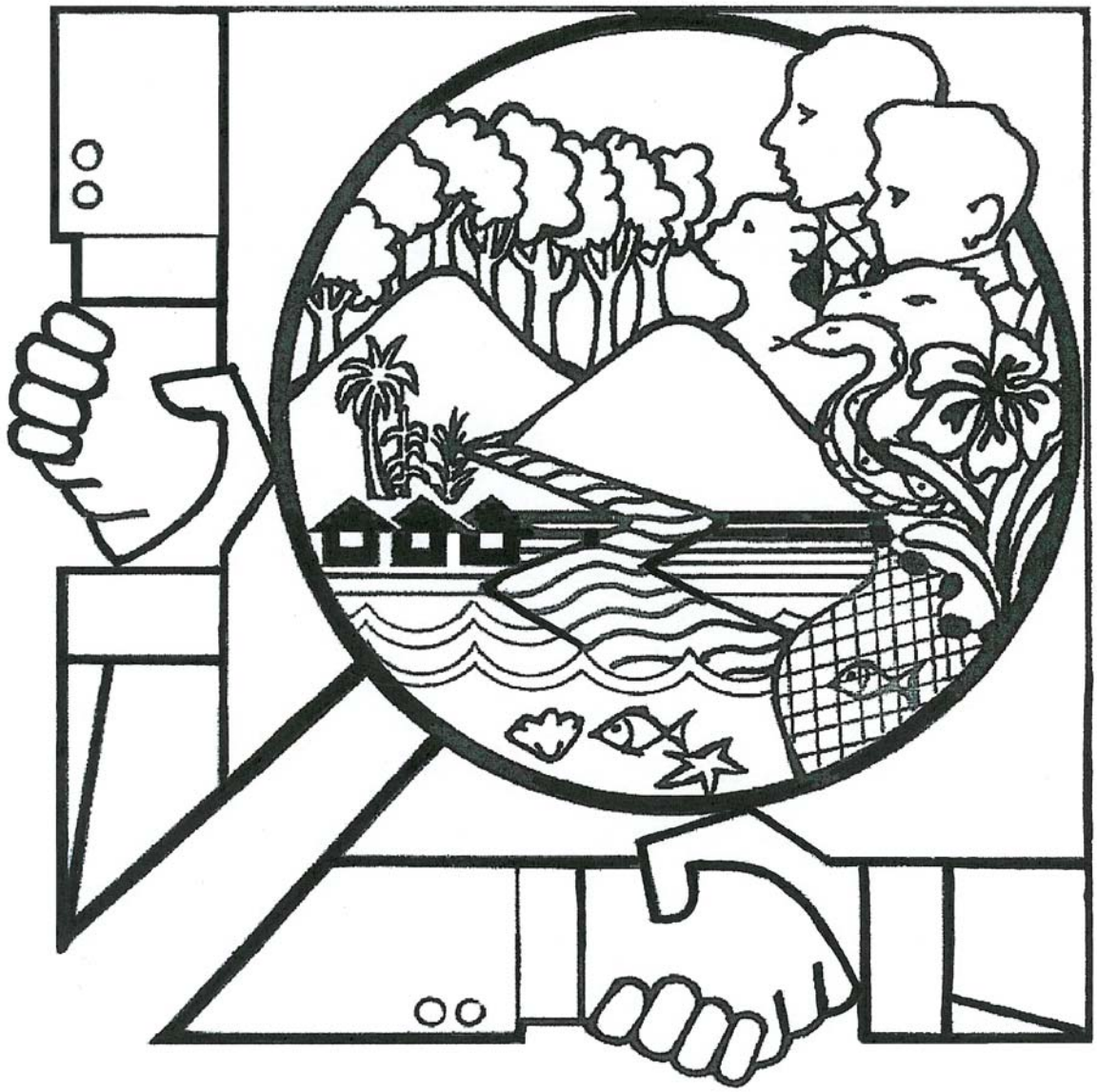
Assessing the Headwaters of Layawan River: Linkage Between the Terrestrial and Aquatic Ecosystems in Mt. Malindang, Misamis Occidental



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SEAMEO SEARCA

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Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs

The Biodiversity Research Programme (BRP) for Development in Mindanao is a collaborative research programme on biodiversity management and conservation jointly undertaken by Filipino and Dutch researchers in Mt. Malindang and its environs, Misamis Occidental, Philippines. It is committed to undertake and promote participatory and interdisciplinary research that will promote sustainable use of biological resources, and effective decision-making on biodiversity conservation to improve livelihood and cultural opportunities.

BRP aims to make biodiversity research more responsive to real-life problems and development needs of the local communities, by introducing a new mode of knowledge generation for biodiversity management and conservation, and to strengthen capacity for biodiversity research and decision-making by empowering the local research partners and other local stakeholders.

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Acknowledgment

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Abstract

This study aimed to characterize the headwaters of Layawan River in Brgy. Sebucal, Oroquieta City, Philippines. The assessment focused on the physiography of the catchment area and the physicochemical and biological components of its major headwater streams. The research also assessed the biota of the riparian zones of the headwater streams as these zones represent the linkage between terrestrial and aquatic ecosystems in the landscape.

Aquatic macroinvertebrates found in the headwater streams were mostly indicators of good water quality, the number of morphospecies ranging from 14 to 29. Eight orders of insects, two classes of arthropods and one phylum represented the terrestrial invertebrate fauna. There were 72 tree species in the nine plots totaling to an area of 3600sq m. The fauna inventory included native and endemic species that are continually being threatened by activities of the local human population.

Results showed that headwater streams have low ion concentration. Total hardness ranged 50-158ppm, total alkalinity 48-156ppm and total dissolved solids (TDS) 89-240ppm. The pH is within a normal range (6.8-7.8). The presence/number of coliforms in all sites makes the river water unsafe for drinking. However, it still meets the standards for recreational purposes.

Although the barangay/village population only consists of 49-52 households consisting of approximately 250 individuals, their land use, hunting and fishing activities, extraction of timber and non-timber forest products, if uncontrolled and unregulated, all present threats to the conservation and sustainable use of biodiversity in this area.

Introduction

Mt. Malindang Range Natural Park is one of the protected areas of the Philippines located in the island of Mindanao (Figure 1). Among the catchment basins of Mt. Malindang Range is the Oroquieta watershed which is drained by Layawan River (Figure 2). The headwaters of Layawan River are located in Brgy. Sebucal, Oroquieta City. The barangay/village proper, where the human community is concentrated, has the coordinates of 8°19.428'N, 123°38.174'E at an elevation of ca. 960 meters.

Brgy. Sebucal is a more or less rolling plateau surrounded by steep mountains. At the base of these mountains are the gullies along which flow the headwater streams of Layawan River. There are three major headwater streams – one is also called Layawan, a stream crossed on the trail from Brgy. Lake Duminagat before reaching the main area of Brgy. Sebucal. The other stream, Panobigon (on the eastern side of Brgy. Sebucal proper) joins another stream, Manimatay, which continues on to join the Layawan tributary to form the single Layawan River. This meeting point is located on the trail going to Brgy. Mialen after one has passed the main settlement of Brgy. Sebucal (Figure 3). A hot spring rich in calcium carbonate is located beside the stream of Panobigon.

The assessment of the headwater streams of Layawan River in Brgy. Sebucal not only completes the profile of Layawan River but also establishes connectivity with the terrestrial ecosystems. Because of the intimate association of the headwaters with its catchment area or surrounding terrestrial ecosystems, the state of biodiversity, demographics and land use patterns in these areas correspondingly make an impact on the headwaters. Thus, the various aspects of study of the headwater streams that will be used for integration with the terrestrial landscape include the following:

- riparian flora (its relation to the surrounding forest plants);
- aquatic macroinvertebrates (its relation to terrestrial butterflies, dragonflies and other insects); and
- water quality and quantity (its relation with the surrounding terrestrial vegetation, bedrock and soil quality).

There is also a correlation between human activities in the headwaters and its catchment area, including agricultural activities and their utilization of the river and its biological resources, as they affect the quality and quantity of the water that flows into Layawan River. Consequently, this headwaters assessment study generated information and knowledge that would serve as inputs to a river basin/watershed/natural resource/land use management plan, which would then lead to the twin goals of biodiversity conservation and sustainable development in the Mt. Malindang area.

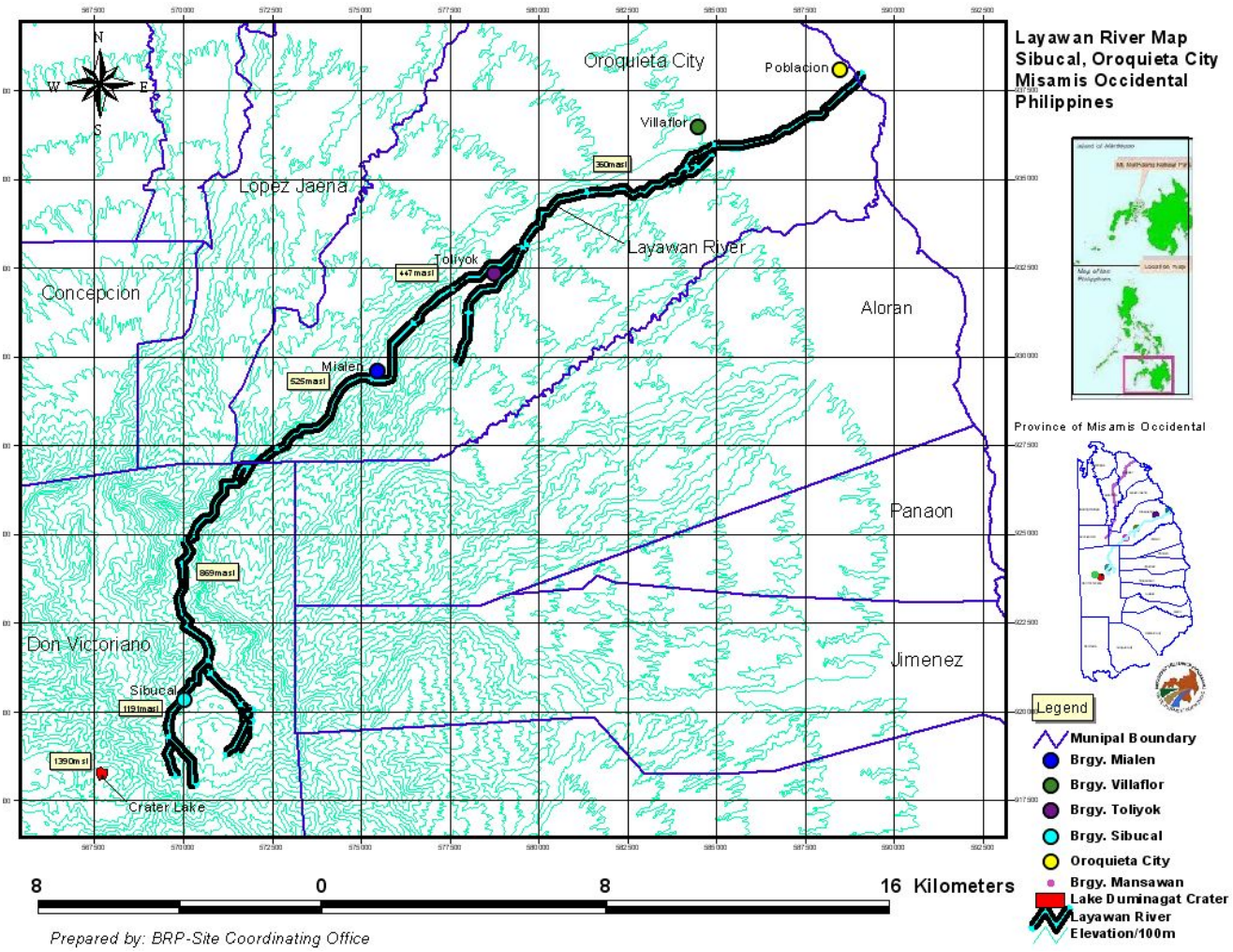


Figure 1. Location Map of the Study Area

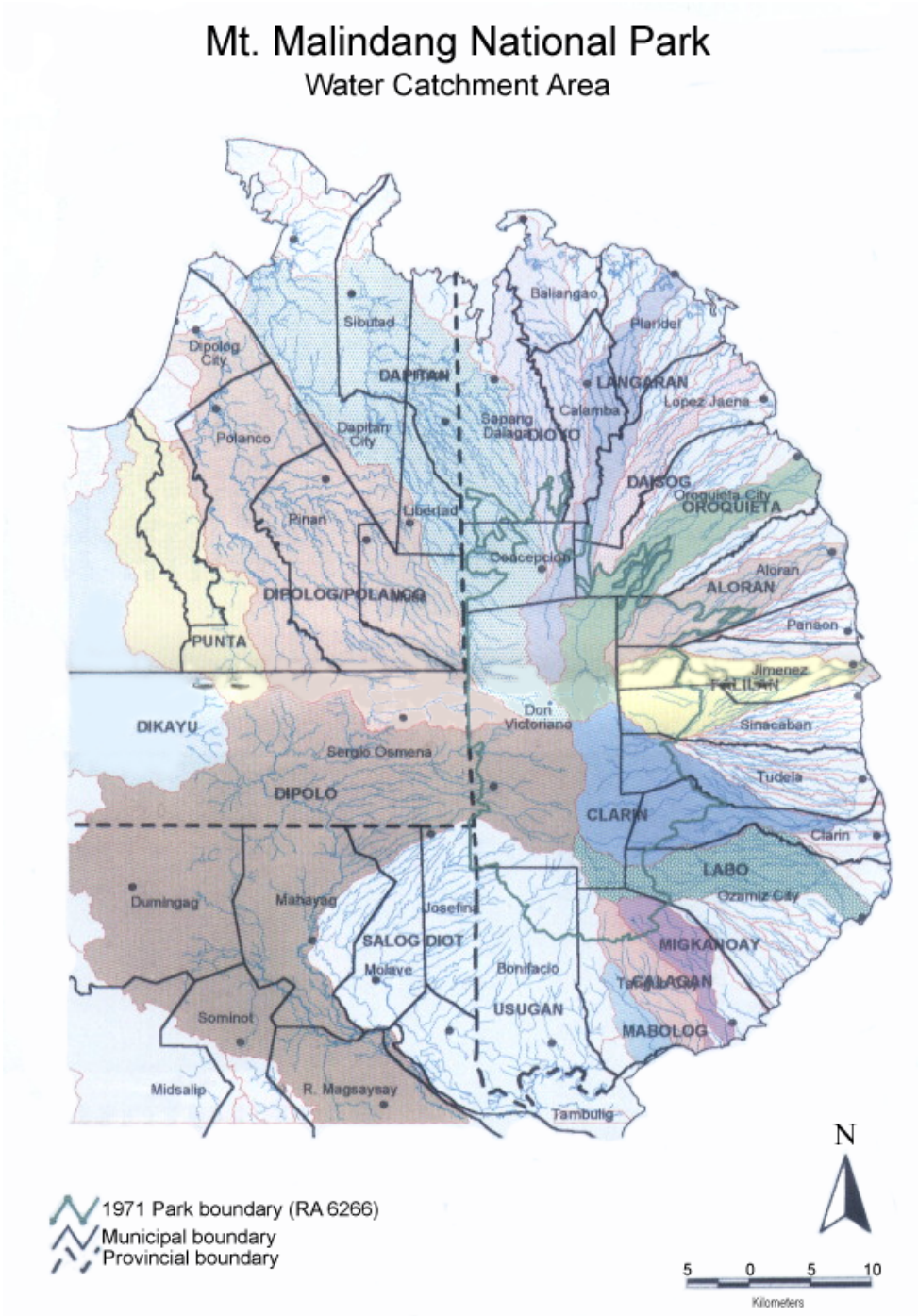


Figure 2. Mt. Malindang Water Catchment Areas, showing Layawan (Oroquieta) Watershed

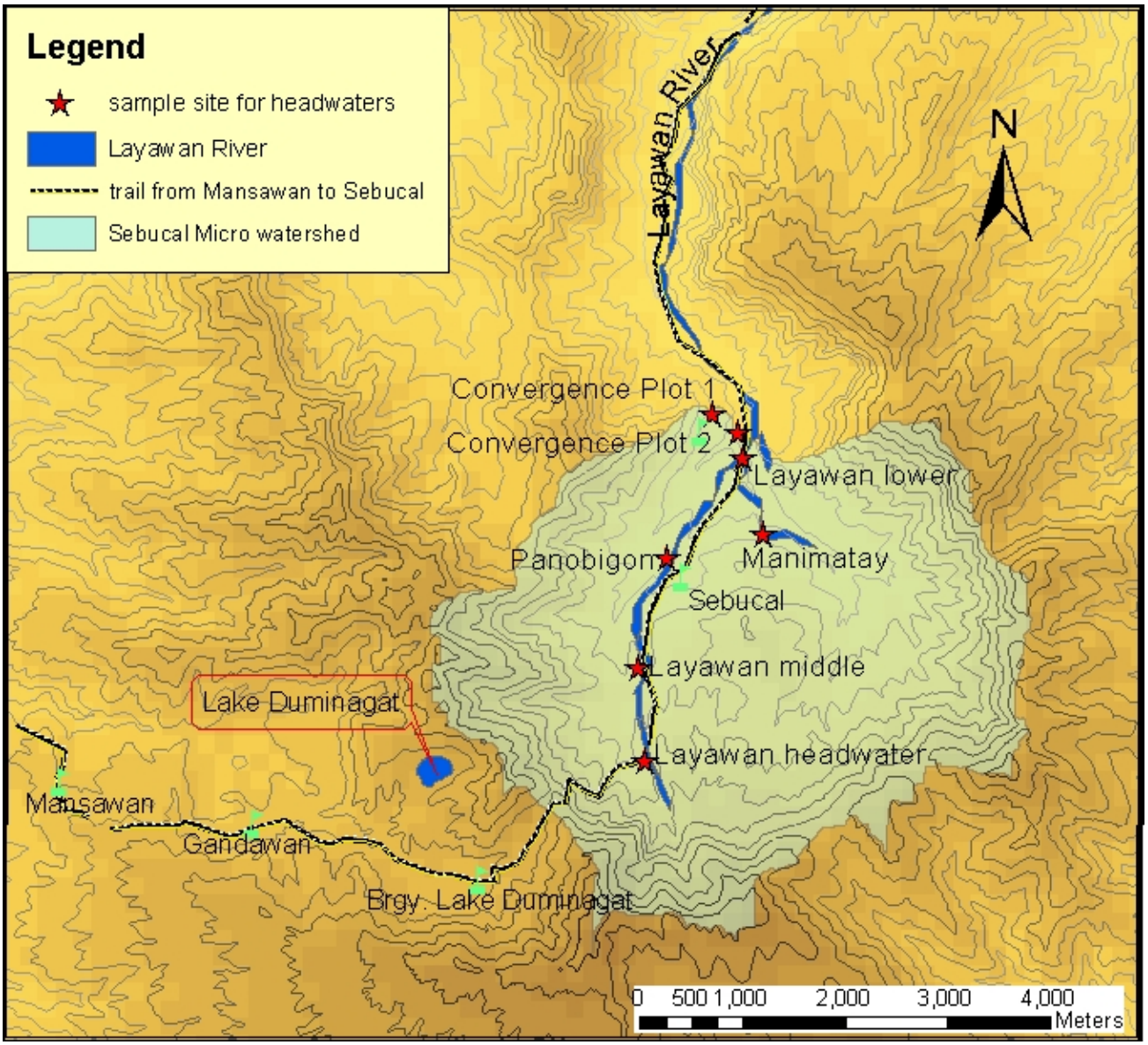


Figure 3. The Headwaters of Layawan River, showing the Study Sites

Review of Literature

Headwaters

Headwater and riparian environments are the areas that border streams, rivers, lakes and wetlands. Headwater streams are small, often perennial (only contain water for part of the year) and serve as the primary source of water for larger streams and rivers. Headwaters can be floodplains, streamside forests, or just plain stream banks. They are usually different from surrounding lands because they have unique soil and vegetation characteristics and are strongly influenced by water. Riparian zones are basically the interface between the water and the land, and they serve many functions, which make them valuable to people (http://www.ecology.uga.edu/outreach/Etowah-reports.htm).

Most of the water in large rivers and lakes comes from headwater streams. These streams provide unique habitat for terrestrial (land-dwelling) and aquatic (water-dwelling) plants and animals. The way we manage forests around these headwaters greatly influences the water quality of rivers and lakes (http://www.umaine.edu/cfru/Public/Research/Hagan_buffer/headwater_streams_generic_legal.pdf). The primary water quality problems of the headwaters region are due to erosion and sedimentation, elevated fecal coliform, temperature and nutrient levels.

Riverine and Riparian Landscape Elements

A river corridor is said to consist of five major landscape elements: surface water, bare gravel, vegetated islands, riparian forest and topographically low areas that are unforested (Tockner *et al.* 2003). A river may also be differentiated into the headwater section at its source, flowing into the upper rhithron zone (characterized by rapid water flow due to drastic changes in elevation), and ending into the lowland potamon zone (Payne 1986). It is expected that there is an important link between the flow regimes, channel geometry and the kind of aquatic plants and animals found.

Aquatic Macroinvertebrates

Benthic macroinvertebrates are animals without backbones that are large enough to be seen with the unaided eye and spend at least part of their life as bottom dwellers in lakes, ponds and streams (Kelly 2002). An extensive body of ecological theory has shown that benthic macroinvertebrate populations reflect the water quality of the streams they inhabit and that biological monitoring is an effective method for quantifying water quality impairment (Sutton 1995; McCafferty 1981). Several characteristics of benthic macroinvertebrates make them good indicators of water quality.

1. Macroinvertebrates show a wide range of sensitivity to physical and chemical changes in their habitat. As a result, their abundance and diversity can be viewed as a good indicator of stream health.

2. Because macroinvertebrates live in water for nearly a year and cannot escape from pollution as easily as fish and other more mobile organisms, they become a year-round barometer of water quality.

3. Macroinvertebrates are easy and inexpensive to collect as compared to other methods of water quality testing (Kelly 2002).

Numerous studies and field observations have shown that macroinvertebrates differ in their sensitivity to water pollution, specifically to dissolved oxygen. Different macroinvertebrates respond to varying amounts of dissolved oxygen in water, thus their presence or absence can indicate levels of pollution (Smith *et al.* 2002).

Terrestrial/Riparian Invertebrates

Different species of terrestrial/riparian invertebrates have different ecological requirements for survival. The butterfly, belonging to order Lepidoptera (fourth largest insect group in terms of diversity), is considered as a biological component of our ecosystem which affects human life in various ways either directly or indirectly, and in tangible or intangible manner. Indirectly, butterflies can be a source of food

and genetic materials, can contribute to psychological, emotional and mental stability, and have non-consumptive uses (inspiration of beauty, appreciation and companion animals or pets). According to Encabo (1999), butterflies play an important role in the living planet. They also have medicinal uses, which specifically identifies the chemical component of their food plants. Their food plants serve as a source of drugs (Feltwell 1993) and as a genetic material for gene diversity (Wu 1993).

Butterflies can be a biological indicator for environmental quality as a component of the natural landscape (Cheng 1993). Butterfly habitats depict the quality of their natural landscape and are indicators of a biologically wealthy environment (Quimpo 1983). The butterfly depicts the abundance of one's place (Brever 1989). Several thousands of species of butterflies are known worldwide. Their distribution varies; although they are found in almost the very coldest regions, they also occur abundantly in warmer climates (Daniels 2002), of which 61.2% of the world's butterfly are found in the Philippines (Treadaway 1995). The plight of imperiled butterfly species around the world continues to generate increased public interest and funding support. Plans have been created to conserve several critically endangered species of butterfly that are more of an aggressive, creative and cooperative nature than of those historically implemented for traditional vertebrate conservation programs (Daniels 2002).

Dragonflies, on the other hand, are highly responsible for keeping the number of small insects, many of which are pests to humans, in check. The number of mosquitoes, for example, would actually be much higher if it were not for dragonflies. Adult dragonflies usually live near water, which is where their reproductive activities take place. Nymphs usually live in water, including rivers, streams, ponds and lakes. However, some species can live in plant-trapped water, such as in tree stumps or among roots. Studies have also been done in which the nymphs do not seem to have preference for the pH level in a body of water. This means that dragonfly nymphs would not be a good indicator of this small part of environmental quality. However, dragonflies are unique among other aquatic insects in that they are able to feed during the nymph and the adult stages.

River Water Quality and its Indicators

The parameters for water quality, namely, total alkalinity, total hardness, total dissolved solids - are indicators of the total concentration of ions in a river. This total concentration, in turn, results largely from the interaction of rainwater with the land in its catchment area, including the nature of the bedrock and vegetation (Payne 1986). The final composition of stream water depends on the interplay of several variables. These include:

- the initial composition and amount of rain, and the nature of the movement of water from the catchment;
- the availability of an unknown number of chemical substances which become dissolved in the water and the reactions between them;
- the sources of these substances, i.e., local geology, soils and ecosystems; and
- the many ways in which the catchment may be altered by human populations, such as forest removal, cultivation and fertilization of land, and the building of settlements (Moss 1988).

Numerous studies and field observations have shown that macroinvertebrates differ in their sensitivity to water pollution, specifically to dissolved oxygen. Different macroinvertebrates respond to varying amounts of dissolved oxygen in water, thus their presence or absence can indicate levels of pollution. Midge larva specifically the "bloodworms" are very tolerant to pollution, while mayfly nymphs and caddisflies are highly sensitive to most types of pollution (Smith *et al.* 2002).

Countries like United Kingdom, Australia and Thailand have developed their own water quality monitoring systems and have come up with appropriate biotic indices that summarize complex biological data to describe water quality. Biotic index systems have also been developed which give numerical scores to specific "indicator" organisms at a particular taxon (Armitage *et al.* 1983).

Philippine Plant Diversity

The flora of the Philippines is composed of at least 13,500 species which represent 5% of the world's flora. The ferns and fern allies, gymnosperms and angiosperms constitute 22.5% of the Malesian and 3.88% of the world's vascular flora.

Among flowering plant families, the Orchidaceae, Rubiaceae, Euphorbiaceae, Myrtaceae and Moraceae have the greatest number of indigenous and endemic species. In some families, species endemism ranges from 15% (Poaceae) to 56% (Dipterocarpaceae) to 70% (Arecaceae) to as high as 94% (Orchidaceae).

There are only 33 species of gymnosperms with 18% endemism while there are 1,011 species of ferns and fern allies with 30% endemism. About 5-8% of the country's flora is believed to be still unidentified (DENR and UNEP 1997).

Avian Diversity Research in Mt. Malindang

To emphasize the ecological importance of Mt. Malindang Range located in western Mindanao, Philippines, the Mt. Malindang Natural Park was established and considered as one of the 117 Important Bird Areas (IBA) in the Philippines. Twenty-eight threatened and restricted-range species of birds were recorded in the park (Mallari *et al*. 2001). The first generation Biodiversity Research Project (BRP) inventory and assessment of riparian habitat focused on the Langaran River at the northeastern part of Mt. Malindang Range. The inventory recorded 52 bird species from Brgy. Singalat with an elevation of about 250m down to the coastal barangay of Catarman, all in the town of Calamba, Misamis Occidental. Two restricted range and threatened species, *Alcedo argentata* and *Penelopides affinis*, were observed, although *A. argentata* was not among the 28 threatened species listed by Mallari *et al.* (2001) for Mt. Malindang. A parallel study by Nuñeza *et al.* (2005) from 14 sampling sites in Mt. Malindang recorded 257 species of vertebrates, which included 26 amphibians, 33 reptiles, 162 birds and 36 mammals.

Rationale

The state of biodiversity, demographics and land use patterns in a catchment area or surrounding terrestrial ecosystems make an impact on the headwaters. Likewise, there is also a correlation between human activities, including agricultural activities, with the quality and quantity of the its river water.

Thus, this study was conducted to characterize the headwaters of Layawan River, assess the physiography of the catchment area and the physicochemical and biological components of its major headwater streams, examine the biota of the riparian zones of the headwater streams as these zones represent the linkage between terrestrial and aquatic ecosystems in the landscape.

Furthermore, this project was conducted to generate information and knowledge that would serve as inputs to the development of a river basin/watershed/natural resource/land use management plan. The plan would then lead to the twin goals of biodiversity conservation and sustainable development in the Mt. Malindang area.

Objectives

The assessment was conducted to characterize the physicochemical and biodiversity parameters of the headwater streams of Layawan River and its riparian zones to establish linkage between the terrestrial and aquatic ecosystems of the area. Research results are expected to contribute to the development of strategies for biodiversity conservation and sustainable development in the Mt. Malindang area.

Specifically, the project aimed to:

1. describe the physiographic, topographic, vegetational and settlement characteristics of the catchment area where the headwater streams of Layawan River are located;
2. assess the composition of the aquatic macroinvertebrate community, to include those in larval stages of the terrestrial insects found at or near the river, make inventory of this macroinvertebrates and identify possible livelihood activities out of them such as butterfly culture;
3. conduct an inventory of and assess the riparian flora, compare it with the surrounding forest ecosystem plants, describe its longitudinal distribution and come up with recommendations of desirable species of plants for restoration of degraded riparian areas;
4. conduct an inventory of the aquatic crustaceans and fishes and riparian vertebrate fauna and determine their diversity;
5. measure the water quantity (flow rate, river discharge) and water quality (total alkalinity, total hardness, total dissolved solids, total suspended solids, nitrate-nitrogen, phosphate-phosphorus, bacteria and coliform) in the three major headwater streams;
6. characterize the human community in this area with regard to certain demographic data (population size, sources of income) and their utilization of the river and its biological resources and possible indigenous knowledge related to this use;
7. establish links between terrestrial and human dimensions of the Mt. Malindang system; and
8. come up with recommendations for the management of natural resources and land use in this area.

Methodology

Ensuring Community Participation

Involvement of the local community was first sought through community meeting where there were presentation and consultation about the proposed study. Furthermore, the services of local researchers/partners for the various components of the study were contracted with the expectation that their training/experience in the study will make them capable of helping the community monitor the state of biodiversity in their area, if and when they so desire. The data and results obtained were presented to the community in a community validation meeting. Recommendations were also presented for feedback.

Landscape Analysis

Using the maps from the Department of Environment and Natural Resources-National Mapping Resources and Information Agency (DENR-NAMRIA), descriptions of the physiography and topography of the catchment of Layawan River, which is concentrated at the headwaters area were made. Various references (e.g., Christopherson & Hobbs 1998) and consultation with a civil engineer (John Hansel) were used in determining certain parameters (area, slope, distance).

The Layawan headwaters section of the map was computer-scanned and subsequently enlarged to facilitate measurements. The catchment area of the headwaters of Layawan River was delineated by drawing the boundary at the ridges of the surrounding mountains, and then choosing the downstream boundary as a line at the convergence of the headwater streams (to form a single Layawan River) which is drawn perpendicular to the lateral boundaries. The catchment area is then divided into three sub-watersheds drained by the three major headwater streams – Layawan, Panobigon and Manimatay.

Their borders were also established at the ridges of the intervening elevated areas. The areas of each subcatchment (Layawan, Panobigon and Manimatay) were measured using a planimeter. The slope of the surrounding mountains in each sub-catchment area was calculated with the use of the formula, Slope=arctan (Vertical distance/ Horizontal distance). Vertical distance was determined by counting the intervening contour lines that were at 20-m intervals and multiplying by 20m, while horizontal distance was determined with a mm ruler and converted to meters based on the scale of the map. The resulting number is the tangent of the angle of the slope, wherein tan 45°=1.00. Slope is expressed in degrees by finding the equivalent angle of the obtained tangent, or expressed as percent by multiplying the quotient with 100.

Knowing the scale of the map, lengths of the headwater streams and distances between designated locations were measured by means of a string. A GPS unit (Garmin eTrex) was used onsite to obtain the coordinates of the specific sampling sites along Layawan River and its headwaters. A Dutch collaborator (Aart van den Berg) and the BRP GIS group utilized LANDSAT infrared maps and ArcView software for vegetational and other land use analysis of the area.

Data Collection and Sampling

Sampling for this study was conducted from October 2004 to March 2005.

Sampling of Macroinvertebrates

Macroinvertebrates in the fast and slow moving sections of the three major headwater streams (Layawan Lower, Panobigon and Manimatay) and at the Layawan Convergence were sampled. Basic characteristics of the habitats were noted onto water quality data sheets (Figure 4). Benthic sampling was done following the modified version of the Environmental Protection Agency Rapid Bioassessment Protocol II using a single habitat approach. In each station, the fast flowing deep and slow moving shallow areas were sampled. Aside from the two habitats, presence/absence of the different kinds of macroinvertebrates was also determined at other randomly selected sites within a 100m reach of the sampling site.

To sample, the research team was organized into eight pairs, had 1x1m macrofaunal net and

BRP Mount Malindang Mindanao Philippines

River	Loc id	Year	Month	Day	No

Locally

Lat	Long	Time from	to	Photo #
8° N	123° E			

Researchers

Weather

Sun	25% clouds	50% clouds	75% clouds	Overcast	Light rain	Storm	Notes

Water width	Water color	Velocity	Water color
m	cm	M/s	

Bottom

Rocks	Cobbles	Pebbles	Coarse Sand	Fine Sand	Silt	Detritus	Other

Shades

No shade	Light shade	Full Shade

Vegetation (bank)

Without	Herbs	Bushes	Forest

Pollution

None	Light	Heavy housh	Heavy other

Vegetation (water)

None	Patchy	Open	Close

Samples

Hand	Kick Scoop w/ net	Surface	Other

Group (Collected)

Porifera	Hydrozoa	Oligochaeta	Hirudinea	Tricladida	Mollusca	Decapoda	Isopoda	Acari
Arachnida	Collembola	Ephemeroptera	Odonata	Plecoptera	Trichoptera	Trichoptera	Dicholironon	Dicother
Nepomorpha	Gerromorpha	Coleoptera	Megaloptera	Other insects			Places	Amphibia

Group (Observed)

Porifera	Hydrozoa	Oligochaeta	Hirudinea	Tricladida	Mollusca	Decapoda	Isopoda	Acari
Arachnida	Collembola	Ephemeroptera	Odonata	Plecoptera	Trichoptera	Trichoptera	Dicholironon	Dicother
Nepomorpha	Gerromorpha	Coleoptera	Megaloptera	Other insects			Places	Amphibia

Sketch

Figure 4. Sample Data Sheet for Hydrobiological Research on Macroinvertebrates

positioned themselves at 1-m intervals along the river width. For each working pair, one member held the net with the tip of the bag in a vertical position against the rocky riverbed with the mouth facing upstream while the partner disturbed (by kicking, jabbing) the area upstream at a distance of about 1m, allowing the macroinvertebrates to be transported and dislodged into the net. Large rocks and logs in the area were kicked and washed off within the net.

In slow or still water, the stones were lifted and stirred with hands or a booted foot just upstream of the net. Scooping and sweeping of the net into the water, beneath submerged wood and debris, allowed the collection of many invertebrates. Sorted macroinvertebrates were then transferred into an ice cube tray and each kind was counted and recorded for use in determining diversity index.

Sampling of Riparian / Terrestrial Invertebrates

Sampling of riparian/terrestrial invertebrates was patterned after the method used by the Terrestrial Ecosystem Master Project (TEMP), with the additional use of the time constraint sampling technique. Three field visits were conducted in the four study sites: Layawan Upper, Layawan Lower, Panobigon and Manimatay, devoting two hours each per field visit for a total of six hours per study site.

Sweep nets were used to collect insects on each site at the different habitats (if present): over the water, over the gravel area, over a vegetated island and over the riparian area. Vegetation was also examined for the presence of insects, carabid beetles (Insecta, Coleoptera) and arachnids, which were collected.

Sampling of Riparian Flora

The tree abundance and profile were determined in the established 40x10m plots. The diameter at breast height (dbh) of each tree was measured by using a metric tape. Counts were done for the shrubs in the 5x5m subplot and that for the herbs and grasses in the 1x1m subplot. Representative specimens with reproductive structures were collected, the appropriate field data was noted, and the specimens were preserved for subsequent pressing, drying and preparation of voucher specimens (Jones and Luchsinger 1986). Collections were made two times so as to catch the different plants in their reproductive stage, which are essential for their identification.

Identification of the plants was done using references (e.g., de Guzman *et al.* 1986; Merrill 1912; van Balgooy 1997, 1998) and in consultation with a research collaborator (Paul Kessler), Filipino systematist (William Gruezo) and the TEMP Flora Team. Plant samples without reproductive structures could not be identified definitively.

Ethnobotanical uses were asked from the local researchers/laborers as collection, preservation and identification (as to local names) of the plants were being done. Key informants (if available) were interviewed using either fresh, or dried pressed specimens, or photographs.

Sampling of Riparian Vertebrate Fauna

Three sampling sites were established along the riparian area of Brgy. Sebucal where collection and observation of specimens were done: Site 1, along Layawan Gamay; Site 2, where Manimatay and Panobigon tributaries joined; and Site 3, after the three tributaries have fused to become the Layawan River (Layawan Convergence). Identification followed those of Kennedy *et al.* (2000) for birds; Heaney *et al.* (1998) for mammals; Alcala (1986) for reptiles and amphibians; Alcala and Brown (1998) for amphibians; and Herre (1924) and ICLARM Fishbase (2000) for fishes.

Sampling of Birds

Forty nets were deployed in the different habitats along the riparian area of the three designated sites. Most of these nets were elevated at about 2m above ground, some were less than 1m and others were much higher at more than 3m reaching the middle level and upper level branches of second-growth trees.

The nets were put up at about 6:30 every morning and taken down every 6:00 in the evening. The nets were inspected twice in the morning and twice in the afternoon. All birds caught by the nets were then brought to the camp, identified and recorded. About 2-4 specimens of each species were used as voucher

specimens. The rest, after marking the under wings with waterproof Pentel pen, were released after gender identification and length measurements were recorded for tail, wing, tarsus, bill, snout bent and total length. Around 200 net days each were done at Sites 1 and 2, while 400 net days for Site 3.

Sampling of Mammals

Live traps (a trap in which animals can be captured alive) baited with ripe banana, corn on cobs, cassava tuber, dried fish and earthworms were used. These were placed on the ground among roots, shrubs, logs and rocks along the riparian area on each site. These traps were left open throughout the day and night. These were inspected every late afternoon and early morning. Traps with specimens were brought to the campsite for processing of the specimens. Voucher specimens were preserved with formalin or skinned. The rest were marked and released after gender identification and length measurements were recorded for tail, tibia and fibula, radius ulna, snout bent and total length.

Forty such traps were deployed for a total of 200 trap days each for Sites 1 and 2 and 400 trap days for Site 3. Readily-identifiable footprints of wild pigs along the trail were recorded. Local hunters who served as assistants facilitated identification of the animals.

Sampling of Herpetofauna

Sampling for herpetofauna was incidental. While checking traps for mammals and bird nets, constant watch for reptiles and amphibians was made. These specimens were collected with bare hands aided by a stick with caution for encountering venomous snakes. Amphibians were collected mostly along the river early in the morning and late in the afternoon.

Sampling of Aquatic Crustaceans and Fishes

Ten fish traps (locally called *balantak*) were deployed each night for five nights among the submerged rocks and underwater crevices in each site. These traps were retrieved every morning and deployed again the next night. Daytime sampling was done with a fish net with mesh measurement of 0.25inch. The net dimension was 10x1m and was dragged upstream for a distance of 10m. At the end of 10m distance, the net was immediately closed and taken ashore. Four such nettings were done for each site.

Because of the nature of this method which requires that the net be dragged upstream, only sections of the river where the current was weak and where the substrate lacked irregularities offered by large protruding rocks could be sampled. Daytime spearfishing was done during late mornings to supplement the above methods. This was done by two local assistants armed with locally-made spear guns, wearing goggles and done for 10 hours in selected sections along the river in each sampling site.

All specimens caught were brought to the camp for processing. Individual measurements for large specimens were taken, like total length and weight and the numbers caught, while very small specimens were weighed in bulk and the length of the biggest and smallest specimens were recorded.

Water Sampling

The important water quality parameters measured in this study included physico-chemical and biological parameters like temperature, dissolved oxygen, percent oxygen saturation, total alkalinity, total hardness, total dissolved solids, total suspended solids, nitrate, ammonia, phosphate, heterotrophic bacterial count and coliform.

On-site measurement of dissolved oxygen, percent oxygen saturation and temperature was done with a DO meter. Measurements were done at and water samples taken from one site each of the three major headwater streams (Layawan Lower, Panobigon, Manimatay) and at the Layawan Convergence. Water samples were subjected to total alkalinity, total hardness and total dissolved solids tests at the Iligan City Waterworks System Office. The test also included bacteriological analysis (heterotrophic bacterial count and coliform test).

Water samples for determination of nitrate, ammonia, phosphate and total suspended solids (TSS) were brought to Mindanao State University (MSU)-Naawan for analysis. Inasmuch as sediment contributing to TSS results from soil erosion and rainfall is the primary agent of erosion, the TSS data was correlated with the TEMP rainfall data.

Data Analyses

Descriptive analyses were done for most of the components of the study. Cluster analyses and correlations among the various parameters were done with the use of certain statistical software, such as Biodiversity Pro, PC-ORD and SPSS.

With the aim of developing appropriate and applicable water quality monitoring system in the country which could be used in a management program, two biotic indices were tried: Water Quality Index (WQI) and Average Score Per Taxon (ASPT).

Measuring Water Quality Using WQI

In this system, the identified macroinvertebrates were sorted and scored. Based on the pictorial guide that comes with the system, the animals were identified. A matrix that indicates corresponding points for a particular macroinvertebrate species present, regardless of the species' abundance, was used for scoring (Table 1). After all the animals were scored, the sum was obtained and then divided by the number of animal types scored. The resulting value is the WQI, described based on the following range of scores:

score 7.6–10:	very clean water
score 5.1–7.5:	rather clean – clean water
score 2.6–5.0:	rather dirty water – average
score 1.0–2.5:	dirty water
score 0:	very dirty water (no life at all)

Measuring Water Quality Using ASPT

The system is based on ascribing scores between 1 and 10 to different families of macroinvertebrates encountered. This system assumes that identification of the organisms must be up to the family level. The families most sensitive to pollution are on the top of the list and are assigned a score of 10. The more tolerant families get a lower score. All families present in the combined samples, which are composed of all samples taken at the two sections of the river, are listed. The ASPT is calculated by dividing the Biological Monitoring Working Party (BMWP) score (Table 2) calculated by adding the individual scores of all indicator organisms present by the number of families present. The ASPT values correspond to a water quality described as follows:

5 and above:	excellent
4-4.5:	good
3-3.5:	moderate
2-2.5:	poor
1-1.5:	very poor

Diversity Indices

The following diversity indices were calculated for both riparian/terrestrial invertebrates and riparian flora: species richness, Shannon's diversity index, Simpson's index of diversity, index of dominance and Sorensen's similarity index, according to the formulas given by Odum (1971). The computer software program Biodiversity Pro was used in the calculations of Shannon index, Simpson index and index of dominance.

Biodiversity Pro uses the logarithm to the base 10 rather than the natural logarithms recommended by ecologists. The index of dominance (Simpson index) for trees is based on the sums of the basal coverage area computed from the dbh for each species. Sorensen's similarity index was used to compare the riparian flora data in the different sampling sites and with the riparian flora data in the downstream barangays of Layawan River (Mialen, Toliyok, Bunga, Villaflor) to find out the longitudinal spatial distribution and migration of plant species.

Demographics, Resource Utilization and Indigenous Knowledge

Demographic data and human activities in the area were assessed through interviews with the barangay captain and the household heads. Because of the limited number of households, complete enumeration was attempted. However, not all household heads were present and some declined to be interviewed. Indigenous knowledge on the use of the river and its resources were gathered through interviews with the household heads and key informants. Participant observation was used to describe other characteristics of the village.

Table 1. Scoring of Macroinvertebrates to Yield the WQI

ANIMAL	SCORE
Stonefly Nymph (Plecoptera)	10
Flattened Mayfly (Ecdyonidae)	10
Prong-gilled Mayfly (Ephemeroptera)	10
Spiny crawling Mayfly Nymph (Ephemeroptera)	10
Caddisfly larvae with sand/gravel cases (Goeridae)	10
Caseless Caddisfly larvae (except*) (Tricoptera)	10
Long-mouthed Saucer Bug (Aphelocheiridae)	10
Dobsonfly Larvae (Corychilidae)	9
River Prawns (Palaemurridae)	8
Caddisfly larvae with cases made from leaf (Lepidoptera)	7
Dragonfly Nymphs (Odonata)	6
Damselfly Nymphs (Odonata)	6
Freshwater Limpets (Aneytidae)	6
Swan Mussels (Unionidae)	6
Pagoda Snails (Hyrobiidae)	6
Lesser Water Boatmen (Pleidae)	5
Greater Water Boatmen (Notonectidae)	5
Other Water Bugs (Hemiptera)	5
Adult Beetles (Dystidae)	5
Beetle Larvae (Coleoptera)	5
Flatworms (Dendrocoedae)	5
Other Fly Larvae (except*)	5
Common Net-Spinner Larvae* (Hydropsychidae)	5
Swimming Mayfly Nymphs (Baetidae)	5
Square-gilled Mayfly Nymphs (Caenidae)	4
Freshwater Shrimps (Gammaridae)	4
Alderfly Larvae	4
Other Snails (Gastropoda)	3
Pea Cockles (Sphaeridae)	3
Water Hoglouse (Asellidae)	3
River Crabs (Decapoda)	3
Leeches (Hirudinea)	3
Rat-tailed Maggots* (Syrphidae)	3
Non-biting Midge Larvae* (Chironomidae)	2
Segmented Worms (Oligochaeta)	1

WQI Scoring System

7.6 – 10	- very clean water
5.1 – 7.5	- clean or rather clean
2.6 – 5.0	- average or rather dirty
– 2.5	- dirty water
0	- very dirty water (no life at all)

Table 2. Biological Monitoring Working Party (BMWP) Average Score per Taxon (ASPT) Scoring System

Taxonomic Class	Taxonomic Families	Score
Ephemeroptera	Ephemeridae	10
	Heptagoniidae	10
	Leptophlebiidae	10
	Pothamanthidae	10
	Siphonurridae	10
Plecoptera	Capniidae	10
	Chloroperlidae	10
	Leuctridae	10
	Perlidae	10
	Taeniopteterygidae	10
Hemiptera	Aphelochereididae	10
Trichoptera	Beraecidae	10
	Brachycentridae	10
	Goeridae	10
	Lepidostomatidae	10
	Leptoceridae	10
	Mollanidae	10
	Odontoceridae	10
	Phyrgancineidae	10
	Sericostomatidae	10
Ephemeroptera	Caenidae	7
Plecoptera	Nemouridae	7
Trichoptera	Rhyacophilidae	7
	Polycentropodidae	7
	Limnepphilidae	7
Mollusca	Neritidae	6
	Viviparidae	6
	Ancylidae	6
	Unionidae	6
Trichoptera	Hydroptilidae	6
Crustacea	Corophiidae	6
	Gammaridae	6
	Paleamonidae	6
Polychaeta	Nereidae	6
	Nephthyidae	6
Odonata	Plaqthycnemididae	6
	Coenagriidae	6
Hemiptera	Mesovelidae	5
	Hydrometridae	5
	Gerridae	5
	Nepidae	5
	Naucoridae	5
	Notonectidae	5
	Pletidae	5
Coleoptera	Corixidae	5
	Haliplitidae	5
	Hygrobiidae	5
	Dytiscidae	5
	Gyrinidae	5
	Hydrophilidae	5
	Helobidae	5
	Dryopidae	5
	Eliminthidae	5
	Chyssomelidae	5
	Curcuionidae	5
Phyrgancineidae	Hydropsychidae	5
Diptera	Tipulidae	5
	Simullidae	5
Planaria	Planariidae	5
	Dendrocoelidae	5
Ephemeroptera	Baeitilidae	4
Megaloptera	Sialidae	4
Hirudinea	Piscicolidae	4
Mollusca	Valvatidae	3
	Hygrobiidae	3
	Lymnaeitidae	3
	Physidae	3
	Planorbidae	3
	Sphaeriidae	3
Hirudinea	Erpobdellidae	3
	Glossiphonidae	3
	Hirudidae	3
Crustacea	Asellidae	3
Diptera		
Oligochaeta		
Others	Alderfly	4
	Shrimps	6
	Hoglice	3
	Blackfly	5
	Cranefly	5
	Madgse	2
	Worms	1

BMWP = sum of score of organism found
ASPT = divided by the number of group found

5 – 5	excellent
4 – 4.5	good
3 – 3.5	moderate
2 – 2.5	poor
1 – 1.5	very poor

Results and Discussion

Physiographic Description of the Study Area

The DENR-NAMRIA Mt. Malindang map, which was based on 1953 aerial photographs, shows the Mt. Malindang mountain range to be forested without any human settlements. However, the map shows a trail from Oroquieta along the Layawan River up to beyond the center of Brgy. Mialen. The human settlement area of Brgy. Sebucal is shown as scrubland or grassland. Theoretically, based on climate, the whole of the Philippines, if left undisturbed, should develop a tropical rainforest. It is a puzzle then why the Brgy. Sebucal area at that time was grassland. Either there was an original rainforest that was destroyed or the soil conditions would favor grassland rather than a rainforest.

The Layawan sub-watershed has an area of 787ha; Manimatay sub-watershed, 980.9ha, while Panobigon has the smallest sub-catchment area of 120.9ha. The main Layawan headwater stream up to the convergence point has a length of about 4775m, and that of the main Manimatay headwater stream, 4200m. The Panobigon headwater stream up to where it joins Manimatay only has a length of 1450m.

Description of Plots / Sampling Sites

Description of the three fauna sampling sites showing their GPS readings and their respective physical parameters are shown on Table 3. Sites for sampling of aquatic macroinvertebrates include Site 2, Site 3, Layawan Lower and Panobigon (beside Hot Spring). Sites for the riparian invertebrates include Site 2, Layawan Lower, Layawan Upper and Panobigon. Sites for the riparian flora plots include Site 1, Site 2, Site 3, Layawan Lower, Layawan Upper and Panobigon.

Table 3. Description of the Three Sampling Sites Showing their GPS Readings and their Respective Physical Parameters

Site / Parameter	Site 1 (Layawan Gamay)	Site 2 (Panobigon and Manimatay Junction)	Site 3 (Layawan River)
GPS readings	N 8°19.064' E 123°37.919'	N 8°19.983' E 123°38.605'	N 8°20.301' E 123°38.581'
Elevation	1023 masl	805 masl	779 masl
River width (average)	2 m	5 m	10 m
River depth (average)	.4 m	.8 m	.8 m
Width of riparian area (average)	5 m	8 m	25 m

Site 1 (Layawan Gamay, specifically Layawan Middle)

Layawan Gamay is one of the tributaries of the Layawan River (Figure 5). It is actually just a stream. The valley through which this stream cuts through is very narrow, bounded on the two sides by high and steep slopes dominated by second growth forest. Along certain areas of the slope are farm lots planted to various crops.

Of the three sites, Site 1 is nearest to the barangay center and is often traversed by the locals who have farm lots on the opposite slope. Shrubs, tall grasses and some small trees dominate the associated riparian area. The streambed itself is dotted with small (less than 1m in diameter) to medium sized (more than 1m to about 2m in diameter) boulders and a few large boulders (more than 2m).

Site 2 (Manimatay and Panobigon Convergence)

This site is the convergence of Panobigon and Manimatay, both are small tributaries. The convergence carries the name Manimatay, the latter being the bigger of the two streams and further downstream joins the Layawan River (Figure 6). It is the least accessible of the three sites, being separated from the center of the barangay by two steep forested slopes. The valley through which the river courses is wider, bounded on the two sides by high slopes dominated by original forest. Shrubs and second-growth trees along with original forest dominate the lower riparian region of this river, while the upper riparian region has patches of second-growth forest and original forest. The riverbed is dotted with boulders of varying sizes.

Site 3 (Layawan Convergence)

The Layawan River in this site is the convergence of the two tributaries, Layawan Gamay and Manimatay (Figure 7). High slopes dominated by original forest bounded the river valley. The riparian area, on the other hand, has patches of this forest interspersed with second-growth and sometimes with active as well as abandoned farm lots overgrown with shrubs and tall grasses. The riverbed, which is wider, is dotted still with boulders. The trail going down Brgy. Mialen and other barangays downstream is along the riverbanks. The locals traverse the trail almost daily.

Land Use Types

Farms are located at the less steep downslopes, where corn and various rootcrops (cassava, sweet potato, gabi) are planted. The steep slopes still have primary forest cover. Coconuts are planted within the political boundary between Brgys. Sebucal and Mialen.

Analysis of the satellite maps and groundtruthing the land use of the various sections of the map generated Figure 8 and Table 4. The figure shows the distribution of land cover type in various sections of the Layawan (Oroquieta) watershed. Although Brgy. Sebucal is within the core protected area of Mt. Malindang Range Natural Park inside the municipality of Don Victoriano, administratively, it is under the City of Oroquieta.

Assessment of Aquatic Macroinvertebrates

The kind of aquatic macroinvertebrates, abundance of each kind and the biotic indices (ASPT and WQI) for the sampling sites are reflected in the following tables: Table 5 for Manimatay, Table 6 for Panobigon, Table 7 for Layawan Lower and Table 8 for Layawan Convergence. Biotic indices in the slow-moving water, fast-moving water and the overall ASPT and WQI are shown in the same tables.

Among the four sampling sites, the most number of aquatic macroinvertebrates was recorded at Manimatay: 782 individuals classified in 25 families with two unidentified macroinvertebrates.

Panobigon stream recorded the highest ASPT (8.04) followed by 7.91 at Manimatay, 7.62 in Layawan Convergence and 7.21 in Layawan Lower. Translation of the overall ASPT values to assess water quality resulted to EXCELLENT water for all sites. This finding slightly differs from that of the WQI computed values. With WQI, the highest value of 7.74 was recorded by Lower Layawan while the three other sites yielded values ranging from 6.55 – 6.96. The WQI of Lower Layawan fell under the category of VERY CLEAN WATER, while that of the other sites fell under the category of a RATHER CLEAN – CLEAN WATER.

Figure 5. Site 1 (Layawan Gamay, specifically Layawan Middle)

Figure 6. Site 2 (Manimatay and Panobigon Convergence)

Figure 7. Site 3 (Layawan Convergence)

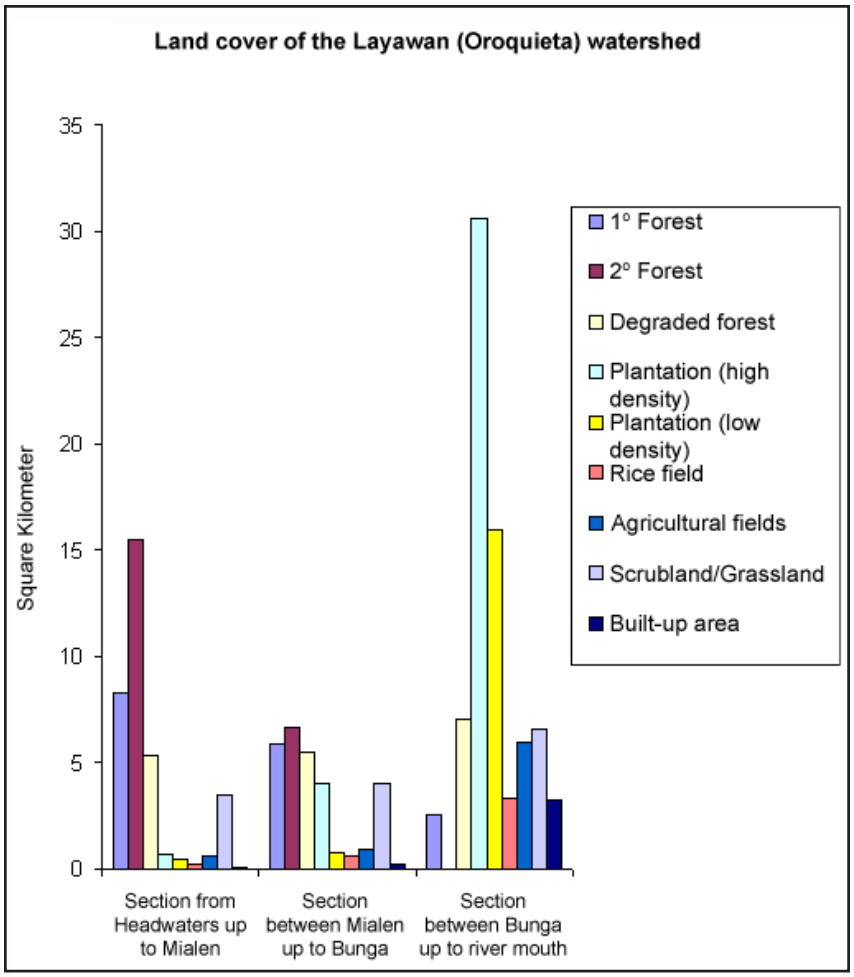


Figure 8. Distribution of Land Cover Type in the Various Sections of the Layawan (Oroquieta) Watershed

Table 4. Distribution of Land Cover Type in the Various Section of the Layawan (Oroquieta) Watershed

Land Cover	Section from Headwaters up to Mialen (Km²)	Section between Mialen up to Bunga (Km²)	Section between Bunga up to River mouth (Km²)
1° Forest	8.2647	5.8482	2.5578
2° Forest	15.4755	6.6609	0
Degraded forest	5.3424	5.5125	7.0281
Plantation (high density)	0.6624	3.9834	30.6378
Plantation (low density)	0.4563	0.7614	15.9849
Rice field	0.189	0.5616	3.2769
Agricultural fields	0.612	0.8991	5.958
Scrubland/Grassland	3.4614	3.9879	6.5682
Built-up area	0.0918	0.1944	3.2082

Table 5. Abundance of Macroinvertebrates at Manimatay

Macro Data
Site: Manimatay
Date: October 27, 2004

	Slow Moving							Fast Moving											
Family Name	**N1**	**N2**	**N3**	**N4**	**Total**	**ASPT**	**WQI**	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**N7**	**N8**	**Total**	**ASPT fast**	**WQI fast**	**ASPT**	**WQI**
Aphelocheiridae	0	0	0	0	0	0	0	0	0	0	5	4	24	0	0	33	10	10	10	10
Baetidae	0	1	1	2	4	4	5	2	107		2	4	4	5	0	124	4	5	7	5
Balloon-tailed Damselfly	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	8	6	10	6
Coleoptera	0	0	0	1	1	5	5	0	0	0	0	0	0	0	0	0	0	0	5	5
Corduliidae	0	1	0	0	1	8	6	0	0	0	0	1	0	0	15	16	8	6	8	6
Decapoda (river crab)	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	0	3	0	3
Dendrocoelidae	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	5	5	5	5
Ecdyonuridae	1	0	0	0	1	10	10	2	48	0	0	1	0	0	0	51	10	10	10	10
Gammaridae	0	0	0	1	1	6	8	2	2	0	0	3	0	0	0	7	6	8	6	8
Gerridae	1	0	0	2	3	5	5	0	0	0	0	0	0	1	0	1	5	5	5	5
Goeridae	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	10	10	10	10
Gomphidae	0	0	1	2	3	8	6	4	0	4	4	3	0	0	15	30	8	6	8	6
Hydropsychidae	3	0	1	3	7	5	10	29	0	14	2	10	21	4	26	106	5	10	7	10
Leaf-cased Caddis	0	1	5	1	7	10	7	2	0	2	0	1	0	0	0	5	10	7	10	7
Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Lepidostomatidae	0	0	2	0	2	10	7	0	1	0	3	0	0	0	0	4	10	7	10	7
Libellulidae	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	8	6	8	6
Naucoridae	0	1	5	8	14	5	5	23	0	30	20	36	53	23	4	189	5	5	5	5
Nemouridae	0	1	0	0	1	7	10	10	0	18	2	21	0	0	6	57	7	10	7	10
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	8	6	8	6
Philopotamidae	0	0	0	0	0	0	0	13	0	6	0	1	0	0	1	21	8	10	10	10
Rhyacophilidae	0	1	0	0	1	7	10	13	0	16	3	10	17	1	5	65	7	10	10	10
Riffle-beetle	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	4	0	5	0	5
Siphlonouridae	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	3	10	10	10	10
Tipullidae	0	1	0	0	1	5	5	0	0	0	2	0	0	0	0	2	5	5	5	2
Unidentified 1	0	1	0	0	1	0	0	0	0	0	2	0	0	0	2	4	0	0	0	0
Unidentified 2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Total					48	95	99									734	157	165	174	167
Number of Families						14	14										21	23	22	24
Index						6.8	7.1										7.48	7.17	7.91	6.96

Vegetation: lush-green, surrounded with trees, predominantly mountain agoho

The River
-- with big rocks
-- narrow river bed
-- deep; greater area of still waters than rapids

Table 6. Abundance of Macroinvertebrates at Panobigon

Macro Data
Site: Panobigon
Date: October 26, 2004

Family Name	Slow Moving				Fast Moving				Rapids				Total
	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4	
Aphelocheiridae					2	1	11						14
Baetidae					9	5			1	5			20
Balloon-tailed Damselfly					6		1		2	1		2	12
Beetle-like ephemeroph					1								1
Beraeidae						1				2			3
Coleoptera				2	25		4			1		4	36
Decapoda (river crab)	1				1			1		1	1		5
Dendrocoelidae					1								1
Ecdyonuridae				1	6	4	5		1	1			18
Gerridae	7	7	3	3			3					1	24
Hydropsychidae					2	2	1	4		1		3	13
Leaf-cased Caddis		1				2			1	1		9	14
Lepidistomatidae			1			8	5		1	1		1	17
Libellulidae				4	2								6
Naucoridae	1				1	1	2		5	4		4	18
Nemouridae							41	3				29	73
Notonectidae		1											1
Odonata	1					1							2
Odonata 1										1			1
Odonata 2										1			1
Odonata 3										1			1
Perlodidae		20			10	11	4		2		38		85
Philopotamidae					1								1
Plecoptera 1		5										5	10
Rhyacophilidae						1	1						2
Simullidae					1			1					2
Unidentified 1								1					1
Unidentified 2									1	1			2
Unidentified 3												1	1
White plecoptera										2			2
Worm-like												1	1
											TOTAL		388

Remarks: very clear water, small river bed, presence of a hot spring tributary
Aphelocheiridae - kato sa tubig
Baetidae - tunga
Cordullidae - alindanao
Dendrocoelidae - guban; mosulod sa ilong (enters the nose)

Table 7. Abundance of Macroinvertebrates at Layawan Lower

Macro Data
Site: Layawan Lower
Date: October 27, 2004

Family Name	Slow Moving				Fast Moving				Rapids				Total
	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4	
Aphelocheiridae						2	2				3		7
Baetidae	1		2	9	8	6	26	1	6	10	4	2	75
Cordulegasteridae				1			1	1					3
Corduliidae			1		9	2	1	6			4		23
Dystiscidae	1	3				4		3	2	3	2	1	19
Ecdyonuridae	1			3	2	3	3		1			1	14
Gammaridae	1												1
Gerridae				1									1
Goeridae				1									1
Gomphidae		1			1		2	1			1		6
Haplipidae		3							5				8
Hydrobiidae	1		2										3
Hydrobiidae									14				14
Hydropsychidae	2		3	1	13	4	5	3		11	3	10	55
Leaf-cased Caddis								1		2			3
Lestiidae									2			1	3
Libellulidae									1	1			2
Messoveillidae	1	7	5	7			1		2		2		25
Mollanidae													
Naucoridae		1		3	2	8	6	5	1	6	1	6	39
Nemouridae							5	2		3	2	5	17
Odonata									1				1
Oligochaeta										1		2	3
Perlodidae					9		1	2		2	2		16
Philopotamidae					2		2	1		1	1	6	13
Polycentropidae													
Rhyacophilidae				1	5	3	3	4	1	4	1	7	29
Riffle-beetle					2		3		1	2	1	1	10
Simullidae	1		1								2		4
Tipullidae							2	2			4		8
Unidentified 1				1			2		1				4
Unidentified 2											1		1
												TOTAL	408

Remarks:
Substrate: pebbles
Riparian: secondary & undergrowth forest, characterized by a 90^0 slope

Table 8. Abundance of Macroinvertebrates at Layawan Convergence

Macro Data
Site: Layawan Convergence
Date: October 28, 2004

Family Name	Slow Moving				Fast Moving				Rapids				Total
	N1	N2	N3	N4	N1	N2	N3	N4	N1	N2	N3	N4	
Aphelocheiridae	2		2		1	1		5	3	3	7		24
Baetidae	2		1	2	5	6		1	1	1	2		21
Dendrocoelidae								1					1
Ecdyonuridae							1	1	1			1	4
Gammaridae			1					2					3
Gerridae	1	4	3	21	1			1					31
Gomphidae			1				1	3	7	3		1	16
Hydropsychidae	1				2	3	5	19	12	1	6		49
Lepidoptera					1			11					12
Naucoridae	2	2	4	1	4	5	3	4	13	8	8	2	56
Nemouridae					1		6		3				10
Perlodidae								2			2		4
Philopotamidae		1				1	2	2	20				26
Rhyacophilidae					3	2	2	12	5	1	2		27
Riffle-beetle									2		3		5
Unidentified 1									1				1
Unidentified 2												2	2
Worm-like	1												1
												TOTAL	293

Legend:
Worm-like: yellow-colored worm, with transparent body

The number of macroinvertebrates was recorded highest at Panobigon with 26, 24 in Manimatay and 14 in Layawan Convergence. Surprisingly, Layawan Convergence which was expected to record the most number of different kinds of macroinvertebrates because of its being a convergence point of Lower Layawan, Manimatay and Panobigon recorded the least number of different macroinvertebrates. It could be that the variability and dynamics of the river water from the different headwater streams limit the kinds of macroinvertebrates in the mentioned site.

Comparison of ASPT & WQI in the two sections of the river revealed some trends. Streams and rivers are often broken into sections of fast/ turbulent flow and slow flow. ASPT of the slow flow section at Panobigon was the highest (8.3), while the lowest with a value of 6.7 was computed from Lower Layawan. Water quality assessment of the computed ASPT values in the slow flow section showed that the slow flow section has EXCELLENT water. Looking at the WQI values of the same river section divulged that Layawan Convergence recorded 7.38 (the highest) while the lowest value (6.1) was computed in the Lower Layawan. Lower Layawan was consistently the lowest in terms of ASPT & WQI though Lower Layawan had the most number of different kinds of macroinvertebrates. However, most of these macroinvertebrates were fair-poor and poor water quality indicators or pollution tolerant.

In the fast-moving section, the ASPT of Manimatay registered a score of 8.05 compared to a 7 ASPT value at the Lower Layawan. All the ASPT values in all sites indicated EXCELLENT water quality. On the other hand, WQI was lowest at Lower Layawan (6.1) and highest at Layawan Convergence (7.74). But when water quality assessment of the values was made, WQI of Layawan Convergence indicated VERY CLEAN WATER while that at the three other sites all fell within the RATHER CLEAN WATER category. Attention must then be given to the fast-moving section of the three sites, most especially at Lower Layawan because slight worsening of the physico-chemical environment of the section would transform the section into rather dirty water.

Generally, the variety of macroinvertebrates is consistently lesser at the slow-moving section of all sampling sites of the Sebucal headwaters. Moreover, it is in the fast-moving section where the most number of indicators for good water quality can be found. The fast-moving section at Panobigon recorded 14 good water quality indicators compared to only six kinds at the slow-moving section. Another noteworthy finding is the fact that all kinds of intolerant/sensitive macroinvertebrates dominated the slow-moving section of the river.

Among the macroinvertebrates found in the slow- and fast-moving section of the river, only one macroinvertebrate (Goeridae) seems confined to the slow-moving section of Manimatay and Layawan Convergence. Fourteen different kinds of macroinvertebrates were found thriving in the fast-moving section of the river. This include the balloon-tailed damselfly, beetle-like Ephemeroptera, three kinds of Odonata (Figure 9), Dendrocoelidae, Libellulidae, Lepidoptera, Lestidae, Riffle beetle, Siphlonouridae, white Plecoptera (Figure 10) and two unidentified species.

Density of taxa classified as good water quality indicators like Apeilocheiridae, Gammaridae, Gerridae, Naucoridae and riffle beetle were highest in Manimatay (5.25) and lowest in Panobigon (1.94). These good water quality indicators were also found to be most abundant in the fast flowing section of the river. Individuals of Order Trichoptera (Figure 11), which was very sensitive to dissolved oxygen level, comprised the most abundant taxon among the good water quality indicators in all sites (Table 9).

The insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) collectively known as EPT, are generally considered pollution-sensitive and are normally used to evaluate community balance. Table 10 shows that the said orders are represented in all the sampling sites but in varied densities. As expected, it is still in the fast-flowing section of the sites where EPT density is greatest. In Panobigon, species of the Order Plecoptera dominated, giving a density of 3.54, while the density of Trichoptera and Ephemeroptera were 1.46 and 0.88 respectively. A very wide fast-flowing section characterizes Panobigon, which in turn provides a lot of dissolved oxygen favoring the existence of stoneflies. Moreover, the abundance of trees in the riparian zone of the stream is a source of plants serving as food for the said organism.

In the three other stream sampling sites, Trichoptera consistently yielded the highest density (5.75 in Manimatay, 2.75 in Lower Layawan and 2.71 in Layawan Convergence). Caddisflies do not like high levels of pollution and they would thrive most in waters characterized by stones, silt and plant material common in the three sites. Single-link cluster analysis of the four sites affirms the high similarity in terms of species encountered in Layawan Convergence and Lower Layawan and the two being closely similar to Manimatay. Panobigon is quite a unique site in terms of macroinvertebrate assemblage encountered.

Figure 9. Odonata Species

Figure 10. Plecoptera Species

Figure 11. Trichoptera Species

Table 9. Density of Good and Poor Water Quality Indicators in the Different Sections of the Sebucal Sampling Sites

Sebucal		Slow		Fast		Whole Site	
		# of Ind	Density	# of Ind	Density	Total	Density
Panobigon	Ephemeroptera	1	0.06	41	1.28	42	0.88
	Plecoptera	25	1.56	145	4.53	170	3.54
	Trichoptera	7	0.44	63	1.97	70	1.46
	Good	24	1.50	69	2.16	93	1.94
	Poor	1	0.06	8	0.25	9	0.19
Manimatay	Ephemeroptera	5	0.31	178	5.56	183	3.81
	Plecoptera	1	0.06	55	1.72	56	1.17
	Trichoptera	21	1.31	255	7.97	276	5.75
	Good	19	1.19	233	7.28	252	5.25
	Poor	1	0.06	6	0.19	7	0.15
Layawan Lower	Ephemeroptera	19	1.19	73	2.28	92	1.92
	Plecoptera		0.00	33	1.03	33	0.69
	Trichoptera	10	0.63	122	3.81	132	2.75
	Good	34	2.13	97	3.03	131	2.73
	Poor	1	0.06	13	0.41	14	0.29
Layawan Convergence	Ephemeroptera			20	0.63	20	0.42
	Plecoptera			14	0.44	14	0.29
	Trichoptera	3	0.19	127	3.97	130	2.71
	Good	43	2.69	76	2.38	119	2.48
	Poor	1	0.06	1	0.03	2	0.04

Table 10. Percent EPT in the Different Sites of the Sebucal Headwaters

Sampling Sites		Slow		Fast		Whole Site	
		# of Ind	%EPT	# of Ind	%EPT	Total	%EPT
Panobigon	% Ephemeroptera	1	3.03	41	16.47	42	14.89
	% Plecoptera	25	75.76	145	58.23	170	60.28
	% Trichoptera	7	21.21	63	25.30	70	24.82
Manimatay	% Ephemeroptera	5	18.52	178	36.48	183	35.53
	% Plecoptera	1	3.70	55	11.27	56	10.87
	% Trichoptera	21	77.78	255	52.25	276	53.59
Layawan Lower	% Ephemeroptera	19	65.52	73	32.02	92	35.80
	% Plecoptera			33	14.47	33	12.84
	% Trichoptera	10	34.48	122	53.51	132	51.36
Layawan Convergence	% Ephemeroptera			20	12.42	20	12.20
	% Plecoptera			14	8.70	14	8.54
	% Trichoptera	3	100.00	127	78.88	130	79.27

Finally, in monitoring the ecological health of the Layawan headwater streams, it is suggested that sampling be more focused in the fast-moving sections of the river.

Assessment of Riparian Invertebrates

Eight orders of invertebrate fauna were represented in the samples from the three different headwater streams of Sebucal: Lepidoptera, Coleoptera, Arachnidae, Ephemeroptera, Plecoptera, Tricoptera, Odonata and Phasmatodea. Order Lepidoptera was represented by the largest number of species (32), with highest species richness in Manimatay stream.

Panobigon stream has the most number of species of invertebrates (21). Unique aquatic fauna were observed in the Panobigon stream like water pennies (Psephenidae) that were found abundantly together with *Gyrinidae* sp. 3 and the colorful beetle *Acronia* sp. 3 (Cerambycidae). Newly emerged mayfly (Ephemeroptera) was observed being preyed upon by the Dystiscid larva. In general, the Panobigon stream is invertebrate-rich than the two other streams of Sebucal. The Manimatay stream was found higher in Odonata species with sp. 1 of Zygoptera as the most abundant in the area. The probable influencing factor why Panobigon is rich in macroinvertebrate species is the presence of varied plants which could be the host plants for Odonata in laying their eggs and also due to the physico-chemical composition of the Panobigon water.

Species richness and status of Lepidoptera. About 32 species of butterflies were collected at the Layawan headwater streams (Figure 12 and Table 11). Highest species richness was observed in Panobigon stream (21), followed by Manimatay stream (9), Upper Layawan (7) and Lower Layawan (5). The differences could be due to the presence of varied vegetation in the area. It was confirmed in this research that availability of food plants and host plants affects the presence of butterflies in the area. Based on the list of plants gathered by the project team, Panobigon stream contains the most number of plant species, which coincides with the data on butterfly presence of the study sites. This observation is consistent with the study conducted in Mt. Musuan on the "Conservation of Endemic, Endangered, Economic Flora and Fauna in Mindanao" in 2002.

Endemic species account for 62.5% of the collected butterfly species, with 34% endemic to the Phillippines in general and with two rare endemics. Thirteen of the 20 endemics were reported by Treadaway in 1997 as Mindanao endemic plus one site-endemic, *Delias diaphana basilisae*, with only northwest Mindanao as its known area of distribution. This species was observed only in Sebucal along Panobigon and Layawan Rivers. The food and host plant of this species is an epiphytic plant (*mangagaw, Helixanthera* sp.) in Sebucal.

Species richness and status of Odonata. Sixteen species of Odonata (dragonflies) were collected from the headwater streams of Layawan River (Table 12). Highest species richness was observed in Manimatay stream (13), lowest in Upper Layawan (1). The differences in species richness of Odonata might be due to differences in light penetration in the sampling sites. Panobigon, Lower Layawan and Upper Layawan have almost the same characteristics in terms of light penetration. *Diplacina braueri* Selys is the most abundant species in the area, consistent with the observation of Kumar *et al.* (1981) that temperature influences the distribution and development of dragonflies.

In Panobigon, both naiads and predators are abundant. Aquatic bugs and *Gyrinidae* sp. (coleopterans which are also predators of naiads) are numerous. During the sampling of immatures, plenty of naiads were observed in Panobigon stream, but less in Manimatay. Naiad sample shows that Odonata is more diverse in Panobigon. At the time of sampling, the Odonata in Panobigon were still in nymph or naiad stage while in Manimatay stream, they were already adults or more advanced in development.

Both naiads and adult Odonata were less in population. This is because the eggs of some Odonatans are laid in forest trees which are no longer available in Lower Layawan. Only two species of adult Odonata were observed in Upper Layawan. Trees were shading the stream sides, but when sampling of the immatures was conducted, many naiads/nymphs were abundant.

FAMILY NYMPHALIDAE

Hypolimnas anomala anomala
common
Manimatay Stream

Mycalesis sp. 1
common
Manimatay Stream

Cyrestis kudrati
uncommon, endemic
Manimatay Stream

Cyrestis maenalis maenalis
common
Manimatay Stream

Ragadia melindena melindena
uncommon, endemic
Panobigon Stream

Mycalesis ita imeldae
common
Panobigon &
Manimatay Streams

Faunis phaon leucis
common
Panobigon Stream

FAMILY LYCAENIDAE

Tajura sp. 1
uncommon
Panobigon Stream

Melitus melanion melanion
common, endemic
Panobigon Stream

Euchrysops cnejus cnejus
common
Panobigon Stream

Jamides alecto manilana
common
Panobigon,
Manimatay & Lower
Layawan Streams

FAMILY PAPILIONIDAE

Troides rhadamantus
common endemic
Manimatay Stream

Menelaides helenus hystaspes
common endemic
Panobigon &
Manimatay Streams

Menelaides deiphobus rumanzovia
common endemic
Panobigon &
Manimatay Streams

FAMILY HESPERIIDAE

Xanthoneura telesinus
common,endemic
Panobigon Stream

FAMILY PIERIDAE

Eurema hecabe tamiathis
common widespread

Figure 12. Samples of Butterflies Collected from the Project Sites

Table 11. List and Status of Butterflies Found in the Headwaters of Layawan River

Species	National / Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
A. HESPERIIDAE						
1. *Potanthus mingo mingo*	Common/common				/	Widespread
2. *Taractocera luzonensis*	Common/common endemic				/	Widespread
B. LYCAENIDAE						
3. *Euchrysops cnejus*	Common/common	/				Widespread
4. *Jamides alecto kawqazoei*	Common/common	/			/	Palawan
5. *Lograni*a sp. 1	Rare	/				
6. *Melitus melanion*	Endemic/rare	/				Rare
7. *Udana dilecta*	Common/rare	/				Mindanao
8. *Zeltus amasa masaya*	Common			/		Mindanao
C. NYMPHALIDAE						
9. *Acropthtalmia albofasciata*	Endemic	/			/	Mindanao
10. *Acrophtalmia leto ochine*	Endemic				/	Mindanao
11. *Cyrestis maenalis maenalis*	Common/endemic	/				Mindanao
12. *C. kudrati*	Uncommon/rare endemic		/			Mindanao
13. *Danaus melanippus edmondii*	Common		/			
14. *Faunis phaon leucis*	Rare endemic	/				Mindanao
15. *Junonia hedonia ida*	Common endemic		/			Widespread
16. *Lexias panopus miscus*	Common/common	/				Mindanao
17. *Mycalesis itaimeldae*	Common/common endemic	/				Mindanao
18. *Mycalesis* sp. 1	Common		/			
19. *Neptis pampanga boholica*	Common/common	/				Widespread
20. *Ragadia melindina*	Common/common endemic	/				Widespread
21. *Ypthima sempera chaboraxas*	Common endemic				/	Mindanao
22. *Y. stellera stellera lisandra*	Endemic	/				Mindanao
23. *Y. sensilis*	Common/common endemic		/			Mindanao
24. *Vagrans sinha sinha*	Common/common	/				Widespread
D. PAPILIONIDAE						
25. *Papilio hystaspes*	Common/endemic rare	/	/		/	Widespread
26. *P. rumanzovia*	Common/common endemic	/	/		/	Widespread
27. *Triodes rhadamantus*	Uncommon/endemic rare		/			Philippines
E. PIERIDAE						
28. *Eurema hecabe hecabe*	Common/common	/	/		/	Widespread
29. *E. blanda vallivolans*	Common/rare		/			
30. *E. sarilata sarilata*	Common/rare endemic	/				Widespread
31. *Delias diaphana basilisae*	Rare/rare endemic	/		/		Mt. Malindang
32. *D. henningia saturnina*	Common/common endemic	/		/		Widespread

Legend: / (present)

Table 12. List and Status of Odonata Found in the Headwaters of Layawan River

Species	National/Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
A. ZYGOPTERA (DAMSELFLIES)						
Euphigidae						
1. *Euphaea amphicyana* Ris	Endemic	/	/	/		
Chlorocyphidae						
2. *Rhinocypha turcanii* Selys	Common	/	/			
Calopterygidae						
3. *Vestalis melania* Selys	Common	/	/	/		
4. *Bayadera* sp. 1	Rare		/			
Coenagrionidae						
5. *Pseudogrion pilidorsum*(Brauva)	Common		/			
6. *Coenagrionidae* sp. 1	Rare		/			
7. *Coenagrionidae* sp. 2	Rare		/			
B. ANISOPTERA (DRAGONFLIES)						
Aeshnidae						
8. *Neurothemis fluctuans*	Very common		/			
9. *Neurothemis ramburii terminata*	Rare		/			
Libellulidae						
10. *Diplacina braveri*	Common		/			
11. *Orethrum pruinosum clelia*			/			
12. *Orethrum* sp.			/			
13. *Heliogomphus bakeri*	Endemic				/	
14. *Lyriothemis* sp. 1	Common		/			

Legend: / (present)

However, tadpoles were also abundant which could be the reason why adults were not observed in Upper Layawan. This observation is consistent with the report of Berkeley (2002) which demonstrated that birds, lizards, frogs, spiders, fish, water bugs and even large dragonflies were observed as predators of Odonata. The Odonata species, *Orethrum pruinosum clelia*, was abundant in Sebucal. Countless numbers of this species were observed in June and July during the rainy season but there was also a swarm in Manimatay stream during the dry season.

Dipterocarp forest favors the growth of Odonata as observed in Sebucal and Peniel, where *Orethrum pruinosum clelia* and *O.* sp. were found to be countless. This is probably due to the fact that dipterocarp trees thrive well near streams or water, such that Odonata can be used to indicate the presence/availability of water in the area. The presence of dragonflies and damselflies may be taken as indication of good ecosystem quality. Their population is largely affected by ecological factors such as pH, type and amount of aquatic vegetation, temperature and current/velocity of water. Damselflies are more tolerant to pollution than dragonflies (Barkeley 2002).

Species richness and status of Coleoptera. Species richness of Coleoptera was more pronounced during the wet season (Table 13). More species of beetles were collected from Sebucal in June compared to October and December. Coleoptera species were scarce during the dry season with only eight species observed. *Gyrinidae* sp. was unique at the surface of Panobigon stream (36 individuals collected), and so with the cerambycid *Acronia* sp. Curculionids were observed only in Upper Layawan. Lowest species richness was observed in Lower Layawan due to the lack of host plants.

Table 13. List and Status of Coleoptera Found in the Headwaters of Layawan River

Species	National / Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
A. CERAMDICYDAE						
1. *Acronia* sp.	Rare	/				
2. *Asthates* sp.						
B. CURCOLIONIIDAE						
3. *Curcolioniidae* sp. 1	Rare				/	
4. *Curcolioniidae* sp. 2	Rare				/	
C. PSEPHENEDAE						
5. *Sclerocyphon* sp. 1	Common	/	/	/	/	
D. GYRINIDAE						
6. *Gyrinidae* sp. 1	Common	/				
7. *Gyrinidae* sp. 2		/	/			
8. *Gyrinidae* sp. 3		/	/	/		
E. SCARABAEIDAE						
9. *Glycyphana* sp.						
10. *Taenidera Jucunta*						
11. *Scarabaeidae* sp. 1						
F. COCCINELLIDAE						
12. *Coccinella* sp. 1						
G. LAGRIIDAE						
H. LAMPYRIIDAE						
13. Sp. 1						
I. OYTISCIDAE						
14. Sp. 1						

Legend: / (present)

National status of Coleoptera cannot be determined yet due to lack of access to literature. However, local assessment showed that rare species of cerambycid and curcolionids (weevils or snout beetles) were collected. Three species of Gyrinidae were observed as locally common.

Species richness and status of Heteroptera. Three species of aquatic bugs were observed in all streams of Layawan headwaters (Table 14). These might be due to the presence of predators that support their survival in the streams, one of which was observed preying on newly-emerged mayflies. Also the biotic factors for

Table 14. List and Status of Heteroptera Found in the Headwaters of Layawan River

Species (Aquatic bugs)	National / Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
NAUCORIDAE						
Naucoridae sp. 1	Common	/	/	/	/	
Naucoridae sp. 2	Common	/	/	/	/	
Naucoridae sp. 3	Common	/	/	/	/	

Legend: / (present)

their survival could be optimum in these streams. National status of the aquatic bugs is not determined yet due to lack of access to literature.

Species richness and status of Arachnida. Four species of spiders were collected in Layawan headwaters, all from Panobigon stream (Table 15). Other streams had no spiders due perhaps to the presence of birds and snakes that prey on them. More spiders were observed in relatively cool areas compared to warm places. Panobigon and Upper Layawan are cool and shady areas. Manimatay and Lower Layawan, however, have clearings, but spiders were not also observed.

Species richness and status of Crustacea. Only two species of crustaceans were observed in Layawan headwaters: the crab locally known as *kalong* and the shrimps which are very abundant in Manimatay stream and Lower Layawan (Table 16). *Kalong* is almost endangered because locals eat them as source of protein. National status is not yet determined for crustaceans. However, these were found common in Mt. Malindang area as they move from one area to another. They also lay numerous eggs so their collection is financially profitable.

Species richness and status of Phasmatodea. Species richness of Phasmatodea near the streams of Layawan headwaters is not pronounced (Table 17). Only one species (locally rare) was observed in Manimatay stream whereas other streams had none. This could be due to the presence of predators like snakes and birds that were abundant in the area. National status is not yet determined.

Species richness and status of Mollusca. Only two species of mollusks were observed in the area (Table 18). One is the common land snail (locally common) and the other is a small gastropod (locally rare).

Table 15. List and Status of Arachnida Found in the Headwaters of Layawan River

Species (Spiders)	National / Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
SPIDER UNIDENTIFIED						
Agriop sp. 1	Rare*	/				
Undet sp. 1	Rare*	/				
Undet sp. 2	Rare*	/				
OXYOPIDAE						
Oxyopidae sp. 1	Rare*	/				
Oxyopidae sp. 2						
Oxyopidae sp. 3						
Oxyopidae sp. 4						

Legend: / (present)
*4, rare by incidence

Table 16. List and Status of Crustacea Found in the Headwaters of Layawan River

Species	National / Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
CRUSTACEA UNIDENTIFIED						
Crustacea unid. sp. 1 (*Crab/kalong*)	Common		/	/		
Crustacea unid. sp. 2 (Shrimp)	Common	/	/	/		

Legend: / (present)

Species Diversity of Riparian Invertebrates

In general, species diversity of invertebrate fauna in Panobigon and Upper Layawan were higher with 4.36 and 4.35 respectively compared to Manimatay and Lower Layawan which were only 3.94 and 3.95 (Table 19). Species richness is highest in Panobigon (41) with 348 individuals and lowest in Layawan (23) with 144 occurrences.

The most abundant species was *Jamides alecto* in Panobigon and Lower Lawayan. *Diplacina braueri* Selys is the abundant species of invertebrate in Manimatay while Heteroptera unidentified sp. 1 in Upper Layawan. The most noteworthy species was the undetermined *Dysticid* in Upper Layawan which was observed only in January 2005. Species uniqueness was highest in Panobigon (39.6), followed by Manimatay (27.2), Lower Layawan (10.6) and lowest in Upper Layawan (0) (Table 20).

Table 17. List and Status of Phasmatodea Found in the Headwaters of Layawan River

Species	National/Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
PHASMATIDAE *Phasmatidae* sp. 1 *Phasmatidae* sp. 2 *Phasmatidae* sp. 3	Rare*		/			

Legend: / (present)

Table 18. List and Status of Mollusk Found in the Headwaters of Layawan River

Species	National/Local Status	Location (Streams)				Distribution
		Panobigon	Manimatay	Lower Layawan	Upper Layawan	
GASTROPODA Gastropoda unid. sp. 1 Gastropoda unid. sp. 2		/ /	/	/		

Legend: / (present)

Table 19. Shannon Biodiversity Index of the Riparian Invertebrate Fauna

Index	Panobigon	Manimatay	Lower Laya	Upper Laya
Shannon H' Log Base 2.	4.364	3.944	3.951	4.354
Shannon Hmax Log Base 2.	5.358	4.755	4.524	4.858
Shannon J'	0.815	0.829	0.873	0.896

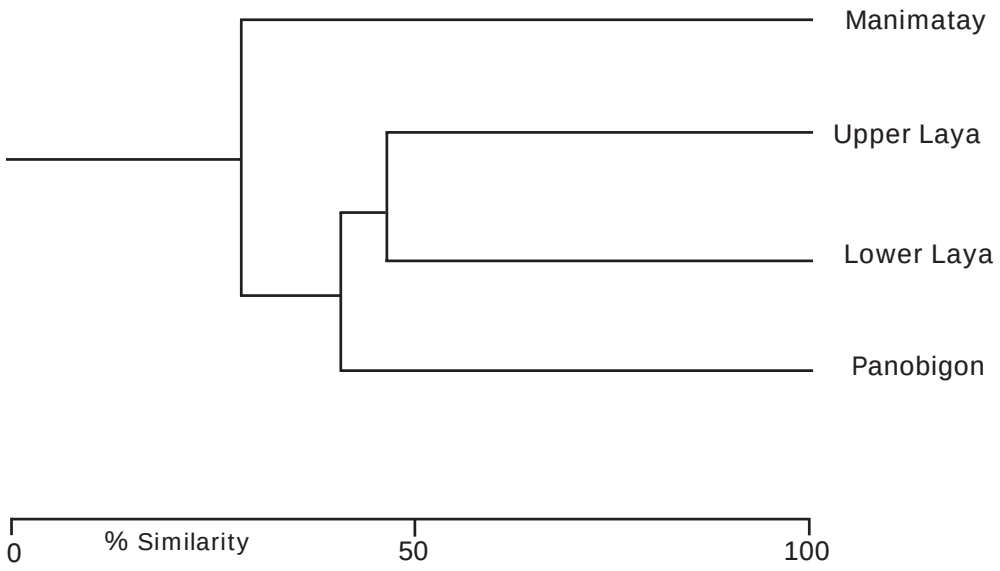
Table 20. Species Uniqueness Analysis of Riparian Invertebrate Fauna

Number of Pooled Samples	Estimator
Panobigon	39.6
Manimatay	27.2
Lower Layawan	10.6
Upper Layawan	0

The most unique species in Panobigon was *Delias diaphana basilisae; Maenalis kudrati* in Manimatay; nymphalid in Lower Layawan; and yellow water beetle in Upper Layawan.

Cluster analysis (Figure 13) shows that species composition of invertebrate fauna is similar in Upper Layawan and Lower Layawan. Panobigon and Manimatay are unique in their species composition. Differences and similarities of these habitats are due to physico-chemical differences in the area.

Bray-Curtis Cluster Analysis (Single Link)



Step	Clusters	Distance	Similarity	Joined 1	Joined 2
1	3	60	40	3	4
2	2	64.24361	35.75639	1	3
3	1	76.33588	23.66412	1	2

Similarity Matrix

	Panobigon	Manimatay	Lower Laya	Upper Laya
Panobigon	*	23.6641	35.7564	22.7642
Manimatay	*	*	14.2433	21.875
Lower Laya	*	*	*	40
Upper Laya	*	*	*	*

Figure 13. Cluster Analysis of Riparian Invertebrates in Four Sites

Species occurrence of invertebrates in Layawan headwaters is influenced by different ecological factors. Different species have different ecological requirements for survival. Butterflies (Lepidoptera) and beetles (Coleoptera) were highly influenced by food plants and weather conditions at the time of sampling. Dragonflies (Odonata) were influenced by the sunlight availability, pH of water and vegetation at the vicinity of the riparian ecosystem. The headwaters of Layawan are still of good quality. To maintain it, the residents should consider seriously the protection and conservation of these water resources.

The Economic Invertebrates in Layawan Headwaters

Sixteen species of invertebrates and 13 species of Odonata found in Layawan headwaters have economic benefits. Nymphs of Odonata are used as baits for fishing by the locals in Sebucal. Aside from bait, the locals do not use mosquito nets as mosquitoes are maintained in relatively low numbers due to the abundance of Odonata that prey on mosquitoes.

Three species of crustaceans namely the *kalong* (crab), *karampal* (larger crab) and *manalsal* (large prawn) were observed in Manimatay. *Kalong* was reported very abundant five years ago, but are now becoming scarce. *Manalsal* is very abundant during rainy season. If there is heavy rain in the mountains, the rise of water brings the *manalsal* downstream. The locals can collect *karampal* to as many as five sacks sold at PhP10 per sack.

The *kalong* are riparian but when heavy rains are about to fall, they are observed to migrate to land and even climb the trees and become singing *kalong*. The migration and the singing of the *kalong* is an indicator for the locals of rainy season, thus it also serves as a weather forecaster.

Assessment of Riparian Flora

Because the primary forest represents the true indigenous flora of the Philippines where specific endemism is expected to approximate 75% (Merrill 1912; 1923-1926), the change in vegetation of the riparian areas (except on the steep river sides where the native plants have been retained) has consequently caused a lowering in its percentage endemism. Considering the total number of tree species found in the headwaters, along Layawan River, and along Langaran River, percent specific endemism in the three locations are respectively 22%, 21% and 14% (Table 21). In addition, because only a single line of indigenous trees at the immediate edge of the riverbank has been usually left uncut, most of these endemic species are threatened. Figure 14 shows some of the dominant trees-- one is *Dillenia philippinensis* which is both endemic and threatened.

Many species of *Ficus* are endemic and threatened, except for *F. minahassae*, which is non-endemic and is quite abundant in the area. For the plants other than trees, *moti-moti* (*Mikania cordata*), *lukdo-lukdo* (*Nephrolepis*) and *lakatan* (*Paspalum* sp.) came out to be the most abundant. Accompanying the clearing of the forest, these plants are characterized by a predominance of introduced weeds, which are mostly of pantropic distribution.

Comparison of riparian tree species with those of the surrounding terrestrial forest ecosystems assessed by the Terrestrial Ecosystem Master Project (TEMP) group was made (Table 22). The forest ecosystems were those at Mt. Capole and the almaciga forest. Similarity coefficients were low, indicating that riparian tree communities are quite distinctive.

Table 21. Tree Species of Headwaters, Layawan River, Langaran River and Endemism

Local Name	Scientific Name	Family Name	Sebucal Headwaters	Layawan	Langaran	Endemism
Abaca	*Musa textilis*	Musaceae	✓	×	×	Endemic, cult.
Abgao	*Premna odorata*	Verbenaceae	×	✓	×	Non-endemic
Agutay	*Musa* sp.	Musaceae	✓	×	×	Uncertain
Alagasi	*Leucosyke capitellata*	Urticaceae	×	✓	✓	Non-endemic
Alangilan	*Cananga odorata*	Anonaceae	×	✓	×	Non-endemic
Alingatong	*Dendrocnide* sp.	Urticaceae	✓	✓	✓	Probably endemic
Alingatong big leaf	*Dendrocnide meyeniana*	Urticaceae	✓	✓	×	Probably endemic
Alipata	*Excoecaria agallocha*	Euphorbiaceae	×	×	✓	Non-endemic
Ambabawod, Hambabalud/ Ambabawod	*Neonauclea* sp.	Rubiaceae	×	✓	✓	Endemic
Anagdong	*Trema orientalis*	Ulmaceae	✓	✓	×	Non-endemic
Ananamsi	*Villebrunea* sp.	Urticaceae	×	✓	✓	Uncertain
Anonang	*Cordia dichotoma*	Boraginaceae	×	✓	×	Endemic
Antotongaw 1, Tungaw sa anot	*Astronia* sp.	Melastomataceae	✓	✓	✓	Non-endemic
Antotongaw na pula	*Astrocalyx calycina*	Melastomataceae	✓	×	×	Endemic
Awom	*Melanolepis multiglandulosa*	Euphorbiaceae	×	✓	×	Non-endemic
Avocado	*Persea americana*	Lauraceae	✓	✓	×	Non-endemic, cult.
Babati	*Elaeocarpus calomala*	Elaeocarpaceae	✓	✓	×	Endemic
Bagnay	*Antidesma* sp.	Euphorbiaceae	×	✓	✓	Endemic
Bahay	*Ormosia calavensis*	Leguminosae/ Fabaceae	×	✓	×	Non-endemic
Bakan	*Prunus clementis*	Rosaceae	×	✓	✓	Endemic
Bakhaw-bakhaw	*Urophyllum* sp.	Euphorbiaceae	✓	×	✓	Endemic
Balangog	*Saurauia involucrata*	Actinidiaceae	✓	×	×	Endemic
Balangog na puti	*Saurauia* sp.	Actinidiaceae	✓	×	×	Endemic
Balete	*Ficus benjamina*	Moraceae	✓	✓	✓	Endemic
Balete 2	*Ficus* sp. 3	Moraceae	×	✓	✓	Endemic
Balete 3	*Ficus* sp. 7	Moraceae	×	✓	×	Endemic
Balete 4	*Ficus* sp.	Moraceae	×	✓	×	Endemic
Balete-balete	*Myrtaceae* sp. 1	Myrtaceae	×	✓	×	Uncertain
Balete laki	*Ficus* sp. 6	Moraceae	×	✓	×	Endemic
Balete lapad ug dahon	*Ficus 10*	Moraceae	✓	×	×	Endemic
Balitadhan	*Bridelia glauca*	Euphorbiaceae	✓	✓	✓	Non-endemic
Balobo	*Diplodiscus paniculatus*	Tiliaceae	×	✓	✓	Endemic
Bamboo	*Bambusa* sp.	Graminae/ Poaceae	✓	×	×	Non-endemic
Bangkal	*Neonauclea* sp.	Rubiaceae	✓	×	×	Endemic
Bangitlong	--	--	×	✓	✓	--
Bangloy	--	--	✓	×	×	--
Banti, Bayanti, Biyanti	*Homalanthus populneus*	Euphorbiaceae	✓	✓	×	Non-endemic
Banti-banti	*Homalanthus* sp.	Euphorbiaceae	×	✓	×	Endemic
Banuwang	*Octomeles sumatrana*	Datiscaceae	×	✓	×	Non-endemic
Bayog	*Pterospermum diversitolium*	Sterculiaceae	×	✓	×	Non-endemic
Binalagas	*Semecarpus* sp.	Euphorbiaceae	✓	×	×	Endemic
Binliw 1, hagdang uwak, payas-payas, Bagumbi	*Osmoxylon* sp.	Araliaceae	×	✓	×	Uncertain
Binliw 2	*Polyscias* sp.	Araliaceae	×	✓	×	Uncertain
Bitan-ag	*Kleinhovia hospita*	Sterculiaceae	✓	✓	✓	Non-endemic
Bitangol	*Calophyllum blancoi*	Guttiferae/ Clusiaceae	✓	×	×	Endemic

Table 21. Tree Species of Headwaters, Layawan River, Langaran River and Endemism *(continued)*

Local Name	Scientific Name	Family Name	Sebucal Headwaters	Layawan	Langaran	Endemism
Bintoko	*Lunasia amara*	Rutaceae	✓	×	×	Endemic
Binunga	*Endospermum peltatum*	Euphorbiaceae	×	✓	×	Endemic
Bongbong	*Gigantochloa lepris*	Graminaea/ Poaceae	✓	×	×	Non-endemic
Bonot-bonot	*Glochidion* sp.	Euphorbiaceae	×	✓	✓	Non-endemic
Bontong, kawayan	*Bambusa* sp. 1	Graminae/ Poaceae	✓	✓	×	Uncertain
Bosyong	*Ficus* sp. 1	Moraceae	✓	✓	×	Endemic
Bosyong 2	*Ficus* sp. 2	Moraceae	×	✓	×	Endemic
Bosyong 3	*Ficus* sp. 5	Moraceae	×	✓	×	Endemic
Bosyong 5	*Ficus* sp. 5	Moraceae	×	✓	×	Endemic
Bosyong w/ pendulous fruit	*Ficus* sp. 4	Moraceae	✓	×	×	Endemic
Bugna	*Glochidion woodii*	Euphorbiaceae	✓	×	×	Not listed
Bugnay	*Xanthophyllum* sp.	Polygalaceae	×	×	✓	Uncertain
Bunga	*Areca catechu*	Arecaceae/ Palmae	✓	✓	×	Non-endemic
Buksakanwasay	*Perrottetia alpestris*	Celastraceae	✓	×	×	Non-endemic
Bulongkanag	--	--	×	✓	×	--
Bunga	*Areca catechu*	Arecaceae/ Palmae	×	✓	×	Non-endemic
Bulase	*Pilea melastomoides*	Urticaceae	✓	×	×	Non-endemic
Camansi	*Artocarpus communis*	Moraceae	✓	×	×	Endemic
Catmon 1	*Dillenia philippinensis*	Dilleniaceae	✓	✓	✓	Endemic
Catmon 2	*Dillenia* sp.	Dilleniaceae	×	✓	×	Endemic
Dahik, daik	--	--	×	✓	✓	--
Damanas/ Palangpalang/ lablab/Magolablab	*Angiopteris* sp.	Marattiaceae	×	✓	✓	Non-endemic
Danlugan	*Shorea contorta*	Dipterocarpaceae	✓	✓	×	Endemic
Dapdap	*Erythrina orientalis*	Leguminosae/ Fabaceae	×	✓	×	Non-endemic
Dibujan	--	--	✓	×	×	--
Doralo, guralo	*Celtis luzonica*	Ulmaceae	×	✓	✓	Endemic
Duguan	*Myristica* sp.	Myristicaceae	×	✓	×	Endemic
Falcata	*Paraserianthes falcataria*	Leguminosae/ Fabaceae	✓	×	×	Non-endemic, cult.
Gabamanok	--	--	✓	×	×	--
Galaran	*Celtis luzonica*	Ulmaceae	✓	×	×	Endemic
Gamong	*Cryptocarya* sp.	Lauraceae	✓	×	×	Endemic
Gantaw	*Cyathea* sp.	Cyatheaceae	✓	×	×	Non-endemic
Gantaw naay tunok	*Cyathea contaminans*	Cyatheaceae	✓	×	×	Non-endemic
Ganon	*Anisoptera thurifera*	Dipterocarpaceae	✓	×	×	Endemic
Gasa	--	--	×	✓	×	--
Gemilina	*Gmelina arborea*	Verbenaceae	×	✓	×	Non-endemic, cult.
Gibo	*Pometia pinnata*	Sapindaceae	×	✓	✓	Non-endemic
Gibo baye	*Dictyoneura acuminata*	Sapindaceae	×	×	✓	Not listed
Gilon	*Bischofia javanica*	Euphorbiaceae	×	✓	×	Non-endemic
Gubol	*Solanum* sp.	Solanaceae	✓	×	×	Endemic
Gulayan/Kulasit	*Lithocarpus* sp.	Fagaceae	✓	✓	✓	Endemic
Gupa	*Litsea grandis*	Lauraceae	✓	×	×	Not listed
Hagdang uwak	*Polyscias nodosa*	Araliaceae	✓	×	×	Non-endemic
Hagimit	*Ficus minahassae*	Moraceae	✓	✓	✓	Non-endemic
Hamindang, Hendang sa anot	*Macaranga tanarius*	Euphorbiaceae	✓	✓	✓	Non-endemic
Harli	--	--	✓	×	×	--
Hawili	*Ficus* sp.	Moraceae	✓	×	×	Endemic
Hindagaw	--	--	✓	×	×	--

Table 21. Tree Species of Headwaters, Layawan River, Langaran River and Endemism *(continued)*

Local Name	Scientific Name	Family Name	Sebucal Headwaters	Layawan	Langaran	Endemism
Ipil-ipil	*Leucaena leucocephala*	Leguminosae/ Fabaceae	×	✓	✓	Non-endemic
Kalayaan	*Shorea palosapis*	Dipterocarpaceae	✓	×	×	Non-endemic
Kalingag	*Cinnamomum mercadoi*	Lauraceae	✓	×	×	Endemic
Kalubi	*Salacca clemensiana*	Arecaceae/ Palmae	✓	✓	✓	Endemic
Kandiis	*Garcinia dives*	Guttiferae/ Clusiaceae	✓	×	×	Endemic
Karupay	*Pinanga insignis*	Arecaceae/ Palmae	✓	×	×	Endemic
Katungaw	--	--	✓	×	×	--
Kopa	--	--	✓	×	×	--
Labalod	*Ludeka bernadoi*	Rubiaceae	✓	×	×	Not listed
Labalon	*Neonauclea calcycina*	Rubiaceae	✓	×	×	Endemic
Lagnob/Labnog	*Ficus septica*	Moraceae	✓	×	✓	Endemic
Labulag na pula	*Macaranga bicolor*	Euphorbiaceae	✓	×	×	Endemic
Lakambing	*Sapindus saponaria*	Sapindaceae	✓	✓	×	Non-endemic
Lakatan, saging	*Musa sapientum* var. lacatan	Musaceae	✓	✓	✓	Non-endemic, cult.
Lalano	--	--	✓	×	×	--
Laloros,doloros	*Ficus* sp.	Moraceae	✓	×	×	Endemic
Langas	*Semecarpus cuneiformis*	Anacardiaceae	×	✓	✓	Endemic
Lanotan	*Dipterocarpus gracilis*	Dipterocarpaceae	✓	✓	×	Non-endemic
Larak	*Ficus irisina*	Moraceae	✓	×	×	Endemic
Laton	*Duabanga moluceanum*	Sonneratiaceae	✓	✓	×	Non-endemic
Lawaan, baric	*Parashorea malaanonan*	Dipterocarpaceae	×	✓	✓	Endemic
Lindang	--	--	✓	×	×	--
Lipata (seedling)	*Sapindus saponaria*	Sapindaceae	✓	×	×	Non-endemic
Lomboy-lomboy	*Calophyllum* sp.	Guttiferae/ Clusiaceae	×	✓	×	Endemic
Ludjaw	--	--	✓	×	×	--
Lunay, salonglunay	*Canarium asperum*	Burseraceae	×	✓	×	Endemic
Lunay-lunay	--	--	×	✓	×	--
Lunas	*Bambusa* sp. 2	Graminae/ Poaceae	×	✓	×	Non-endemic
Luyaw	*Dracontomelon dao*	Anacardiaceae	✓	✓	×	Non-endemic
Lukos	*Palaquium philippense*	Sapotaceae	✓	✓	×	Endemic
Madre de Cacao	*Gliricidia sepium*	Leguminosae/ Fabaceae	×	✓	×	Non-endemic, cult.
Magasile	*Radermachera whitfordi*	Bignoniaceae	✓	×	×	Endemic
Magasuso	*Hopea pinuata*	Dipterocarpaceae	✓	×	×	Non-endemic
Magasuwa	--	--	×	✓	×	--
Magkape	--	--	×	✓	×	--
Maglarino	*Alstonia macrophylla*	Apocynaceae	×	✓	✓	Non-endemic
Magsapoy	--	--	✓	×	×	--
Mahogany	*Swietenia macrophylla*	Meliaceae	✓	✓	✓	Non-endemic, cult.
Magtalisay	*Terminalia nitens*	Combretaceae	×	✓	✓	Endemic
Malabago, malibago	*Hibiscus tiliaceus*	Malvaceae	✓	✓	✓	Non-endemic
Malabuaya	*Radermachera* sp.	Bignoniaceae	×	✓	✓	Endemic
Malakube	*Platea* sp.	Icacinaceae	✓	×	×	Endemic
Malobo, marobo	--	--	×	✓	×	--

Table 21. Tree Species of Headwaters, Layawan River, Langaran River and Endemism *(continued)*

Local Name	Scientific Name	Family Name	Sebucal Headwaters	Layawan	Langaran	Endemism
Mana-mana	*Guioa bicolor*	Sapindaceae	×	×	✓	Endemic
Mangga	*Mangifera indica*	Anacardiaceae	×	✓	×	Non-endemic, cult.
Manga-manga	*Mangifera monandra* Merr	Anacardiaceae	×	✓	×	Endemic
Marang	*Artocarpus odoratissimus*	Moraceae	✓	×	×	Non-endemic, cult.
Mardium	*Hedyotis philippinensis*	Rubiaceae	×	×	✓	Endemic
Mamali	*Maesa* sp.	Myrsinaceae	✓	×	×	Endemic
Munggay-munggay	*Leguminosae* unid. sp.	Leguminosae/ Fabaceae	×	✓	✓	Uncertain
Naga, Narra	*Pterocarpus indicus*	Leguminosae/ Fabaceae	×	✓	×	Non-endemic
Nanagon	*Flacourtia* sp.	Flacourtiaceae	×	✓	×	Uncertain
Nangka	*Artocarpus heterophyllus*	Moraceae	✓	×	×	Non-endemic, cult.
Niyop	*Callicarpa erioclona*	Verbenaceae	✓	×	×	Non-endemic
Palang 1, gantaw	*Cyathea contaminans*	Cyatheaceae	×	✓	✓	Non-endemic
Pampalan	--	--	✓	×	×	--
Pangi	*Pangium edule*	Flacourtiaceae	×	✓	✓	Non-endemic
Pangkil	--	--	✓	×	×	--
Papaya	*Carica papaya*	Caricaceae	✓	×	×	Non-endemic, cult.
Pili-pili	*Canarium* sp.	Burseraceae	×	✓	×	Endemic
Ple	*Ficus calycina*	Moraceae	✓	✓	×	Not listed
Potat sa bukid	*Litsea garciae*	Lauraceae	×	×	✓	Endemic
Pugahan	*Caryota rumphiana*	Arecaceae/ Palmae	×	✓	×	Endemic
Pulayo, tagilomboy	*Syzygium* sp.	Mrytaceae	×	×	✓	Probably Endemic
Romblon	*Pandanus* sp.	Pandanaceae	✓	×	×	Endemic, cult.
Roborobod, Borobod	*Villebrunea* sp.	Urticaceae	✓	×	×	Non-endemic
Sabon-sabon	*Ternstroemia* sp.	Theaceae	✓	×	×	Not listed
Saging	*Musa x paradisiaca*	Musaceae	✓	×	×	Non-endemic, cult.
Sakod bagulang	--	--	✓	×	×	--
Sakom	*Clethra lancifolia*	Clethraceae	✓	×	×	Endemic
Sagusahis	*Ficus involucrata*	Moraceae	×	✓	✓	Not listed
Salangkugi, sangkogi	*Albizia saponaria*	Leguminosae/ Fabaceae	×	✓	×	Non-endemic
Salawag	*Pinanga* sp.	Arecaceae/ Palmae	✓	✓	×	Endemic
Salindata	*Acer laurinum*	Aceraceae	✓	✓	×	Not listed
Salonglunay	*Canarium* sp.	Burseraceae	✓	×	×	Endemic
Saloot	*Ficus guyeri*	Moraceae	×	×	✓	Endemic
Salumay	*Macaranga dipterocarpifolia*	Euphorbiaceae	✓	×	×	Non-endemic
Salumay na lapad	*Macaranga* sp.	Euphorbiaceae	✓	×	×	Non-endemic
Suwa-suwa	--	--	✓	×	×	--
Sigatak	--	--	✓	×	×	--
Tagibokbok, tagibulok	*Homalium oblongifolium*	Flacourtiaceae	×	✓	✓	Endemic
Talisay	*Terminalia catappa*	Combretaceae	×	✓	×	Non-endemic
Taluto	*Pterocymbium tinctorium*	Sterculiaceae	×	✓	×	Non-endemic
Tambangalan	*Pinanga* sp. 2	Arecaceae/ Palmae	×	✓	✓	Endemic
Tamoyan	--	--	✓	×	×	--
Tangulamas	*Melicope* sp.	Rutaceae	×	×	✓	Endemic
Tapalak	*Voacanga* sp.	Apocynaceae	✓	✓	✓	Endemic
Tapay-tapay	*Lasianthus appresifolius*	Rubiaceae	✓	×	×	Not listed
Tatanok	*Ficus botryocarpa* Mig.	Moraceae	✓	✓	✓	Not listed

Table 21. Tree Species of Headwaters, Layawan River, Langaran River and Endemism *(continued)*

Local Name	Scientific Name	Family Name	Sebucal Headwaters	Layawan	Langaran	Endemism
Tipolo	*Artocarpus blancoi*	Moraceae	x	✓	✓	Endemic
Tubog	*Ficus variegata*	Moraceae	x	✓	✓	Non-endemic
Tulan manok	*Chionanthus* sp.	Oleaceae	✓	x	x	Non-endemic
Tumating	--	--	✓	x	x	--
Tungaw sa anot	--	Melastomataceae	✓	x	x	Non-endemic
Tungaw-tungaw, antutungaw 2	*Melastoma malabathricum*	Melastomataceae	✓	✓	✓	Non-endemic
Tutungaw	*Everittia pulcherima* Merr.	Melastomataceae	✓	x	x	Endemic
Ulingon	*Cratoxylum sumatranum*	Guttiferae/ Clusiaceae	✓	✓	✓	Endemic
Upa	--	--	x	✓	x	--
Wild mahogany	*Dipterocarpaceae* unid. sp.	Dipterocarpaceae	x	✓	x	Uncertain
Total no.of tree species	**195**		**111**	**105**	**54**	

Legend: ✓ = present x = absent

Species Richness and Diversity

There were 415 trees and plants other than trees in nine plots (total area of 3600sq m). Species richness in terms of number of species was highest in Panobigon Plot 1 (23) and lowest in Panobigon Plot 2 (10). The Shannon index was highest in Panobigon Plot 1 (1.219) and lowest in Layawan Convergence Plot 1 (0.615), part of which was actually occupied by a mahogany plantation. The Shannon index for the whole Sebucal area was 1.53, a relatively high value, and which reflects evenness in the distribution trees totaling 74 species (Table 23).

The relatively high value of Simpson's index or index of dominance in certain plots (e.g., Convergence Plot 1) shows the dominance of a particular species, which in this case was mahogany (*Swietenia macrophylla*), an introduced cultivated plant promoted as a reforestation species. Outside of Northern Luzon, Mt. Malindang is sufficiently elevated to support temperate zone species and has attained its present elevation before recent (geologic epoch) time (Dickerson 1928). How extensively Mt. Malindang has been botanically explored with scientifically identified collections is a question that needs to be pursued. Considering the theory of island biogeography, the mountain ranges surrounding the Layawan headwaters catchment area should effectively isolate it and make its flora have a high percentage of endemism.

Ficus sp.

Pinanga sp.

Papilionaceae unid. sp.

Passifloraceae unid. sp.

Bambusa sp.

Bischofia javanica

Cyrtandra sp.

Elatostema sp.

Malvaviscus arboreus

Gymnostoma rumphianum

Malvaceae unid. sp.

Araceae unid. sp.

Araceae unid. sp.

Homalanthus alpinus

Sphaenomeris sp.

Asclepias curassavica

Figure 14. Some Plants Found in the Layawan Headwaters

Rubus rosaefolius

Solanum torvum

Salacca clemensiana

Pinanga sp. *"salawag"*

Macaranga grandifolia

Angiopteris sp.

Badjang (Alocasia odora)

Nepenthaceae unid sp.

Platea sp.

Melastomataceae unid. sp.

Piper catubiguense

Ficus sp.

Impatiens montalbanica

Passiflora sp.

Medinilla sp.

Figure 14. Some Plants Found in the Layawan Headwaters *(continued)*

Table 22. Comparison of Tree Species of Sebucal Headwaters with TEMP

Species	Local Name	TEMP		
		Sebucal	Mt. Capole	Almaciga
Acer laurinum Hassk	Salindata	✓	✓	×
Agathis philippinensis	Almaciga	×	×	✓
Albizzia sp.	Talugaw	×	✓	×
Alstonia scholaris	Biyak	×	✓	×
Angiopteris sp.	Lablab, magolablab	✓	×	×
Anisoptera thurifera	Ganon/Tumating	✓	✓	×
Artocarpus communis	Camansi	✓	×	×
Artocarpus heterophyllus	Nangka	✓	×	×
Astrocalyx calycina	Antutugnaw na pula	✓	×	×
Astronia cumingiana	Tutungaw	✓	×	✓
Astronia sp.	Antutugnaw	✓	×	×
Bambusa sp.	Bongbong (Bamboo)	✓	×	×
Bischofia javanica	Gilon	✓	✓	×
Blumeodendron sp.	Bakhaw/Tagilumboy	✓	×	✓
Bridelia glauca	Talan	✓	✓	×
Callicarpa erioclona	Niyop	✓	×	×
Calophyllum blancoi	Bintangol	×	×	✓
Calophyllum sp. 1	Bentangol	✓	✓	×
Cananga odorata (LamK.) Hook.f.et Thoms	Bakan	×	✓	×
Canarium luzonicum (Blume) A.Gray	Manog	×	✓	✓
Carica papaya	Papaya	✓	×	×
Chionanthus sp.	Tulan manok	✓	×	×
Chisocheton cumingianus	Babakang	✓	✓	×
Cinnamomum mercadoi	Kalingag	×	✓	✓
Cinnamomum mindanaense	Kalingag	×	×	✓
Cratoxylum sumatranum	Ulingon	✓	×	×
Cryptocarya sp.	Gamong	✓	✓	✓
Cyathea sp.	Gantaw	✓	×	×
Dacrycarpus cumingii	Igem	×	×	✓
Dendronide meyeniana	Lingatong/Alingatong	✓	✓	×
Dillenia philippinensis	Katmon	✓	×	✓
Dracontomelon dao	Luyaw	✓	×	×
Dysoxylum decandrum	Babakang	×	✓	×
Dysoxylum sp.	Lipata	×	✓	×
Elaeocarpus sp.	Babate/Santol	✓	✓	✓
Elaeocarpus sp. 2	Santol-santol	×	✓	×
Ficus minahassae	Hagimit	✓	✓	×
Ficus 10	Balete lapad ug dahon	✓	×	×
Ficus botryocarpa Mig.	Tatanok	✓	×	×
Ficus calycina	Ple	✓	×	×
Ficus irisina var *irisina*	Larak/Saginsil	✓	✓	×
Ficus odorata	Bosyong	✓	×	×
Ficus septica	Labanog, labnog, lagnob	✓	×	×
Ficus sp.	Balete	✓	✓	×
Ficus sp.	Hawili	✓	×	×
Ficus sp.	Laloros, doloros	✓	×	×
Ficus sp.	Tubog	×	✓	×
Ficus sp. 2	Bosyong	✓	✓	×
Ficus variagata var. syncomoroides	Tatanak/Tatanok	✓	✓	×
Garcinia dives	Magalis/Malibatoan	×	✓	✓
Glochidion sp.	Libang-na	×	✓	×
Gordonia luzonica	Sabon-sabon	×	✓	×
Gymnostoma rumphianum (Mig.) L.	Mariabuhok	×	✓	×
Hibiscus tiliaceus	Malabago	✓	×	×
Homalanthus populneus	Bayanti, biyanti	✓	×	×
Hopea pinuata	Magasuso	✓	×	×
Horsfieldia megacarpa Merr.	Hendang-hendang	×	✓	×
Lithocarpus apoensis	Gulayan/Kulasit	✓	×	×
Lithocarpus sp.	Gulayan	×	×	✓
Lithocarpus sp. 1	Gulayan	×	✓	×
Lithocarpus sp. 2	Gulayan puti	×	✓	×

Table 22. Comparison of Tree Species of Sebucal Headwaters with TEMP *(continued)*

Species	Local Name	TEMP		
		Sebucal	Mt. Capole	Almaciga
Ludeka bernadoi	Labalod	✓	×	×
Lunasia amara	Bintoko	✓	×	×
Macaranga bicolor	Labulag na pula	✓	×	×
Macaranga dipterocarpifolia	Salumay	✓	✓	×
Macaranga tanarius	Hamindang	✓	×	×
Magnolia reticulata	Bunot-bunot	×	✓	×
Mastixia premnoides	Magatalo	×	×	✓
Maesa sp.	Gusip/Mamali	✓	✓	×
Melicope confusa	Bintoko	×	×	✓
Melicope monophylla	Dalo/Bintoko puti	×	✓	✓
Melicope sp.	Bintoko	×	✓	×
Meliosma sp.	Bogsakan-wasay/Buksakanwasay	×	✓	✓
Musa sp.	Agutay	✓	×	×
Musa textilis	Abaca	✓	×	×
Musa x paradisiaca	Saging	✓	×	×
Neonauclea calycina	Labalod/labalon	✓	×	✓
Neonauclea sp.	Bangkal	✓	×	×
Oreocnide rubescens	Goborobod/Roborobod	✓	✓	×
Palaquium philippense (Perr.) C.B.Rob.	Lucos/Lokos	✓	✓	×
Palaquium luzoniense (F. Vill.) Vid.	Nato	×	✓	✓
Pandanus sp.	Romblon	✓	×	×
Perrottetia alpestris	Buksakanwasay	✓	×	×
Pilea melastomoides	Bulase	✓	×	×
Pinanga insignis	Karupay	✓	×	×
Pinanga sp.	Salawag	✓	×	×
Platea sp.	Lacobe/Malakobe	✓	✓	✓
Podocarpus sp.	Subing	×	×	✓
Polyosma cyanea	Babasa pino	×	×	✓
Polyscias nodosa	Hagdang uwak	✓	×	×
Pouteria macrantha (Mer.) Baehni	Nato puti	×	✓	×
Protea sp.	Protea	×	×	✓
Prunus grisae	Gabamanok/Tanga	✓	✓	✓
S. polysperma	Balâbaan	×	✓	×
Salacca clemensiana	Kalube	✓	×	×
Sanduricum vidallii	Santol-santol	×	✓	×
Sapindus saponaria	Kulambing/Lakambing	✓	✓	×
Saurauia involucrata	Balangog	✓	×	×
Shorea contorta	Danlugan	✓	✓	×
Shorea mindanaense	Danlugan	×	✓	✓
Shorea palosapis	Kalayaan	✓	✓	×
Solanum sp.	Gubol	✓	×	×
Sterculia sp	Lanutan	×	✓	×
Swietenia macrophylla	Mahogany	✓	×	×
Syzygium sp. 1	Polayo/Palayo	✓	✓	✓
Syzygium sp. 2	Polayo	×	×	✓
Syzygium sp. 3	Polayo lagwis	×	×	✓
Syzygium sp. 4	Polayo pula	×	×	✓
Syzygium sp. 5	Polayo puti	×	×	✓
Syzygium sp. 6	Polayo lagpad	×	×	✓
Syzygium sp. 7	Polayo pino	×	×	✓
Terminalia nitens Presl.	Nangka-nangka	×	✓	×
Terminalia sp.	Nangka-nangka	×	✓	×
Ternstroemia sp.	Sabon-sabon	✓	×	×
Toona calantas	Ple	✓	✓	×
Trema orientalis	Hanagdong/Hinagdong/Anagdong	✓	✓	×
Turpinia sp.	Bintoko	×	✓	×
Unidentified	Bangloy	✓	×	×
Unidentified	Binalagas	×	✓	×
Unidentified	Dibujan	✓	×	×
Unidentified	Gabamanok	✓	×	×
Unidentified	Galaran	×	✓	✓

Table 22. Comparison of Tree Species of Sebucal Headwaters with TEMP *(continued)*

Species	Local Name	TEMP		
		Sebucal	Mt. Capole	Almaciga
Unidentified	Gupa	×	✓	×
Unidentified	Harli	✓	×	×
Unidentified	Katungaw	✓	×	×
Unidentified	Kolumboy	×	✓	×
Unidentified	Kopa	✓	×	×
Unidentified	Magsapoy	✓	×	×
Unidentified	Pamasiton	×	✓	×
Unidentified	Pangkil	✓	×	×
Unidentified	Ple	×	✓	×
Unidentified	Sakod bagulang	✓	×	×
Unidentified	Salimbangon	×	✓	×
Unidentified	Tabako-tabako	✓	×	×
Unidentified	Talo/Bueno-bueno	×	✓	×
Unidentified	Tulan-manok	✓	✓	×
Unidentified	Dapuan tigbay	×	×	✓
Unidentified	Lanutan	×	×	✓
Unidentified	Rubia	×	×	✓
Unidentified	Zazan/Balikoko	×	×	✓
Villebrunea sp.	Roborobod, Borobod	✓	×	×
Voacanga sp.	Tapalak	✓	×	×
Wienmania sp.	Malabago puti	×	✓	×
Total no. of species	**148**	**85**	**65**	**38**

Table 23. Diversity Indices of Riparian Flora

Indices		Panu 1	Panu 2	Lay 1	Lay 2	Lay 3	Mani 1	Mani 2	Con 1	Con 2
Shannon index of diversity	Trees	1.219	0.883	1.152	1.097	0.912	0.952	0.896	0.615	1.168
	Plants	0.749	1.354	0.987	0.999	0.915	0.919	0.807	0.737	0.758
Simpson's index of dominance	Trees	0.093	0.23	0.099	0.123	0.255	0.215	0.255	0.434	0.149
	Plants	0.248	0.041	0.153	0.123	0.136	0.149	0.237	0.25	0.234

Assessment of Aquatic Crustaceans and Fishes

Despite several efforts at net fishing, not a single specimen was caught in all three sites. All the specimens recorded were caught by daytime spearfishing and fish traps deployed during nighttime. Table 24 shows the list of crustaceans and fishes caught in the two sampling sites.

The anga (*Sicyopterus* sp.) and the lapunan (unidentified) were all caught by spearfishing, the rest were caught by fishtraps. The total catch belongs to four fish families – Cyprinidae, Anguillidae, Gobiidae and Kuhlidae. The cyprinids represent the only true freshwater fish caught in Sebucal which is represented by a single species locally called pait-pait (*Puntius* sp.). The kasili or eel (*Anguilla* sp., family Anguillidae) is known to spend a part of their life in freshwater and migrate to the seas to breed, while the *lapunan* (Kuhliidae) and *anga* (*Sicyopterus* sp., family Gobiidae) are both marine families with members in the freshwater habitats.

In terms of the numbers caught and the total weight, *pait-pait* or *paitan* (*Puntius* sp.) dominated the catch with a total weight of 3800g and a total of 269 individuals. This species, together with another species of *Puntius* locally called *lapisan*, dominated the catch in the lower barangays along the Layawan River. *Lapisan*, which dominated the fish netting catch in the downstream barangays of Layawan, is notably absent in all the fish nettings in the three sites. Interviews with locals confirmed that the species was never caught in the Sebucal area.

Two individuals represent the *kasili* in the collection, collected in Site 1. The *lapunan* with 19 individuals were all collected from Site 3 and the *anga* with 34 individuals were collected from both Sites 2 and 3. The only species of crustacean collected is the river prawn locally called *manalsal* (*Macrobrachium* sp.). A total of 13 individuals were collected of the species for a total weight of 820g.

All fishes mentioned above, including the crustacean, are widely used as food and source of protein requirement by the locals and are normally collected by spearfishing and the use of fish traps.

Table 24. List of Aquatic Crustaceans and Fishes in Brgy. Sebucal, Oroquieta City

Scientific Name	English Name	Local Name	Site 1		Site 2		Site 3		Total	
			Count	Weight (g)	Count	Weight (g)	Count	Weight (g)	Count	Weight (g)
CYPRINIDAE *Puntius* sp.		Pait-pait	0	0	132	1900	137	1950	269	3850
ANGUILIDAE *Anguila* sp.	River eel	Kasili	2	800	0	0	0	0	2	800
GOBIIDAE *Sicyopterus* sp.		Anga	0	0	10	600	24	700	34	1300
KUHLIIDAE Unidentified species		Lapunan	0	0	0	0	19	70	19	70
CRUSTACEANS *Macrobrachium* sp.	River prawn	Manalsal	0	0	12	710	1	110	13	820

Total No. Species: 5

Diversity Index	Site1	Site2	Site3	Total
Shannon H' Log Base 10.	0.007	0.221	0.323	0.317

Assessment of Riparian Vertebrate Fauna

Birds. Of the three sites, Site 1 (Layawan Middle) has 16 species and six endemic species. Site 3 (Layawan Convergence) has 22 species and 10 endemic species. Site 2 (Panobigon-Manimatay junction) has 27 species and 13 endemic species. Habitat diversity is related to diversity of organisms inasmuch as the more diverse the habitat is, the more niches would be available (Odum 1971). Overall, 46 species of birds in 24 families were recorded from the three sampling sites in Brgy. Sebucal (Figure 15). Twenty-two of these species are Philippine endemics while nine are endemic to Mindanao/ Mindanao faunal region. Two migrant species, *Lanius cristatus* and *Motacilla cinerea*, were also recorded, while another two species -- *Alcedo argentata* and *Actenoides hombroni* are considered threatened (WCSP 1997). *Alcedo argentata* was recorded in fair numbers all along the four downstream barangays of the Layawan River, even in the lowermost barangay, which is within the city suburbs.

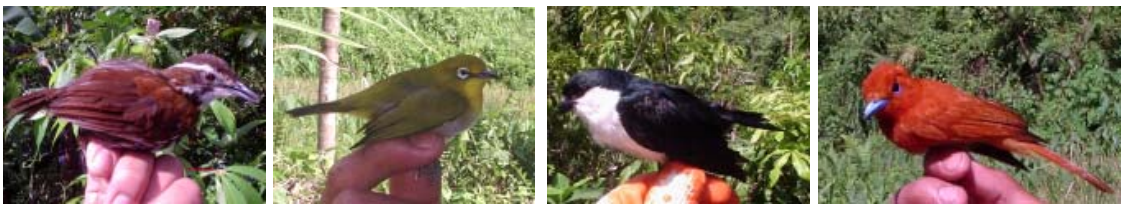
The high number of endemic species (22) describes the diversity of well-defined niches that accommodate species with very specific requirements. As most of these species are intolerant forest species, their presence or absence would indicate the degree of disturbance in an environment.

A comparison of the bird population along the riparian areas of the five barangays along the Layawan River shows the trend of increasing number of endemic species from Villaflor to Sebucal (Table 25). It also shows a higher number of species in Villaflor and Sebucal compared to the four other barangays downstream, which all support a number of endemic species.

Sorenson's similarity index of the bird population in Sebucal with the four other barangays downstream (Table 26) shows the similarity decreasing as one goes downstream. A gradual change in species composition is evident from this similarity with Sebucal. Around 19 species of birds recorded in Sebucal were not found in the four other barangays (Table 27). Some of these species were recorded in higher elevations only. On the other hand, 32 species were recorded in the four lower barangays which were not recorded in Sebucal (Table 28).

Interview with local officials and inhabitants disclosed that active hunting for birds is not widely practiced in the area, as it requires much effort with a small return compared to hunting for mammals. However, opportunistic hunting or shooting for some of the larger bird species is usually done when the bird is accidentally encountered while hunting for mammals or gathering edibles from the forest.

Actenoides hombroni | *Dicaeum hypoleucum* | *Hypsipetes rufigularis* | *Sarcops calvus*



Ptilocichla mindanensis | *Zosterops everetti* | *Microhierax erythrogenys* | *Terpsiphone cinnamomea*

Figure 15. Samples of Birds from the Project Sites

Table 25. Abundance of Birds Along Layawan River

	Sebucal	Mialen	Toliyok	Bunga	Villaflor
Number of Species	46	40	40	41	47
Number of Endemics	22	16	16	14	13

Table 26. Sorensen's Similarity Index of the Bird Population in Sebucal with the Four Other Barangays Downstream

	Mialen	Toliyok	Bunga	Villaflor
Sebucal	59.09%	53.48%	46.97%	43.01%

Table 27. List of Birds in Sebucal Not Found in Other Barangays

Scientific Name	Common Name
*Actenoides hombroni***	Blue-capped Kingfisher
*Amaurornis olivaceus**	Plain Bush-hen
Brachypterx montana	White-browed Shortwing
*Dicaeum hypoleucum**	Buzzing Flowerpecker
Dicrurus hottentottus	Spangled Drongo
Ficedula hyperythra	Snowy-browed Flycatcher
*Hypsipetes rufigularis***	Zamboanga Bulbul
*Lanius validirostris**	Mountain Shrike
Megalurus palustris	Striated Cane-Grass Warbler
*Microhierax erythrogenys**	Philippine Falconet
*Orthotomus cinereiceps***	White-eared Tailorbird
Orthotomus cucullatus	Mountain Tailorbird
*Parus elegans**	Elegant Titmouse
*Ptilocichla mindanensis***	Streaked Ground-Babbler
*Rhipidura nigrocinnamonea***	Black and cinnamon Fantail
Sitta frontalis	Velvet-fronted Nuthatch
*Stachyris plateni***	Pygmy Babbler
Zosterops everetti	Everett's White-eye
Zosterops montanus	Mountain white-eye

Legend: * - Philippine endemics
** - Mindanao/Mindanao faunal region endemics

Table 28. List of Birds in Lower Barangays of Layawan Not Found in Sebucal

Scientific Name	Common Name
*Aethopyga shelleyi**	Lovely Sunbird
Anthreptes malacensis	Plain-throated Sunbird
Artamus leucorynchos	White-breasted Woodswallow
*Bolbopsittacus lunulatus**	Guaiabero
Bubulcus ibis	Cattle Egret
*Centropus viridis**	Philippine Coucal
Ceyx lepidus	Variable Dwarf Kingfisher
Cocomantis merulinus	Plaintive Cuckoo
Copsychus saularis	Oriental Magpie-Robin
Corvus macrorhynchos	Large-billed Crow
Cyornis rufigastra	Mangrove Blue Flycatcher
Egretta garzetta	Little Egret
Ficedula sp	
Gallirallus torquatus	Barred Rail
Gallus gallus	Red Jungle Fowl
Geopelia striata	Zebra Dove
H. chloris	White-collared Kingfisher
Hirundo tahitica	Pacific Swallow
*Hypothymis azurea**	Black-naped Monarch
*Irena cyanogaster**	Philippine Fairy-Bluebird
Lalage nigra	Pied Thriller
Lonchura leucogastra	White -bellied Munia
*Loriculus philippensis**	Colasisi
Merops philippinus	Blue-tailed Bee-eater
Nectarinia jugularis	Olive-backed Sunbird
Nycticorax nycticorax	Black-crowned Night Heron
Oriolus chinensis	Black-naped Oriole
*Orthotomus castaneiceps**	Philippine Tailorbird
Passer montanus	Eurasian Tree Sparrow
Rhipidura javanica	Pied Fantail
Streptopelia chinensis	Spotted Dove

Legend: * - Philippine endemics
** - Mindanao/Mindanao faunal region endemics

Mammals. There were nine species of mammals recorded: five rodents, one civet cat, one pig, one monkey and one tree shrew. Five of these ten species are endemic, while three are Mindanao endemics (Table 29).

The Philippine Warty Pig (*Sus philippensis*) is recorded in the Philippine Red Data Book (WCSP 1997) as heavily hunted and its population declining rapidly. This record of nine mammals is a low count compared to the 20 documented for Misamis Occidental (Heaney *et al.* 1999). This could be due to insufficiency of sampling or the limited area of disturbed riparian zone in the study site. Eight of these species were captured in Site 1, four from Site 2 and two from Site 3 (Figure 16).

Interviews with local barangay officials and inhabitants disclosed that the larger mammals (*Sus philippensis, Cervus mariannus* and even *Macaca fascicularis*) that strayed into the riparian areas are relentlessly hunted for three principal reasons: 1) they are pests to their crops; 2) easy to hunt as the animals get trapped between the steep slopes that border the gully; and 3) they are an excellent source of meat.

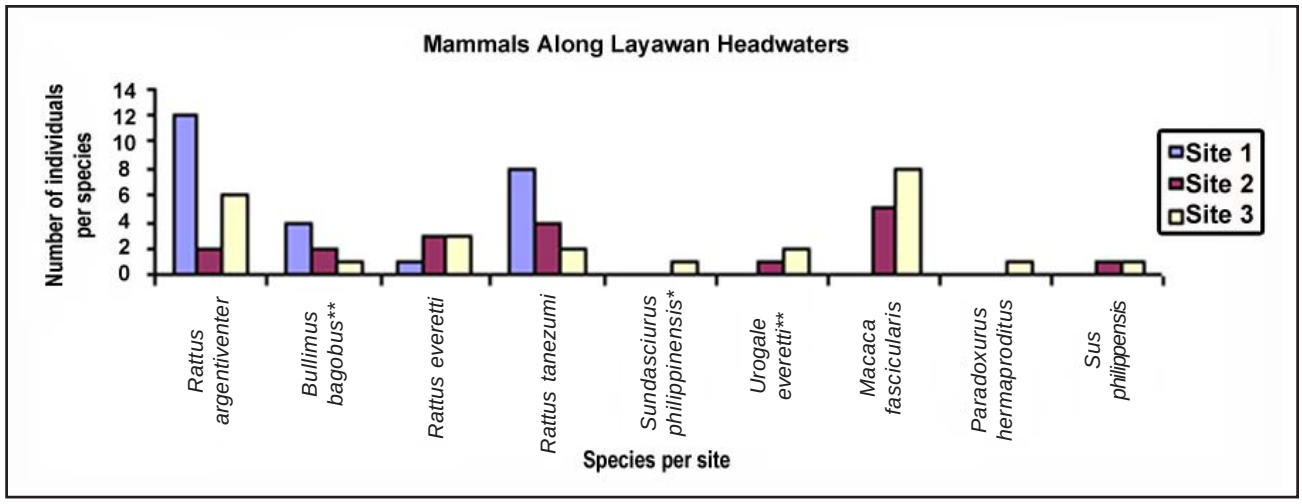


Figure 16. Mammals Captured Along the Layawan Headwaters

Table 29. List of Mammals Recorded in Brgy. Sebucal, Oroquieta City

Scientific Name	Local Name	Site 1		Site 2		Site 3		Total
		Observed	Captured	Observed	Captured	Observed	Captured	
RODENTIA MURIDAE								
Rattus argentiventer	Rice-field rat	0	12	0	2	0	6	20
*Bullimus bagobus***	Large Mindanao forest rat	0	4	0	2	0	1	7
*Rattus everetti**	Common forest rat	0	1	0	3	0	3	7
Rattus tanezumi	Oriental house rat	0	8	0	4	0	2	16
SCIURIDAE *Sundasciurus philippinensis***	Philippine tree squirrel	0	0	0	0	0	1	1
SCADENTIA TUPAIIDAE *Urogale everetti*** *Primate*	Mindanao tree shrew	0	0	0	1	0	2	3
CERCOPITHECIDAE *Macaca fascicularis*	Long-tailed macaque	0	0	0	5	0	8	13
CARNIVORA VIVERRIDAE *Paradoxurus hermaproditus*	Common palm civet	0	0	0	0	0	1	1
ARTIODACTYLA SUIDAE *Sus philippensis**	Philippine warty pig	0	0	1	0	1	0	2

** - Mindanao/Mindanao faunal region endemics

Total No. of Species: 9
Number of Endemic: 5

Index of diversity:	Site 1	Site 2	Site 3	Total
Shannon H' Log Base 10.	0.495	0.786	0.849	0.718

Reptiles. Eight species of snakes were collected from the area; seven were colubrids, while the other one was a pit-viper (Table 30). All the Natrix species (*Natrix lineata, N. auriculata, N. dendrophiops*) collected in the shallow water right at the riverbank were endemic and common. The lizards collected in the three sites in the shallow waters of the river were all skinks. One notable species (*Hydrosaurus pustulatus*) which was observed most commonly in the lower barangays along Layawan River and recorded to favor clear mountain streams was never collected nor observed in the three sites. From interviews, no species of reptiles is actively hunted for food in the area.

Table 30. List of Reptiles Captured in Brgy. Sebucal, Oroquieta City

Species	Common Name	Local Name	Site 1	Site 2	Site 3	Total
SNAKE						
Colubridae						
*Natrix auriculata**	White-lined Water Snake	Bogongol	3	4	0	6
*Natrix lineata**	Zigzag-lined Water Snake	Momo-an	0	2	2	4
*Natrix dendrophiops**	Spotted Water Snake	Dopong	0	1	0	1
Natrix sp. 1		Tangkig	1	1	1	3
Natrix sp. 2		Momo-an	0	1	0	1
Aplopeltura boa	Snail-eating Snake	Ogto-ogto	0	1	0	1
Calamaria virgulata	Southern Worm Snake	Manyok	0	1	0	1
Viperidae						
Trimeresurus venustus			0	0	1	1
LIZARD						
Scincidae						
*Tropidophorous misaminus**	Misamis Waterside Skink	Baryok	1	5	1	7
Sphenomorphus sp. 1		Tabili sa lasang	0	1	0	1
Sphenomorphus sp. 2			0	0	1	1
Mabuya multicarinata			0	0	1	1
Mabuya sp.			1	0	0	1

Legend: * - Philippine endemics

Total No. of Species: 13
Total No. of Endemic Species: 4

Diversity Index	Site 1	Site 2	Site 3	Total
Shannon H' Log Base 10.	0.54	0.759	0.848	0.996

Amphibians. Eight species in three families of amphibians were recorded (Table 31). The two bufonid species (*Ansonia mcgregori* and *Ansonia muelleri*) are Mindanao endemics and considered rare. Both were reported by Alcala (1986) to inhabit forest floors at altitudes up to 2000 masl. Twenty-two individuals of *A. muelleri* and five of *A. mcgregori* were collected.

The most number of individuals collected was *Rana magna* species with a total of 58 individuals captured. Only one of this species was collected in Site 1 and was in fact the only species collected there. Twenty-five unidentified inch-long tadpoles of several species were caught in the fish traps in Site 1. Fifteen individuals of *Rana cancrivora*, a brackish water frog, were caught in the area. This is a rare record of that species at high elevation, as it has been reported to occupy areas at or near sea level by Alcala and Brown (1998). The species, together with *R. magna*, is a favorite collected food species among the amphibians because of its large size.

Most of the larger species of frogs in the area are actively hunted for food, but since they are mostly abundant along the streams and rivers and are active only during nighttime, not much frog collection is done by the villagers.

Table 31. List of Amphibians in Brgy. Sebucal, Oroquieta City

Species	English Name	Site 1	Site 2	Site 3	Total
RANIDAE					
*Rana magna**	Giant Philippine Frog	1	9	48	58
Rana cancrivora	Asian Brackish Water Frog	0	1	14	15
*Platymantis corrugatus**	Rough-blacked Forest Frog	0	0	1	1
*Platymantis dorsalis**	Common Forest Frog	0	0	1	1
BUFONIDAE					
*Ansonia mcgregori***	McGregor's toad	0	0	5	5
*Ansonia muelleri***	Mueller's toad	0	7	15	22
RHACOPHORIDAE					
Rhacophurus bimaculatus	Asiatic Tree Frog	0	1	0	1
Polypedates leucomystax	Common Tree Frog	0	0	1	

Legend: * - Philippine endemics
** - Mindanao/Mindanao faunal region endemics

Total No. of Species: 8
Total No. of Endemic Species: 5 (2 are Mindanao endemic)

Index	Site 2	Site 3	Total
Shannon H' Log Base 10.	0.45	0.543	0.546

Water Quantity and Water Quality Analysis

Amount of river discharge, temperature and dissolved oxygen are shown in Table 32, physical and chemical analyses results in Table 33 while bacteriological analysis results in Table 34.

River discharge. Among the three headwater streams of Sebucal, Panobigon, where the mudspring is located, has the lowest average discharge of 1.26m^3/s. Manimatay has the highest average discharge of 7.35m^3/s while Middle Layawan has an average discharge of 6.63m^3/s. The differences in the water volume of these streams are understandable considering the differences in their sub-catchment areas. The discharges of the three headwater streams converge to Layawan River junction site with the total volume of 8.32m^3/s during the rainy season (Figure 17).

Table 32. Summary Table for Temperature, Dissolved Oxygen, Percent Oxygen Saturation and River Discharge (October 2004)

Sampling Station	Temperature	Dissolved Oxygen	Saturation	Total discharge, m^3/s	
				October 2004	January 2005
Panobigon	21.2	5.72	87.1	0.44	2.08
Manimatay	22.2	5.68	87.2	1.18	13.5
Layawan lower	21.4	5.87	88.6	1.79	9.40
Layawan convergence	22.5	5.75	87.8	3.87	14.84
Panobigon hot spring	35.5	1.43	-	0.0000491 (49.11ml/sec)	-

Table 33. Physical and Chemical Analysis of Water Samples (October 2004)

Sampling Area (Brgy. Sebucal)	Appearance/ Sediments	pH	Turbidity (NTU)	TDS (ppm)	Alkalinity (ppm)	Total Hardness	NO_3 (ppm)	PO_4 (ppm)	NH_3 (ppm)	TSS (mg/L)
1. Manimatay	Clear/fine brown particles	6.80	2.30	89.00	48.00	50.00	0.005	0.011	0.026	3.13
2. Panobigon	Clear/fine brown particles	7.40	2.40	99.00	98.04	82.00	0.036	0.013	0.064	4.43
3. Layawan Convergence	Clear/fine brown particles	7.80	2.65	150.00	100.80	90.00	n.d.	0.02	0.038	3.43
4. Layawan Lower	Clear/fine brown particles	7.60	3.12	240.00	156.00	158.00	n.d.	0.014	0.036	4.66

Legend: n.d. - not detected

Table 34. Bacteriological Analysis of Water Samples Performed by ICWSO (October 2004)

Sampling Area (Brgy. Sebucal)	Colony Count after 48 hrs	Coliform Test		MPN	EMB Colonies	E.coli test	Remarks
		Presumptive	Confirmatory				
1. Manimatay	1,780	5/5	5/5	More than 16	Typical	4/5	Unsafe
2. Panobigon	2,020	5/5	5/5	More than 16	Typical	1/5	Unsafe
3. Layawan Convergence	1,854	5/5	5/5	More than 16	Typical	2/5	Unsafe
4. Layawan Lower	910	5/5	5/5	More than 16	Typical	5/5	Unsafe

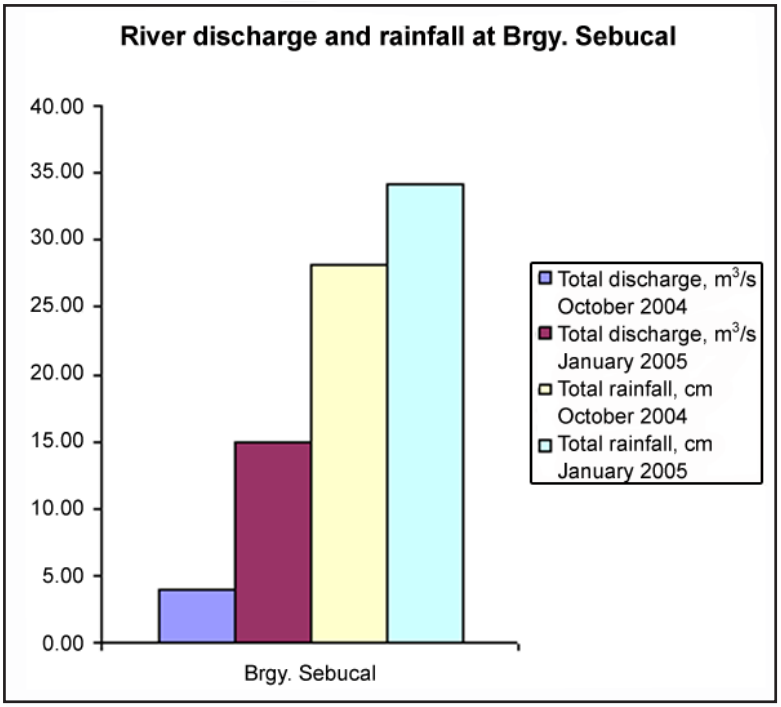


Figure 17. River Discharge and Rainfall in Brgy. Sebucal

Temperature. The mean water temperature readings vary among sampling sites, ranging from 21.2°C to 22.5°C. The hot spring effluent did not influence the temperature reading of the Panobigon River because the temperature reading in this site appears to be the lowest among the four sites. The discharge of the hot spring is only 0.0000491m^3/s. The differences of the temperature readings among sampling sites could be due to the differences in the time of sampling (Figure 18).

Dissolved oxygen. Dissolved Oxygen (DO) reading at Middle Layawan headwater (5.87mg/L) is relatively higher than the Panobigon (5.72mg/L) and Manimatay (5.68mg/L) sampling sites. Based on DENR standards, the DO reading of the four sampling sites is slightly higher than the limit of Class AA waters which is 5.0mg/L. The DO readings obtained meet the general water quality standard for the warm water fisheries, which is 5.5mg/L. The saturation of the DO in all sampling sites can be classified as adequate conditions (80-90% saturation).

Total dissolved solids. Total dissolved solids (TDS) recorded at Middle Layawan obtained the highest level of 240ppm among the four sampling sites. TDS reading in all sampling sites meet the Environmental Protection Agency (EPA)'s recommended maximum of TDS in water, which is 500ppm (Figure 19).

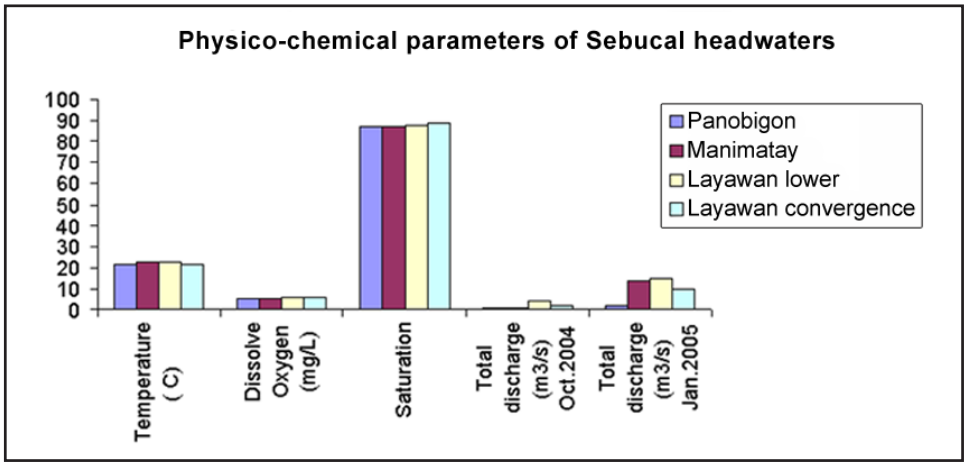


Figure 18. Physico-Chemical Parameters (Temperature, DO, Percent O_2 Saturation, River Discharge) of Layawan Headwater Streams

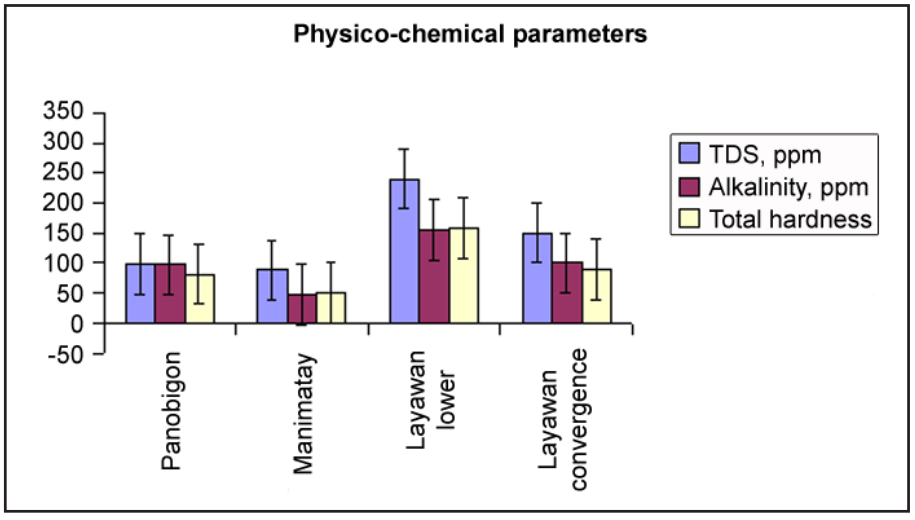


Figure 19. Total Hardness, Total Alkalinity and Total Dissolved Solids at Various Sites of Layawan Headwaters

Total suspended solids. Total suspended solids (TSS) in surface waters occur primarily from storm water runoff, stream bank and channel erosion, dead plant matter, plankton and re-suspension of sediment into the water column. A high concentration of TSS negatively affects the surface water's ecosystem and aesthetics. TSS ranged from 3.13 to 4.66mg/L, with river discharge in the single Layawan River (or Layawan Convergence) amounting to 3.87m^3/s (Figure 20 and Figure 21).

Hardness. Manimatay sampling site is classified as soft water, Panobigon and Layawan junction sites as moderately hard and middle Layawan as hard. Soft waters are mainly derived from the drainage of igneous rocks, because these rocks do not weather very easily and so do not release many cations. Hard water is often derived from the drainage of calcareous (calcite-rich) sediments, because calcite ($CaCO_3$) dissolves, releasing the calcium. Calcium, magnesium, and other polyvalent cations such as iron and manganese may be added to a natural water system as it passes through soil and rock containing large amounts of these elements in mineral deposits.

pH. The pH level recorded in the four sampling sites ranges from 6.8 to 7.8. Manimatay has the lowest pH among the four sampling sites followed by Panobigon, Manimatay, Lower Layawan and Layawan Convergence sites. pH reading in the sampling sites meet the DENR standards for Class AA waters (Figure 22).

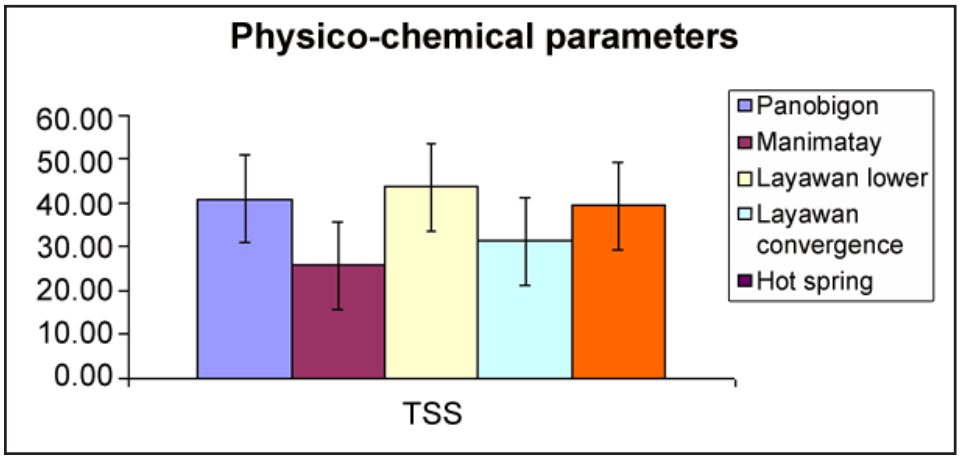


Figure 20. Total Suspended Solids at Various Sites of Layawan Headwater Streams

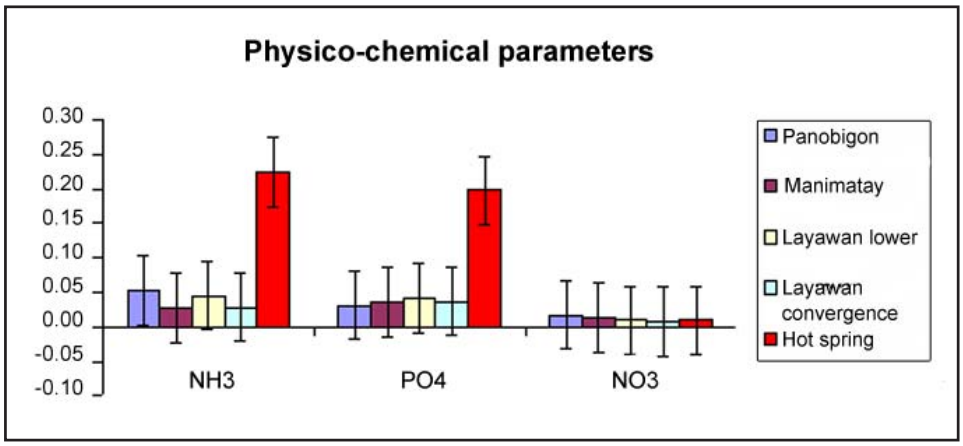


Figure 21. Inorganic Nutrients (NH_3, PO_4 and NO_3) at Various Sites of Layawan Headwater Streams

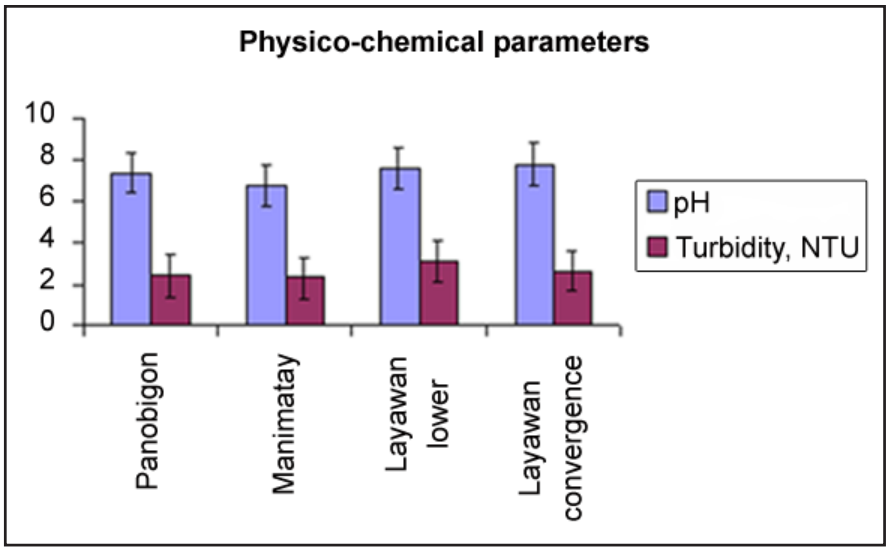


Figure 22. Turbidity and pH at Various Sites of Layawan Headwater Streams

Alkalinity. Lower Layawan has the highest alkalinity reading of 156ppm among the four sampling sites while Manimatay has the alkalinity of 48ppm.

Bacteriological analysis. The river itself is not used as drinking water by the residents. The barangay has a water system that taps a spring beside Panobigon, installed in 1994. The colony count (heterotrophic bacterial count) after 48 hours which is expressed in colonies per ml is indicative of the general bacterial population. The bacteria metabolize any particulate and dissolved detrital organic matter that is synthesized either autochthonously within the river/stream, or allochthonously and which is brought to the river by surface water runoff.

The coliform test is positive for *Escherichia coli*, an indicator of fecal pollution. The most probable number (MPN) is greater than 16/100ml in all samples. Guidelines for Canadian recreational water quality (1993) set the maximum limits for recreational waters to be not exceeding 2000 *E.coli* per liter, which should be the geometric mean of at least five samples taken during a period not to exceed 30 days. Although the headwater streams samples were one-time samples, one may probably generalize that their *E.coli* load still meets the standard for recreational purposes.

Socioeconomic-Cultural Profile of Brgy. Sebucal

Sebucal is one of the barangays/villages of Oroquieta City. Oroquieta City is the capital of the province of Misamis Occidental, classified as a third class city composed of 47 barangays. It was formerly known as Barrio Layawan when it was under the Municipality of Jimenez from 1861-1879 but was renamed Oroquieta when it grew to become a separate municipality. It has a total land area of 263.934sq km.

Total population is 56,012 in 1995 and 60,257 in 2000. However, it is projected to grow to 64,237 in 2005 and 67,528 in 2010. Its coastal barangays are estimated to have a total area of 1,193.09 ha. The Subanuns of Mialen, Toliyok and Sebucal have filed their Ancestral Domain Claims and 300ha of land were released by the DENR in 1998 for the four barangays covered by TOCSEMISE (Toliyok, Clarin Settlement, Mialen and Sebucal). Most households depend on fishing and farming for their livelihood.

With the use of survey method (house to house interviews), ocular observations and document reviews, the current demographic, socioeconomic and a bit of the environmental profile of Brgy. Sebucal of Oroquieta City is described. The survey results showed that majority of households

are composed of males with four or more members and the household heads are 50 years old and younger. Households are usually of nuclear type with parents and children composing the homes. Many of them had stayed in this community for some time beginning from the 1950s or 1960s. They were brought here by their parents or other relatives coming mostly from the various places within the province or the neighboring province of Zamboanga del Norte. They decided to settle in the area because of available fertile land to grow their food.

Residents are mostly Subanuns who have embraced Roman Catholicism as their religion. More than 80% of household heads and 50% of household members only have elementary education. However, younger members of the households pursue high school (15.43%) and college education (8.06%). Generally, households depended on on-farm income sources that provide them low income. Despite the situation, the majority (68.29%) of those surveyed have no plans to transfer to other places where they can improve their living condition.

The community is endowed with rivers, springs and creeks. It has also rich forests with native trees apart from the reforested species that people have planted along the trails such as gemelina (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*) species. The steep slopes partly protected their forests from human disturbances and so, forests are still rich in wildlife flora and fauna. The lands (in the plateau and in the low and midslopes of the surrounding mountains), though considered slightly acidic are still considered by many as fertile. The flat riparian areas have lost their expected forest cover and have generally been cultivated or been planted with other kinds of trees.

The survey data also revealed that for the residents in the barangay, the three rivers have varying importance attached to them. Layawan River was considered by almost all of the respondents (97.57%) as the most important as it contained rich aquatic resources and community members extracted these resources for food. Panobigon River was claimed valuable by 85.37% of the respondents and Manimatay by 53.66%. Only Panobigon River was valued as an electricity source. All the three rivers were equally valued for bathing purposes and for washing.

Summary and Conclusions

The headwaters of Layawan River are located at Mt. Malindang Range Natural Park, one of the protected areas of the Philippines. The assessment of the headwater streams of Layawan River and its riparian areas not only completes the profile of the riverine and riparian ecosystems comprising the Layawan River but also establishes linkages between the terrestrial and aquatic ecosystems of this part of the Mt. Malindang landscape. This assessment includes the riverine biota (aquatic macroinvertebrates, aquatic crustaceans and fishes); the riparian biota (terrestrial invertebrates, riparian flora and riparian vertebrate fauna) and the quality and quantity of water in the three major headwater streams. In addition, how the human community (which is more or less isolated in this area) impacts on and relates to the headwaters serves as a prototype for the development of a management plan that will incorporate the goals of biodiversity conservation and sustainable development.

Aquatic macroinvertebrates found in the headwater streams are mostly indicators of good water quality. Some of them are the larval stages of certain terrestrial/riparian invertebrates. The terrestrial invertebrate fauna were represented by eight orders of insects, two classes of arthropods (Arachnida and Crustacea) and one phylum (Mollusca). The eight orders of insects included the Lepidoptera (butterflies), Odonata (dragonflies), Coleoptera (beetles and weevils), Hemiptera (water bugs), Phasmatodea (walking sticks), Ephemeroptera (Mayfly, dayfly), Plecoptera and Trichoptera (caddisflies). There is a high percentage of endemism (ca. 40%) for Lepidoptera, due in part to their restriction to certain food plants which are also restricted to the riparian areas. The accessible flat riparian areas usually have owners and were frequently cultivated to varying degrees. Thus, their tree vegetation has been usually removed except for a line of trees at the immediate edge of the river/stream bank.

There were 72 tree species in the nine plots totaling to an area of 3600sq m. Floristically, these trees should be distinctive to that of the Zamboanga biogeographic province. Some of these trees though are introduced cultivated such as abaca (*Musa textilis*), camansi (*Artocarpus communis*), mahogany (*Swietenia macrophylla*), nangka (*Artocarpus heterophyllus*), papaya (*Carica papaya*), romblon (*Pandanus* sp.) and saging (*Musa x paradisiaca*). The fauna (birds, mammals, reptiles, amphibians, aquatic crustaceans and fishes) inventory included native and endemic species but these are continually being threatened by activities of the local human population.

The volcanic nature of the Mt. Malindang area is responsible for the low concentration of ions in the headwater streams, where in October 2004 total hardness ranged from 50-158ppm, total alkalinity from 48-156ppm and total dissolved solids (TDS) from 89-240ppm. The differing sizes of the sub-catchments upon which surface water runoff flows and through which groundwater seeps would account for these differences in values in the three headwater streams. Total suspended solids (TSS) ranged from 3.13 to 4.66mg/L, with river discharge in the single Layawan River (or Layawan Convergence) amounting to 3.87m^3/s. The pH ranged from 6.8-7.8, normal values for a freshwater ecosystem. The presence/number of coliforms in all sites makes the river water unsafe for drinking, although the river water still meets the standards for recreational purposes.

Although the barangay/village population only consists of 49-52 households consisting of approximately 250 individuals, their land use, hunting and fishing activities, extraction of timber and non-timber forest products, if uncontrolled and unregulated, threaten the conservation of biodiversity in this area and their sustainable use.

Recommendations

1. The bacteriological analysis showed that there is fecal contamination of river waters. Even though the rivers are usually not used for drinking, it is recommended that households have latrines to avoid further contamination. Drinking river water should be avoided at all times.

2. Flat riparian areas were usually cleared and farmed, leaving only a single line of trees at the immediate edge of the riverbank. A riverbank buffer zone of, at the minimum, 3-5m should be established where there is absolutely no clearing and cutting of vegetation. It is better to plant indigenous trees and plants along the 3-m side of the river where these areas no longer have the original native vegetation.

3. There are endemic butterflies, birds and other animals in the area. A butterfly farm can be established as a possible source of income for the local community and to encourage conservation.

4. There are a good number of birds and other animals which are food sources. Regulations should be enforced to limit the hunting and eating of these species.

5. Brgy. Sebucal is located in a forested zone. It is just a small plateau surrounded by forests. The human settlement can create disturbances to the forest resources. Inasmuch as resettlement would mean displacement of people including disruptions of their existing social relationships, massive campaign should be undertaken to increase awareness on the need for environmental protection and conservation. Strict monitoring should be enforced to prohibit expansion of cultivated lands to prevent further environmental destruction that will subsequently affect both residents and other people in the lowland and coastal areas.

6. There is too much reliance by households on the produce of land for their livelihood. This results to low income among the residents, which is aggravated by limited opportunities due to low educational attainment. Alternative income sources in the community should be enhanced and supported to avoid expansion of cultivation to forested parts of the community. Such alternative income sources must also be in harmony with the environment, such as butterfly and honey culture, bonsai plants propagation and native food processing. Marketing assistance is needed for these livelihood options.

7. There is a need for the government to offer scholarship programs to members of the community with good academic potentials to better their socioeconomic condition through education.

8. To prevent pressure on the Mt. Malindang Range Natural Park (a buffer zone), additional migrants should be regulated and barangay officials should enforce close monitoring.

9. The changes observed in the rivers in terms of water level and the aquatic resource quantity imply that if people continue to cut trees and harvest aquatic resources indiscriminately, the water level will continue to recede and the fishes and shellfishes will continue to decrease in supply vis-à-vis the human needs for food. Thus, the community should limit the areas for the slash and burn cultivation. Alternative sources of food should be explored to lessen dependence on the rivers.

10. To maintain the quality of water and riparian environment of the Layawan headwaters, reforestation with indigenous tree species must be done at the banks of Middle Layawan and Lower Layawan especially where slash-and-burn farming is rampant. Infrastructure like roads may bring further destruction to the forest, so a cable car may be a good alternative for transporting agricultural products.

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