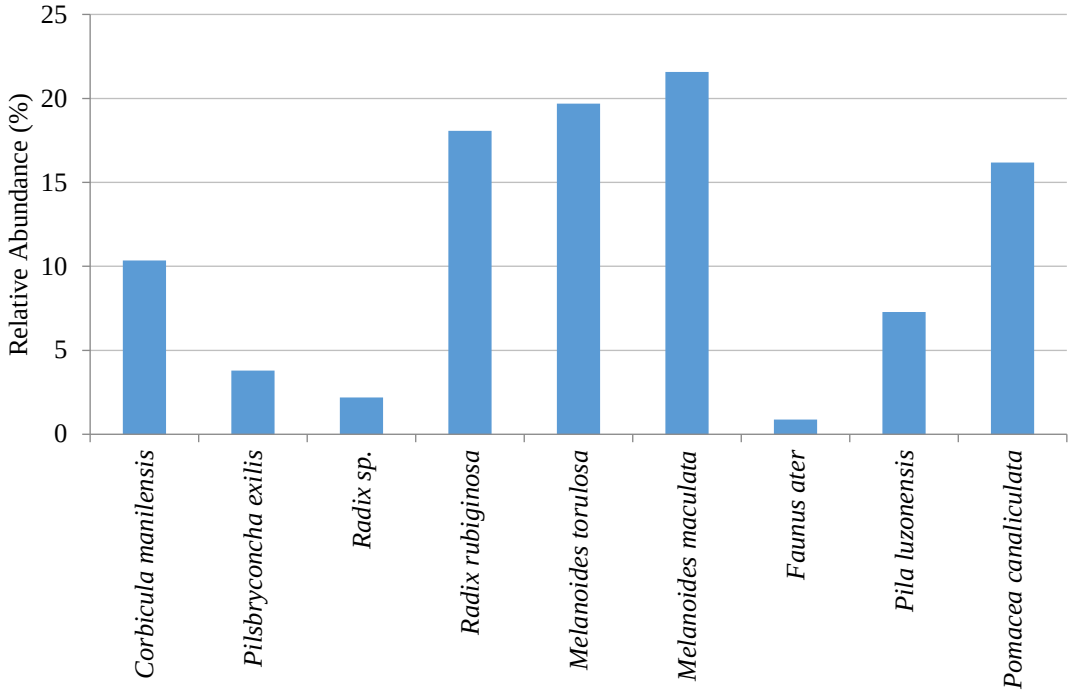


'Wadingan' (*Pseudogobius javanicus*) is a small fast moving fish commonly found in riffles. It has disc shape pelvic fin which acts as suction cups enabling them to cling to stones and prevent them from being swept away by water currents. More sizeable than

'wadingan' is 'bunog' (*Glossogobius circumspectus*), also a goby species. However, in contrast to 'wadingan', 'bunog' occurs mainly in pools and channels of the river since they lack the stone-clinging disc shape pelvic fin. Instead, they have two elongated pelvic fins. 'Tibek' (*Eleotris melanosoma*) and 'kampa' (*Rhyacichthys aspro*) only occur along Amburayan River and its tributaries, the former is more abundant but the latter is reportedly more palatable. *Misgurnus anguillicaudatus* or mudfish occurs mainly in rice paddies but reportedly thrives in rivers with slow flow and clayey substratum. However, this species is threatened by application of synthetic inputs in rice farming as well as conversion of paddies into vegetable gardens. The latter is reportedly more potent since it dries up the paddy thus losing the habitat required by the fish.

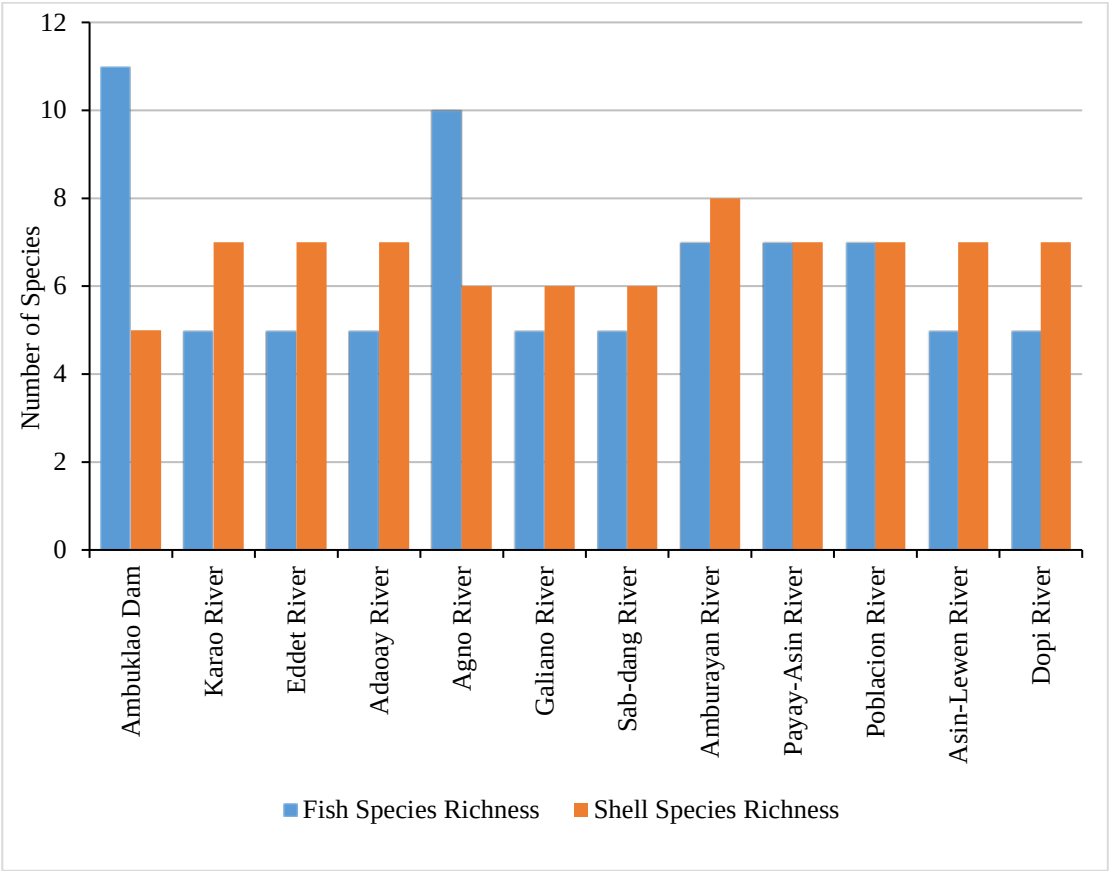
'Nuso' (*Melanoides maculata*), 'ket-an' (*Melanoides torulosa*), 'tumdid' (*Radix rubiginosa*) and golden kuhol (*Pomacea canaliculata*), all univalves, are found in all sampled rivers. 'Ben-nek' (*Corbicula manilensis*), 'tikam' (*Pilsbryconcha exilis*) and native kuhol (*Pila luzonensis*) are also common and widely distributed but are absent in few areas. Consequently, these are the shell species with high relative abundance (see Fig. 3). An unidentified species of *Radix* locally known as 'binga' or 'ginga' is highly endangered and already extinct in some areas. It is a small univalve with very delicate and thin shell, smooth, shiny, very low spire, almost semi-circular aperture and golden brown in color. The shell has a diameter of 1.3 - 1.6 cm and the aperture measures 1.3 - 1.5 cm. It is also a favored species for its distinct taste. 'Agudong' (*Faunus ater*), a low land species, thrives only in Amburayan River in Kapangan where the temperature is relatively warmer. On the other hand, 'ben-nek' (*Corbicula manilensis*), is the only commercially abundant shell in Ambuklao.

Figure no. 3 Relative abundance of shells collected in major rivers of Benguet



Fish and shell species richness of the sampled rivers is presented in Figure 4. It can be readily gleaned from the graph that Ambuklao Dam and Agno River has the highest number of fish species at 11 and 10, respectively. However, this is due to addition of 5 introduced fish species. If only indigenous species would be considered, Amburayan and Asin-Lewen River would have the highest species richness at 7 species. Other rivers usually have 5 or 6 fish species. In terms of shell species, Amburayan River also has the highest number at 8 while lowest in Ambuklao Dam with only 5. Other rivers have usually 6 or 7 shell species.

Figure no. 4 Fish and shell species richness in major rivers of Benguet



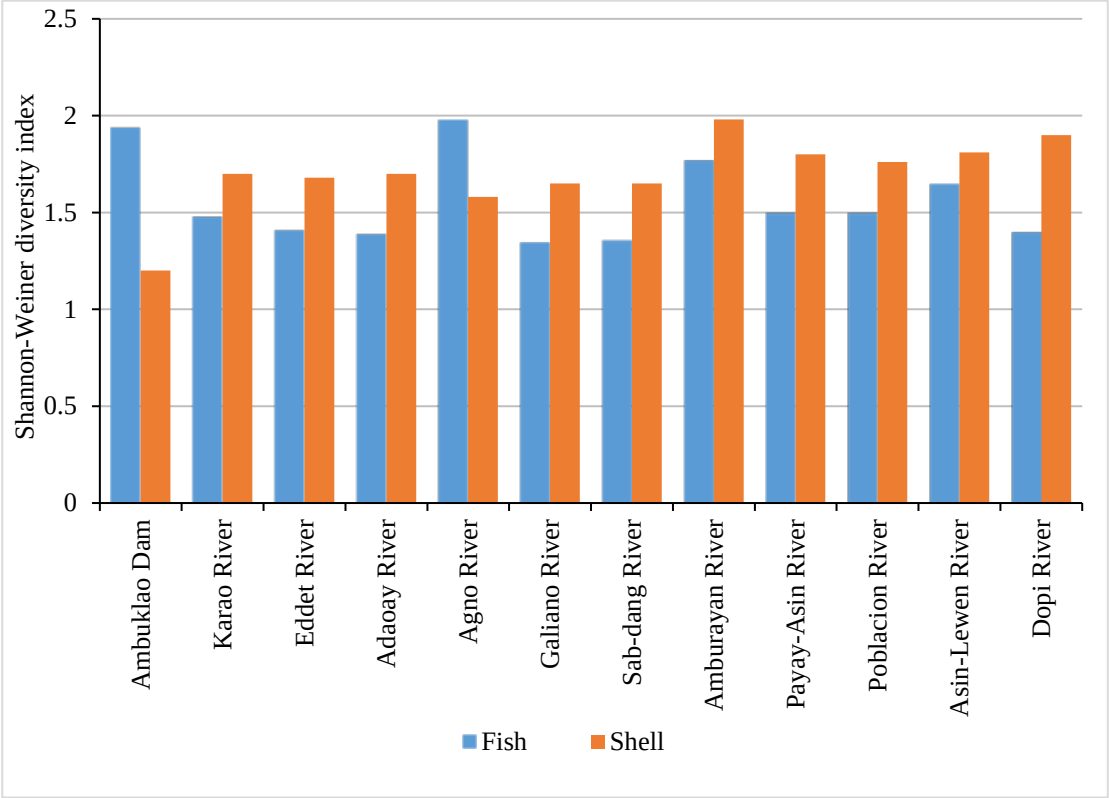
Ambuklao Dam, Agno River and Amburayan River have the highest fish species richness, thus consequently have the highest Shannon-Weiner diversity index at 1.94, 1.99 and 1.77 respectively (Fig. 5). The other rivers in the study have lower diversity, though not significantly different, with values ranging from 1.36 to 1.51. These values are comparable with the diversity index of Tikub Lake, Quezon at 1.87 (Labatos and Briones 2014) but much lower than the 2.17-3.05 index of Taal Lake River System, Batangas (Corpuz et al. 2016). In the natural ecosystem, diversity index usually ranges from 1.0 to 3.5 wherein the value above 3.0 indicates a stable habitat while the value under 1.0 indicates a highly disturbed environment (Magurran 2004).

Shell diversity index is generally higher than fish except in Ambuklao Dam and Agno

River. Amburayan and Dopi River have highest shell diversity index at 1.98 and 1.93, respectively while lowest in Ambuklao Dam at 1.15.

On the other hand, Table 4 (Annexes) presents the evenness and Simpson's index of dominance. Evenness values generally range from 0.4 to 0.5 both for fish and shell diversity. However, evenness value for shell in Ambuklao Dam is much lower but with highest Simpson's index of dominance at 0.41. This is due to the dominance of 'bennek' (*Corbicula manilensis*) which is commercially marketed in the dam. This shell is not being cultured in the dam but its abundance is attributed to its association with tilapia in terms of reproduction.

Figure no. 5 Shannon-Weiner diversity index of major rivers of Benguet



Jaccard's index of similarity, as presented in Table 5 (for fish, Annexes) and Table 6 (for shells, Annexes), compares the fish and shell composition of the sampled rivers. Usually, tributaries of the same river system have high similarity of fish and shell composition. For example, Eddet, Adaoay and Karao River are 100% similar due to the fact that these are tributaries of Upper Agno River System. Ambuklao Dam and Agno River in Itogon, which lies downstream, have basically the same fish composition plus the introduced fish species. The introduced fish such as 'ayungin', 'banak', tilapia and carp species are commercially abundant in Ambuklao Dam and mostly like some individuals are being washed off to Agno River, explaining their high similarity. 'Ayungin' (*Leiopotherapon plumbeus*) and 'banak' (*Glossogobius celebius*) are

native in country but usually occur in lowland rivers. However, these introduced species are unable to colonize upstream as indicated by their absence in Eddet, Adaoay and Karao River. It was also reported that the population of *Anguilla marmorata* is diminishing in these rivers due to the dams. This eel is a catadromous (marine spawner) fish and the dams prevent the young eels from returning upstream.

The fish composition of the rivers in the province is generally the same except in Ambuklao Dam and Agno River with introduced fish species. Amburayan and Asin-Lewen River also differs due to the presence of two fish species namely 'tibek' (*Eleotris melanosoma*) and 'kampa' (*Rhyacichthys aspro*) that are not found in other rivers of the province.

Same trend is also observed in shell composition. Rivers in the province have high similarity with values generally ranging from 62.50 to 100%. Lower similarity was observed with Amburayan River due to presence of 'agudong' (*Faunus ater*) and 'ginga' (*Radix* sp.) which are not common in other rivers.

Conclusions:

A total of 13 fish species, 9 shells, 2 crustaceans, 1 amphibian and 1 insect were identified in major rivers of Benguet Province and are reportedly economically important as food. Among the 13 fish species, 8 were indigenous, while 5 were introduced particularly in Ambuklao Dam. Among shells, 7 are univalve and 2 are bivalve species. Family Gobiidae was the most common among the indigenous fishes represented by 3 species, while other families were represented by single species. Family Cyprinidae has highest number of introduced species (3), but this carp family occurs only in Ambuklao Dam. These carps were deliberately introduced in the dam for food and livelihood together with tilapia. *Pseudogobius javanicus*, *Glossogobius circumspectus*, *Anguilla marmorata*, *Misgurnus anguillicaudatus* and *Gambusia affinis* are the most common fish species while *Melanoides maculata*, *Melanoides torulosa*, *Radix rubiginosa* and *Pomacea canaliculata* are the most common shells.

Among the 11 rivers sampled, Ambuklao Dam, Agno River and Amburayan River have highest number of fish species at 11, 10 and 8, thus consequently have highest diversity index. However, the high diversity index of Ambuklao Dam and Agno River is mainly attributed to the introduced fishes. Other rivers in the study have lower diversity at values ranging from 1.36 to 1.51. Shell diversity index is generally higher than fish except in Ambuklao Dam and Agno River. Amburayan and Dopi River have highest shell diversity index at 1.98 and 1.93, respectively while lowest in Ambuklao Dam at 1.15. 'Agudong' (*Faunus ater*), a low land shell species, was documented only in Amburayan River. On the other hand, evenness in the rivers generally ranges from 0.4 to 0.5 both for fish and shell diversity except in Ambuklao Dam which features much lower shell evenness value but with highest Simpson's index of dominance at 0.41. This is due to the dominance of 'ben-nek' (*Corbicula manilensis*) which is commercially marketed in the dam. Lastly, the fish and shell composition of these rivers is generally the same as indicated by high index of similarity. Only Amburayan and Asin-Lewen River slightly differs due to the presence of two fish species namely *Eleotris melanosoma* and *Rhyacichthys aspro* that are not found in other rivers of the province.

Rezumat:

DIVERSITATEA PEȘTILOR ȘI MOLUȘTELOR DIN RÂURILE MAJORE DIN BENGUET, FILIPINE

Studiul a cercetat diversitatea peștilor și moluștelor din râurile majore din Benguet, Filipine, ca parte a efortului global de a actualiza datele privind situația peștilor și moluștelor din regiune. Au fost identificate 13 specii de pești și 9 de moluște, care se consumă ca hrană. Dintre speciile de pești, 8 au fost indigene, în timp ce 5 au fost introduse, în special în barajul Ambuklao. *Pseudogobius javanicus*, *Glossogobius circumspectus*, *Anguilla marmorata*, *Misgurnus anguillicaudatus* și *Gambusia affinis* sunt cele mai răspândite specii de pești, în timp ce *Melanoides maculata*, *Melanoides torulosa*, *Radix rubiginosa* și *Pomacea canaliculata* sunt cele mai comune moluște. O specie neidentificată de *Radix*, cunoscută local ca 'ginga' a fost, de asemenea, studiată, dar este pe cale de dispariție. Dintre cele 11 râuri studiate, Ambuklao Dam, râul Agno și râul Amburayan au cel mai mare indice de diversitate, respectiv 1.94, 1.99 și 1.77. Cu toate acestea, indicele ridicat de diversitate al barajului Ambuklao și al râului Agno este atribuit în special peștilor introduși, cum ar fi *Leiopotherapon plumbeus*, *Glossogobius celebius*, *Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Hypophthalmichthys nobilis* și *Oreochromis mossambicus*. Alte râuri au o diversitate mai mică, cu valori cuprinse între 1.36 și 1.51. Indicele de diversitate al moluștelor este în general mai mare decât al peștilor, excepție făcând barajul Ambuklao și râul Agno. Râurile Amburayan și Dopi au cel mai mare indice de diversitate pentru moluște, respectiv de 1.98 și 1.93, în timp ce cel mai mic este la barajul Ambuklao, de 1.15. În general, în aceste râuri întâlnim aceleași specii de pești și moluște, fapt ce rezultă și din indicele înalt de similaritate. Râurile Amburayan și Asin-Lewen diferă ușor datorită celor două specii de pești, și anume *Eleotris melanosoma* și *Rhyacichthys aspro*, care nu se găsesc în alte râuri ale provinciei. Aceste rezultate indică prezența unei diversități semnificative a faunei de pești și moluște în interiorul provinciei, de care trebuie să se țină seama în managementul global al bazinelor hidrografice.

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Annexes:

Figure no. 1 (a-l) Freshwater fishes in major rivers of Benguet

a. *Pseudogobius javanicus*

b. *Glossogobius circumspectus*

c. *Glossogobius celebius*

d. *Anguilla marmorata*

e. *Misgurnus anguillicaudatus*

f. *Gambusia affinis*

Istros – Museum of Braila "Carol I"

g. *Eleotris melanosoma*

h. *Rhyacichthys aspro*

i. *Leiopotherapon plumbeus*

j. *Cyprinus carpio*

Istros – Museum of Braila "Carol I"

k. *Hypophthalmichthys molitrix*

l. *Hypophthalmichthys nobilis*

Figure no. 2 (a-h) Freshwater shells in major rivers of Benguet

a. *Corbicula manilensis*

b. *Pilsbryconcha exilis*

Istros – Museum of Braila "Carol I"

c. *Radix* sp.

d. *Radix rubiginosa*

e. *Melanoides torulosa*

f. *Melanoides maculata*

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g. *Faunus ater*

h. *Pila luzonensis*

Figure no. 3 (a-d) Other freshwater macrofauna associated with fish and shell in major rivers of Benguet

a. *Sundathephusa monatanoanus*

b. *Cardina laoagensis*

c. *Polypedates leucomyutax*

d. *Orthetrum separia* (larvae)

Table no. 1 Checklist of freshwater fishes that occur in major rivers of Benguet

Scientific name	Local name / Common name	Family	Remarks
Pseudogobius javanicus	Goby/ wading/ paideng/ daring	Gobiidae	Occurs in all rivers of Benguet; relatively abundant
Glossogobius circumspectus	Bunog/Goby	Gobiidae	Occurs in major rivers of Benguet; abundant in Ambuklao Reservoir
Glossogobius celebius	Banak/Goby	Gobiidae	Abundantly in Ambuklao Reservoir, reported common also in other reservoir in the province
Anguilla marmorata	Eel/Kiwet	Anguillidae	Occurs in all major rivers of Benguet; endangered in some areas particularly at upper stream blocked by Ambuklao Dam
Misgurnus anguillicaudatus	Yoyo/dojo/ susay/mudfish	Cobitidae	Found in ricefields or in river with clay substrate; Endangered/extinct in areas where ricefields have been converted to vegetable gardens
Gambusia affinis	Million fish/ bidaka/ tamtampi	Poeciliidae	Occurs in ricefield and in Karao and Asin-Lewen River; predominate in dirty waters of Balili River; abundant
Eleotris melanosoma	Tibek	Eleotridae	Abundant but occur only in Amburayan River and its tributaries, reportedly extinct in Payay-Asin River;
Rhyacichthys aspro	Kampa	Rhyacichthyidae	Occur only in Amburayan River; less abundant than 'tibek'
*Leiopotherapon plumbeus**	Ayungen	Terapontidae	Introduced and commercially abundant in Ambuklao Reservoir
*Cyprinus carpio **	Common carp	Cyprinidae	Introduced in Ambuklao reservoir; commercially abundant
*Hypophthalmichthys molitrix**	Silver carp	Cyprinidae	Introduced in Ambuklao reservoir; commercially abundant
*Hypophthalmichthys nobilis **	Big-head carp	Cyprinidae	Introduced in Ambuklao reservoir; commercially abundant
*Oreochromis mossambicus**	Tilapia	Cichlidae	Introduced and commercially abundant in Ambuklao reservoir; established also in Payay-Asin River

Note: * Introduced species

Table no. 2 Freshwater shell species that occur in rice paddies and rivers of Benguet

Scientific name	Local name / Common name	Family	Remarks
Corbicula manilensis	Tik-am/ ben-nek	Corbiculidae	Abundant in Ambuklao reservoir and fishponds
Pilsbryconcha exilis	Kappo	Unionidae	Endangered in some areas
Radix sp.	Binga/ginga	Lymnaeoidae	Highly endangered/ extinct in other areas
Radix rubiginosa	Tumdid	Lymnaeoidae	Endangered; extinct in some municipalities
Melanoides torulosa	Ket-an	Thiaridae	Common
Melanoides maculata	Nuso	Thiaridae	Abundant in Kapangan; endangered in some areas
Faunus ater	Agudong	Melanopsidae	Occurs only in Kapangan
Pila luzonensis	Bisokol/Native kuhol	Viviparidae	Still common, found in all study areas but slowly being displayed by golden kuhol
Pomacea canaliculata	Golden kuhol	Ampullariidae	Common and dominant in rice paddies

Table no. 3 Associated freshwater species inventoried in major rivers of Benguet

Scientific name	Local name	Family	Remarks
Sundathelphusa montanoanus	Gakki	Gecarcinucidae	Found in most rivers of Benguet
Caridina laoagensis	Pasayan	Atyidae	Found in rivers of most study sites
Polypedates leucomystax	Bay-yek / tukak	Rhacophoridae	Found in most rivers of Benguet
Orthetrum separia	Babachi / Dayap	Libellulidae	Endangered; found in most rivers of Benguet

Table no. 4 Evenness and Simpson's index of dominance in major rivers of Benguet

River Sampled	Fish Diversity Index		Shell Diversity Index	
	Evenness Index	Simpson's Index	Evenness Index	Simpson's Index
Ambuklao Dam	-0.4015	0.1638	-0.2949	0.4090
Karao River	-0.4969	0.2000	-0.4264	0.1845
Eddet River	-0.4775	0.2263	-0.4261	0.1899
Adaoay River	-0.4196	0.2562	-0.4308	0.1797
Agno River	-0.5684	0.1458	-0.4451	0.2319
Galiano River	-0.3993	0.2805	-0.5016	0.1815
Sab-dang River	-0.4166	0.2678	-0.4069	0.1974
Amburayan River	-0.4542	0.1726	-0.4614	0.1393
Payay-Asin River	-0.4236	0.2471	-0.4341	0.1622
Poblacion River	-0.4340	0.2137	-0.4164	0.1738
Asin-Lewen River	-0.4809	0.2069	-0.4385	0.1611
Dopi River	-0.4004	0.2641	-0.4481	0.1541

Table no. 5 Jaccard's Index of Similarity in Fish Composition of Rivers Sampled

	Ambuklao Dam										
Karao River	45.45	Karao River									
Eddet River	45.45	100.00	Eddet River								
Adaoay River	45.45	100.00	100.00	Adaoay River							
Agno River	90.91	41.67	41.67	41.67	Agno River						
Galiano River	45.45	100.00	100.00	100.00	36.36	Galiano River					
Sab-dang River	45.45	100.00	100.00	100.00	36.36	100.00	Sab-dang River				
Payay-Asin River	54.55	83.33	83.33	83.33	45.45	83.33	83.33	Payay-Asin River			
Amburayan River	38.46	71.43	71.43	71.43	25.00	71.43	71.43	62.50	Amburayan River		
Asin-Lewen River	38.46	71.43	71.43	71.43	25.00	71.43	71.43	62.50	100.00	Asin-Lewen River	
Poblacion River	45.45	100.00	100.00	100.00	36.36	100.00	100.00	83.33	71.43	71.43	Poblacion River
Dopi River	45.45	100.00	100.00	100.00	36.36	100.00	100.00	83.33	71.43	71.43	100.00

Table no. 6 Jaccard's Index of Similarity in Shell Composition of Rivers Sampled

	Ambuklao Dam										
Karao River	71.43	Karao River									
Eddet River	71.43	100.00	Eddet River								
Adaoay River	71.43	100.00	100.00	Adaoay River							
Agno River	83.33	85.71	85.71	85.71	Agno River						
Galiano River	83.33	85.71	85.71	85.71	100.00	Galiano River					
Sab-dang River	83.33	85.71	85.71	85.71	100.00	100.00	Sab-dang River				
Payay-Asin River	71.43	100.00	100.00	100.00	85.71	85.71	85.71	Payay-Asin River			
Amburayan River	44.44	66.67	66.67	66.67	55.56	55.56	55.56	66.67	Amburayan River		
Asin-Lewen River	50.00	75.00	75.00	75.00	62.50	62.50	62.50	66.67	87.50	Asin-Lewen River	
Poblacion River	50.00	75.00	75.00	75.00	62.50	62.50	62.50	66.67	87.50	100.00	Poblacion River
Dopi River	62.50	87.50	87.50	87.50	75.00	75.00	75.00	66.67	77.78	87.50	87.50